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Estimating Equilibrium level of public lending of banks in Sweden and in largest foreign markets of Swedish banks

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Abstract

This paper studies future opportunities of the largest banks in Sweden regarding expanding their foreign household and non-financial corporation lending to the main foreign markets (Norway, Denmark, Finland) by estimating the long term equilibrium levels of bank lending to GDP in each of the foreign country and estimating the short term shocks to the equilibrium levels in each of the countries by computing impulse response functions. In addition, the paper aims to answer the question regarding what is the equilibrium level of bank lending to GDP in Sweden itself and explores the short term shocks to the Credit/GDP level. In this paper it is assumed that variables influencing the Bank lending/GDP ratio are inflation rate, interest rate and housing prices. The equilibrium levels in each of the countries are modelled by a vector error correction model (VECM), by considering a common set of models and sample sizes for all countries.

Keywords: credit modelling, corporate lending, household lending, VECM, Sweden, bank credit, equilibrium levels, non-financial corporations, cointegration, vector error correction model.

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2 Abbreviations

ADF	Adjusted Dicky Fulller test
AIC	Aikike Information Criterion
AR	Auto Regression
BIC	Bayesian Information Criterion
BIS	Bank of International Settlements
CEE	Central and Eastern Europe
CIS	Commonwealth of Independent States
CPI	Customer price index
DKK	Danish krona
ECM	Error correction model
EMU	European Monetary Union
ERM	Exchange Rate Mechanism
EU	European Union
EUR	Euro
HQIC	Hannan – Quinn Information Criterion
IMF	International Monetary Fund
IRF	Impulse Response Function
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
LS	Least Squares
MFI	Monetary Financial Institution
Mill.	Million
NOK	Norwegian Krona
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PPI	Producer price index
R^2	R squared
SEB	Skandinavinska Enskilda Banken
SEK	Swedish Krona
UK	United Kingdom
VAR	Vector Auto Regression
VEC	Vector error correction
VECM	Vector error correction model

3 Introduction

In many countries public is borrowing from banks heavily; it is important to understand what the trends in these countries are and to be able to identify a potential credit boom. The reason is that too rapid credit growth, a credit boom, can have serious macroeconomic consequences. According to Calza et al. (2001), credit that has been granted to public is a significant part of household and corporation sources of financing. That makes the credit developments an important source for analyzing and forecasting economic activity, prices and monetary developments.

There is empirical of a positive correlation between the credit and growth; the elasticity is assumed to be higher than one in the long run. Meaning that that credit/GDP levels rise as per capita GDP increases; this process is known as the financial deepening (Terrones & Mendoza, 2004). There have been conducted many studies on theoretical aspects of financial deepness. However, the developments in credit in Scandinavia and euro area have not received too much of empirical research and, therefore, it can be concluded that a study related to this topic is beneficial.

Credit institutions include banks and non-bank credit institutions such as mortgage institutions that have a particular focus of business. The credit institutions have developed professional skills in assessing and monitoring credit risk due to the often long-term relationships they have with their customers, in addition to which they have a thorough business experience. These determinants imply that credit institutions are important in supplying credit in the economy. For example, lending to the public in Sweden takes place mainly through banks and mortgage institutions. Banks provide loans with different types of security and also smaller loans without collateral. Banks, like mortgage institutions, also provide loans secured on homes and other buildings and property (The Swedish Financial Market, 2015).

Banking companies, foreign banks, savings banks and co-operative banks are the four main categories on the Swedish banking market. At the end of 2014, Sweden had a total of 117 banks. The four largest banks - Swedbank, Handelsbanken, Nordea and SEB - account for 75% of the total banks' assets (The Swedish Financial Market, 2015).

Banks account for a large part of the credit institutions' total lending to the public in Sweden. At the end of January, 2016 total lending by monetary financial institutions accounted up to 9 759 SEK billion out of which 2 010 billion SEK: to non-financial corporations and 3 299 billion SEK: to households. Bank lending at the end of the before mentioned period accounted to 6 244 billion SEK in total with 1 261 billion SEK to non-financial companies and with 1 108 SEK billion – to households. These facts imply that out of total lending to non-financial companies and households 63% and 34% are made up by banks, respectively (Financial market statistics, 2016). Since the main focus of this paper is bank lending, hereinafter we refer to amount of credit as amount of particularly bank lending.

This paper aims to understand the bank lending trend in Sweden and in countries that are the main foreign markets of Swedish banks as well as to spot potential credit booms by dividing the bank lending into two parts: long term equilibrium part and boom component. According to Brzoza-Brzezina (2005),

lending booms can be considered as a potential danger to banking sector as they are associated with subsequent episodes of crises.

Foreign non-MFI borrowers account for 33% of the total bank credit to non-MFI in Sweden at the end of March, 2016 (Financial market statistics, 2016). The main foreign markets for largest Swedish banking groups are Norway, Denmark, Finland, Germany, UK and Baltics. According to data collected on lending by Swedish banks, it is obvious that yearly lending amount in total as well as lending specifically to foreign countries has been increasing lately. Therefore, the research question of this paper is:

May Swedish banks reach optimal level of credit by increasing the lending to foreign markets?

Based on the question presented before, two hypotheses have been presented further. An important concept that has to be taken into account is the equilibrium level of lending. That can be indicated by the equilibrium levels of Credit/GDP of Sweden's banks and the banks in the main foreign markets of Swedish banks; this ratio is a common measure in literature and practice for measuring financial deepness.

H1: The Credit/GDP ratio of Sweden currently is lower than the equilibrium level.

Banking crisis caused the pace of increase in bank lending amounts in Sweden to slow down; therefore, it has been assumed that the credit/GDP level in Sweden is below the equilibrium level. Similar tendency had been observed also in the main foreign borrowers of Swedish banks. Another caveat that is worth mentioning is the fact that developing countries have been on the way of developing their financial systems and, therefore, the bank lending may have not reached the equilibrium level yet. These considerations lead to the second hypothesis:

H2: The level of Credit/GDP ratios in main foreign lenders of Swedish banks (Denmark, Finland, and Norway) is below their equilibrium level.

On the one hand, this paper is of interest for banks and alternate lenders to public in all of the studied countries. Understanding the current situation of the credit/GDP ratio and its relation to the equilibrium level helps the banks to understand its business possibilities – if there are upside opportunities for lending business. This ratio also warns banks and alternate non-bank lenders as the credit/GDP ratio may also be used an early warning indicator for assessing the credit boom risks.

On the other hand, the paper may be beneficial for policy makers. As the credit/GDP ratio provides information about the overall condition in the economy. Based on its value, deviation from the

equilibrium level, determinants and historical trends, the policy makers may alter the monetary policies in each of the countries.

The results are based on the VECM methodology; the Credit/GDP ratio is assumed to be affected by such variables like Housing prices, lending interest rates and inflation rate in Sweden, Norway, Denmark and Finland. The main results of the Paper are that Credit/GDP ratio of Sweden is below long run Equilibrium level by the end of Q3, 2015 by 30%. The Equilibrium of Sweden may be optimized by increasing foreign lending to its main foreign business partners: Denmark and Finland. However, in Norway the long run Credit/GDP ratio is very close to optimal level. According to study, Finland has the fastest pace of reverting back to the LR Credit/GDP ratio: during one quarter the ratio is corrected by 20.36%. The slowest pace of response is for Denmark meaning that LR disequilibrium of Credit/GDP ratio in Denmark is corrected only by 3.07% during a quarter towards the LR equilibrium. Also the impulse response functions have been performed and show how shocks in housing prices, lending rates and inflation rates affect the Credit/GDP ratio during 5 years. In all the countries a short run positive shock in housing prices have a positive effect on Credit/GDP. However, in Sweden in 12 quarters the effect starts to revert. Effect of other variables has a more diverse effect for different countries. Speed adjustments to short run Equilibrium indicate that in the short run equilibrium in all assessed countries is mostly affected by lagged Credit/GDP ratios.

To sum up, Sweden's banks have opportunities of increasing the foreign lending in Denmark and Finland and optimize the LR Credit/GDP ratio.

The Paper is structured in the following way: following the first three introductory sections where the table of contents, abbreviations and introductory parts are presented the section 4 starts discussion with the background information on the Sweden's banking system with a particular focus on lending issues to public. This section is followed by the 5th section outlining Literature review on credit modelling and determinants of lending that can be found in the surveyed papers listed in a comprehensive manner in the Appendix. Based on the found approaches the chosen methodology is described and justified in section 6. Sections 7 and 8 provide information on data used and theoretical description of the employed methodology accordingly. The results are described in section 9 with concluding remarks found in 11th section. The 10th section presents and discusses the limitations of the paper as well as gives suggestions for future researches. The two final sections (12th and 13th) include lists of references and appendices respectively.

4 Background

This section provides information regarding relevant theoretical knowledge as well as background statistical data on the lending to non-financial corporations and households by Swedish banks during years 1995 – 2015 with a light focus on foreign lending and describing lending changes during crisis in 2008.

4.1 Theoretical background

There are many studies related to financial development. According to IMF (2000), process of financial deepening is described by the fact that credit typically grows more quickly than GDP during development stage of an economy. A large part literature has tried to address the causality link between GDP and credit; however, most of the evidence favors the view that a more developed financial sector helps to boost economic growth (IMF, 2000). It has to be noted that the discussion of causality is outside the scope of this paper.

Credit/GDP ratio is the measure that has been used as an indicator of financial development and leverage level of economies, the aggregate private sector's indebtedness, (consequently, also riskiness) in the majority of studies as addressed by Ruiz A.U. (2015) and also in this paper. There has been a debate regarding this measure if it is the most suitable for exploring the previously mentioned topics especially in the context of Basel III requirements. However, also this topic is not assessed in more detail in this paper and can be explored more in such papers like Ruiz A.U. (2015) and Drehmann M., Tsatsaronis K. (2014).

Credit booms create important risks for both, developed and emerging market countries. One of the main reasons of this riskiness is that credit booms are often followed by sharp adverse economic situations and by even financial crises. Credit booms are difficult to identify, making policymakers to pursue difficult decisions (IMF, 2000).
The equilibrium level of private credit is level of the private credit that can be explained by the economic fundamentals. If the actual credit-to-GDP ratio cannot be explained by changes in the economic fundamentals and is inconsistent with the equilibrium level, the deviations from the equilibrium level are observed. The deviations are defined as undershooting or overshooting (Backe et al., 2006).

Credit growth can be separated in three components: trend, cycle and boom (Backe et al., 2006):

- Trend part identifies financial deepening and is assumed to be the equilibrium state.
- Cycle part is described in theoretical models of real business cycles that show that temporary technology shocks can create fluctuations in output, asset prices and credit.

- Excessive cyclical movements or lending boom identification in literature is more empirical.

The lending of banks is determined by both, supply and demand factors of lending. On the supply side, a variety of credit channel models consider how changes in the financial positions of banks (bank lending channel) and borrowers (balance sheet channel) are affecting the availability of credit in an economy (Hall, S. 2001). It has been noted in the literature that modelling in this area is complicated due to the difficulties regarding separation of demand and supply effects of lending. However, when one is interested in aggregated macroeconomic variables, the differences between the supply and demand sides do not play a crucial role since the total amount of lending is that of interest (Backe et al., 2006).

The problem of identifying demand and supply effects is common in the literature regarding addressing credit aggregates. Therefore, there are not many studies that address this particular issue. However, it is of importance to be able to distinguish the factors driving credit development despite the fact that demand and supply factors are difficult to separate (Hofmann, 2011).

Rapid credit expansion has been an important issue lately. On the one hand, rapid credit growth can be explained by a very low initial level of intermediation in some countries (such as transition countries) and the convergence towards levels observed in developed countries. According to Kiss et al. (2006), large part of the credit growth in transition economies can be supported by the catching-up process; therefore, the observed credit/GDP ratios are below the equilibrium levels. However, there are countries in which credit growth rate is higher than what would be supported by macroeconomic factors. The catching-up process of transition economies can be initiated by several factors: macroeconomic stabilization, reforms, privatization process in the financial sector, and introduction of market institutions (Backe et al., 2006).

In this paper bank lending to non-financial corporations as well as to households is intended to be explored. According to the Organization for Economic Co-operation and Development (OECD), non-financial corporations are defined as “corporations whose principal activity is the production of market goods or non-financial services” (OECD Statistics). The concept of household is based on the arrangements made individuals or groups for providing themselves with essentials for living. A household may be either a one-person household (a person provides himself or herself essentials for living) or a multi-person household (a group of two or more persons living together who make common provision for essentials for living). In case of multi-person household the income of individuals may be pooled together; these persons may be related, unrelated, the group of people may also include both, related and unrelated persons (OECD Statistics). According to the Organization for Economic Co-operation and Development (OECD) (OECD Statistics), non – financial corporations are “corporations whose principal activity is the production of market goods or non-financial services”.

One of the main indicators of financial instability is perceived the credit boom which is reinforced by the financial crisis of 2007. An important policy implication is to focus the attention to the ratio of private sector credit to GDP for an economy and spotting important deviations between the actual and long-run trends of the credit/GDP ratio. Therefore, the defining the equilibrium of the before mentioned ratio is of great importance for each economy (Kelly R., McQuinn K., & Stuart R., 2013)

Policy makers have to evaluate implications of financial deepening for macroeconomic developments and financial stability (Cottarelli et al., 2003). From a Central Bank perspective, it is important to monitor credit developments as they show important information about economic and financial activity. Besides credit shows strong correlation with asset prices and provides information regarding cycles in asset prices. According to Hofmann (2001), financial cycles coincide with cycles in economic activity; financial developments are pro-cyclical.

Credit is also a significant component of euro area banks' asset side of their balance sheet and, therefore, the most significant counterpart to the monetary aggregates. To sum up, bank lending is an important measure to consider in the regular assessment of the monetary policy (The Swedish Financial Market, 2015).

4.2 Lending in Sweden

4.2.1 Banking system in Sweden

Generally monetary financial institutions (MFI's) include banks, housing credit institutions, finance companies and other monetary financial institutions (Financial market statistics, 2016). Banking companies, foreign banks, savings banks and co-operative banks are the four main categories in the Swedish banking market. Since the beginning of the 1990s the number of Swedish commercial banks and foreign banks has increased rapidly. The reason for this increase is primarily the entry of niche banks, the transformation of savings banks/building societies into banking companies and the establishment of foreign banks. By the end of 2014, there were a total of 117 banks in Sweden's banking market (The Swedish Financial Market, 2015).

Number of banks in Sweden (2011 - 2014)

Banks	2011	2012	2013	2014
Total number	**114**	**117**	**118**	**117**
Swedish commercial banks	33	37	37	37
foreign commercial banks	3	2	1	2
foreign banks' branches	27	27	29	27
savings banks	49	49	49	49
cooperative banks	2	2	2	2

Table 1: Number of banks in Sweden (2011 - 2014)

The four largest limited liability banks comprise 75% of the banks' total assets in the Swedish market. (The Swedish Financial Market, 2015). The four largest banks in Sweden are Swedbank, Handelsbanken, Nordea and SEB. The largest share of lending by MFI's to the public is made up by banks. The total lending of MFIs in Sweden at the end of 2015 was SEK 9 759 221 mill., out of which 64% were made up by banks. Out of total lending by MFIs in Sweden 21% go to Swedish non-financial corporations and 34% - go to Swedish households. The amount of lending by banks in Sweden has been increasing. In 2015 the total lending by MFI's increased by 5% p.a. The lending of banks rose by 4% during the same period.

4.2.2 Lending during crisis in Sweden

An important topic related to financial deepening in Sweden is lending crisis which occurred in the early 1990's. There has been identified a common pattern for banking crises in developed countries. The crises have been initiated by deregulation which logically leads to growth in crediting amounts. The next step in this process is an asset bubble which bursts afterwards causing a massive disruption in the market (mainly in real estate sector); prices of assets fall dramatically and bankruptcies across the whole economy are observed. This process is followed by banking crisis fostered by credit losses. The banking crisis, in turn, impacts the private sector as a result of credit crunch. The credit crunch is affected by the activities of the government (Englund, 1999). This pattern could have been spotted also during crisis in Sweden.

According to Englund (1999), there are three main reasons behind the occurrence of crisis in Sweden. The crisis was initiated by a highly leveraged private sector that was affected by 3 significant events: a shift in monetary policy with an increase in pre-tax interest rates, a tax reform increasing after tax interest rates, and the ERM crisis. However, the underlying cause was deregulation in Sweden that started back in 1985. In conjunction with expansive macroeconomic policy it created an asset price boom. The three exogenous events together with overinvestment in property resulted in collapse of asset price boom which resulted in bankruptcies and massive credit losses. The government bailed out the banking system by issuing a general guarantee of bank obligations. The overall cost to the taxpayers has been estimated at around 2% of GDP. During the last 10 years the financial sector in Sweden has been experiencing changes in its structure. Established companies have widened the scope of their business activities; many new companies have entered the market. Swedish banks have increased their activities abroad which show the increase in competitiveness.

4.2.3 Largest Banks in Sweden and foreign lending

The four major banking groups also conduct a significant part of their operations outside of Sweden. Around 35% of the major banking groups' lending is lending to the public abroad. This, in turn, means that a large share of the banks' risk is abroad. Nordea is the bank undertaking the largest proportion of lending to borrowers outside Sweden. About 75% of Nordea's lending is to the general public abroad;

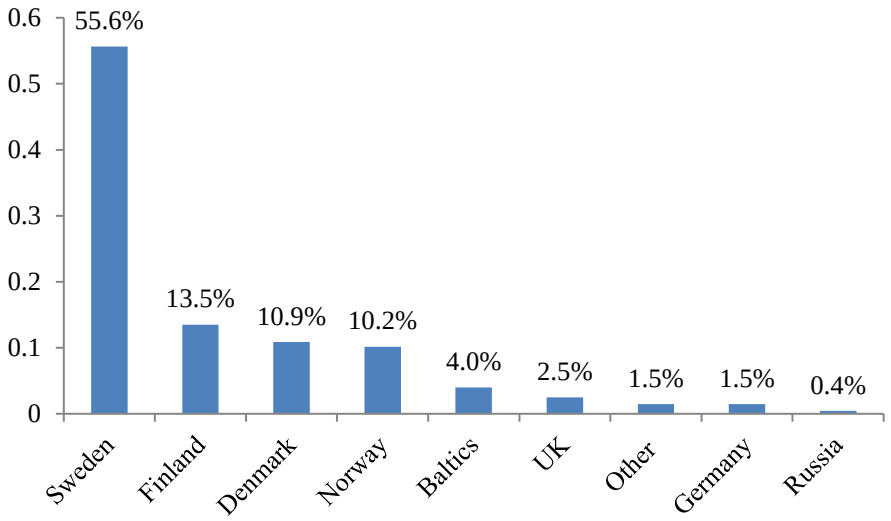
only a minor portion refers to the Swedish public. The other three major banking groups have their largest markets in Sweden and an average of one quarter of their operations abroad (The Swedish Financial Market, 2015).

Table 2: Operations of the four dominant banking groups of the Swedish financial market at year-end 2015, SEK billion

	Handelsbanken	Nordea	SEB	Swedbank	Total four major banks
Total Assets	2 522	5 938	2 496	2 149	13 105
Loans to public:	1 866	3 130	1 383	1 371	7 750
Loans to Swedish public	1 214	881	1 027	1 189	4 311
Loans to public abroad	652	2 249	356	182	3 439

The financial groups also have significant operations outside Sweden. Half of the banks' lending takes place abroad. The main foreign borrowers from Swedish banks are Finland, Denmark, Norway, Germany, Baltics and UK (The Swedish Financial Market, 2015). The largest foreign bank is Danske Bank, which is the fifth largest bank in Sweden (Banks in Sweden, 2013). Loans to the public in Sweden and abroad accounts for around 57% of the largest banks' total assets. As a consequence, a major portion of the banks' risks is located abroad (The Swedish Financial Market, 2015). According to the audited financial accounts (year 2015) of the four largest banking groups in Sweden, the aggregate public lending by major banking groups in Sweden as of end of 2015 is presented below:

Figure 1: Geographical breakdown of the major banks' public aggregate lending 2015



5 Literature Review

In the Literature Review section previous researches related to credit modelling are described with a particular focus on the choice of variables determining bank lending, methodology used in relevant studies and the reasoning behind each of the choices. As the outcome of literature review the next section points out the most suitable methodology for answering the research question of this paper. This section also provides a sufficient justification of the chosen methodology and its limitations.

The literature on the bank lending determinants and equilibrium levels can be revised from several points of view. In several studies the dependent variable of interest has been credit level in absolute terms while in other: credit growth or Credit/GDP ratio have been observed over time. For example, Kiss et al. (2006), Backe et al. (2006), Boissay et al. (2006) and Cottarelli et al. (2003) focus on the finding equilibrium Credit/GDP ratio. Calza et al. (2001 and 2003) as well as Brzoza-Brzezina (2005), Sorensen at al. (2009), Hulsewig (2003) and Hofmann (2001) focus on the level of real loans rather than the ratio.

Some of the researches focus on investigating the determinants of the lending solely; other studies focus on modelling and forecasting lending for the future and investigating different scenarios by applying various shocks. For example, Calza et al. (2003) uses forecasting technique. Brzoza-Brzezina (2005) uses VECM for forecasting loan developments in three biggest Central-European countries during euro area accession – Czech Republic, Hungary and Poland on basis of previously created model on other countries. Hofmann (2001) applies different shocks to forecast the reaction to loan level. Similarly to him, Sorensen et al. (2009) applies temporary shocks to the policy rate on bank lending to non-financial companies and uses VECM for forecasting.

It should be noted that the literature on lending may be divided in studies that have been implemented for separate countries and for groups of countries based on different assumptions. Cottarelli et al. (2003) researches the developed and developing (non-transition) countries in aggregate. Boissay et al. (2005) uses data of Central and Eastern European countries and applied both one-country model and panel technique for the estimation in the sample. Backe et al. (2006) estimated panel ECM model on various combinations of OECD and emerging countries and, similar to Cottarelli et al. (2003) and Schadler et al. (2004), applied their estimated parameters out of sample for the developing countries.
The study by Kiss et al. (2006) uses a dynamic panel (Pooled Mean Group Estimator) model and applied such variables like GDP per capita, real interest rate and inflation of 11 euro area countries to generate out-of-sample estimates for private sector Credit/GDP ratios of the three Baltic countries and of the 5 CEE countries. Calza et al. (2001 and 2003) and Sorensen et al. (2009) study euro area countries in aggregate. Brzoza-Brzezina (2005) and Hofmann (2001) use Vector Error Correction model (VECM) for individual countries. Hofmann (2001) estimates long-run relationships in several industrialized countries (such as Belgium, Germany, Spain, France, Ireland, Italy and other). As a part of systems also

including supply equations, Kakes (2000) and Hulsewig et al. (2003) model the behavior of bank lending demand in the Netherlands and Germany, respectively.

Previously mentioned distinction of literature may be attributed also to sectorial view of crediting. Some papers focus on modelling the aggregate private lending (such as Hofmann (2001), Hulsewig (2003), Calza et al. (2001 and 2006), Backe et al. (2006) and Gambacorta (2007)). Kiss et al. (2006) stress that the total credit is what matters and, therefore, uses aggregate private credit in the study. Others have a particular focus on household or business lending (Focarelli, Rossi, (1998), Bridgen and Mizen, (1999 and 2004), Kakes (2000), Casolaro et al., (2006), Sorensen et al., (2009), Boissay et al. (2006)). Brzoza-Brzezina (2005) focuses on both, aggregate private lending and loans denominated in local currency.

Many studies, including Calza et al. (2001 and 2003), do not separate between household and corporate credit due to constraints in the availability of data. It is assumed in these works that the demand for credit by corporations and households is affected by an improvement in economic activity or to changes in the level of interest rates in a similar way. According to Calza et al. (2001 and 2003), the before mentioned assumption is not overly restrictive, especially in case of long term relationship investigation. However, it is also mentioned that the availability of sectorial data would allow for a more refined modelling of the behavior of loan demand (Calza et al., 2001).

Despite the fact that there are many theoretical and empirical studies that have been researching credit growth, financial deepening and lending booms, there is no standard model that is widely used. As mentioned in the previous section, on the supply side, a variety of credit channel models consider how changes in the financial positions of banks (bank lending channel) and borrowers (balance sheet channel) affect the a availability of credit in an economy (see Hall, 2001, for a deep literature overview).

5.1 Credit modelling

A broad part of the literature is related to the credit modelling. Credit to public has been part of a growing literature material starting with the early 1990's. This literature has been mainly popular within the community of Central Banks due to its application for making decisions regarding different policies (Sorensen et al., 2009). Further in this paper different approaches to modelling have been presented with a goal to provide an overview of the existing literature and to make a sound decision regarding choosing the most appropriate technique for this paper. Several methodical approaches have been developed. To be able to determine if the credit level is in excess over the equilibrium level is strongly related to the issue of what the equilibrium level is. Similarly to Kiss et al. (2006) three main directions are distinguished in the literature that attempt to determine credit boom and equilibrium level:

- "speed limits",
- univariate time series method,
- other econometric approaches using macroeconomic variables.

"Speed limits"

Using "speed limits" identifies a credit boom as an excess growth over a certain growth rate of credit level within an economy. This approach is mentioned in papers of Honohan (1997) and Duenwald et al. (2005). Using "speed limits" is most often used in transition economies. This approach is used less extensively than the ones described further. After assessing the literature of credit modelling and based on paper describing credit equilibrium in the Baltics by Ertuganova (2010) it can be concluded that this approach is the least popular one for modelling credit levels.

Univariate time series method

Another approach of identifying trend and boom composition of credit growth is using univariate time series method. This approach identifies a country specific trend of the credit growth and identifies a credit boom when credit growth exceeds certain growth threshold around the trend, according to Gourinchas et al. (2001).

On the one hand, the plus of this kind of methodology is that it is possible to construct a rolling backward looking trend by using the historical information solely which allows to examine the recent developments of credit. On the other hand, this methodology does not provide the opportunity to predict what is going to happen in the future, including a scenario of credit boom. Nevertheless, since the majority of banking crises can be predicted by credit booms, this method provides insight for assessing the progress of a credit boom (Kiss et al., 2006).

Several econometric approaches using macroeconomic factors

Most widely used approach is finding the equilibrium level of credit growth with the help of macroeconomic variables and then comparing it to actual credit development. Papers apply a wide range of different econometric techniques. The size of deviation between the two values can indicate potential excessiveness of credit growth if it exceeds a certain threshold. Afterwards techniques are implemented in a sample or out of sample estimation. Most papers carry out this type of estimation mainly for developed countries based on longer periods. Papers focusing on transition countries apply the estimated parameters of developed and other emerging countries with longer time series. The structural breaks and short historical data are the reasons why this approach cannot be used for transition economies directly (Kiss et al., 2006).

One set of studies uses Vector Error Correction Model (VECM) for individual countries as well as for aggregate data. Within the general VECM approach, one or more than one long-run relationships are identified. As mentioned before, when using the aggregate data, supply and demand side factors do not have to be necessarily separated.

The surveyed papers applied a wide range of econometric techniques and implemented in sample or out of sample estimation. Some used VECM models. For example, Hofmann (2011) was estimating the Credit/GDP ratio in equilibrium in developed countries separately. Brzoza-Brzezina (2005) used in the

sample estimation for selected new and old EU states. Aggregate data in VECM model was used in such studies like Calza et al. (2001 and 2003) and Schadler et al. (2004).

According to Sorensen et al. (2009), there are two challenges regarding using VECM. On the one hand, modelling aggregate loan developments raises a question how to distinguish between demand and supply factors that affect bank lending on the macroeconomic level; this issue has been addressed already in the previous sections. On the other hand, a choice regarding researching flows or outstanding amounts of credit is to be done. As in paper of Sorensen et al. (2009), most often the levels of credit instead of flows are used. The flow-based approach is modelled as a function of a financing gap and costs of financing as described in theory in the study of Friedman and Kuttner (1993).

Panel techniques are used in work of Cottarelli et al. (2003) where both developed and developing countries were united. In the econometric model, equation based on non-transition economies is used and then applied to the countries of interest. As mentioned by Kiss et al. (2006), this technique has been used for its flexibility and efficiency. This model describes the long term relationship between credit growth and several factors rather than causality. Kiss et al. (2006) uses for a panel of small open OECD economies (out of sample panel) to derive the equilibrium credit level for a panel of transition economies (in sample panel). The out of sample estimation has been employed due to the fact that coefficient estimates for transition economies are rather unstable. As financial depth in majority of transition economies is comparatively low, it may be the case that these economies are still in catching up process which may cause some estimation bias. Therefore, it is important to assess the out of sample panel and apply the results to the transition economies.

There are also combined techniques in the literature spotted in the literature. For example, Boissay et al. (2006) used data from Central and Eastern European countries and applied ECM model as well panel technique for the estimation in the sample. Backe et al. (2005) used panel technique via OLS method where several combinations of OECD and emerging countries have been researched.

5.2 Determinants of lending

This section describes the most commonly variables used in the previous research as determinants of lending; the survey covers 18 papers. A detailed view on the variables used in different studies may be viewed in the Appendix 13.1. As mentioned before, when modelling solely the equilibrium level of Credit/GDP ratio, there is no need to distinguish between the determinants of credit supply and demand. However, as seen further, a major impact is put on the demand factors justified by the fact that supply side factors have only a limited impact on equilibrium credit ratios, and are influencing the adjustment path to the equilibrium to a great extent (Schadler et al., 2004).

- GDP is one of the most often used factors used in explaining credit growth. There are arguments in favor of a positive relationship between credit supply/demand and growth of economy. PPP-

based per capita GDP is used in the major part of the studies (to capture the effect of development) like in the study of Backe et al. (2006), Kiss et al. (2006), Calza et al. (2011 and 2003) and Hofmann (2001). Real GDP is mostly used for studies in developed countries. The expected sign is positive; countries with higher income should have a higher financial deepening. In the paper of Cottarelli (2003) log of PPP GDP per capita was used.

- Aggregate credit is one of the most important variables. Kiss et al. (2006) includes both domestic and foreign currency loans in the credit aggregate and does not distinguish between loans to households and corporations. While at a theoretical level it might prove more reliable to estimate domestic and foreign currency loans separately, this approach is constrained by data availability and can be less meaningful for policymakers. Brzoza-Brzezina (2005) used only domestic currency loans for Hungary, Poland and the Czech Republic in its estimations while for other countries aggregate private loan was used. Hulsewig (2003) used loans to domestic firms and private households. According to Hofmann (2001), the real credit is linked to GDP positively.

- Bank credit to the government sector was used in Backe et al. (2005) and Cottarelli et al. (2003) as a % of GDP. According to Cottarelli (2003), this variable captures possible crowding-out effects, any increase (decrease) in bank credit to the government sector is thought to give rise to a decrease (increase) in bank credit to the private sector. Public debt is used in Cottarelli (2003) measured as a ratio of stock of public debt (domestic and external) to GDP; domestic debt would be a more suitable measure but total measure was used due to constraints on availability of data.

- Business investment calculated as total investment minus housing investment is used by Sorensen et al. (2009). In this study it is proved that there is a positive relationship between the annual increase of fixed investment and gross operating surplus meaning that investment is linked to the economic development.

- According to Kakes (2000) the demand for loans is determined by cost of lending. Real interest rate determines supply and demand of loans (Kyotaki, Moore, 1997). According to Backe et al. (2006), lower interest rates should promote credit to the private sector, consequently implying a negative sign for this variable. Horizon of the interest rate should be appropriate. One set of studies uses some both, short and long term interest rates (Calza et al. 2003); the effect of rates is affected by the share of loans with fixed and variable interest rates. Calza et al. (2001) uses real market interest rates as weighted averages of national short-term and long-term market

interest rates, deflated by contemporaneous inflation as measured by annual percentage changes in the GDP deflator. Also Sorensen et al. (2009) uses weighted short and long term rates. Hulsewig (2006) uses short term interest rate (monthly averages of three month money market rate) and long term interest rates (monthly averages of yield on bonds outstanding issued by domestic residents). Second set of studies introduces an aggregate time series (Horwath et al., 2004). Studies usually use the market rate for calculations of real interest rates. Brzoza-Brzezina (2005) uses real interest rates. Since no consistent data on lending rates was available, this study used the 3-month money market rate. Hofmann (2001) also uses real interest rates, measured as 3 month interbank money market rate, and adjusted for inflation. In the study of Backe et al. (2006) short term and long term nominal lending rates are used.

Another issue that should be addressed are the different currencies in which loans are denominated; aggregating local and foreign currency real rates is not straightforward. The loans in different currencies are particularly common in transition economies. It has been noted that weighted average of domestic and foreign real interest rates as an explanatory variable would be a solution (Kiss et al., 2005). Nominal rates should be adjusted for inflationary expectations. However, due to observational difficulties, another factor, inflation, is usually added to the factors explaining credit growth. In addition, if inflation has a significant impact, there is a possibility that loans in foreign currency do not play an important role in the credit demand.

- High inflation is expected to have a detrimental effect on financial deepening. According to Backe et al. (2006) high inflation is associated with a decrease in bank credit level to the public. There is a close correlation between the level of inflation and its variance. Volatility of inflation can cause uncertainty in financial markets and hinder functioning of financial markets as a consequence (Kiss et al., 2006). High inflation has an effect on credit constraints. According to Kiss et al. (2006), when nominal rates are high, households and firms cannot have loans with long duration. Cottarelli et al. (2003) uses inflation threshold of 4% as an explanatory variable (a high inflation dummy that takes the value of 1 when the inflation is above the threshold). Backe et al. (2006), uses inflation variable in terms of producer price index (PPI) and the consumer price index (CPI). Inflation is used as a factor also in such studies of Calza et al. (2001), Brzoza – Brzezina (2005), Boissay et al. (2006).

- Several studies, including Sorensen et al. (2009), Friedman & Kuttner (1993), Casolaro et al. (2005) include also the cost of alternative financing (the assumption used in these studies is that main alternative form of financing are debt securities). Casolaro et al. (2005) proxies alternative cost of financing with speared between the cost of (short term) lending and the 3 month money market rate. The cost of the non-bank forms of financing is constructed as a weighted average

of the cost of corporate debt securities and equities issued by non-financial corporations where the weights are flows of debt securities and quoted shares. Sorensen et al. (2009) includes cost of alternative (non-bank) forms of external financing. Both the cost of lending and the relative cost of lending (spread between the cost of lending and the cost of the other forms of financing) are introduced.

- Financial liberalization is an important aspect when very different countries are pooled together. According to McKinnon (1973), liberalized financial and capital markets have a positive effect financial deepening due to open capital flows facilitating the import of financial services and competition, efficiency of financial system. Also according to Backe et al. (2006), a higher degree of financial liberalization makes easier to banks to fund credit supply.
  Liberalization index is used in Cottarelli et al. (2003); this index includes information regarding liberalization of policies concerning direct credit, interest rate controls, entry barriers, regulation and securities markets, privatization in the financial sector, international capital flows. Backe et al. (2006) uses the spread between lending and deposit rates in order to capture the effect of financial liberalization. When the spread decreases it is an indication of financial liberalization, a greater competition among banks and perhaps other financial intermediaries It should be noted that constructing liberalisation indices on a yearly basis can prove to be difficult; the thorough and very detailed database created by Abiad & Mody (2004) does not cover transition countries and smaller EU members (Kiss et al., 2006).

- Bank regulation factor was introduced by Cottarelli et al. (2003); it measures the stringency of legal requirements for obtaining a license for operating a bank. It is expected that less regulation leads to higher credit development.

- Accounting factor included by Cottarelli (2003) as an index of accounting standards to proxy information quality on which the credit decisions are based. It is expected that more information leads to higher financial deepening.

- Dummies for legal origins were included by Cottarelli (2003). Country's legal origin has had a significant effect on financial deepening Beck et al. (2000). In literature German civil law is described as having stronger protection of private property, effective contract enforcement and better developed banking system leading to higher levels of credit within economies.

- Property prices are considered an important factor of credit growth by Hofmann (2001); several studies before (Borio et al. (1994), IMF (2000), BIS (2001)) have pointed to the close correlation between developments in credit markets and property prices. According to Backe et al. (2006),

there are many reasons why housing prices have an effect on credit demand. Firstly, the increase in housing prices may generate more credit in the following way: when the prices rise, the total amount to be spent on the purchase of real estate increases. As a result, more credit is demanded from banks. Secondly, higher real estate prices increase lifetime wealth (lifecycle theory of Modigliani), increase in wealth leads to smoothing of consumption by an increase in borrowing. However, on the other side, increase in housing prices lead to rise in rents which result in lower borrowing of those who choose to rent (Hofmann, 2001). Thirdly, Tobin's Q-theory implies that higher property prices cause more construction due to the fact that new constructions of property become more valuable compared with the acquiring costs (Kiss et. al, 2006). As indicated by Backe et al (2006), this promotes a higher demand of bank credit.
Hofmann (2001) in his study uses weighted average of residential and commercial property prices deflated by the consumer price index to proxy for housing price variable.

- It is claimed that the existence of credit registries diminishes problems related to asymmetric information and reduces the probability of credit fraud; as a result it leads to higher bank credit supply. Therefore, this variable is included in study by Backe et al. (2006).

- M&A developments were explored in Sorensen et al. (2009). As noted in this study M&A developments alter loan dynamics in the short-term due to their impact on both the demand and the supply of loans. However, it did not seem to have a significant effect.

- Studies focusing on loan supply use such variable like equity level of banks. For example, Hulsewig (2003) uses banks' overall equity position.

6 Choice of methodology and data

In this section the choice of methodology and variables used are described based on the literature survey outlined in the previous section and in the Appendix 13.1. The advantages and limitations of the given methodology are outlined in subsequent section. This section aims also at describing data availability and other data related issues.

6.1 Choice of methodology

As described in the literature review section, there are three main approaches for addressing the research of excess credit in an economy. The research question aims to answer the situation in Sweden which is a developed country, therefore, the methodology most suitable for developed countries has been chosen: the econometric method using macroeconomic factors, following approach of Hofmann (2001) and Calza et al. (2001, 2003, and 2006). Besides this approach is also more suitable for making predictions than the univariate methodology approach; the latter one focuses more on the historical trend. The size of deviation between the country specific trend and actual credit development indicates a potential excessiveness of credit growth if it exceeds a certain threshold.

There are several pluses of using the VECM approach. As stated by Calza et al. (2001):" the use of a VECM allows to specify both the long-run and the short-run dynamics of the model, while also capturing potential endogeneity of the determinants of credit demand." Therefore, this method allows not only to determine the long run relationships between the variables but also to estimate the short run dynamics and describe the adjustment process to the equilibrium level. According to Brzoza – Brzezina (2005), the VECM methodology is beneficial in this case as the availability of time series for all of the countries is limited. Number of time series starts relatively recently; besides for consistency purposes the same data set is taken for all countries which limits the paper to the shortest available data series. However, the limits on data set saves the degrees of freedom of the model. Kakes (2000) implies that advantage of this approach is that long term relationships may be analyzed based on a very limited number of variables; the outcome of this analysis may be used for more detailed research. Another advantage of this approach is suitable for forecasting as mentioned before.

Based on this methodology, a vector error correction model has been built in this paper for each of the countries using the variables described in the section 7.1.2. The multivariate approach to co-integration analysis by Johansen (1988, 1991, and 1995) has been employed. According to Hofmann (2001), this approach is preferred over single equation estimators due to the possible existence of multiple long-run relationships. According to Johansen, there are two tests for the co-integration rank: the Trace test and the Maximum-Eigenvalue test. However, in this paper solely the Trace test has been used as the Maximum-Eigenvalue test does not provide a coherent testing strategy (Johansen (1994)). While the Johansen methodology has been used for identifying long term co-integrating relationships, short run dynamics have been modelled by the help of VECM.

The first step for using Johansen methodology are the unit root tests. As in the study of Calza et al. (2001) we use Augmented Dickey-Fuller test and the Phillips-Perron tests. The null hypothesis for these both tests is of a unit root (non-stationary). In order to confirm the results of the traditional stationary tests, also Kwiatkowski test has been performed. The null hypothesis for this test is of a stationary. The first step for performing the unit root tests is the selection of the optimal lag length. According to Calza et al. (2001), the number of lags should be chosen so that the vector autocorrelation has been eliminated in the residuals. Similarly as in the work of Brzoza-Brzezina (2005), we use 3 information criteria (Akaike, Schwarz and Hannan-Quinn).

6.1.1 Disadvantages of the methodology

While in the previous paragraph (6.1.) the pluses of used methodology have been highlighted, there are several limitations that have to be taken into account as well. According to Brzoza – Brzezina (2005), the results of VECM method may be misleading in case the time span used in the analysis the countries contains data of an experienced significant transformation in their economic systems; the time series are not long. According to him, the VECM models based on the quarterly data are not "top quality". Also the accession of euro and other significant changes may be the reason for econometric relationship regarding loan behavior breakdown. Therefore, it can be concluded that this methodology is more suitable for developed countries rather than developing ones and those in transition period. When it comes to forecasting using VECM, the disadvantage is its inability to predict credit booms and its effects and that estimates are subject to the Lucas critique (Gambocharta et al., 2006). According to Lucas (1976), Lucas critique implies that it is not possible to predict the effects of change in economic policy based only on the historical data (particularly on the aggregated data.)

7 Data

In this section the data used in the study is described; the choice of variables and studied countries is justified. As the paper's goal is to address the lending equilibriums in particular countries and the underlying factors, some decisions regarding variables and data sources have to be made. Therefore, the section provides an overview regarding the used data sources. In addition, detailed Summary statistics have been performed and explained.

7.1 Choice of countries and variables

7.1.1 Choice of countries

The paper aims at discovering the Swedish bank lending business potential in foreign countries. Therefore, the countries chosen for the research are the main business markets for the four main Swedish banks (SEB, Swedbank, Nordea and Handelsbanken): Norway, Denmark and Finland.

7.1.2 Choice of variables

In the previous section many variables affecting the credit level to GDP are described. However, due to data availability constraints for some of the countries, the following variables that can be found for all of the countries were chosen: Gross Domestic Product, bank credit to households and non-financial corporations, inflation rates, interest rates and housing prices. The dependent variable for all the countries is Credit/GDP leaving the inflation rate, lending rate and house prices as explanatory variables. The time series for most of the data series end at the first quarter of 2016. The beginning of time series varies across variables and may be seen in more detail in Appendix 13.2.

7.2 Data description

According to previous research, there are several ways how each of the variables may be measured. A more detailed description of the data used of the countries is presented in the Appendix 13.2 where data sources, time spans of series as well as brief comments of the used data are provided. Quarterly data has been gathered for all the variables. The underlying idea is briefly outlined further in the paragraph.

Gross Domestic Product data is seasonally adjusted. For consistency total Gross Domestic product has been selected instead of Gross Domestic product per capita as for majority of countries time spans of total data was longer than the one for GDP per capita. The GDP data is reported in each country's currency and at a current market prices. For all the countries (except for Norway and Finland) expenditure approach of GDP has been employed. For Norway's and Finland's data income approach has been employed.

As the interest of Thesis is bank credit, the quarterly data of total bank credit for households and non-financial corporations was selected. The total bank credit includes both credit to domestic and foreign

households and corporations in all currencies. The household credit includes consumption loans and property loans.

Preferred kind of data on rates in different countries is annual bank lending rate weighted on maturities and kind of loan (household and non-financial). For, Sweden, Denmark, Norway weighted average annual rates of household and non-financial corporation lending (outstanding amounts) has been employed. Due to the lack of data availability for Finland, short term money market rates have been used instead.

For each of the countries house pricing index has been used as a proxy of house prices, for all the countries the property prices of all the country's locations have been calculated without distinction of particular more urban areas or major cities. Despite the fact that residential property prices have been taken into account, more detailed statistical distinction is different among countries. For example, in Sweden prices of one- and two-dwelling buildings for permanent living have been included in the housing index. In Denmark: sales of owner occupied flats. For Norway and Finland the total housing index has been used. The base year for each of the indexes has been reported in Appendix 13.2. The house price indexes have not been seasonally adjusted.

As noted in the Literature review section measure of inflation is HICP. According to Eurostat, HICP is calculated on a basis of harmonized approach and a united approach for all the countries. HICP provides the official measure of consumer price inflation. For Sweden HICP has been employed. For rest of the countries CPI (Consumer Price Index) has been employed. For obtaining more detailed information on base years of indexes for each of the countries may be found in the Appendix 13.2.

7.3 Summary statistics

Table 13.3 in the Appendix shows the Summary statistics for data that has been used for analysis of credit market and equilibrium level grouped on the variables. In the first column the all the names of countries involved in the analysis are outlined. In the second column the number of observations can be seen. The first four moments of the data have been reported. The mean and standard deviation is reported in the columns three and four, respectively. Skeweness and Kurtosis measures have been reported in fifth and sixth columns. Also media, minimum and maximum values have been reported in the table. As a final step for the descriptive statistics the p-values of a Jarque-Bera test of normality have been reported (10th column in the Descriptive statistics' table); this has been investigated by Jarque and Bera (1987). The Null hypothesis of this test is that the sample comes from a normal distribution with unknown mean and variance. The alternative hypothesis indicates that the sample does not represent a Normal distribution. In addition to Appendix 13.5, graphical depiction of time series has been reported making more sound decisions especially regarding stationary indicating parameters.

Majority of the quarterly data ends on Q1 of 2016; that is the latest available quarter for the data series. However, the available start for each of the data series differs and may be analyzed in more detail in Appendix 13.2.

The highest number of GDP observations is Norway with 117 observations, the shortest time series available are for Sweden (91 quarterly observations). The mean is higher than standard deviation for all GDP time series. According to the results Skewness and Kurtosis, it can be concluded that GDP data is not skewed or peaked strongly. For example, Kurtosis amounts from 1.06 to 1.8. Skewedness measure was reported for Sweden from – 0.08 to 0.45. However, it should be noted that the highest skewness of 0.45 is for Norway's GDP time series. The values for skeweness and kurtosis in a normally distributed data is 0 and 3 respectively. Even though there is no major deviation from Normality for this data detected by the previous measures, it requires additional Normality test. According to the results of the tests it can be concluded that data GDP data series do not follow Normal distribution (the Null hypothesis has been rejected) as the probability reported in the final column does not reach 5%. That can be explained by the fact that GDP is an aggregate measure.

Data on bank credit is one of the most restrained one as the availability of data on this topic has been limited. That can be easily observed in the number of available observations. The largest sample is for Norway (99 observations) while the shortest one consists only of 53 observations for Denmark. Similarly to GDP, in all cases mean is higher than standard deviation. Credit data is slightly more skewed (the skewness ranks from -0.27 to +0.15). Data on Credit in Denmark shows normality in its nature as Kurtosis is 2.16 and probability reported by Jarque-Bera: 16.28% which is higher than 5%.

Data on annual rates shows that the highest number of observations is for Norway (117 number of quarterly observations), the lowest number again is for Denmark (57). Means and standard deviations for all the series follows the same pattern as for GDP and Credit time series: mean is higher than standard deviation for each of the countries. The results do not reveal any significantly skewed data. However, on the one hand, Kurtosis is quite high almost reaching 3 for Norway (2.56) showing signs of normally distributed data. On the other hand, Jarque-Bera test does not indicate that data on credit follows normal distribution. In the Appendix 13.5 it can be seen that for all the countries the annual rates have been decreasing over the last quarters. In data of Norway and Sweden a clearer trend shifting down over time may be observed while for Denmark and Finland the data has more volatile nature.

Housing prices' time series are quite long for all the countries; the shortest available time series are for Denmark and Norway (97 for both). In the Minimum and Maximum columns it is seen that data contains very low and high values. From the graphical depiction of data series of housing it can be clearly concluded that data contains a trend which explains the significant difference between min and max values. The data is slightly skewed and peaked, as compared to Credit and GDP because of the upwards shifting trend. Trend is also the reason behind the data not being normally distributed.

The longest available data on inflation is on Denmark and Norway (117 observations for each country). For all countries mean is higher than standard deviation. Data is not skewed, Kurtosis is close to normal level amounting up to 2.04 for Sweden. Jarque-Bera test does not indicate any data normality signs. In Appendix 13.5 it can be observed that the inflation has a clear trend present in the data as the inflation index has been rising throughout quarters.

Credit/GDP ratio for all the countries has been calculated by dividing Bank credit with GDP. Both measures have aggregating nature, therefore, can be compared. Both credit and GDP have been reported in local currencies, therefore, they may be compared to each other and consequently result in a ratio form. Number of observations is closely linked to the number of observations for Credit and GDP; the highest number of observations of the ratio is for Norway (82 observations), the lowest one: for Denmark (53 observations). Due to rather lo amount of observations for Denmark, the data shows quite high skewness (0.39) as compared to other data series. However, Kurtosis for all the countries does not show a significant deviation from a normal level. Jarque-Bera test implies that Norway data might have been normally distributed (the probability reported is above 5% and reaches 5.7%).

Appendix 13.4 shows the correlation matrices for each country's data. Correlation matrices have been created to see the correlation level between one country's variables to check if the overall logic of the variables' correlation sign (plus or minus) is in place. The correlation indices between pairs of variables have been calculated for the longest available data. Even though the correlation results do not indicate a neither a precise relationship nor causality, an overview of the data's behavior and relations can be obtained. In line with the descriptions in the Literature Review, the correlation of Credit and GDP has a positive relation (the correlation coefficient is +0.967 for Sweden). For all the countries this relation is highly positive; for Denmark the coefficient is +0.487 (slightly lower) which can be explained by shorter data series. Also Housing prices and Credit have a positive relationship. One way of possible relation is that higher housing prices lead to higher value of collateral and a subsequent rise in crediting. Another way is that crediting allows to purchase more of housing assets and, therefore, drives the demand and prices up. In Sweden the correlation coefficient between housing prices and bank credit is +0.966. In the correlation analysis it is seems that also inflation levels have a positive relation to the credit level which is in line with previous researches. The inflation and housing prices are strongly connected (also seen in the correlation analysis where, for example, the coefficient between housing prices and inflation for Sweden is +0.981). Correlation between rates and lending show reasonable result for all countries except for Denmark (probably due to shorter time series available); the rate and lending is negatively correlated meaning that less credit is demanded as the lending rate grows.

7.4 Availability of data

The list of data sources is outlined in the Appendix 13.2. The prevailing sources are National Statistical Data Bases for each countries (Statistics Sweden, Statistics Denmark, Statistics Norway, and Statistics Finland). For interest rates statistical data bases of Central Banks have been used (Suomenpankk). In

addition such data bases have been used: Financial Market Statistics in Sweden, Eurostat, OECD Data, and Genesis.

8 Methodology

In this section the research method used in the Thesis is explained. The section is structured in the following way: the first one addresses the issues regarding the use of non-stationary data which is followed by an outline of tests that help in identifying data non stationarity. This section also explains the importance of stationarity and briefly discusses the implications towards the data used in this Thesis. In the second section, cointegration and the possible data transformations are explained. The following parts provide a brief description of the use of multivariate models in the Thesis. Finally, different model set-ups and their specifications are defined and their intentions are explained in a summarized manner. For the justification of the chosen methodology, please, see the section 6. All the analysis that has been carried out was performed by using statistical software STATA (Version 11).

8.1 Unit Root and non-stationary

There are several reasons, why it is important to be able to differentiate between unit roots and stationarity within data. The ways it may affect the results of analysis are pointed out in further sub-sections.

8.1.1 Stationary

A stochastic process (y_t) is called stationary if it has time-invariant first and second moments (Lütkepohl and Krätzig, 2004). According to their paper, stochastic process is described as "a collection of random variables": y_t is stationary in case both of the conditions are fulfilled:

1. $E(y_t) = \mu y \; for \; all \; t \in \mathrm{T}$
2. $E[(y_t - \mu y)(y_{t-h} - \mu y)] = \gamma h \; for \; all \; t \in \mathrm{T} \;\; and \; all \; integers \; h \; such \; that \; t - h \in \mathrm{T}$

According to Lütkepohl and Krätzig (2004), the notations showed above imply that the means, variances, and covariance are finite numbers.

8.1.2 Unit Root

A nonstationary stochastic process that can be made stationary by considering first differences is said to be integrated of order one (I(1)). To be more specific, a data generation process is said to be *integrated of order d* (I(*d*)) if first differences have to be applied *d* times to make the process stationary. An I(*d*) process with $d \geq 1$ is called a *unitroot process*, or it is said to have a *unit root*. The Unit root hypothesis has been described by by Lütkepohl and Krätzig (2004).

It is important to distinguish stationary processes from unit root processes, for the following reasons (Bierens, H.J., 2001):

the first reason is that regressions involving unit root processes may give spurious results, according to Granger and Newbold (1974). Other examples of spurious regressions may be found in works of Phillips (1986) and Durlauf and Phillips (1988). The main idea behind the spurious results is that if the time series involved are unit root processes, naive application of regression analysis may yield nonsense results. So the problematic nature of using such variables in regressions is that they tend to increase the R-squared and record too high t-statistics. Such behavior of these variables causes them to appear significant when they actually are not and do not have any economic explanation.

The second reason is that for two or more unit root processes there may exist linear combinations which are stationary, and these linear combinations may be interpreted as long-run relationships. This phenomenon is known as cointegration (described in more detail further, 8.2.).

As noted before, the importance of data stationarity is crucial for performing a research of a high quality. Therefore, a brief summary regarding the variables of different countries in relation to data stationarity used in this Thesis is presented further.

This Thesis observes how Nominal GDP per capita to bank lending level is affected by inflation rates, interest rates and housing prices. Since GDP and Bank lending are aggregate time series data, according to the definition of stationarity, these variables are not stationary (due to upwards sloping trend caused by aggregation). This is also supported by Lütkepohl and Krätzig, 2004, according to whom, many macroeconomic variables tend to grow over time which makes them non-stationary.

There has been a great debate regarding the stationarity of inflation rate. Nelson and Schwert (1977), Baillie (1989), Ball and Cecchetti (1990), and Johansen (1992), using different countries and time periods, have all found evidence consistent with two unit roots in prices, so that any shock to inflation has a permanent effect. Barsky (1987) argues that inflation was stationary until 1960 and non-stationary thereafter. Based on the previous research it is assumed that interest rates are non-stationary.

There has been a debate regarding it stationarity also regarding housing prices. According to papers by Abraham and Hendershott (1996), Capozza, Hendershott, and Mack (2004), Gallin (2006), Mikhed and Zemcik (2009), they have relied on the assumption that time series data of housing prices has a unit root.

Stationarity of real interest rate has been questioned in several studies including Rose (1988) who concluded that interest rate is non-stationary. On the other hand, Lopez & Reyes (2007) as well as Sekioua S. and Zakane A. (2007) proved that real interest rates are stationary. There is also mixed results regarding researching stationarity of both, real and nominal interest rates, by Hansen (1999), Romano and Wolf (2001) and others.

As the results from previous studies of all variables used in this Thesis are contractionary, in order to gain deeper understanding of the stationarity of the data used in this paper, several tests will be applied to check for stationary for each of the variables. As discussed further, in case the data is non-stationary, data transformation is applied until the stationarity of data is achieved.

8.1.3 Unit Root tests

The order of integration of a time series is of great importance for the analysis, several statistical tests have been developed for investigating it. There is a large literature on unit root testing with many more proposals and refinements that will be only slightly outlined here. See, for example, A. Bhargava (1986) and M. Ogaki (1993). According to Lütkepohl & Krätzig (2005) the unit root tests may be divided in several sets.

The first set of tests checks the null hypothesis that there is a unit root against the alternative of stationarity of a data generation. It is important to note that the null hypothesis is accepted unless there is strong evidence against it. Therefore, an alternative explanation for the common failure to reject a unit root is that most economic time series are not very informative about whether or not there is a unit root (D. Kwiatkowski, P.C.B. Phillips, P. Schmidt, 1991). According to different sources of previous researches described by D. Kwiatkowski, P.C.B. Phillips, P. Schmidt (1991), it would be useful to have available tests of the null hypothesis of stationarity as well as tests of the null hypothesis of a unit root. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests take a quite different view at the unit root testing problem by checking a stationarity null hypothesis against an alternative of a unit root.

As described in the 6th section where the choice of methodology is presented the following tests were chosen: Augmented Dickey-Fuller (ADF), Phillips– Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS). For all the models it is essential to understand if the trend and constant should be included in the testing, according to Stock&Watson (2001), a trend is "a persistent long-term movement of a variable over time, a time series variable fluctuates around its trend". The trend and constant may be spotted after visual analysis or the time series. In the same section the lag order determination choice has been indicated; based on the literature survey, we use 3 information criteria (Akaike, Schwarz and Hannan-Quinn). The lag order is described in a greater detail in the section nunber: 8.4.1. In the following sections most popular unit root tests are described.

8.1.4 Augmented Dicky-Fuller test (ADF)

The standard Dickey-Fuller unit root test was presented in the paper of Dickey-Fuller (1979). Tha Augemented Dickey-Fuller unit root test (ADF test) is an extension of this standard test. It is common to visualize the data before running this test; it is needed for making decision

whether the data contains constant or trend. If the regression is specified without this decision, it may lead to wrong conclusions regarding the stationarity in the data.

The first step in explaining the Augmented Dickey Fuller test is this AR(1) model:

$$y_t = a_1 y_{t-1} + \varepsilon_t$$

Then y_{t-1} is subtracted from the both sides of the above equation. It is an equation is basis of regression that is used for the standard Dickey-Fuller test:

$$\Delta y_t = \gamma y_{t-1} + \varepsilon_t$$

$\gamma = \alpha_1 - 1$ is the variable based on which the stationarity is determined

The extension of the standard DF test, ADF, is obtained by linking a constant and a drift term.

$$\Delta y_t = \alpha_0 + \alpha_2 t + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

where:

$$y_t = dependent\ variable$$
$$a_0 = constant,$$
$$a_2 t = trend\ term,$$
$$p = lag\ order\ of\ AR\ process,$$
$$\gamma = -(1 - \sum_{i=1}^{p} a_i)$$
$$\beta_i = \sum_{j=i}^{p} a_j$$

In the standard Dickey-Fuller test γ is the coefficient that determines whether the time series contains a unit root. By including lags of the order p the ADF formulation allows for higher-order autoregressive processes. The hypotheses used in Augmented Dickey-Fuller test are following:

Null hypothesis: $H_0: \gamma = 0$

Alternative hypothesis: $H_A: \gamma \neq 0$

If the null hypothesis is rejected, there is no unit root in the time series at the considered significance level. If one fails to reject the null hypothesis, unit root evidence has been found in the time series at the given significance level. According to Y.W. Cheung & K.S. Lai (1995), lag order and sample size can affect the behavior of ADF test.

There have been critics towards ADF test. It is important to note that the unit root is the null hypothesis to be tested; the way in which classical hypothesis testing is carried out ensures that the null hypothesis is accepted unless there is strong evidence against it (Kwiatkowski et al., 1992). Alternative explanation for the common failure to reject a unit root is simply that most time series are not very informative about whether or not there is a unit root; standard unit root tests have not been proved very powerful. Taking into account the disadvantages and limitations of ADF, two additional unit root tests will be performed. Two other popular tests that have been employed are Philips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin test (KPSS).

8.1.5 Philips-Perron test (PP)

The null and alternative hypotheses of Philips-Perron test (PP) are identical to the ones of Augmented Dicky-Fuller test. According to Enders (2009), Phillips – Perron test (PP test) should be used as a complement to ADF test as is has a greater power of rejecting the wrong null hypothesis of a unit root. It is justified by the fact that requirements of error terms in PP test are more relaxed than in the ADF test (they are allowed to be weakly dependent and heterogeneously distributed). Similarly to ADF test the reliability of PP test is highly dependent on the correct decisions regarding inclusion constant and trend.

8.1.6 Kwiatkowski–Phillips–Schmidt–Shin test (KPSS)

Contrary to the both unit root tests described before (ADF test and PP test), the KPSS is a stationarity test and hence its null hypothesis is that the series are stationary (data contains no unit root at the given significance level). The following model has been used for the KPSS model:

$$y_t = \varepsilon t + r_t + \varepsilon_t$$

where:

$y_t = dependent\ variable\ for\ which\ to\ observe\ stationarity$,

$\varepsilon t = deterministic\ trend,$

$\varepsilon_t = stationary\ error,$

$r_t = random\ walk.$

The random walk r_t can be decomposed further:

$$r_t = r_{t-1} + u_t$$

where u_t is identically and independently distributed $(0; \sigma_u^2)$.

The null hypothesis of this test that the series are stationary. The hypotheses are used to determine the existence of a unit root*:*

Null hypothesis: $H_0: \sigma_u^2 = 0$

Alternative hypothesis: $H_A: \sigma_u^2 > 0$

8.2 Cointegration

When a linear combination of unit root nonstationary variables is stationary, they are said to be cointegrated (Ogaki M.). According to Lütkepohl, H. & Krätzig (2001), a special situation may arise if several variables are driven by a common stochastic trend. In that case they have a particularly strong link that may also be of interest from an economic point of view. Following Granger (1981) and Engle & Granger (1987), variables are called c*ointegrated* if they have a common stochastic trend. In the cases when the time series are found to have a unit root, cointegration tests are performed to check the existence of a long-term relationship between the variables. In theory two tests are performed for checking cointegration with the help of Johansen test (Johansen, 1988, 1991, and 1995). Despite that fact that there are also other test, the most studies related to credit modelling use the Johansen cointegration test as mentioned in the 6th section. The Johansen test is described in more detail in section 8.4.2.

VECM is accounting for variables that are cointegrated. In case two or more variables (non-stationary ones) have a common path in the long run, tests for cointegration may be performed. In case two or more variables have been cointegrated, a standard VAR approach is not applicable and VECM should be used to get correct results.

8.3 Number of lags

The main decision in cointegration testing is the selection number of lags (Bharat, B. & Takala, K., 1998). There are several ways of determining the number of lags of VAR model. Among the few methods available for choosing the lag length of the model, this paper employs an information criterion (Lütkepohl, 2005) which is perhaps the most common one (Stock, J.H.&Watson, M.W., 2011).

Three commonly used information criterion procedures used are: Bayesian information criterion (BIC), also known as Schwarz's information criterion (SIC), the Akaike's information criterion (AIC), and the Hannan and Quinn information criterion (HQIC) (Stock, J.H.&Watson, M.W., 2011).

AIC

$$\mathrm{AIC}\ (\mathrm{p}) = \ln\left[\left|\tilde{\sum} p\right|\right] + \frac{2pn^2}{\mathrm{T}}$$

BIC

$$\mathrm{BIC}\ (\mathrm{p}) = \ln\left[\left|\tilde{\sum} p\right|\right] + \frac{lnT}{\mathrm{T}} pn^2$$

HQIC

$$\mathrm{HQIC}(\mathrm{p}) = \ln\left[\left|\tilde{\sum} p\right|\right] + \frac{2\ln(\ln(T))}{\mathrm{T}} pn^2$$

Where:

$$p = number\ of\ lags,$$
$$T = time\ factor,$$
$$n = number\ of\ coefficients\ (including\ intercept),$$
$$\left|\tilde{\sum} p\right| = maximum\ likelihood\ of\ variance - covariance\ matrix\ of\ residuals.$$

An appropriate number of lags (p) must be chosen. Too many lags could increase the error and uncertainties in the forecasts, too few may leave out relevant information and decrease the level of accuracy (Stock, J.H.&Watson, M.W., 2011).

AIC, BIC and HQIC have different penalty functions that react differently to the number of variables, lags and sample size. Because AIC tends to penalize less for using more variables, using this criterion creates a higher risk of choosing an excessively high order of the VAR. BIC, on the other hand, runs the risk of underfitting the model. It is determined that AIC performs better than BIC in smaller samples (Liew, 2004). However, as the sample size grows BIC tends to become a more reliable measure. Similarly to BIC, the Hannan Quinn criteria are performing in large samples. For more information on HQIC see Hannan and Quinn (1979). According to Kuha (2004), researchers should make use of the three criteria. For each candidate model, the Information criterion can be evaluated, and the model with the lowest value of the Information criterion is the preferred model.

In addition to the information criterions as mentioned before it is important to confirm the lag length selected. The residuals of the models must not be correlated; that can be confirmed by Portmanteau Tests for autocorrelations. In case the autocorrelation prevails, lag length may need to be modified. In this case the Portmanteau Test has been used which has been developed and described by Box and Pierce (1970) and Ljung and Box (1978). In general, it is possible to pick a separate number of lags for each variable, but due to symmetry problems and issues with the effective use of OLS, such an approach is not common (Enders, 2009). Therefore, for each of the models I used the same number of lags. To sum up, similarly to the paper of (Bharat, B. & Takala, K., 1998), in this Thesis I used BIC, AIC and HQIC information criterions. For result verification purposes I used residual analysis described before.

8.4 Multivariate Models

Vector Auto-regression (VAR) models are used for finding the relationships among variables of interest as well as the level of strength of existing relationships. VAR was introduced by Sims (1980) as a framework that could be used by to characterize the joint dynamic behavior of a collection of variables in a flexible way and without requiring strong restrictions of the kind needed to identify underlying structural parameters. It has become a prevalent method of time-series modelling (Economic models at the Bank of England, 1999). VARs are dynamic systems of equations that examine the inter-relationships between the indicated variables, using minimal assumptions about the underlying structure of the economy.

A VAR model describes the evolution of a set of k variables (called endogenous variables) over the same sample period (t=1..., T) as a linear function of only past values (k-1). The endogenous variables are collected in a $k * 1$ vector, y_t. In addition, an error term is added. The error term represent parts of variables that are not related to their past values; it indicates the "innovation part" in variables.

The standard form of a VAR can be written as follows:

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + \mu + \varepsilon_t$$

Where:

$y = vector\ of\ edegenous\ variables\ (k * 1)$,

$\mu = vector\ of\ constants\ or\ intercepts\ (k * 1)$,

$\varepsilon = vector\ of\ error\ terms\ (k * 1)$,

$p = number\ of\ lags$,

$B = time\ invariant\ matrix\ (k * k)$.

Using the previous notations, the same VAR expression can be rewritten in a matrix form:

$$\begin{pmatrix} y_{1,t} \\ y_{2,t} \\ \dots \\ y_{k,t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \dots \\ \mu_k \end{pmatrix} + \begin{pmatrix} B_{1,1} & B_{1,2} & \dots & B_{1,k} \\ B_{2,1} & B_{2,2} & \dots & B_{2,k} \\ \dots & \dots & \dots & \dots \\ B_{k,1} & B_{k,2} & \dots & B_{k,k} \end{pmatrix} * \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \\ \dots \\ y_{k,t-1} \end{pmatrix} + \dots + \begin{pmatrix} B_{1,1} & B_{1,2} & \dots & B_{1,k} \\ B_{2,1} & B_{2,2} & \dots & B_{2,k} \\ \dots & \dots & \dots & \dots \\ B_{k,1} & B_{k,2} & \dots & B_{k,k} \end{pmatrix}$$

$$* \begin{pmatrix} y_{1,t-p} \\ y_{2,t-p} \\ \dots \\ y_{k,t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \dots \\ \varepsilon_k \end{pmatrix}$$

8.4.1 VECM

According to Lütkepohl, H. & Krätzig (2005), if cointegrating relations are present in a system of variables, the VAR form is not the most convenient model setup. In that case it is useful to consider specific parameterizations that support the analysis of the cointegration structure. The resulting models are known as *vector error correction models* (VECMs) or *vector equilibrium correction models*. VECM's particular difference from a standard VAR model comes from the existence of a long-term linear relationship between the variables, the cointegration relationship. When a cointegrating vector can be detected, error correction terms are built and added to the VAR. The purpose of the error correction terms is to adjust the model for the residual disturbance that can lead the cointegrated variables to deviate from their long-term equilibrium relationship.

The VAR model can be reformulated into the vector-error form:

$$\Delta x_t = C_1 \Delta x_{t-1} + \cdots + C_{k-1} \Delta x_{t-k+1} + C_0 \Delta x_{t-1} + \mu + \varepsilon_t$$

Based on the number of long term relationships (rank of cointegration), matrix C_0 can be factorized as:

$$C_0 = \alpha \beta'$$

Where:

$\alpha = n * r \; matrix \; of \; loading \; or \; adjustment \; coefficients,$

$\beta = n * r \; matrix \; of \; cointegration \; vectors,$

$n = number \; of \; variables,$

$r = number \; of \; long \; term \; relationships.$

The cointegrating vectors that form the matrix β describe the long term relationship between the variables. However, the matrix α describes the dynamic adjustment of the variables from the long term equilibrium level defined by β.

Estimating "Speed of adjustment" coefficients using VECM provides explanation how quickly the system of variables reverts back to the equilibrium after short run shock, it also gives understanding of which variables are the ones that respond the most to shocks. Extension of estimating VECM is plotting impulse response functions and conducting variance decomposition analyses which help to analyze the response of each time series to shocks in itself and other variables. The impulse response analysis (IRF) shows the effect of external shocks to the system throughout a particular time span. As the VECM takes into account the changes in all variables, considering also the lagged values and speeds of adjustments, it can be used for forecasts which are based on the historical information.

8.4.2 Johansen test

As mentioned previously, Johensen test will be used in Thesis for testing cointegration of the time series of all the vraibles. According to Bo Sjo (2008), the Johansen test is central for testing cointegration. This test provides a test statistic for determining the number of co-integrating relationships among several variables. According to S. Johensen (1991), just like in unit root test, there can be a constant term, a trend term, both or neither in the model.

The test is commonly regarded as a multivariate generalization of the ADF (Johansen and Juselius, 1992).

The Johansen test is based on maximum likelihood estimation and has two statistics: maximum eigenvalue and trace statistics. The trace test is more commonly used in academic papers and there are studies that also consider it to be marginally better in comparison to the maximum eigenvalue test (Cheung and Lai, 1993; Lütkepohl et al., 2000 and 2001). Hence, the trace statistic is preferred in this Thesis.

8.5 Data transformations and filtering

Stationary data is preferred for VECM analysis; the theory and previous researches have highlighted that spurious regressions may be result of using data that is not stationary. Spurious regressions easily lead to senseless results. In order to tackle the problem of stationary is data transformation with the aim of removing the unit root (Lütkepohl, 2005).

According to Lütkepohl (2005), there are several data transformations that can be used in order to obtain stationarity in the data. The standard way of transforming data that has a unit root is to employ simple first differences. Such an approach would be appropriate and coherent for data series that do not have strong trends and rapid changes throughout the years. If larger fluctuations for greater values of the series have been observed, logarithmic transformation may

help in stabilizing the variance. To improve the level of stationarity, first differences of the logs of variables are taken.

With respect to the data used in this paper it can be said that different data transformations are suitable for the different variables due to differences in their nature. The paper investigates the aggregate amount of GDP and credit value within different economies; this data by definition is not stationary. Such variables as housing prices, inflation rate and lending rate are different in their nature since these values are not aggregate.

The transformed data is once again tested for a unit root to make sure there is no non-stationarity within the variables. Although, these transformations are expected to remove any sources of non-stationarity, in case the variables are actually I(2) (integrated of order 2) and stationarity is not achieved, further differencing may be performed.

The decision, whether to use the previously mentioned data transformation techniques largely relies on the unit root test results. However, due to the limitations of the unit root tests and the potential risk of spurious regressions, data transformations are undertaken if the majority of the series are found to have a unit root, even if some of them are found to be stationary. The results of the unit root tests are presented in the empirical findings part.

8.6 Model specification

With regard to choice of methodology, the most suitable way of creating the model would be the one described in the work of Cottarelli et. al. (2003) due to the fact that both developed countries are used in this studies and are explored which is exactly what is planned to be explored in the Thesis (Sweden, Denmark, Norway and Finland). Cottarelli (2003) uses aggregated data on Credit/GDP data. This paper estimates the equilibrium lending level in each of the countries and identifies overshooting or undershooting.

The economic specification which we estimate for the private Credit/GDP ratio relies on explanatory variables used in previous studies, but also extends them. For estimating the equilibrium credit growth and identify potential overshooting or undershooting of economies, factors affecting the credit growth need to be explored. The factors described in the previous section will be used. However, another aspect such as supply side effects (bank liquidity level and capital requirements) would be an interesting part. However, they were not included in any of aggregate lending models. As already mentioned before, the time series data has to be stationary, otherwise it may cause spurious regressions. If the data is stationary and has a long run relationship (cointegration relationship), the relationship among the variables may be written is a certain form.

The model for each of the countries is given by:

$$\frac{Credit}{GDP}_t = b_0 + b_1 Rate_t + b_2 Inflation_t + b_3 Housing\ Prices_t + U_t$$

$$where:$$

$$\frac{Credit}{GdP} = financial\ deepness\ ratio, Credit\ and\ GDP\ expressed\ in\ local\ currencies,$$

$$Rate_t,\ Inflation_t, House\ Prices_t\ are\ the\ independent\ variables\ foe\ each\ country,$$

$$U_t = error\ term\ (differences\ between\ estimated\ and\ observed\ values),$$

$$b_1, b_2, b_3, b_4\ are\ the\ paraemeters\ that\ have\ to\ be\ estimated;$$

$$parameters\ represent\ the\ long\ term\ equilibrium.$$

In addition to exploring long run equilibrium levels of Credit/GDP ratios for each of the countries, the speeds of adjustments towards long run equilibrium are reported. In addition to the LR equilibrium detection, also the SR effects are researched. On the one hand, speeds of adjustments are reported in the Appendix 13.7. Estimation of the speeds of adjustments within VECM provide information on how quickly the VECM system reverts back to the equilibrium level after short run deviations. This adjustment also helps in detecting which of the variables is responsible more for "error correction" – which one has the greatest impact on that. On the other hand, impulse response functions are performed. Extension of estimating VECM is plotting impulse response functions and that help in analyzing the response of Credit/GDP to short term shocks in other variables in time span of 20 quarters (5 years), depicted in Appendix 13.9.

9 Empirical Results

VECM is used to describe the dynamic relationships among stationary variables. Therefore, the first step towards any conclusions was analysis of time series: determination if the levels of data series are stationary. In Appendix 13.6 the results of Unit Root tests (p values of ADF and PP) have been reported for specifications with constant only and for constant with trend. The test of data levels is reported as well as test for first difference of each variable.

Firstly, the selection of lag length should be done for performing the Unit root tests. For being sure how many lags to use three criteria had been used (AIC, BIC and QHIC are described in the Methodology section). The lag that was indicated by two or more criteria was chosen. For obtaining knowledge of number of lags for each of the countries, see Appendix 13.7 upper row. For all the variables of Sweden, Norway, Denmark and Finland the time series indicated non-stationarity in data levels (Appendix 13.6). Therefore, data series were transformed; all the

variables are stationary in their differences, they are integrated of order one I(1). That can be concluded from the reported p-values (test statistics were not significant at the 5% level). The stationarity is concluded based on the results of all the tests, ADP, PP and KPSS. Unit root tests require some judgement about the specification, meaning if the constant or trend should be included in the specification. For seeing full picture the graphical representation of time series (in Appendix 13.5) and tests on both specifications (constant only and trend with a constant) were made.

After the data has been transformed and concluded that time series are stationarity, the cointegration analysis was done using Johansen cointegration test which allows to determine if there is a co-movement between the time series for each of the countries. It is worth mentioning that cointegration analysis is performed on non-adjusted data. In case the cointegration analysis concludes that there is one or more than one cointegration vectors (error terms) VECM may be used. Cointegration vectors represent the long term relationship among variables. The number of lags used for cointegration analysis is the same that were obtained when making Unit root tests before. As mentioned in the Methodology section Johansen test is used for detecting cointegration; despite the fact that test is based on two statistics, maximum eigenvalues and trace statistics, only trace statistics test is used. According to Johansen test, all the countries have at least one cointegrating relationship (a long term equation or long term equilibrium level of Credit/GDP ratio). The exact cointegration equations may be identified by running VECM; the results for each countries' VECM results are reported in Appendix 13.7.

According to Johansen test, it was concluded that Norway has one co-integrating vector while in data of Sweden, Finland and Denmark two co-integrating equations were observed. However, after assessing the significance of the coefficients of the second equation, it was concluded that the coefficients are not significant at 10% level. Therefore, a restriction to the VECM system for all the countries of one rank was imposed. The results of VECM reported in the Appendix 13.7 report the results, taking into account the restriction of one co-integrating equation.

9.1 Long- run relationships

According to the VECM results reported (Cointegration equation in the table), the long run equilibrium equations of Credit/GDP in each of the countries is reported in the sections below. All the coefficients reported below are significant at 5% significance level.

Sweden:

$$Sweden: \frac{Credit}{GDP} = 3.47E18 * \text{Inflation} + 0.33907 * \text{Rate} + 0.0059 * \text{Housing prices} - 1.669949$$

The Long run equilibrium equation shows that inflation has a rather small impact on the long run equilibrium as the magnitude of the coefficient is small. The inflation coefficient is positive implying that increase in inflation causes the Credit/GDP ratio to increase. Also rate and

housing prices have a positive impact on the credit depth in Sweden. The effect of inflation and housing prices has a positive impact on credit as increase in the price levels of collateral has a positive impact on the lending amounts. The impact of rate (bank lending rate of outstanding contracts) has a positive impact on the Credit/GDP ratio in Sweden; the coefficient of rate has the largest magnitude of the coefficient (0.33907). Below the actual Credit/GDP and the long run equilibrium level is depicted. According to calculations by the end of 2015 the Equilibrium level is higher than the actual level of credit depth. By the end of Q3 of 2015 the Equilibrium level of Credit/GDP in Sweden was 2.94 while the actual ratio was 2.25; the equilibrium level is 30% higher than the actual one.

In history in can be seen that there has been a period of time when actual Credit/GDP ratio exceeded the Equilibrium level. This period of time when the actual Credit/GDP exceeded the Equilibrium level corresponds to the credit boom observed in Sweden.

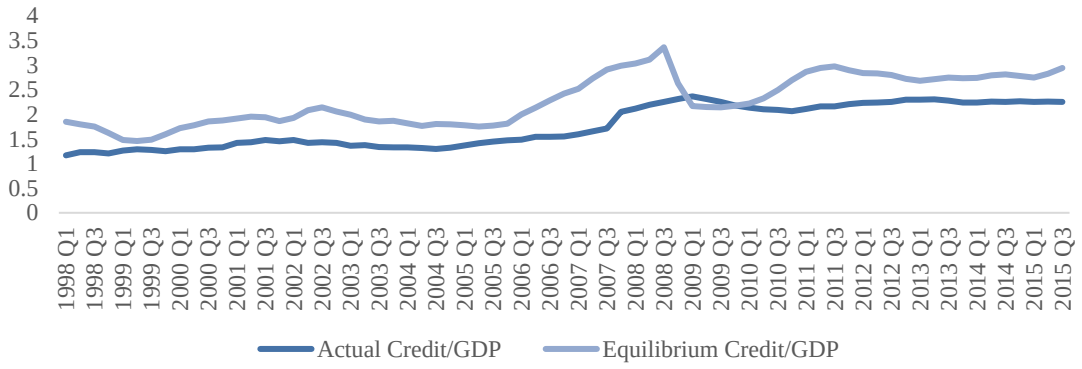


Figure 2: Credit/GDP in Sweden

Denmark:

In Denmark the Long run Credit/GDP equation is depicted below. The coefficient on inflation is 0. Impact of rate is negative and the magnitude of coefficient is large; the coefficient is 0.573 meaning that lending rate decreases the Credit/GDP which is line with the theory. However, also the housing price index has a negative impact on the credit depth which may be explained by the fact that an increase in housing prices causes the GDP grow more than bank credit.

$$Denmark: \frac{Credit}{GDP} = 0 * Inflation - 0.573 * \text{Rate} - 0.025 * \text{Housing prices} + 6.905$$

Similarly as in Sweden the most recent actual Credit/GDP ratio in Denmark is lower than the Equilibrium level. According to calculations the actual Credit/GDP ratio in Denmark by the end of Q1 2016 was 1.86. However, the Equilibrium level of Credit/GDP ratio was 2.55 which was 37% higher than the actual one. Also a similar historical situation can be observed; starting

from 2006 by the end of 2009 the Long run equilibrium level was below the actual Credit/GDP ratio indicating credit boom in Denmark.

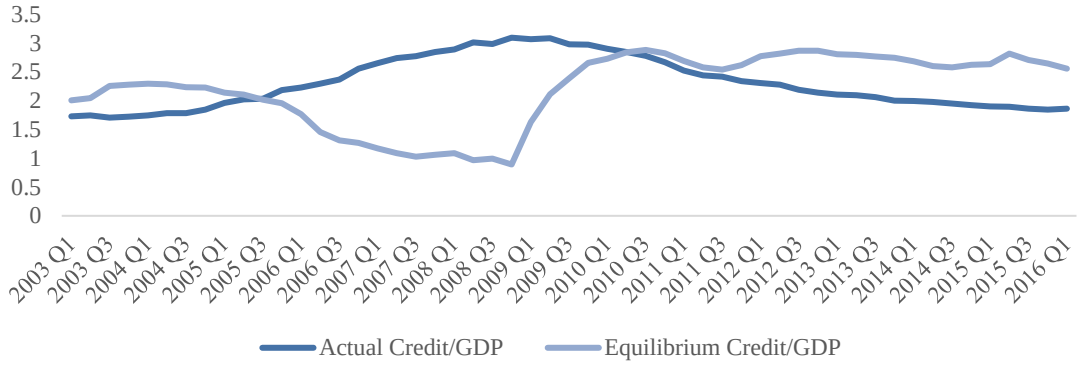


Figure 3: Credit/GDP in Denmark

Finland:

In Finland, both inflation and rate have negative impact on the Credit/GDP ratio. Also for Finland the highest magnitude of coefficient is for the Rate. As the lending rate increases, the financial depth decreases. The coefficient of housing prices is rather small; according to the theory the housing price index has a positive impact on the Credit/GDP level.

$$Finland: \frac{Credit}{GDP} = -0.02 * Inflation - 0.037 * \text{Rate} + 0.00395 * \text{Housing prices} + 0.955$$

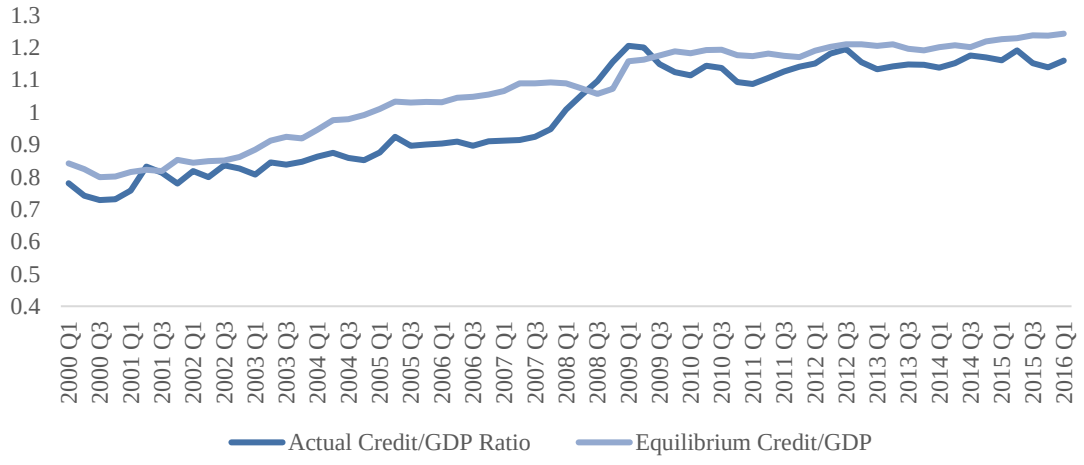


Figure 4: Credit/GDP in Finland

The Actual Credit/GDP ratio at the end of Q1, 2016 was 1.16 while the Long run Equilibrium level of Credit/GDP level in Finland was 1.24 (7% higher than the actual credit depth defining ratio). Similarly to results of Sweden and Denmark, a credit boom in 2008 can be observed as the Equilibrium level at that point is lower than the actual ratio in the economy.

Norway:

The signs of coefficients for Norway's LR Equilibrium level of Credit/GDP ratio are opposite, if compared with the ones of Finland. By the end of Q1, 2016 the Equilibrium level of Credit/GDP was very close to the actual ratio: the Equilibrium level was 2.12 while the actual ratio was 2.11. In Norway the actual results are the closest to the LR Equilibrium of credit depth ratio leaving low level of opportunities of increasing the bank lending in the country's economy.

$$Norway: \frac{Credit}{GDP} = 0.12321 * \text{Inflation} + 0.00711 * \text{Rate} - 0.039248 * \text{Housing prices} - 8.187582$$

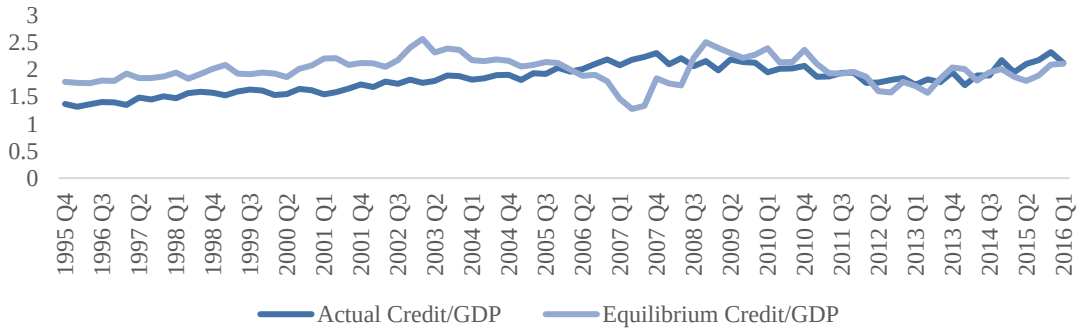


Figure 5: Credit/GDP in Norway

The coefficient ce1 in the Appendix 13.7 have to be negative and significant. These coefficients (error correction coefficient) show the speed of adjustment of previous period's long term disequilibrium to the long term equilibrium in the current period. The long run speed of adjustment provides the direction for variables in the system to restore back to long run equilibrium (makes corrections to disequilibrium).

Country	Sweden	Denmark	Norway	Finland
Speed of adjustment	10.22%	3.07%	14.36%	20.36%

Table 3: Speed adjustment coefficients to the LR Equilibrium

For example, in Sweden the coefficient ce1 is 0.1022 and is significant at 5% significance level. This number shows that system's previous period's disequilibrium is corrected at a speed of 10.22% quarterly to reach long run equilibrium the in current period. The coefficient for Finland is significant at 15% level. From the assessed countries the Credit/GDP ratio in Finland is corrected to reach LR Equilibrium at the highest speed: during one quarter the ratio is corrected by 20.36%. The slowest pace of response is for Denmark (coefficient significant at 5% level)

meaning that LR disequilibrium of Credit/GDP ratio in Denmark is corrected only by 3.07% during a quarter towards the LR equilibrium.

As a final step of VECM, the testing autocorrelation and normality of residuals is done. The outcome of the Lagrange-Multiplier test for autocorrelation in errors is reported in Appendix 1389; it can be concluded that no autocorrelation in residuals is observed for VECM systems of Sweden, Denmark, Finland and Norway. The decision is based on the p (chi^2) which shows that statistic is significant at 5% level. The test used for determining normality of residuals is depicted in the Appendix 13.8 where all the variables and the system in total have been tested.

9.2 Short-run relationships

An extension of VECM are impulse response function (IRF) which help to understand how the shocks in Inflation rate, lending rate and housing prices affect the VECM system. A unit shock is applied to the variables for time span of 20 steps in order to assess the impact on the Credit/GDP ratio over the next 20 quarters (5 years). For all the researched countries the one unit shocks have been made to the respective inflation, housing price and lending rate variables with the purpose of defining the behaviour of Credit/GDP. In the Appendix 13.9 impulse response functions for each of the countries has been depicted.

Positive short term shocks in housing prices have a positive impact on Credit/GDP ratio for Sweden during the first 10 quarters. After reaching the peak the shock gradually decreases the credit depth. Short term shocks in inflation rate tend to increase the Credit/GDP in the first quarters and decrease over time. The shock in rate of lending in the short term has a positive impact, after the 9^{th} quarter the rate starts to decrease the Credit/GDP ratio.

Similarly to Sweden also in Denmark the shock in housing prices has a positive impact on Credit/GDP ratio. However, during the 20 quarters it does not start reverting back as in case of Sweden. The same pattern is observed also for impulse response functions caused by inflation and rate variables in Denmark.

In Finland the impulse response function of caused by housing prices has a similar behaviour as in Denmark. However, the shocks in inflation and rate have higher level of variability than the ones observed in Sweden and Denmark. Also in Norway the impulse response functions have high level of fluctuations which are difficult to interpret.

In Appendix 13.7 also the speeds of adjustments towards short run equilibriums have been reported. The speeds of adjustments identify which of the variables respond more if there is a change (shock) in the system. Not all of the SR speed adjustments are significant at 5%. However, the significant coefficients are depicted below.

	Sweden		**Denmark**		**Norway**		**Finland**	
	Coeff.	Lag	Coeff.	Lag	Coeff.	Lag	Coeff.	Lag
Credit/GDP	+0.16	2	+0.45	4	+0.36	4	+0.24	1
Inflation rate			+0.12	1	-0.03	1	-0.009	1
Lending rate	+0.009	4			+0.03	3	+0.036	2
Housing price	+0.007	3	+0.007	3	+0.008	1		

Table 4: Speeds of adjustments to the short run Credit/GDP Equilibriums

For all countries the largest impact on the equilibrium levels of Credit/GDP is made by lagged Credit/GDP ratios. For example, in Sweden the Credit/GDP ratio 2 quarters ago has the highest impact of 16%. For Denmark and Norway the impact is higher (45% and 36% respectively) at higher lags. In Finland the Credit/GDP ratio lagged by one period (quarter) has the highest impact.

To sum up, in all the researched countries (Sweden, Norway, Denmark and Finland) the actual Credit/GDP ratio is below the long run Equilibrium level. However, in Norway the actual ratio by the end of Q1, 2016 was very close to the long run Equilibrium level leaving little space for increase in the bank lending in this country. By comparing the actual levels of bank lending to GDP and LR equilibrium levels a clear evidence of bank lending boom in 2008 was spotted. Speed of adjustment towards long run equilibrium shows that Finland has the fastest reversion rate: during one quarter the ratio is corrected by 20.36%. The slowest pace of response is for Denmark meaning that LR disequilibrium of Credit/GDP ratio in Denmark is corrected only by 3.07% during a quarter towards the LR equilibrium.

10 Limitations and future research

In this section limitations of this paper have been spotted and their effect on the conclusions discussed. Also suggestions for future research have been proposed, based on the factors defining limitations and on other ideas.

10.1 Limitations

There are several limitations related particularly to the chosen methodology that have been described in section 6.1.1. Other limitations are mainly related to the choice of variables and various data-related issues. There are several variables that could have been included in the model in addition that are used in this paper, according to the literature as it has been mentioned in the section 5.2. Besides the used variables, we could have employed also such ones like: bank credit to the government sector, business investment, alternative financing sources, financial system liberalization variables, bank regulation and legal origin dummies. However, there are other significant points that have to be mentioned.

Firstly, one of the main limitations are the restrictions on data series length. The available timeframe for several variables differs, therefore, causing inconsistent time series and forcing to choose the shortest data set that is available. The sample data is particularly subject to limitations for countries that have experienced significant changes (such as privatization, euro accession etc.) and may cause structural breaks. For example, as mentioned in the work of Brzoza - Brzezina (2005) the euro accession is an important aspect; in some countries the lending booms were observed during the euro adoption summing reaching 20% of quarterly growth rate in loans to private sector. Mostly affected were the lower-income, catching-up countries such as Baltic States represented in our study. According to this study, structural brakes cause imperfections in the results of VECM.

Secondly, a shortcoming may come from the fact that aggregation principles of data may differ across countries which may make the results incomparable. According to Hofmann (2001), this issue is particularly important for the countries that have experienced banking crises.

Thirdly, the use and choice of variables has some drawbacks. Using structural data would give more plausible and detailed results. For example, if the loans for corporations and households would have been analyzed separately taking into account also the corresponding interest rates, the results would have been more reliable. Also the analysis of loans regarding maturity, their rates (magnitude, fixed and variable rate loan proportions) and purposes would have been beneficial. The loans may be analyzed based on the collateral kind (single-family dwellings, condominiums and tenant-owner apartments, multi dwelling buildings, agricultural buildings, different kinds of guarantees, other collaterals or unsecured loans).

Regarding the choice of variables there may be many limitations as well. For example, as spotted by Hofmann (2001), the housing prices are often calculated on the country basis but the major economic activity happens in cities, therefore, it would have been better to use the prices on real estate in cities rather than in countries in total. Another example are the interest rates. According to Hofmann (2001) it would be more appropriate to use interest rates deflated by the expected inflation, not the current one.

10.2 Suggestions for future research

After the assessment of the results in combination with limitations of this paper it is concluded that future research should be directed towards at least five additional issues.

Firstly, as mentioned in the previous section (10.1), the follow up papers could focus on more detailed data including data on loans broken down by sectors, purposes, maturities and their rate compositions.

Secondly, other variables could be included in the research such as variables related to liberalization of financial system, euro adoption, alternative financing. Also the supply side factors such as bank profitability and regulation related variables could be added in the research.

Thirdly, by introducing supply side factors more research could be done for distinguishing the supply and demand side factors. This would add to the existing literature defining and exploring different determinants of the bank lending in total and financial deepness.

Fourthly, the results of the study may be used for proposals and changes of the existing monetary policies in each of the countries. For example, more attention may be paid to the credit booms, their forecasting and possible using as an early warning indicator.

Finally, the business opportunities of Swedish banks could be assessed in more detail with regard to each of the foreign market of banks. For example, a more in-depth analyses of the each of the observed countries should be made and impact on lending opportunities of Swedish banks assessed.

11 Conclusion

Bank lending is an important source of economic development as it is a significant source of household and corporation financing. Therefore, development in crediting is an important source for analyzing and also forecasting economic development.

Based on the research done in this paper, the hypotheses stated in the introduction should be answered in order to answer the main research question. The results are based on the VECM methodology; the Credit/GDP ratio is assumed to be affected by such variables like Housing prices, lending interest rates and inflation rate in Sweden, Norway, Denmark and Finland.

H1: The Credit/GDP ratio of Sweden currently is lower than the equilibrium level.

By using VECM analysis a Long run Credit/GDP equation was determined. According to this equation and actual Bank lending to GDP in Sweden, it is concluded that the Equilibrium level at the end of Q3 of 2015 was higher than the actual credit level: Equilibrium level was 2.94 while the actual ratio was 2.25; the equilibrium level was 30% higher than the actual one. Therefore, the first hypothesis may be accepted.

H2: The level of Credit/GDP ratios in main foreign lenders of Swedish banks (Denmark, Finland, and Norway) is below their equilibrium level.

Long run Crredit/GDP ratio in Denmark is 1.86 by the beginning of 2016, the Equilibrium level is 2.55, 37% higher. In Finland the levels of bank lending to GDP in the long run are lower than in other countries: the Equilibrium level was at 1.24 and the actual ratio of 1.16 (7% lower than actual ratio. However, in Norway Equilibrium level is close to the actual one (the actual ratio at the beginning of 2016 was 2.11 and equilibrium one: 2.12). Therefore, it may be concluded that the second hypothesis may be accepted.

Since both of the hypotheses have been accepted, the research question stated in the introduction section of the Thesis:

"May Swedish banks reach optimal level of credit by increasing the lending to foreign markets?"

may be answered positively. The Equilibrium level of Credit/GDP ratio in Sweden has not been reached. Also in the largest foreign bank lending markets of Sweden (Denmark and Finland) the equilibrium levels have not been reached. However, in Norway the Credit/GDP ratio has been almost reached. Therefore, by increasing the level of bank lending amount in Denmark and Finland, the LR Equilibrium level of bank lending to GDP in Sweden may be reached. As

a result, it may be concluded that banks in Sweden have business opportunities in Denmark and Finland.

According to study, Finland has the fastest pace of reverting back to the LR Credit/GDP ratio: during one quarter the ratio is corrected by 20.36%. The slowest pace of response is for Denmark meaning that LR disequilibrium of Credit/GDP ratio in Denmark is corrected only by 3.07% during a quarter towards the LR equilibrium. Also the impulse response functions have been performed and show how shocks in housing prices, lending rates and inflation rates affect the Credit/GDP ratio during 5 years. In all the countries a short run positive shock in housing prices have a positive effect on Credit/GDP. However, in Sweden in 12 quarters the effect starts to revert. Effect of other variables has a more diverse effect for different countries. Speed adjustments to short run Equilibrium indicate that in the short run equilibrium in all assessed countries is mostly affected by lagged Credit/GDP ratios.

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13 Appendix

13.1 Survey of credit modelling studies

	Authors	Title & Year	Target countries	Variables used	Methodology
1	G. Kiss , M. Nagy, Vonnak B.	Credit growth in Central and Eastern Europe: Trend, Cycle or Boom?, 2006	Euro area in aggregate, three Baltic countries and the CEE-5 (Czech Republic, Hungary, Poland, Slovakia and Slovenia	Aggregate private credit/nominal GDP; PPP adjusted GDP per capita, short real interest rate and inflation	ECM on aggregate euro area data, panel econometric techniques, pooled mean group estimator
2	B. Egert, P. Backé, T. Zumer	Credit Growth in Central and Eastern Europe. New (over) shooting stars?, 2006	11 Central and Eastern European countries (Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia)	Private credit/GDP, PPP based GDP, government credit, short and long nominal interest rate, inflation, house prices, liberalization index (spread between lending and deposit rates), credit registries, competition in the banking sector	Panel econometric technique
3	A. Calza, C. Gartner AND J. Sousa	Modelling the demand for loans to the private sector in the euro area, 2001	Aggregate euro area countries	Real loans, GDP per capita in PPS, short term and long term real interest rates	VECM for aggregate countries
4	A.Calza, M. Manrique, J. Sausa	Aggregate loans to the euro area private sector, 2003	Aggregate euro area countries	Real loans, real GDP growth, nominal lending rate, inflation rate	VECM for aggregate countries
5	M.Brzoza-Brzezina	Lending booms in Europe's periphery: South Western Lessons for Central Eastern members, 2005	Portugal, Ireland, Greece, Hungary, Czech republic, Poland	Private, domestic currency Credit & GDP for Greece, Portugal and Ireland, total credit for euro area members, real 3 month interest rate.	VECM for individual countries

6	B. Hofmann	2001, The determinants of private credit in industrialised countries: do property prices matter?	16 developed countries: US, Japan, Germany, France, Italy, UK, Canada, Australia, Spain, Netherlands, Belgium, Ireland, Switzerland, Sweden, Norway, Finland	Real loans, aggregate private credit, Real GDP, real short term interest rate, housing price index (weighted average of residential and commercial property prices).	VECM for individual countries
7	C.Cottarelli, G.Dell'Ariccia, I. Vladkova-Hollar	Early birds, late risers, and sleeping beauties: bank credit growth to the private sector, 2003	15 Central European and Balkan countries: Bulgaria, Croatia, Estonia, Hungary, Latvia, Poland, Slovenia, Bosnia and Herzegovina, Serbia and Montenegro, Lithuania, Albania, Czech Republic, Macedonia, Romania, Slovak Republic	Credit to the private sector (%GDP), GDP per capita in PPS, inflation rate, financial liberalisation index, accounting standards, index of entry restrictions to the banking sector, legal system, public debt (%of GDP)	Random effect panel estimation of 24 developed and non-transition emerging countries, (in sample/HP filter), out of sample (random effects panel).
8	F. Boissay,O. Calvo-Gonzalez,T. Kozluk	Is Lending in Central and Eastern Europe Developing too Fast?, 2006	Bulgaria, Croatia, Romania and the 8 transition countries that joined the EU: Latvia, Hungary, Estonia, Lithuania, Slovenia, Poland, Czech Republic, Slovakia	Credit to the private sector (%GDP), GDP per capita, real interest rate (Euribor), quadratic trend	Time series, modelling credit/GDP equilibrium levels and elasticities of credit
9	C. Kok Sorensen, D. Marques Ibanez and C. Rossi	Modelling loans to non-financial corporations in the euro area, 2009	Euro area	M&A activity, cost of bank lending , money market rate, risk premium, investment, gross operating surplus, cost of equity issuance and debt securities	VECM for aggregate countries
10	O. Hulsewig	Bank behavior, interest rate targeting and monetary policy transmission, 2003	Germany	Loans (households and domestic companies), bank equity	VECM for one country

11	A.Calza et al.	Credit in the Euro Area: An Empirical Investigation Using Aggregate Data, 2006	Euro area (1980 - 2001)	Private credit/GDP: real GDP, short and long interest rate	VECM
12	S. Schadler et al.	Credit booms, demands booms and Euro adoption, 2004, International Monetary Fund	Euro area, New EU members, based on out of sample estimation (Czech Republic, Hungary, Poland, Slovak Republic, and Slovenia)	Private credit/GDP: PPP-based GDP long real interest rate.	VECM on aggregate euro area data
13	J. Kakes	Monetary Transmission in Europe: The Role of Financial markets and Credit, 2000	The Netherlands	Short term interest rate, long term interest rate, GDP, CPI, effective exchange rate, oil prices, aggregate credit	VECM
14	L. Gambocharta and C. Rossi	Modelling Bank lending in the Euro Area: A Non-Linear Approach, 2007	Euro area	Four endogenous variables (loans to the private sector, real GDP, lending rate, and consumer price index) and one exogenous variable (money market rate).	VECM
15	A. Brigden and P. Mizen	Money, Credit and Investment in the UK corporate sector, 1999	UK	Real money, real whole economy investment and real lending	VECM
16	A. Brigden and P. Mizen	Interactions between money, lending and investment in the UK private non-financial corporate sector, 2004	UK	Real money, real whole economy investment and real lending	VECM
17	L. Casolaro et al.	Un Modello Econometrico per il Credito Bancario alle Imprese in Italia, 2006	Italy	Fixed capital, stock of capital, difference between the interest rate on short-term loans, relative cost of bank credit compared to alternative forms of financing	VECM

18	B. Berkel and T. Werner	Modelling Loans to Non-financial Corporations, 2005, European Central Bank	Euro area	Real market based cost of debt, the GOS/GDP ratio, debt/GDP.	VECM

13.2 List of variables

Country	Variable	Description	Available time span	Source
Sweden	GDP	Seasonally adjusted, expenditure approach, quarterly data, SEK million	1993 Q1 – 2015 Q3	Statistics Sweden
Sweden	Credit	Bank total currency lending to public (households and non-financial corporations), SEK million	1998 Q2 – 2015 Q3	Statistics Sweden
Sweden	Interest rates	Banks' lending rates, outstanding agreements (percent, Swedish non-financial corporations and households)	1987 Q1 – 2015 Q3	Financial Market Statistics, April 2016
Sweden	Property prices	Real estate price index for one- and two-dwelling buildings for permanent living (1981=100) by region and quarter. For Sweden in total.	1987 Q1 – 2015 Q3	Statistics Sweden
Sweden	Inflation rates	HICP: Consumer prices: harmonized consumer prices (index)	1990 Q1 – 2015 Q3	Organization for economic co-operation and development
Denmark	GDP	Gross domestic input, current prices, seasonally adjusted, DKK mill.	1990 Q1 – 2016 Q1	Statistics Denmark
Denmark	Credit	Total loans from banks to non-financial corporations and households, DKK mill.	2003Q1 - 2016Q1	Statistics Denmark
Denmark	Interest rates	The banks' averagelending interest rates (p.c. per annum)	2002 Q1 – 2016 Q1	Statistics Denmark
Denmark	Property prices	Price index for sales of property (2006=100) owner occupied flats, all Denmark\	1992 Q1 – 2016 Q1	Statistics Denmark
Denmark	Inflation rates	Consumer Price Index (2015=100)	1980 Q1 – 2016 Q1	Statistics Denmark
Norway	GDP	Production account and income generation, by industry, time and contents, NOK million	1978 Q1 – 2016 Q1	Statistics Norway
Norway	Credit	Banks. Loans (NOK million), by type of loans, borrower sector, time and contents. Non-financial corporations and households.	1995 Q4 – 2016 Q1	Statistics Norway

Norway	Interest rates	Interest rates on outstanding loans (per cent), by financial corporation, type of loans, sector, time and contents	2009 Q1 – 2016 Q1	Statistics Norway
Norway	Property prices	House price index, by region, type of building, time and contents, seasonally adjusted	1992 Q1 – 2016 Q1	Statistics Norway
Norway	Inflation rates	Consumer Price Index (1998=100):	1979 Q1 – 2016 Q1	Statistics Norway
Finland	GDP	GDP income approach quarterly by Transaction, Price, Series, Year and Quarter, mill EUR.	1990Q1 - 2014Q1	Statistics Finland
Finland	Credit	Loans to non-financial companies and households,EUR million	1997Q4 - 2016Q1	Statistics Finland
Finland	Interest rates	The Euribor rate is calculated on the rate quoted by prime banks, operating in the euro area. There are approximately 50 banks represented in the arrangement, in Finland's case it is Nordea. The quotation is given at midday, Finnish time. The calculation is made leaving the 15% lowest and highest offers out and by calculating the unweighted average. Quarterly average rates 6m.	1999Q1 - 2016Q1	Suomenpankk
Finland	Property prices	Building cost indices, total index by Year, Month, Index and Data (1980 = 100)	1980Q1 - 2016Q1	Statistics Finland
Finland	Inflation rates	Consumer Price Index (2000=100)	2000Q1 - 2016Q1	Statistics Finland

13.3 Summary statistics

Tables present the summary statistics for the used data of each of the countries. Besides the standard summary statistics, the p-values of Jarque-Bera normality test are reported. The null-hypothesis of the test is that the data follows a normal distribution.

GDP									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	105	359 086	92 659	-0.08	1.06	210 498	498 006	355 533	0.0000
Finland	97	34488.05	9719.873	-0.04	1.56	20556	48574	35419	0.0000
Norway	117	693443.6	349321.4	0.45	1.80	263875	1365022	624557	0.0000
Sweden	91	704 361	184 970	0.04	1.74	401 798	1 043 682	696 272	0.0000
Credit									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	53	1 015 093	220 359	-0.23	2.16	612 269	1 371 157	998 444	0.1628
Finland	74	0.969966	0.162126	-0.05	1.43	0.720763	1.204597	39227	0.0000
Norway	99	1702213	667263.5	-0.27	1.79	532463	2965031	1989680	0.0000
Sweden	71	1418194	580475	0.15	1.37	606889	2351921	1223160	0.0000
Rates									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	57	4.65	1.13	0.11	1.76	2.60	7.00	4.80	0.0012
Finland	69	2.199246	1.607128	0.16	1.78	-0.186	5.024	2.139	0.0002
Norway	117	8.02188	3.980796	0.90	2.56	3.57	16.87	7.28	0.0021
Sweden	115	7.33	4.36	0.78	2.34	1.97	19.43	5.62	0.0026
Housing prices									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	97	62	27	-0.07	1.63	21	109	63	0.0000
Finland	117	233.0738	43.09085	0.25	1.81	155.8	303.37	224.66	0.0000
Norway	97	98.84227	47.82346	0.26	1.77	32.5	187.8	91	0.0000
Sweden	115	330.0609	154.9682	0.48	1.75	124	668	283	0.0000
Inflation									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	117	78.67	13.89	0.06	1.78	54.20	100.30	78.40	0.0000
Finland	65	113.8525	9.255911	0.19	1.58	99.34	127.93	114.53	0.0000
Norway	117	107.9154	19.23316	-0.01	1.92	71.2	143.4	108.9	0.0001
Sweden	103	87.19	11.27	-0.15	2.04	61.9	104.2	87.2	0.0045
Credit/GDP									
	Obs.	**Mean**	**Std.d.**	**Skewness**	**Kurtosis**	**Min**	**Max**	**Media**	**Jarque-Bera**
Denmark	53	2.30	0.45	0.39	1.8	1.7	3.1	2.2	0.0013
Finland	74	0.969966	0.162126	0.06	1.37	0.720763	1.204597	0.912433	0.0000
Norway	82	1.829685	0.253477	-0.14	2.15	1.315612	2.32258	1.790307	0.0574
Sweden	71	1.76	0.43	0.12	1.2	1.2	2.4	1.5	0.0000

The reported currencies:

Denmark: DKK Mill.

Finland: EUR Mill.

Norway: NOK Mill.

Sweden: SEK Mill.

13.4 Correlation matrices

Correlation matrix: Sweden					
	Housing price	Inflation rate	GDP	Rate	Credit
Housing price	1.000				
Inflation rate	0.981	1.000			
GDP	0.994	0.983	1.000		
Rate	-0.793	-0.784	-0.768	1.000	
Credit	0.966	0.974	0.967	-0.715	1.000
Correlation matrix: Denmark					
	Housing price	Inflation rate	GDP	Rate	Credit
Housing price	1.000				
Inflation rate	0.460	1.000			
GDP	0.668	0.951	1.000		
Rate	-0.329	-0.780	-0.664	1.000	
Credit	0.290	0.361	0.487	0.105	1.000
Correlation matrix: Finland					
	Housing price	Inflation rate	GDP	Rate	Credit
Housing price	1.000				
Inflation rate	0.973	1.000			
GDP	0.987	0.944	1.000		
Rate	-0.591	-0.683	-0.516	1.000	
Credit	0.987	0.970	0.962	-0.624	1.000
Correlation matrix: Norway					
	Housing price	Inflation rate	GDP	Rate	Credit
Housing price	1.000				
Inflation rate	0.991	1.000			
GDP	0.993	0.986	1.000		
Rate	-0.718	-0.741	-0.700	1.000	
Credit	0.851	0.890	0.838	-0.761	1.000

13.5 Graphical depiction of summary statistics

Figure 6: Housing index in Sweden

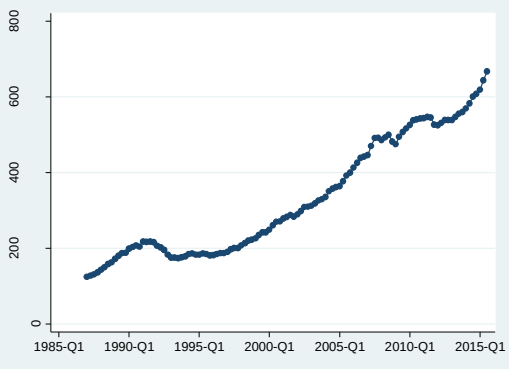


Figure 7: Interest rate in Sweden

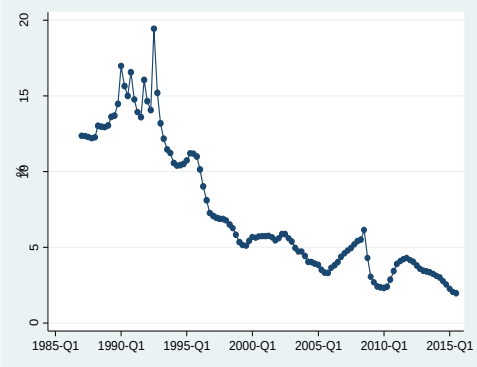


Figure 8: Inflation in Sweden

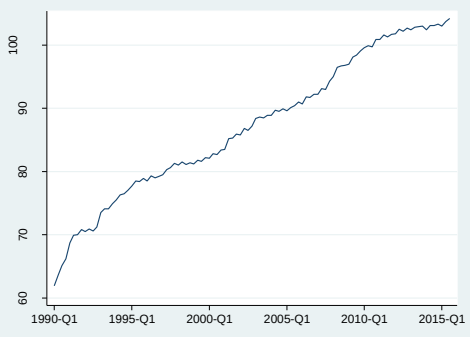


Figure 9: Quarterly GDP in Sweden

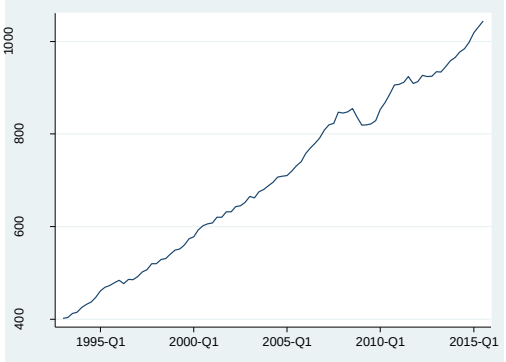


Figure 10: Bank credit in Sweden

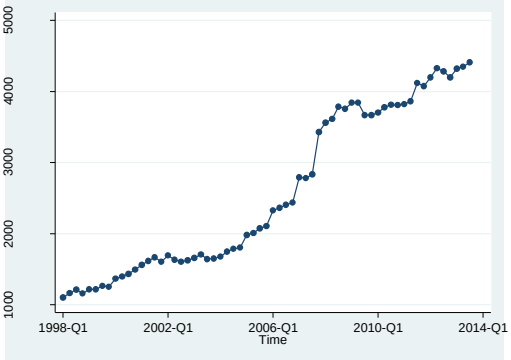


Figure 11: Credit/GDP ratio in Sweden

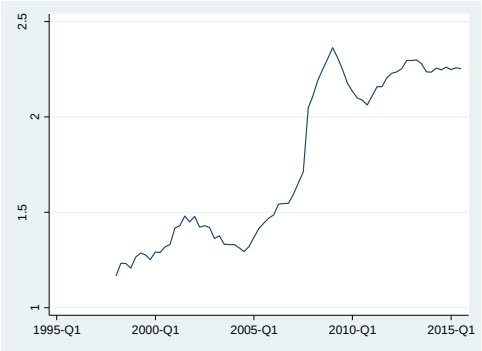


Figure 12: Housing index in Denmark

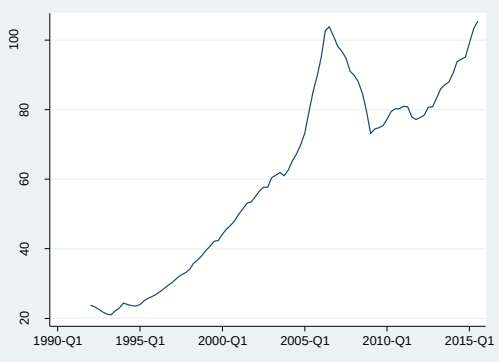


Figure 13: Interest rate in Denmark

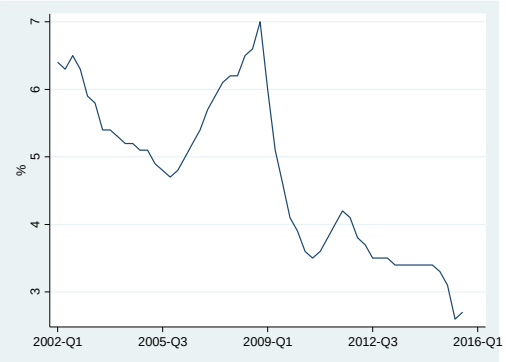


Figure 14: Inflation in Denmark

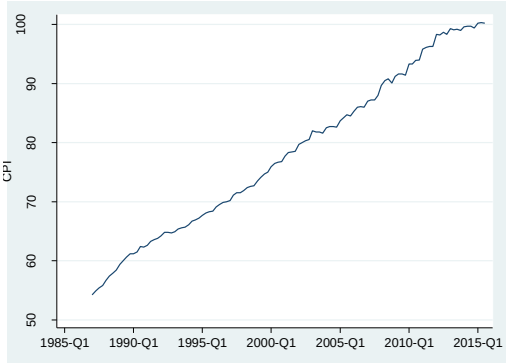


Figure 15: Quarterly GDP in Denmark

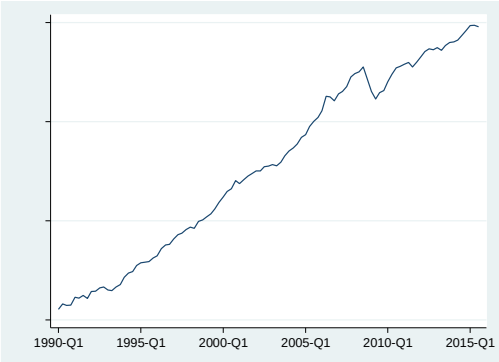


Figure 16: Bank Credit in Denmark

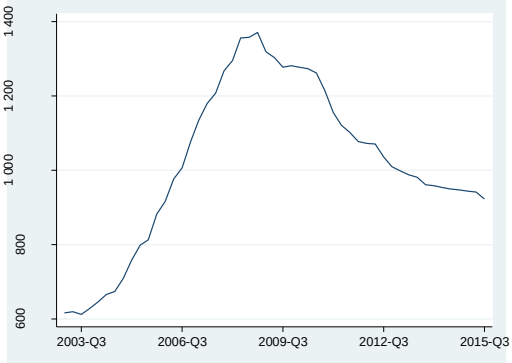


Figure 17: Credit/GDP in Denmark

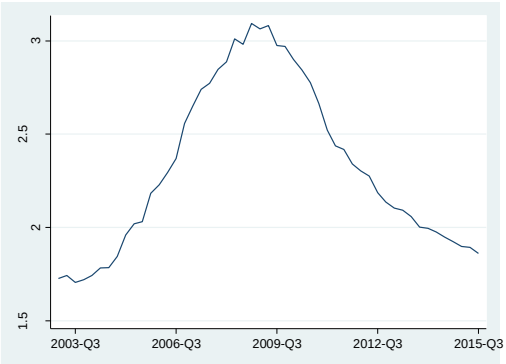


Figure 18: Housing index in Norway

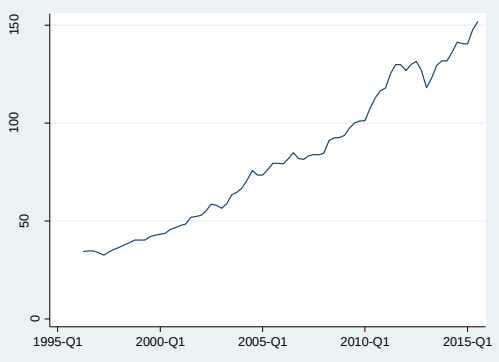


Figure 19: Interest rate in Norway

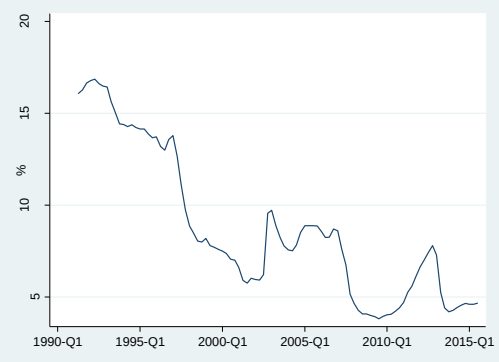


Figure 20: Inflation in Norway

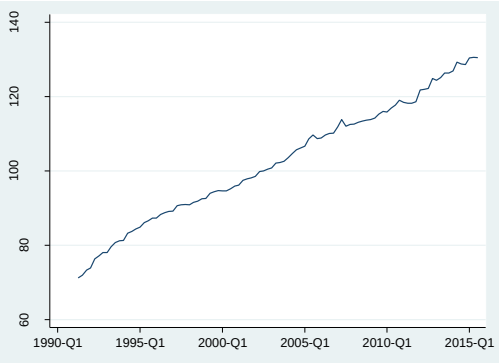


Figure 21: Quarterly GDP in Norway

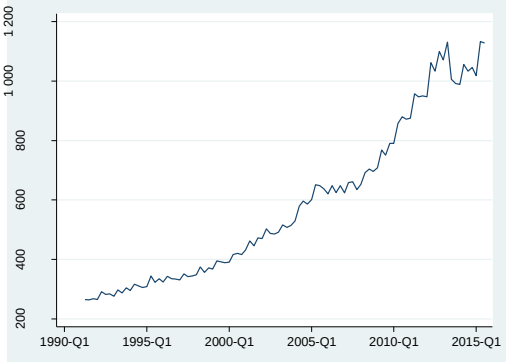


Figure 22: Bank Credit in Norway

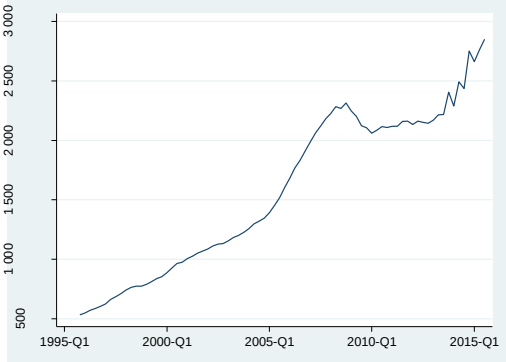


Figure 23: Credit/GDP in Norway

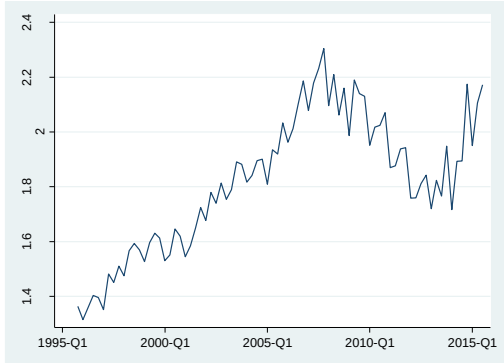


Figure 24: Housing index in Finland

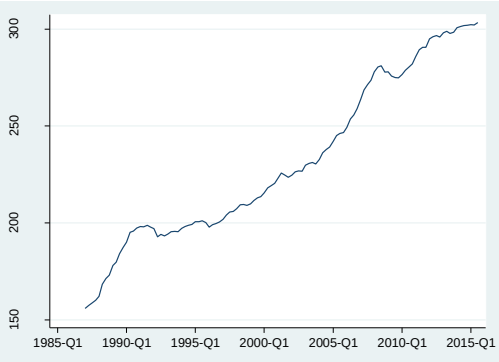


Figure 25: Interest rate in Finland

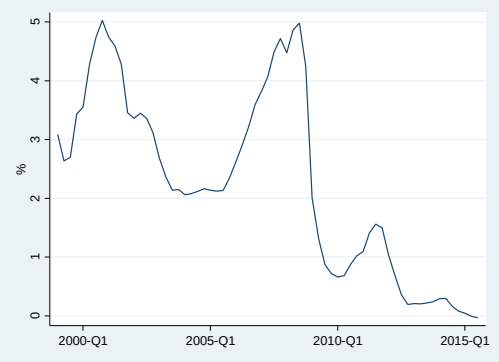


Figure 26: Inflation in Finland

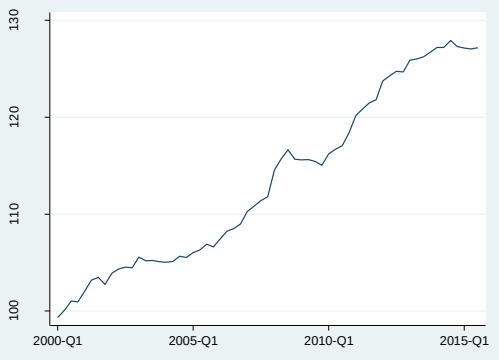


Figure 27: Quarterly GDP in Finland

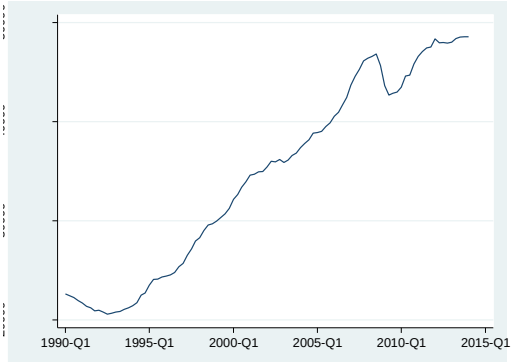


Figure 28: Bank Credit in Finland

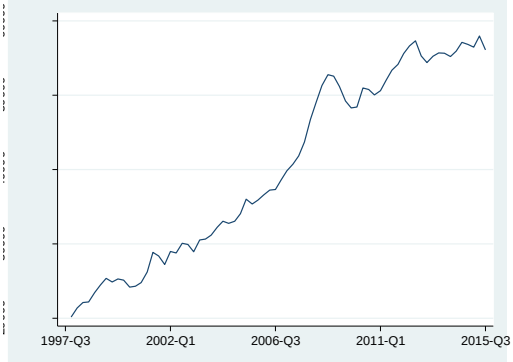
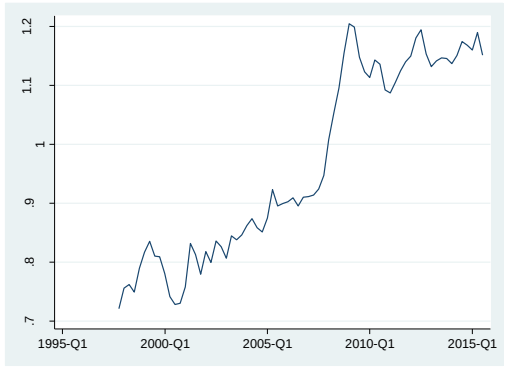


Figure 29: Credit/GDP in Finland



13.6 Stationarity tests of variables

Sweden				Denmark				Finland				Norway			
		P values				P values				P values				P values	
Lags	**Specification**	**ADF**	**PP**	**Lags**	**Specification**	**ADF**	**PP**	**Lags**	**Specification**	**ADF**	**PP**	**Lags**	**Specification**	**ADF**	**PP**
GDP				**GDP**				**GDP**				**GDP**			
6	Const.	0.0000*	0.0000*	2	Const.	0*	0*	2	Const.	0.0031*	0*	5	Const.	0.0004*	0*
6	Trend, const.	0.0001*	0.0000*	2	Trend, const.	0*	0*	2	Trend, const.	0.0211*	0.0004*	5	Trend, const.	0.0007*	0*
6	Const.	0.971	0.980	2	Const.	0.869	0.897	2	Const.	0.889	0.967	5	Const.	0.995	0.997
6	Trend, const.	0.2544	0.348	2	Trend, const.	0.398	0.521	2	Trend, const.	0.059	0.241	5	Trend, const.	0.709	0.626
Housing prices				**Housing prices**				**Housing prices**				**Housing prices**			
6	Const.	0.0002*	0*	2	Const.	0.0369*	0.0014*	7	Const.	0.0217*	0*	6	Const.	0.0043*	0*
6	Trend, const.	0.0015*	0*	2	Trend, const.	0.1427*	0.0089*	7	Trend, const.	0.0922*	0*	6	Trend, const.	0.0085*	0*
6	Const.	0.6528	0.724	2	Const.	0.843	0.939	7	Const.	0.960	0.865	6	Const.	0.996	0.997
6	Trend, const.	0.9809	0.907	2	Trend, const.	0.428	0.814	7	Trend, const.	0.738	0.684	6	Trend, const.	0.535	0.382
Rate				**Rate**				**Rate**				**Rate**			
2	Const.	0.0045*	0.0001*	2	Const.	0.0141*	0.0005*	2	Const.	0.0033*	0.0002*	2	Const.	0*	0*
2	Trend, const.	0.0279*	0.0008*	2	Trend, const.	0.0691*	0.004*	2	Trend, const.	0.0221*	0.0014*	2	Trend, const.	0*	0*
2	Const.	0.1565	0.228	2	Const.	0.407	0.774	2	Const.	0.534	0.714	2	Const.	0.317	0.490
2	Trend, const.	0.0484	0.278	2	Trend, const.	0.181	0.674	2	Trend, const.	0.108	0.474	2	Trend, const.	0.487	0.682
Inflation				**Inflation**				**Inflation**				**Inflation**			
7	Const.	0.3191*	0*	6	Const.	0.002*	0*	6	Const.	0.0012*	0*	3	Const.	0*	0*
7	Trend, const.	0.7079*	0*	6	Trend, const.	0.012*	0*	6	Trend, const.	0.0076*	0*	3	Trend, const.	0.0003*	0*
7	Const.	0.6877	0.953	6	Const.	0.886	0.225	6	Const.	0.936	0.905	3	Const.	0.740	0.627
7	Trend, const.	0.2382	0.164	6	Trend, const.	0.351	0.730	6	Trend, const.	0.345	0.639	3	Trend, const.	0.043	0.024
Bank Credit				**Bank Credit**				**Bank Credit**				**Bank Credit**			
2	Const.	0*	0*	2	Const.	0*	0*	2	Const.	0.0012*	0*	1	Const.	0.0376*	0*
2	Trend, const.	0.0001*	0*	2	Trend, const.	0*	0*	2	Trend, const.	0.0069*	0*	1	Trend, const.	0.1158*	0*
2	Const.	0.9098	0.958	2	Const.	0.060	0.379	2	Const.	0.765	0.747	1	Const.	0.990	0.988
2	Trend, const.	0.4096	0.750	2	Trend, const.	0.449	0.972	2	Trend, const.	0.732	0.748	1	Trend, const.	0.990	0.910
Credit/GDP				**Credit/GDP**				**Credit/GDP**				**Credit/GDP**			
3	Const.	0*	0*	5	Const.	0.0499*	0*	2	Const.	0.0005*	0*	6	Const.	0*	0*
3	Trend, const.	0.0004*	0*	5	Trend, const.	0.1943*	0*	2	Trend, const.	0.0035*	0*	6	Trend, const.	0.0001*	0*
3	Const.	0.6252	0.776	5	Const.	0.051	0.645	2	Const.	0.758	0.717	6	Const.	0.676	0.424
3	Trend, const.	0.2722	0.748	5	Trend, const.	0.137	0.959	2	Trend, const.	0.459	0.492	6	Trend, const.	0.352	0.251

Table 5: Stationarity tests of variables

*the variable has been transformed to the first difference

13.7 VECM results

Table 6: VECM results

	Sweden (Lags: 5)		Denmark (Lags: 5)		Finland (Lags: 4)		Norway (Lags: 5)	
D(Credit/GDP)	Coeff.	P(z)	Coeff.	P(z)	Coeff.	P(z)	Coeff.	P(z)
ce1	-0.1022194	0.003	-.0307176	0.001	-.2036189	0.150	-0.14363	0.006
Credit/GDP								
1	-.0686557	0.603	-.0394064	0.871	.2377945	0.005	-0.12693	0.209
2	.1602598	0.045	.1911017	0.271	-.0531605	0.742	0.058552	0.582
3	.0204791	0.877	.2033347	0.240	.2003636	0.217	-0.19303	0.07
4	-.0915488	0.498	.452958	0.012			0.357473	0.002
5								
Inflation								
1	-.007349	0.626	.0121617	0.047	-.0086937	0.047	-0.02865	0.007
2	-.0102353	0.503	.0049209	0.749	-.0066084	0.507	0.008443	0.462
3	-.0059734	0.707	-.0025359	0.880	-.0027077	0.684	-0.01902	0.064
4	-.0019626	0.895	-.0022085	0.883			0.014514	0.167
5								
Rate								
1	-.0053966	0.780	-.0177792	0.688	-.0204284	0.186	0.020239	0.125
2	-.0001541	0.995	.053872	0.228	.0359423	0.023	-0.01681	0.255
3	-.0058321	0.787	-.0127232	0.758	-.0093711	0.559	0.033535	0.02
4	.0087116	0.056	.0123819	0.733			-0.01935	0.125
5								
House Price								
1	.0026505	0.626	0.001867	0.769	.0001191	0.975	0.007974	0.02
2	.0052925	0.369	0.004773	0.457	.0002142	0.958	-0.00136	0.756
3	.0070631	0.053	0.006913	0.002	-.0021857	0.549	-0.00336	0.415
4	.0012861	0.816	0.001273	0.824			0.007906	0.05
5								
Const.	-.0542989	0.026	-.0019027	0.919	.0173077	0.142	-0.01653	0.427
Cointegration equation 1								
D(Credit/GDP)	1		1	0	1	0	1	
Inflation	3.47E-18		0	0	.0201092	0	-0.12321	0
Rate	-0.33907	0	0.572618	0	.0370122	0	-0.00711	0.712
Housing prices	-0.0059	0	.025191	0.024	-.009357	0	0.039248	0
_cons	1.669949		-6.90518	0	-.9551707	0	8.187582	0

13.8 VECM tests

Autocorrelation:

In the table below the p(chi^2) is reported of Lagrange Multiplier test.

Lag	Sweden	Denmark	Finland	Norway
1	0.09581	0.60281	0.09581	0.45796
2	0.14357	0.58342	0.14357	0.75083

Table 7: VECM error autocorrelation test

Normality:

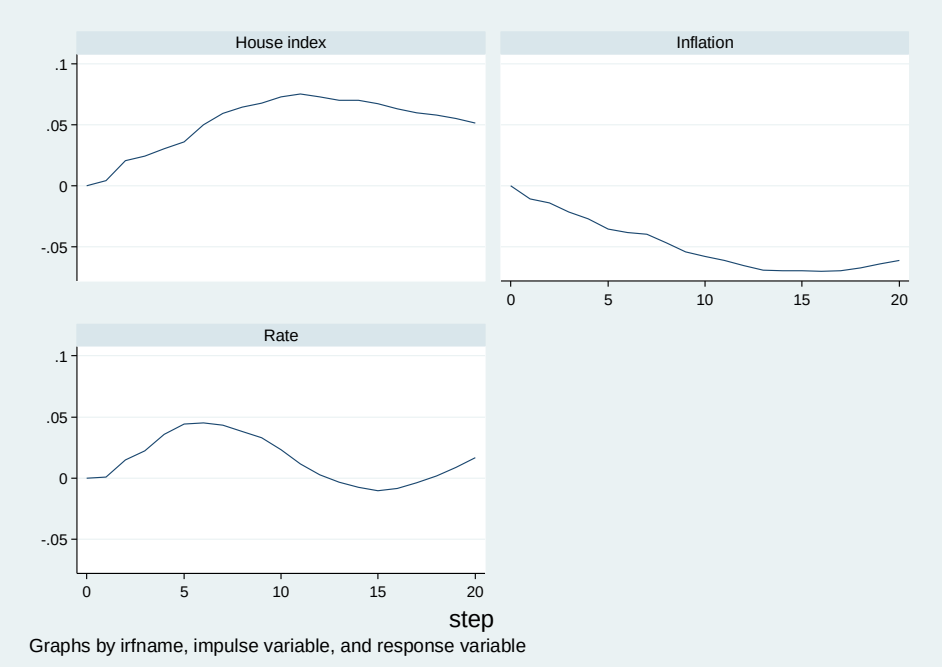
In the table below the p(chi^2) is reported.

Equation	Sweden	Denmark	Finland	Norway
Credit/GDP	0.00000	0.61609	0.35743	0.29513
Inflation	0.00001	0.35833	0.03230	0.35632
House	0.28254	0.39797	0.02860	0.00000
Rate	0.96046	0.35281	0.95992	0.50603
All	0.00000	0.54228	0.04078	0.00000

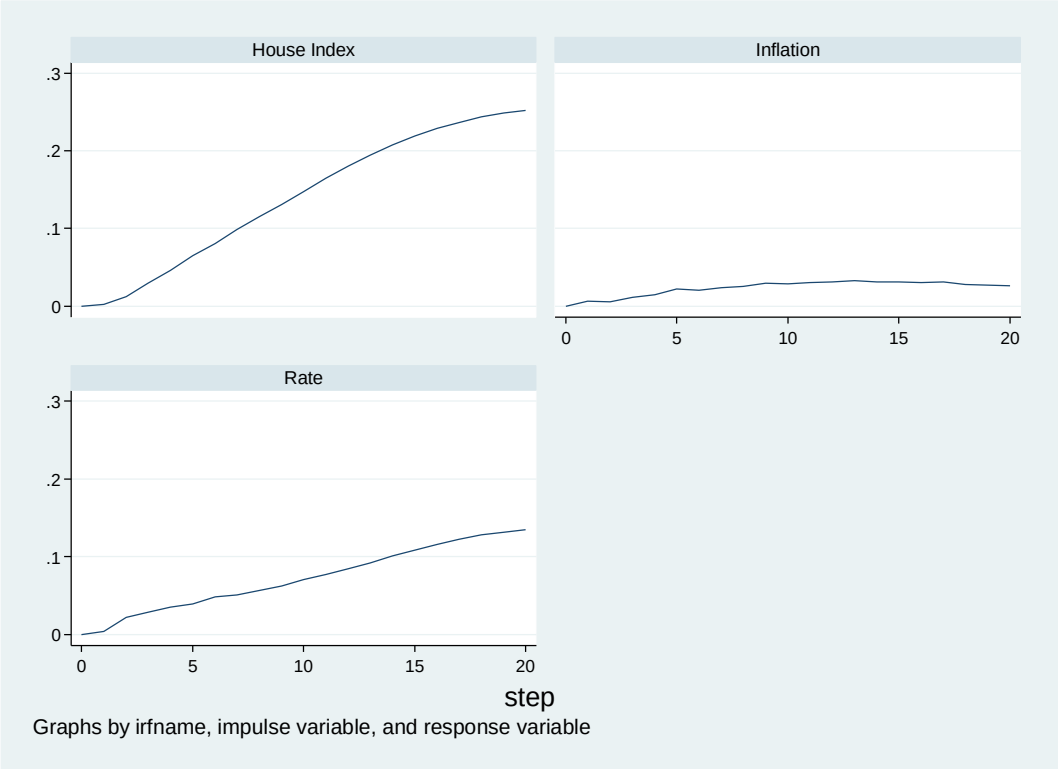
Table 8: Jarque – Bera test of residual normality

13.9 Impulse Response functions

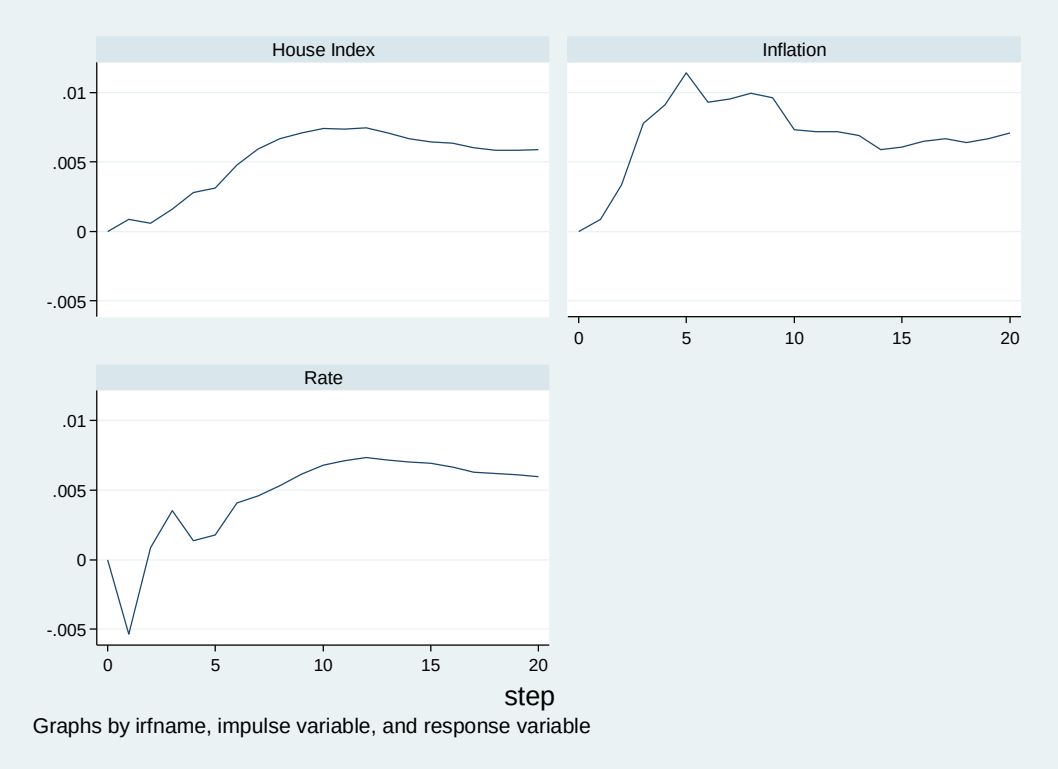
Sweden:



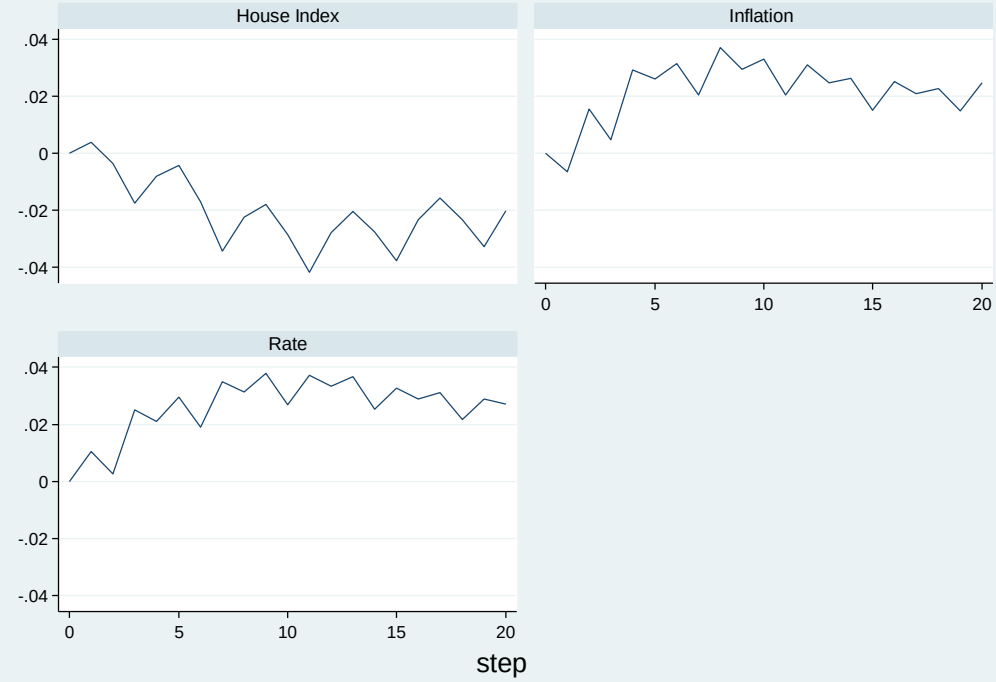
Denmark:



Finland:



Norway:


House Index
Inflation
Rate
.04
.02
0
-.02
-.04
0
5
10
15
20
step
Graphs by irfname, impulse variable, and response variable