Could stronger capital requirements have negative effects on the Finnish economy?

Estimating the impact of implementing Basel III

Åbo Akademi University

Alexandra Granlund

Master's Thesis in Economics

Supervisor: Eva Österbacka

Åbo Akademi University

Faculty of Social Sciences, Business and Economics

2020

Åbo Akademi University – Faculty of Social Sciences, Business and Economics

Abstract for master's thesis

Subject: Economics	
Author: Alexandra Granlund	
Title: Could stronger capital requirements have negative effects on the Finnish economy? Estimating the impact of implementing Basel III	
Supervisor: Eva Österbacka	

Abstract:

The purpose of this thesis is to examine the macroeconomic effects of implementing the Basel III capital requirements in the Finnish economy, to conclude whether the effects could be different from what the Basel committee estimates in their long-term economic impact study (BCBS, 2010). The thesis applies the theoretical framework of optimal bank capital from the BCBS 2010 report, to increase the comparability of the results.

The cost of increasing the bank capital requirements in Finland is estimated using a dynamic stochastic general equilibrium (DSGE) model created by the Bank of Finland (Suomen Pankki). The model, named Aino 2.0, features a complex banking sector with bank capital requirements, making it possible to impose shocks directly to the requirements. The benefit of increasing the bank capital requirements in Finland cannot be estimated using the same DSGE model; instead, the analysis is conducted as a literature overview.

The results of the macroprudential policy simulations imply that the output drag could be smaller in Finland than the BCBS (2010) average. However, the small output drag could partly be explained by the lack of household debt in the Aino 2.0 model. The literature overview implies that the reduced crisis probability might be smaller in Finland than the BCBS (2010) average, because of the low risk profile and loan losses of the Finnish banking sector. However, the high levels of systemic risk in the Finnish economy suggest that the cost of crisis could be much larger than the BCBS (2010) average.

All in all, it is difficult to conclude the optimal level of bank capital in Finland without any exact estimates of the benefit of bank capital. Nevertheless, the results of this study suggest that there is still room to strengthen the bank capital requirements in Finland, from the Basel II level.

Keywords: Bank capital requirements, Basel III, optimal bank capital, DSGE modeling

Date: 22.04.2020	Number of pages: 77

Table of Contents

Åbo Akademi University – Faculty of Social Sciences, Business and Economics i

Abstract for master's thesis i

1. Introduction 1

1.1. Disposition 3

2. Background and literature overview 3

2.1. Modern banking 4

2.2. Risk in the banking industry 7

2.3. A history of bank regulation 9

2.4. Basel III and the post-crisis reforms 12

2.5. The costs and benefits of stronger capital requirements 15

2.5.1. The BCBS's long-term economic impact study 16

2.5.2. Results from recent literature 18

3. Theory and methodology 21

3.1. The Finnish banking sector 22

3.2. The DSGE modeling method 26

3.3. Aino 2.0 – A DSGE model of the Finnish economy 29

3.3.1. The real side of the economy 29

3.3.2. The financial side of the economy 32

3.3.3. Calibration and structural parameter values 35

3.3.4. Simulating an exogenous shock to the bank capital requirements 37

4. Results 39

4.1. Simulation one: raising the capital requirements from 8% to 9% 39

4.2. Simulation two: raising the capital requirements from 8% to 13% 42

4.3. Simulation three: Raising the capital requirements from 13% to 14% 44

4.4. Response to unexpected loan losses at different capital levels 46

4.4.1. Simulation four: initial level of bank capital: 8% 47

4.4.2. Simulation five: initial level of bank capital: 13% 49

5. Analysis 51

5.1. The costs of increasing the bank capital requirements in Finland 52

5.2. The benefits of increasing the bank capital requirements in Finland 54

6. Discussion 58

6.1. Peer comparison 58

6.2. Optimal bank capital in Finland 61
6.3. Critique of the theoretical framework..63
7. Conclusions 64
8. Swedish summary – Svensk sammanfattning 66
References 71

1. Introduction

The overall capital requirements for the banking sector will increase as a result of implementing the Basel Committee of Banking Supervision's (BCBS) latest accord Basel III (sometimes referred to as Basel IV[1])[2]. Basel III has been a reaction to the financial crisis of 2008, after which the current norms for bank regulation received harsh criticism. The accord aims to increase bank resilience in times of economic instability. Larger reserves of bank capital are thought to decrease the risk of bankruptcy because of unexpected losses due to negative macroeconomic shocks. The previous framework, Basel II, was built on the idea that the capital requirements should reflect the risk profile of the individual bank. The banks could estimate their risk exposure using internal models, which then became the basis for the capital requirement. The BCBS now believe that the internal ratings-based approach is somewhat unreliable, due to unexplained variations in the calculations. Thus, Basel III is a step away from self-regulation by banks and a step towards standardization of the capital framework. (BCBS, 2017b)

The Nordic (Swedish, Finnish and Danish) and the Dutch banking associations came forward with a joint position statement in 2016 regarding Basel III. In the statement, the banking associations express their concerns regarding the new regulations, namely, that they might be unsuited for the Nordic and Dutch markets. They emphasize that the banks in these areas generally have a low-risk profile (low exposure), which results in low capital requirements based on the internal ratings-based approach. If the capital requirements become more standardized and less dependent on the risk profile of the individual bank, there is a risk that the overall capital ratio will be unreasonably high. Another feature of the Nordic (and Dutch) banking sector is that the banks provide most of the credit in the economy. The banking associations argue that the new capital requirements might have unwanted macroeconomic effects due to the decrease in

[1] The Basel III accord has been edited several times and the latest editions (essentially the enhanced focus on standardization of the capital requirements) is often referred to as Basel IV. However, this thesis refers to the complete accord as "Basel III" and the phrase "Basel IV" will not be used.
[2] The paper *Reform of Bank Capital Regulation Enters Final Phase* (2016) written by Tuulia Asplund, senior economist at the Bank of Finland, summarizes the new capital requirements that will be implemented in Finland. This will also be discussed more thoroughly in chapter 2.4.

access to credit in the economy. It is important to note that the banking associations represent the commercial banks. They might be motivated to criticize the regulatory framework for different reasons than say, the national regulatory authorities.

Since the regulations stipulated by the BCBS play an important part in how extensive the next global financial crisis will be, it is of utmost importance that the regulations have the desired effect. The BCBS believes that the benefits of strengthening the capital requirements will outweigh the costs (BCBS, 2010). However, if the Nordic banking markets are low risk in comparison to other regions, the same may not apply here. Even though harmonization is essential for stabilizing the global banking market, it is still important to consider regional differences when formulating the standards. This thesis examines what macroeconomic effects the implementation of the renewed capital requirements according to Basel III might have in the Finnish economy. To assess whether the concerns of the Nordic banking associations are justified, the following question is asked: Could stronger capital requirements have negative effects on the Finnish economy?

The BCBS published an analysis regarding the possible impact of Basel III in their 2010 report: "An assessment of the long-term economic impact of stronger capital and liquidity requirements". Also, they released a brief literature review on the costs and benefits of bank capital in 2019. Other researchers have also asked themselves similar questions, *e.g.* Firestone, Lorenc and Ranish (2017), Brooke et al. (2015) and Miles, Yang and Marcheggiano (2013). The Swedish national bank (Sveriges riksbank) published a prognosis in 2017, which is especially interesting since the Nordic economies are similar in many ways (Almenberg et. al., 2017). In most of the studies, the researchers conclude that there is still room to raise the capital requirements from the Basel II level. However, the results are varying and dependent on assumptions about the analyzed economy. No one has yet conducted a similar analysis of the Finnish economy, which is why such a study would be necessary.

The 2010 BCBS report presents a theoretical framework for estimating the optimal bank capital level in an economy. This framework compares the assumed benefits of bank capital (a lower probability of banking crises) to the assumed costs of bank capital (the negative effects of higher loan spreads on GDP). Quantifying the net benefits of bank capital has proven to be a tedious task. In the literature, the costs of higher capital requirements are usually estimated using structural models, such as DSGE (dynamic stochastic general equilibrium) models, whereas the benefits must be estimated separately.

The Bank of Finland (Suomen Pankki) has constructed a DSGE model called Aino that they use for long-term prognosis. The latest version of the model, Aino 2.0, was published online in 2016 (Kilponen, Orjasniemi, Ripatti & Verona, 2016). Aino 2.0 is a small, open-economy model, calibrated using Finnish time-series data from 1995-2014. Aino 2.0 features a complex banking sector with bank capital requirements, making it possible to impose shocks directly to the requirements. This thesis will use the Aino 2.0 model to estimate the impact of said shocks on key variables such as consumption, investments and total output, thereby determining the costs of increasing the bank capital requirements in Finland. The results will be discussed in light of the assumed benefits of bank capital in Finland. Thus, the theoretical framework of optimal bank capital is roughly applied. With this, the goal of the thesis is to give guidance to regulatory authorities as to what impact international macroprudential policies might have on the economy of a small country like Finland.

1.1. Disposition

Chapter two provides some background regarding the risks of modern banking and explains the essence of the Basel III accord. Furthermore, the theoretical framework of optimal bank capital is presented, alongside a literature overview of studies that apply said framework. Chapter three describes the Finnish banking sector, the DSGE modeling method and more specifically, the Aino 2.0 model. Chapter four is dedicated to presenting the results of the macroprudential policy simulations performed using the Aino 2.0 model. Chapter five presents an analysis of the costs and benefits of bank capital in Finland based on the results from the simulations. Chapter six further discusses the results in relation to peer studies and the theoretical framework of optimal bank capital. Finally, chapter seven concludes.

2. Background and literature overview

Chapter 2.1 and 2.2 introduce modern banking and explain why risks arise within the banking industry. Chapter 2.3 and 2.4 proceed by summarizing the history of banking regulation and the latest international regulatory accord, Basel III. Lastly, chapter 2.5

outline the literature concerning the costs and benefits of raising the capital requirements and address empirical results in the matter.

2.1. Modern banking

The business of banking has a long history. There have been agents in the economy handing out loans of different kinds for ages. Nevertheless, the history of modern banking is much shorter. Modern banking was born with the Industrial Revolution and the rise of capitalism. The banking sector created money through fractional reserve banking to still the need for an ever-growing global economy. Since then, credit has become an essential part of the economic progress of a country. Today, banks are at the heart of our economic system.

The core purpose of a modern bank is to function as a financial intermediary. Freixas and Rochet (2008, p. 15) define a financial intermediary as an economic agent who buys and sells financial claims. Brokers and dealers are another example of financial intermediaries. However, these agents deal with stocks, bonds and other financial instruments, which are classified as financial securities. The loans and deposits that banks primarily deal with are financial contracts. Because of the nature of the claim, it is possible to trade financial securities to a greater extent than financial contacts. (Freixas and Rochet, 2008, p. 15) To separate a bank's activities from the rest of the financial intermediaries, Freixas and Rochet (2008, p. 1) use the same definition as regulatory authorities: "a bank is an institution whose current operations consist of granting loans and receiving deposits from the public".

At the most basic level, a bank generates profit by charging borrowers a higher interest rate than what it pays to depositors. Thus, the bank's revenue is the interest margin between these two rates. In the modern banking industry, this description fits the commercial banking activities of a bank. However, the banks usually engage in many different forms of profit-making activities. For example, investment banking deals with financial aid for companies, such as helping them raise debt or equity and giving advice on mergers and acquisitions. Large banks usually also engage in some trading activities. Commercial banking can be further divided into retail banking and wholesale banking. Retail banking refers to affairs with individuals or small companies, whereas wholesale banking involves dealing with larger corporate customers and financial institutions. (Hull, 2018, pp. 25-26) In addition, there is a monetary authority controlling the banking market and conducting monetary policy, a central bank. The central bank acts as a banker to the commercial banks, thereby controlling interest rates and money supply. The main purpose of the central bank is to ensure price stability and preserve the value of the currency. Somashekar (2009, pp. 27-28)

To illustrate the balance sheet of a bank, Hull (2018, p. 28) presents a model of a small retail bank:

ASSETS	$ millions	LIABILITIES	$ millions
Cash	5	Deposits	90
Marketable securities	10	Subordinated Long-term Debt	5
Loans	80	Equity Capital	5
Fixed Assets	5		
Total	100		100

From the bank's perspective, loans granted to customers are assets, whereas deposits owed to customers are liabilities. Out of the bank's total assets of $100 million, $80 million consists of loans. Furthermore, the bank has $15 million in cash and cash equivalents, and $5 million in fixed assets (*e.g.* buildings or equipment). Ninety percent of the liabilities of this bank consists of debt in terms of deposits. The capital of the bank is composed of $5 million in subordinated long-term debt[3] and another $5 million in shareholder equity. If a bank would conduct both traditional banking activities and trading activities, these would be reported separately in what is known as the banking book and the trading book (Hull, 2018, pp. 38-40).

Commercial banks function as creators of credit in the economy. New loans can be granted if the value of the bank's deposits increase. However, a bank is only obliged to cover a small fraction of its deposits by actual cash holdings. Consequently, a one-unit increase in deposits, increase the bank's ability to grant credit multiple times that unit. This system is called fractional reserve banking and is the reason why the system of banking itself fuels economic expansion. Somashekar (2009, pp. 16-18) gives an example of how fractional reserve banking works in practice. If the fraction of deposits that banks must keep as a reserve is 10% and a customer deposits $1000 in bank A, then bank A can grant a loan of $900 to another customer. The second customer, X,

[3] Subordinated debt is a midway between equity and debt. It is issued like debt (bonds), but it is subordinated to regular deposits in case of liquidation.

might use this money to purchase something from Y. Y then proceeds to deposit his 900$ in bank B, which now can grant yet another customer a loan of $810. In theory, the process of credit expansion continues until the sum is too small to have an impact.

How big the reserves should be, or what the capital requirements are, is decided by the monetary authorities of a country. The size of the reserves has implications on how extensive the credit expansion process will be. If the required capital ratio is 10%, the increase in credit compared to the original deposit is tenfold. The formula to calculate the credit multiplier, K, is 1/r, where r is the capital requirement. If the banking system loses cash, the process is reversed. Consequently, the fractional reserve system should be reviewed in a state of balance between new deposits and withdrawals. Somashekar (2009, pp. 16-18)

Freixas and Rochet (2008, pp. 2-7) discuss some further functions of commercial banks in the economy from the perspective of contemporary banking theory. Firstly, the banks facilitate transactions between economic agents by offering payment and currency exchange services. These services make it possible to quickly and safely transfer funds between bank accounts and, thereby, undergo otherwise costly transactions. Secondly, the banks transform assets to meet the needs of the borrowers and depositors. For example, when a bank combines deposits with short maturity to create a mortgage loan with long maturity, they have transformed both the unit and the maturity of the assets. Additionally, the bank could offer small depositors a better risk-return relationship than they would acquire through direct investment. Hence, transforming the quality of the asset. Furthermore, the banks manage the risks that arise with the activities mentioned above. The next chapter will deal with these risks more thoroughly. Lastly, banks have a better starting position for handling the problems caused by imperfect information on the credit market. They can screen loan applicants using information technologies and, thereby, reduce the impact of moral hazard. Both Freixas and Rochet (2008, p. 7) and Somashekar (2009, p. 24) emphasize that the banking sector affects the development of the entire economy, by facilitating important investments and economic growth.

Today’s large banks are operating internationally, on a market that is becoming more global by the day. The Governor of the Bank of Finland, Olli Rehn, held a speech about current developments in the banking industry at the Financial Times Middle East

Banking Forum in Dubai in 2018. He highlights three major forces that will challenge the practice of banking in the future: digital technology, bank resilience and climate change. Currently, innovation is spiking in the banking sector due to fintech, or financial services technologies. Banks are embracing new technologies, such as open-source software, to improve payment services and the overall customer experience. The second force, which is also the theme of this thesis, is the process of increasing bank resilience by improving the regulatory frameworks. This has been on the agenda since the financial crisis of 2008. Lastly, the banking industry, like so many other industries, will be affected by climate change. According to Rehn, climate change is the largest market failure of all times. Banks will have to adjust their business model to both changes in policies and the real economy. (Rehn, 2018)

2.2. Risk in the banking industry

The fractional reserve system is based on the idea that the depositors will have no desire to withdraw their funds simultaneously. Thus, the banks are dependent on the confidence of the public. A breach of the public's trust might result in a bank run, which could force the bank into a liquidity crisis or even bankruptcy. Moreover, banks are often in business with each other and can experience great losses if another bank goes bankrupt. The public is aware of this; however, they have no way of knowing how much each bank is affected. The breach of trust might spread to other banks, and in the worst-case scenario: to the whole credit system. This is what happened in the United States during the financial crisis of 2008. The risk of such an event is called systemic risk. (Hull, 2018, pp. 347-349; Bodie, Kane & Marcus, 2018, p. 458) Since the financial markets of today are becoming increasingly global, the systemic effects could reach almost anywhere. Governments often bail out troubled banks to avoid the social cost of a systemic crisis. The American Emergency Economic Stabilization Act of $700 billion in 2008[4] and the even larger bank bailouts in Europe in the following years, were all attempts to restore faith in the credit market after the crisis.

Regulatory authorities usually define the most important risks facing banks as credit risk, operational risk and market risk (see *e.g.* BCBS, 2017b). Credit risk is especially relevant for banks since it relates to the core profitmaking activity of the bank. It is the risk that the counterparty of a transaction will default. The most common example

[4] More about the $700 billion bail-out in Muolo (2008).

would be borrowers that are unable to repay their loans. (Freixas & Rochet, 2008, p. 42) The exposure to credit risk stems from three different sources: on-balance sheet assets (excl. derivatives), off-balance sheet items (excl. derivatives) and over-the-counter (OTC) derivatives. On-balance sheet assets refer to the typical assets on a bank's balance sheet, *e.g.* cash, loans to corporations or governments and residential mortgages. Off-balance sheet items are assets or liabilities which have not yet been recorded on the balance sheet, *e.g.* banker's acceptances and loan commitments[5]. An example of OTC derivatives could be interest rate swaps or forward contracts. (Hull, 2019, pp. 350-351)

Operational risk is the risk of incurring losses due to mistakes within the organization or some external event. Mistakes could be caused by faults in the internal systems, but also by the people of the organization. Even though credit risk may be considered the greatest risk of the banking industry, operational risk has caught the spotlight in more recent days. There are many examples of large financial institutions that have suffered severe losses due to operational failure. One example would be Société Générale, which lost $7.2 billion in 2008 due to the actions of a rogue trader. (Chernobai, Jorion & Yu, 2011)

Market risk is the risk associated with the trading book of the bank. The market prices of the traded assets are in constant movement, and it is sometimes difficult to foresee the steep turns of the market. The trading book may include everything from complex derivatives to stocks, bonds and currencies. Changes in commodity prices, equity prices, exchange rates, interest rates, and credit spreads[6] will influence the market price of these assets. (BCBS, 2019b) Furthermore, the fact that there is an imbalance between the assets and the liabilities in the bank's balance sheet is a cause for both interest rate risk and liquidity risk. The long-term assets (the loans) are more sensitive towards interest rate changes than the short-term funding (deposits or *e.g.* commercial paper) and the marketability of the claims used for short-term funding is more sensitive towards breaches in public confidence. (Freixas & Rochet, 2008, pp. 5-6)

[5] A banker's acceptance is a guarantee that the bank will go through with a specified payment at a future date. Similarly, a loan commitment is guarantee that the bank will offer a specified loan to a borrower at a future date. (LaRoche, 1993)

[6] The credit spread is the additional interest rate that investors demand for holding a specific credit risk. For example, the bond yield spread is the additional interest required on corporate bond over similar, risk-free government bonds.

A bank will not be able to completely avoid sustaining losses due to the risks mentioned above. Therefore, capital reserves are important to circumvent a liquidity crisis. The question is how large these capital reserves should be. If the bank could decide on its own, governments and monetary authorities fear that they would acquire too much risk. Especially since governments in many countries provide banks with deposit insurance, thereby transferring some of the banks' risks onto their balance sheets (Hull 2019, pp. 30-31). As a result, regulatory authorities, such as the Basel Committee on Banking Supervision, have been established to formulate regulations which will enable economic growth while keeping the risks associated with banking at a reasonable level. The following chapter will explain the foundation of the capital requirements according to the Basel accords.

2.3. A history of bank regulation

Before the 1980s, every country had its own standards for banking supervision. It was common that the national authorities regulated the capital levels of the banks by requiring them to keep a specific capital-to-assets ratio. However, as the financial markets were advancing due to technological and financial innovations and were no longer bound by country borders, the need for internationally viable frameworks for banking supervision emerged. In 1974, the central bank Governors of the Group of Ten countries (G10)[7], established the Basel Committee on Banking Supervision (BCBS) to formulate global standards for banking regulation. The committee's first meeting was held at the Bank for International Settlements (BIS)[8] in Basel, Switzerland, where it still has its headquarters. Today, the BCBS is "[…] the primary global standard-setter for the prudential regulation of banks […]" and has 45 member institutions from 28 jurisdictions, according to the webpage of BIS. (BIS, 2019a)

The initial focus of the BCBS was to standardize the quality of banking supervision worldwide, thus, preventing international banks from escaping supervision by establishing branches in less regulated countries. Subsequently, the BCBS shifted its focus to capital adequacy following the Latin American debt crisis in the early 1980s.

[7] The member countries of the G10 are Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States.

[8] The Bank for International Settlements is the oldest international financial institution, founded in 1930 at the Hague Conference. Today, BIS works for global monetary and financial stability and advises central banks all over the world. (BIS, 2019b)

The crisis highlighted a previous concern of the BCBS: large banks kept decreasing their capital reserves while risks were growing on an international level. In 1988, BCBS published the Basel Accord (now Basel I), the first-ever international agreement regarding banking regulation. The accord introduced a minimum capital requirement for credit risk that applied to all internationally active banks (regardless of membership in the BCBS). From 1992 onwards, banks had to keep capital reserves corresponding to a ratio of 8% of their risk-weighted assets (RWA). This ratio is called the Cooke ratio, an innovation that constituted the foundation of Basel I. (BIS, 2019a)

The calculation of RWA is a method of estimating the bank's total exposure to credit risk. It includes both on- and off-balance sheet assets and OTC derivatives. Assets are weighted based on the level of credit risk so that riskier assets are assigned bigger weights. Risk-free assets, such as cash and government bonds[9], have a weight of zero (meaning they do not contribute to the capital reserve). For example, corporate loans are considered the riskiest and therefore have a weight of 100%, residential mortgages have a weight of 50%, and loans to banks and other financial institutions[10] have a weight of 20%. Ultimately, the calculation of RWA results in higher capital requirements for banks that hold a large portion of risky assets. (Hull 2019, pp. 347-353)

In Basel I, capital is classified as either Tier 1 capital or Tier 2 capital. Tier 1 capital includes equity and capital instruments that do not have a fixed maturity date[11], less goodwill. This is the most important form of capital since there is no obligation to repay the investors. Hence, it can be used to cover losses. Tier 2 capital includes instruments with the characteristics of subordinated debt. This capital is helpful as an additional safety measure for depositors since the repayments are subordinated to repayments of deposits. According to Basel I, 50% of the capital reserves must be Tier 1 capital (and 50% of this capital must be common stock). (Hull 2019, pp. 352-353)

---

[9] To be considered risk free, the government bonds should have been issued by countries with next to zero default risk, such as members of the Organisation for Economic Co-operation and Development (OECD).

[10] This level of risk only applies to financial institutions in OECD countries.

[11] An example of such an instrument is noncumulative perpetual preferred stock, which is a stock with predetermined dividends. Noncumulative implicates the dividends are lost if the company is unable to pay dividends one period. In this sense, the instrument is similar to equity. On the contrary, a cumulative perpetual preferred stock is defined as Tier 2 capital, since the dividends, in this case, are accumulated as a future obligation for the company.

The first version of Basel I was too incomprehensive since it only addressed credit risk. In 1996, the BCBS attempted to improve the accord by issuing an amendment that covered market risk. Market risk is usually estimated using quantitative models that apply historical simulations or Monte Carlo simulations[12] to estimate a loss probability density function, such as the Value-at-Risk (VaR) model. The VaR-model estimates the maximum trading book loss a bank could be expected to incur over the next period (commonly ten days), with a certainty of 99% (Hull 2019, p. 357). The BCBS allowed large banks to estimate their market risk exposure using VaR-models, thus, introducing internal models into the calculation of capital requirements. (BIS, 2019a) Smaller banks that did not have the resources to perform these quantitative calculations were presented with a standardized approach. Within the standardized approach, capital was allocated to each instrument in the trading book separately. It is worth mentioning that the internal model-based approach could result in lower capital requirements, since the models, as they were more complex, considered diversification benefits (by including correlations between different instruments). (Hull 2019, p. 357) After the 1996 Amendment, the minimum capital requirement was defined as follows:

$$Total\ capital = 0.08 * (credit\ risk\ RWA + market\ risk\ RWA) \quad (1)$$

The BCBS continued perfecting their first accord and in 1999 they released new standards now known as Basel II. This time, the committee had re-assessed the calculation of the capital requirement for the banking book. The standardized approach from Basel I was improved so that loans to corporations, financial institutions and countries now would be weighted according to their credit rating. Credit ratings are given by credit rating agencies, such as Moody's and Standard & Poor's (S&P) and indicate the solvency of the debtholder. A loan to an institution with a good rating (AAA to BBB-) was given a low weight (less than 100%), and a loan to an institution with a bad rating (less than BBB-) was given a high weight (from 100% to 150%). The BCBS also introduced the possibility for the banks to calculate their banking book VaR by applying an internal rating-based (IRB) approach, in the spirit of the 1996

[12] Monte Carlo simulations are used to estimate the probability distribution of a variable using a random number generator. Arguably, this method offers a more reliable outcome than historical distributions, which assume that the future can be predicted by the past alone. (Liyanage, Fernando, Arachchi, Karunathilaka & Perera, 2017).

Amendment[13]. (Hull 2019, pp. 359-370) In addition, Basel II introduced capital requirements for operational risk, so that the total capital now would be:

$$Total\ capital = 0.08 * (credit\ risk\ RWA + market\ risk\ RWA + operational\ risk\ RWA) \quad (2)$$

2.4. Basel III and the post-crisis reforms

Basel II received a great deal of criticism after the financial crisis in 2008. Some even argued that poor regulations worsened the crisis. The IRB approach was especially criticized for relying too much on models with questionable assumptions[14] and letting the banks calculate their own need for regulatory capital. Furthermore, empirical analysis has shown that there is unexplained variability in the RWA of different banks (BIS 2019a). Immediately after the crisis, the BCBS started working on renewing the standards. They began with the framework for market risk.

The IRB approach for calculating the market risk VaR, contained two major flaws. Firstly, the models were often based on historical simulations that could not forecast situations of financial turmoil. Secondly, the same instruments could give lower capital requirements if they were placed in the trading book instead of the banking book. Consequently, the models used in the internal calculations were improved and a floor was introduced so that the overall capital requirement for market risk rose. These changes are now known as Basel II.5 and they were to be implemented by 2011. Of course, the work of the BCBS was not yet done. The committee felt that it was necessary to conduct a fundamental review of the whole framework for capital requirements to increase the banks' equity capital reserves even further. In 2009, the BCBS proposed a new accord, Basel III. After discussing with banks and conducting a comprehensive quantitative impact study (which will be discussed in the following chapter), the accord was released in 2010. (Hull 2019, pp. 377-381) The document that presents the initial standards included in Basel III is titled: "Basel III: A global regulatory framework for more resilient banks and banking systems" (BCBS, 2011).

[13] The Basel II IRB approach is divided into the foundation and the advanced IRB approach, which the banks can apply as per their abilities. An explanation of how to calculate the banking book VaR according to the IRB approach can be found in Hull 2019, pp. 363-369.

[14] Nocera (2019) and Salmon (2012) summarize the criticism directed at the quantitative models. Nassim Taleb is another famous critic of the quantitative measurements of risk.

This chapter will summarize the most important changes to the framework and how Basel III will impact the legislation in Finland.

An important part of Basel III was to redefine bank capital in order to enhance the role of common equity. Common equity, which essentially consists of share capital and retained earnings, is now the only capital that can be classified as Tier 1[15]. Capital instruments that do not have a fixed maturity date, which were previously included in Tier 1, are now classified as additional Tier1, or AT1 capital. Out of the total minimum capital requirement of 8%, 6% of the total RWA must be Tier 1 or AT1 capital. Additionally, 4.5% of the total RWA must be purely Tier 1 capital. Furthermore, Basel III introduced an additional capital conservation buffer of 2.5% of the total RWA, consisting of Tier 1 capital. The idea is that banks should accumulate capital when the market is stable, which can then be used to cover losses during financially difficult times. The banks' dividend payments will be restricted if the capital conservation buffer is below 2.5% of the total RWA. The BCBS also added a countercyclical buffer of Tier 1 capital, with the same supporting effect as the conservation buffer. The level of the countercyclical buffer is decided by the national authorities and can range from 0% to 2.5%[16].

All the capital requirements above are calculated as a percentage of RWA. To make sure that the measurement of RWA does not paint the wrong picture of the banks' risk profile, the BCBS introduced another requirement which is based on the total exposure of a bank's leverage. In addition to satisfying the capital requirements based on RWA, the bank must also keep Tier 1 capital corresponding to 3% of total exposure (non-risk-weighted). (BCBS, 2011) Yet another capital requirement introduced within the framework of Basel III is an additional buffer for global systemically important banks. The capital ratio ranges from 1% to 3.5% of RWA depending on how important the bank is. National authorities may also give extra requirements to banks that they deem to be domestic systemically important. The details of this agreement can be found in a BCBS document, titled: "Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement". (BCBS, 2013a)

[15] Since Tier 1 capital consists of common equity it is sometimes called Common Equity Tier 1 or CET1.

[16] Authorities should follow leading indicators, *e.g.* credit growth, and adjust the countercyclical buffer thereafter.

Except for the general increase in the capital requirements, Basel III is also a step away from self-regulation by banks and a step towards standardization. At the end of 2017, the BCBS reported that from 2022 onwards, all the capital requirements would depend less on the IRB approach and more on a revised standardized approach. The revision of the standardized approach, as well as a summary of the final version of Basel III, can be found in the document "Basel III: Finalising post-crisis reforms". The revised standardized approach would function as a basis for an output floor, reducing the role of risk-based capital requirements. By January 2022, the floor would be set at 50%. However, the goal is to gradually increase the floor, so that it would reach 72.5% by January 2027. In practice, the output floor works like this: if RWA calculated using the IRB approach is less than 50% of RWA calculated using the standardized approach, the bank will have to increase the value of its RWA until the gap is accounted for. (BCBS, 2017a) In connection with Basel III, the BCBS also released a comprehensive report in 2013 titled: "Fundamental review of the trading book: A revised market risk framework", that explains the revised framework for market risk in detail[17] (BCBS, 2013b).

Before the crisis, the BCBS had not properly addressed liquidity risk. After seeing how quickly Lehman Brothers' (among others) access to short-term funding dried up after they started experiencing trouble, the BCBS felt that there is a need to regulate how the banks fund their activities. Consequently, the committee introduced the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), to ensure the banks hold enough high-quality liquid assets and stable funds for financing activities. (BCBS, 2011)

The initial thought was that banks would have the opportunity to implement the changes that Basel III entailed between the years 2013 and 2019. However, the implementation of further revisions, introduced in the 2017 framework, had to be postponed until January 2022. (BCBS, 2017b) The European Union (EU) adopted Basel III in its own set of standards called the Capital Requirements Directive[18]. The implementation process started on the 1st of January 2014. As a member state of the

[17] Besides a revision of the models used in the internal calculations and the standardized approach, this framework also focuses on defining which instruments can be placed in the trading book and which cannot. Because of the ambiguity in the older accords, banks had begun placing instruments in the trading book for the sole purpose of achieving lower capital requirements.
[18]Capital Requirements Directive (2013/36/EU), also called CRD IV (European Commission, 2013).

EU, Finland followed by adopting the Capital Requirements Directive in the national legislation. (Asplund, 2019) Figure one below presents an illustration of the old and the new capital requirements that are relevant for the EU countries. The figure is based on calculations by the Bank of Finland and the stipulations of the European Commission. Essentially, the only capital requirement that is unimportant for the Finnish banking industry is the highest systemic risk buffer.

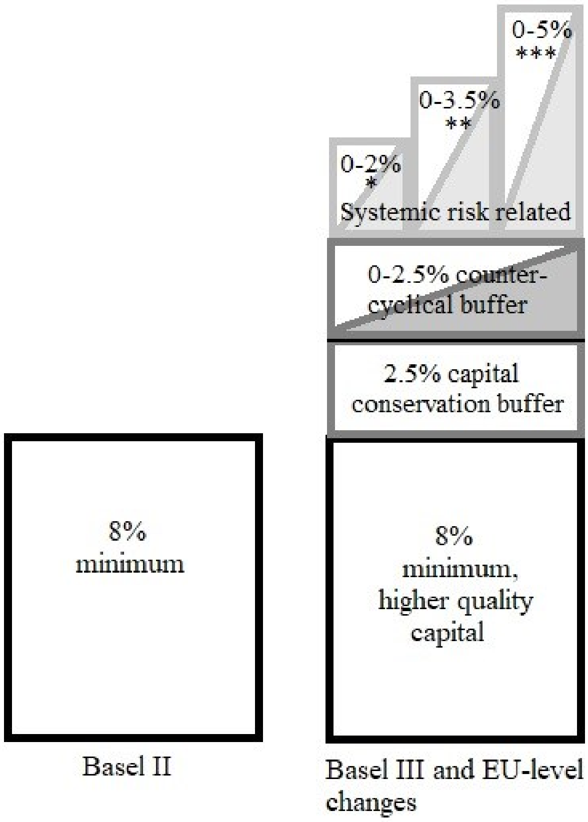


Figure 1. Old and new capital requirements for the banking sector in the EU

Note. All capital ratios are relative to risk-weighted assets. The highest requirement is in force as a rule.
*Additional capital requirement for global systemically important credit institutions.
** Additional capital requirement for domestic systemically important credit institutions.
*** Systemic risk buffer. This one is not relevant to Finland.
Source: European Commission and Bank of Finland in Asplund (2019)

2.5. The costs and benefits of stronger capital requirements

The expected benefits of stronger capital requirements become quite clear after considering the motivation behind Basel III: banks become more resilient to negative macroeconomic shocks. However, there are also costs of increasing the capital requirements. Since the BCBS has moved forward with Basel III, they must believe that the net benefits will be positive. Understanding how the committee came to this conclusion is essential when assessing if the same assumptions can be made about the Finnish economy. Consequently, this chapter will summarize the 2010 BCBS report: "An assessment of the long-term economic impact of stronger capital and liquidity requirements", which main goal was to evaluate whether there is still room to strengthen the capital requirements. Chapter 2.5.1 outlines the methodology used in the 2010 report and summarizes the results. Thereafter, chapter 2.5.2 compares the 2010 report to more recent literature in the field, *inter alia*, the BCBS's own 2019 revision.

2.5.1. The BCBS's long-term economic impact study

The 2010 BCBS report applies a theoretical framework that defines the economic costs and benefits of bank capital in order to analyze the net benefits of increasing the capital requirements[19]. The authors use averages of estimates from various studies as the basis for the comparison. They focus on long-term effects, meaning potential costs during the transition from one regulatory framework to another are disregarded. The capital of a bank is defined as the total holdings of tangible common equity to RWA (according to the Basel II definition), no distinction is made between the basic capital ratio of 8% and additional buffers.

The theoretical framework used in the BCBS 2010 report can be summarized as an equation, where the net benefits of bank capital depend on the reduced crisis probability when increasing the capital requirements times the discounted cost of that crisis, less an output drag[20]:

$$Net\ benefits = reduced\ crisis\ probability * crisis\ cost - output\ drag\ (loan\ speads) \tag{3}$$

The reduced probability of a banking crisis is seen as the benefit of bank capital. The theory proposes that higher levels of equity reduce the probability of crises since equity increases the banks' ability to recover from unexpected loan losses. The output drag is the negative effect that stronger capital requirements would have on total output or

[19] The theoretical framework can be compared to another method for estimating the optimal capital ratio of a bank: stress testing. Stress testing is a method for banks to test their capacity for handling different types of shocks.

[20] This expression was introduced in the 2019 BCBS revision, although it describes the theoretical framework of the 2010 report.

GDP. The theoretical explanation behind the output drag is that an increase in the capital requirements would raise the banks' cost of funding, since equity is more expensive than debt. The increased funding cost would then be passed on by the banks to the borrowers by raising the lending rates. The BCBS assumes that the cost would be passed on in full. This, in turn, would lower consumption and investments and, thereby, total output. The optimal bank capital ratio is the ratio where the marginal benefits and the marginal costs of bank capital are equal.

To quantify the benefits of bank capital one must start by estimating the discounted expected cost of a banking crisis. In the report, the BCBS reviews the estimates of several comparable econometric studies and concludes that the median cumulative output loss is 63% of pre-crisis GDP. This implies that a 1% decrease in the probability of a crisis yield benefits corresponding to about 0.6% of total output. The estimates are highly sensitive to whether the study assumes that the effects of the crisis are permanent or not. The estimated median output loss is only 19% among the studies that assume the effects are temporary, whereas the median is 158% among the studies that assume the effects are permanent.

The second step in the analysis would be to estimate the probability of a crisis occurring at different capital levels. This calculation is much more difficult, which is why the results from studies using both empirical models and simulations are considered. The empirical models use aggregate data to estimate the relationship between the occurrence of banking crises and different levels of banks' leverage (and other crisis indicators). The simulation models view the banking market as a portfolio of securities, making it possible to apply methodologies for portfolio theory and risk to calculate the effects of increasing the capital requirements. The results indicate that increasing the capital requirements does reduce the probability of banking crises. For example, increasing the capital ratio from 7% to 8% would lower the probability of crises with one third (from 4.6% to 3.0%). However, the effect is strictly decreasing[21]. (BCBS, 2010)

The common way to estimate the costs of stronger capital requirements is by using structural macroeconomic models, such as DSGE models, or semi-structural models. How the analysis is performed depends on the structure of the model. Some models

[21] Increasing the capital ratio from 12% to 13% would only lower the probability of a crisis with 0.2%.

have a more complex banking sector, making it possible to inflict changes to the bank capital directly. If this is not an option, one must first estimate the effect that stronger capital requirements have on the loan spreads, and then estimate the effect that changes in the loan spreads have on total output. The results of the BCBS report indicate that the loan spreads increase by 13 basis points[22], on average, for every percentage point increase in the capital ratio.[23] Furthermore, a one percentage point increase in the capital ratio is estimated to lower GDP by 0.09%[24].

The BCBS summarize their main results of the 2010 report in a graph, where the net benefits of reducing the probability of banking crises are shown relative to different levels of capital ratios. The results indicate that the net benefits are positive up to a capital ratio of approximately 13%, where they gradually start decreasing (to finally become negative). In other words, the BCBS predicts that the optimal capital ratio is 13%. The BCBS interprets the result as an indication that there is still room for strengthening the capital requirements. A huge disadvantage of the report is that it is based on many assumptions and generalizations. The BCBS state that the results may vary for different countries, and that this is just a general assessment to support the policy discussions. Consequently, it is necessary to also consider the results of other, less generalized, studies.

2.5.2. Results from recent literature

In 2019, the BCBS published a paper that revises the 2010 report by reviewing studies which have been released after the original assessment. Essentially, they come to the same conclusion as before. It is possible to strengthen the capital requirements from the Basel II level and still have positive net benefits. This paper even indicates that the 2010 report might have understated the net benefits of stronger capital requirements. The BCBS 2019 review includes an overview of the estimated optimal capital ratios of other later studies. Even though all the studies estimate higher optimal capital ratios than the Basel II level of 8%, there are still large variations in the results. The variations stem from differences in the assumptions made about the structure of the analyzed economy.

[22] A one basis point change translates to a 0.01% change.

[23] These results do not hold if the assumption that the cost of increased capital requirements is passed on to the customer in full is violated. The results are also sensitive to the bank's return on equity.

[24] Total output refers to total output in the modelled economy, it can be thought of as GDP.

A huge cause for variation in the estimates of the optimal capital ratio is the treatment of the cost of a banking crisis. The cost of a crisis can be accounted for in many ways. The 2010 BCBS report defines the cost of crisis purely as a reduction in GDP. Theoretically, it would be more accurate to also include social costs, such as political instability. However, the social costs are difficult to quantify. Furthermore, the results from the more recent studies are, as before, dependent on whether the effects are assumed to be permanent or not. (BCBS, 2019a) In an IMF[25] working paper, Chen, Mrkaic and Nabar (2019) analyses the global economic recovery after the financial crisis of 2008. Their findings indicate that the economic loss has been persistent in most parts of the world, regardless of whether the crisis hit the national economy directly or not. The main channels through which the negative effects manifested was decreasing growth of investments and total factor productivity compared to the pre-crisis trends. Structural factors and policy decisions mattered for the persistency of the negative effects. Naturally, countries with good fiscal positions and a flexible labor market managed better than countries with large deficits or rigidities. Moreover, countries with flexible policy rates recovered faster. The Euro-area managed worse than other industrialized economies, partly due to the absence of national policy rates and large sovereign debt. (Chen et al., 2019)

One estimate included in the 2019 BCBS review stands out from the others. This is an estimate for the Swedish economy, produced by the national bank of Sweden (Sveriges Riksbank). It indicates that the cost of a banking crisis in Sweden would be a cumulative output loss of 180% of pre-crisis GDP (*cf.* the BCBS 2010 average of 63%). The authors state that the estimate is higher than the international average because of the structure of the Swedish banking industry. The Swedish banks provide most of the credit in the economy, and the banking sector is very large (equivalent to 350% of GDP). In addition, the bond market is small, and mortgages are usually not securitized (*e.g.* as in the USA). Even though the banking sector is large, it is highly concentrated and consists mainly of four big banks. Hence, the bankruptcy of a bank would have huge systemic effects and the access to credit would immediately shrink. (Almenberg et al., 2017)

[25] International Monetary Fund

The assumption that an increased level of bank capital would reduce the probability of a banking crisis has been up for debate recently. Jorda, Richter, Schularick and Taylor (2018) perform an empirical analysis of a large historical dataset covering 17 OECD countries (including Finland) between the years 1870 and 2013, to estimate the relationship between bank capital and systemic risk. They find no evidence that higher levels of bank capital would reduce the probability of a banking crisis. However, their results indicate that countries with well-capitalized banks before the crisis recovered from the losses quicker. Therefore, the authors conclude that higher regulatory capital lowers the cost of crisis, while it cannot prevent the crisis itself. Regardless, most studies still assume that higher levels of bank capital reduce the probability of crisis to some extent.

The concept of the output drag, or cost of higher capital requirements, has also been a cause for dispute. The BCBS 2010 report assumes that equity is more expensive than debt and that higher capital requirements therefore will increase the banks' cost of funding. However, it might not be true that equity is, in fact, more expensive than debt. In their groundbreaking 1958 paper, Modigliani and Miller propose that the capital structure of a firm does not have any implication for the firms' value (or cost of capital). Intuitively, this means that if the debt to equity-ratio falls, equity becomes less risky and therefore cheaper, offsetting the increase in the funding cost. Consequently, if the MM-offset would be applied in full, the transition to a higher level of capitalization among banks would not affect their funding costs at all. The MM theorem is highly theoretical and does not hold in full when market rigidities (*e.g.* transaction costs, taxes, asymmetric information and default risk) are introduced. Because of this, few studies apply the MM-offset in full, while many estimate some MM-effects. For example, Miles et al. (2013) and Brooke et al. (2015), studying the UK, and Cline (2017) and Firestone et al. (2017), studying the US, all estimate that the MM-offset for banks would be just below 50%. Hence, it is reasonable to assume that the MM theorem is only partly true and an increase in the capital requirements would generally raise the banks' cost of funding[26].

The structural models used for estimating the cost of higher capital requirements on total output, or GDP, have become more advanced since the BCBS 2010 report was

[26] Almenberg et al. (2017) assumes zero MM-offset, just like BCBS (2010).

conducted. Especially in the sense that the banking sector has been developed in many of the models. Because of this, one would assume that later studies would produce more exact cost estimates. Firestone et al. (2017) still use the same two-step approach as the BCBS 2010 report, where they first establish the impact of higher regulatory capital on the lending rates and then estimate the impact of higher lending rates on GDP. Using the US Federal Reserve's large-scale macroeconomic model, they estimate that a one percentage point increase in the Tier 1 capital would lower GDP by 0.074% (assuming the higher lending cost is passed on in full[27]). Brooke et al. (2015) (Bank of England) estimates that the negative effect on GDP would range between 0.01% and 0.05% for the United Kingdom. Both these estimates are lower than the BCBS 2010 report's estimate of 0.09%. Contrary to this, Almenberg et al. (2017) estimate an average decline in GDP of 0.11% for Sweden. Almenberg et al. (2017) use two different models in their analysis: the DSGE model RAMSES, made by the Swedish national bank (Sveriges riksbank) and the DSGE model from Iacoviello (2015), calibrated to Swedish conditions. The RAMSES model does not feature bank capital; thus, the authors must apply the two-step approach. The Iacoviello (2015) model, however, does feature bank capital, making it possible to perform the analysis in one step. The decline in GDP is estimated to be 0.09% and 0.13% for the RAMSES and Iacoviello models respectively. Even though the Iacoviello (2015) model might be more suited for the study, Almenberg et al (2017) argue for the value of using a model designed for the Swedish economy.

3. Theory and methodology

The following chapter presents the methodology used to estimate the impact of implementing Basel III in the Finnish economy. First and foremost, a description of the structure of the Finnish banking sector is in order, since the Finnish banking sector is the empirical example of this study. This will be done in chapter 3.1. As was discussed in the previous chapter, the cost of raising the capital requirements can be estimated using structural macroeconomic DSGE models, which is also the method applied in this study. Consequently, the theory behind the DSGE modeling method is explained in chapter 3.2. Furthermore, chapter 3.3 explains the structure and

[27] The effect would only be 0.037% if the cost is passed on in half.

calibration of the DSGE model used in this study, Aino 2.0, as well as the method for imposing a shock to the bank capital requirements in the model.

3.1. The Finnish banking sector

The banking sector in Finland is highly concentrated, much like in the rest of the Nordic countries. According to the Herfindahl index, the Finnish banking sector has the highest level of concentration out of all the countries in the EU (Savolainen & Vauhkonen, 2015). The three biggest credit institutions hold approximately 80% of the corporate loan stock (market shares in parentheses): OP Financial Group (39.9%) Nordea (29.7%) and Danske Bank (9.1%). Out of the housing loan market, the shares are: OP Financial Group (39.6%), Nordea (28.6%) and Danske Bank (10.8%). The remaining market shares are divided among several credit institutions, *e.g.* Savings Bank Group, Aktia Bank and Handelsbanken. (Bank of Finland, 2019a)

The OP group consists of 153 independent member cooperative banks (Osuuspankki in Finnish, hence the abbreviation OP), operating in both cities and peripheral areas in Finland (OP Financial Group, 2019a). From the 2000s, the OP group is a financial group, providing everything from banking and investment to insurance services (OP Financial Group, 2019b). In 2018, the balance sheet of OP Financial Group was 140 billion Euros (Finance Finland, 2019). Nordea is a multinational financial group, operating in 20 different countries (Nordea, 2019). It is the largest financial group on the Nordic market, as well as the 20th largest in the world. In 2018, Nordea moved its headquarters from Sweden to Finland, a significant event considering the structure of the Finnish banking sector. The balance sheet of Nordea was 551 billion Euros in 2018. (Finance Finland, 2019) Lastly, Danske Bank is a Danish bank, large in the Nordic market and with some broader international activities (Danske Bank, 2019).

OP Financial Group and Nordea are domestic, systemically important institutions because they hold a large share of the Finnish credit market. Since 2016, these banks have been required to uphold a domestic systemic risk capital buffer of 2%. In 2019, the EU Capital Requirements Directive (CRD IV) imposed yet another systemic risk buffer. This time, the buffer was set at 3% for Nordea, because of its international position, 2% for OP Financial Group and 1% for the rest of the credit institutions in

Finland.[28] Nordea has been classified as a global systemically important bank before; however, as of 2018, Nordea no longer fits the criteria. Moreover, Nordea and OP Financial Group (as well as Municipality Finance) are under the direct supervision of the European Central Bank, whereas the rest of the Finnish banks are under the supervision of the Finnish Financial Supervisory Authority (FIN-FSA). (Finance Finland, 2019)

Savolainen and Tölö (2017), from the Bank of Finland, examine the strengths and weaknesses of the Nordic banking system using the American CAMELS (Capital adequacy, Asset quality, Management capability, Earnings, Liquidity, and Sensitivity to market risk) model. According to them, it is necessary to examine the structure of the whole Nordic banking market to assess the risk of the Finnish banking sector, since cross-border banking has a long history in the Nordic countries. The core capital ratios have been strengthened in the Nordic countries during the past decade, due to stronger requirements. Finland had the highest level of capital adequacy out of all the Nordic countries in 2016: the average core Tier 1 capital ratio was approximately 22%. In comparison, the same ratio was closer to 17% in Norway and Denmark. (Savolainen & Tölö, 2017) Today, Finland has a total capital adequacy ratio of 20.6%, a Tier 1 ratio of 18.4% and a CET1 ratio of 16.6% (Bank of Finland, 2019b). With the use of the Basel II internal rating-based approach, the average risk weights of assets in the Nordic countries have shifted downwards. In Finland, the average risk weights of assets were only about 25% in 2016. Norway had already begun the process of strengthening the minimum risk weights (*cf.* the output floor) by this time, which can be seen in the level of the average risk weights of just above 40% in Norway. (Savolainen & Tölö, 2017)

Considering the distribution of the banks' risks, just above 80% of the total risk exposure stems from credit risk (and most of that credit risk is related to lending) in all the Nordic countries. Roughly estimated, 10% of the remaining risk exposure stems from operational risk, 5% from market risk and the rest (if there is any) from other factors. Covered bonds issued by the banks are common in Europe (*cf.* asset-backed securities in the USA). The Nordic banking sector is exceptional in the sense that banks

[28] For Municipality Finance, the buffers would be 0.5% and 1.5% respectively. However, the focus is on commercial institutions in this case.

can serve as market makers for the covered bond market, and the cross-holdings of covered bonds between banks is significant. When examining asset quality in terms of loan losses, the Nordic banks outperform the rest of the world. The share of non-performing loans has constantly been below 2% in the Nordic countries (except for Denmark after the financial crisis) during the past decade[29]. Naturally, this has a positive effect on retained earnings. A relatively large proportion of the Nordic loan stock consists of housing loans. In 2016, the Finnish housing loan stock was slightly larger than the corporate loan stock. (Savolainen & Tölö, 2017) The banking sectors of the Nordic counties are notably large in comparison to GDP, and Finland is no exception. The relocation of Nordea increased the total banking sector balance in Finland by 3.4 times the annual GDP[30], making the Finnish banking sector one of the largest in Europe. The total banking sector balance in Finland was close to 800 billion Euros in 2018. (Finance Finland, 2019)

In terms of management structure, the Nordic multinational banks usually have branches in their neighboring countries[31]. Traditionally, the Finnish banking market has mostly consisted of branches of banks from other Nordic countries (*e.g.* Danske Bank, Handelsbanken). However, since Nordea moved to Finland, Finland now hosts the headquarters of a multinational bank. Not to be forgotten, the national financial group OP naturally also has its headquarters in Finland. Savolainen and Tölö (2017) emphasize that multinational banks might reduce their lending more than national banks following a negative shock, because of their interdependence on international markets. (Savolainen & Tölö, 2017) Another interesting feature of the Finnish and Danish banking sectors is that a large proportion of the market is covered by a cooperative banking entity.

Because of the constantly low interest rate levels in Europe, the Nordic banks have experienced trouble generating interest rate income. Nevertheless, they have stayed profitable. (Savolainen & Tölö, 2017) In 2018, the return on equity (ROE) for the Finnish banking sector was 8.5%, which is good in comparison to the European

---

[29] This can be compared to average of the rest of Europe, which was between 5% and 6% in 2016. However, this ratio has also been much more volatile.

[30] According to a prognosis by Statistics Finland (2019), Finnish GDP was around 234 billion in 2018.

[31] For reference, the difference of a branch and a subsidiary is that the subsidiary operates with a balance sheet of its own, while the branch do not. (Finance Finland, 2019)

average of 6.2% (Finance Finland, 2019). Since the cost of equity on the Finnish market is ranging between 5.4% and 6.6% as of 2019 (PWC, 2019), it is reasonable to assume that the Finnish banking sector is indeed profitable.

Compared to international standards, the Nordic banks generally have quite large loans-to-deposits ratios. In 2016, the loans-to-deposits ratio was as high as 300% in Denmark and closer to 200% in Norway and Sweden. (Savolainen & Tölö, 2017) In Finland, the ratio was below 120%. However, the relocation of Nordea caused the Finnish credit market to grow immensely, increasing the ratio to just above 160% in 2018. (Bank of Finland, 2019c) Thus, the excessive lending creates a funding gap. The funding gap is usually covered by equity or market funding with covered bonds. A covered bond is securitized by both collateral in terms of *e.g.* a mortgage portfolio, as well as the bank's other assets. The risk premia of the covered bonds will increase if the risk increases on the housing market, making this way of funding more expensive for the banks. Consequently, it becomes important for the bank that the housing market remains stable. Furthermore, the Nordic banks have been upholding larger liquidity buffers than required by the Basel liquidity requirements, due to their funding situation. (Savolainen & Tölö, 2017)

The Nordic banking sectors are not particularly sensitive to market risk, since the exposure from market risk constitutes such a small share of the total risk exposure. Out of the market risk that does affect the banks, interest rate risk is the most important factor. Interest rate risk stems from assets and liabilities in the banks' balance sheets reacting differently to interest rate changes. For example, the Finnish banking sector would profit from an increase in the interest rates, since the change would affect the loans more than the deposits. Savolainen and Tölö (2017) also emphasize that major interest rate changes could affect the real side of the economy. They fear that if households are too indebted, they might not be able to handle increases in the interest rates. As of 2016, household debt relative to GDP was close to 70%.

In summary, the Nordic banking sector has strong capital adequacy. This is mainly due to the risk weights of the banks' assets being very low when calculated using the internal rating-based approach, and the banks' good profitability. All the Nordic banking sectors are extremely concentrated and interconnected, as well as large in comparison to GDP, causing the systemic risk level to be high. These vulnerabilities increase the sensitivity of the Nordic banking system to macroeconomic shocks. Savolainen and Tölö (2017) believe that unfavorable developments in the level of the household debt, housing prices and domestic demand are particularly important indicators of crisis in the Nordic economies.

3.2. The DSGE modeling method

DSGE (dynamic stochastic general equilibrium) models are advanced structural macroeconomic models used for economic prognosis or macroprudential policy simulations. As the name suggests, DSGE models are general equilibrium models, meaning they explain the whole economy as opposed to individual markets. Moreover, DSGE models are dynamic and stochastic, meaning they illustrate the movement of the economic aggregates over time and consider that the aggregates can be affected by random shocks. The structure of the model is based on microeconomic theory, a mean for modern macroeconomics to address the Lucas critique[32] (Lucas, 1976). Essentially, the DSGE method is a way of modeling economic fluctuations to closely resemble the dynamics of the real-world economy. (Torres, 2016)

In order to properly understand the development of DSGE models, it is necessary to start with the models' predecessors. The first step towards the modern DSGE models could be the Ramsey-Cass-Koopman model, based on the 1928 "A Mathematical Theory of Saving" by Frank P. Ramsey. This model resembles the classical Solow growth model; however, the dynamics of the model variables depend on decisions made at the microeconomic level. In practice, this means that the structure of the model is based on known microeconomic relationships between the economic agents (households, firms and the public sector). The modifications to the model endogenized the savings rate. The Ramsey-Cass-Koopman model proved to be too simplistic, it ignored issues such as market failure and heterogeneity among the economic agents.

Following the release of Kydland and Prescott's (1982) paper "Time to Build and Aggregate Fluctuations", macroeconomic analysis instead became dominated by the real business cycle (RBC) theory. The RBC models introduced exogenous shocks to the setting, forming a fluctuating economy, as opposed to a steady growth path. In

[32] Robert Lucas argued that macroeconomic predictions should not be based on aggregated historical data alone. Instead, the macroeconomic models should have stronger micro-foundations. (Lucas, 1976)

RBC theory, the shocks were either technology shocks, affecting production, or shocks to government purchases. The shocks only affected the real side of the economy, hence the name real business cycle theory. In addition, the RBC models introduced variations in employment, by making the choice of labor part of the households' utility functions. The renewed methods seemed promising, yet the RBC models were unsuccessful in explaining real-world macroeconomic fluctuations. The reason for the imprecise predictions was assumed to be the models' disregard of the impact of monetary shocks. Empirical evidence indicates that nominal rigidities (such as price or wage stickiness) significantly influence the real economy, implying that Keynesian ideas might be relevant for the analysis. Thus, the natural next step was to start designing models that would include nominal rigidities. (Romer, 2012) It is now, that modern DSGE models start taking form.

Costa Junior and Garcia-Cintado (2018) explain how an RBC model (simple DSGE model) is solved in their paper "Teaching DSGE models to undergraduates". The authors' model only features two kinds of economic agents: households and firms. The agents' behavior is described using microeconomic theory. The households' problem is to maximize their intertemporal utility functions in consumption and labor, subject to a sequential budget constraint. The authors derive the first-order conditions from the Lagrangian and solve for the labor supply equation, which states that the real wage must equal the marginal rate of substitution between consumption and leisure. They then solve for the consumption Euler equation, which states that the real interest rate must equal the marginal rate of substitution between current consumption and future consumption. Similarly, the authors derive the demand for capital and labor from the firms' profit function.

With the behavior of the agents known, Costa Junior and Garcia-Cintado (2018) proceed to describe the competitive general equilibrium of the model. The general equilibrium is defined by a set of equations that fulfill the market clearing conditions. In this model, the equations are the supply and demand for labor and capital, the price level, the law of motion for capital, the production function, the equilibrium condition and finally, a shock to productivity. Thereafter, the next step is to define the steady-state values of the endogenous variables in the model (total output, consumption, investments *etc*.). This model is presented so that all endogenous variables have the same value throughout time if no shock occurs. By removing the time subscripts from the endogenous equations, and defining the parameter values, the equations can be used to estimate the steady-state values. The parameter values (different elasticities and coefficients) are calibrated to match the target economy, using time-series data. Since the model is nonlinear, it is generally impossible to find explicit solutions. Consequently, it is necessary to estimate a linear approximation of the model. Costa Junior and Garcia-Cintado (2018) do this by log-linearizing all the equations around their steady-state.

It is possible to solve the linearized model for its recursive competitive equilibrium, finding the recursive law of motion for the different variables (or policy functions). These are key equations to the DSGE modeling method, as they explain the estimated response of the variables to shocks. It is possible to do this by hand, however, much more efficient to let a computer program find the dynamic solution. A common program used for this purpose is Dynare, which consists of Matlab routines. Dynare can read the linearized DSGE model equations and solves (or estimates) the model given some parameter values (Jones & Kulish, 2016). For example, Costa Junior and Garcia-Cintado (2018) simulate a positive shock to total factor productivity. The output from the simulation, the impulse response functions (IRF), show how the variables (total output, consumption, investments *etc*.) initially rise and then move back to their steady-state value after some periods.

Today, modern DSGE models are quite complicated and typically feature rigidities such as imperfect competition, sticky prices and wages, consumer habit formation, non-Ricardian agents, government-imposed taxes, and additional costs, *e.g.* investment adjustment costs and capacity underutilization costs. (Costa Junior, 2016) Except for households and firms (as in the example above), modern DSGE models usually also feature a government that conducts fiscal policy through taxes and public purchases, a central bank that conducts monetary policy by determining the real interest rate and an export and import sector. (Romer, 2012) Lately, DSGE models have become important tools for economic policy analysis for central banks around the globe. This has driven further development of the DSGE model structure to incorporate an advanced financial sector. (Costa Junior, 2016)

3.3. Aino 2.0 – A DSGE model of the Finnish economy

The Bank of Finland (Suomen Pankki) has constructed a DSGE model named Aino, which they currently use for long-term prognosis. The latest version of the model, Aino 2.0, was published online in 2016 (Kilponen et al., 2016). Aino 2.0 is a small and open economy model, designed to match the Finnish economy. The parameter values are estimated using Bayesian methods, based on Finnish time-series data from 1995-2014. Aino 2.0 features a monopolistically competitive banking sector and bank capital requirements, making it possible to directly estimate the negative effect of increasing these requirements on total output.

Kilponen et al. (2016) provide a detailed explanation of the model structure in their paper "The Aino 2.0 model". The authors start by describing the basic sectors of the model in the following order: goods production, export and import sector, households and the government sector. They continue with a description of the general equilibrium, before moving on to the banking sector. The banking sector is the newest addition to the model and, therefore, receives a chapter of its own. The following chapter will summarize the most important points of the Kilponen et al. (2016) paper, with a clear focus on the structure of the banking sector and the bank capital channel. The chapter ends with an explanation of how Aino 2.0 is used to estimate the impact of increasing the capital requirements in the Finnish economy.

3.3.1. The real side of the economy

The model is essentially designed as a single good economy. Domestic firms produce varieties of a single intermediate good, which is then aggregated and merged with imported intermediate goods to produce final goods. The final goods are finished in three different sectors of the economy, thus, creating a consumption good, an investment good and an export good. Both the domestic intermediate good producers and the exporters operate under monopolistic competition. Production of the domestic homogenous intermediate good follows a Constant Elasticity of Substitution (CES) production function, with a time-varying markup and a Harrod neutral technological progress. These features seem to match the Finnish data better than, *e.g.* the traditional Cobb-Douglas production function, due to substantial fluctuations in capital and labor productivity following the collapse of Nokia and the financial crisis. Moreover, the empirical evidence supports the use of an elasticity of substitution significantly below one. (Kilponen et al., 2016)

The technological progress describes the efficiency growth in the input factors. In the case of Harrod neutrality, the capital-to-output ratio must be constant at a constant rate of return to capital[33]. Consequently, if the capital-to-output ratio increases while the interest rate remains constant, the progress is labor-saving. If the capital-to-output ratio instead were to fall, all else equal, the progress would be capital-saving. (Harrod, 1948). Kilponen et al. (2016) include parameters to denote the capital- and labor-augmenting technical progress in the production function. These “factor-specific productivity shifters” in combination with the elasticity of substitution being below one, gives the CES-production function the ability to shift between being capital- or labor-augmenting in the short run. In the long run, the progress is assumed to be labor augmenting, as the theory predicts. The firms then minimize their cost function, taking the production function as a given constraint. Solving this problem yields a nominal marginal cost, which is the same for all firms. Essentially, this is the cost of varying the use of capital and labor during the production process. (Kilponen et al., 2016)

As for the pricing of the intermediate good, Kilponen et al. (2016) apply the Calvo model (Calvo, 1983). Calvo pricing is a variation of time-dependent pricing, where only some of the firms can re-optimize their prices each period, creating the effect of sluggish price development. The prices are assumed to be bound by contracts that last over several periods. The opportunity to change a price is granted to a firm at random, thus, some contracts are in effect longer than others. Even if the firm is not able to re-optimize its price, it can still change the price to account for inflation. Normally, the firms’ optimal price would be the expected future nominal marginal cost. However, since the firms are not certain they will have the opportunity to re-optimize their price in future periods, they add a markup to the price to account for this uncertainty. Consequently, the price of the intermediate good depends on the current and expected cost of capital and labor, past prices and the markup, which can be thought of as the pricing power of the firm. (Kilponen et al., 2016)

[33] Harrod neutral technological progress is suited for dynamic modeling.

The domestic final goods market is characterized by perfect competition, as opposed to the monopolistically competitive intermediate goods market. Domestic retailer firms produce either a consumption good or an investment good, by combining the domestic and imported intermediary products. Both the production processes are specified by a CES-production function, and the prices of the final goods are a function of the prices of the intermediary goods. (Kilponen et al., 2016)

Since Finland is a small and open economy, the export and import sectors also play an important part in the structure of the model. The structure of the export sector largely follows the same logic as the intermediate goods-producing sector, with the production and price building functions having the same form and the market being monopolistically competitive. A difference, however, is that the price of the export good (which is denoted in foreign currency) is dependent on the nominal exchange rate, and the demand is dependent on foreign demand. The import sector in the model consists of two different foreign import firms, that operate outside Finnish borders, and an import retailer. One of the foreign import firms prices their products in local currency and the other in foreign currency, this facilitates control of how much foreign price levels affect domestic inflation. The price of the imported good depends on the expected future import price inflation, the import firms' marginal cost and the current and expected future nominal exchange rate. Concerning market structure, the foreign import firms and the import retailers have similar roles as the intermediate goods producer and the final good producers, respectively. (Kilponen et al., 2016)

Other important agents in the economy are the households. The households buy consumption goods and invest their savings in domestic, euro area and "the rest of the world" bonds. They supply labor to both firms and the government in a monopolistically competitive labor market, where the households have wage-setting power. The households' preferences are affected by how much they value consumption today, or the discount factor, to what degree their consumption choices are affected by past consumption, or habit formation, and the labor supply elasticity. In addition, the preferences can be affected by random consumption preference shocks. The households' budget consists of after-tax wage and dividend income, returns on bonds and government transfers, less the cost of consumption (including consumption tax). The wage-setting mechanism is sluggish, as wages are bound by contracts, similarly to Calvo pricing. The households that do not receive the opportunity to re-optimize their wages follow a wage indexation function. A wage contract is being optimized so that the present value of the expected future cost and benefit of working are equal, meaning the wage-setting mechanism is forward-looking. In the end, the aggregated nominal wage is a weighted average between the past and the re-optimized wages. (Kilponen et al., 2016)

Finally, the government uses tax income and capital from issuing euro bonds to finance public purchases, investments and production. It is assumed that the government's budget is always in balance. Since Finland is part of the euro-zone, there is no independent central bank that conducts monetary policy through a policy rate rule. (Kilponen et al., 2016)

3.3.2. The financial side of the economy

In order to create the desired banking sector response system, Kilponen et al. (2016) introduce a completely new agent into the economy: the entrepreneur. This agent buys and sells physical capital, thereby facilitating investments in the economy. The entrepreneurs have insufficient financial resources on their own and need to borrow from the bank to continue their operations. The banks fund lending with deposits from the households and retained earnings. (Kilponen et al., 2016)

A capital goods producer purchases capital from the entrepreneurs and combines the capital with investment goods to produce new capital. The production process occurs in period t, thus, new capital enters the economy in period $t+1$. The investment good is transformed in the production process, which is costly for the capital producing firm. (Kilponen et al., 2016)

The entrepreneurs rent capital to the intermediate goods producers and sell capital to the capital goods producer in period t. From this activity, they receive income to purchase more capital in period $t+1$. However, their expenditure is always larger than their equity, forcing the entrepreneurs to borrow money from the bank in period t. Loans are paid back in period $t+1$. The dependence on loan funding resembles the real-world situation in Finland, where banks are the main source of credit in the economy. The profit function (and value of equity) of the entrepreneurs is thereby dependent on the price and rental rate of capital and the nominal interest rate on loans. To prevent the entrepreneurs from becoming self-financed by building up equity, entrepreneurs always exit the economy at random in each period. When an entrepreneur seizes to exist, he transfers his equity to the households. Additionally, new entrepreneurs are born at random in the same period. The new entrepreneurs receive an initial transfer of equity form the households to be able to start their operations. (Kilponen et al., 2016)

As in the real world, the modeled banks' main role in the economy is to function as financial intermediaries. The banks in the model operate under monopolistic competition, reflecting the high levels of concentration in the Finnish banking sector (as discussed in chapter 2.1). Consequently, when the entrepreneurs decide how much to borrow from a bank, they compare the banks' loan rates. Naturally, the entrepreneurs will borrow more from banks that offer a lower loan interest rate than the average. The degree of competition is determined by the elasticity of demand for loans, which varies over time. (Kilponen et al., 2016)

The banks in the model change their interest rate in response to shocks or cyclical fluctuations of the economy, as in Gerali, Neri, Sessa and Signoretti (2010). The balance sheet of a bank is similar to the example in chapter 2.1, the assets consist of loans while the liabilities consist of deposits and a fraction of bank capital (retained earnings). The banks are subject to an exogenous optimal capital-to-asset ratio, which is costly to deviate from, reflecting a regulatory capital requirement. The level of bank capital affects the credit supply for the rest of the economy. This creates a loop where *e.g.* a negative shock to the real side of the economy affects the financial side negatively, which in turn has further negative effects on the real side. (Kilponen et al., 2016)

All banks in the model have two retail branches and one wholesale branch. The wholesale branch handles the capital position of the bank by managing the bank capital and deposits, while issuing wholesale loans to entrepreneurs. The wholesale market is perfectly competitive, however, the activities of the wholesale branch become more expensive if the capital position of the bank deviates from the target capital-to-asset ratio. Moreover, this deviation cost is quadratic and proportionate to the level of bank capital in the bank's balance sheet. As discussed in chapter 2.2, credit risk is the largest risk facing banks. To reflect this, the retained earnings function also includes an exogenous financial shock, to simulate unexpected loan losses. (Kilponen et al., 2016)

The wholesale branch determines the capital position (the volume of loans and deposits) by optimizing its discounted cash flows, taking the interest rates on wholesale loans and deposits as given. The first-order condition illustrates how the spread between the wholesale and deposit rates are affected by the bank's leverage position. Furthermore, it is assumed that the banks have unlimited access to funding and can lend at the rate of government bonds. This rate is, by arbitrage, the same as the wholesale deposit rate. By writing the equation so that the wholesale loan spread stands alone on the left-hand side, the equation states that the optimal level of loans is where the marginal benefit from increasing lending is equal to the marginal cost of doing so. Intuitively, an increase in lending will increase the bank's profit (the spread shows how much), however, it will also increase the cost of deviating from the target capital-to-asset ratio (or the capital requirement). (Kilponen et al., 2016) This relationship is shown by the following equation:

$$R_t^b - r_t^{FI} = -\kappa_{K^b}\left(\frac{K_{t+1}^b}{BL_{t+1}} - \nu_t^b\right)\left(\frac{K_{t+1}^b}{BL_{t+1}}\right)^2 \quad (4)$$

where $R_t^b - r_t^{FI}$ constitutes the spread between the wholesale loan rate and the return on government bonds, $\frac{K_{t+1}^b}{BL_{t+1}}$ is the ratio of capital to total loans in the bank's balance sheet in period *t+1*, ν_t^b is the target bank capital-to-asset ratio and κ_{K^b} is the cost of deviating from ν_t^b. This equation is shown because of its importance for understanding the response of the bank to changes in ν_t^b. (Kilponen et al., 2016)

The first retail branch grants differentiated loans to entrepreneurs, while the second retail branch collects deposits from the households. The loan branch has some market power, due to the differentiated good, and can influence the lending rate. The deposit branch, however, takes the interest rate as given. Changing the interest rate entails an adjustment cost, which is proportionate to the loan returns of the bank. This feature makes the interest rate mechanism sluggish and causes delays in the response of the lending rates to changes in the policy rate, imitating real-world dynamics. Consequently, the interest rate on loans is determined by its past and future expected values, variations in market power and the bank capital situation. If, for example, the bank would experience unexpected losses, it would have to compensate by raising the lending rates to keep the level of the capital reserves constant. All in all, the banks' total profit is the sum of the profit generated by the three branches. (Kilponen et al., 2016) Figure two below illustrates the complete structure of the model.

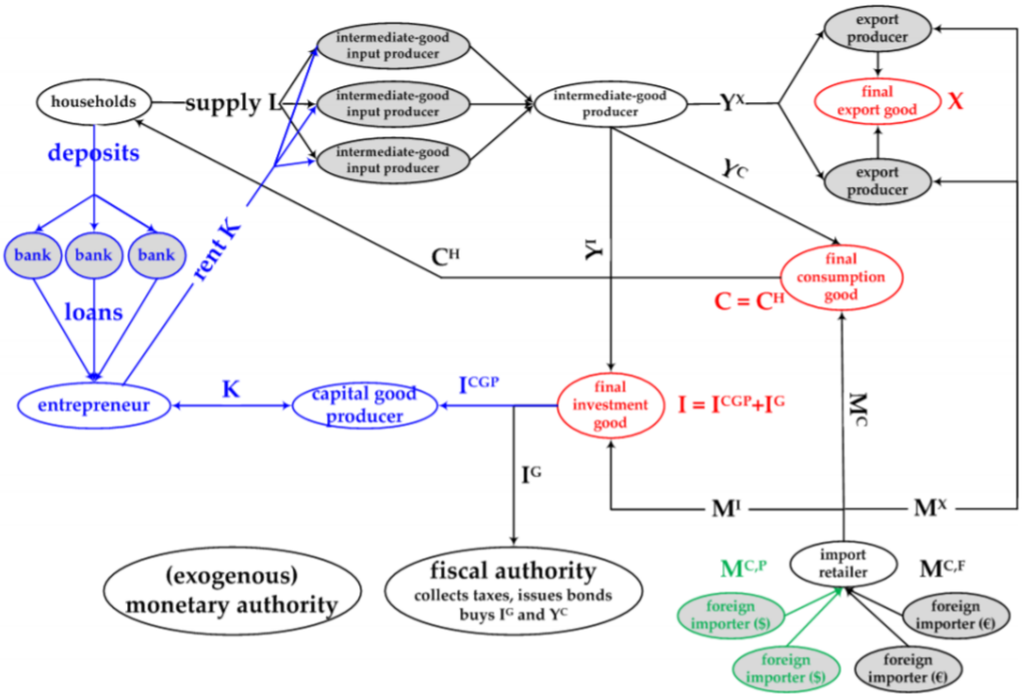


Figure 2. Aino 2.0 model structure

Note. The financial sector is in blue. Source: Kilponen et al. (2016)

3.3.3. Calibration and structural parameter values

As became clear in chapter 3.2, it is necessary to define the structural parameter values and the steady-state values of the DSGE model to find a solution. These values essentially define the properties of the analyzed economic system, which in the case of Aino 2.0 is the Finnish economy. For the most part, the relevant structural parameters are unobservable in the economy and therefore need to be estimated. The common way to estimate parameter values in DSGE models is by applying Bayesian inference methods[34]. Bayesian inference, as a form of statistical inference, is a method for determining the probability distributions of different variables with the help of empirical data. Bayesian inference is based on Bayes' theorem, which defines the posterior (conditional) probability of an event A, given the probability of B, when B is derived from the prior probability of A and the prior and posterior probabilities of

[34] Generally, Bayesian inference is suited for dynamic model calibration.

B. The prior probabilities are essentially hypotheses regarding the sought-after distributions. Hence, Bayesian inference is a way of estimating the probability distributions of unobservable variables, by using data analysis, previous literature or other empirical sources. (Tejedor, 2017)

Kilponen et al. (2016) use a total of 24 observables (domestic real variables, prices and price deflators, interest rates, wages, *etc.*) in the process of estimating Aino 2.0. The data is collected from Statistic of Finland's Quarterly National Account, the Bank of Finland and the European Central Bank's databases and covers the period 1995Q2 to 2014Q4. The time series are detrended, thus, the variables are compatible with the balanced growth path of the model.

The steady-state is calibrated by fixing the value of some structural parameters and choosing the remaining parameters optimally. Key macroeconomic ratios reflecting the Finnish economy, such as consumption, investments or export to total output, are used as a benchmark for the calibration. (Kilponen et al., 2016)

As for the result of the Bayesian estimation, the prior and posterior distributions are quite unlike each other, which implies that the empirical data was informative. Kilponen et al. (2016) discuss the most interesting structural parameter values derived from the posterior distributions. The external consumption habit in Finland seems to be unusually high (the parameter value is 0.95), meaning the shock response of consumption is very sluggish. For this estimate, the posterior distribution is narrow, meaning the result is reliable. Moreover, the investment adjustment cost is also relatively large, although this estimate is much more uncertain.

In addition to the consumption habit, wage stickiness seems to be the other great source of rigidity in the Finnish economy. On average, wage contracts are effective for over three years at a time. Price stickiness, on the other hand, is much weaker and prices change approximately four times a year. The estimate for wage stickiness is also more reliable than the estimate for price stickiness, which has a wider posterior distribution.

Furthermore, price indexation is quite high, as prices are adjusted to a degree of 75% to past inflation. Export prices change more often than import prices (and have a higher indexation parameter). Consequently, import prices are somewhat robust to changes in the prices of oil or raw materials. Only 26% of the import firms price their products in foreign currency, causing a low pass-through of exchange rate fluctuations to the import price. Unfortunately, the indexation parameter estimates are very uncertain. (Kilponen et al., 2016)

The financial side of the economy seems to be less rigid than the real side of the economy. The loan interest rate generally adjusts to shocks over a four-quarter long period, and the cost of deviating from the target leverage ratio is lower than expected. The estimates are reliable. (Kilponen et al., 2016)

Finally, the model also features structural shocks and exogenous processes, which are all first-order autoregressive processes (except for the intermediate good price markup and wage markup shocks). The AR1 parameters retrieved from the Bayesian estimation describe the persistence of these shocks. In summary, labor productivity shocks and shocks to hours worked in the government sector are the most persistent, whereas capital productivity and consumption preference shocks are the least persistent. The former estimates are more reliable than the latter, however, none of these estimates have very wide distributions. (Kilponen et al., 2016)

3.3.4. Simulating an exogenous shock to the bank capital requirements

As stated, the goal of this thesis is to analyze the impact of implementing the Basel III capital requirements in the Finnish economy. The following chapter explains how Aino 2.0 is applied for this purpose.

The banks in Aino 2.0 are subject to an exogenous target capital-to-asset ratio, v_b, as was discussed in chapter 3.3.2. The target capital-to-asset ratio can be used to simulate a regulatory bank capital requirement since the banks in the model must uphold the ratio to avoid additional costs. This feature makes it possible to directly estimate the impact of changes to the capital requirements on total output and other relevant aggregates. Many of the previous studies presented in chapter 2.5 analyzed the cost of increasing the capital requirements in a two-step process[35], as their models did not have the required structure to do otherwise. Naturally, more estimates mean more

[35] Two-step process refers to the method of first estimating the impact of raising the capital requirements on the banks' lending rates, and then estimating the impact of higher lending rates on total output.

uncertainty, hence, using a model that already features bank capital requirements, like Aino 2.0, should give deeper insight into the problem.

To be able to impose a shock to v_b in the model, the shock first needs to be specified and added to the model's system of equations. Hence, the structural shock is specified as:

$$v_b = 1 * v_{b_{t-1}} + \varepsilon^{v_b} \quad (5)$$

The shock is a first-order autoregressive process with the AR1 parameter set to one, meaning the shock is completely persistent. The level of the bank capital-to-asset ratio is initially set to 8%, reflecting the Basel II level. Furthermore, the standard deviation is set to one percentage point. Intuitively, this means that if a shock is imposed, the bank capital requirement is raised from 8% to 9%, and then stays at 9% throughout all the periods.

The fact that the banks must pay a penalty cost for deviating from the target capital-to-asset ratio is essentially what makes it possible to simulate changes to the capital requirements in the model. The parameter representing this deviation cost in Aino 2.0, κ_{K^b}, has a mean of 0.08 according to the Bayesian estimation. Kilponen et al. (2016) argue that this value is very low and even test some other values for the parameter. To force the banks in the model to comply with the new requirement within a shorter period of time, κ_{K^b} is set to 25, which is the highest values tested by Kilponen et al. (2016). When raising κ_{K^b}, Kilponen et al. (2016) also raises the loan rate adjustment cost, κ_b, from its estimated value of 4.55 to 200. By doing so, the pass-through mechanism of the funding cost to the lending rate is preserved. Generally, one could say that raising the parameter values of κ_{K^b} and κ_b strengthens the bank capital channel in the model.

In practice these changes are done to the Aino 2.0 model code in Matlab, as the program Dynare is used for simulating the shock. To perform the simulation (solve the model) and obtain the impulse response functions (IRF), the command "stoch_simul" is used. The stoch_simul command solves stochastic models by computing Taylor approximations (in this case, first-order approximations) around the steady-state of the model system of equations. When simulating an exogenous shock to v_b, the solution is the dynamic response corresponding to this shock and all other shocks are inactive in the model code. The number of periods for which the IRFs are computed is 40. (Adjemian et al., 2020) In the next chapter, the results from various shock simulations using these settings are presented.

4. Results

The following chapter presents the results of various simulations done in the Aino 2.0 model. The goal of the simulations has been to test the structural shock described in chapter 3.3.4. The first three chapters present the main results of the analysis, as three different simulations. These simulations are all the result of imposing exogenous shocks to the bank capital requirement. Furthermore, chapter 4.4 presents the result of simulating a bank crisis at different initial levels of bank capital.

4.1. Simulation one: raising the capital requirements from 8% to 9%

Figure three below contains graphs of the impulse response functions (IRF) following a one standard deviation shock to v_b, when the initial target capital-to-asset ratio is set to 8% (the Basel II minimum requirement). The x-axis represents the number of periods for which the IRF are computed and the y-axis represents the change in the variables. One period in this model is equivalent to one quarter, thus, four periods make up a year. All the IRFs are reported as percentage deviations from the non-stochastic steady state except for the IRF for inflation, the loan interest rate and the bank capital-to-asset ratio, which are reported as annual percentage points. The uncertainty about the IRFs stems from the estimation of the posterior distributions, or the structural parameter values. The simulation will always suggest the same solution to the model, taking these exogenous parameter values as given. Hence, the simulation, in itself, does not include any uncertainty (which is why no uncertainty bands are shown).

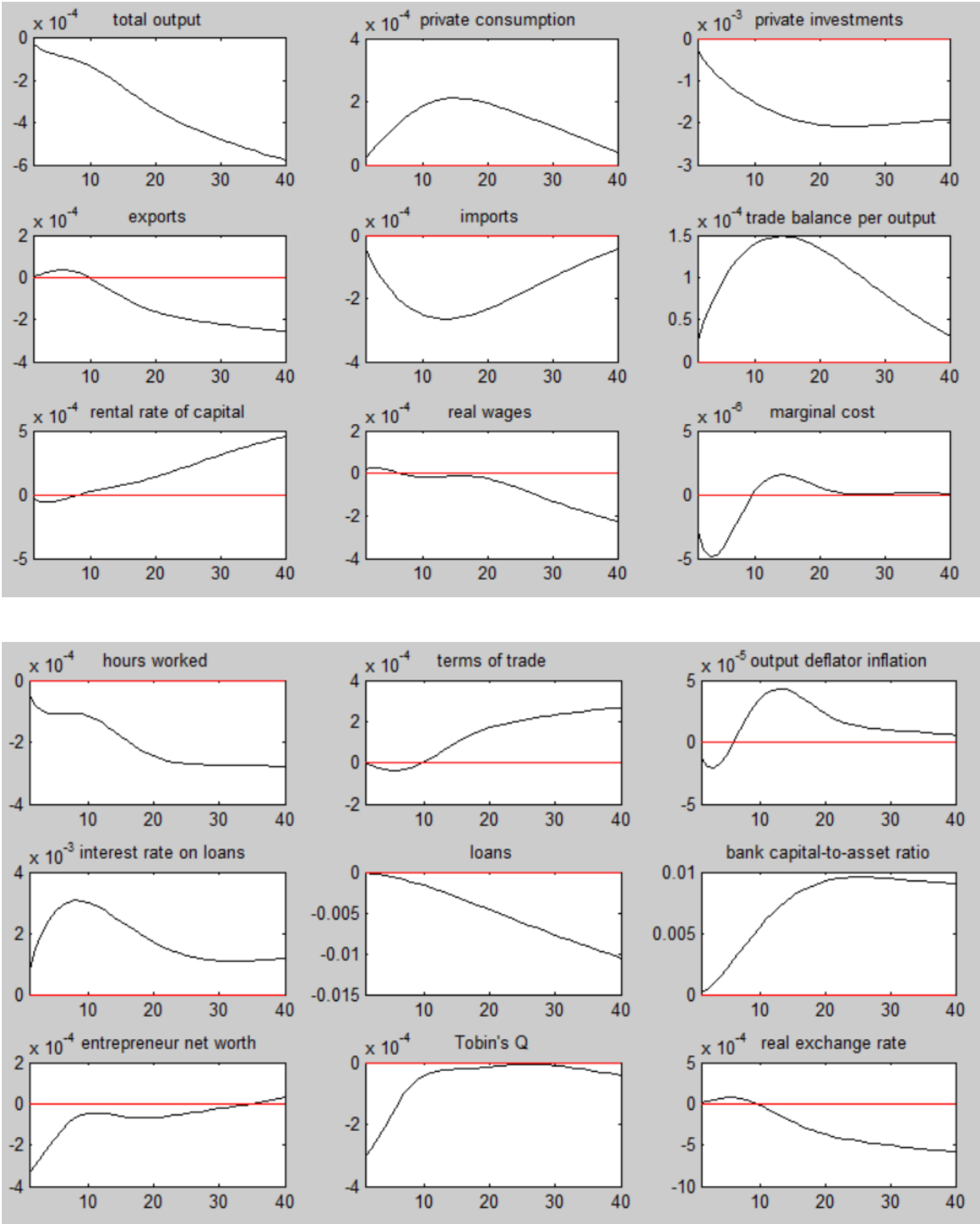


Figure 3. Impulse response functions – shock to the target bank capital-to-asset ratio
Note. The standard deviation of the shock is one percentage point and the initial bank capital-to-asset ratio is 8%.

When the target capital-to-asset ratio is raised from 8% to 9%, the banks must adjust their capital structure and raise their capital (or deleverage) to fulfill the new requirements and avoid the deviation cost. The IRF for the bank capital-to-asset ratio illustrates the reaction of the banks. They manage to slowly increase their capital-to-asset ratio until it finally approaches 9% in period 20[36]. Since the variable is reported in quarters, 20 periods are equivalent to five years. The banks achieve this by increasing the lending rate, which can be seen in the IRF for the loan interest rate[37]. At its peak (periods eight and nine), the loan interest rate has been raised by 31 basis points (or 0.31 percentage points). The effects wear off after some periods, however, the interest rate stays above the steady-state level with at least 11 basis points throughout the 40 periods. The hump shape of the IRF is due to the interest rate adjustment cost.

As explained in chapter 3.3.2, the entrepreneurs are the loan takers and private investors in this economy. When the interest rate on loans becomes more expensive, the entrepreneurs decrease their lending and investments. Private investments start declining immediately and stabilizes at a decline of around 0.2% from its steady-state value after 20 periods. Furthermore, the percentage of loans in the economy decreases with about one percentage point. Hence, the new capital requirement has caused a contraction of credit in the economy. The entrepreneurs' net worth also suffers when the loan interest rate raises.

Because of the decline in investments, total output starts declining. After 10 periods, output has declined by about 0.013% from its steady-state value. In period 20, output has already declined by 0.034% and in period 40 by 0.058%. The fall in total output causes demand for both capital and labor to fall, which can be seen in the decrease in hours worked and initially in the rental rate of capital. Prices in this model are more flexible than wages, as was discussed in chapter 3.3.3. This is visible in the IRFs for inflation, the marginal cost (for the intermediary goods-producing firm) and Tobin's Q (the price of capital), which all show a quick initial decline. The real wages increase slightly as hours worked and inflation decreases, due to the nominal wage rigidity.

Since the marginal cost depends on the rental rate of capital and the nominal wages, the marginal cost rises again as the rental rate of capital increases. After period 20, the increase in the rental rate of capital is about as large as the decline in the wages, which

[36] The IRF shows the movement from the steady state (0) to approximately 0.01, which is equivalent to a one percentage point increase.

[37] Recall from equation four that the interest rate on loans need to be raised in order to keep the marginal benefit of lending equal to the marginal cost if the target capital-to-asset ratio has increased.

cancels out the effect on the marginal cost. The reason for the increasing rental rate of capital is that the lower capital accumulation makes the existing capital relatively more productive. Increases in the productivity of capital in turn increase the productivity of labor by even more, due to the electricity of substitution being less than one between capital and labor (the two input factors are gross complements). This means that the firms can increase the input of labor by less than capital in the production process[38]. Since hours worked have somewhat stabilized at this point (and inflation is above its steady-state level), real wages respond by decreasing. Furthermore, inflation follows the development of the marginal cost.

The IRF of private consumption is concave upwards with a maximum deviation from its steady state of approximately 0.021% after 15 periods. The response of consumption is explained by the income effect. When the prices decline, the consumers' purchasing power increases. However, after a while wages start to decline as well (and inflation increases again), causing the consumers' purchasing power to deteriorate. The decrease in consumption affects total output negatively and accelerates the regression.

The real exchange rate depreciates slightly between periods zero and 10, as domestic inflation is below its steady-state level. After period 10, the real exchange rate starts slowly appreciating, since inflation is now above the steady-state level. A depreciation increases exports and reduces imports, as the terms of trade become worse for Finland. Naturally, an appreciation has the opposite effect. This is reflected in the IRFs for exports and imports. Before period 10, exports increase slightly while imports decrease. After period 10, exports start decreasing and imports increase instead.

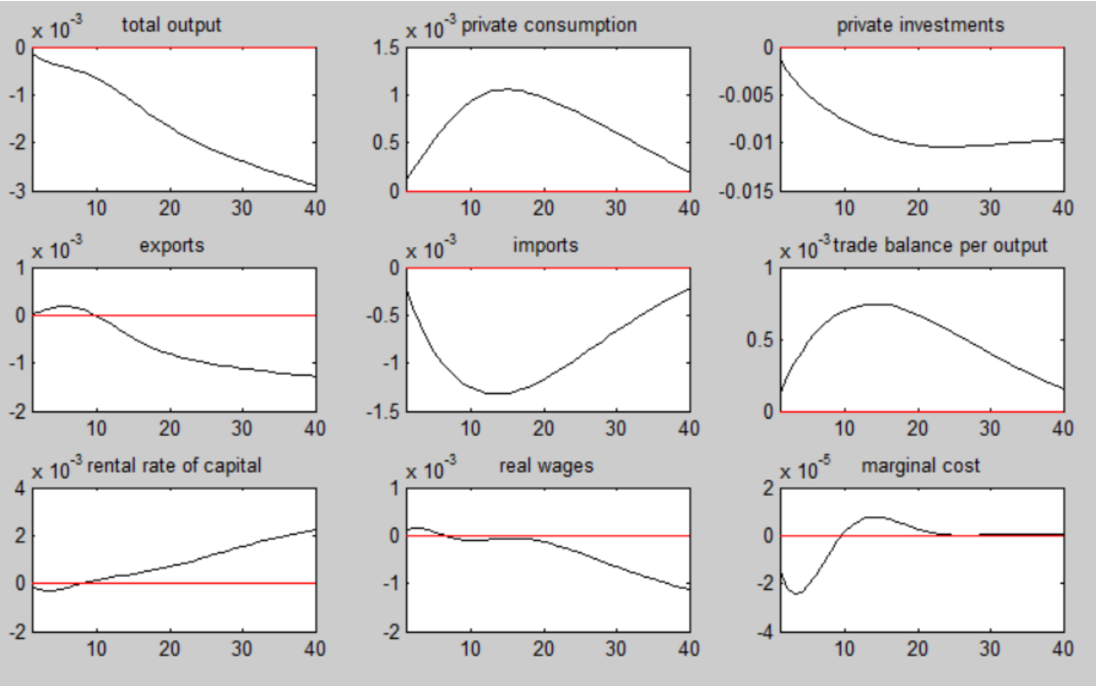
4.2. Simulation two: raising the capital requirements from 8% to 13%

Simulation one shows the response of the model economy to a one standard deviation shock to the bank capital requirements when the standard deviation is one percentage point. Since most of the previous studies also analyze the response of a one percentage point shock, this result has the most comparability. However, since Basel III constitutes more than a one percentage point increase in the regulatory capital, a larger

[38] Recall that the production process is labor augmenting.

shock is also tested. For example, assume that both the capital conservation buffer (2.5%) and the countercyclical buffer (maximum 2.5%) were implemented, how would this affect the scenario?

In order to analyze the effect of increasing the capital requirements by five percentage points, from 8% to 13%, the standard deviation of the shock is set to five percentage points. Otherwise, the interpretation of the IRFs following the shock is the same as in the first simulation.



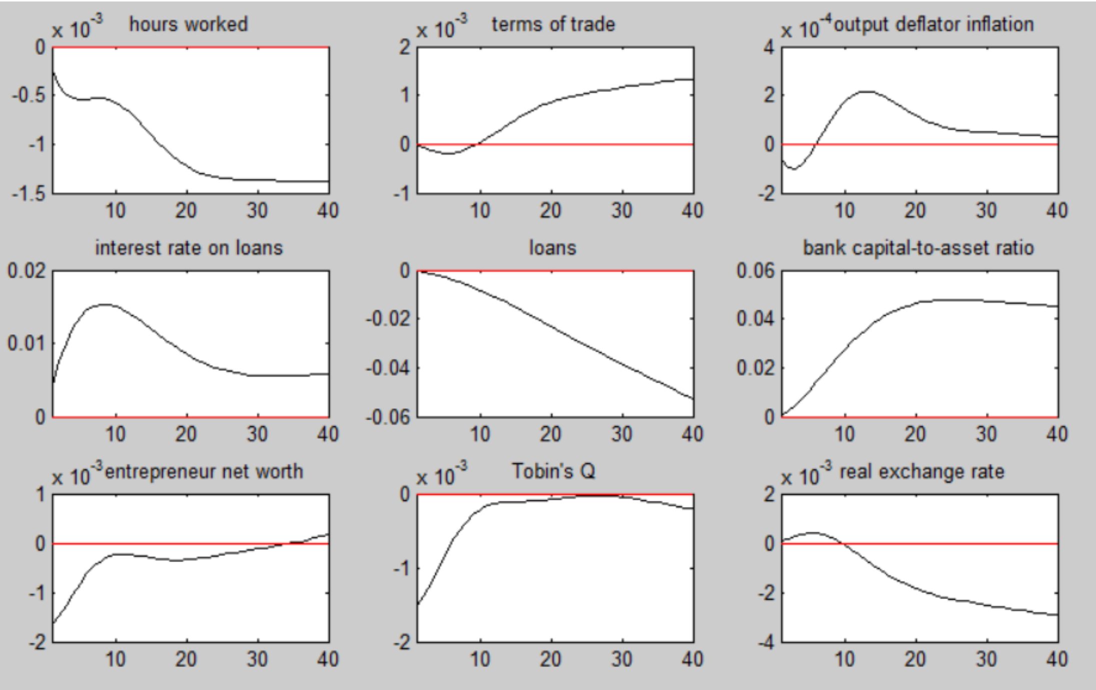


Figure 4. Impulse response functions – shock to the target bank capital-to-asset ratio
Note. The standard deviation of the shock is five percentage points and the initial bank capital-to-asset ratio is 8%.

The IRF of the bank capital-to-asset ratio illustrates how the banks increase their capital levels until the new target of 13% is nearly reached. Naturally, the banks must increase their interest rate by much more this time, to meet the new target within the same number of periods. The loan interest rate again peaks in periods eight and nine, where it has increased as much as 153 basis points (or 1.53 percentage points). It stays above its steady-state value by about 55 basis points throughout the 40 periods.

The dynamics of the economy are the same as in the first simulation. However, the effects are larger on all variables due to the large increase in the lending rate. Private investments decline by slightly over 1% from the steady-state value, which is quite a sizable effect. Private consumption peaks at an increase of 0.11% from the steady-state value, before it starts declining. In period 10, total output has declined by 0.066% from its steady-state value, in period 20 by 0.17% and period 40 by 0.29%. In comparison to the result of the first simulation, the effect on all the variables is approximately five times larger.

4.3. Simulation three: Raising the capital requirements from 13% to 14%

In order to evaluate if there is a difference in the effect of a one percentage point increase in the target bank capital-to-asset ratio at different starting points, the shock from the first simulation is imposed at an initial capital level of 13% (five percentage points higher than the Basel II minimum requirement). The interpretation of the IRFs following the shock is the same as in the first simulation.

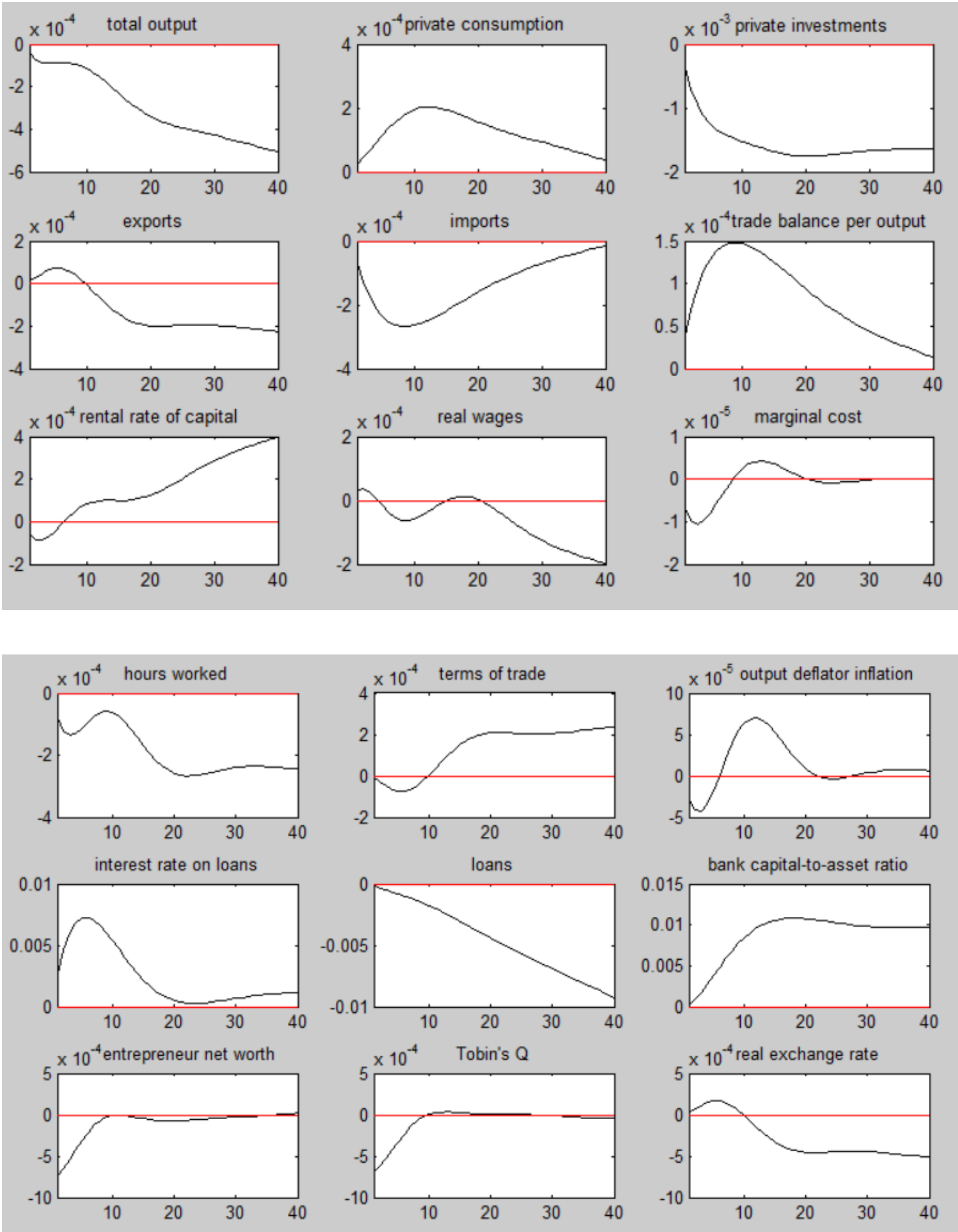


Figure 5. Impulse response functions – shock to the target bank capital-to-asset ratio
Note. The standard deviation of the shock is five percentage points and the initial bank capital-to-asset ratio is 13%.

When the initial bank capital-to-asset ratio was 8%, the banks had a hard time reaching the new target and the process of deleveraging was slow. This time, however, the new target is achieved already after 13 periods (little over 3 years). At most, the ratio increases by 1.08 percentage points before it settles at the new target of 14%.

Recall from equation four that a higher initial level of both the bank capital and the target capital-to-asset ratio would require a higher initial loan interest rate as well. Since the deviation cost is proportional to the level of bank capital, the cost is larger in real terms this time. The banks will raise their lending rate in proportion to the initial level of the rate and the increased deviation cost until the new target is achieved. Since the IRF of the loan interest rate is reported in annual percentage points, the effect will be larger in terms of percentage point increases. This is quite visible in the IRF of the loan interest rate. At its peak in period six, the loan interest rate has increased by as much as 73 basis points. Furthermore, a one percentage point increase is a proportionately smaller change when the initial bank capital-to-asset ratio is 13%, compared to 8%. Consequently, the process of reaching the new target is faster than in the previous simulation and interest rate returns to its steady-state level (or very close to it) after 20 periods, when the new target is achieved.

Again, the dynamics of the economy are the same as in the first simulation. However, because the response of the loan interest rate is more flexible this time, all the responses are less sluggish. The IRF of private investments is a little steeper and the maximum decline from the steady-state value of 0.18% is also less. Consumption peaks already in period 12, at an increase of 0.020% from the steady-state level. The effect on total output is a decline of 0.011% from the steady-state level in period 10, a decline of 0.034% in period 20 and a decline of 0.051% in period 40. All in all, the values are slightly smaller than in the first simulation.

The second simulation is also run with an initial capital-to-asset ratio of 13%. The results will not be shown as they were very similar to the simulation above. Even though the percentage point increase in the lending rate will be larger, the relative increase is the same. The only difference is that the shock is proportionately smaller, making it easier for the economy to adjust.

4.4. Response to unexpected loan losses at different capital levels

The simulations above are examples of how the Finnish economy might respond when the regulatory bank capital requirements are raised in connection with the implementation of Basel III. This could be interpreted as a test of how large the output drag of Basel III would be in Finland. Recall that the cost of crisis also is a part of how the net benefits of bank capital are measured theoretically. In this model, a bank crisis could be interpreted as unexpected loan losses, in an environment where the banks experience trouble raising new funding. In the previous setting, the bank capital requirement deviation cost, κ_{K^b}, and the loan rate adjustment cost, κ_b, were set to 25 and 200 respectively, to force the banks in the model to comply with the new requirement. This time around, the high values of the cost parameters could be used to simulate a "stress scenario in which banks are poorly capitalized […]", as in Kilponen et al (2016, p. 39). Hence, it is possible to simulate a banking crisis by imposing a negative shock to the bank capital. Consequently, the goal of the following simulations is to test whether there is a difference in how costly a banking crisis would be in Finland, depending on the initial level of the bank capital.

4.4.1. Simulation four: initial level of bank capital: 8%

In the IRFs below, an exogenous shock to bank capital has been imposed, simulating an event of unexpected loan losses for the banks. The AR1 parameter is 0.49 [according to the estimation performed by Kilponen et al (2016)], meaning the shock is not very persistent. Kilponen et al. (2016) also estimate an average standard deviation of the shock; however, this parameter has quite a small value. Since the goal here is to simulate a banking crisis, the standard deviation is instead set to 3.5 percentage points, representing the net impairment losses that the Finnish banks experienced at the end of 2009 (Kilponen et al. 2016). The interpretation of the IRFs following the shock is the same as in the first simulation.

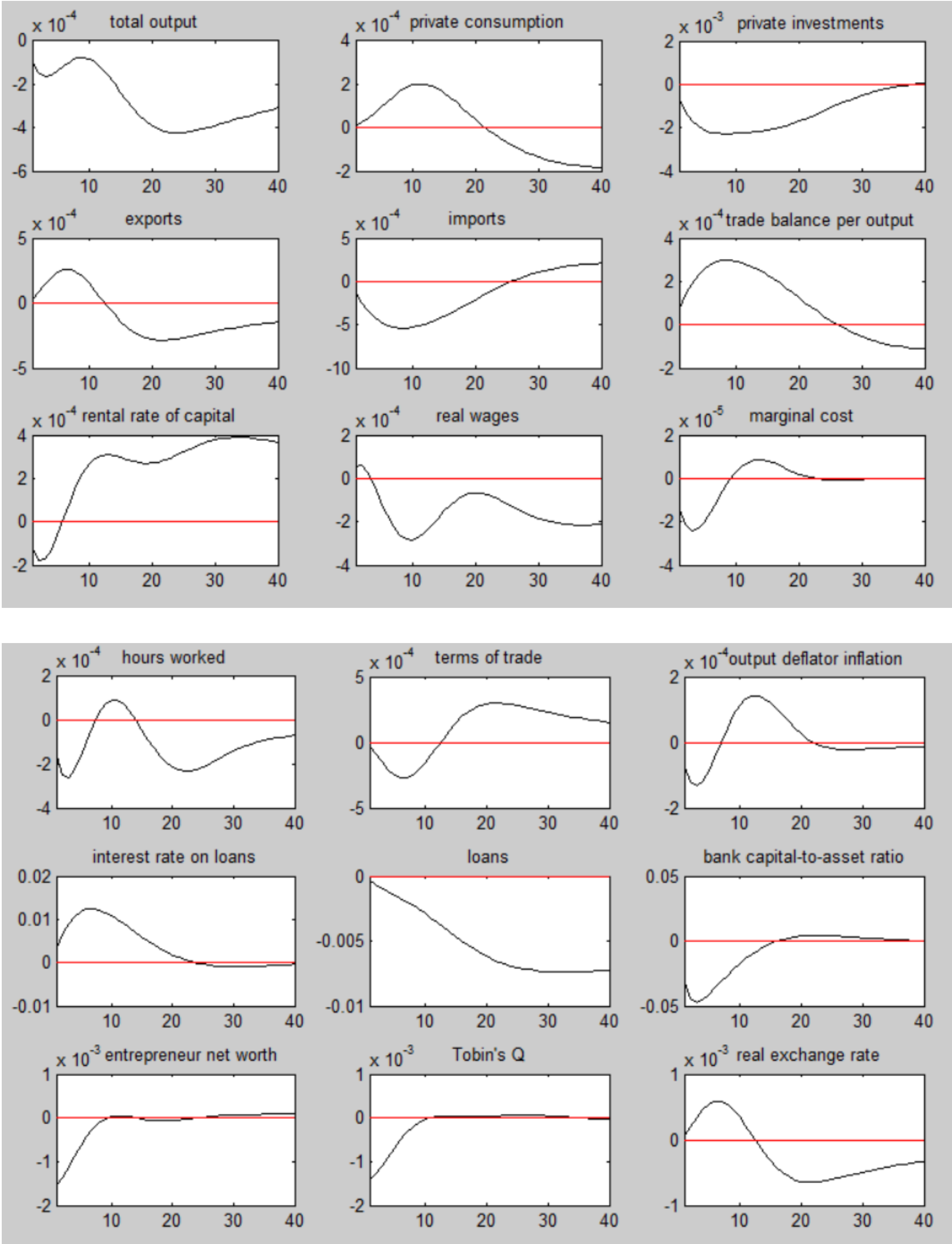


Figure 6. Impulse response functions – negative shock to bank capital

Note. The standard deviation of the shock is 3.5 percentage points and the initial bank capital-to-asset ratio is 8%.

The dynamics of the economy following the shock are essentially the same as in simulations one to three, since a negative shock to the bank capital and a positive shock to the bank capital requirement has the same effect. The difference is that in this case, the change in the bank capital-to-asset ratio is larger: approximately 3.2 percentage points to be exact. Furthermore, the shock is less persistent, as can be seen in the IRF for the bank capital-to-asset ratio (the effect of the shock is almost gone after period 20). At most, the bank capital-to-asset ratio drops by 4.7 percentage points, which is more than half of the initial level of the ratio.

As before, the banks need to raise their lending rate to increase their retained earnings and restore the bank capital-to-asset ratio. Remember that the deviation cost still forces the banks to comply with whatever target bank capital-to-asset ratio is in place. Since the deviation from the target is much larger in this simulation compared to simulations one to three, the rate is also raised by much more (at most, 124 basis points in period seven). The rate then settles at approximately the steady-state level after period 20.

Since the economy recovers from the shock faster in this simulation compared to the previous ones, the effect on investments, consumption and total output is not as large (with regards to the size of the shock). Investments respond to the shock by declining and moving back to the steady-state level in period 40. The maximum decline of investments is 0.230% from the steady-state level. Consumption peaks in period 11 at an increase of about 0.020% from the steady-state level. After period 20, consumption drops approximately equally much below the steady-state level. Consumption reacts due to the same reasons as in the first simulation. However, the reason why it drops below the steady-state level is that the shock is less persistent. The IRF of total output can be explained by the movements of investments and consumption. In period 10, total output has declined by 0.008% from the steady-state level, in period 20 by 0.039% and finally, in period 40 by 0.031%.

The simulation does not illustrate the full effect of a banking crisis since neither the banks nor the producing firms can go bankrupt. Furthermore, there is no systemic risk in the model.

4.4.2. Simulation five: initial level of bank capital: 13%

In order to analyze whether the effect is different if the initial capital level is higher, the same shock as in simulation four is run with the initial bank capital-to-asset ratio set to 13%. The interpretation of the IRFs following the shock is the same as in the first simulation.

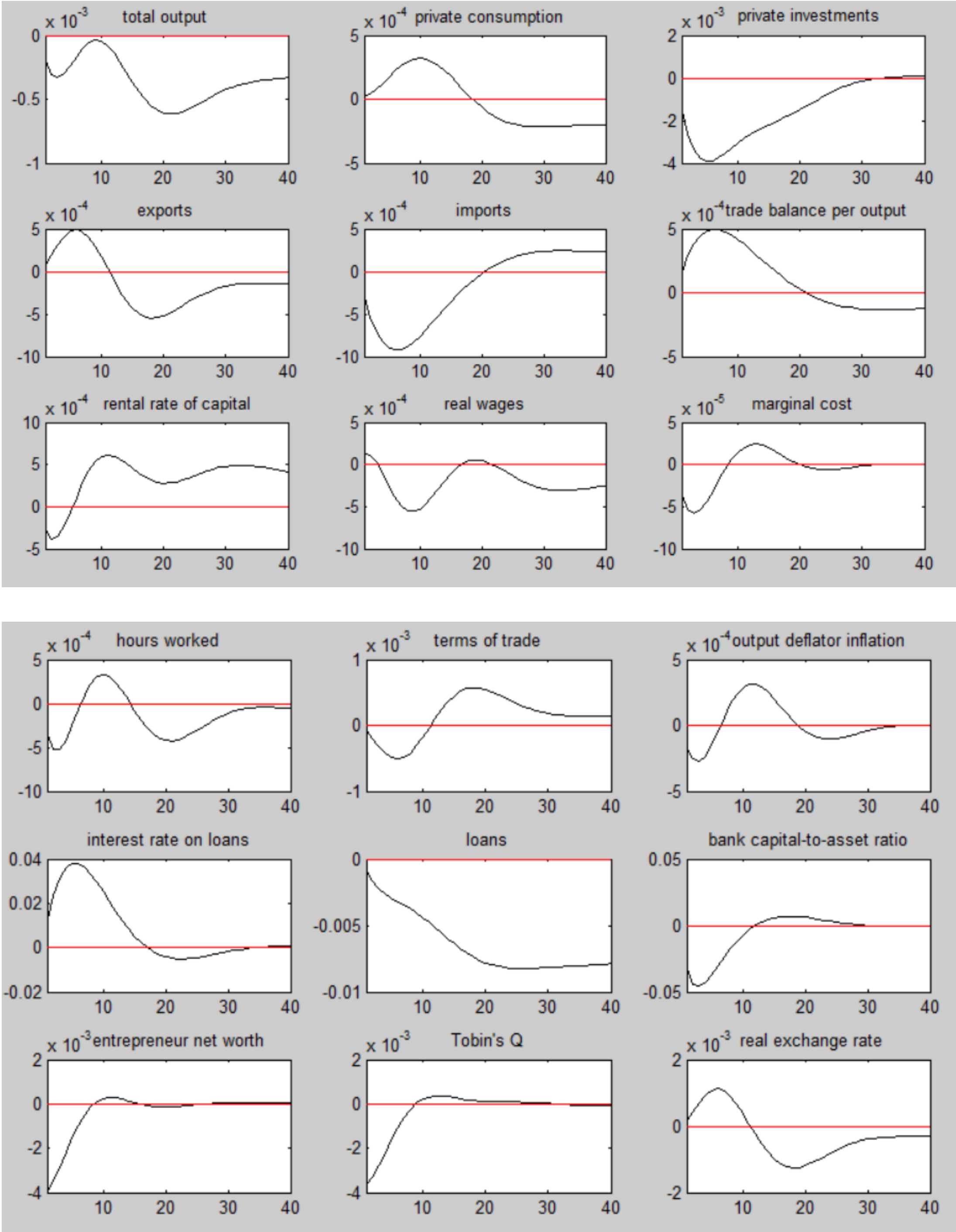


Figure 7. Impulse response functions – negative shock to bank capital

Note. The standard deviation of the shock is 3.5 percentage points and the initial bank capital-to-asset ratio is 13%.

The explanation of the results of this simulation follows the same logic as simulation three (when the first simulation was run at a higher initial capital level). Again, the bank capital-to-asset ratio declines by about 3.2 percentage points in response to the shock. However, the shock is smaller in proportion to the initial bank capital level, facilitating a faster recovery for the banks. Recall that the deviation cost is proportional to the level of the bank capital. As in simulation three, the lending rate therefore must be raised by more in terms of percentage points (at most, 380 basis points in period five). The maximum decline in investments is a deviation of 0.39% from the steady-state level. Consumption also reacts stronger than last time. The effect on total output is a decline of 0.0049% from the steady-state level in period 10, 0.061% in period 20 and 0.033% in period 40.

In summary, the economy recovers faster when the initial bank capital-to-asset ratio is higher since the unexpected loan losses (the shock) are smaller in proportion to the level of the bank capital. However, to increase the retained earnings, the banks must raise the interest rate on loans by more in terms of percentage points, to compensate for the larger deviation cost.

When comparing simulations one and three, where the effect of raising the target capital-to-asset ratio was tested for different initial capital ratios, the overall effect on investments and total output was similar between the two simulations. However, because of the characteristics of the shock in simulations four and five (larger and less persistent) the interest rate was raised by relatively more in the simulation with the higher initial capital level. Hence, the results from simulations four and five suggest that with higher initial capital levels, the economy recovers faster while the effect of the shock on investments and total output is greater.

5. Analysis

The macroprudential policy simulations above give some insight into how the Finnish economy could react when the Basel III capital requirements are implemented. The goal is to apply the results from the simulations to the theoretical framework of optimal bank capital levels presented by the BCBS (2010). In order to do this, the most relevant effect needs to be isolated: the percentage decline in total output. In this chapter, the effect on total output from the different simulations is further analyzed. Chapter 5.1 discusses the negative effect on total output when implementing the stronger capital requirements, the output drag, and what assumptions lay behind the results. Chapter 5.2 then analyze the cost and probability of crises in Finland, mostly from reviewing relevant literature.

5.1. The costs of increasing the bank capital requirements in Finland

Recall from chapter 2.5.1 that the optimal bank capital ratio is achieved when the marginal benefit of increasing the bank capital ratio equals the marginal cost, according to the BCBS (2010) theoretical framework. The benefit of increasing the level of the bank capital is assumed to be a reduction in the frequency of banking crises. To quantify this concept, the BCBS (2010) multiplies the probability of a banking crisis occurring with the expected future cost of a crisis. The cost of increasing the bank capital is explained as an output drag, a negative effect on GDP. The theory assumes that an increase in the capital requirements would raise the banks' cost of funding since equity is more expensive than debt. The banks would then pass on their increased costs to the borrowers, by raising the lending rates.

Simulations one to three can be interpreted as macroprudential policy simulations of the output drag following an increase in the bank capital requirements in Finland. Table one below shows the effect on total output in the Aino 2.0 model after the bank capital requirement has been shocked.

Table 1. Decline in total output following a shock to the bank capital requirement

	Simulation 1	Simulation 2	Simulation 3
Initial bca ratio (%)	8	8	13
Shock size (pp)	1	5	1
10 periods	0.013%	0.066%	0.011%
20 periods	0.034%	0.17%	0.034%
40 periods	0.058%	0.29%	0.051%

Note. Source: Granlund (2020)

A comparison between simulations one and three shows that the effect of a one percentage point increase in the target bank capital-to-asset ratio is not much different regardless of the initial level of bank capital. At least when comparing the initial level of 8% with the initial level of 13%. In the theoretical world of Aino 2.0, a five times larger shock also constitutes a five times larger response, as can be seen in simulation two. The banks in the model do not achieve their new target capital ratio until period 20. However, total output is still declining in period 40. Period 40 could be perceived as the long run, as this is 10 years after the rise in the bank capital requirement.

Naturally, these results are sensitive to changes in the exogenous structural parameter values in the model. Kilponen et al. (2016) (Bank of Finland) performed the estimation using Bayesian inference methods on Finnish time-series data from 1995-2014, as was explained in chapter 3.3.3. The only uncertainty about the simulations stems from the Bayesian estimation. As always, there is some uncertainty. However, since this seems to be the best estimation that the Bank of Finland could produce, the results should still be reliable. It is also unlikely that the structural parameter values would have changed considerably within five years, since this would require a change in the structure of the Finnish economy. Therefore, the parameter values should not provide too much uncertainty to the simulation results.

Another cause for uncertainty would be the model assumptions. Since the simulations are based on theoretical relationships, model deficiencies could easily distort the results. The most important assumptions, in this case, have to do with the banks' actions when they are forced to raise their bank capital reserves. Theoretically, the output drag occurs because equity is more expensive than debt: when the banks are forced to raise their equity, their overall funding costs increase as well. However, recall the proposition made by Modigliani and Miller (1958), which states that the capital structure of a firm does not have any implication for the firms' value (or cost of capital). This would imply that the transition to a higher level of capitalization among banks would have no effect on their funding costs. As was discussed in chapter 2.5.2, few papers apply the MM-offset in full, because of its highly theoretical nature. In the Aino 2.0 model, the MM-offset is zero [same as Almenberg et al. (2017)]. Still, the output drag would likely be smaller than in the simulations, if the Finnish banks are affected by the MM-offset.

Furthermore, the assumption about how the banks pass on their increased cost of funding to the loan-takers is another cause for uncertainty. Recall that in the BCBS (2010) theoretical framework, the banks' increased funding cost is assumed to be passed on to the borrowers in full. This assumption affects the size of the output drag. Firestone et al. (2017) achieve quite variating results when they test both the assumption that the banks pass on 100% of the additional cost to the borrowers and the assumption that they only pass on 50%.[39] If the cost is not passed on to the borrowers, the banks will have to accept a decline in their retained earnings.

In the Aino 2.0 model, the increased funding cost is passed on in full. However, according to the theoretical framework, the households are dependent on loan funding and are therefore directly affected by the increased lending rate. This causes a direct negative effect on both consumption and investments. Most of the studies presented in this thesis have, in one way or another, applied this concept. Recall that in the Aino 2.0 model, the only agents that are dependent on funding from the banks are the entrepreneurs. The households do not take any loans, they only place deposits in the banks. Consequently, the households' budget constraint is not directly affected by changes in the lending rate[40]. Furthermore, the entrepreneurs' only job is to buy and sell capital, they do not consume anything of the final good. Hence, consumption is only indirectly affected by changes in the lending rate. This is quite a large difference in how the model is designed and it probably dampens the effect of the output drag somewhat.

5.2. The benefits of increasing the bank capital requirements in Finland

Simulations four and five can be interpreted as a test of how well the Finnish banks would handle a situation of increased loan losses depending on their level of capitalization. Since both the capital requirement deviation cost and the loan rate adjustment cost are quite high, it is expensive for the banks to raise new funding. This somewhat resembles the state of the banking market in a financial crisis. The results indicate that the economy recovers faster from the crisis at a higher initial capital level. However, the effects of the crisis seem to be larger, as the banks must raise the interest rate by proportionately more to increase the retained earnings. Table two below illustrates the difference in simulation four and five: in period 20, the decline is roughly 40% greater in simulation five. However, the difference decreases as the economy in

[39] Assuming 100% pass on, the decline in GDP is estimated to be 0.074% and with only 50% pass on, the same effect is 0.037%.

[40] Recall that in the model description by Kilponen et al (2016), the lending rate is called "the wholesale lending rate", to enhance the fact that the rate is irrelevant for the households.

simulation five recovers faster, and in period 40, the effect is about as large in the two simulations.

Table 2. Decline in total output following a negative shock to bank capital

	Simulation 4	Simulation 5
Initial bca ratio (%)	8	13
Shock size (pp)	3.5	3.5
10 periods	0.008%	0.0049%
20 periods	0.039%	0.061%
40 periods	0.031%	0.033%

Note. Source: Granlund (2020)

However, since the banks and the firms in the model cannot go bankrupt, it is impossible to simulate the full cost of a banking crisis on total output. Instead, the cost and probability of a banking crisis in Finland can be analyzed through a literature overview.

As became clear in chapter 3.1, the Finnish banking sector is in many ways comparable to the Swedish banking sector. Furthermore, recall from chapter 2.5.2 that the overall largest estimate of the cost of crisis in an economy came from the Swedish study by Almenberg et al. (2017). Almenberg et al. (2017) estimate that the cost of a banking crisis in Sweden would be a cumulative output loss of 180% of pre-crisis GDP. When compared to the BCBS 2010 average of 63%, this is quite a large difference. As in Sweden, the Finnish banking sector is highly concentrated and large in comparison to GDP. Furthermore, the banks provide most of the credit in the economy, meaning that the real side of the economy could be greatly affected by declines in the banks' ability to give credit. Consequently, it is reasonable to assume that the high levels of systemic risk would cause the cost of a banking crisis to be very high in Finland. In addition, the systemic effects are not isolated to the Finnish economy. Recall from chapter 3.1 that cross-holdings and branches between the Nordic countries are very common. Because of this, the risk of the Swedish banking sector becomes relevant to Finland as well. Consequently, one could assume that the cost of a banking crisis in Finland could be close to the Swedish estimate.

In the literature, there are some estimates of the cost of past financial crises in Finland, most of them from the 1990s recession. Even though these estimates are not comparable to the current situation in Finland or the future expected cost of crisis, it is still interesting to compare them to estimates for other counties. The extensive IMF working paper "Systemic banking crises: an update" (Laeven & Valencia, 2012), presents estimates of the cost of systemic financial crises worldwide from 1970 to 2011. According to Laeven and Valencia (2012), the total cumulative output loss of the recession between 1991 and 1995 in Finland was 69.6% of GDP. This is well above the average output loss of a systemic banking crisis in the advanced economies in the data set, which is 32.9% of GDP. Table three below shows a comparison between the cost of a systemic banking crisis in a few counties.

Table 3. Total output loss following a systemic banking crisis

Country	Finland	Sweden	Denmark	France	Germany	US	UK	Average
Years	1991-1995	1991-1995	2008	2008	2008	2007	2007	1970-2011
Ouput loss % of GDP	69.6	32.9	36.00	23.00	11.00	31.00	25.00	32.9

Note. Source: Laeven and Valencia (2012)

All in all, it seems reasonable to assume that the future expected cost of a banking crisis in Finland would be larger than the BCBS (2010) estimated average of 63% of GDP.

The relevance of bank capital is also dependent on the probability of a banking crisis occurring in the analyzed economy. Chapter 2.2 discussed risks related to banking. Economies in which the banking sector is highly exposed to these risks will, naturally, have a higher probability of banking crisis. The high levels of systemic risk in the Finnish and Nordic banking sectors not only increases the costs of a potential financial crisis, but the probability as well. Recall from chapter 3.1 that most of the risk in the Finnish banking sector stems from credit risk related to lending. In addition, the loans-to-deposits ratio in Finland is around 160%, creating a funding gap. The funding gap is usually covered by equity or market funding with covered bonds. If the covered bonds are securitized by mortgage loans, this further increases the banks' interdependence on the housing market.[41] On the other hand, the average portfolio of a Finnish bank constitutes mostly low-risk assets, and the loan losses are lower than anywhere else in the world. (Savolainen & Tölö, 2017) In summary, it is safe to say

[41] According to Lainà, Nyholm and Sarlin (2015), growth in the loan-to-deposit ratio and the housing prices are both prominent leading indicators of financial crisis in Finland.

that the Finnish banks generally have a low risk profile. However, the high levels of systemic risk, both within Finland and internationally, will inevitably increase the probability of crisis. This is quite common for small and open economies.

From an empirical perspective, the frequency of systemic banking crises from 1970 – 2011 has been lower in Finland than in, *e.g.* the US and even Sweden (Laeven & Valencia, 2012). However, the numerical difference is one crisis compared to two crises, making it difficult to draw any conclusions.

Essentially, the power of bank capital is its assumed ability to reduce the probability of a banking crisis, by making the banks more resilient to unexpected loan losses. Thus, part of the analysis of higher capital requirements should include an estimate of the reduced crisis probability. As was discussed in chapter 2.5.1, it is difficult to estimate how the probability of crisis reacts to increases in the bank capital. Recall that the BCBS 2010 report estimated that the probability of crisis would decrease with 1.6 percentage points when raising the minimum bank capital requirement from 7% to 8%. However, the estimate proved to be sensitive to the initial bank capital level, and the effect was diminishing. When increasing the capital requirement from 12% to 13%, the effect was only 0.2. (BCBS, 2010)

In the literature, there are no real estimates of how the probability of crisis in Finland would react to changes in the bank capital levels. The closest estimate available could be assumed to be the Almenberg et al. (2017) study from Sweden. Almenberg et al. (2017) use two different models to estimate how the probability of crisis reacts to changes in the bank capital ratio in Swedish banks: a standard model for credit risk and an empirical model based on historical data. Both models assume that the banks start experiencing trouble when the value of their assets falls below the value of their liabilities. The more volatile the assets are, the greater the risk is that the market value drops considerably. Higher levels of bank capital allow for more volatility in the market value of the asset before the situation becomes critical. Almenberg et al. (2017) produce a range of estimates with their two models. The BCBS (2019) meta-analysis then summarizes these results as a 0.7 percentage point decrease in the probability of crisis, following a one percentage point increase in the bank capital ratio. The effect is much smaller than the BCBS (2010) average of 1.6, which can only be assumed to depend on the generally low volatility of the market value of assets in the portfolios of the Swedish banks. Since the average risk-weights of assets in Finnish and Swedish banks are at approximately the same level (Savolainen & Tölö, 2017), it is reasonable to assume that the Finnish banking sector would react similarly if tested in the same setting.

In summary, one could say that the probability of a banking crisis in Finland is lower than average. However, if a crisis were to happen, extensive systemic effects in the banking sector could cause the cost of the crisis to be enormous.

6. Discussion

The relevant effects of the simulations were isolated and further analyzed in the foregoing chapter. In this chapter, the results will be discussed in relation to previous studies and the BCBS (2010) theoretical framework of optimal bank capital. Chapter 6.1 provides a peer comparison of the results from the simulations, chapter 6.2 concludes what can be said about the optimal capital ratio in Finland, and chapter 6.3 discusses some critique of the theoretical framework of optimal bank capital.

6.1. Peer comparison

This thesis has studied the costs (and benefits) of increasing the bank capital requirements in Finland, as these concepts have been theorized by the BCBS (2010). By using a DSGE model for the Finnish economy, unique estimates of the output drag have been produced. Table four below compares one of these estimates to similar studies, which have also applied the theoretical framework of the BCBS (2010). All of the estimates show the long-term effect on total output of a one percentage point increase in the minimum bank capital requirement when the initial level of bank capital was around 8%. The estimate chosen to represent this study is the long-term effect on total output from simulation one.

Table 4. Percentage decline in GDP following a one percentage point increase in the minimum bank capital requirement

Paper	Brooke et al. (2015)	Granlund (2020)	Firestone et al. (2017)	BCBS (2010)	Almenberg et al. (2017)
Country	UK	Finland	US	BCBS members	Sweden
Effect	0.01%-0.05%	0.058%	0.037%-0.074%	0.09%	0,09%-0.13%

Note. Source: Brooke et al. (2015); Granlund (2020); Firestone et al. (2017); BCBS (2010) & Almenberg et al. (2017)

The Finnish estimate falls in the lower end of this sample. Compared to the BCBS (2010) average, the Finnish estimate is approximately 36% lower. Furthermore, the difference to the Swedish estimate is even larger. The remaining question is therefore: what causes the difference in the estimated output drag?

The most straightforward answer would be differences in the estimated structural parameter values of the models used in the studies. In other words, differences in the structure of the analyzed economy. Generally, one could say that the movements of the economy could be more or less rigid. The similarities between the Finnish and Swedish economies have been emphasized several times in this study; thus, it is somewhat nonintuitive that the estimates of the output drag differ to this degree. According to Kilponen et al. (2016), the Finnish economy is characterized by high levels of consumption habit formation and wage stickiness. The estimated consumption habit formation in the RAMSES model of the Swedish national bank is notably smaller than in the Aino 2.0 model. However, a high degree of price stickiness still leaves the Swedish economy sluggih. (Adolfson, Laséen, Christiano, Trabandt & Walentin, 2013) Consequenly, differences in the structural parameter values might explain some of the variation in the estimates of the output drag, but not all of it.

The natural next step would be to compare model assumptions. Both the Brooke et al. (2015) and the Firestone et al. (2017) studies apply a MM-offset of 50%. Thus, 50% of the would-be increase in the cost of funding is offset when the higher level of capitalization transforms the bank into a less risky investment. If Brooke et al. (2015) and Firestone et al. (2017) had assumed a 0% MM-offset, like the rest of the studies, their estimates would probably have been larger. Taking this into consideration, the Finnish estimate is even smaller in comparison to the sample.

According to the BCBS (2010) theoretical framework [and the BCBS (2010) estimate of the output drag], the banks' increased cost of funding is passed on to the loan takers in full by raising the lending rate. The increased cost of borrowing shrinks the households' budget constraint and both private consumption and investments decrease. All of the studies included in table four assume that the increased cost is passed on to the borrowers in full. One exception is the Firestone et al. (2017) estimates, where the lower estimate assumes a pass-through of 50% and the higher assumes a pass-through of 100%.

In most of the previous studies, the output drag is estimated in a two-step process: firstly, the effect of higher funding costs on the lending rate is estimated, and secondly, the effect of higher lending rates on total output is estimated. The Aino 2.0 model features bank capital and a target capital-to-asset ratio, making it possible to directly estimate the effect of increasing the minimum capital requirement on total output. However, recall from chapter 5.1 that in the Aino 2.0 model, the households are completely independent of loan funding. Furthermore, "the entrepreneurs", who only deal with investments and do not contribute to private consumption, are the only ones affected by the increased lending rate. Consequently, even though the increased cost of funding is passed on to the borrowers in full, private consumption is only indirectly affected.

This is probably the main reason why the estimated output drag in Finland is so small in comparison to the other studies, which all assume that the increased lending rate has a direct negative effect on both consumption and investments. Since, in reality, the Finnish households are quite indebted, this could be seen as a flaw in the model. As of 2019, the Finnish households' debt to disposable income was 127.3% and the interest expenses to disposable income was 1.5%. Most of the household debt is composed of mortgage loans. In addition, Finnish housing corporations are also becoming more indebted, further increasing household debt indirectly. Moreover, private consumption is likely to be negatively affected if, *e.g.*, interest rates rise, at the current level of household debt in Finland. (Nykänen, 2019)

Forcing the households in Aino 2.0 to take mortgage loans from the banks would probably make the model more realistic. Kilponen et al. (2016) have also noted this flaw and discuss how the model could be improved. They suggest including a housing market in the model, in the spirit of Iacoviello (2005). The households would then be dependent on loan funding and their ability to take loans would be tied to the value of their houses. In such a model, it would be possible to differentiate between the risk weights of assets in the banks' portfolios as well.

Furthermore, the results from simulation four and five are in line with the findings from Jorda et al. (2018), who concludes that banks recover from loan losses quicker at a higher level of capitalization. The results from Kanngiesser, Martin, Maurin and

Moccero (2017), who perform a Bayesian vector autoregression analysis, also indicate that higher capital buffers dampen the negative effects of a financial crisis.

6.2. Optimal bank capital in Finland

According to the BCBS 2010 report and the BCBS (2019a) literature overview, the optimal minimum bank capital ratio among the member countries lies somewhere around 13%. Consequently, it would still be possible to raise the minimum capital ratio from the Basel II level. The implementation of the Basel III capital requirements could have negative effects in Finland if the optimal capital ratio here was much lower.

The optimal bank capital ratio in the BCBS 2010 report is composed of an estimated average output drag of 0.09%, a cost of crisis equivalent to a cumulative output loss of 63% of pre-crisis GDP and a reduced crisis probability of 1.6 percentage points following a one percentage point increase in the capital requirements. According to the findings of this study, the estimated long-term output drag in Finland, when raising the minimum bank capital requirement from 8% to 9%, is 0.058%. The literature overview and the analysis of the structure of the Finnish banking sector imply that the reduction in crisis probability is lower than the BCBS (2010) average, whereas the cost of crisis is higher.

The fact that the output drag in Finland is estimated to be lower than the BCBS (2010) average indicates that the optimal bank capital level might be higher than 13%. Furthermore, the relatively high expected future cost of crisis in Finland also increases the optimal bank capital level. However, a lower reduction in the probability of crisis when the capital requirements are raised would somewhat offset the increased benefit of bank capital. Thus, without any real estimates, it is difficult to draw conclusions about the benefits of bank capital in Finland. In addition, the absence of household debt in the model implies that the estimated output drag could be too small. Consequently, it is not possible to say with certainty, whether the optimal bank capital ratio in Finland differs from the BCBS (2010) average.

Almenberg et al. (2017) present a quite simple way of determining the net benefits of bank capital from the components of the BCBS (2010) theoretical framework. They multiply the reduction in the probability of crisis with the cost of crisis to receive the expected benefit of bank capital. After this, they simply subtract the output drag to receive an estimate of the net benefit of bank capital. If the net benefit is positive, there is still room to increase the bank capital requirements. Table five below shows what the net benefit from increasing the capital requirement with one percentage point would be using the average estimates from the BCBS 2010 report (the first row) and compares this to different scenarios for Finland.

In the first scenario, the BCBS (2010) average estimate for the benefits of bank capital is compared to the estimated output drag for Finland. Since the estimated output drag is smaller than the BCBS average, the net benefit in scenario one is larger. In scenario two, the estimate for the benefit of bank capital is taken from the Almenberg et al. (2017) study. Recall that, in the literature, it is most likely that estimates from Sweden could describe the Finnish economy. Even though the decrease in the probability of crisis is much smaller, the large cost of crisis still increases the expected net benefits from scenario one. The last scenario combines the estimated cost of the 1991 recession in Finland from Laeven and Valencia (2012), with the reduction in crisis probability from Almenberg et al. (2017) and the estimated output drag for Finland. This is the only scenario where the net benefits of bank capital are lower than the BCBS (2010) estimated average.

Table 5. Net benefits of increasing the minimum bank capital requirement by one percentage point (from the initial level of 8%)

	Increase in bca ratio	Decline in P(crisis) %	Cost of crisis % of GDP	Benefit % of GDP	Output drag % of GDP	**Net benefit % of GDP**
BCBS average	1pp	0.016	63	1.01	0.09	**0.92**
Scenario 1	1pp	0.016	63	1.01	0.058	**0.95**
Scenario 2	1pp	0.007	180	1.26	0.058	**1.20**
Scenario 3	1pp	0.007	70	0.49	0.058	**0.43**

Note. Source: Granlund (2020); BCBS (2010); Almenberg et al. (2017) & Laeven and Valencia (2012)

In summary, the estimated output drag implies that there is still room to increase the capital requirements in Finland. However, if a renewed version of the Aino 2.0 model that includes a housing market and household debt, is released, it would be interesting to run the simulations again. The probability of crisis is most likely lower than average in Finland, because of the low risk profile and loan losses of the banks. However, the high degree of systemic risk causes the cost of crisis to be large in Finland. Taking scenario three as given, the cost of crisis would have to be larger than approximately 140% of GDP (cumulative) to keep the net benefit of crisis higher than average in Finland. If the cost of crisis is smaller than 140% of GDP, the optimal bank capital ratio in Finland would be lower than the BCBS (2010) average of 13%. However, as the net benefit in all the scenarios is still positive, it is reasonable to assume that there is still room to raise the bank capital requirements from the Basel II level in Finland.

6.3. Critique of the theoretical framework

Even though the optimal bank capital ratio for Finland cannot be concluded with the efforts of this study, the results indicate that there is still room to raise the capital requirements from the Basel II level. However, the credibility of the analysis does not only depend on the credibility of the method, but on the credibility of the theoretical framework as well. This chapter is dedicated to reviewing the assumptions behind the BCBS (2010) theoretical framework of optimal bank capital.

Recall from chapter 2.3 and 2.4 that the regulations of the Basel III accord are quite complicated. In the theoretical framework there is a minimum capital requirement and several buffers which are in force only when certain criteria are met. The theoretical framework does not separate the minimum requirement and the possible additional buffers. Moreover, bank capital in the theoretical framework is defined as common equity to risk-weighted assets according to the Basel I and II accords. This causes two problems: firstly, there are several different forms of capital in the Basel III accord (CET1, Tier 1 and Tier 2 capital), and secondly, the calculation of risk-weighted assets has changed in the Basel III accord. Recall from chapter 2.4 that Basel III is a step away from self-regulation (by the internal ratings-based approach) and a step towards standardization. Consequently, the 8% minimum capital ratio of the Basel I and II accords is not comparable to the 8% minimum capital ratio of the Basel III accord. The actual capital reserves are much larger if the Basel III requirements are followed. Thus, the theoretical optimal capital ratio is to be taken with a pinch of salt, if it is to be applied to the conditions of the Basel III accord. What the theoretical optimal capital ratio does tell us, is whether there is still room to increase the capital reserves from the Basel II level. In addition, the Basel III accord also includes liquidity requirements, which are completely excluded from this analysis. These issues are also discussed in the BCBS 2010 report.

7. Conclusions

The purpose of this thesis has been to examine the macroeconomic effects of implementing the Basel III capital requirements in the Finnish economy, to conclude whether the effects could be different from what the Basel committee estimates in their long-term economic impact study (BCBS, 2010). In an effort to respond to the concerns of the Nordic and the Dutch banking associations (Svenska Bankföreningen, Dutch Banking Association, Danish Bankers Association & Finanssialan Keskusliitto, 2016), the thesis asks the question: could stronger capital requirements have negative effects on the Finnish economy?

The thesis applies the theoretical framework of optimal bank capital from the BCBS 2010 report. The framework defines the benefit of bank capital as the reduced probability of banking crises times the expected future cost of crises. The cost of bank capital is defined as the negative effect that higher loan spreads have on total output, in other words, the output drag. By using the theoretical framework of the BCBS 2010 report, the results of this thesis are comparable to both the BCBS study and other studies of optimal bank capital.

In order to estimate the output drag for Finland, a dynamic stochastic general equilibrium (DSGE) model created by the Bank of Finland (Suomen Pankki) was used. The latest version of the model, Aino 2.0, was published online in 2016 (Kilponen et al., 2016). Aino 2.0 is a small, open-economy model, calibrated using Finnish time-series data from 1995-2014. Aino 2.0 features a complex banking sector with bank capital requirements, making it possible to impose shocks directly to the requirements. The reduced crisis probability following an increase in the capital requirements and expected future cost of crisis cannot be estimated using the same model. Thus, the benefit of bank capital in Finland was analyzed through a literature overview.

The results of the macroprudential policy simulations imply that the output drag could be smaller in Finland than the BCBS (2010) average. However, the small output drag could partly be explained by the lack of household debt in the Aino 2.0 model. Hence, an improvement to the model would be a housing market and mortgage loans. If a renewed version of the model were to be released, it would be interesting to run the simulations again. The literature overview implies that the reduced crisis probability might be smaller in Finland than the BCBS (2010) average, because of the low risk profile and loan losses of the Finnish banking sector. However, the high levels of systemic risk in the Finnish economy suggest that the cost of crisis could be much larger than the BCBS (2010) average.

All in all, it is difficult to conclude the optimal level of bank capital in Finland without any exact estimates of the benefit of bank capital. Nevertheless, the results of this study imply that the net benefits are still positive when increasing the bank capital ratio with one percentage point from the Basel II level. Consequently, the results are in line with the BCBS 2010 report and the answer to the question "Could stronger capital requirements have negative effects on the Finnish economy?" would be: probably not.

The use of the Aino 2.0 model was suitable as a method for simulating the costs of raising the capital requirements in Finland. Other models or estimation techniques would have to be applied to properly estimate the benefits of bank capital. Hence, there is still room for further research in the field. As for the theoretical framework of optimal bank capital: there is a risk that the simplicity of the framework complicates the comparability between the requirements of Basel II and III, since the risk weights of the assets are calculated differently in the two accords. In addition, this analysis ignores the liquidity requirements of Basel III. It might be interesting to also research how the capital and the liquidity requirements act together.

This thesis extends the research of optimal bank capital in countries affected by Basel III. Analyses of individual economies, such as this one, are used by the Basel committee when researching the possible impact of policy changes. This thesis could also guide national policymakers when deciding on domestic capital requirements.

8. Swedish summary – Svensk sammanfattning

Skulle högre kapitalkrav kunna skada den finländska ekonomin? En estimering av effekten av att implementera Basel III

Kapitalkraven för banksektorn kommer att höjas som en följd av implementeringen av det senaste fördraget från Baselkommittén för banktillsyn[42] (i fortsättningen: Baselkommittén), Basel III[43]. Grundtanken med de nya standarderna är att öka bankernas uthållighet i tider av ekonomisk ostabilitet. Det tidigare ramverket, Basel II, fick motta hård kritik efter finanskrisen 2008, på grund av dess lediga förhållningssätt till bankernas riskbedömning[44]. I samband med Basel III har Baselkommittén gått in för att standardisera och höja minimikraven för bankkapital. I den finländska lagstiftningen anpassas EU:s adaption av Basel III: direktivet CRD IV (Europeiska kommissionen, 2013). Sammanfattningsvis kan sägas att minimikvoten mellan bankkapital och riskvägda tillgångar förblir 8 %, men att beräkningen av de riskvägda tillgångarna skärps. Således stiger kapitalkravet i verkliga termer. Ett antal buffrar med olika villkor (t.ex. buffrar för banker vars position på marknaden medför stor systemisk risk) har även tagits i bruk.

År 2010 publicerade Baselkommittén en utvärdering av hur Basel III kan antas påverka ekonomin i medlemsländerna (BCBS, 2010). Rapporten formulerar ett ramverk för att beräkna den optimala nivån av bankkapital för en ekonomi. Enligt ramverket uppnås den optimala nivån av bankkapital där marginalnyttan av kapitalet är lika stor som marginalkostnaden. Nyttan av bankkapital definieras som den minskning av sannolikheten för att det ska uppstå en bankkris som höjningen av bankkapitalet medför, gånger den förväntade framtida kostnaden av en bankkris. Kostnaden definieras däremot som den minskning av BNP som höjningen av bankkapitlet orsakar. Den teoretiska motiveringen till att ökat bankkapital minskar BNP är att högre

[42] Baselkommittén för banktillsyn är det främsta internationella organet som arbetar för stabilitet på bankmarknaden. De fördrag som publiceras fungerar som standarder och bör implementeras i nationell lagstiftning. Baselkommittén består av 45 medlemsinstitutioner från 28 jurisdiktioner och har sitt huvudkontor vid Banken för internationell betalningsutjämning (BIS) i Basel.

[43] Basel III har reviderats flera gånger och ibland används benämningen Basel IV när de nyaste tilläggen diskuteras. Denna avhandling omnämner dock hela fördraget som Basel III.

[44] Nocera (2019) och Salmon (2012) sammanfattar kritiken mot Basel II och hur bankerna enligt detta ramverk kunde beräkna risken i deras verksamhet med interna modeller. Nassim Taleb är en annan känd kritiker av kvantitativa riskberäkningsmodeller.

kapitalkrav antas höja bankernas finansieringskostnad, eftersom eget kapital är dyrare än främmande kapital. Bankerna antas då överföra ökningen i finansieringskostnaden till kunderna genom att höja utlåningsräntan. En höjning i utlåningsräntan skulle höja kostnaderna för hushållen och därmed minska den privata konsumtionen, investeringarna och slutligen BNP.

Resultatet av Baselkommitténs rapport tyder på att medelkostnaden i medlemsländerna skulle vara en minskning i BNP med 0,09 % efter att kapitalkraven höjs med en procentenhet. Motsvarande minskning i sannolikheten för kris skulle vara 1,6 procentenheter. Vidare estimeras den kumulativa kostnaden av en bankkris vara 63 % av BNP (före krisen). Detta utgör en optimal kapitalkvot på 13 %, alltså konstaterar kommittén att det borde finnas utrymme att höja kapitalkraven från Basel II-nivån. (BCBS, 2010) Baselkommitténs estimat är ett grovt medeltal och flera andra studier har därför försökt estimera den optimala kapitalkvoten för deras länder (Firestone m.fl., 2017; Brooke m.fl., 2015; Miles m.fl., 2013 & Almenberg m.fl., 2017). Ingen liknande studie har ännu genomförts för Finland. Ifall den optimala kapitalkvoten i Finland skulle visa sig vara mycket lägre än Baselkommitténs estimat, så skulle högre kapitalkrav kunna skada den finländska ekonomin. Syftet med den här studien är således att analysera den optimala nivån av bankkapital i Finland, enligt Baselkommitténs teoretiska ramverk, för att undersöka ifall särdragen i den finländska ekonomin kan ge upphov till en avvikande optimal kapitalkvot. Studien ger riktlinjer till både nationella och internationella myndigheter om hur en liten, öppen ekonomi som Finland kan påverkas av internationella policyer.

För att estimera kostnaderna av att höja kapitalkraven i Finland använder denna studie Finlands banks DSGE-modell vid namn Aino 2.0. DSGE står för dynamisk stokastisk allmän jämvikt (*dynamic stochastic general equilibrium*). I praktiken är DSGE-modeller stora, makroekonomiska tillväxtmodeller vars allmänna jämvikt baserar sig på mikroteori, medan de strukturella parametrarna är estimerade för att matcha den undersökta ekonomin. DSGE-modeller används vanligen för makroekonomiska policysimuleringar och långsiktiga prognoser. Aino 2.0 är konstruerad av Kilponen m.fl. (2016) för att efterlikna den finländska ekonomin. Parametervärdena är estimerade utifrån finländskt seriedata från åren 1995 till 2014. Nyttan av bankkapital i Finland kan inte estimeras med hjälp av samma modell. Istället diskuteras sannolikheten och kostnaden för en bankkris i Finland utgående från tidigare forskning och litteratur. En viktig källa i denna litteraturanalys är en svensk studie av Almenberg m.fl. (2017), eftersom Sveriges och Finlands ekonomier har många gemensamma drag.

Genom att chocka olika variabler i en DSGE-modell, och analysera de makroekonomiska aggregatens impulsresponsfunktioner, är det möjligt att undersöka hur ekonomin reagerar till följd av en förändring. Aino 2.0 innehåller en komplicerad banksektor med bankkapital. Bankerna måste upprätthålla en viss kapitalkvot för att undvika straffkostnader. Denna kapitalkvot kan representera ett kapitalkrav infört av myndigheterna. För att simulera effekten av att höja kapitalkravet definieras en permanent strukturell chock. Följden av chocken blir således en höjning i kapitalkravet med en standardavvikelse genom alla perioder som ingår i analysen.

I huvudsak görs tre olika simuleringar. I den första simuleringen är kapitalkravet till en början 8 % och standardavvikelsen av chocken är en procentenhet. Detta innebär att kapitalkravet höjs från 8 % till 9 %. I den andra simuleringen är standardavvikelsen istället fem procentenheter, så att kapitalkravet höjs från 8 % till 13 %. I den sista simuleringen testas effekten av simulering ett från ett högre utgångsläge, kapitalkravet höjs då från 13 % till 14 %. Kort sagt leder ökningen i kapitalkravet till att bankerna höjer utlåningsräntan för att öka de balanserade vinstmedlen. Detta påverkar de privata investeringarna negativt och realkapitalet i ekonomin minskar. Hushållen i modellen är inte beroende av lånefinansiering, vilket betyder att den privata konsumtionen endast påverkas indirekt. Den slutliga effekten är en bestående minskning i BNP. Skillnaden mellan simulering ett och tre är mycket liten och effekten av simulering två är, som förväntat, fem gånger så stor.

Ytterligare görs två simuleringar (simulering fyra och fem) för att testa ifall den negativa effekten av oförväntade låneförluster för bankerna skulle variera beroende på vad kapitalkravet är. Bankernas reaktion på låneförluster liknar deras reaktion på höjda kapitalkrav, eftersom båda händelserna tvingar bankerna att höja utlåningsräntan. Dock är chocken i det här fallet icke-permanent och standardavvikelsen av chocken är hela 3,5 procentenheter, vilket motsvarar de finländska bankernas förluster år 2009 (Kilponen m.fl., 2016). I den första av dessa simuleringar är kapitalkravet 8 % och i den andra är det 13 %. Analysen indikerar att effekten av chocken är större (eftersom bankernas straffkostnad för att avvika från kapitalkravet beräknas i relation till kapitalkravet), men att ekonomin återhämtar sig snabbare (eftersom chocken är mindre i relation till bankernas kapitalreserver) när kapitalkraven är högre.

Simulering ett är mest jämförbar med Baselkommitténs rapport (BCBS, 2010) och andra studiers estimat för marginalkostnaden av bankkapital. Enligt simulering ett är den långsiktiga effekten av att höja minimikapitalkravet i Finland med en procentenhet en minskning av BNP med 0,058 %. Jämfört med Baselkommitténs medelvärde på 0,09 % tyder resultatet på att marginalkostnaden är lägre i Finland[45]. Eftersom hushållen i Aino 2.0-modellen inte är beroende av lånefinansiering, och den privata konsumtionen endast påverkas indirekt, kan den estimerade effekten vara för låg. En förbättring av modellen, som även Kilponen m.fl. (2016) föreslår, är att inkludera en bostadsmarknad och bostadslån i modellen. Detta skulle antagligen ge en mera verklighetstrogen bild av situationen i Finland, eftersom de finländska hushållen i själva verket är mycket skuldsatta (Nykänen, 2019).

Den finländska banksektorn är den mest koncentrerade i Europa (Savolainen & Vauhkonen, 2015) och banklån utgör den största källan till kredit i ekonomin. Dessutom kännetecknas den nordiska bankmarknaden av en stor andel korsinnehav mellan bankerna och samma bank har ofta filialer i alla nordiska länder. (Savolainen & Tölö, 2017) Till följd av detta är nivån av systemisk risk väldigt hög i Finland, vilket innebär att en bankkris skulle kunna ha förödande effekter. Vidare tyder empirin på att den framtida förväntade kostnaden av en finanskris kunde vara högre i Finland än Baselkommitténs medelvärde på 63 % av BNP[46]. Gällande minskningen i sannolikheten för en bankkris till följd av högre kapitalkrav finns inga egentliga estimat att gå efter för Finland. Almenberg m.fl. (2017) estimerar att sannolikheten i Sverige skulle minska med ungefär 0,7 procentenheter, vilket är mycket lägre än Baselkommitténs medelvärde på 1,6 procentenheter. Generellt är de finländska bankernas riskprofil låg och bankerna upplever sällan betydande låneförluster

---

[45] Andra estimat är exempelvis Brooke m.fl. (2015) som estimerar en effekt på 0,01 % – 0,05 %, Firestone m.fl. (2017) som estimerar en effekt på 0,037 % – 0,074 % och Almenberg m.fl. (2017) som estimerar en effekt på 0,09 % – 0,13 %.

[46] Den kumulativa förlusten av recessionen mellan 1991 och 1995 i Finland estimeras ha varit 69,6 % av BNP (Laeven & Valencia, 2012). Almenberg m.fl. (2017) estimerar att den framtida förväntade kostnaden av en bankkris i Sverige kunde vara så mycket som 180 % av BNP (kumulativt), vilket kan vara jämförbart med situationen i Finland.

(Savolainen & Tölö, 2017). Detta kan tyda på att sannolikheten för en bankkris är relativt låg i Finland.

Resultaten av simulering fyra och fem är i linje med Jorda m.fl. (2018) och Kanngiesser m.fl. (2017), vilka även konstaterar att högre kapitalkrav antagligen dämpar den negativa effekten av låneförluster för bankerna.

Sammanfattningsvis kan sägas att det inte går att härleda den optimala nivån av bankkapital i Finland utan exakta estimat av marginalnyttan. Resultatet av denna studie indikerar trots allt att nettomarginalnyttan av att öka minimikapitalkravet med en procentenhet från Basel II-nivån är positiv och större än Baselkommitténs estimerade medelvärde. Precis som Baselkommitténs rapport (BCBS, 2010) tyder alltså denna studie på att det fortfarande finns utrymme att höja kapitalkraven i Finland från Basel II-nivån. Det är dock viktigt att komma ihåg att minimikvoten på 8 %, beräknad utifrån Basel II, inte motsvarar samma minimikvot beräknad utifrån Basel III. Detta innebär att det teoretiska ramverket för att beräkna den optimala kapitalkvoten bör tas med en nypa salt vid jämförelser mellan kapitalkraven för Basel II och Basel III.

References

Adjemian, S., Bastani, H., Juillard, M., Karamé, F., Maih, J., Mihoubi, F., Perendia, G., Pfeifer, J., Ratto M., Villemot, S., (2020). Dynare: Reference Manual Version 4. *Dynare Working Paper series, No. 1.* https://www.dynare.org/wp-repo/dynarewp001.pdf

Adolfson, M., Laséen, S., Christiano, L., Trabandt, M., & Walentin, K. (2013). Ramses II: Model description. *Occasional Paper No. 12.* Sveriges Riksbank. https://www.riksbank.se/contentassets/e01d64fc644b462cb345ba0f4c85cf24/rap_occasional_paper_nr12_130306.pdf

Almenberg, J., Andersson, M., Buncic, D., Cella, C., Giordani, P., Grodecka, A., ... & Söderberg, G. (2017). Appropriate capital ratios in major Swedish banks–new perspectives. *Staff Memo*. Financial Stability Department, Sveriges riksbank. http://lup.lub.lu.se/record/de24ca48-0c40-46eb-ae0a-bcfb4cdd286c

Asplund, T. (2016). Reform of Bank Capital Regulation Enters Final Phase. *Bank of Finland Bulletin, 2/2016,* pp. 91-96. https://www.bofbulletin.fi/en/2016/2/reform-of-bank-capital-regulation-enters-final-phase/

Bank for International Settlements. (2019a). History of the Basel Committee. Retrieved 2019-10-24 from: https://www.bis.org/bcbs/history.htm

Bank for International Settlements. (2019b). History – overview. Retrieved 2019-10-24 from: https://www.bis.org/about/history.htm

Bank of Finland. (2019a). Statistics. Retrieved 2019-12-03 from https://www.suomenpankki.fi/en/Statistics/

Bank of Finland. (2019b). Capital ratios for the banking sector in Finland. Retrieved 2019-12-09 from https://www.suomenpankki.fi/en/Statistics/chart-gallery/financial-cycle-indicators/risks-related-to-credit-institutions/pankkisektorin_vakavaraisuussuhdeluvut/

Bank of Finland. (2019c). Loan-to-deposit ratio in the Finnish banking sector*. Retrieved 2019-12-10 from https://www.suomenpankki.fi/en/Statistics/chart-gallery/financial-cycle-indicators/risks-related-to-credit-institutions/lainojen_ja-talletusten_suhde/

Basel Committee on Banking Supervision. (2010). *An assessment of the long-term economic impact of stronger capital and liquidity requirements*. Bank for International Settlements, Basel. https://www.bis.org/publ/bcbs173.pdf

Basel Committee on Banking Supervision. (2011). *Basel III: A global regulatory framework for more resilient banks and banking systems.* Bank for International Settlements, Basel. https://www.bis.org/publ/bcbs189.pdf

Basel Committee on Banking Supervision. (2013a). *Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement.* Bank for International Settlements, Basel. https://www.bis.org/publ/bcbs255.pdf

Basel Committee on Banking Supervision. (2013b). *Fundamental review of the trading book: A revised market risk framework.* Bank for International Settlements, Basel. https://www.bis.org/publ/bcbs265.pdf

Basel Committee on Banking Supervision. (2017a). *Basel III: Finalising post-crisis reforms.* Bank for International Settlements, Basel. https://www.bis.org/bcbs/publ/d424.pdf

Basel Committee on Banking Supervision. (2017b). *Finalising Basel III: In brief.* Bank for International Settlements, Basel. https://www.bis.org/bcbs/publ/d424_inbrief.pdf

Basel Committee on Banking Supervision. (2019a). *The costs and benefits of bank capital – a review of the literature.* Bank for International Settlements, Basel. https://www.bis.org/bcbs/publ/wp37.htm

Basel Committee on Banking Supervision. (2019b). *The market risk framework: In brief.* Bank for International Settlements, Basel. https://www.bis.org/bcbs/publ/d457_inbrief.pdf

Brooke, M., Bush, O., Edwards, R., Ellis, J., Francis, B., Harimohan, R., ... & Siegert, C. (2015). Measuring the macroeconomic costs and benefits of higher UK bank capital requirements. *Bank of England Financial Stability Paper, 35*.

Bodie, Z., Kane, A. & Marcus, A. J. (2018). *Investments* (11th. ed.). Boston: McGraw-Hill/Irwin.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics, 12(3),* pp. 383-398.

Chen, W., Mrkaic, M. & Nabar, M. (2019). The Global Economic Recovery 10 Years After the 2008 Financial Crisis. *IMF Working Papers, 19(83),* p. 1. doi:10.5089/9781498305426.001

Chernobai, A., Jorion, F & Yu, F. (2011). The determinants of operational risk in U.S. financial institutions. *Journal of Financial and Quantitative Analysis*, 46(6), 1683-1725. doi:10.1017/S0022109011000500

Cline, W. R. (2015). Testing the Modigliani-Miller theorem of capital structure irrelevance for banks. *Peterson Institute for International Economics Working Paper*, (15-8).

Costa, C. J. (2016). *Understanding DSGE models: Theory and applications.* Wilmington, Delaware; Malaga, Spain: Vernon Press.

Costa Junior, C. J. & Garcia-Cintado, A. C. (2018). Teaching DSGE models to undergraduates. *EconomiA, 19(3),* pp. 424-444. doi:10.1016/j.econ.2018.11.001

Danske Bank. (2019) About us. Retrieved 2019-12-03 form https://danskebank.com/about-us

European Commission. (2013). Regulation (EU) No.575/2013 of the European Parliament and the Council of 26. June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No. 648/201. *Official Journal of the European Union, L 176*, p. 1-337.

Finance Finland (FFI). (2019). Finnish Banking in 2018. https://www.finanssiala.fi/en/material/FFI-Finnish-Banking-in-2018.pdf

Firestone, S., Lorenc, A. & Ranish, B. (2017). An Empirical Economic Assessment of the Costs and Benefits of Bank Capital in the US. *Finance and Economics Discussion Series, 2017(034).* doi:10.17016/FEDS.2017.034

Freixas, X. & Rochet, J. (2008). *Microeconomics of banking* (2nd ed.). Cambridge, Mass.: MIT Press.

Gerali, A., Neri, S., Sessa, L. & Signoretti, F. M. (2010). Credit and Banking in a DSGE Model of the Euro Area. *Journal of Money, Credit and Banking*, *42(supplement s1),* pp. 107-141. doi:10.1111/j.1538-4616.2010.00331.x

Harrod, R. F. (1948). *Towards a Dynamic Economics: Some recent developments of economic theory and their application to policy*. MacMillan and Company, London.

Hull, J. (2018). *Wiley finance: Risk management and financial institutions* (5th edition) (5th ed.). New York: John Wiley & Sons, Incorporated.

Iacoviello, M. (2015). Financial business cycles. *Review of Economic Dynamics*, *18(1),* 140-163.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American economic review, 95(3),* 739-764.

Jones, C., & Kulish, M. (2016). A Practical Introduction to DSGE Modeling with Dynare. https://callumjones.github.io/files/dynare_man.pdf

Jorda, O., Richter, B., Schularick, M. & Taylor, A. (2018). Bank Capital Redux: Solvency, Liquidity, and Crisis. *Journal of Economic History*, *78(2),* p. 624.

Kanngiesser, D., Martin, R., Maurin, L., & Moccero, D. (2017). Estimating the impact of shocks to bank capital in the euro area. *ECB Working Paper No. 2077*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2989605

Kilponen, J., Orjasniemi, S., Ripatti, A., & Verona, F. (2016). The Aino 2.0 model. *Bank of Finland Research Discussion Paper, (16).* Dynare code retrieved from https://helda.helsinki.fi/bof/handle/123456789/14144

Kydland, F. E. & Prescott, E. C. (1982). Time to Build and Aggregate Fluctuations. *Econometrica*, 50(6), pp. 1345-1370. doi:10.2307/1913386

Laeven, L. A. & Valencia, F. V. (2012). Systemic Banking Crises Database: An Update. *SSRN Electronic Journal.* doi:10.2139/ssrn.2096234

Lainà, P., Nyholm, J. & Sarlin, P. (2015). Leading indicators of systemic banking crises: Finland in a panel of EU countries. *Review of Financial Economics, 24(1),* pp. 18-35. doi:10.1016/j.rfe.2014.12.002

LaRoche, R. (1993). Bankers acceptances. *FRB Richmond Economic Quarterly*, *79(1),* 75-85. https://ssrn.com/abstract=2129297

Liyanage, D., Fernando, G., Arachchi, D., Karunathilaka, R. & Perera, A. (2017). Utilizing Intel Advanced Vector Extensions for Monte Carlo Simulation based Value at Risk Computation. *Procedia Computer Science, 108,* pp. 626-634. doi:10.1016/j.procs.2017.05.156

Lucas Jr, R. E. (1976). Econometric policy evaluation: A critique. *In Carnegie-Rochester conference series on public policy, Vol. 1*, pp. 19-46). North-Holland.

Miles, D., Yang, J. & Marcheggiano, G. (2013). Optimal Bank Capital*. *Economic Journal, 123(567),* pp. 1-37. doi:10.1111/j.1468-0297.2012.02521.x

Modigliani, F. & Miller, M. H. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. *The American Economic Review, 48(3),* pp. 261-297. doi:10.2307/1809766

Muolo, P. (2008). *$700 Billion bailout: The emergency economic stabilization act and what it means to you, your money, your mortgage and your taxes.* John Wiley & Sons.

Nocera, J. (2009-01-04). Risk Mismanagement. *The New York Times*. Retrieved 2019-12-12 from http://www1.idc.ac.il/Faculty/Kobi/RiskMGT/riskmgmt%20nyt%20nocera.pdf

Nordea. (2019). Nordea at a glance. Retrieved 2019-12-03 from https://www.nordea.com/en/about-nordea/who-we-are/nordea-at-a-glance/

Nykänen, M. (2019). The structure of household debt is changing – new macroprudential instruments are needed. *Bank of Finland Bulletin 2/2019 press briefing*. https://www.suomenpankki.fi/en/media-and-publications/releases/2019/The-structure-of-household-debt-is-changing-new-macroprudential-instruments-are-needed/

OP Financial Group. (2019a). Group member cooperative banks. Retrieved 2019-12-03 from https://www.op.fi/op-financial-group/about-us/group-member-cooperative-banks/presentation

OP Financial Group. (2019b). Corporate History. Retrieved 2019-12-03 from https://www.op.fi/op-financial-group/about-us/op-financial-group-in-brief/history

PWC. (2019). Valuation corner Finland /Banking. Retrieved 2019-12-09 from https://www.pwc.fi/en/services/deals/valuations/valuation-corner.html

Ramsey, F. P. (1928). A mathematical theory of saving. *The economic journal*, *38(152),* 543-559.

Rehn, O. (2018). *Future proofing your bank? Digital transformation and regulatory reform in the financial sector.* Bank for International Settlements, Basel. https://www.bis.org/review/r181113j.htm

Romer, D. (2012). *Advanced macroeconomics (4th ed.).* New York: McGraw-Hill/Irwin. Chapters 2, 5, 6 & 7.

Salmon, F. (2012). The formula that killed Wall Street. *Significance, 9(1),* 16-20. https://doi.org/10.1111/j.1740-9713.2012.00538.x

Savolainen, E. & Tölö, E. (2017). Finland, the land of branches – the landscape of the Nordic banking sector. *Bank of Finland Bulletin, 2/2017,* pp. 38-48. https://www.bofbulletin.fi/en/2017/2/finland-the-land-of-branches--the-landscape-of-the-nordic-banking-sector/

Savolainen, E. & Vauhkonen, J. (2015). Concentrated banking system amplifies banking crises. *Bank of Finland Bulletin, 2/2015*, pp. 37-41. https://www.bofbulletin.fi/en/2015/2/concentrated-banking-system-amplifies-banking-crises/

Svenska Bankföreningen, Dutch Banking Association, Danish Bankers Association & Finanssialan Keskusliitto (today: Finanssiala ry). (2016). *Basel IV Joint positions paper: Basel IV – A serious threat to European banks and the ability of banks to support economic growth.* http://www.finanssiala.fi/materiaalit/Basel_IV_Joint_Position_Paper_15112016.pdf

Somashekar, N. T. (2009). Banking. New Delhi: New Age International.

Tejedor, J. P. (Ed.). (2017). *Bayesian Inference.* IntechOpen. Chapter 1.

Statistics Finland (Tilastokeskus). (2019). Kansantalous. Retrieved 2019-12-09 from https://www.tilastokeskus.fi/tup/suoluk/suoluk_kansantalous.html

Torres, J. L. (2016). *Introduction to dynamic macroeconomic general equilibrium models.* Wilmington, Delaware: Vernon Press.