COPENHAGEN BUSINESS SCHOOL

MASTER OF SCIENCE IN APPLIED ECONOMICS AND FINANCE

BASEL II AND LENDING POLICIES OF DANISH BANKS UNDER ON-GOING ECONOMIC CRISIS

OLGA KONTOGEORGIS

SUPERVISOR: ANETTE BOOM, Associate Professor, Ph.D.

Department of Economics

November 2010

Preface

The author would like to thank Prof. Anette Boom for her valuable advices, passion in the research topic and understanding. An additional thank you is for Cedric Shnejder for his contribution in the econometric analysis of this project.

In addition, I would like to thank Jørn Kofod-Hansen, Lisbeth la Cour, specialists from Nykredit, Nordea, SaxoBank, Finanstilsynet and National Bank of Denmark for their assistance and constructive discussions related to this project.

Executive summary

The introduction of Basel II in 2006 was part of the framework on how global markets and institutions can better serve the needs of people in different countries. Unfortunately, the beginning of the Basel II implementation practically coincided with a recent so-called Subprime mortgage crisis (SMC) that started in USA in 2007 and affected later economies worldwide. This fact raised debate on whether Basel II has been released too late and whether it is not a solution to a crisis but instead maybe even its cause.

The idea of this project is to investigate how Basel II affected the Danish banking system, in particular lending policies of the Danish banks. The Basel II has been introduced in the Danish legislation since 2007. In our research we take also into consideration the influence of the on-going international financial crisis, started in 2007, on the Danish banking sector.

This work was inspired by the published research of Ruthenberg and Landskroner (2008) who formulated a model for loan pricing under Basel II and made an empirical analysis based on the data from one of the largest banks in Israel.

In our research, based on the Danish economy data, we focus on the following research questions:

- Is the published model valid in the case of the Danish economy?
- Which was the influence of Basel II and the on-going economic crisis on the Danish banking sector?
- How did the introduction of the Basel II affect the competition between Danish banks?

Methods of the industrial organization and econometric analysis are applied in this thesis, thus differentiating this work from the other projects recently carried at Copenhagen Business School on Basel II.

Although the published article presented a forecasting model on loan pricing under Basel II with exiting results, a number of difficulties appeared after its thorough reading. The mathematical model had to be corrected, and data used in some cases by authors was a little confusing.

A regression model here was formulated in a similar way, and credible data used for econometric analysis was retrieved from the publicly available databases of the National Bank of Denmark, Danish FSA (Finanstilsynet), NASDAQUE OMX Group and Denmark Statistics. The cases of loans to non-financial companies of different maturity: a) up to 1 year; b) 1 to 5 years and c) over 5 years have been considered.

Our results showed that although most of the regression coefficients were significantly different from zero for cases of the loans with different maturities, the estimated coefficients for the cost of equity sensitivity (the Basel II related term) were received insignificantly different from zero. A detected evidence of the positive autocorrelation brought us to the conclusion that our model based on published research cannot be used as a forecasting model on loan pricing under Basel II in the case of the Danish economy. The other conclusion was that lending policies of the Danish banks in 2007-2009 were significantly affected by on-going crisis and political decisions, much more than by the implementation of the Basel II. The conclusion on competition from the published research may still be applicable to the case of the Danish banking sector: low risk highly quality customers will be attracted by schemes of the large Danish banks, while more risky customers will obtain loans from the small banks (which use the standardized approach).

Table of content

Chapter 1. Introduction

1.1. Problem Formulation

The release of the Basel II Accord (2006) was a milestone in the efforts of the international banking supervisors to update the original international bank capital accord (Basel I), which was introduced in 1988. The revised accord aimed to improve the consistency of capital regulations internationally, make regulatory capital more risk sensitive, and promote enhanced risk-management practices among large, internationally active banking organizations.

The introduction of Basel II was part of the framework on how global markets and institutions can better serve the needs of people in different countries. Unfortunately, the beginning of the Basel II implementation practically coincided with a recent so-called Subprime mortgage crisis (SMC) that started in USA in 2007 and affected later economies worldwide. This fact raised debate on why the financial crisis has happened on the first place if the Basel II´s target was to avoid it. Has Basel II been released too late, or it is not a solution to a crisis but instead maybe even its cause?

The idea of this project is to investigate how Basel II affected the Danish banking system, in particular lending policies of the Danish banks. The Basel II has been introduced in the Danish legislation since 2007. In our research we take also into consideration the influence of the on-going international financial crisis, started in 2007, on the banking sector.

1.2. Research Questions

This work was inspired by the published research of Ruthenberg and Landskroner (2008) who formulated a model for loan pricing under Basel II and made an empirical analysis based on the data from one of the largest banks in Israel. Originally, our target was to test this model for the case of some large Danish bank and compare the results. However, a number of difficulties was encountered and shaped the final outcome of our research.

In this project, based on the Danish economy data, we focus on the following research questions:

- Is the published model valid in the case of the Danish economy?
- Which was the influence of Basel II and the on-going economic crisis on the Danish banking sector?

- How introduction of the Basel II affected the competition between Danish banks?

1.3. Methodology and Limitations

The work on the project has started by the preparation of the literature review that allowed to narrow down the subject of research. The published article (Ruthenberg and Landskroner, 2008) has been selected as a basis for the current project, although it became very soon apparent that this specific article has the purpose of providing only indicative solutions. All the mathematical part has been formulated again, though we kept the original equation of the bank´s profits as a starting point of our research.

Our model is formulated using one of the approaches of Industrial Organization, an economic discipline that is rather new and only recently has evolved from a niche area in economics to an independent research area. The main focus of the Industrial Organization is related to functioning markets and industries, in particular the ways firms compete in real markets with imperfect competition.

Collecting data for empirical analysis, a next step of the work on the project, consisted of several attempts to contact large Danish banks (Nordea and Nykredit) in order to get bank-specific data for our analysis. Unfortunately, the final conclusion was that these banks did not have (or could not provide) explicit data required for our analysis, and therefore the decision to use public databases was made. In our research, we use data from the databases of the Danish National Bank, Danish FSA (Finanstilsynet), Denmark´s Statistics and Copenhagen Stock Exchange.

The empirical analysis has been performed with a help of the software SAS, while some intermediate calculations have been also performed in Excel.

There were a number of limitations that occurred throughout writing this project. The original plan to use the bank specific data for the analysis did not materialize as neither Nykredit nor Nordea have ready data, suitable for our research. Therefore the decision about using data from the publicly available database has been made.

The next challenge was the discovery of a number of mistakes in the published article that was chosen as a basis for our research project. These mistakes have been found and corrected. It leads to a slightly different formulation of the mathematical model which is discussed in this project.

The third challenge occurred due to the fact that while Danish is not the native language for the author of the project, most of the relevant material about Danish banks is published in Danish.
The fourth limitation is closely related to the data used in the project. The on-going economic crisis significantly affected interest rates and especially demand function in the period of 2007-2009. For the final regression model, we use a reduced sample of data for the years 2003-2006.
At the same time, the project was interesting and enriching from many perspectives, including collaboration with specialists in banking industry, professors in CBS and ex-colleagues from Saxo Bank.

1.4. Outline of the thesis

The thesis includes executive summary, 9 chapters, the table of contents, literature reference list, and two appendices. The files in Excel with data for the econometrical models are provided on the CD-ROM.
The chapter 1 is the introduction where research questions, problem formulation and limitations of the project are discussed. The chapter 2 gives an overview of the Basel Accords I and II and provides a comparison between the two documents with a focus on the new features of the "new" Basel II Accord. The reasons of the Basel II release are also discussed. The chapter 3 is a literature review where the articles, books and MSc projects carried at CBS about the Basel II are discussed. The chapter 4 is addressed to the Danish banking system, in particular to the structure of the Danish banking sector and the introduction of the Basel II in Denmark. In 2008-2009, the Danish government developed two programs to help Danish banks to survive over the turbulent period for the international economy. These programs were named The Bank Rescue Packages I and II and also discussed in the chapter 4.
The chapter 5 presents a model of loan pricing under Basel II. We present our version of the mathematical model which differs slightly from the one published in the article (Ruthenberg and Landskroner, 2008). A derivation of the model is shown in details. In the chapter 6, data for the model is discussed: a proxy for the probability of default, calculations of the cost of equity, assumptions for the capital requirement term under Basel II, the interbank borrowing rates in Denmark and the HH index, measure of the market concentration, for the Danish market of loans to non-financial companies for the period of 2003-2009. In the chapter 7, the elasticity of demand for loans to non-financial companies in Denmark in the period of 2003-2009 is discussed. Unexpectedly, the results of the OLS regression showed a positive slope for the demand curve

instead of the negative one that is the assumption for the optimization models of the industrial organization.

The chapter 8 presents the results that have been received with our econometric model and compares our results with the published in the article (Ruthenberg and Landskroner, 2008). The chapter 9 is the overall conclusion to the thesis.

Chapter 2. Basel Capital Accords

This chapter gives an overview for the Basel Committee and its scope of work. We discuss about the main risks for the banks, the reasons of creation of the Basel I Accord and for its later revision. A new Accord, Basel II, was released in 2006. A discussion about the differences between Basel I and Basel II is also provided.

2.1. Basel Committee

The Basel Committee was established in 1974. The reason of its creation was a negative experience with failures of internationally active banks in the 1970s that provided an ample reason to be concerned with the financial stability of the banks worldwide (Tarullo, 2008). Linkages through the interbank lending market or the payments system meant that a foreign bank´s failure could create problems for domestic banks as well.

Originally created by the central-bank Governors of the Group of Ten countries (1974), the Basel Committee expanded its geography over the years and now consists of members from Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong SAR, India, Indonesia, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.[1]

Countries are represented by their central bank and also by the authority with formal responsibility for the prudential supervision of banking business in cases where this is not the central bank. Since 1974 the Committee meets regularly four times a year. It has four main working groups which also meet regularly. The present Chairman of the Committee is Dr. Nout Wellink, President of the Netherlands Bank (since July 1st, 2006).

[1] http://www.bis.org

2.2. Basel I Accord

The annual reports of the Basel Committee in the early 1980s consistently mentioned the supervisors concern over the erosion of bank capital levels worldwide. Supervisors had apparently anticipated the risk of what has since, in various contexts, become known as a "race to the bottom" (Tarullo, 2008), whereby one country´s lower regulatory standards make it more difficult for other countries to maintain rigorous, but necessarily more costly standards.

In July 1988, the Basel Committee released the final version of the Accord, known now as Basel I. Basel I was motivated by two interacting concerns – the risk posed to the stability of the global financial system by low capital levels in internationally active banks and the increasing competitive advantage of the banks with lower capital requirements (Tarullo, 2008). One of the main targets of Basel I was to create a convergence in banking sector across the countries.

The accord addressed only credit risk, while acknowledging that banks must guard against other kinds of risk as well. The main banking risks are presented in Fig.2.1. Credit risk is the most important one and is connected to the default risk, a major source of losses (Bessis, 2002). The default risk is addressed to the situations when customers fail to comply with their obligations to service debt. Default triggers a total or partial loss of any amount lent to counterparty.

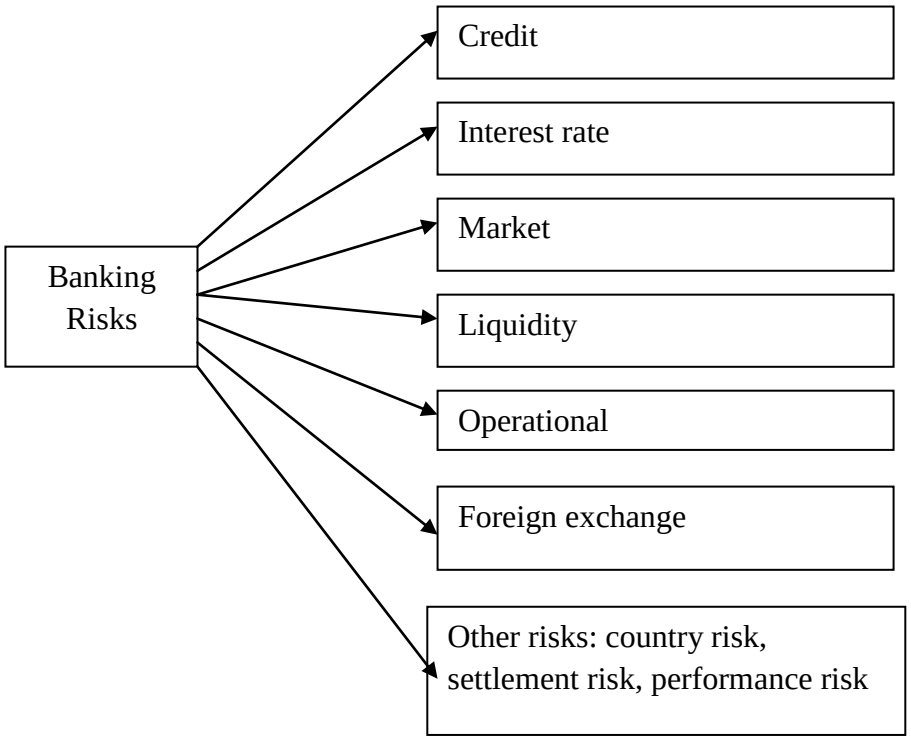


Fig.2.1. Main banking risks. Source: Bessis, 2002.

The basic approach of Basel I was to assign each asset or off-balance-sheet item held by a bank to one of five risk categories (presented in Table 2.1), calculate the capital required for each asset or item based on the risk weighting, and then add all these amounts together to produce the total minimum capital to be held by the bank.

Bank Asset Classification System under Basel I (five risk categories)
0% - cash, central bank and government debt and any OECD government debt
0%, 10%, 20% or 50% - public sector debt
20% - development bank debt, OECD bank debt, OECD securities firm debt, non-OECD bank debt (under one year maturity) and non-OECD public sector debt, cash in collection
50% - residential mortgages
100% - private sector debt, non-OECD bank debt (maturity over a year), real estate, plant and equipment, capital instruments issued at other banks

Table 2.1. Bank Asset Classification System under Basel I. Source: http://www.investopedia.com

The accord created two minimum capital ratios: a bank´s core capital, called by the committee "tier 1" capital, which was to be at least 4% of risk-weighted assets, and a bank´s total capital, which included so-called "tier 2" components and was to be at least 8% of risk-weighted assets. The structure of Basel I is presented in the Table 2.2.

Capital Elements
Tier 1 - Paid-up share capital/common stock - Disclosed reserves
Tier 2 - Undisclosed reserves - Asset revaluation reserves - General provisions/ general loan-loss reserves - Hybrid (debt/equity) capital instruments - Subordinated debt
Limits and Restrictions - Total of tier 2 elements limited to a maximum of 100 % of the total of tier 1 elements - Subordinated term debt limited to a maximum of 50% of tier 1 elements - Loan-loss reserves limited to a maximum of 1.25 percentage points - Asset revaluation reserves that take the form of latent gains on unrealized securities subject to a discount of 55 %

Table 2.2. Definition of capital in Basel I. Source: Basel Committee (1988), from (Tarullo, 2008).

Thus, the key elements of the Accord were the definition of the two capital measures, the allocation of assets among the risk categories, and the conversion factors by which off-balance-sheet items were made equivalent to assets for risk–weighting purposes.

The 1988 Accord has had an impressive success story. It was adopted in over 100 countries, and contributed to the strengthening of bank capital at a time when a number of countries had experienced problems in their banking systems.[2] It has become one of the benchmark measures of a bank's financial health.

2.3. Basel II framework

However, few years later, developments in risk measurement and management have widened the gap between the regulatory capital measure under the 1988 Accord and the internal capital measures used at many internationally active banks. More sophisticated technology and telecommunications, as well as market innovations, have enabled banks to better measure and manage their risks.

As a result, the Basel Committee determined that a new capital framework was needed that would address these developments for the most complex and sophisticated banks, but also be appropriate for less complex banks. The Committee determined that the new capital framework should additionally provide incentives for banks to improve their risk management practices without reducing the overall level of capital, held in the banking system.

A new Accord, which received the name Basel II, was presented by Jaime Caruana[3] on the international conference in May 2005: "Basel II, in my view, is fundamentally about better risk management and corporate governance on the part of banks, as well as improved banking supervision and greater transparency. It is also about increasing the stability of the global financial system, to the benefit not only of banks, but also consumers and businesses" (Caruana, 2005).

The final version of Basel II Accord was released in June, 2006 and is available on the website of the Bank for International Settlements.[4] The full name of the Accord is the "International Convergence of Capital Measurement and Capital Standards".

[2] http://www.bis.org
[3] president of the Basel Committee in the period from May, 2003 to June, 2006
[4] http://www.bis.org/publ/bcbs128.pdf?noframes=1

2.4. Basel II – document

The document of Basel II accord is divided into four parts as illustrated in Fig.2.2 and uses a "three pillars" concept. The first part, scope of application, gives an overview of how the capital requirements are to be applied within a banking group. Calculation of the minimum capital requirements for credit risk, operational risk, and market risk (Pillar 1) are provided in part two. The third and fourth parts outline expectations concerning supervisory review (Pillar 2) and market discipline (Pillar 3), respectively. The main target of Pillar 3 is to promote greater stability in the financial system.

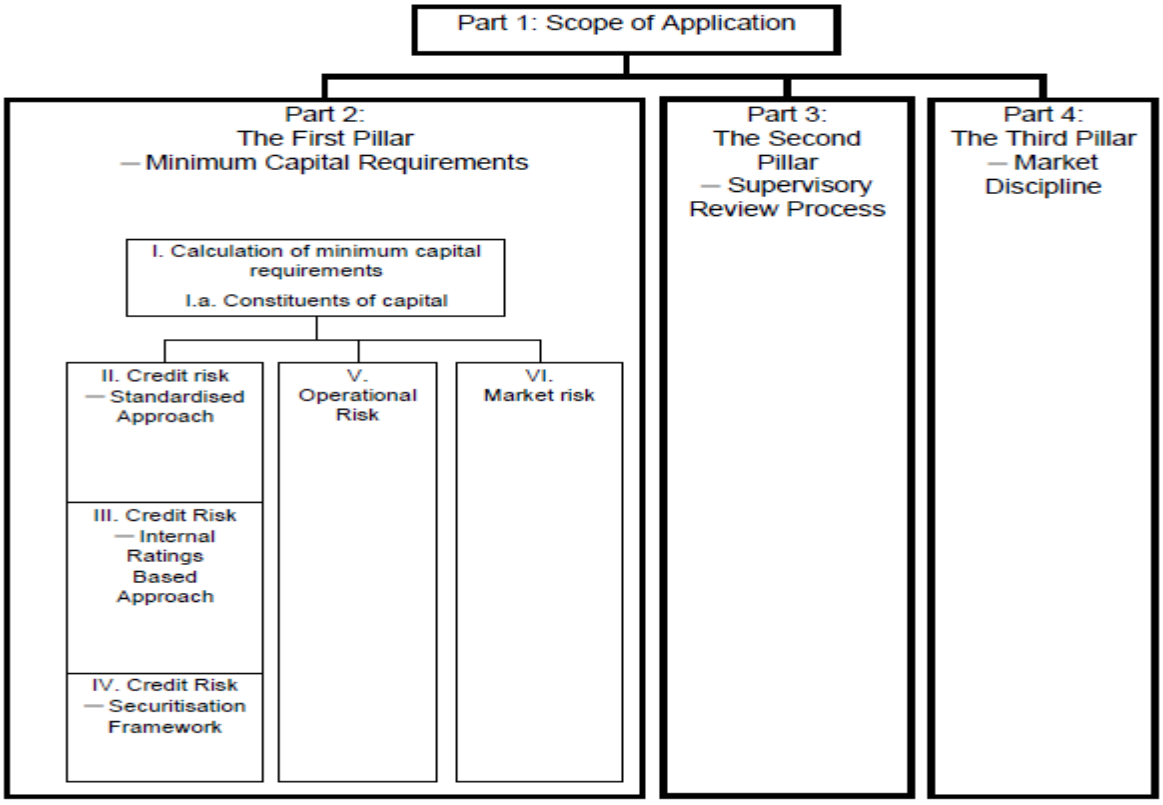


Fig.2.2. The structure of the document of Basel II Accord. Source: http://www.bis.org

The Basel Committee emphasized that "the revised Framework provides a range of options for determining the capital requirements for credit risk and operational risk to allow banks and supervisors to select approaches that are most appropriate for their operations and their financial market infrastructure."

Basel II retained key elements of the 1988 capital adequacy framework, including the general requirement for banks to hold total capital equivalent to at least 8% of their risk-weighted assets. At the same time, Basel II provided a choice between three approaches to credit risk that are discussed in the next section.

2.5. The three approaches of Basel II

Three sets of credit risk measurement techniques have been developed under Basel II capital adequacy rules for banking institutions. They are known as the standardized, foundation internal rating based (F-IRB) and advanced internal rating based (A-IRB) approaches. A summary of the differences between three approaches is provided in Table 2.3.

	Probability of default (PD)	**Loss Given Default (LGD) and other parameters for Risk Weighted Asset (RWA) calculation**
Standardized approach	Ratings from External Credit Rating Agencies	
Foundation internal rating based (F-IRB) approach	Bank own estimates	Local supervisor
Advanced internal rating based (A-IRB) approach	Bank	Bank

Table 2.3. Comparison of the three approaches under Basel II.

Under the Standardized approach the banks are required to use ratings of their customers from External Credit Rating Agencies (for example, Standard& Poor´s ratings) to calculate the required capital for credit risk. This approach, as Basel I, sets out specific risk weights for certain types of credit risk. The standard risk weight categories, used under Basel I (Table 2.1), remained in Basel II. A new 150% rating appears in Basel II for borrowers with poor credit ratings (Table 2.4). The minimum capital requirement (the percentage of risk weighted assets to be held as capital) remains at 8%.

Credit Assessment	AAA to AA-	A+ to A-	BBB+ to BBB-	BB+ to B-	Below B-	Unrated
Risk Weight	0%	20%	50%	100%	150%	100%

Table 2.4. Risk weighting for different rating of customers under Basel II. Source: http://www.bis.org.

In order for banks to use internal rating based approaches (IRB), they should make an application to the local (national) supervisory authority and get its approval.

The Foundation internal rating based approach allows the banks to develop their own empirical model to estimate the probability of default (PD) for individual clients or groups of clients. However, it is required under the F-IRB approach that banks use local supervisor's prescribed LGD (Loss Given Default) and other parameters required for calculating the RWA (Risk Weighted Asset). Then total required capital is calculated as a fixed percentage of the estimated RWA.

The Advanced IRB approach gives more flexibility to the banks to develop their own empirical model to quantify required capital for credit risk. In this case banks are supposed to use their own quantitative models to estimate PD (probability of default), EAD (Exposure at Default), LGD (Loss Given Default) and other parameters required for calculating the RWA (Risk Weighted Asset). Then total required capital is calculated as a fixed percentage of the estimated RWA, as for the F-IRB approach.

The next section provides a detailed discussion about the calculation of the capital requirement and the risk-weighted assets under the A-IRB approach.

2.6. Derivation of risk-weighted assets under the IRB approach

The algorithm for the calculation of the capital requirements under the IRB approach includes four steps that are described below. These rules have been established by Basel II for corporate, sovereign, and bank exposures.[5] Here we present formulae in the ordinary format (Basel II provides all the formulae in the Excel^{TM} format.

Step 1. Calculation of the correlation R as a function of probability of default (PD):

$$R = \frac{0.12\left(1-e^{-50PD}\right)}{1-e^{-50}} + 0.24\left[1-\frac{1-e^{-50PD}}{1-e^{-50}}\right] \tag{2.1}$$

Step 2. Calculation of the maturity adjustment as a function of PD

$$b = \left(0.11852 - 0.05478\ln(PD)\right)^2 \tag{2.2}$$

[5] http://www.bis.org

Step 3. Calculation of the capital requirement[6] K as a function of the loss given default (LGD), correlation R, probability of default (PD), maturity M and coefficient b[7].

$$K = \left[LGD \times N\left[(1-R)^{-1/2} G(PD) + \left(\frac{R}{(1-R)} \right)^{1/2} \times G(0.999) \right] - PD \times LGD \right] \times \frac{(1+(M-2.5)b)}{(1-1.5b)} \quad (2.3)$$

With very few exceptions for short-term exposures (such as margin lending), maturity M is defined as the greater of one year and the remaining effective maturity in years. In all cases, M will be no greater than 5 years. For an instrument subject to a determined cash flow schedule, effective maturity M is defined as:

$$M = \sum_t t \times CF_t \Big/ \sum_t CF_t \quad (2.4)$$

where CF_t denotes the cash flows (principal, interest payments and fees) contractually payable by the borrower in period t.

Step 4. Calculation of the risk-weighted assets (RWA) from the capital requirement K and exposure-at-default (EAD):

Risk-weighted assets = K x 12.5 x EAD (2.5)

Therefore, the risk-weighted asset amount for the defaulted exposure is the product of capital requirement K, 12.5 (i.e. the reciprocal of the minimum capital ratio of 8%), and the exposure-at-default EAD.

Basel II also provides the formulae for K for the other cases, such as: Calculation of risk-weighted assets for exposures subject to the double default framework; Residential mortgage exposures; Qualifying revolving retail exposures; and Other retail exposures. These cases are not relevant to our project, and they are not considered here.

[6] If this calculation results in a negative capital charge for any individual sovereign exposure, banks should apply a zero capital charge for that exposure.

[7] Here, N(x) denotes the cumulative distribution function for a standard normal random variable (i.e. the probability that a normal random variable with mean zero and variance of one is less than or equal to x). G(z) denotes the inverse cumulative distribution function for a standard normal random variable (i.e. the value of x such that N(x) = z). The normal cumulative distribution function and the inverse of the normal cumulative distribution function are, for example, available in Excel as the functions NORMSDIST and NORMSINV (http://www.bis.org).

2.7. Conclusion to chapter 2

The financial stability is an important indicator of the development of any country. It has been closely examined in the beginning of 70's, and it is one of the highest priorities now.

With a world globalization, the necessity of setting the international standards for banks has appeared, since one country´s lower regulatory standards make it more difficult for other countries to maintain rigorous, but necessarily more costly standards.

The capital requirement for the banks is a major part of both Basel Accords. The Basel Committee, created in 1974, released two Accords on the bank´s capital requirement: Basel I (1988) and Basel II (2006). The 1988 Accord has had an impressive success story. It was adopted by over 100 countries, and has become one of the benchmark measures of a bank's financial health.

A few years later, a new Accord has been released. The main argument for it was that more sophisticated technology and telecommunications, as well as market innovations, have enabled banks to better measure and manage their risks. Basel II created a bridge between the most complex and sophisticated banks and the less complex banks. The last ones got the possibility to improve their risk management practices without reducing the overall level of capital, held in the banking system.

Basel II retained the key elements from the Basel I, such as the allocation of assets among the risk categories and the conversion factors by which off-balance-sheet items were made equivalent to assets for risk–weighting purposes. At the same time, Basel II introduced three approaches for calculating the capital requirement that banks can select independently and then apply for the approval by the local/national supervisor. Basel II benefits these banks that have customers with lower probability of default, therefore the banks hold lower capital requirement.

Chapter 3. Literature Review

The aim of this literature review is to give an overview of the existing research, both theoretical and empirical, on Basel II. As the final version of the Basel II Accord was released in June 2006, we focus here mostly on the recent publications that are classified in four groups according to the main research questions: pro-cyclicality effect of Basel II, effects of the IRB approach, Basel II and Subprime mortgage crisis, and influence of the Basel II on Danish banks. A number of articles provide a criticism of the Basel II framework and suggest new improvements.

3.1. Pro-cyclicality effect of the Basel II

Since the release of the Basel II there was a lot of debate about the potential pro-cyclicality of the Basel II that may result in the situation when the new Accord will make it much harder for policy makers to maintain macro-economic stability.

The cyclical behavior of European bank capital buffers[8] has been examined in the research by T. Jokipii and A. Milne (2008). Unlike much of the literature in this field which focused on a single country (Ayuso at al. 2004; Lindquist, 2004; Stolz and Wedow, 2005; Andersen, 2009, Sironi and Zazzara, 2003), this study provides a cross-country analysis, comparing behavior in different sub-sample groups of countries and for different groups of banks. The empirical data for this analysis is collected from the annual reports of 486 banks of 25 European countries for the period of 1997-2004.

The authors find that capital buffers of commercial and savings banks, and of large banks, exhibit negative co-movement with upturn and recession periods of the business cycle. Co-operative and smaller banks exhibit positive co-movement. Speeds of adjustments are fairly slow. They therefore conclude that the negative co-movement of capital buffers will increase the pro-cyclical impact of Basel II.

The research by F. Heid (2007) also contributes to the discussion about the behavior of the capital buffers both under Basel I and Basel II. This simulation study (calibration exercise) is based on balance sheet data drawn from *Bankscope* of *Bureau van Dijk* for banks operating in OECD[9] countries in the year 2004. The total number of observations was 945 and includes commercial banks, savings banks and credit cooperatives.

[8] The amount of capital that banks hold in excess of the required capital by national regulators
[9] Organization for Economic Corporation and Development (OECD)

Based on the empirical model, the author gives an explanation why, under Basel I, the capital buffers tend to increase in an economic downturn (i.e. they behave in anti-cyclical manner) while, under Basel II, the capital buffers are most likely to move pro-cyclically.

The article provides a good understanding of the macroeconomic impact of Basel II showing that this impact on aggregate demand can be significant. The pro-cyclical effects on macroeconomic fluctuations will vary among the countries. "Bank –based economies will most probably experience the biggest effects, while the effects in financial market-based economies will be smaller," – concludes the researcher.

However, according to Bessis (2010), Basel II adopts a long-term prospective for defining chances of customer default over a one–year period, presumably for reducing the pro-cyclicality of the capital charge. This book about risk management in banking is the third edition of the original from 2002, and includes new chapters about the Basel II implementation. The author, for example, presents extensive discussion about credit ratings and the methodology for obtaining the mapping of default probabilities (a new feature under the IRB approach) to ratings of the agencies S&P and Moody´s, based on the historical statistical data of the period of 1983-2000.

The simulation given by Gordy and Howells (2004)[10] makes clear that the extent of cyclicality in capital requirement depends quite strongly on how new lending varies with macroeconomic conditions. The authors find that empirically realistic reinvestment rules reduce pro-cyclicality dramatically when compared to the passive portfolio strategy imposed by other models (Kashyap and Stein, 2004).

The discussion about pro-cyclicality of the Basel II is very extensive[11]. Recently it has been supplemented by publishing models that also incorporate the current financial crisis. We present them later in this chapter, after analyzing the effects of the IRB approach that narrow the discussion on Basel II.

3.2. Effects of the IRB approach

As it was mentioned in chapter 2, the new Basel II accord allows banks to choose the methods for the calculation of the minimum capital requirements: the standardized and two internal rating based

[10] http://www.bis.org/bcbs/events/rtf04gordy_howells.pdf
[11] Google Search gives 2.400.000 results on this subject in 0.21 sec., October 2010

(IRB) approaches. This section presents published research about the effects of adopting the IRB approach by banks.

First, we give a summary of the article by Ruthenberg and Landskroner (2008) which presents an investigation based on an empirical model and bank-specific data. This article became the foundation for the current project and for this reason we provide a more detailed description of this article here.

The purpose of the article is to investigate possible effects of the implementation of the new rules on the pricing of bank loans. The authors consider two approaches for capital requirements that are allowed by Basel II (internal rating based (IRB) and standardized) and two different groups of customers (retail and corporate). The model presented in the article describes the behavior of a banking firm facing uncertainty and operating in an imperfectly competitive market. The equation for the loan price (interest rate) is derived.

In this loan pricing model, the interest rate charged on loans has four components: the financial funding cost, a risk premium to compensate for the risk of default by the borrower, a premium reflecting market power exercised by the bank, and the sensitivity of the cost of capital raised to changes in loans extended.

The authors use Israeli economic data and data of a leading Israeli bank. According to them, data on prices and quantities of retail and corporate lending are usually not readily available for individual banks, a limitation of numerous previous studies. The authors were able to obtain such data for one of the leading banks in Israel. This data enabled them to consider the effect of the differential market power which the banks may be able to exercise on households relative to corporate customers.

The main results of the article indicate that high quality corporate and retail customers will enjoy a reduction in loan interest rates in (big) banks which most probably will adopt the IRB approach. On the other hand, high risk customers will benefit by shifting to (small) banks that adopt the standardized approach. With respect to retail customers, almost all these customers will enjoy a loan rate reduction if they obtain loans from banks that adopt the IRB approach.
These results have direct implications on the risk distribution among the banks. In particular, the big and high quality banks, which are expected to adopt the IRB approach, will tend to serve the less

risky customers while the small banks, which are expected to adopt the standardized approach, will tend to serve the more risky customers and thus become riskier.

The findings of this work may benefit both academic researchers and practitioners.

The measurement of a bank counterparty risk is a widely discussed topic both in practice and in the literature. Hasan and Zazzara (2006) underline that in order to create value for their shareholders and subordinated note-holders, the bank managers must correctly measure risk and price it accordingly. This is a successful key for banking business, especially in the activity of customer loans, where clients represent the main asset of a commercial bank. The new Basel II rules, based on the recognition of the bank´s internal rating systems make the estimation and pricing of credit risk official in the banking environment.
The authors present the pricing risk-adjusted framework and conclude that their results confirm the existence of a significant relationship between risk and spreads of loans, spurring further studies in this field. Particularly, more sophisticated banks will have to adequately value the guarantees and collaterals offered by their counterparties with respect to prospective loans, as well as the impact of the historical recovery rate estimates deriving from their complete loan work-out processes.

An article by Gordy (2003) shows how risk-factor models of credit value-at-risk can be used to justify and calibrate a ratings-based system for assigning capital charges for credit risk at the instrument level. Ratings-based systems, by definition, permit capital charges to depend only on the characteristics of the instrument and its obligor, and not the characteristics of the remainder of the portfolio. Risk-factor models deliver this property. It is a heavy theoretical work.
Large commercial banks and other financial institutions with significant credit exposure rely increasingly on models to guide credit risk management at the portfolio level. Models allow management to identify concentrations of risk and opportunities for its diversification, and thus offer a more sophisticated, less arbitrary alternative to traditional lending limit controls.

3.3. Basel II and Subprime mortgage crisis

The Subprime mortgage crisis (SMC) started in 2007 and, unfortunately, coincided in time with the beginning of the implementation of Basel II. The effect of Basel II is difficult to isolate from the SMC at this moment, and therefore some researchers consider both issues simultaneously.

According to Fouche et al. (2008), the ongoing subprime mortgage crisis (SMC) and the implementation of Basel II Capital Accord regulation have resulted in issues related to bank valuation and profitability becoming more important than before. The main theoretical part of this work is concluded by the mathematical formulation of the optimal loans supply and loan rate, that lead further to the formulation of the optimal deposit, deposit withdrawal and profits for the banks. The authors also provide the historical evidence for the member countries of OECD to support the fact that the output gap (proxy for business cycle) and the provisions for loan losses-to-total assets ratio are negatively correlated. They discuss about the pro-cyclicality effect of credit, profitability and provisioning for OECD countries. In the end, the authors underline that this paper makes a connection between discrete-time stochastic banking models and the macroeconomic activity, the SMC and Basel II.

The other interesting article (Blum, 2008) is both related to the Third pillar of the Basel II, Market discipline, and the current financial crisis. It is about the truthful risk level reporting by banks, and the background story is that despite of the innovations of Basel II, the US Federal Deposit Insurance Corporation (FDIC) proposed to introduce a leverage ratio restriction at an international level.

A leverage ratio restriction is the simplest and historically oldest form of capital regulation, mentioned in the financial literature. The leverage ratio restriction is defined as the minimum ratio of the Bank Capital to Bank Total Assets.

The motive of FDIC was to have an additional tool to identify and to sanction dishonest banks and to encourage the truthful risk reporting.

On the other hand, banks opposed the introduction of the leverage ratio restriction emphasizing that this ratio is old-fashioned in today´s bank risk management. They argued that this ratio would reduce or even eliminate the benefits of the new framework of Basel II.

The research by Blum (2008) makes a first attempt of the formal analysis about pro and cons of such an adjustment. The author presents an analytical model and considers the behavior of safe and risky banks under different capital regulations. His key results are presented in Table 3.1.

This research seems interesting because the author formulates strictly in mathematical language the facts that have been previously discussed mostly on the intuitive level.

Case	Result
Basel II: The IRB approach	"Risk –sensitive capital requirements that rely on banks´ voluntary disclosure of their risk profiles do not work"
Basel II: The IRB approach plus sanctions	"If the supervisor detects dishonest bank only with low probability or if the supervisor is weak (i.e. cannot enforce high penalties), risky banks understate their risk"
Basel II: The IRB approach plus leverage ratio restriction	"If the supervisor imposes a leverage ratio restriction … in addition to the risk-sensitive capital requirement, all banks announce their type truthfully"

Table 3.1.Three cases analyzed in the article of Blum (2008).

The financial distress that followed the implosion of markets for securitized mortgages in 2007 has raised profound doubts about the adequacy of supervision of the financial markets – in US and in other countries. One of the questions of the debate was whether the condition of financial institutions could have been better if Basel II Accord, negotiated between 1999 and 2004, had been already implemented.

In his book, Tarullo (2008) considers the Basel II both as a paradigm for US domestic banking regulation and as the basis for an international cooperative arrangement. Being highly skeptical of Basel II as a domestic regulatory system, he does not definitely reject some use of bank´s own risk models in setting minimum capital requirements.

Some researchers are going even further and discuss a revision of the Basel II and arrival of the new Basel III Accord. Some of the reasons for a new revision were the recent financial crisis and a new framework of addressing the bank´s operational risk.

For example, the book by Gregoriou (2009) offers the latest research in the operational risk area and includes chapters, written by well-known professors, practitioners, and consultants from large and well respected money management firms. The topics discussed include: Basel Accord II, getting ready for the New Basel III, Extreme Value Theory, the new capital requirements and regulations in the banking sector in relation to financial reporting (including developing concepts such as Operational Risk Insurance which was not a part of the Basel II framework). The book further discusses quantitative and qualitative aspects of operational risk, as well as fraud and applications to the fund industry.

Overall, the Basel III Accord is an even more popular topic of discussion than the pro-cyclicality of the Basel II. [12]

3.4. Danish banks and Basel II

This section provides an overview of the MSc projects on Basel II, carried at Copenhagen Business School in the period of 2008-2009. The projects are interesting from the perspective of analysis of the Danish banking sector and helped to formulate the topic of research for the current project.

One of the research questions of the MSc thesis by Valler (2009) was about how the claimed pro-cyclicality effect of Basel II affected the solvency of large and medium sized Danish banks in the current economic downturn (2007-2008). The empirical model was based on 17 indicators determined the downturn pro-cyclicality effect on each of the 14 Danish banks in the sample. The conclusion was that the banks using standardized approach under Basel II (medium sized Danish banks in the sample) seemed to be more negatively affected by the downturn pro-cyclicality effect than the banks, which use the IRB approach.

Andersen and Andreasen (2008) performed an analysis of the influence of Basel II on the competition between large and small banks in Denmark. Their hypothesis was that the use of the IRB approach by Danish banks can reduce their capital requirements to such an extent, that it will lead to a competitive advantage over the banks using the basic (standardized) approach. For their analysis, the authors constructed the synthetic loan portfolio in order to measure capital requirements under Basel I, and standardized and IRB approaches of Basel II. The conclusion was that since in the present situation in the Danish financial industry only large banks in Denmark have possibilities to implement the most advanced models, they will get a relative competitive advantage over small banks, when the competition parameter is loan pricing.

The project by Waage (2008) is related to the effect of Basel II on Danish banks concerning operational risk, the home-host situation and liquidity risk. This study has used an inductive approach and qualitative methods that included interviews with banks, Finanstilsynet, Finansrådet and experts from PricewaterhouseCoopers. The examination showed that the implementation of the Basel II has a lot of benefits for the Danish banks, including increased knowledge and control over

[12] 9.600.000 results in Google Search (0,15 seconds), October 2010

risk. However, liquidity, not being a big part of Basel II, should be also introduced to the bank risk models, since liquidity appeared to be one of the most important risks for banks. The overall conclusion was that the benefits of adopting Basel II by Danish banks exceed the costs.

The described projects considered different research questions of introducing Basel II in the Danish banking sector: pro-cyclicality effect, competitive advantage of the Danish banks using the IRB approach, overall benefits for the Danish banking sector and liquidity risk. Therefore, the idea of this project has become to go further in investigation of the effects of Basel II on the Danish banking system and focus on the lending policies of the Danish banks under Basel II. In our project, methods of the industrial organization and econometric analysis are applied, that were not used in the other projects.

3.5. Conclusion to chapter 3

The literature review showed that there is an enormous international interest for the effects of the implementation of the Basel II. It can be considered as hot topic of research for the banking sector. Most of the published literature presents the empirical models. These models are based on data collected from the annual reports of the banks, balance sheet data from *Bankscope* of *Bureau van Dijk* or bank specific data, like for example from one of the largest banks of Israel. Few articles discuss purely theoretical research.

Unfortunately, the beginning of the implementation of the Basel II coincided in time with the beginning of the Subprime Mortgage Crisis (SMC), started in 2007. The effect of Basel II is difficult to isolate from the SMC at the current moment. Under these circumstances, bank valuation and profitability require more attention than before. A connection between discrete-time stochastic banking models and the macroeconomic activity, the SMC and Basel II can possibly help in the evaluation process.

A part of this literature review has been dedicated to the MSc theses on Basel II, carried at Copenhagen Business School in the period of 2008-2009. These theses illustrate again a big research interest to the Basel II implementation, but at the same time they helped narrowing down the research questions and choosing the methodology for this project.

Chapter 4. Danish banking system

This chapter gives an overview of the Danish banking sector (section 4.1) and the introduction of Basel II in Denmark (section 4.2). Since the period of research in our project includes the three years of the recent financial crisis (2007-2009), it was important to look at the measures, proposed in Denmark in order to help to Danish banks in difficult times and provide the basis for financial stability of the country. These measures are discussed in the section 4.3.

4.1. Banking industry in Denmark

According to Jensen (2000), the Danish banking sector in the year 2000 consisted of mutually interacting industries and industry segments such as traditional banks, mortgage credit institutions and insurance companies, making it difficult to establish the boundaries of the banking industry in Denmark. In this research, the Danish banking sector has been characterized as an oligopolistic market with few large players. Large banks such as BG bank (a part of Danske Bank today), Den Danske Bank, Jyske Bank, Sydbank and Unibank (later a part of Nordea) had a total market share of 69% in 1998.

A concept of the "financial supermarkets" has been developing in Denmark over last years. This concept is based on the philosophy that buying real estate entails a need for loans, insurance and advices on tax legislation and budgets. The basic motive for the creation of such "supermarkets" was the opportunity to get an access to more customers through common/shared databases. The Danish banking sector successfully adopted this approach.

According to (Jensen, 2000), the total number of banks in Denmark decreased from 300 in 1990 to 200 in 1998. More recent statistics shows that the number of the Danish banks continued to decrease: from 177 in 2003 down to 132 in 2009[13].

The large and medium banks in Denmark are combined in groups 1 and 2, as listed in Table 4.1. Group 1 comprises institutions with working capital of at least kr. 50 billion, while group 2 comprises institutions working capital of at least kr. 10 billion (up to kr. 50 billion). The remaining Danish banks, which constitute majority, are combined in the groups 3 and 4. Group 3 comprises

[13] www.finanstilsynet.dk

institutions with working capital of at least kr. 250 million (up to kr. 10 billion), while group 4 comprises institutions with working capital below kr. 250 million[14].

Group 1	Group 2
Danske Bank	Alm. Brand Bank
FIH Erhvervsbank	Amagerbanken
Jyske Bank	Arbejdernes Landsbank
Nordea Bank Danmark	Forstædernes Bank
Nykredit Bank	Ringkjøbing Landbobank
Sydbank	Spar Nord Bank
	Sparbank
	Sparekassen Sjælland
	Vestjysk Bank

Table 4.1. Large and medium- sized banks in Denmark. Source: The National Bank of Denmark, 2010

In 2009-2010, the number of Danish banks in the groups described above followed a normal distribution: 6 banks in the group 1; 9 banks in the group 2; 84 banks in the group 3; and 33 banks in the group 4.

Lending by groups 1 and 2 was approximately 85% and 10%, respectively, of total lending by Danish banking institutions as at 31 December 2009[15]. Overall, the Danish loan market may be characterized as highly concentrated (more discussion is provided in section 6.4).

4.2. Basel II and Danish legislation

The guidelines from the National Bank of Denmark of 2006 declared that the new capital rules, Basel II had to be introduced in the Danish law since 1 January, 2007.[16] As mentioned previously, Basel II proposes several approaches for calculating the minimum capital requirements – starting from the standard up to more sophisticated ones. According to Basel II, the banks have to be approved by the national supervisors in order to be able to apply the IRB approaches in their practice.

[14] http://finanstilsynet.dk/da/Tal-og-fakta/Statistik-noegletal-analyser/Statistik-om-sektoren/2009/~/media/Tal-og-fakta/2010/Statistik/StatistiskMaterialePengeinstitutter/Indledning_PI.ashx

[15] Financial stability report, National Bank of Denmark, 2010

[16] www.nationalbanken.dk

In Denmark, the Danish Financial Supervisory Authority (or "Finanstilsynet" in Danish) has a role of the national supervisor. The Danish FSA is a part of the Ministry of Economic and Business Affairs and acts as secretariat for the Financial Business Council, the Danish Securities Council and the Money and Pension Panel. Danish FSA´s activities take place within three core areas: supervision, regulation and information. Financial companies which come under supervision by the Danish FSA are stipulated in legislation.

Table 4.2 shows that the Danish banks of the group 1 seem more efficient regarding the implementation of the most advanced methods for credit risk calculation under Basel II, while Danish banks of the group 2 are mostly following the standardized approach. By the end of 2008, only five Danish banks (Danske Bank, Nordea, Jyske Bank, Sydbank and Nykredit Bank) have been approved to use their own internal rating models in order to calculate the regulatory capital for credit risk, and only four out of those banks (Danske Bank, Jyske, Sydbank and Nykredit) could use the most advanced (A-IRB) method. All the other banks from the group 1 and 2 had been employing the standardized approach of Basel II for calculating their credit risks.

Bank	Approaches to the Credit Risk
Group 1	
Danske Bank	A-IRB, F-IRB, Standardized
Nordea	F-IRB, Standardized
Jyske Bank	A-IRB, Standardized
Sydbank	A-IRB, F-IRB, Standardized
FIH	Standardized
Group 2	
Nykredit	A-IRB, F-IRB, Standardized
Spar Nord	Standardized
Forstædernes	Standardized
Amagerbanken	Standardized
Fionia	Standardized
Arbejdernes	Standardized
Alm. Brand	Standardized
Sparbank	Standardized
Vestjysk	Standardized

Table. 4.2. Basel II approaches to credit risk used by Danish banks in 2007-2008 (Valler, 2009).

The other interesting feature is that Danish banks can use a combination of the different approaches of the Basel II. For example, The Nykredit Group was one of the first banks in Denmark that has

been authorized by the Danish FSA to apply the advanced approaches for the determination of its capital requirements. They got an approval to use a combination of various techniques of Basel II since the beginning of 2008. They are presented in Table 4.3. However, according to the Nykredit Risk report, the full effect of the change of the capital requirement could not be seen until the end of 2009 when the transitional rules lapse (Nykredit, 2008).

Basel II approaches to credit risk in Nykredit Group

Advanced IRB approach to:

- Mortgage lending by Nykredit Realkredit A/S and Totalkredit A/S
- Retail lending by Nykredit Bank A/S
- Equity exposures

Foundation IRB approach to:

- Commercial lending by Nykredit Bank A/S

Standardized approach to:

- Central government and credit institution exposures
- Individual minor portfolios

Table 4.3. Basel II approaches to credit risk in Nykredit Group, approved by Danish FSA, 2007. Source: www.finanstilsynet.dk

4.3. Influence of the on-going crisis on the banking sector in Denmark

Years 2008-2009 have been dominated by the international financial crisis. After a number of years with high profits, Danish banks had to make large write-downs on loans, and several banks had negative earnings in 2008.

For example, for groups 1 and 2, the total profits of banks fell from 31.3 billion Kr. in 2007 to 0.4 billion Kr. in 2008. Write-downs on loans accelerated throughout 2008, and its total amount reached the level of 19 billion Kr. Capital losses of 5 billion Kr., the majority on equities, also contributed to the decrease in earnings. On the other hand, net interest income increased by 10 billion Kr. due to higher lending margins and increased lending.[17] The overall situation for the years 2005-2009 is presented in Fig. 4.1.

The Danish government developed two programs to help Danish banks under such turbulent times. These programs received the names of Bank Rescue Packages I and II. First, in October 2008, the

[17] Danish National bank (Financial Stability 1st half of 2009)

government and the Danish banks have reached an agreement on a crisis plan which has been considered to be historic in Danish financial history and received the name of "Bank Rescue Package I". Over the next two years, banks had to make 30 billion Kr. available in a so-called liquidation fund, with banks contributing funds in relation to their size. This means that banks such as Nordea and Danske Bank had to contribute most. The target of the package was to remove the ceiling on a deposit guarantee, so that all deposits were secured irrespectively of the size.

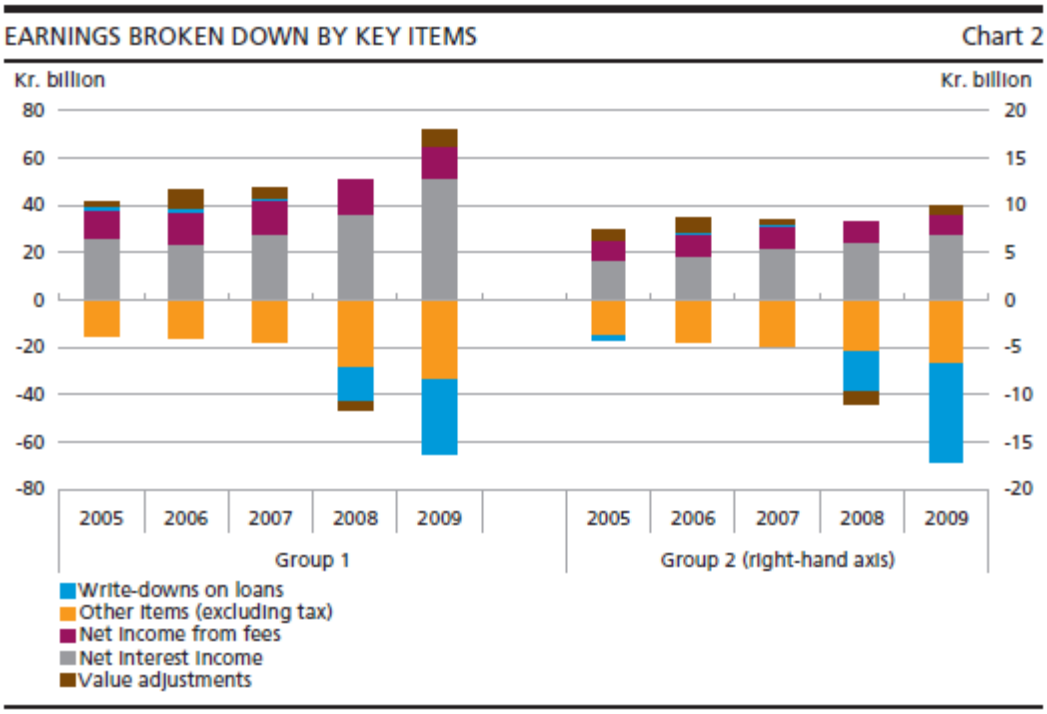


Fig.4.1. Earnings of the Danish banks (groups 1 and 2) in 2005-2009. Source: National Bank of Denmark, 2010

Second, in January 2009, the Danish government and a broad majority of the political parties in the Danish parliament have agreed to make a 100 billion Kr. credit package available to banks and mortgage lenders in Denmark. The package, named "Bank Rescue Package II", provided a total of 75 billion Kr. for banks and a total of 25 billion Kr. for mortgage lenders.

The financial institutions received a possibility to apply for a state guarantee for bond loan issues and other senior debt expiring no later than 1 January 2013. At the same time, the state guarantee for ordinary deposits expired on 30 September 2010, as agreed under the previous financial stability scheme (Bank Rescue Package I). The document underlined that Bank package II was not a gift for

Danish banks. They were supposed to borrow the funds and must pay interest on the loans like any other borrower. The rate of interest on the loans granted by the Danish state was around 10%.

Later reports of the National bank of Denmark discussed that the stress tests of the largest 14 banks showed that if the opportunities for capital injections under Bank Rescue Package II are exploited, these banks will be relatively robust. These packages helped to reduce the institutions' costs for short-term financing.

The impact of the international financial crisis in the Danish economy and the Danish banking industry cannot be uncovered in full at this stage. So far the Danish economy has experienced the collapse of only medium-sized banks like Roskilde Bank and BankTrelleborg[18]. The main reasons of these collapses were bank lending policies that resulted in high exposure to the overvalued Danish property market. In this way the Danish economy was exposed as the other wealthy western economies, for example, in UK and the US where the financial unbalances commenced in the building and housing industry and spread to the other parts of the economy.

As mentioned in chapter 2, a foreign bank´s failure can create problems for domestic banks due to the globalization, as banks from different countries are connected through the interbank lending market or the payments system. The bankruptcy of the large American banks, Lehman Brothers and Bear Stearns, in 2008 might lead to similar collapses in the European banking sector including in Denmark. Therefore, the Danish political and legislative 'ring fence' was to avoid a 'domino effect' in case a small or medium Danish bank filed for bankruptcy, whereas it was imperative to secure that none of the large banks, like Danske Bank or Nordea, would collapse.

4.4. Conclusion to chapter 4

Basel II is an important part of the Danish legislation since the beginning of 2007. A number of large Danish banks have been approved by Danish FSA in 2007-2008 for the use of the IRB approaches for calculation the minimum capital requirements. However, it appears that the implementation of the Basel II into the Danish economy was 'too little and too late' to help the Danish financial system in counter-balancing the international financial crisis started in 2007. High exposure to the overvalued Danish property market led some of the Danish banks to collapse in the domestic market. The other possible risk for the Danish economy was entering from abroad. It seems that lending policies of the Danish banks in 2007-2009 were significantly affected by on-going crisis and political decisions, much more than by the implementation of the Basel II.

[18] Bought by Sydbank in January 2008

Chapter 5. Model of loan pricing under Basel II

The current work has been inspired by the research published in the article of Ruthenberg and Landskroner (2008). The short resume of the article is presented in the literature review (section 3.2). The idea of this project is to apply an approach described in the aforementioned article to the case of the Danish economy. Here we keep the original equation of the expected profits of the individual bank in the short term and use the scientific approach described in the article. However, the model is presented in a modified (corrected) form compared to the version given in the article.

5.1. The published model and assumptions

In this section a description of the published model of loan pricing under Basel II is provided (Ruthenberg and Landskroner, 2008). Making an estimation based on the data from the period before Basel II, the authors simulate the loan market dynamics in Israel after the introduction of Basel II. Their empirical model is based on two equations, which in general terms are presented below:

(1) The interest rate on loans is the function of the following parameters:

$(1+R_L) = \text{g}$ (credit risk, market structure (power), cost of debt, cost of equity and the sensitivity of capital to loans extended)

(2) The demand for loans is the following function:

$L_d = \text{F}$ (interest rate on loans, shift parameter)

The shift parameter includes inflation and GDP growth.

The interest rate on loans and the demand for loans were simultaneously estimated using the two stage least squares (2SLS) technique. The sample period of the study is from September 1998 to May 2006, the frequency of the data is monthly and the bank-specific data were obtained from one of the largest banks in Israel.

We provide some critical comments of this model later in this chapter.

In our research we kept the original assumptions of Ruthenberg and Landskroner (2008) which are:

- the commercial bank operates both in the primary and secondary markets in order to raise a capital;

- the bank holds capital as required by the regulator (it serves as a cushion against unexpected losses);
- the bank is risk neutral;[19]
- the bank´s objective function is to maximize its expected profits with respect to its decision variables, amount of loans (L) and deposits (D).

5.2. Expected profits equation for the individual bank

In this section we derive the loan-pricing equation under Basel II from the equation of the expected profits of the individual bank in the short term, originally presented by Ruthenberg and Landskroner (2008).

The equation of the expected profits of the individual bank in the short term is formulated as follows (Ruthenberg and Landskroner, 2008):

$$E(\Pi_i) = \underbrace{(1-PD)(1+R_L)\cdot L_i}_{revenue} - \underbrace{(1+R_D)D_i\left(R_d,\tilde{\beta}\right)-(1+R)\cdot Z_i - k_i\cdot K_i^*(L_i)-F_i}_{costs} \quad (5.1)$$

Here

PD is the probability of default (Basel II – related term),

$R_L(L,\tilde{\alpha})$ is the bank own interest rate, the inverse demand function for loans;

L_i is a supply of loans by bank *i*;

$\tilde{\alpha}$ is a shift parameter (represents macroeconomic factors such as changes in GDP (income effect) and conditions in the capital markets (substitution effect))

$D_i\left(R_d,\tilde{\beta}\right)$ is the supply function of the public´s deposits

R_D is the interest rate on deposits

[19] This assumption is related to the risk preferences of agents: if all the agents are risk neutral, they are only interested in the expected value of risky payments and do not prefer a certain payment over an uncertain payment with the same expected value. Mathematically it is described as follows (Paroush and Ruthenberg, 2003) : $PD = \frac{R_L - R_f}{1+R_L}$

$\tilde{\beta}$ is a shift parameter

Z_i is the activity of the bank i in the secondary market,

$Z_i = \left[L_i - (1-r)D_i\right]$, where r = the reserve requirements on public deposits

The interest rate related to secondary market activities of the bank, $R = R_b + I(R_w - R_b)$,

where

$$I = \begin{Bmatrix} 1, Z_i > 0 \\ 0, Z_i < 0 \end{Bmatrix}.$$

If $Z_i > 0$, the bank has a shortage of resources in the primary market, and will have to raise funds in the secondary market at interest rate R_w, where R_w is the rate of the discount-window borrowing or interbank borrowing.

If $Z_i < 0$, the bank has excess sources (funds) and buys assets in the secondary market, such as deposits with the central bank, treasury securities, earning an interest rate R_b.

The remaining variables in the equation (5.1) are:

F_i is the operating cost function of the bank, which is assumed constant in the short term;

k_i – cost of equity (required rate of return);

K_i^* - the required regulatory capital in monetary terms, a Basel II related term.

Assuming that the market structure for loans in Denmark is Cournot-oligopolistic (implying that there are few competitors, more than one, but less than "very large number" of perfect competition) we maximize the profit of an individual bank from eq. (5.1) by taking its first derivative with respect to the number of loans L_i.

5.3. Derivation of the loan-pricing model under Basel II

First of all, we apply the profit maximization condition for the bank i . For that we apply the first derivative of eq. (5.1) with respect to the number of loans outstanding for the bank i, that is presented below:

$$\frac{\partial \Pi}{\partial L_i} = (1-PD)\frac{\partial}{\partial L_i}\left[(1+R_L)L_i\right] + 0 - \frac{\partial}{\partial L_i}\left\{(1+R_w)\left[L_i - (1-r)D_i\right]\right\} - k_i \cdot \frac{\partial K^*(L_i)}{\partial L_i} - 0 = 0 \tag{5.2}$$

Here we imply that the interest rate R_L is a function of the demand for loans L and the shift parameter $\tilde{\alpha}$, or $R_L(L,\tilde{\alpha})$, where $L = \sum_{i=1}^{N} L_i$ is the sum of all the loans on the loan market in Denmark and N is the number of banks.

The other assumption is that the interest rate in the secondary market R_w is determined by the National Bank of Denmark. The discussion about a proxy for R_w , which is CIBOR, is provided in section 6.3.

The next step is to get an explicit expression for the interest rate R_L. In order to achieve this, a number of the transformations of the equation (5.2) has been made. They are presented below:

$$(1-PD)\left[\frac{\partial R_L(L)}{\partial L_i}L_i + (1+R_L(L))\frac{\partial L_i}{\partial L_i}\right] = \frac{\partial}{\partial L_i}\left\{(1+R_w)\left[L_i - (1-r)D_i\right]\right\} + k_i \cdot \frac{\partial K^*(L_i)}{\partial L_i} \tag{5.3}$$

$$(1-PD)\left[\frac{\partial R_L(L)}{\partial L_i}L_i + (1+R_L(L))\right] = (1+R_w) + k_i \cdot \frac{\partial K^*(L_i)}{\partial L_i} \tag{5.4}$$

Taking into consideration that

$$\frac{\partial R_L(L)}{\partial L_i} = \frac{\partial R_L(L)}{\partial L}\frac{\partial L}{\partial L_i} = \frac{\partial R_L(L)}{\partial L} \tag{5.5}$$

and

$$\frac{\partial R_L}{\partial L}L_i\frac{L}{L}\frac{R_L}{R_L} = -\frac{1}{\eta}s_i R_L \tag{5.6}$$

where η is the elasticity of demand of loans, and $s_i = L_i / L$ is the share of the bank *i* in the loan market, we get the following expression:

$$(1-PD)\left[(1+R_L)-\frac{1}{\eta}s_i R_L\right]=(1+R_w)+k_i\cdot\frac{\partial K^*(L_i)}{\partial L_i} \tag{5.7}$$

In order to get the Herfindal-Hirshman index *H* of concentration in the loan market, we multiply both sides of the equation (5.7) by the share s_i and sum up over all the banks:

$$\sum_{i=1}^{N}(1-PD)\left[(1+R_L)s_i-R_L\frac{1}{\eta}s_i^2\right]=\sum_{i=1}^{N}(1+R_w)s_i+\sum_{i=1}^{N}k_i\cdot\frac{\partial K^*(L_i)}{\partial L_i}s_i \tag{5.8}$$

Here:

$$\sum_{i=1}^{N}s_i=1,\sum_{i=1}^{N}s_i^2=H \tag{5.9}$$

Assuming a perfect market, where the cost of equity is the same for any bank, meaning that for any combination of i and j

$$k_i=k_j=k$$

and that the first derivative of the required regulatory capital is a constant (meaning that the required regulatory capital K^* is a linear function) :

$$\frac{\partial K^*(L_i)}{\partial L_i}\cong\alpha$$

we get from equation (5.8) the final equation of the interest rate R_L for our model:

$$(1-PD)\left[(1+R_L)-R_L\cdot\frac{H}{\eta}\right]=(1+R_w)+k\frac{\partial K^*(L_i)}{\partial L_i} \tag{5.10}$$

$$(1-PD)\left[1+R_L\left(1-\frac{H}{\eta}\right)\right]=(1+R_w)+k\frac{\partial K^*(L_i)}{\partial L_i} \tag{5.11}$$

Equation (5.11) as derived for our model is a slightly different form compared to the one presented by Ruthenberg and Landskroner (2008). The authors have a different left side of the equation, as presented below:

$$(1-PD)(1+R_L)\left(1-\frac{H}{\eta}\right)=(1+R_w)+k\frac{\partial K^*(L\ )}{\partial L} \tag{5.12}$$

We believe that our equation (5.11) is correct, and it will be used in our further research.

Below the explicit expression for bank own interest rate obtained from the equation (5.11) is presented:

$$R_L=\frac{1}{\left(1-\frac{H}{\eta}\right)}\left(\frac{1}{(1-PD)}\left[(1+R_w)+k\frac{\partial K^*(L_i)}{\partial L_i}\right]-1\right) \tag{5.13}$$

After some transformations of equation (5.13), we obtain:

$$R_L=\frac{1}{\left(1-\frac{H}{\eta}\right)}\frac{1}{(1-PD)}\left(\left[(1+R_w)+k\frac{\partial K^*(L_i)}{\partial L_i}\right]-(1-PD)\right) \tag{5.14}$$

Finally, <u>the loan pricing model under Basel II</u> is presented by equation (5.15):

$$R_L=\frac{1}{\left(1-\frac{H}{\eta}\right)}\frac{1}{(1-PD)}\left(R_w+k\frac{\partial K^*(L_i)}{\partial L_i}+PD\right) \tag{5.15}$$

For the sake of understanding, we repeat the main parameters of the model here again:

R_L bank own interest rate;

PD is the probability of default;

H is the Herfindahl-Hirschman index of concentration in the loan market;

$\eta = -\frac{\partial L}{\partial R_L}\frac{R_L}{L}$ is the elasticity of demand of loans;

$L = \sum_{i=1}^{N} L_i$ is the sum of all the loans on the loan market in Denmark;

N is the number of banks in Denmark;

R_w is the interest rate in the secondary market, e.g. discount-window borrowing or interbank borrowing;

k is the cost of equity (required rate of return);

K^* is the required regulatory capital in monetary terms according to the Basel II.

5.4. Variables

The bank own interest rate R_L in our model (eq. 5.15) is a function of the six variables, which are the market concentration, the elasticity of demand for loans, the probability of default, the interbank borrowing rates, the cost of capital and the sensitivity of capital charges to the amount of loans of the bank i :

$$R_L = F\left(\mathrm{H}, \eta, PD, R_w, k, \frac{\partial K^*(L_i)}{\partial L_i}\right) \tag{5.16}$$

The discussion about these variables and data for them as well as the assumptions introduced are provided in section 6. Here we merely give a summary of the possible impact of each variable to the interest rate.

A qualitative analysis shows that:

- Since the Herfindahl-Hirschman index[20] H is positive, and it varies between 0.257 and 0.2858 for the Danish loan market, then if H grows, R_L will also grow (more discussion is provided in section 6.4);

[20] Market concentration measure

- The probability of default *PD* varies between 0 and 1. If *PD* grows, R_L will also grow (more discussion is provided in section 6.1.1);
- The interbank borrowing rates R_w for Danish loan market varies in the interval of 1 to 6%. If R_w grows, R_L will also grow (more discussion is provided in section 6.3);
- The cost of equity *k* is also positive, so if *k* grows, R_L will also grow (more discussion is provided in section 6.2.2);
- Further we use the assumption of 8% for the sensitivity of capital charges to the amount of loans $\frac{\partial K^*(L_i)}{\partial L_i}$ (more discussion is provided in section 6.1.2), therefore this parameter has a positive impact on the interest rates as well.

Before performing regression analysis, two main challenges have been identified at this stage of the work. The first problem is addressed by the fact that equation (5.15) is non-linear. In order to be able to apply the econometrical methods, this equation should be preferably transformed in the linear structural equation. The other problem is that the elasticity η is also a function of the interest rate R_L and cannot be used as an exogenous explanatory variable in the regression model.

5.5. Conclusion to chapter 5

In this chapter we present our model for the loan pricing under Basel II. This model has been derived from the equation for the expected profits for the individual bank originally published in the article of Ruthenberg and Landskroner (2008). The authors apply their model, derived from the same equation, to the case of Israeli economy, using the bank specific data from the biggest bank of Israel for the period 1998-2006. Our idea is to apply the loan pricing model under Basel II to the case of the Danish economy.

We kept the main assumptions from the article about bank risk neutrality, bank operations both in the primary and secondary markets in order to raise a capital, holding capital as required by the regulator, and bank´s objective function is to maximize its expected profits with respect to its decision variables, amount of loans and deposits. The other important assumption was that the market structure for loans in Denmark is Cournot-oligopolistic, implying that there are few competitors, more than one, but less than "very large number" of perfect competition.

However, our model slightly differs from the one published in the article. The mathematical derivation of our model is presented in detail. In the end we get a non-linear equation for the bank own interest rate (eq. 5.15). The interest rate here is a function of six variables: market concentration, elasticity of demand for loans, probability of default, interbank borrowing rates, cost of capital and sensitivity of capital charges to the amount of loans of the bank. The possible impact of each of the variables was also discussed in the chapter.

The next step is to perform the regression analysis. However, there are two main challenges for the future work that are identified at this stage: non-linearity of the model and endogeneity of one of the variables, namely the elasticity of demand for loans. Also it is very important for our analysis to have credible data. Therefore, the next chapter 6 provides the discussion about the data used in the project.

Chapter 6. Data and variables for the loan pricing model under Basel II

In this chapter we present data for our model and provide a deeper discussion and necessary estimation for the variables, appearing in equation (5.15). Most of the data has been retrieved from the online database of the National bank of Denmark[21]. The other data sources were the database of the Danish FSA[22] (Finanstilsynet) and the website of NASDAQUE OMX Group[23]. The period of analysis is Jan., 2003-Dec., 2009.

First, we discuss about the credit risk components related to the Basel II (a proxy for probability of default and capital requirement). Later we present an estimation of the bank cost of equity. Data of CIBOR have been selected for the interbank borrowing rates of the model. The HH index in the Danish market of loans to non-financial companies is explicitly calculated in section 6.4.

6.1 Credit risk components (Basel II)

As mentioned before, according to Basel II, banks that have received supervisory approval to use the IRB approach may use their own internal estimates of risk components for the determination of the capital requirement. The risk components include measures of the probability of default (PD), loss given default (LGD), the exposure at default (EAD), and the effective maturity (M).

Basel II also stresses that banks must use information and techniques that take appropriate account of the long-run experience when estimating the average PD for each rating grade. Basel II recommends that banks may use, for example, one or more of the three specific techniques: internal default experience, mapping to external data, and statistical default models.

6.1.1. Probability of default

The probability of default (PD) is one of the variables in our model. It quantifies the chances of a borrower´s default. Therefore it was important to understand for the sake of our research, which PD models and how Danish banks use in their daily operations.

The research by Barclays Capital (Aguais et al., 2008) has given an overview of the possible techniques that banks are currently using in order to meet the requirements of Basel II. For example, in developing the required PD models, many banks have had to redesign or refine their risk-rating approaches. In this process, banks have found it necessary to determine whether various PD

[21] http://nationalbanken.statistikbank.dk/statbank5a/default.asp?w=1366
[22] http://finanstilsynet.dk/da/Tal-og-fakta/Statistik-noegletal-analyser.aspx
[23] https://www.nasdaqomxnordic.com/index?languageId=5

measures are “point-in-time” (PIT), “through-the-cycle” (TTC) or a hybrid, somewhere between PIT and TTC.

Aguais et al. (2008) conclude that they can see mostly four types of PD models in banks, namely:

- single obligor statistical ones, in which one obtains a large representative sample of the company (or account) default and no default outcomes and fits a model based on earlier values of the company (or account) credit indicators, that offer the best explanation of the observed outcomes;
- approaches based on agency ratings, in which one translates each agency rating to the PD that it currently implies;
- scorecard (expert-system) models in which one starts with often subjective, ordinal measures of an obligor’s creditworthiness and applies a conventional, low default portfolio (LDP) algorithm in establishing a calibration based on a small sample of default and no default observations;
- derivative credit risk models in which one typically uses simulation or stress methods in evaluating the likelihood of default and loss on a structured position affected by the performance of an underlying asset pool involving many obligors.

Based on this overview, an interview with Kathrine Dam Laursen (Segment Corporate Nordea Bank Danmark A/S) was conducted. The rating system for corporate clients in Nordea is based on the scorecard, a type of the expert system developed specifically for the bank. The rating system for the private sector, including households is different and has been separately developed for the private sector of Nordea.

Having the scorecard and the rating value for each customer, originally it seemed possible to convert this number to the scale from 0 to 1 in order to make a proxy of the probability of default for our model. Probability of default, PD, is the probability that the customer will not be able to repay the credit. However, the explicit procedure of matching a rating number of Nordea´s customer to the specific PD in decimals has not been found.

Similar difficulties appeared while contacting Nykredit Bank A/S. During the meeting in their headquarters it was mentioned that Nykredit has the *PD* distribution for its current customers, but does not store historical data. It is a dynamic parameter that is being recalculated for the current point in time.

Since explicit data for the probability of default from the Danish banks has not been found, it became very important to find an alternative way to obtain such data in a form of a proxy for this variable.

In the article by Ruthenberg and Landskroner (2008) the authors use a loan loss provision (for corporate customers as a percent of loans extended) as a proxy for the term $\theta = R_L - R_f = PD(1 + R_L)$ in their model. This term is derived from the risk neutrality assumption, defined in chapter 5, and is used as a proxy for the probability of default of loans. We do not have this parameter, as our model is formulated slightly different. Additionally, the parameter θ includes the interest rate R_L which is the dependent variable in the modeling equation. We would like to deviate from this approach and find alternative data that can give us better proxy for the PD as an exogenous variable.

At this stage a new suggestion has been considered: could "write-downs" be a good proxy for the probability of default? A write-down is an accounting treatment that recognizes the reduced value of an impaired asset. An impaired asset is a condition in which an asset's market value falls below its carrying amount and is not expected to recover.[24] Therefore, the "write downs" are forecasted defaults that need to be secured by a bank.

Under current accounting rules in Denmark[25], banking institutions must write down the value of a loan when there is objective evidence of impairment. Consequently, the write-downs are normally recognized before the actual losses are observed.

Data for annual write-down rate ("Årets nedskrivningsprocent" in Danish) and accumulated annual write down rate ("Akkumuleret nedskrivningsprocent" in Danish), has been found in the reports of the Danish FSA on the market development in 2007 and 2009[26] and they are presented in Table 6.1.

Year	2003	2004	2005	2006	2007	2008	2009
Annual write-down rate	0,4	0,1	-0,03	-0,07	-0,02	0,96	2,17
Accumulated write-down rate	2,3	1,8	0,94	0,66	0,55	1,58	3,29

Table 6.1. Data for annual write-down rate, a proxy of PD, 2003-2009. Data source: Danish FSA reports (2007, 2009).

[24] http://en.wikipedia.org/wiki/Write-off
[25] www.nationalbanken.dk
[26] http://www.ftnet.dk/upload/Tal-og-fakta/2010/MU/Markedsudvikling_PI_2009_001.pdf

A difference between the two rates is that the annual write-down is the profit and loss figure, while the accumulated write-down rate represents total loss on the loans in the balance sheet. The negative (net) data for the annual write-down rate means that the profit and loss figure has more reversals than new losses.[27] Therefore, the accumulated write-down rate has been selected as a proxy of probability of default in our project.

6.1.2. Capital requirement

Except for the probability of default, the other variable that describes the effect of Basel II in our model, is the sensitivity of capital charges to the amount of loans of the bank i : $\frac{dK^*(L_i)}{dL_i}$.

It turned out to be a very challenging term to estimate. The algorithm for calculations of the capital requirements under Basel II has already been presented in section 2.6. There it is shown that the risk-weighted asset (RWA) amount (in monetary terms) for the defaulted exposure is the product of the coefficient K (defined by the Basel Committee), 12.5 (i.e. the reciprocal of the minimum capital ratio of 8%), and the exposure-at-default EAD (measured by bank in monetary terms):

Risk-weighted assets (RWA) = K x *12.5* x *EAD*. (6.1)

The Loss given default (LGD), the exposure at default (EAD), and the effective maturity (M) are bank specific data, different for each individual bank, and they can be realistically calculated only by banks themselves. Since we were not able to apply bank specific data in our project, an assumption for the Basel II related term in our model has been introduced.

In our model, the term describing the required regulatory capital in monetary terms must be at least 8% RWA:

$K_i^* \geq$ 8% RWA= *K* x *EAD* (6.2)

[27] From the e-mail correspondence with Morten H. Johansen, Deputy Director, Banking Analysis Division, Danish FSA

This is in accordance with the guidelines of the Danish FSA saying that "in a credit institution, the *capital base* must constitute at least 8 per cent of its *risk-weighted items*. The Danish Financial Supervisory Authority may order a credit institution to hold capital in excess of 8 per cent".[28]

Therefore, an assumption for our model is formulated as follows:

$$\frac{dK^*(L_i)}{dL_i} = 0.08 \qquad (6.3)$$

A similar approach has been used in the published research and is described below.

Estimation of the capital requirement term in the published article

In the article by Ruthenberg and Landskroner (2008) the authors refer to the formula for calculating the capital requirements *K* under an IRB approach similar to the one described in the section 2.6. They state that the capital requirement term in their model is considered similar to that in equation (6.2), meaning that:

$$K^* = K \times EAD. \qquad (6.4)$$

However, after having said that, the authors are using a simplification for the calculations with their model. In the regression model, the sensitivity of capital charges to the amount of loans extended $\frac{\partial K^*}{\partial L}$ was assumed to be 9%. This is the minimum capital adequacy requirement in Israeli banking system.

The authors conclude that this parameter was found, as expected, to have a positive and significant impact on the interest rate. At the same time they mention that "although all banks met the minimum capital adequacy requirement of 9%, the excess capital ratio above the minimum required in Israel was one of the lowest among developed countries" (Ruthenberg and Lanskroner, 2008).

Therefore, our assumption for the capital requirement term in our model is in agreement with the published research.

[28] www.finanstilsynet.dk

6.2. Cost of equity

For our model we have an assumption that the cost of equity is the same for any bank (section 5.3), meaning that for any *i* and *j*

$$k_i = k_j = k \tag{6.5}$$

Obviously, this is a strong simplification, however it is necessary for our model formulation[29]. This assumption permits us to deviate from bank specific data and use data, available from public sources (databases of the National Bank of Denmark and NASDAQUE OMX Group). We calculate the cost of equity of Danish banks in 2003-2009 based on the monthly average data.

Below we present an approach from the published article for the estimation of the cost of equity (section 6.2.1). Later we make an estimation of the cost of equity also with the CAPM model (section 6.2.2), using monthly average data for the indices OMXC, OMXC20 and OMX Copenhagen Banks_GI (performance of the Danish banking sector) over the period of 2003-2009. The risk free rate R_f in our model is represented by Danish government bond yields with 2 years maturity for the same period.

6.2.1. Cost of equity (published research)

In the article of Ruthenberg and Landskroner (2008), the Capital Asset Pricing Model (CAPM) is applied for the measurement of the cost of equity (required rate of return) k_i of the bank *i*:

$$k_i = R_f + \beta_i (R_M - R_f), \tag{6.6}$$

where

R_f is the risk free rate represented in the article by the average annual yield to maturity on a Makam[30] with 360 days maturity;

R_M is the expected market rate of return, represented in the article by the average annual yield on the TA (Tel Aviv) 100 index[31] measured during a 5 year period;

β_i is the beta of bank *i* (it describes the risk).

[29] It means that the banks with higher cost of equity will not survive in the market.
[30] short term government bills issued by the Bank of Israel
[31] http://www.bloomberg.com/apps/quote?ticker=TA-100:IND

The beta was estimated by a series of OLS regression equations of the monthly stock return of bank *i* (R_i) on the monthly return of the TA-100 index (R_M):

$$R_i = \alpha_0 + \beta_i R_M + e_i . \qquad (6.7)$$

Having the estimated beta, and data for R_M and R_f, the estimate for the cost of equity for the bank *i* in Israel has been calculated with the Capital Asset Pricing Model (CAPM).

6.2.2. Cost of equity (our model)

Our idea in this chapter is to check whether it is possible to apply an approach similar to the one described in section 6.2.1 for the estimation of the average cost of equity of banks in Denmark.

The estimation of the average cost of equity of Danish banks includes two steps: estimation of the average beta in the bank sector of Denmark in the period of 2003-2009, and calculation of the cost of equity via the CAPM model. Both steps are described in detail below.

Step 1 – estimation of the average beta in the banking sector of Denmark

The estimation of the average beta (β) in the Danish banking sector has been performed by running the OLS regression for the equation (6.7) with data for Denmark. In our case, R_i is the average monthly return in the Danish banking sector, and R_M is the average monthly return on the OMXC20 or OMXC share price indices.

OMX Copenhagen 20 (OMXC20, formerly KFX) is the equity index consisting of the 20 most traded and liquid Danish shares listed on the Copenhagen Stock Exchange. The composition of the index is revised twice a year.[32] OMX Copenhagen (OMXC, formerly KAX) is the equity index consisting of almost 200 shares listed on the Copenhagen Stock Exchange.[33]

Fig. 6.1 presents monthly average data of the Danish OMXC20 and OMXC share price indices for the period of 2003- 2009. Both trends are following each other (highly correlated) on the whole period of research. It is also important to notice that a growth in 2003 -2006 experiences a dramatic change in the second half of 2007. Here, in the period from the second half of 2007 to the beginning of 2009, we can observe a downward slope, reaching the level of the beginning of 2003. The

[32] http://www.nasdaqomxnordic.com, http://www.nationalbanken.dk

[33] http://penge.dk/ordbog/omxc

highest point is registered in October, 2007 (504.65 for OMXC20, and 492.42 for OMXC). The lowest point (226.49 for OMXC20, and 205.04 for OMXC) has been reached in March, 2009. However, later both indices again experience a positive change towards the end of 2009. From this graph we can see that the behavior of OMXC and OMXC20 share price indices has been significantly affected by the recent economic crisis, started in 2007.

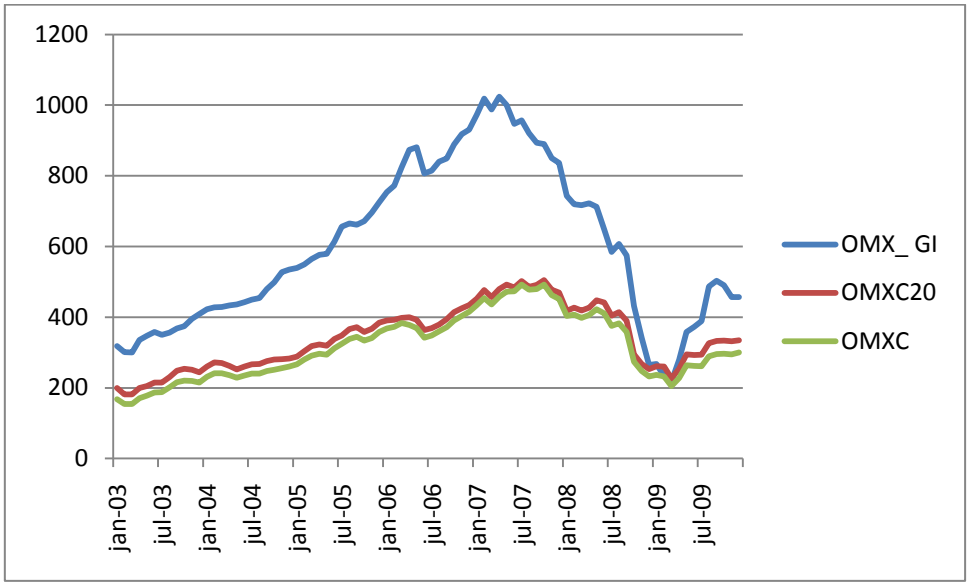


Fig. 6.1. Monthly average data of the Danish OMXC20 and OMXC share price indices and the OMX Copenhagen Banks_ GI index (2003- 2009). Data source: www.nationalbanken.dk, http://www.nasdaqomxnordic.com

The OMX Copenhagen Banks_ GI index shows the performance in the Danish banking sector. The main instruments of OMXC_GI are listed in Appendix A-1. The historical monthly average data for the OMXC_GI index for the period of 2003-2009 is also presented on Fig.6.1. This index shows higher growth in the period of 2003-2006 comparing to the other two indices. It reaches the peak in April, 2007 (1023.71) and then falls up to the same level as OMXC and OMXC20 by March, 2009 (217.76), later this index experiences a certain growth again.

In order to calculate the return on index, we use the following approach. The return on index R_I is calculated as change in the index value I, as follows:

$$R_I = \frac{I_{t+1} - I_t}{I_t} \tag{6.8}$$

where t is month. For our model, I= OMXC_GI for R_i, while I= OMXC20 or OMXC for R_M . The similar methodology of calculating of the return on index OMXC20 and OMXC, the annual yield, has been used in (Larsen, 2010).

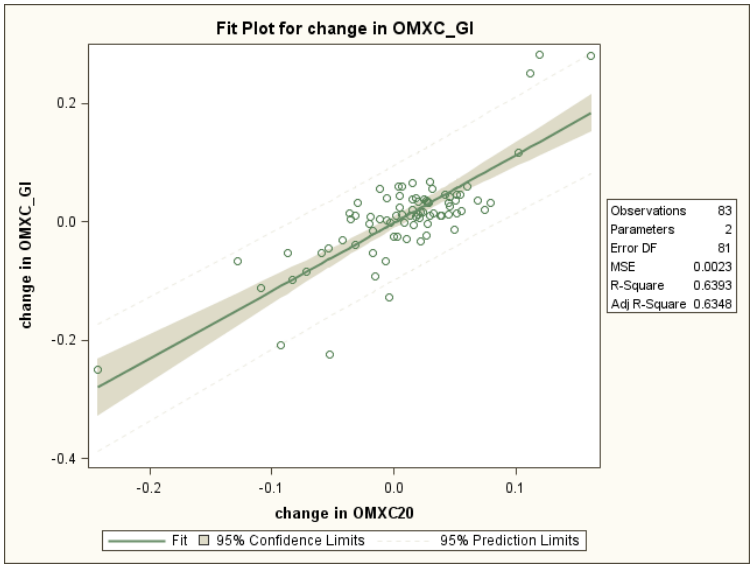
Fig.6.2 shows a graphical representation of the change in OMXC_GI index versus the change in a) the OMXC20 index and b) the OMXC index. A linear OLS regression on this data gives us the necessary value for the average beta in the Danish banking sector for 2003-2009 (beta is a slope in the linear structural equation (6.7)). The SAS output is presented in Figures 6.3 and 6.4 for OMXC20 and OMXC indices correspondingly. The null hypothesis here is that the slope β_i is equal to zero, or H_0: β_i=0.

The slope for the case with OMXC20 index has the estimated value 1.15 (R^2=64%, t-value = 11.98), and the slope for the case with OMXC index is 1.19 (R^2=66%, t-value = 12.61).

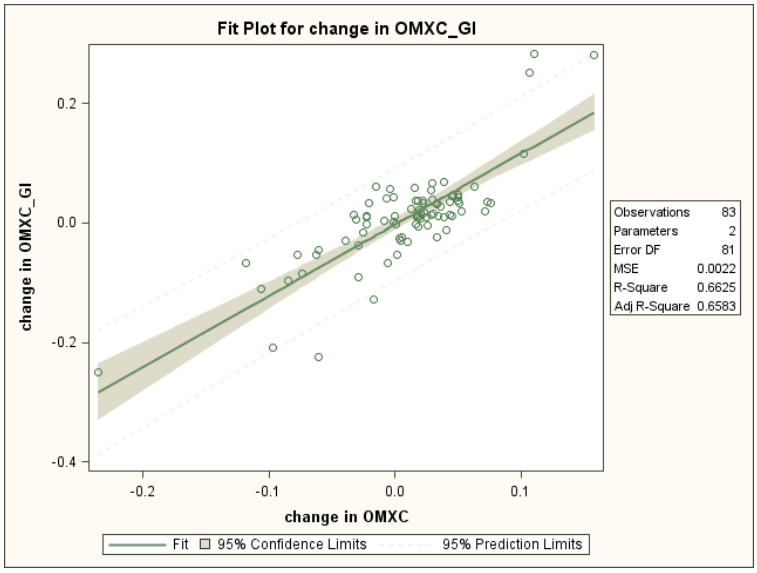
R^2 shows explanatory power of the model which is relatively high in these cases.

The probabilities of significance Pr> |t| (p-values) are less than 0.01% in both cases, meaning that the regression coefficients have <0.01% probability of being equal to zero. H_0 is rejected, when p-value < 0.05 (5% significance level). Therefore, the estimated values of beta are significantly different from zero.

Therefore, the average beta in the banking sector of Denmark based on OMXC20 index has been estimated as 1.15, and 1.19 with the OMXC index on the sample of data for the period (2003-2009).



a)



b)

Fig. 6.2. Graphical representation of the return on OMXC_GI vs. return on index a) OMXC20 and b) OMXC. Source: SAS output.

Number of Observations Read	84
Number of Observations Used	83
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.33618	0.33618	143.55	<.0001
Error	81	0.18970	0.00234		
Corrected Total	82	0.52588			

Root MSE	0.04839	R-Square	0.6393
Dependent Mean	0.00755	Adj R-Sq	0.6348
Coeff Var	641.36654		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.00147	0.00536	-0.27	0.7851
change in OMXC20	1	1.14759	0.09578	11.98	<.0001

Fig.6.3. Results on the linear OLS regression, dependent variable: Change in OMXC_GI, explanatory variable: Change in OMXC20. Source: SAS output

Number of Observations Read	84
Number of Observations Used	83
Number of Observations with Missing Values	1

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.34840	0.34840	159.01	<.0001
Error	81	0.17748	0.00219		
Corrected Total	82	0.52588			

Root MSE	0.04681	R-Square	0.6625
Dependent Mean	0.00755	Adj R-Sq	0.6583
Coeff Var	620.36641		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.00267	0.00520	-0.51	0.6091
change OMXC	1	1.19074	0.09443	12.61	<.0001

Fig.6.4. Results on the linear OLS regression, dependent variable: Change in OMXC_GI, explanatory variable: Change in OMXC. Source: SAS output

Step 2 – calculation of the cost of equity via CAPM model

Risk free rate R_f for CAPM model can be represented by Danish government bond yields with 2 years maturity. Maturity of 2 years has been selected among various other possibilities as the minimum maturity available from database of the National Bank of Denmark. Monthly average data on Danish government bonds yields with 2 years maturity for the period of 2003-2009 is presented on Fig.6.5.

The graph on Fig. 6.5 shows that there are at least three periods that can be distinguished in developing risk free rates. The first period is of 2003-2005 when risk free interest rates oscillate between 2 and 3%. The second period is related to the beginning of 2006 –August 2007, where one can see the growth of rates from 3 to 4.5 %. The last period up to 2009 is characterized by ups and downs in the values of risk free rates. The highest point is registered in July 2008 (4,7923 %), and the lowest point is in May, 2009 (1,7153 %). So again, data of 2007-2009 has been severely affected by on-going financial crisis.

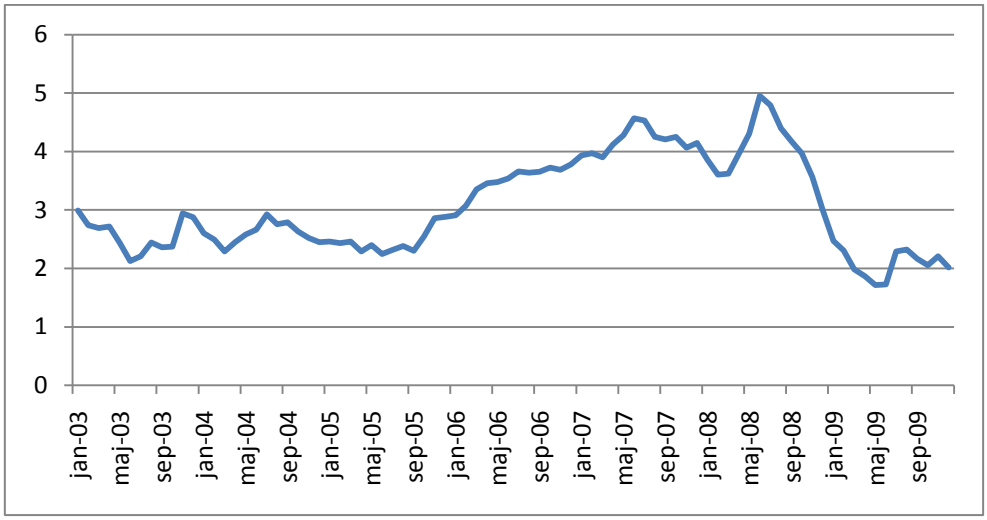


Fig. 6.5. Denmark bond yields, central-government bonds, 2 years maturity, %. Monthly average data for the period 2003-2009. Data source: www.nationalbanken.dk

CAPM model is given by equation (6.6). The difference from the published research, except different indices, is that in our case we calculate the average cost of equity k of the Danish banks and use the average beta β for the Danish banking sector in 2003-2009. Calculations with CAPM and data for the Danish economy have been performed in Excel, and an example of the results for the year 2004 is presented in Table 6.2.

year	R_f, %	OMX_ GI	OMXC20	change in OMX_GI	change in OMXC20	beta OMXC20	k, OMXC20, %
jan-04	2,60	422,86	260,52	0,035	0,069	1,15	7,54
feb-04	2,49	427,80	272,04	0,012	0,044		4,71
mar-04	2,29	428,77	270,43	0,002	-0,006		-1,02
apr-04	2,45	433,31	261,74	0,011	-0,032		-4,06
maj-04	2,58	435,61	252,52	0,005	-0,035		-4,44
jun-04	2,66	442,06	260,63	0,015	0,032		3,29
jul-04	2,93	449,59	266,81	0,017	0,024		2,29
aug-04	2,76	454,51	267,30	0,011	0,002		-0,20
sep-04	2,79	479,80	275,57	0,056	0,031		3,14
okt-04	2,63	498,08	279,79	0,038	0,015		1,36
nov-04	2,52	527,45	281,53	0,059	0,006		0,34
dec-04	2,45	534,55	283,33	0,013	0,006		0,37

Table. 6.2. Example of calculations of the average cost of equity k of the Danish banks for 2004 (on OMXC20 index).

Here the sign of k is both positive and negative due to the fact of using monthly data that corresponds to the relatively short term planning. Below (Table 6.3) we present calculations based

on the annual average data for indices OMXC20 and OMXC, and risk-free rates. One can see that annual risk premium varies between 3-5 % (based on OMXC) and 1-3 % (based on OMXC20), and the cost of equity, calculated annually, has a positive sign. Its average for the years 2003-2008 is around 5% with OMXC20 and 8% with OMXC that corresponds to the data from different literature sources in the Danish market (Larsen, 2010).

year	OMXC	Change, %	OMXC20	Change, %	Bond yield, Rf	Risk premium OMXC	Risk premium OMXC20
2003	189,648	-1,04	219,1747	-6,88	2,58	4,65	2,62
2004	242,609	27,93	269,628	23,02	2,59	4,64	2,61
2005	315,72	30,14	341,2764	26,57	2,47	4,76	2,73
2006	375,05	18,79	395,7938	15,97	3,49	3,74	1,71
2007	465,654	24,16	481,2155	21,58	4,19	3,04	1,01
2008	359,947	-22,7	383,8918	-20,22	4,02	3,21	1,18
2009	264,037	-26,65	295,4028	-23,05	2,09	5,14	3,11
Average		7,23		5,28	3,06	4,17	2,14

a)

year	Bond yield, Rf	Risk premium OMCX	Risk premium OMXC20	beta, OMXC20	cost of equity, k, OMXC20	beta, OMXC	cost of equity, k, OMXC
2003	2,58	4,65	2,62	1,15	5,593	1,19	8,1135
2004	2,59	4,64	2,61		5,5915		8,1116
2005	2,47	4,76	2,73		5,6095		8,1344
2006	3,49	3,74	1,71		5,4565		7,9406
2007	4,19	3,04	1,01		5,3515		7,8076
2008	4,02	3,21	1,18		5,377		7,8399
2009	2,09	5,14	3,11		5,6665		8,2066
Average	3,06	4,17	2,14		5,52		8,02

b)

Table. 6.3. Calculation of the cost of equity based on the annual data for indices OMXC and OMXC20.

6.3 Interbank borrowing rates

The interest rate in the secondary market R_w, e.g. discount-window borrowing or interbank borrowing, is a next variable in our model.

In the published research (Ruthenberg and Landskroner, 2008), the interest rate R_w represents the cost of debt in secondary market, and the data used for calculations is the yield to maturity on 1 year

Makam. This fact raises some doubts as the authors use, as mentioned in section 6.2.1, the average annual yield to maturity on a Makam with 360 days maturity as a risk-free rate for the calculation of the cost of equity.

The possible approximation for the variable R_w in the Danish loan market can be CIBOR.

Copenhagen Interbank Offered Rate (CIBOR) is a reference interest rate for liquidity offered in the inter-bank market (in Denmark) on an uncollateralised basis[34]. CIBOR is calculated on the basis of rates offered by a number of individual banks, called the CIBOR offerers.

CIBOR is calculated as follows: every day at 10.30 a.m. each CIBOR offerer fixes a CIBOR rate to two decimal places. This is reported to the National Bank of Denmark that calculates the average rate depending on the number of the offerers. After the CIBOR rates have been calculated, they are being published by the National Bank. CIBOR is calculated for fourteen different maturities: 1 week, 2 weeks, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 months.

The monthly data for CIBOR with maturity of 1 month for the period of 2003- 2009 has been found in the database of the National Bank of Denmark and presented on Fig. 6.6.

Looking at this graph, one can see a period of the flat CIBOR interest rates between June 2003 and December 2005, that changes later for the period of growth (2006-2007). In this period CIBOR with 1 month maturity increased from 2.1% to 4.6%. The last period of 2007-2009 is characterized first by sharp growth (peak at 5.7% in Nov. 2008) and later even sharper fall up to the level of 1.1 %. As in the case of indices and risk free rates, these rates have been also affected by the recent economic crisis, and their dynamics reflect possible increased liquidity problems that many companies experienced in 2008-2009.

[34] http://www.nationalbanken.dk

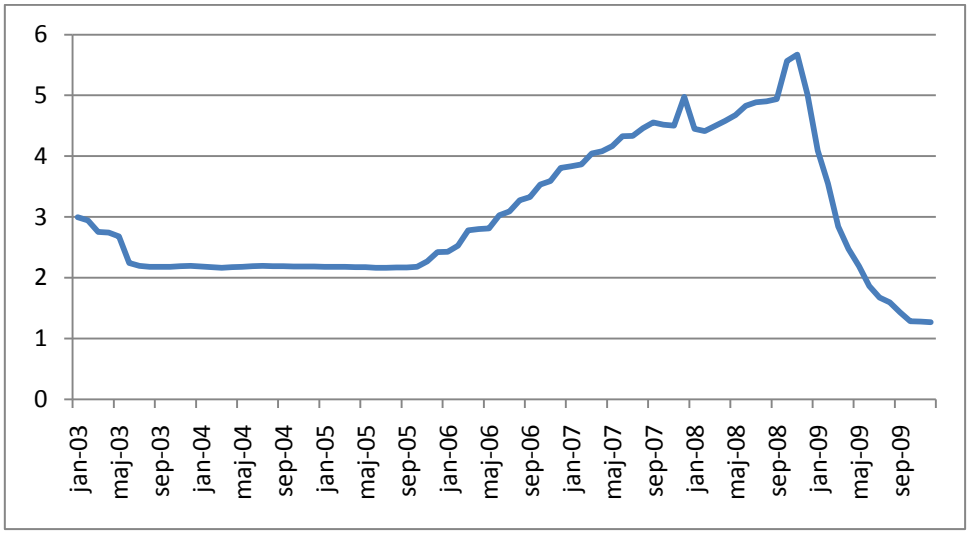


Fig. 6.6. Interbank interest rates – CIBOR, 1 month maturity (2003-2009), %. Data source: www.nationalbanken.dk

6.4. Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (or HHI), next variable of our model, is a commonly accepted measure of the market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers[35]. The Herfindahl-Hirschman index of concentration in the loan market in Denmark is calculated as follows:

$$H = \sum_{i=1}^{N} s_i^2 \tag{6.9}$$

where s_i is the share of the bank i on the Danish loan market, N is number of banks in Denmark.

The HH index takes into account the relative size and distribution of the firms in a market and approaches zero when a market consists of a large number of firms of relatively equal size. The HH index increases both as the number of firms in the market decreases and as the disparity in size between those firms increases. Therefore, the HH index gives proportionately greater weight to the market shares of the larger firms, in accord with their relative importance in competitive interactions.

In our research the HH index for the Danish loan market has been explicitly calculated based on the data for the loans of the individual banks in Denmark to non-financial companies over the period of

[35] http://www.justice.gov/atr/public/testimony/hhi.htm

research (2003-2009). The authors in the published article (Ruthenberg and Landskroner, 2008), however, made a regression analysis using only market shares of the Israeli banks, having *ln(1+MS)* as an explanatory variable. Our data is presented in the Table 6.4.

	2003	2004	2005	2006	2007	2008	2009
HH index	0,2628	0,2636	0,2641	0,2663	0,2858	0,2731	0,257
total loans, billion Kr.	940	1.070	1.346	1.694	2.144	2.277	1.934

Table 6.4. HH index of concentration in the loan market of Denmark, 2003-2009. Data source: www.finanstilsynet.dk

This part of data collection was rather challenging and required guidance from Christian Overgård, Special Adviser, Banking Analysis Division of the Danish FSA. Data for 2007-2009 has been directly downloaded from the website of the Danish FSA in the format of Excel spreadsheets, while the same data for 2003-2006 had to be manually collected through the balance statements of the individual Danish banks (published in Danish), also available in the Danish FSA´s database.

For the calculation of HH index, we used an assumption that only shares of the Danish banks have been taken into consideration. Faroese Banks have not been considered, although the balance data for them is also available on the Danish FSA's (Finanstilsynet) website.[36] The reason for this assumption was that there are only three banks mentioned in Danish FSA report, and their impact on the overall loan market in Denmark is very small. This fact is presented on Fig. 6.7.

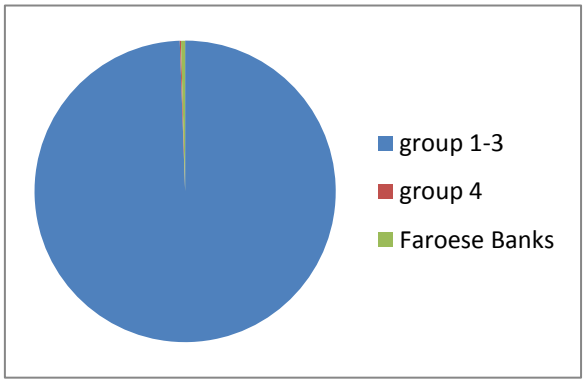


Fig.6.7. Loan market in Denmark in 2008. Shares of the Danish banks (group 1-3 and group 4) and Faroese banks. Source: www.finanstilsynet.dk

[36] http://finanstilsynet.dk/da/Tal-og-fakta/Statistik-noegletal-analyser/Statistik-om-sektoren.aspx

The division of the Danish banks in groups is provided in the chapter 4. As an example, the detailed data on lending of the Danish banks to non-financial companies for 2008 is provided in the Appendix A-2, Tables A1-A3, for the banks of the groups 1-3 (large and medium sized banks, 101 in total), group 4 (the smallest banks, 37 in total) and three Faroese Banks.

A graphical representation of the data from Table 6.4 shows that HHI is not a permanent parameter (Fig. 6.8). In the period of 2003-2006, the HHI was around 0.26. Later, the HHI value experienced a rise up to 0.2858 in 2007 and its consequent fall up to 0.257 in 2009 (that corresponds to a change of approximately 11%). At the same time, the amount of loans decreased only in 2009, experiencing a stable growth in the period of 2003-2008 (Fig. 6.9), while a number of the Danish banks decreased from 177 to 132 over the period of 2003-2009 (section 4.1). Additionally, it is important to mention that the recent crisis influenced a lot the liquidity of the companies forcing them to get more short term loans; and some banks became bankrupt as, for example, Roskilde bank (2008).

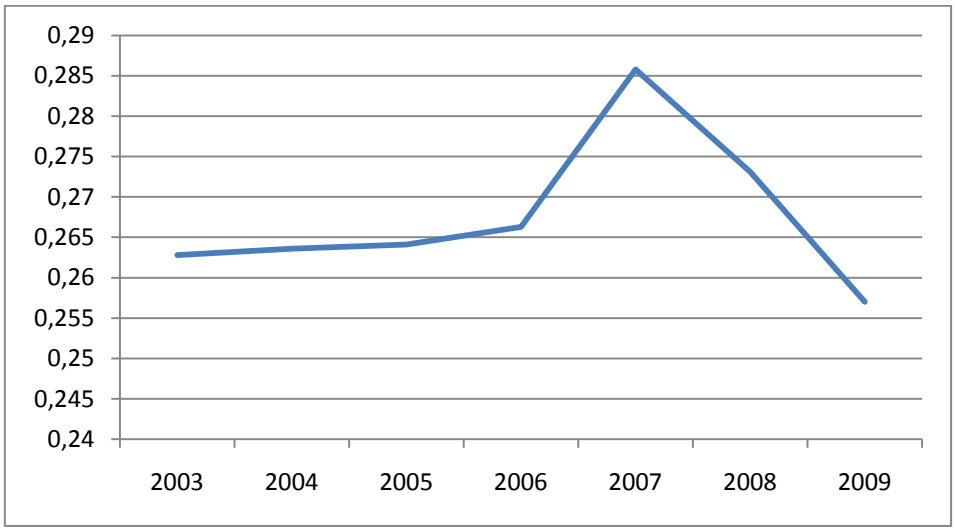


Fig. 6.8. HH index of concentration in the loan market of Denmark, 2003-2009. Data source: Table 6.4.1

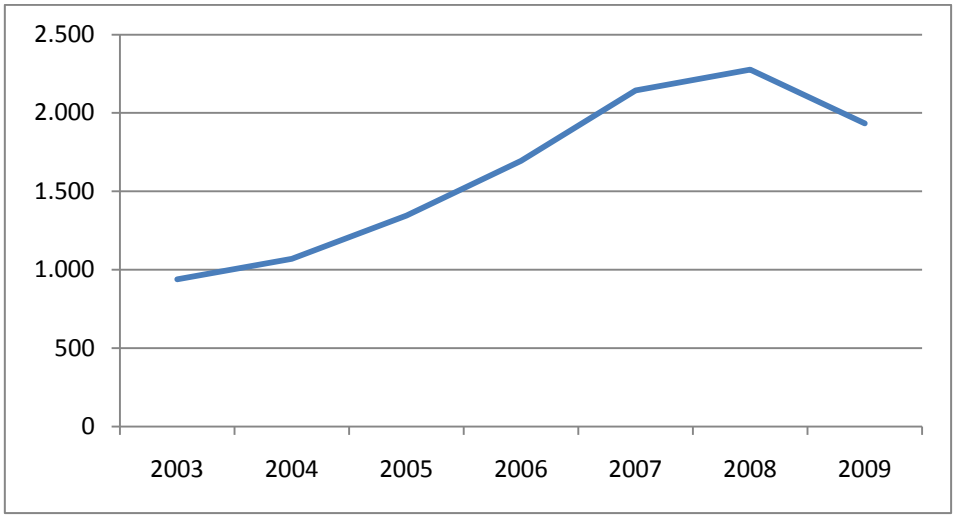


Fig. 6.9. Total amount of loans to non-financial sector by Danish banks, annual data, billion DKK (2003-2009). Data source: Table 6.4.1

Therefore, for the period of 2003 -2006, there is a slight growth in HHI mostly due to the fact of the reduction of the number of the Danish banks and growing shares of some of them. However, it is difficult to get a clear cut analysis of the reasons that shaped a dynamics of the HHI of the Danish loan market last years (2007-2009).

The US Department of Justice divides the spectrum of market concentration measured by the HHI into three regions that can be broadly characterized as unconcentrated (HHI below 0.1), moderately concentrated (HHI between 0.1 and 0.18), and highly concentrated (HHI above 0.18) markets.[37] Following these guidelines from the US Department of Justice, our conclusion is that Danish loan market with HHI varying between 0.26 and 0.28 may be characterized as highly concentrated.

6.6. Conclusion to chapter 6

This chapter presents an extensive discussion about variables and data for our model described in chapter 5. The bank own interest rate in our model is a function of six variables: market concentration, elasticity of demand for loans, probability of default, interbank borrowing rates, cost of capital and sensitivity of capital charges to the amount of loans of the bank.

Basel II Accord puts a lot of attention on the risk components for the determination of the capital requirements for the banks. Therefore, probability of default and sensitivity of capital charges to the

[37] http://www.justice.gov/atr/public/guidelines/horiz_book/15.html

amount of loans of the bank (capital requirement) are essential variables in our model with respect to Basel II. Originally, the idea was to get a bank specific data (for performing the regression analysis) from one of the largest banks in Denmark. For this reason, Nykredit and Nordea have been contacted. However, throughout the communication it became clear that it was not possible to receive an explicit data, especially for the probability of default, for our model from them. Therefore, the decision has been made to move towards the analysis of the publicly available data.

In this project we use data that has been mostly downloaded from the online database of the National bank of Denmark. The other data sources were database of the Danish FSA (Finanstilsynet) and the website of NASDAQUE OMX Group. The period of analysis is Jan., 2003-Dec., 2009.

At this stage of work, the OLS regression analysis has been performed for the estimation of the average beta in the Danish banking sector. This has been done in order to calculate the average cost of equity of the Danish banks (via CAPM model).

HH index (characterizes the market concentration) for loans market in Denmark has been explicitly calculated based on the data received from Danish FSA. Additionally, our conclusion was that Danish loan market with HHI varying between 0.26 and 0.28 may be characterized as highly concentrated.

CIBOR was selected as a proxy for the variable that describes the discount-window borrowing or interbank borrowing in our model.

It is important to mention that all data in our research period (2003-2009) has experienced a significant influence of the on-going economic crisis (since 2007).

We have also provided a critical analysis of data used in the published article.

7. Calculation of the elasticity of demand for loans

In chapter 5 we have stated the problem that since the elasticity of demand for loans η is also a function of the interest rate R_L, it cannot be used as an exogenous explanatory variable in our regression model. This chapter is related to the modeling of the demand function that would later permit us to calculate the elasticity of demand. A number of unexpected difficulties appeared on this way and lead to a decision to reduce the sample of data for our analysis.

We present data for interest rates and amount of loans (in monetary terms) for non-financial companies in Denmark for three types of loans, differentiated according to the maturity: up to 1 year, from 1 to 5 years, and over 5 years. Later, we make an estimation of the curve of inverse demand for loans in order to calculate the elasticity of demand for loans in Denmark in the period 2003-2009.

7.1. Data for elasticity of demand for loans

The elasticity of demand for loans is the last variable in our model, formulated in equation (5.15). Price elasticity of demand, commonly known as just price elasticity, measures the rate of response of quantity demanded due to a price change[38]. The mathematical definition of elasticity in our project is formulated like in (Cabral, 2000), as follows:

$$\eta = -\frac{\partial L}{\partial R_L}\frac{R_L}{L} \tag{7.1}$$

where R_L is the interest rate for loans (price for loans), and $L = \sum_{i=1}^{N} L_i$ is the sum of all the loans to the non-financial companies in Denmark (in Danish Kr.). L describes a demand for loans.

Data for interest rates and lending to non-financial companies in Denmark has been found in the database of the National Bank of Denmark for three categories: up to 1 year, from 1 to 5 years, and over 5 years[39]. The graphical representation of this data is given on Fig.7.1 and 7.2.

A first quick visual inspection of these graphs shows that interest rates and quantity of loans negatively correlated up to a certain point in time. The negative correlation means that the interest rates for all three types of loans decrease while demand for loans increases simultaneously.

[38] http://economics.about.com/cs/micfrohelp/a/priceelasticity.htm
[39] http://nationalbanken.statistikbank.dk/statbank5a/default.asp?w=1366

However, later there is a turning point when both sets of data (interest rates and quantities of loans) first increase and then dramatically fall down. It means that for this period of time (approximately 2007-2009) interest rates and quantities of loans may be positively correlated, that may pose a problem in our modeling. Later this analysis was confirmed.

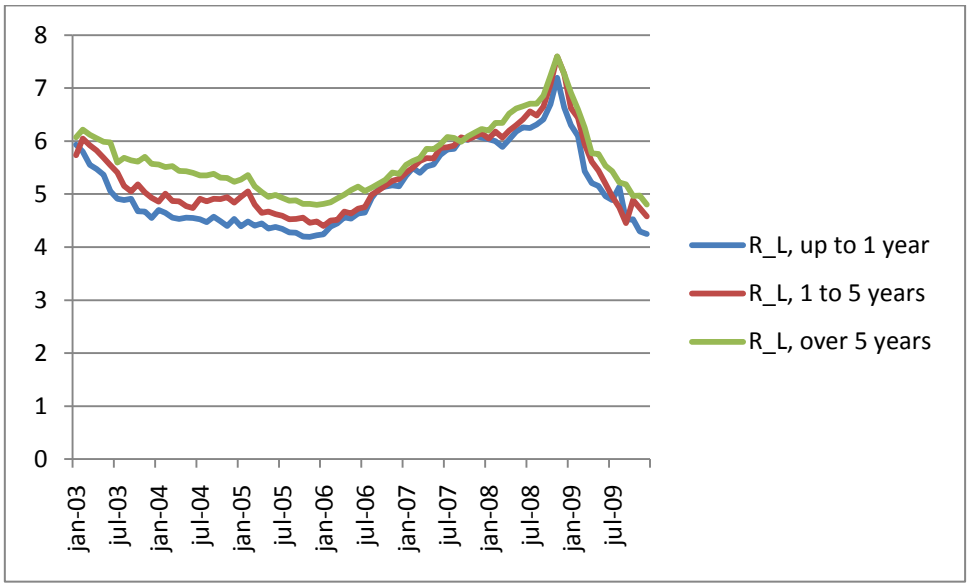


Fig. 7.1. Interest rates for loans R_L to non-financial companies in Denmark, %. Data source: www.nationalbanken.dk

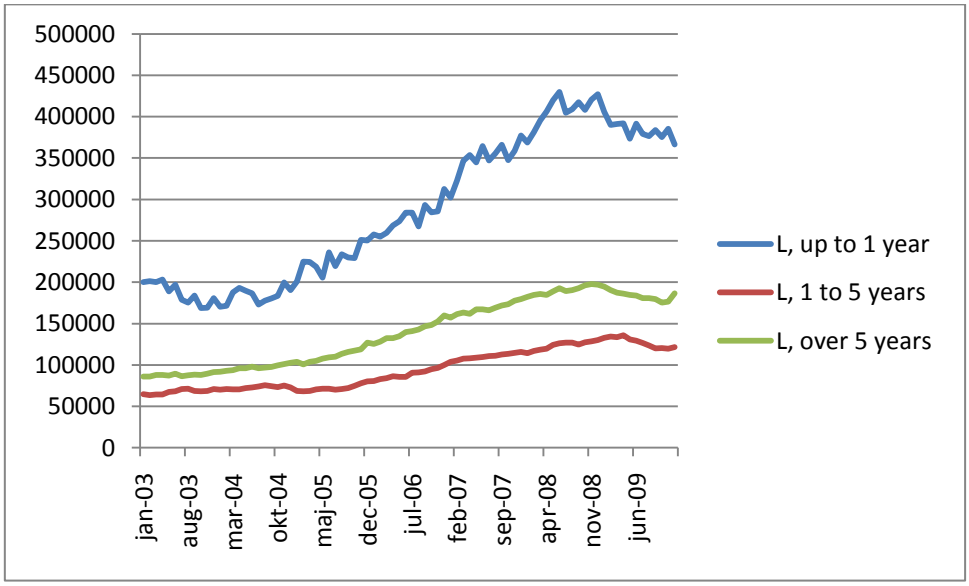


Fig. 7.2. The quantity of loans L to non-financial sector by Danish banks, Mio. Kr. Data source: www.nationalbanken.dk

7.2. Estimation of the inverse demand function for loans in Denmark

In order to calculate the elasticity of demand for loans in our project, we need to obtain an inverse demand function for loans in Denmark $R_L(L)$, similar to the one which is shown on Fig.7.3.

This function should have been received via running the linear OLS regression for equation (7.2):

$$R_L = \alpha + \beta * L + \varepsilon \qquad (7.2)$$

where the parameters α and β are estimates, and ε is an error term (assumed that it tends to 0).

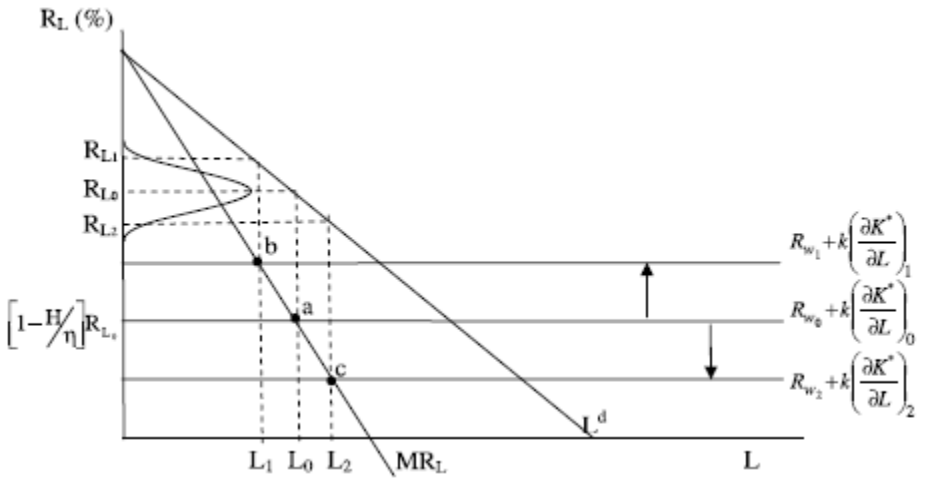


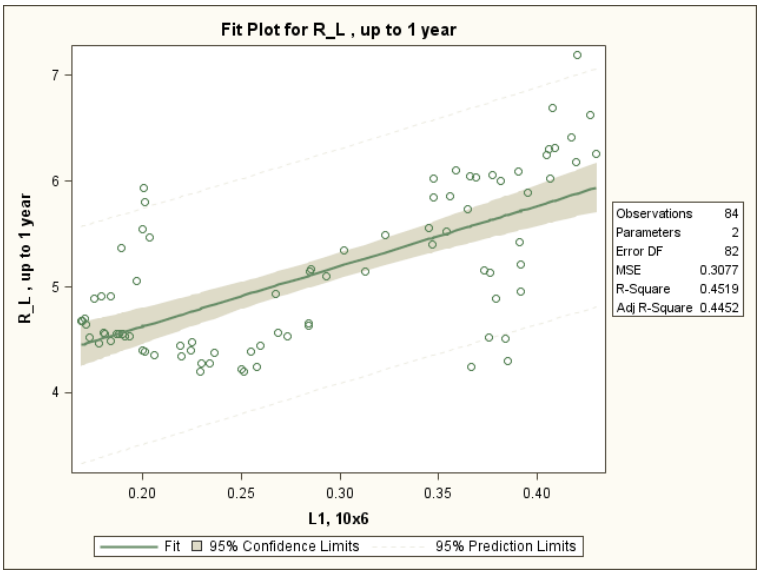
Fig 7.3. Interest rate on loans (R_L) and the quantity of loans (L) in a non-competitive market in response to changes in capital requirements within the Basel II framework (Ruthenberg and Landskroner, 2008).

Unexpectedly, all three sets of the historical data for interest rates on the Danish loan market and demand for loans for the period of 2003-2009 gave us a positive slope β in the equation (7.2). Below we present the graphical representation of the statistical data (interest rates versus amount of loans) for three cases: a) loans up to 1 year; b) loans from 1 to 5 years and c) loans over 5 years (Fig. 7.4). On the same plots the OLS regression lines are shown, and all three of them exhibit positive slopes. One can also see that it is easier to describe trends of existing data with a parabolic function or two linear functions with both negative and positive slopes than with a linear function that has a negative slope for the whole period of research.

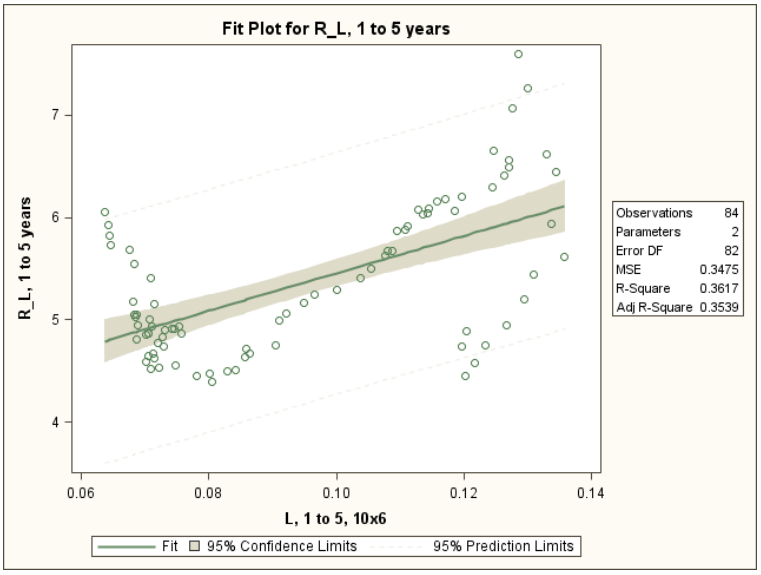
The results of the OLS regression for the interest rates versus amount of loans, described by equation (7.2), are shown on Fig.7.5.

The null hypothesis here is that the slope β is equal to zero, or H_0: $\beta = 0$.

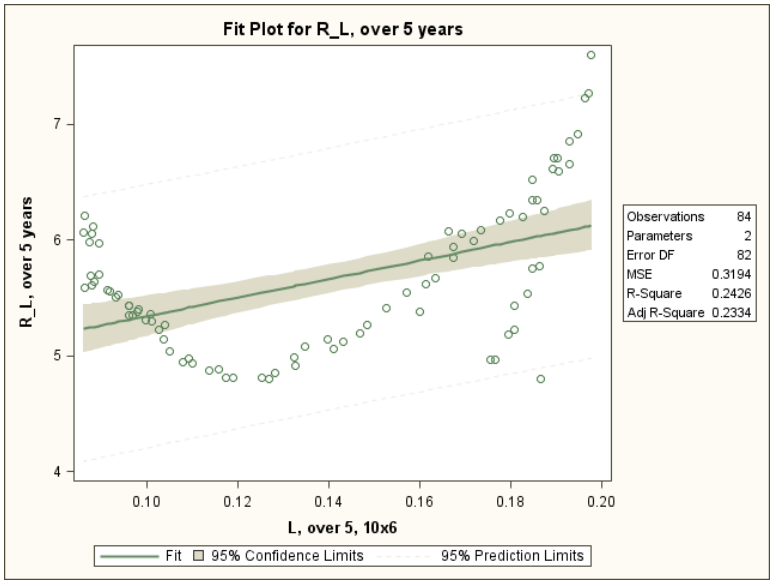
All the estimated parameters has been received positive with the probabilities of significance Pr> |t| (p-values) of less than 0.01%, meaning that all the regression coefficients are significantly different from zero. R^2 = 45% for loans up to 1 year, R^2= 36% for loans from 1 to 5 years and R^2=24% loans over 5 years. R^2 shows explanatory power of the model which is not very high in these cases.



a)



b)



c)

Fig. 7.4. Graphical representation of the interest rates versus amount of loans for the cases: a) loans up to 1 year; b) loans from 1 to 5 years and c) loans over 5 years, 2003-2009. Source: SAS output

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.49033	0.20823	16.76	<.0001
L, up to 1 year	1	0.00000569	6.919518E-7	8.22	<.0001

a)

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.62943	0.26171	13.87	<.0001
L, 1 to 5 years	1	0.00001826	0.00000268	6.82	<.0001

b)

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.54165	0.22702	20.01	<.0001
L, over 5 years	1	0.00000801	0.00000156	5.13	<.0001

c)

Fig.7.5. Results of the OLS regression for the interest rates R_L versus amount of loans L for the cases: a) loans up to 1 year (R^2=45%); b) loans from 1 to 5 years (R^2= 36%) and c) loans over 5 years (R^2=24%), 2003-2009. Source: SAS output

The negative slope of the inverse demand function is always required for the optimization models. Since we cannot use the existing set of data for our further modeling because of the results received

in this section (positive slopes for all three cases of loans), the possible approaches to solve the problem are discussed in the next section.

7.3. Extended equation for demand for loans

In this section we make an attempt to get a negative slope for the demand function by introducing some macroeconomic variables in the equation for demand for loans in Denmark. These new variables are the growth in Danish Gross Domestic Product (GDP) and inflation. We run an OLS linear regression for the extended demand for loans which is formulated as follows:

$$L = \alpha_0 + \alpha_1 R_L + \alpha_2 \%\Delta GDP + \alpha_3 \%\Delta I + error \tag{7.3}$$

where $\%\Delta GDP$ is percentage change in Gross Domestic Product, $\%\Delta I$ is inflation in Denmark; L and R_L are the demand function for loans and the interest rates for loans, respectively.

Equation (7.3) is similar to the second equation in the published article (more discussion about the published regression model is provided in chapter 8)

Originally, the Producer Price Index for Services (PRIS15)[40] has been selected to calculate the inflation for the Danish corporate sector. The purpose of this index is to analyze trends in prices relating to the first commercial transaction of each service, e.g. producers' selling prices to other producers. However, this data was available only for the period of 2006-2010, and the aggregated index was not available.

Then, we have selected the consumer price index (CPI) for our calculations. This index is used as a measurement of inflation. The purpose of the consumer price index is to measure the development of the prices charged to consumers for goods and services bought by private households in Denmark. The consumer price index is calculated on the basis of 25000 prices collected from approx. 1800 shops, companies and institutions throughout Denmark. Data on the annual rate of change of the CPI is presented in Table 7.2.

	2003	2004	2005	2006	2007	2008	2009
Consumer price index, annual rate of change	2,1	1,2	1,8	1,9	1,7	3,4	1,3

Table. 7.2. Data for Inflation. Source: Danmarks Statistik, www.dst.dk

[40] http://statbank.dk/405, Danmarks Statistik

	2003	2004	2005	2006	2007	2008	2009
GDP, annual rate of change	0,4	2,3	2,4	3,4	1,7	-0,9	-4,7

Table 7.3. GDP growth in Denmark, 2003-2009 Source: www.dst.dk

We run an OLS regression for the equation (7.3) on the sample of data of 2003-2009 for the same three cases as in section 7.1: a) loans up to 1 year; b) loans 1 to 5 years; and c) loans over 5 years. Data for the amount of loans L has been divided by 10^6 for the convenience of the calculations. We can possibly expect that the value of α_1 will be negative.

The null hypothesis here is that coefficients α_1 is equal to zero, or H_0: $\alpha_1 = 0$.

The results are presented on Fig. 7.6. and show that the estimated parameter α_1 is positive in all three cases: a) α_1= 0.05752, t-value = 5.03, R^2 = 61%; b) α_1= 0.01385, t-value = 4.21, R^2 = 60%; and c) α_1= 0.01073, t-value = 1.44, R^2 = 43%. The explanatory power of these models, shown by R^2, was higher than in the previous case (section 7.1).

The probabilities of significance Pr> |t| (p-values) are less than 0.01% for α_1 in the cases a) and b), meaning that these regression coefficients are significantly different from zero. The probability of significance for α_1 in the case c) is 15.41%, much larger than 0.05-level set up automatically by SAS program. Therefore, in the case for loans over 5 years, we reject the null hypothesis, meaning that α_1 is insignificantly different from zero.

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-0.01618	0.04824	-0.34	0.7382
R_L , up to 1 year	1	0.05752	0.01143	5.03	<.0001
real growth in GDP, %	1	-0.01465	0.00258	-5.67	<.0001
inflation= Forbrugerprisindex, %	1	0.00978	0.01188	0.82	0.4128

a)

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	0.02414	0.01457	1.66	0.1015
R_L, 1 to 5 years	1	0.01385	0.00329	4.21	<.0001
real growth in GDP, %	1	-0.00493	0.00072794	-6.78	<.0001
inflation= Forbrugerprisindex, %	1	-0.00020628	0.00333	-0.06	0.9508

b)

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.05955	0.03586	1.66	0.1008
R_L, over 5 years	1	0.01073	0.00746	1.44	0.1541
real growth in GDP, %	1	-0.00736	0.00146	-5.03	<.0001
inflation= Forbrugerprisindex, %	1	0.01272	0.00656	1.94	0.0561

c)

Fig. 7.6. Results for the OLS linear regression, extended demand function for loans, Danish loan market (2003-2009). Cases: a) loans up to 1 year; b) loans 1 to 5 years; and c) loans over 5 years. Source: SAS output

The conclusion was that we did not receive a negative coefficient for R_L neither in this case nor in the cases of introduction of only GDP and only inflation (one parameter at the time). This situation seemed strange, but on the other hand there must be a reason for these trends.

A possible explanation of these results can be the effect of the on-going crisis that started in 2007 and affected our data for the years 2007-2009. Perhaps, trends of these years have a very big influence on the whole sample of research changing the direction of the demand function for the entire period.

This hypothesis was confirmed by series of calculations in Excel. They showed that the inverse demand function $R_L(L)$ has a negative slope (as it should be) for the period of 2003-2006 and positive slope for the period of 2007-2009. The results are presented in Table 7.1.

This conclusion goes in line with the National Bank of Denmark, stating in the report on market development in 2008 that both lending margins and lending increased in 2008 because of the international financial crisis.

	2003-2006	2007-2009
intercept, up to 1 year	4,75	2,02
Slope	-2,46E-07	9,70E-06
intercept, 1 to 5 years	5,9	3,36
Slope	-1,26E-05	2,11E-05
intercept, over 5 years	6,55	-0,44
Slope	-1,11E-05	3,62E-05

Table. 7.1. Results of linear OLS regression for eq. (7.2) for three types of loans broken in two periods (2003-2006) and (2007-2009). Data source: Fig. 7.1 and 7.2.

Since the negative slope is essential for our model, the decision of using only data for 2003-2006 with a negative slope for the inverse demand function has been made. The regression analysis provided in the chapter 8 is based on the reduced sample of data.

7.4. Conclusion to chapter 7

In this chapter we discussed the regression analysis performed for estimation of the demand function for loans in Denmark that would later permit us to calculate the elasticity of demand for loans. The elasticity of demand is the last variable in our model, formulated in the chapter 5.

Unfortunately, modeling, performed in this chapter, was not straight forward as it seemed originally. The OLS linear regression analysis performed on the full set of data (2003-2009) provided us with a positive coefficient for the relation between interest rates and amount of loans in the demand function, even after the introduction of the additional macroeconomic variables as growth in GDP and inflation. A possible and very realistic reason for this development may be the on-going financial crisis that significantly affected data for the years 2007-2009.

Therefore, a decision to reduce the sample of data to the years of 2003-2006 has been made. The reduced sample showed a correct (negative) slope in the inverse demand function, necessary for the optimization models.

8. Regression model and results

In this chapter we present a number of attempts to formulate the regression model of loan pricing under Basel II for the case of the Danish economy. In section 8.1 we present a more strict mathematical approach to the problem and later a new version of the regression model with some simplifications. However, none of these models provided us with good results. Therefore we looked at the published article (Ruthenberg and Lanskroner, 2008) and used a model similar to the one presented in the article that also allowed us to easier compare the results (sections 8.2 and 8.3). The discussion about the results for the case of the Danish economy is provided in section 8.4.

8.1. Possible regression models for loan pricing under Basel II

In this section we apply an analytical approach that has the target to substitute the elasticity of demand in our modeling equation (5.15) with an estimated parameter from the equation (7.2) for the inverse demand function. In this way we got an explicit function for the bank own interest rate R_L.

From the equation (7.2) we obtain that:

$$L = \frac{1}{\beta} R_L - \frac{\alpha}{\beta} \tag{8.1}$$

It is assumed (as usual) that the expected value of error term ε is zero: $E(\varepsilon)=0$.

Then the elasticity of demand is calculated as a function of R_L, as follows:

$$\eta = -\frac{\frac{\partial L}{\partial R_L}}{\frac{L}{R_L}} = -\frac{\frac{1}{\beta}}{\frac{1}{\beta} R_L - \frac{\alpha}{\beta}} \cdot R_L = \frac{R_L}{\alpha - R_L} \tag{8.2}$$

Introducing (8.2) in our model (5.15), we get

$$R_L \left(1 - \frac{H}{\frac{R_L}{\alpha - R_L}} \right) = \frac{1}{(1 - PD)} \left(R_w + k \frac{\partial K^*(L_i)}{\partial L_i} + PD \right) \tag{8.3}$$

Reorganizing the right part of equation (8.3) as follows

$$R_L\left(1-\frac{H}{\frac{R_L}{\alpha-R_L}}\right)=R_L\left(R_L-H\left(\alpha-R_L\right)\right)/R_L=R_L-H\left(\alpha-R_L\right)=R_L\left(1+H\right)-H\cdot\alpha \tag{8.4}$$

we finally get the explicit function for the bank own interest rate:

$$R_L=\frac{1}{1+H}\cdot\frac{1}{\left(1-PD\right)}\left[\left(R_w+k\frac{\partial K^*\left(L_i\right)}{\partial L_i}+PD\right)+H\cdot\alpha\left(1-PD\right)\right] \tag{8.5}$$

Our model is non-linear in variables, but a suitable transformation with taking *ln* of both parts of the equation (8.5) gives us a linear-in-the parameters regression model as presented below:

$$\ln(R_L)=\beta_0+\beta_1\ln\left[\left(R_w+k\frac{\partial K^*\left(L_i\right)}{\partial L_i}+PD\right)+H\cdot\alpha\left(1-PD\right)\right]-\beta_2\ln(1+H)-\beta_3(1-PD)+\varepsilon_1 \tag{8.6}$$

Here α is the intercept in the demand function for loans, the estimated parameter from Table (7.1); β_i are regression coefficients, ε_1 is an error term. The other variables are the same as in chapter 5.

In this formulation the OLS linear regression is enough to get the estimates β_i. However, this version was rejected, because a) it was difficult to interpret the results that were received with this model, and b) the same variables (H and PD) are repeated twice in the explanatory variables, what can make the estimates biased. The conclusion was that the strict mathematical approach did not work for our model because of its complexity.

The next attempt was in going one step back and reorganizing our modeling equation (8.5). As a result, we got the following equation:

$$R_L=\frac{1}{\left(1+H\right)}\cdot\left[\frac{1}{\left(1-PD\right)}\left(\left(1+R_w\right)+k\frac{\partial K^*\left(L_i\right)}{\partial L_i}\right)+H\cdot\alpha-1\right] \tag{8.7}$$

and specified the regression equation as follows:

$$R_L = \gamma_0 + \gamma_1(1+H) + \gamma_3(1-PD) + \gamma_4(1+R_w) + \gamma_4(k\frac{\partial K^*(L_i)}{\partial L}) + \gamma_5(H\alpha - 1) + \varepsilon_2 \quad (8.8)$$

Here γ_i are regression coefficients, ε_2 is an error term.

However, this specification of the regression model was also problematic. While running this regression the estimated parameter *(Hα-1)* was automatically included in the intercept by SAS program (as expected), and the message about biased estimates was received. The same happened after a substitution of the explanatory variable *(Hα-1)* for just *α* (also expected result). For this reason we abandoned this way of modeling and looked at the model in the published article. The idea behind this choice was that by using a similar model it will be easier to compare the results. The regression model from the article by Ruthenberg and Lanskroner (2008) is discussed in the next section.

8.2. Regression model (published research)

We present here a system of equations of loan rates (R_L) and demand for loans (L^d) that has been used for the regression analysis in the published article (Ruthenberg and Landskroner, 2008) and solved simultaneously using 2SLS method. First equation (8.9) is a regression model for the equation (5.12), while a second equation (8.10) is the one which was introduced additionally following the methodology of the 2SLS method (Wooldridge, 2009).

Loan rate equation (R_L), for corporate customers:

$$R_L = \alpha_0 + \alpha_1 \ln(1+LLPC) + \alpha_2 \ln(1+MS) + \alpha_3 \ln(1+TB) + \alpha_4(\ln(1+k) + \ln(1.09)) + error \quad (8.9)$$

where *LLPC* is a risk component measured by ratio of loan loss provisions for corporate customers to the average amount of loans (a proxy for probability of default *PD*);

MS is a market share of the individual bank in total banking assets (a proxy for H);

TB is a cost of debt on secondary market measured by yield to maturity on a 1-year Makam[41] (a proxy for R_w);

[41] short term government bills issued by the Bank of Israel

ln(1+k)+ln(1.09) is a product of the cost of equity and sensitivity of capital charges to the amount of loans, the last one is assumed 9% (more discussion is in section 6.1.2).

Demand for loans equation (L^d), for corporate customers:

$$L^d = \alpha_0 + \alpha_1 \ln(1 + RLC) + \alpha_2 \ln(1 + \%\Delta GDP) + \alpha_3 \ln(1 + \sigma_p) + \alpha_4 \ln(1 + \%\Delta F) + \varepsilon rror \quad (8.10)$$

where

RLC is the interest rate on loans (R_L) measured by interest income plus management fees divided by the average amount of loans;

$\%\Delta GDP$ is an income effect measured by percentage change in Gross Domestic Product;

σ_p is a substitution effect measured by standard deviation of expected inflation during 24 month period;

$\%\Delta F$ is also a part of substitution effect measured by percentage change in funds (bonds and stocks) raised on the Tel Aviv stock exchange.

8.3. Final regression model for loan pricing under Basel II in Denmark

This section presents the final formulation of the regression model used in this project. It also has two equations like the model from the section 8.2. The first equation is related to the banks interest rates for the corporate customers. The other equation is the extended demand function for loans to non-financial companies in Denmark.

Loan rate equation (R_L), for corporate customers:

$$R_L = \alpha_0 + \alpha_1 \ln(1 + PD) + \alpha_2 \ln(1 + H) + \alpha_3 \ln(1 + R_w) + \alpha_4 (\ln(1 + k) + \ln(1.08)) + \varepsilon_t \quad (8.11)$$

Demand for loans equation (L^d), for corporate customers:

$$L^d = \alpha_0 + \alpha_1 \ln(1 + R_L) + \alpha_2 \ln(1 + \%\Delta CPI) + \nu_t \quad (8.12)$$

Here, *PD* is the probability of default, *H* is the HH index of market concentration, R_w are the interbank borrowing rates, *k* is the coat of equity, *%ΔCPI* is the annual rate of inflation.

Before running the statistical test, it is important to get an idea on the possible impact of each explanatory variable. Based on the analysis, provided in section 5.5, it is expected to obtain a positive relation between the interest rates and all explanatory variables included in the equation (8.11), meaning that the interest rates will increase:

- with higher PD (more risky customers), $\alpha_1 > 0$;
- with growth of the Danish loan market concentration described by H, $\alpha_2 > 0$;
- with growth in interbank borrowing rates R_w in Denmark (or cost of debt), $\alpha_3 > 0$;
- with growth in cost of equity sensitivity (Basel II term), $\alpha_4 > 0$.

For equation (8.12) we expect that we get a necessary negative coefficient for interest rates, meaning that $\alpha_1 < 0$ (more discussion is provided in chapter 7) and positive coefficient for inflation, $\alpha_2 > 0$.

8.4. Regression results

The results for 2SLS regression for the equations (8.11) and (8.12) are provided in Table 8.1. Here the null hypothesis for (8.11) is that all the estimated coefficients are equal to zero, or $H_0 : \alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. And similarly for the equation (8.12), it is $H_0 : \alpha_0 = \alpha_1 = \alpha_2 = 0$.

The t-value appears in parentheses in Table 8.1 under the estimated coefficient, and the significance level is shown by star-sign. The results show that regression coefficients for the probability of default, the market concentration and the cost of debt are significantly different from zero for two cases: a) loans 1 to 5 years and b) loans over 5 years of maturity.

Unfortunately, it was not possible to get any results for the case of loans up to 1 year because of the low variation in HH index. We have only annual data for the HH index.

Considering the expected signs of the regression coefficients, all of them were consistent with our expectations except for the case of the market concentration. These estimates have a negative sign meaning that with an increase of the market concentration the interest rates will fall.

A possible explanation for this phenomenon can be the structure of the banking market in Denmark, where large banks dominate a market. The article by Berger at al. (2001)[42] examines how the size structure of a banking market affects the way participants compete to serve small business borrowers. Their market size structure results suggest that banks compete differently in markets dominated by small banks than in markets dominated by large banks, and in particular that banks may compete less aggressively in markets dominated by small banks. The authors conclude that the interest rates for small business are lower when large banks dominate a market all else equal, than when small banks dominate.

	Loans, 1 to 5 years	**Loans, >5 years**
a) Loan rate equation, R_L		
Intercept	0.75 (4.66)***	0.30 (2.24)**
Accumulated write down rate, ln(1+PD)	0.19 (2.20)**	0.46 (6.25)***
Market concentration ln(1+H)	-3.08 (-4.50)***	-1.14 (-1.98)*
Cost of debt ln (1+R_W)	0.89 (10.60)***	0.51 (7.30)***
Cost of equity sensitivity (Basel II), ln(1+k)+ln(1.08)	0.002 (0.37)	0.001 (0.28)
R^2	0.85	0.88
b) Demand for loans equation , L^d		
Intercept	0.11 (6.56)***	0.28 (8.24)***
Interest rates on corporate loans ln(1+R_L)	-0.84 (-2.33)**	-3.87 (-5.92)***
Inflation ln (1+%ΔCPI)	0.49 (1.19)	1.70 (2.40)**
R^2	0.11	0.45

Table. 8.1. Results of 2SLS regression for the loans to corporate customers in Denmark with maturity a) 1 to 5 years and b) over 5 years. *,**,*** denotes statistical significance on 10%, 5%, 1% level respectively. Source: SAS output

A rather surprising result was about the regression coefficients for the cost of equity sensitivity (the Basel II related term in our model). They were received insignificantly different from zero for both cases.

[42] http://www.federalreserve.gov/pubs/feds/2001/200163/200163pap.pdf

At one of the meetings with specialists from the Research and Development department of Nykredit, we have discussed the potential outcome from this research project. Their concern was that our project with the proposed model may not catch any effects in change of the interest rates due to the "new" Basel II capital requirement rules. According to Nykredit's experience, it is the price that the consumer has to pay that makes a difference and not the actual mid market "economic" interest rate level. "Perhaps there will be a theoretical second- or perhaps third order effect (due to minimal changes in supply/demand), but I am afraid that there will be too much noise in the data to catch it. Perhaps that is a result in itself?"[43]

It seems that the results received with our regression model for equations (8.11)-(8.12) confirm the opinion of the Danish experts.

At the same time there are some other possible reasons for the results that we received. They are discussed in section 8.6.

8.5. Durbin Watson statistical test

Since our data are time series, it is important to make a test for the presence of the autocorrelation. The autocorrelation represents a degree of similarity between a given time series and a lagged version of itself over successive time intervals[44]. One of the statistical tests that detects the presence of the autocorrelation is the Durbin-Watson test.

In the Durbin-Watson test the null hypothesis implies no correlation, and mathematically formulated as follows:

H_0: Cov (ε_i, ε_j) = 0, for i≠j (no correlation)

H_1: Cov (ε_i, ε_j) ≠ 0, for i≠j

In equation (8.11) N= 47; k= 4 (N is number of observations, k is a number of variables). The significance level of 0.05. Hence, from the Table D.5A (p.970) in Gujarati we find that:
$d_l(0.05)=1.336$;

[43] From the e-mail correspondence with Peter Mortensen, Analyst, Investment & Financial Products, R&D, Nykredit

[44] http://www.investopedia.com/terms/a/autocorrelation.asp

$d_u(0.05)=1.720$.

The Durbin Watson statistic, calculated for (8.11) for loans 1 to 5 years , is 0.975 that belongs to the area $< d_l$ (Fig. 8.1). Therefore, H_0 is rejected and there is an evidence of positive autocorrelation. Due to the sign of the autocorrelation the estimators are not BLUE (Best Linear Unbiased Estimators), only LUE (Linear Unbiased Estimators).

Durbin-Watson D	0.975
Number of Observations	47
1st Order Autocorrelation	0.480

Fig. 8.1. The results of the test on the presence of the autocorrelation , eq.(8.11), loans 1 to 5 years. Source: SAS output

A similar result of signs of the positive autocorrelation was received also for the interest rates equation in case of the loans over 5 years.

The possible causes of the autocorrelation are business cycles, data manipulations or incorrect model specification (missing explanatory variables etc.). The forecasting models should not have autocorrelation. So, the conclusion is that our model cannot be considered as a forecasting model for loan pricing in Denmark under Basel II.

8.6. Comparison with the published results

The research by Ruthenberg and Landskroner (2008) presents positive signs and statistical significance for all the regression coefficients of the model (Table 8.2). The tests showed the absence of the autocorrelation in their sample of data. For this reason, the published model can provide a good forecast for loan pricing under Basel II.

The question here is why we have obtained a completely different result with almost the same model and credible data for the Danish economy? For example, our data for the cost of equity is monthly while the authors use annual data. That means that we must have better data sensitivity than in the Israel case.

In my view, there are a number of reasons:

- The sample of data for our research was reduced from 7 years to only 4 years, because of the crisis. We could not extend our sample by year before 2003, as data for these years was not available. The regression in the article was performed on a sample of data for 9 years.
- The assumption of our model that the cost of equity is equal for all the banks in Denmark is strong simplification.
- The capital requirement term is assumed 8% (minimum) while it is a dynamic parameter, but it can be calculated only by banks themselves (chapter 6).
- And of course, research from the article is based on the bank specific data that makes it unique. We use the average economic data of the country.

	Corporate customerss
a) Loan rate equation, R_L	
Intercept	-0.12 (-2.24)**
Loan loss provisions, ln(1+PD)	1.08 (1.87)*
Market share ln(1+H)	0.39 (1.85)*
Cost of debt (secondary market) ln $(1+R_W)$	1.35 (8.99)***
Cost of equity sensitivity ln(1+k)+ln(1.09)	0.11 (1.63)*
AR(1)	0.38 (4.67)***
DW	2.25
R^2	0.95
b) Demand for loans equation , L^d	
Intercept	
Interest rates on corporate loans	13.20 (62.87)***
Changes in gross domestic product ln (1+%ΔGDP)	-2.27 (-1.62)*
Standard deviation of expected inflation ln$(1+\sigma_p)$	-0.41 (1.68)*
AR(1)	0.91 (14.80)***
DW	1.52
R^2	0.98

Table.8.2. Regression results of simultaneous equation system (using 2SLS) of loan rates and demand for loans for corporate customers, 09/1998 -05/2006. Source: (Ruthenberg and Landskroner, 2008). The t-statistics appear in the parentheses under the coefficient. *,**,*** indicates statistical significance at the 10%, 5%, 1% level respectively.

Overall, it seems that the main reason for the difference in the results came out because of the data sample and assumptions in our model.

8.7. Conclusion to chapter 8

The discussion in the chapter 8 focused on the specification of the regression model and the regression results which have been presented in comparison with the results from the research published by Ruthenberg and Landskroner (2008).

After a number of attempts to specify the regression model based on the mathematical model from the chapter 5, the final version was accepted. It consists of a system of two linear equations similar to the model from the published article. The first one is formulated for the interest rates with four explanatory variables: the probability of default, the market concentration, the cost of debt on the secondary market and the Basel II related term which is represented by the cost of equity sensitivity. The second equation was formulated for the demand for loans to non-financial companies in Denmark, and has two explanatory variables: the interest rates and inflation which is represented by change in Consumer Price Index.

Following the 2SLS approach, the regression coefficients have been received. The results showed that the regression coefficients for the probability of default, the market concentration and the cost of debt are significantly different from zero for two cases: a) loans 1 to 5 years and b) loans over 5 years of maturity. It was not possible to get any results for the case of loans up to 1 year because of the low variation in HH index. We have only annual data for the HH index.

A rather surprising result is related to the regression coefficients for the cost of equity sensitivity (the Basel II related term in our model). They were received insignificantly different from zero for both cases.

Unfortunately, an evidence of the positive autocorrelation was detected with a help of the Durbin Watson test. The autocorrelation may occur because of a number of reasons. However, this shows that our model cannot be a forecasting model on loan pricing for the case of the Danish economy.

Chapter 9. Conclusions and future work

In the current project we focused on the following research questions:

- Is the model, published by Ruthenberg and Landskroner (2008), valid in the case of the Danish economy?
- Which was the influence of Basel II and the on-going economic crisis on the Danish banking sector?
- How did the introduction of Basel II affect the competition between Danish banks?

Below we provide a summary of our findings.

Research question 1:

Although the published article presented a forecasting model on loan pricing under Basel II with exciting results, a number of questions appeared after its thorough reading. First of all, the mathematical model had to be corrected. Using the methods of Industrial Organization, we have reformulated the model from the very beginning and received it in a form, that slightly differs from the one published in the article. In our research we kept the original equation for profits of the bank and a number of assumptions.

Secondly, some data used by authors was a little confusing. For example, in the article the risk free rate R_f is represented by the average annual yield to maturity on a Makam with 360 days maturity; later the data used for the cost of debt in secondary market R_w is the yield to maturity on 1 year Makam. It seems that the same data was used for two different variables. Nevertheless, the authors received a good forecasting model for loan pricing under Basel II.

We have formulated a regression model in a similar way and used credible data from the publicly available database of the National Bank of Denmark, Danish FSA (Finanstilsynet), NASDAQUE OMX Group and Denmark Statistics. However, our results showed that although most of the regression coefficients were significantly different from zero for cases of the loans with different maturities, the estimated coefficients for the cost of equity sensitivity (the Basel II related term in our model) was received insignificantly different from zero both for loans 1 to 5 years and loans over 5 years of maturity.

A detected evidence of the positive autocorrelation brought us to the conclusion that our model based on research by Ruthenberg and Landskroner (2008) cannot be a forecasting model on loan

pricing under Basel II in the case of the Danish economy.

Research question 2:

Basel II is an important part of the Danish legislation since the beginning of 2007. A number of large Danish banks have been approved by Danish FSA (Finanstilsynet) in 2007-2008 for the use of the IRB approaches for the calculation of the minimum capital requirements. However, it appears that the implementation of the Basel II into the Danish economy was 'too little and too late' to help the Danish financial system in counter-balancing the international financial crisis started in 2007. High exposure to the overvalued Danish property market led some of the Danish banks to collapse in the domestic market. The other possible risk for the Danish economy comes from abroad. It seems that lending policies of the Danish banks in 2007-2009 were significantly affected by on-going crisis and political decisions, much more than by the implementation of the Basel II.

Research question 3:

Unfortunately, we cannot make a conclusion about the competition between the Danish banks based on our model as it is required further specification. The market structure for loans in Denmark can be characterized as Cournot-oligopolistic as in Israel, and the Danish banking sector is similarly dominated by the large and medium sized banks. The IRB approach of Basel II is adopted mostly by the large Danish banks. That means that in principle, the conclusions of the published research may be applicable to the case of the Danish banking sector: low risk highly quality customers will be attracted by schemes of the large banks, while more risky customers will go to the small banks (which use the standardized approach).

A possible future work on this subject may be related to the further specification of the cost of the equity sensitivity term and getting more detailed data (from a bank). However, Basel II may be soon substituted by the coming Basel III Accord that puts more attention on the operational risk.

Literature

Aguais, S.D., Forest Jr L.R, King M., Lennon M.C., Lordkipanidze B. Designing and Implementing a Basel II Compliant PIT–TTC Ratings Framework. Barclays Capital. MPRA Paper No. 7004, posted January, 27, 2008. Online at http://mpra.ub.uni-muenchen.de/7004/ http://mpra.ub.uni-muenchen.de/7004/1/MPRA_paper_7004.pdf

Andersen, C.J., Andreasen, K. Basel II Konsekvenser for konkurrencen mellem store og små pengeinstitutter. Institut for finansiering, Cand. Merc.(FIR), CBS, Maj 2008. 119p.

Andersen, H. Norwegian banks in a recession: Procyclical implications of Basel II. Norges Bank. Financial Market department. Working paper 2009/04

Ayuso, J., Perez, D., Saurina, J. Are capital buffers pro-cyclical? evidence from Spanish panel data. Journal of Financial Intermediation 13 (2004) 249-264

Basel Committee on Banking Supervision. International Convergence of Capital Measurement and Capital Standards. A Revised Framework Comprehensive Version. Bank for International Settlements, June 2006 http://www.bis.org/publ/bcbs128a.pdf

Bessis, J. Risk management in banking. Wiley, 2002

Bessis, J. Risk management in banking. 3d edition, Wiley, 2010, 821p.

Blum, J.M. Why ´Basel II´ may need a leverage ratio restriction. Journal of Banking and Finance 32 (2008) 1699-1707

Cabral, L.M.B. Industrial Organization. Massachusetts Institute of Technology. 2000

Caruana, J. Overview of Basel II and its reflections on financial stability. Speech at the International Conference on Financial Stability and Implications of Basel II, Central Bank of the Republic of Turkey, Istanbul, 16 May 2005, http://www.bis.org/review/r050517a.pdf

Fouche, C.H., Mukuddem-Petersen, J. , Petersen, M.A. Continuous-time stochastic modeling of capital adequacy ratios for banks. Applied Stochastic Models in Business and Industry (2008); 22:41-71

Gordy, M. A risk-factor model foundation for ratings-based bank capital rules. Journal of Financial Intermediation, 12 (2003) p. 199-232

Gordy, M.B., Howells, B. Pro-cyclicality in Basel II: Can we treat the disease without killing the patient? Board of Governors of the Federal Reserve System, published online: http://www.bis.org/bcbs/events/rtf04gordy_howells.pdf May, 2004.

Gregoriou, G.N. Operational Risk Toward Basel III: Best Practices and Issues in Modeling, Management, and Regulation. Wiley, 2009, 497 p.

Gujarati D.N. Basic Econometrics. 4th edition. McGraw-Hill Higher Education, 2003. 1002 p.

Hasan, I., Zazzara, C. Pricing risky bank loans in the new Basel 2 Environment. Journal of Banking

Regulation Vol. 7, 3/4 (2006) pp.243-267

Heid, F. The cyclical effects of the Basel II capital requirements. Journal of Banking and Finance, 31 (2007) pp. 3885-3900

Jensen, B. Survival of the Dinosaurs – the Danish Banking Sector in the New Economy. Department of Management, Politics and Philosophy, CBS. April 2000. 116p.

Jokipii, T., Milne, A. The cyclical behavior of European bank capital buffers. Journal of Banking and Finance. 32 (2008) 1140-1451

Kashyap, A. K. and Stein, J. C. "Cyclical Implications of the Basel-II Capital Standard," Federal Reserve Bank of Chicago Economic Perspectives, First Quarter 2004, pp. 18–31.

Larsen, M.J. A shareholder value evaluation of the merger between Vestas and NEG Micon. Copenhagen Business School, MSc thesis in Finance and Strategic Management, Feb. 2010, 71 p.

Lindquist, K. Banks´ buffer capital: how important is risk? Journal of International Money and Finance 23 (3) (2004) 493-513

National bank of Denmark. Report on Financial Stability 1st half of 2009, 2009

Nykredit Real Group. Risk and Capital Management 2008. 2009

Ruthenberg D., Landskroner Y. Loan pricing under Basel II in an imperfectly competitive banking market. Journal of Banking & Finance 32 (2008) 2725–2733

Sironi, A., Zazzara, C. The Basel Committee proposals for a new capital accord: implications for Italian banks. Review of Financial Economics 12 (2003) 99-126

Stolz, S., Wedow, M. Banks´ Regulatory Capital Buffer and the Business Cycle: Evidence for German Savings and Co-operative Banks. Deutsch Bundesbank Discussion Paper No. 07/2005 (2005)

Tarullo Daniel, K. Banking on Basel. The future of International Financial Regulation. Peterson Institute for International Economics. Washington, DC. August 2008

Valler, S. Basel II and Solvency of Danish Banks in the On-going Economic Crisis. MSc thesis in Finance and Strategic Management. CBS. September, 2009

Waage, K. Hvilken virkning har implementeringen av Basel II hatt for danske pegneinstitutter – spesielt med tanke på operasjonell risico, home-host situasjonen og likviditets risiko? Cand.merc.aud.-studiet, Institut for Regnscab og Revision Kandidatafhandling, CBS, September 2008, 90p.

Wooldridge, J.M. Introductory Econometrics. A Modern Approach. 4th edition, South Western, 2009

Appendix A-1.

OMX Copenhagen Banks_GI, the list of instruments. Sept. 14, 2010

Instrument in index

Fullname	CCY	Last	+/-	%	Bid	Ask	Volume	Turnover	Updated (CET)
Aarhus Lokalbank	DKK	46.00	2.00	4.55	44.00	45.70	78	3,588	17:00:00
Amagerbanken	DKK	7.75	0.60	8.39	7.70	7.75	3,680,549	26,755,117	17:00:00
BankNordik	DKK	139.00	0.00	0.00	138.50	142.00	2,100	292,200	17:00:00
Danske Bank	DKK	136.60	-1.40	-1.01	136.60	136.90	1,286,533	176,813,582	16:59:59
DiBa Bank	DKK	60.00	0.00	0.00	60.00	61.00	177	10,620	17:00:00
Djurslands Bank	DKK	134.50	-0.50	-0.37	130.50	134.50	191	25,745	17:00:00
Eik Banki	DKK	68.00	-2.00	-2.86	66.00	69.00	6,471	438,844	17:00:00
Grønlandsbanken	DKK	410.00	0.00	0.00	415.00	420.00	1,595	653,950	17:00:00
Holdingselskabet af 1958	DKK	0.27	0.00	0.00	0.26	0.29			17:00:00
Sparekassen Hvetbo	DKK	170.00	0.00	0.00	167.00	172.00			17:00:00
Hvidbjerg Bank	DKK	65.00	0.00	0.00	65.00	67.50	656	43,066	17:00:00
Jyske Bank	DKK	209.40	-0.60	-0.29	209.40	210.00	222,557	46,942,274	17:15:02
Kreditbanken	DKK	1,563.00	0.00	0.00	1,501.00	1,648.00			17:00:00
Lån og Spar Bank	DKK	265.00	0.00	0.00	265.00	275.00			17:00:00
Lollands Bank	DKK	179.50	6.00	3.46	175.00	180.00	75	13,463	17:00:00
Max Bank	DKK	61.00	0.00	0.00	60.00	61.00	424	25,602	17:00:00
Møns Bank	DKK	120.00	1.00	0.84	117.00	120.00	280	33,999	17:00:00
Morsø Bank	DKK	452.00	6.00	1.35	455.00	495.00	27	12,250	17:00:00
Nordea Bank	DKK	57.10	0.10	0.18	57.10	57.25	369,045	21,027,921	16:59:59
Nordjyske Bank	DKK	105.00	2.00	1.94	105.00	105.50	666	69,560	17:00:00
Nordfyns Bank	DKK	425.50	0.00	0.00	390.00	420.00			17:00:00
Nørresundby Bank	DKK	175.00	5.00	2.94	169.50	172.00	60	10,500	17:00:00
Østjydsk Bank	DKK	370.00	11.50	3.21	370.00	388.00	227	84,770	17:00:00
Ringkjøbing Landbobank	DKK	575.00	-6.00	-1.03	575.00	590.00	343	199,912	17:00:00
Salling Bank	DKK	335.00	20.00	6.35	320.00	335.00	55	18,370	17:00:00
Skjern Bank	DKK	135.00	4.00	3.05	132.00	135.00	10,444	1,395,008	17:00:00
Sparekassen Lolland	DKK	200.00	0.00	0.00	200.00	230.00	148	29,600	17:00:00
Sparbank	DKK	84.00	4.00	5.00	82.00	84.00	675	57,900	17:00:00
Sparekassen Faaborg	DKK	840.00	0.00	0.00	840.00	844.00			17:00:00
Sparekassen Himmerland	DKK	255.00	0.00	0.00	252.00	255.00			17:00:00

Spar Nord Bank	DKK	57.00	0.00	0.00	57.00	58.00	2,384	135,888	17:00:00
Svendborg Sparekasse	DKK	815.00	0.00	0.00	800.00	840.00			17:00:00
Sydbank	DKK	128.10	0.10	0.08	128.10	128.40	167,203	21,434,887	16:59:59
Tønder Bank	DKK	242.00	2.00	0.83	223.00	235.00	50	12,100	17:00:00
Totalbanken	DKK	95.00	-2.00	-2.06	93.50	99.00	290	27,291	17:00:00
Vestfyns Bank	DKK	579.00	29.00	5.27	552.00	579.00	5	2,877	17:00:00
Vinderup Bank	DKK	82.00	-8.00	-8.89	83.50	89.00	10	820	17:00:00
Vestjysk Bank	DKK	65.00	-0.50	-0.76	65.00	66.00	6,514	429,183	17:00:00
Vordingborg Bank	DKK	425.00	2.43	0.58	420.00	425.00	25	10,650	17:00:00

Appendix A-2

Table A1. Group 1-3, large and medium sized banks, 1.000 Kr. Danish FSA, 2008

Name of the bank	AS0204	AS0205
Alm. Brand Bank A/S	950437	16047298
Amagerbanken Aktieselskab	0	25796452
Arbejdernes Landsbank, Aktieselskabet	0	17401113
Balling, Sparekassen	8899	334455
Bank DnB Nord A/S	0	19565391
Basisbank A/S	0	1449898
Bredebro, Sparekassen	0	743913
BRFbank a/s	62789	5915368
Broager Sparekasse	7073	863790
Brørup Sparekasse	7000	1631840
Cantobank A/S	0	407875
Capinordic Bank A/S	0	802959
Carnegie Bank A/S	0	459401
Danske Andelskassers Bank A/S	0	1250198
Danske Bank A/S	0	1120719254
Den lille Sparekasse	8731	421303
Dexia Bank Denmark A/S	1509690	0
DiBa Bank A/S	0	4683471
Djursland, Sparekassen	5937	572128
Djurslands Bank A/S	0	4235007
Dragsholm Sparekasse	5000	312161
Dronninglund Sparekasse	4938	1738189
E*Trade Bank A/S	212311	0
EBH Bank A/S	253154	4895217
Eik Bank Danmark A/S	106196	7341580
EkspresBank A/S	0	2176719
Fanefjord Sparekasse	0	159178

Fanø Sparekasse	8260	170434
Farsø, Sparekassen	28415	3000031
FIH Erhvervsbank A/S	0	58782554
FIH Kapital Bank A/S	0	13995129
Finansbanken A/S	2103	2268702
Fionia Bank A/S	7738	21561143
Folkesparekassen	0	248914
Forstædernes Bank A/S	54465	22259608
Frørup Andelskasse	0	313523
Frøs Herreds Sparekasse	0	2070724
Frøslev-Mollerup Sparekasse	0	282866
Fælleskassen, Andelskassen	0	269123
Faaborg A/S, Sparekassen	0	5477368
Grønlandsbanken, Aktieselskab	0	2690959
Gudme Raaschou Bank A/S	2134778	1535969
Hals Sparekasse	7041	224157
Himmerland A/S, Sparekassen	3362	5955472
Hobro, Sparekassen	27562	3136957
Hvetbo A/S, Sparekassen	35280	1302397
Hvidbjerg Bank, Aktieselskab	0	589527
Jyske Bank A/S	0	114053277
Jyske Sparekasse, Den	45639	7244433
Kreditbanken A/S	0	1729362
Kronjylland, Sparekassen	0	7610664
Langå Sparekasse	604	319802
Limfjorden, Sparekassen	5434	757337
Lokalbanken i Nordsjælland a/s	0	3625295
Lolland A/S, Sparekassen	0	5164891
Lollands Bank, Aktieselskabet	0	1215594
Lægernes Pensionsbank A/S	0	2489493
Løgumkloster, Sparekassen	12716	694971
Løkken Sparekasse	9034	1466167
Lån & Spar Bank A/S	0	6314071
Max Bank A/S	0	4215583
Merkur, Den Almennyttige Andelskasse	0	897148
Middelfart Sparekasse	8163	3497839
Midtfjord, Sparekassen	4078	432511
Morsø Bank, Aktieselskabet	0	3497517
Morsø Sparekasse	0	6662928
Møns Bank, A/S	0	906893
Nordea Bank Danmark A/S	91240777	257442472
Nordfyns Bank, Aktieselskabet	0	1313890
Nordjyske Bank A/S	10238	5690478
Nr. Nebel og Omegn, Sparekassen for	12388	1100118
Nykredit Bank A/S	24598643	50218051
Nørresundby Bank, A/S	0	7088786
Pen-Sam Bank A/S	5000	778779
Ringkjøbing Landbobank, Aktieselskab	0	13897101
Roskilde Bank A/S	0	20456598
Salling Bank A/S	0	1406877
Sammenslutningen Danske Andelskasser	0	9877994

Saxo Bank A/S	0	109503
Sjælland, Sparekassen	0	8305220
Skals, Sparekassen i	2840	1096581
Skandinaviska Enskilda Banken A/S	0	757472
Skjern Bank, Aktieselskabet	0	3770131
Skælskør Bank Aktieselskab	0	1897755
Spar Nord Bank A/S	0	44153113
Spar Salling Sparekasse	2994	1069580
Sparbank A/S	92208	12997436
Svendborg Sparekasse A/S	0	1835001
Sydbank A/S	13282129	82306265
Thy, Sparekassen	0	3381019
Totalbanken A/S	10257	1930804
Tønder Bank A/S	0	1662010
Vendsyssel, Sparekassen	33861	5700624
Vestfyns Bank A/S	0	1237762
Vestjysk Bank A/S	0	24069237
Vinderup Bank, A/S	0	264101
Vorbasse-Hejnsvig Sparekasse	14734	742458
Vordingborg Bank A/S	0	721462
Østjydsk Bank A/S	0	4343472
Østjylland, Sparekassen	47305	4811128
Aarhus Lokalbank Aktieselskab	0	3712604

Table A2. Group 4, smallest banks, 1.000 Kr. Danish FSA, 2008

Name of the bank	**AS0204**	**AS0205**
"Den lille Bikube", Sparekassen	0	61710
Agri-Egens Sparekasse	0	41608
Arts Herred, Sparekassen for	0	57917
Boddum-Ydby Sparekasse	0	103634
Borbjerg Sparekasse	0	110874
Brenderup, J.A.K. Andelskassen	1949	0
Ebeltoft, Andelskassen J.A.K.	0	27785
Faster Andelskasse	0	120471
Fjaltring-Trans Sparekasse	0	6478
Flemløse Sparekasse	0	102499
Fruering-Vitved Sparekasse	0	29932
Funder Fælleskasse Andelskasse	0	16995
Helgenæs Sparekasse	0	25815
Hunstrup-Østerild Sparekasse	2375	99634
Klim Sparekasse	0	160798
Kongsted Sparekasse	0	139576
Københavns Andelskasse	0	102962
Leasing Fyn & Factoring Bankaktieselskab	0	172419
Lunde-Kvong Andelskasse	0	65484
Midtdjurs, Sparekassen	0	48028
OIKOS, Andelskassen	35589	0

Refsnæs Sparekasse	0	11108
Rise Spare- og Lånekasse	5266	140062
Ryslinge Andelskasse	0	74892
Rønde og Omegns Sparekasse	0	138202
Slagelse, Andelskassen J.A.K.	0	215627
Stadil Sogns Spare- og Lånekasse	0	32374
Søby-Skader-Halling Spare- og Lånekasse	0	89325
Sønderhå-Hørsted Sparekasse	0	169927
Thisted Andelskasse	16903	0
Tved Sparekasse	1187	118367
Ulfborg Sparekasse	0	2872
Varde, J.A.K. Andelskassen	16203	0
Vistoft Sparekasse	0	97810
Vokslev Sogns Spare- og Laanekasse	12201	0
Ø. Brønderslev Sparekasse	0	204755
Østervraa, J.A.K. Andelskasse	0	59908

Table A3. Faroese Banks, 1.000 Kr. Danish FSA, 2008

KORTNAVN	**FB0204**
Føroya Banki P/F	7746820
Nordoya Sparikassi	1858858
Suduroyar Sparikassi P/F	434149