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MASTER THESIS

The effect of Loan-to-Value restrictions on Norwegian household debt

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Declaration of Authorship

We, Joël HEER and Vigdis LUND, declare that this thesis titled, 'The effect of Loan-to-Value restrictions on Norwegian household debt' and the work presented in it are our own. We confirm that:

- This work is the result of joint research and was done wholly while in candidature for a Master of Science degree in Economics (Joël Heer) and Financial Economics (Vigdis Lund) at this University.

- Where we have consulted the published work of others, this is always clearly attributed.

- Where we have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely our own work.

- This thesis or any part of it has not previously been submitted for a degree or any other qualification at this University or any other institution.

Joël Heer   Vigdis Lund

Signed: Signed:
_____   _____

Place, Date: Place, Date:
_____   _____

Preface

Writing an empirical master thesis is about finding an interesting topic, gathering and analyzing data, and hopefully coming up with a striking conclusion. Finding the right topic was a demanding process that required many hours of reading articles, having conversations with our supervisor and endless discussions in the cafeteria at Dragvoll Campus. Several possible topics were outlined, and eventually, while drinking a cup of refreshing coffee, we decided to analyze the effect of loan-to-value restrictions on household debt in Norway, which beautifully combined our interests in macroeconomic policy and financial markets.

When we decided on the topic, our optimism and enthusiasm were skyrocketing. However, we quickly realized that writing a master thesis is a challenging process, where obstacles and frustrations arise in intervals, while knowledge and valuable experiences are gained. Nevertheless, it sometimes felt like our way was covered with stumbling blocks, and we are therefore grateful for the help we received in trying to overcome them.

Firstly, we would like to thank our supervisor Dr. Xunhua Su, who safely guided us through the difficulties from the beginning to the end. Secondly, Senior Researcher Eilev Jansen at Statistics Norway deserves our special thanks for politely answering all our requests and providing the data needed. We also want to express our sincere thanks to Reidar Støre and Torgeir Kråkenes for proofreading our thesis. Finally, we are much obliged to Prof. Dr. Kåre Johansen and Prof. Dr. Sjur Westgaard, who provided valuable inputs in performing the different analyses in OxMetrics.

June 2014,

Joël Heer and Vigdis Lund

"A person who never made a mistake never tried anything new."

Albert Einstein

Abstract

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Master of Science

The effect of Loan-to-Value restrictions on Norwegian household debt

by Joël HEER and Vigdis LUND

Household debt has reached record high levels in Norway and is considered to be a threat to the financial stability. To dampen the rapid accumulation of household debt and increasing housing prices, the Financial Supervisory Authority of Norway has introduced loan-to-value restrictions on mortgages of 90% in March 2010 and 85% in December 2011. This study contributes empirical evidence of the effect of these loan-to-value restrictions on Norwegian household debt. Firstly, we show that there are self-reinforcing effects between housing prices and household debt, using a structural VARX model. Secondly, we extend this particular model and show that the restrictions apparently have failed to dampen household debt on an aggregate level. Thirdly, using a single-equation model for household debt, we provide evidence that the restrictions have slowed down the growth in household debt among young people. This effect, however, has been counteracted by an increase in the older generation's household debt, which can be explained by (grand)parent financing as well as a higher willingness of holding debt among the elderly. We therefore conclude that loan-to-value restrictions can be seen as a valuable tool for reducing the accumulation of debt among the younger and more sensitive group. They may, however, have limited power to dampen household debt on an aggregate level.

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List of Variables

Anundsen and Jansen model

ph real housing prices

d real household debt

yh real disposable income

R real after-tax interest rate

th housing turnover

h real housing stock

Age group model

$debt$ real household debt

ph real housing prices

inc real income

R real after-tax interest rate

th housing turnover

1 Introduction

Recently, the Organisation for Economic Co-operation and Development (OECD) reported alarmingly high debt-to-income ratios in countries such as Denmark, Ireland, the Netherlands and Norway (OECD, 2014). At moderate levels, debt improves welfare and encourages growth (Cecchetti et al., 2011). Conversely, high debt may lead to vulnerabilities and undermine the macroeconomic stability. For instance, high public debt levels may reduce the government's ability to respond to future crises with expansionary fiscal policies. In the eurozone, government debt has been soaring after the onset of the recent global financial crisis, which Sutherland et al. (2012) suggest is because of a migration of debt across balance sheets from the private sector to the public sector. According to IMF (2012), the ratio of household debt to income rose by an average of 39 percentage points to 138% in advanced economies in the five years preceding the recession of 2007. Hence, in the wake of the recent financial crisis, the role of household debt has been brought into the limelight of economic policy debates.

Ideally, high and low debt levels would be determined by fundamentals, but there is often little consensus on what these are. Several economists do, however, stress the danger of excessive household debt. For instance, IMF (2000) argues that recessions preceded by a large build-up in household debt are more severe, as high debt levels can amplify slumps and weaken the following recoveries. Empirical evidence suggests that when private debt levels, particularly for the household sector, rise above trend, the likelihood of a recession increases (Sutherland and Hoeller, 2012). Furthermore, in a study of the rising household debt in several OECD countries, Debelle (2004b) argues that regardless of whether the increase in household debt is sustainable, the greater indebtedness of households has important macroeconomic implications.

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Hence, an issue for policymakers is whether they should impose measures against the build-up of high debt levels, or clean the mess when a recession strikes. As a matter of fact, the build-up of debt has previously been subject to benign neglect among politicians, as monetary policy, i.e. increasing the interest rate, may be costly to deploy in an otherwise healthy economy. However, the unexpectedly large loss in wealth due to the recent global recession as well as sovereign debt crises in several European countries appears to have changed this attitude. Policies are currently being deployed in several countries to prevent a crisis of the same extent from reoccurring. Crowe et al. (2011) note that macro-prudential regulations protecting against excessive credit growth are likely to reduce the risk of such financial crises, and that these measures may be less costly than monetary policy. However, these measures are relatively new and may therefore face some practical implementation issues. As a consequence, the empirical evidence of the effect of such measures is in general limited.

When assessing the potential risk of high household debt, it is important to note that nearly all lending to households is mortgage related (OECD, 2014). Thus, understanding the relationship between housing prices and household debt becomes crucial. As a matter of fact, one of the causes of the financial crisis in the U.S. was the strong growth in mortgages and a substantial rise in housing prices, which laid the basis for further growth in mortgages. A large portion of this borrowing was held by households with poor debt servicing ability. In particular, the drop in housing prices was the root of distress in the market for mortgage-backed securities. When housing prices fell below the nominal value of loans, both speculative buyers and home owners started to default and the value of mortgage-backed securities began to decline. As a result, it became increasingly difficult to obtain financing for both investors and issuers of these securities. Some were forced to leave the market, and this in turn decreased the available funds for mortgage financing, starting a downward spiral.

In Norway, average debt to disposable income has currently reached a record high of 212%, which is among the highest levels worldwide. In comparison, the U.S. ratio was 110% before the recent financial crisis. Furthermore, housing prices adjusted by the consumption deflator has increased by 191% from 1985 to 2013. As a result, both national and international institutions (e.g. the Ministry of Finance, IMF and OECD) have stressed that the

debt level in Norwegian households in conjunction with the high housing prices are considerable risk factors for the financial stability in Norway (Finanstilsynet, 2014b). Therefore, the FSA responded by introducing new macro-prudential tools as a part of more general guidelines in March 2010, to ensure a more prudent mortgage lending practice. In these guidelines, they defined a maximum loan-to-value (LTV) ratio of 90% of a property's market value. In December 2011, the guidelines were further tightened and the LTV ratio was lowered to 85%. Even though four years have passed since the introduction of LTV restrictions, they are still subject to heated discussions in Norway.

This study aims to contribute new and unique evidence to the debates which previously have been based on political agendas rather than on economic arguments. The main objective is to analyze the impact of the measures imposed, using empirical evidence from Norway.

Previous empirical studies conducted for other countries have mainly concentrated on single-equation setups to analyze the impact on household debt and housing prices. This may, however, lead to endogeneity problems, as empirical evidence suggests that there is a financial accelerator at work between the two variables. We therefore use a cointegrated vector auto-regressive model with exogenous variables (VARX) and show that there is a financial accelerator between housing prices and household debt. A slightly extended version of this model is then used to show that the LTV restrictions apparently have failed to dampen aggregate household debt. This study therefore contributes to the existing literature by providing evidence of the limited effect of LTV restrictions on an aggregate level, using a more sophisticated model that controls for self-reinforcing effects between housing prices and credit.

Furthermore, we examine whether the restrictions have affected household debt among age groups differently, which has important implications for financial stability. For that purpose, we derive a linear model which allows us to study the different effects of the LTV restrictions on household debt across age groups in the short run. The latter model is estimated using the first difference method, and the results indicate a dampening effect on household debt among the young. The elderly, however, were less affected by the LTV restrictions, and they accumulated debt even faster after the tightening in 2011. This

outcome can partly be explained by (grand)parent financing and a higher willingness to hold debt among the elderly.

In general, we are able to provide a more nuanced analysis on the effect of this particular macro-prudential tool.

The outline of this master thesis will be as following: Chapter 2 provides an overview of the existing literature on the subject matter. A description of the development in housing and credit markets in Norway is given in chapter 3, which also contains a short description of the LTV restrictions. In chapter 4, we show evidence of the existence of a financial accelerator between housing prices and credit. In chapter 5, we investigate the effect of the LTV restrictions on aggregate household debt in Norway, while we study the different impact of the LTV restrictions on household debt across age groups in chapter 6. Finally, chapter 7 contains our conclusion.

2 Literature review

2.1 Potential problems with high household debt

Debelle (2004a) analyzes the role of household debt from a macroeconomic perspective. The study concludes that the substantial rise in household debt over the preceding two decades has made the household sector more sensitive to changes in interest rates, income and asset prices. The author notes that this is particularly the case in countries with mainly variable rate mortgages, as the household sector is more exposed to the risk of fluctuation in interest rates. He further argues that even though household debt itself is not likely to be the source of a negative shock in the economy, it could amplify recessions caused by other sources. In addition, the study points out that macroeconomic implications of a greater indebtedness do not only depend on the aggregate level, but also on the distribution of debt across the household sector.

Sutherland and Hoeller (2012) provide an overview of the literature regarding debt and macroeconomic stability, and analyze the channels through which high debt level affects this stability. In line with Debelle (2004a), the authors find that relatively high levels of debt could increase the sectors' sensitivity to changes in fundamentals, which can induce households or firms to adjust their borrowing, consumption and investment behavior. The authors also find that at higher debt levels, exposure to asset price movements may become more of a problem for companies, governments and households, as a collapse in for example housing prices reduces collateral. Hence, mortgage equity withdrawal available for consumption smoothing becomes limited. The authors further note that high debt levels can create weaknesses in balance sheets in one sector and migrate and spill over

to other sectors. The authors point out that empirical evidence suggests that when debt levels in the private sector, especially for households, rise above trend the probability of a recession increases.

Cecchetti et al. (2011) study the turning point when debt goes from improving welfare and enhancing growth to become damaging. The authors address the question by using a data set that includes the level of government debt, non-financial corporate debt and household debt in 18 OECD countries from 1980 to 2010. The analysis reveals that a 1% increase in household debt-to-GDP[1] is associated with a 2.5 basis points reduction in per capita GDP growth. Further, they find that household debt above a threshold of approximately 85% of GDP will become a drag on growth. This result does, however, lack statistical precision.

Another approach is applied by Barnes and Young (2003), who investigate the causes behind the rising debt and its sustainability in the U.S. since the early 1970s. The authors use an overlapping generation model where they assume that different generations have different needs regarding borrowing and asset accumulation. They conclude that debt levels chosen by households are sustainable as long as the expectations about income growth, housing prices, interest rates and other determinants of borrowing that underlie that decision are not falsified or revised.

In a working paper from Norges Bank[2], Lindquist (2012) evaluates the sustainability of household debt using a data set over the period 1987–2009. The author defines sustainability of household debt as the debt households are able to service conditional on historical consumption to income patterns. Furthermore, she stresses the importance of the distribution of debt across age groups. As a matter of fact, it turns out that households aged 25–44, which are the primary first-time home buyers and second-steppers group, are found to be vulnerable, when interest rates increase from the current very low levels. According to Lindquist, this rises concerns from a financial stability perspective, as this particular group holds 60% of household debt.

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[1]GDP = Gross Domestic Product
[2]The Central Bank of Norway

2.2 The long run relationship between household debt and housing prices

Borio and Lowe (2002) show that sustained rapid credit growth combined with large increases in asset prices appears to increase the likelihood of financial instability. Mian and Sufi (2011) also argue that the relationship between household borrowing and housing prices play an important role in macroeconomic fluctuations. The authors use individual-level data and an instrumental variable methodology to estimate the magnitude of home-equity based borrowing and identify which groups responded the most. Their analysis shows that the strong increase in housing prices in the US in 2002–2006 resulted in existing home owners borrowing significantly more debt. It is further argued that this home-equity based borrowing channel may be an important source of the rapid rise in household leverage that preceded the economic recession.

Many studies have analyzed bank lending and property prices separately, but explore the link only in one direction and are often based on single-equation setups. For instance, Collyns and Senhadji (2002) find empirical evidence that credit growth has a significant effect on residential property prices, and conclude that bank lending is one explanation to the real estate bubble in Asia. An example from Norway is Jacobsen and Naug (2004) who try to determine household debt, using an ordinary least squares (OLS) model. A general problem with these studies is the potential two-way causality between bank lending and property prices. This endogeneity problem implies that the studies may suffer from biased results. In addition, they are unable to separate the direction of causality between credit and property prices.

The theoretical foundation of a financial accelerator between housing prices and credit is found in Bernanke and Gertler (1989). They construct an overlapping generations model where financial market imperfections cause temporary shocks in net worth[3] to be amplified. Inspired by Bernanke and Gertler's work, Kiyotaki and Moore (1997) conclude that when the effects of a shock persist, the cumulative impact on asset prices, and hence on net worth at the time of the shock, can be significant. The authors consider a model

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[3]Net worth = Total assets minus total liabilities

where they assume an economy where borrowers' credit limits are affected by the prices of the collateralized assets, and at the same time these prices are affected by the size of the credit limits. Kyotaki and Moore find that the accelerator between credit limits and asset prices is a powerful transmission mechanism where effects of shocks persist, are amplified, and spread out.

The two-way causality can give rise to mutually reinforcing cycles in credit and property markets. The coincidence of cycles in bank credit and property prices has been widely discussed in literature oriented around policies (e.g. IMF (2000) and BIS (2001)). However, there are few studies based on empirical research focusing on the interaction between bank lending and property prices. There is currently no consensus in literature on the direction of causality between the two variables. Differing methodological approaches, different data sets, sample sizes and institutional differences between countries may explain some of these discrepancies. The empirical findings on the interaction between housing prices and credit are listed in table 2.1.

Author(s)	$ph \rightarrow d$	$ph \leftarrow d$	$ph \leftrightarrow d$
Hoffmann (2003)	$*$		
Gerlach and Peng (2005)	$*$		
Oikarinen (2009)		$*$	
Fitzpatrick and McQuinn (2007)			$*$
Gimeno and Martinez-Carrascal (2010)			$*$
Anundsen and Jansen (2013)			$*$

TABLE 2.1: Evidence of the long-run relationship between housing prices (ph) and credit (d).

Hofmann (2003) analyzes the patterns of dynamic interaction between bank lending and property prices, based on quarterly data from 20 countries in the period 1985–2001. In a similar study, Gerlach and Peng (2005) examine the relationship between credit to the

private sector and housing prices in Hong Kong. Both studies estimate a long run cointegrating relationship between real bank lending and real property prices. In Hofmann's article, the results suggest that the long run causality goes in both directions, but that the effect from property prices to bank lending appears to be stronger than in the opposite direction. Gerlach and Peng obtain the same result, that is, causality runs from property prices to lending, rather than conversely. Following these studies, Oikarinen (2009) shows that there has been a significant two-way interaction between housing prices and mortgages in Finland using a quarterly dataset in the period 1975–2006. Oikarinen estimates a long-run relationship for housing prices as a function of GDP and the loan-to GDP ratio. Oikarinen's results, however, suggest that the direction of causality goes from household lending to housing prices in the long run.

Like Hofmann (2003), Fitzpatrick and McQuinn (2007) analyze the long-run dependence between housing prices and credit in Ireland. In Ireland, property prices rose by 12% annually in real terms between 1996 and 2002 in a rapidly growing economy with low nominal interest rates. Particularly, Fitzpatrick and McQuinn explore the relationship between credit growth and asset prices by adding a credit equation to an existing model of the Irish housing market. Then, they estimate a cointegrating econometric model of mortgage credit, housing prices, disposable income, real interest rates and demographic variables in order to coherently investigate the influence of credit and house prices on each other. Fairly conclusive evidence of a mutually reinforcing relationship is found. They further conclude that the effect of greater credit availability, ceteris paribus, means that mortgage-holders have outstanding loans that are larger than what they otherwise would have been if availability had been curtailed.

Gimeno and Martinez-Carrascal (2010) use a similar econometric methodology to study the interaction between housing prices and household borrowing in Spain with quarterly data for the period 1984–2009. In the study, they focus on house purchase loans rather than total bank lending and total household lending, as they expect this variable to be more closely linked to housing prices. Further, they include interest rates as a determinant of the credit aggregate in the long run. The cointegration analysis indicates that both variables are interdependent in the long run. Loans for house purchase depend positively on housing prices, while housing prices adjust when this credit aggregate departs from

the level implied by its long-run determinants. In contrast, disequilibria in housing prices are corrected only through changes in this variable.

Anundsen and Jansen (2011) adopt the same econometric approach as Gimeno and Martinez-Carrascal to analyze the relationship between housing prices and credit in Norway over the period 1986 Q2 to 2008 Q4. The study has been extended in Anundsen and Jansen (2013). They apply a structural vector equilibrium correction model (SVECM) to examine both the long-run interaction and the short-run dynamics between the two variables. The authors find that real housing prices are dependent on household debt, real disposable income and housing stock, while real debt in the long run depends on the real housing prices, real interest rate and the housing turnover. Thus, they find a mutual dependency between housing prices and household debt in the long run. This two-way interaction means that higher housing prices lead to a credit expansion, which in turn puts an upward pressure on housing prices. This results from Anundsen and Jansen (2011) has been confirmed by Jacobsen and Vatne (2011).

2.3 The effect of LTV ratios: Theory and Empirical Evidence

In an IMF discussion note, Crowe et al. (2011) evaluate different policy options to deal with real estate booms. The authors argue that what matters may not be the boom itself, but rather how the boom is funded. Booms financed through credit with leveraged institutions directly involved have tended to be followed by a more costly bust, and should hence be the focus of policy. The problem with using monetary policy is that it is both blunt and costly in dealing with real estate booms, given that the macroeconomic environment is calm. The reason for this is that the interest hikes needed to stop the boom may be costly in terms of output gap and desired inflation rates (Crowe et al., 2011). Macro-prudential tools, such as maximum loan-to-value ratios, however, appear to have the best chance to curb a boom, as their narrower focus also reduces the costs of using them. Their potential impact is to limit household leverage and housing prices appreciation while decreasing

probability of default. However, the authors argue that such macro-prudential tools may suffer from loopholes.

From an empirical perspective, there is little evidence for the effectiveness of these specific tools due to the fact that macro-prudential policy frameworks are still in their infancy. Lamont and Stein (1999) show that in cities where a greater fraction of homeowners have high LTV ratios, housing prices react more sensitively to city-specific shocks, such as changes in per-capita income. Almeida et al. (2006) also provide evidence that economic activity is more sensitive to movements in housing prices if the LTV ratio is higher. The results of the empirical analysis indicate that debt capacity is more strongly procyclical[4] in countries with high LTV ratios, and that the procyclicality of debt capacity affects housing price dynamics through a collateral constraint.

Igan and Kang (2011) investigate the effect of the loan-to-value (LTV) and debt-to-income (DTI) limits on housing prices dynamics, residential real estate market activity, and household leverage, using empirical evidence from Korea. A baseline regression is estimated separately for each equation of interest, i.e. the real estate and mortgage markets, using ordinary least squares. In addition to a matrix of control variables, dummy variables for both one, three and six months before and after a rule change are constructed. The assumed two-way relationship between housing prices and credit, however, makes it difficult to separate the causal effect of LTV and DTI limit adjustments. The analysis suggests that price appreciation slows down in a six-month window and that the expected increase in housing prices decline after policy intervention. They do not, however, find evidence that potential first-time buyers are more likely to postpone the plans to buy a home. These findings suggest that tighter lending practices, especially related to LTV restrictions, curb expectations and speculative incentives. Hence, the authors argue that limits on LTV can be effective tools to dampen real estate booms and restrain the associated risks. Contrary to the authors' expectations, they do not find evidence of the expected negative link between the growth of household leverage and the tightening of macro-prudential rules.

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[4]Procyclicality: The tendency of financial variables to fluctuate around a trend during the economic cycle. Increased procyclicality thus means fluctuations with broader amplitude.

Wong et al. (2011) evaluate maximum LTV ratios based on Hong Kong's experience and cross-country evidence. They perform an econometric analysis of panel data from 13 countries, using dummy variables for economies with LTV policies. The estimation results show that LTV policy enhances banking stability by reducing the responsiveness of mortgage default risk to property price shocks. When assessing the effectiveness of LTV policy as a tool for stabilizing property markets, the authors specify a generalized autoregressive conditional heteroscedasticity (GARCH) model with dummies. Two of the property market indicators they use are the real property price growth and mortgage loans to GDP. Using quarterly data from Hong Kong, Korea and Singapore, which have all adopted LTV policies, the estimation results show that the dampening effect of LTV policy on household leverage is more apparent than the effect on property market activities. The indirect effect of the LTV policy through the impact of household leverage on the property market is ignored in the analysis, and is thus a caveat when interpreting the results.

Price (2014) analyzes the effects of LVR restrictions [5] implemented in October 2013 in New Zealand. A vector autoregression (VAR) modelling framework is specified to estimate the historical relationships between housing market variables. A counterfactual scenario is then constructed as a forecast based on these historical relationships, starting in September 2013 (to allow for pre-implementation effects). The results of the analysis show that house price inflation declined below the counterfactual scenario, although not significantly. Housing-related credit growth declined, reaching 0,9% below the counterfactual scenario.

As examined in this chapter, literature suggests that high aggregate household debt as well as the distribution of debt across age groups have important implications for financial stability. LTV restrictions may remedy the accumulation of high debt and its associated risks. However, the empirical evidence on the effects of these measures are limited and some of them may suffer from endogeneity problems, as they ignore the self-reinforcing effects between housing prices and credit. In this context, it seems highly relevant to analyze the effects of LTV restrictions using a model that controls for this potential source of biased results. Furthermore, as far as we know, the impact on household debt across age groups has not been examined yet.

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[5] LVR = LTV with a speed limit. The policy requires banks to restrict the share of mortgage lending with LTVs over 80% to no more than 10% of their new mortgage flows

3 Credit market and housing prices

3.1 The credit market in Norway

3.1.1 Developments in household debt

In the period after World War II and up to the 1980s, the banks, which mainly consisted of state lending institutions, were subject to strict quantitative regulations (Gjerdrem, 2010). After the gradual deregulation of the credit market in the 1980s, savings and commercial banks took over the major part of residential mortgages. The deregulation resulted in a bank lending boom, which can be seen from the sharp rise in debt growth in Figure 3.1 (d).

In the late 1980s, Norway experienced increasing distress in the banking sector, which eventually led to a banking crisis. The crisis reached its peak in 1991 when the second and fourth largest banks with a combined market share of 24% lost all their capital (Steigum, 2011). The early part and the peak of the banking crisis coincided with the deepest post World War II recession in Norway, severely reducing financial institutions' willingness to offer credit. Despite the recession, the Nordic countries were forced to increase real interest to keep the exchange rate fixed relative to the strong German mark. In addition to this, a major overhaul of the tax system came into force in 1992. Income tax rules in Norway were changed to reduce tax deductions for nominal interest payments, which had a dampening effect on demand for mortgage among households. Steigum (2011) argues that this asymmetric shock was *"bad luck and triggered a rapid decline in asset prices"*. This led to a fall in real household debt, which is evident in Figure 3.1 (b).

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At the end of 1992, Norges Bank reduced the key policy rate[1] quite extensively after the European Exchange Rate System broke down (Fordelingsutvalget, 2009). The reduction in the key policy rate quickly transmitted to the banks' lending rates, reducing households' borrowing costs. The real interest rate after tax was reduced from 7% to below 4%. In 1994, the Norwegian economy entered a period of high growth, even though unemployment remained fairly high from a historical perspective. As a result, real household debt began to rise again in the late 1990s, though at a moderate pace.
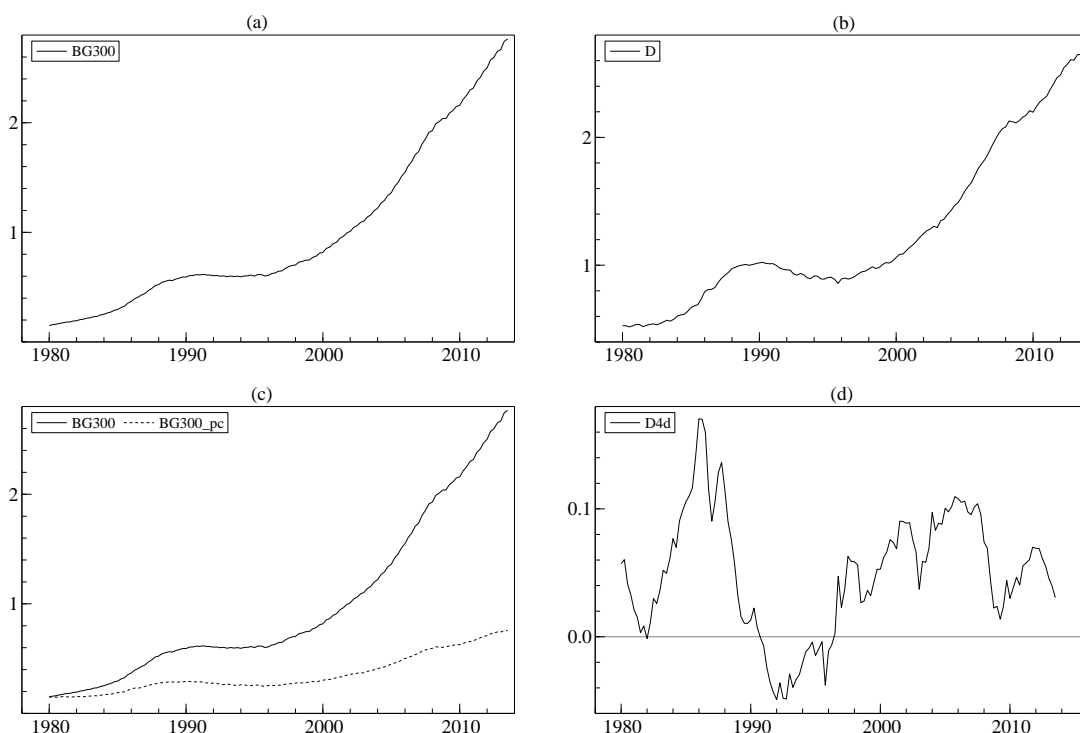
FIGURE 3.1: (a) Nominal household debt in trillion NOK. (b) Real household debt in trillion NOK. (c) Household debt deflated by price index, base year 1980 Q1. (d) Annual growth rate in real household debt. (1980 Q1 – 2013 Q3)

During the IT boom in 2000, Norges Bank increased the key policy rate to prevent high inflation. In March 2001, the inflation targeting goal was implemented. When the IT bubble burst, the key policy rate was reduced from 7% in December 2002 to 1.75% in March 2004. Along with increased competition in the banking sector and better mortgage

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[1]the interest rate on banks' deposits

lending arrangements, mortgages became cheaper for the households, reaching approximately the same price level as in the early 1950s. In addition, the economic growth picked up both internationally and in Norway. This brought the unemployment rate down to 2.5%, the lowest rate in 20 years. Consequently, mortgage lending increased substantially in the period 2004–2006. On average, the growth in household debt has been very high since the mid-1990s with two considerable drops during the IT burst in 2002 and in the wake of the financial crisis in 2008 (see Figure 3.1 (d)). The crises did, however, only lead to a relatively short downturn in the Norwegian economy, and growth in household debt was quickly back on high levels. At the end of 2013, household debt reached 2823 bn. NOK in Norway, which is over 200% of disposable income (Statistics Norway, 2014) (see Figure 3.1 (a)).

3.1.2 Household debt across age groups

The younger part of the population has the highest debt-to-income ratio. In addition, the share of households with debt three times larger than income has increased the most among young couples, couples with small children and single parents. A possible reason for this may be that high loans required to enter the housing market combined with a lower relative income early in the career.

In Figure 3.2 (a), it appears that nominal household debt has increased not only for the young generation, but for all age groups in the period 1993–2012. However, in the age group 25–34, the number of indebted households declined from 2000–2010 (see Figure 3.2 (d)), which may partly explain why the same age group reduced its share of total debt after 2000 (see Figure 3.2 (c)). Lindquist (2012) notes that particularly the age groups above 55 show an increasing share with debt, indicating that it has become more common among older households to hold debt. This is also evident in Figure 3.2 (b), where it appears that the older age groups have experienced high growth rates in debt since 2002. Lindquist argues that the reason for this may be explained by parents providing financial support to their children, helping them enter the housing market. From 2009 to 2012, this development appears to have continued.
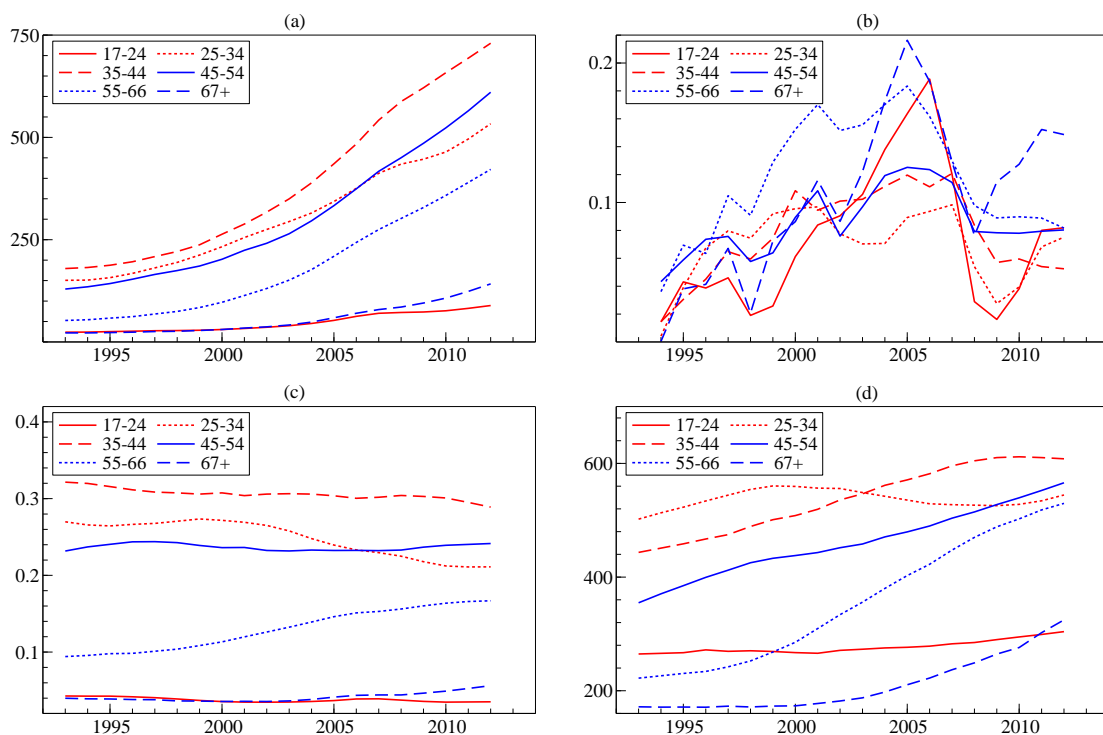
FIGURE 3.2: (a) Nominal household debt across age groups in billion NOK. (b) Annual growth rate across age groups. (c) Debt distribution across age groups. (d) Number of indebted persons in thousands. (1993–2012)

3.2 Housing prices

The Norwegian housing market remained fairly stable from the 1970s to the mid-1980s (see Figure 3.3 (a)). Real housing prices, however, fell by almost 10% from the first quarter of 1982 to the third quarter of 1984 (See Figure 3.3 (b)). The gradual easing of credit regulations in the 1980s combined with low interest rates initiated a mortgage financed boom in the housing market in the mid-1980s (with a nominal increase in housing prices of almost 60% in the period 1984–1988) (Gjerdrem, 2010). A major drop in the oil price in 1985–1986 contributed to the authorities tightening the economic policy (Fordelingsutvalget, 2009). The following economic recession and high real interest rates around 7-8% resulted in a large fall in housing prices. The tax reform, as mentioned earlier, also contributed to the decline in the housing market. Real housing prices dropped by 42% from the peak in the beginning of 1988 to the lowest point in 1993.

Recovering from the trough in 1993, the housing prices increased more or less until the financial crisis in 2007. One minor exception was in late 2002 until early 2003, when housing prices had a slight drop due to a small recession in the Norwegian economy. From 1993 to 2007, nominal housing prices almost tripled, while real housing prices increased by 183%. During the financial crisis, real housing prices fell by 14% from 2007Q2–2008Q4.

Current housing prices in Norway are at record high levels and have in the past 25 years increased twice as much as consumer prices (see Figure 3.3 (c)). Since the previous peak in 2007, housing prices have risen by 31% to the next peak in 2013 (Finanstilsynet, 2014a). Through 2013, however, the growth in housing prices declined (see Figure 3.3 (d)). From a twelve-month growth of 8.2% in February 2013, the growth rate fell every month and became negative in December 2013. In March 2014 the growth rate became positive again. Nevertheless, housing prices are still record high.
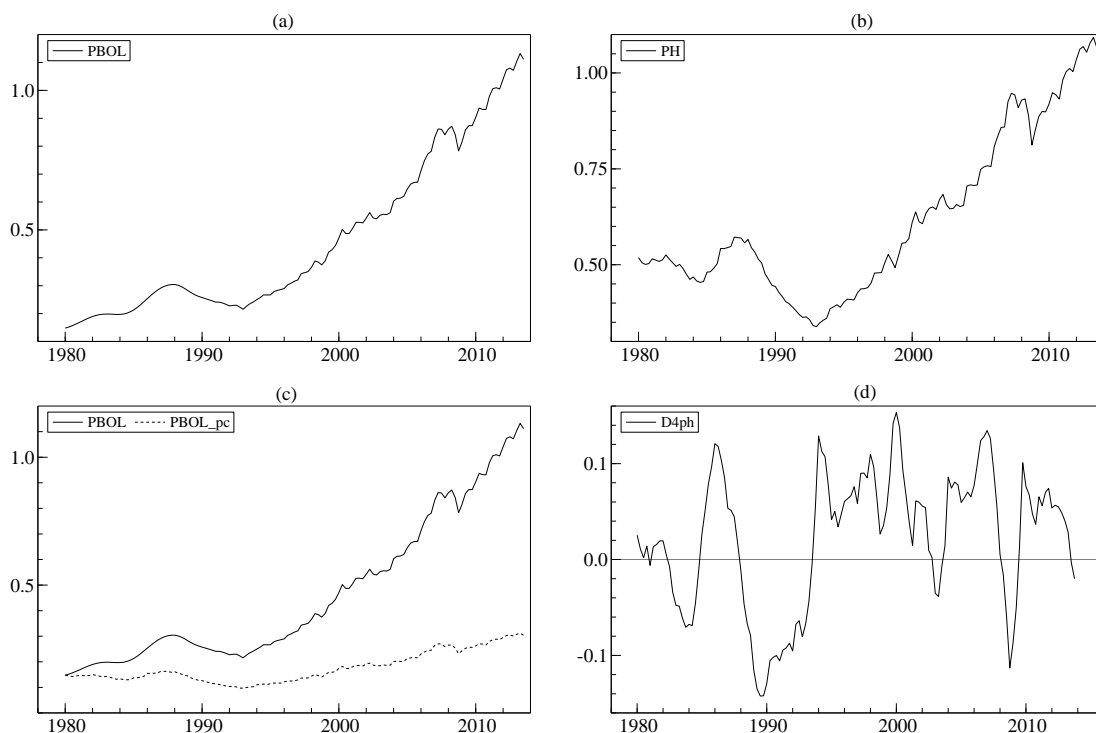

FIGURE 3.3: (a) Nominal housing price index. (b) Real housing price index. (c) Housing price index deflated by price index, base year 1980 Q1. (d) Real growth rate in housing prices. (1980 Q1–2013 Q3)

Over the last 30 years, housing prices deflated by wage growth have reached the current level on three different occasions. The first time was before the banking crisis and the second time was before the financial crisis, while the latter occurred in 2013. The common denominator following all of these events was that housing prices or the growth in housing prices halted. A crucial difference between the banking crisis around 1990 and the situation today is that the current real after-tax interest rate is low, while aggregated household debt is at a considerably higher level. Thus, a fall in housing prices is likely to deteriorate household net wealth, affecting consumption negatively. The aim of the new guidelines was to *"promote solid institutions and financial stability and to safeguard consumer interests"* (Finanstilsynet, 2011b). The guidelines[2] were a part of general-good rules designed to maintain financial stability in Norway, and therefore applied to Norwegian banks, financial institutions, as well as to foreign banks' branches in the country.

3.3 LTV restrictions

Since 1994, the Financial Supervisory Authority of Norway (FSA) has conducted annual surveys on banks' mortgage lending practices with the aim of revealing structural development trends in the Norwegian mortgage loan market. In the last decade, a rising debt burden has been observed along with a greater use of interest-only facilities and longer terms to maturity. The surveys further show a substantial increase in the share of mortgages with a LTV ratio above 80%, while the share of the more secure loans with a LTV ratio below 60% has fallen. In a report from 2010, Finanstilsynet (2011a) stated that debt has increased the most among groups with the highest debt-to-income ratios. In Norway, bank lending to households accounts for around 60% of overall lending to the private sector, of which 90% is secured by dwellings. Thus, Norwegian banks have an indirect exposure to the housing market (See Figure 3.4). The FSA expressed concerns that many Norwegian households were vulnerable to a hike in interest rates or economic setbacks. Thus, to dampen the build-up of risk in the household sector, the FSA issued guidelines for residential mortgage lenders in March 2010.

---

[2]The complete list of guidelines is listed in Appendix F.
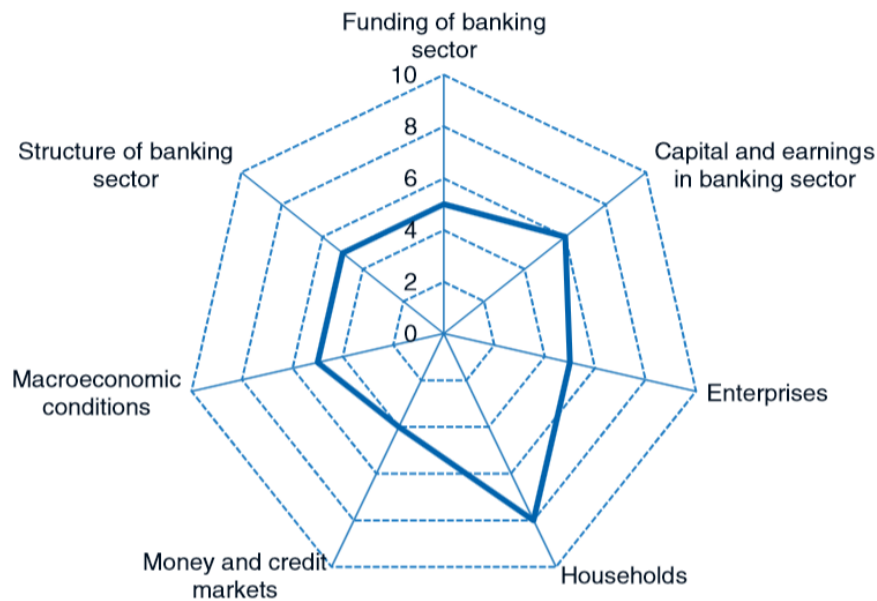
FIGURE 3.4: Vulnerabilities in the Norwegian banking sector, November 2012. A value of 0, i.e. origo, denotes the lowest level of risk or vulnerability. A value of 10 denotes the highest level of risk or vulnerability. Source: Norges Bank (2012).

Among the guidelines in 2010, a more specific rule was introduced, requiring that

- **Loans should normally not be given with an LTV ratio above 90%.**

However, due to continued high growth in household debt and housing prices, the guidelines were tightened in December 2011:

- **Loans should normally not be given with an LTV ratio above 85%.**

Furthermore, when assessing the borrower's debt servicing capacity, the revised guidelines advise the banks to make allowance for an increase in the interest rate of at least 5 percentage points. When the above threshold value is exceeded, the guidelines require additional collateral or a special prudential assessment. According to OECD (2014), this applied to 15% of the new loans by the autumn of 2013.

Before the guidelines had been implemented in 2010, it was common that banks had their own general rules regarding mortgage lending. Mortgage lending in Norway has traditionally been based on the value of collateral and debt-servicing capacity. Banks have for example used a rule of thumb that loans should not exceed three times household income (Norges Bank, 2006), while annual household LTV-ratios around 80% have been most common (Finanstilsynet, 2008). Nevertheless, mortgage surveys prior to 2010 revealed that banks have increasingly deviated from these general rules.

The new requirements have been criticized for affecting mostly young people who may actually have an adequate debt servicing capacity. The graph below shows the developments in the demand for loans to first-time home buyers and other loans, according to a quarterly survey conducted by Norges Bank. In the two quarters following the introduction of the LTV restriction, loans to first-time home buyers experienced a fall in demand. The demand for the loans to first-time home buyers responded more negatively than the other loans, and this was particularly the case right after the tightening in December 2011 (see Figure 3.5).
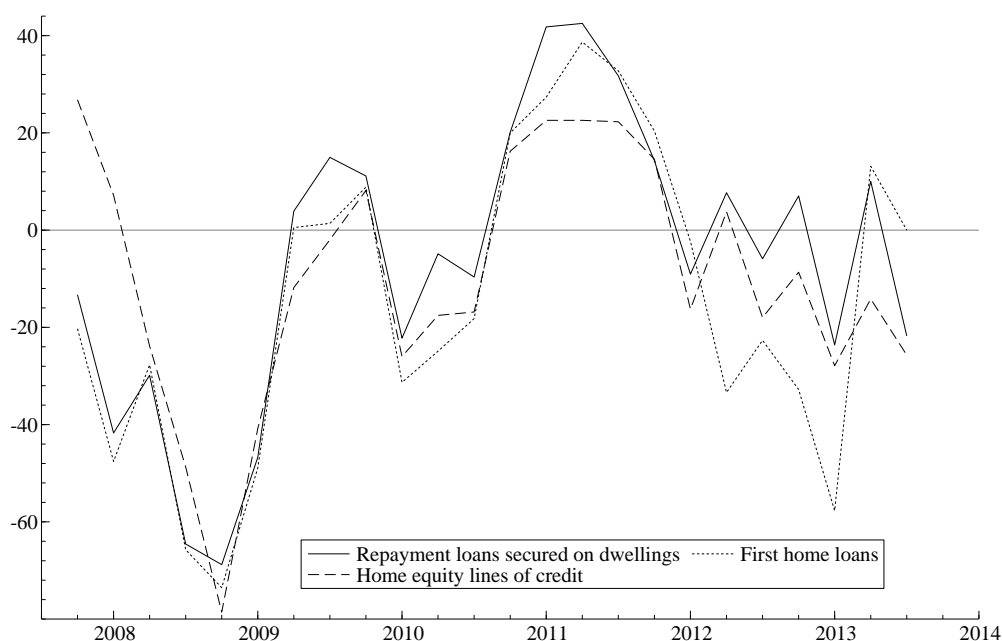
FIGURE 3.5: Household credit demand (secured on dwellings). Net percentage balances are calculated by weighting together the responses in the survey. 2007 Q4 – 2013 Q3. Source: Norges Bank (2013).

Then again, Finance Norway's household survey from 2013 concluded that 4 out of 10 receive help from parents when buying a dwelling, which is a doubling from 2010 numbers (Finans Norge, 2014). Parents can help finance the down payment requirement by for example giving advancement on inheritance or loans using home equity credit lines. Finans Norge (2014) as well as Lindquist (2012) point out that the increase in debt growth is highest among the age group 40–60.

Another alternative to parent financing has been acquiring loans from the State Housing Bank[3], which is the Norwegian government's main implementing agency for housing policy. According to Husbanken (2014), the main part of start-up loans has been granted to young people entering the housing market for the first time. In 2013, however, this share decreased as the State Housing Bank instructed the municipalities to prioritize the groups more likely to remain economically disadvantaged. In the years from 2010–2012, the amount of start-up loans increased from 5.527 to 7.473 billion NOK. From 1st of April 2014, the government further tightened the rules for receiving start-up loans for first time buyers from the State Housing Bank, as this would undermine FSA's tool for reducing the increasing debt (Kommunal- og Moderniseringsdepartementet, 2014).

---

[3]Husbanken

4 Self-reinforcing effects between housing prices and credit

Our main interest is to find evidence that the guidelines regarding the LTV restrictions have a dampening effect on household debt. As emphasized in chapter 2, there may be a bi-directional causality between housing prices and credit. The potential existence of such a financial accelerator implies that single-equations setups may suffer from an endogeneity problem. Therefore, the aim of this chapter is

> **to provide evidence of self-reinforcing effects between housing prices and household debt.**

For that purpose, we re-estimate a model presented by Anundsen and Jansen (2013), using a data set over a longer time horizon. There are two main reasons that justify this choice. Firstly, it enables us to find a long-run relationship between housing prices and credit, even though both time series exhibit I(1) behavior. Secondly, a slight extension of this framework can be used to analyze the impact of the LTV restrictions on household debt in chapter 5.

This chapter is structured as following: In section 4.1, we present the underlying theoretical framework. In section 4.2, we derive the empirical framework. Finally, we perform a cointegration analysis and compare the results with Anundsen and Jansen's findings in section 4.3.

4.1 Theoretical model

The theoretical model includes two equations, one for the determination of real housing prices and one for the determination of real household debt. The determination of real housing prices at the aggregate level in a long-run equilibrium is given by

$$PH_t = f(D_t, YH_t, R_t, H_t), \tag{4.1}$$

where housing prices PH is a function of real household debt D, real disposable income YH, the real after-tax interest rate R and the housing stock H. Equation (4.1) expresses the market clearing price for any given level of the housing stock. The partial effects are expected to be

$$\frac{\partial f}{\partial D} > 0, \quad \frac{\partial f}{\partial YH} > 0, \quad \frac{\partial f}{\partial R} \gtrless 0, \quad \frac{\partial f}{\partial H} < 0. \tag{4.2}$$

Higher household debt and higher disposable income are expected to increase housing prices, while an increase in housing services works in the opposite direction. The partial effect of the real after-tax interest rate, however, is ambiguous. On the one hand, a higher interest rate indirectly affects housing prices through disposable income and real household debt — variables which we control for in equation (4.1). On the other hand, there is a direct substitution effect which can have either sign from a theoretical point of view.

The determination of real household debt at the aggregate level in a long-run equilibrium is given by

$$D_t = g(PH_t, YH_t, R_t, TH_t, H_t), \tag{4.3}$$

where real household debt D is a function of housing prices PH, real disposable income YH, the real after-tax interest rate R, the housing turnover TH and the housing stock H.

Equation (4.3) is an extended version of Fitzpatrick and McQuinn (2007), where Anundsen and Jansen have included the additional explanatory variables housing turnover, TH, and housing stock, H. The partial effects are expected to be

$$\frac{\partial g}{\partial PH} > 0, \quad \frac{\partial g}{\partial YH} > 0, \quad \frac{\partial g}{\partial R} < 0, \quad \frac{\partial g}{\partial TH} > 0, \quad \frac{\partial g}{\partial H} > 0. \tag{4.4}$$

In other words, we expect that higher housing prices, higher disposable income, higher activity in the housing market and an increase in the housing stock all lead to higher household debt, whereas a higher interest rate has a negative impact on household debt.

4.2 Data set and Empirical model

4.2.1 Data set

All variables that enter the model are provided by Statistics Norway[1]. Our sample covers the period 1986 Q4 – 2013 Q3, since we do not have data for the number of housing transactions prior to 1985 Q1. All data are seasonally unadjusted. Moreover, most data have been revised compared with the data used by Anundsen and Jansen. In particular, we found that the statistics for household debt reveal a structural break in 1995 Q4. How we handle this issue, will be explained in section 4.2.2 and appendix D.

4.2.2 Empirical model

First of all, we perform a logarithmic transformation of the variables in equation (4.1) and (4.3), which can be seen as a linearization of the theoretical model. The exception is the interest rate, which is kept on level form. Therefore, variables on logarithmic form are indicated by small letters, while we use capital letters for level-form variables.

---

[1]See Appendix A.1.

Since all variables in equation (4.1) and (4.3) are usually found to be non-stationary and integrated of first order, Anundsen and Jansen suppose that there should be a cointegrated relationship between housing prices and household debt conditioning on the other variables[2]. Hence, we formulate a I(1) cointegrated VARX(p,q) system, where housing prices, household debt and disposable income are the endogenous variables, while conditioning on the interest rate, housing turnover and housing stock. We further assume that the housing stock has no impact in the short term. Following Harbo et al. (1998), we include a deterministic trend, which is restricted to lie in the cointegrated space, as well as a constant term and centered seasonal dummies. We also include dummy variables in order to control for a structural break in the household debt statistics. For that purpose, we specify the dummy variables as proposed by Johansen et al. (2000) so that we allow for structural breaks both in the trend variable as well as in the constant term[3]. All in all, we can formulate the VARX(p,q) system as a vector error correction model VECM(p,q) (see e.g. Johansen (1988), Johansen (1995) and Juselius (2006)) given by

$$
\begin{pmatrix} \Delta ph_t \\ \Delta d_t \\ \Delta yh_t \end{pmatrix} = \Pi \begin{pmatrix} ph_{t-1} \\ d_{t-1} \\ yh_{t-1} \\ R_{t-1} \\ th_{t-1} \\ h_{t-1} \\ t \\ t \cdot E_{2,t} \end{pmatrix} + \sum_{i=1}^{p} \Gamma_i \begin{pmatrix} \Delta ph_{t-i} \\ \Delta d_{t-i} \\ \Delta yh_{t-i} \end{pmatrix} + \sum_{i=0}^{q-1} \Psi_i \begin{pmatrix} \Delta R_{t-i} \\ \Delta th_{t-i} \end{pmatrix}
$$

(4.5)

$$
+ \Phi \begin{pmatrix} \mu_1 \\ \mu_2 \cdot E_{2,t} \\ CS1_t \\ CS2_t \\ CS3_t \end{pmatrix} + \sum_{i=1}^{p} \kappa_{2,i} D_{2,t-i} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix},
$$

---

[2]A set of I(1) variables is defined as cointegrated if a linear combination of them is stationary.

[3]The specification of the structural break dummies is given in appendix D.

where

$$
\Pi = \alpha\beta' = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \alpha_{2,ph} & \alpha_{2,d} \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} \beta_{ph,1} & \beta_{d,1} & \beta_{yh,1} & \beta_{R,1} & \beta_{th,1} & \beta_{h,1} & \beta_{t,1} & \beta_{sb,1} \\ \beta_{ph,2} & \beta_{d,2} & \beta_{yh,2} & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & \beta_{t,2} & \beta_{sb,2} \end{pmatrix}. \tag{4.6}
$$

The error terms $\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix}$ are assumed to be independently Gaussian distributed.

4.3 Cointegration analysis

4.3.1 Methodology

The final empirical model[4] has been found by Anundsen and Jansen, using a general-to-specific modelling approach. This approach involves several steps in order to ensure that the final model represents a valid formulation of the theoretical model given by equation (4.1) and (4.3). Since a general-to-specific approach is data sensitive, we perform all the different tests[5] on our own data set instead of just using the final model.

First of all, we test the time series for stationarity by applying an Augmented Dickey-Fuller test. Second, using information criteria and F-tests we analyse the optimal lag length of the variables. Third, we perform Johansen's trace test to determine the number of cointegration relationships. After having decided the rank of the cointegration matrix, we normalize the equations with respect to housing prices and private debt respectively, and impose identifying restrictions. Finally, we successively introduce overidentifying restrictions and test them for validity.

---

[4]The final empirical model reported in panel 5, p. 17, in Anundsen and Jansen (2013).

[5]For a detailed description of the tests applied, see Brooks (2008), Doornik and Hendry (2009a, 2009b).

4.3.2 Stationarity test

The Augmented Dickey-Fuller tests (Dickey and Fuller, 1979) indicate that all variables exhibit non-stationarity on level form[6]. Moreover, they become stationary when being differenced once, that is, the time series are I(1). The exception, however, is the time series for housing stock, which reveals I(2) behavior. Nevertheless, we follow Anundsen and Jansen (2013) and treat all variables integrated of order one at most.

4.3.3 Lag length test

Defining an appropriate lag length for both endogenous and exogenous variables is essential in a VARX model. We therefore start with a lag length equal of 7 and test the validity of lag reductions for the exogenous variables.

Consequently, we performed lag reduction tests based on information criteria such as Schwarz, Hannan-Quinn and Akaike, as well as F-tests. The results indicate that the optimal lag length for the exogenous variables would be zero[7]. Nonetheless, we decided to choose the same lag length for the exogenous variables as Anundsen and Jansen, that is, including one lag for the exogenous variables.

As a result, the endogenous variables enter the model with 7 lags, while the exogenous variables have a lag length equal to 1[8].

---

[6]The results are reported in appendix B.

[7]The results are reported in appendix C.

[8]Anundsen and Jansen used only 5 lags for the endogenous variables. This specification, however, produced unstable estimates when using our data.

4.3.4 Trace test

After having decided the lag length, we proceed to test for cointegration relationships by performing Johansen's trace test (Johansen, 1988). The usual critical values, however, are no longer valid due to the fact that our model includes three exogenous variables. The appropriate critical values are obtained from table 13 in Doornik (2003), and are reported along with the results in table 4.1.

The results show that there are two cointegrated vectors — housing prices and household debt. Residual diagnostics show that there is neither autocorrelation nor heteroskedasticity. However, the vector normality test indicates that the residuals are not normally distributed[9].

Eigenvalue λ_i	H_0	H_1	λ_{trace}	Crit. value 5%
0.332	$r = 0$	$r \geq 1$	85.872	64.48
0.221	$r \leq 1$	$r \geq 2$	41.472	40.95
0.119	$r \leq 2$	$r = 3$	13.980	20.89
Diagnostics	Test statistic	Value [p-value]		
Vector AR 1-5 test:	$F(45,199)$	1.352 [0.087]		
Vector Normality test:	$\chi^2(6)$	45.490 [0.000]		
Vector Hetero test:	$F(276,354)$	1.170 [0.086]		

TABLE 4.1: Trace test. Estimation period: 1986 Q4 – 2013 Q3.

---

[9]Graphic residuals analysis reveals that the rejection of normality may be due to the fact that there are outliers at the time of the structural break.

4.3.5 General-to-specific modelling

In order to test for overidentifying restrictions, we start with normalizing the cointegrated vectors given by equation (4.6). The first vector is normalized on housing prices, i.e. $\beta_{ph,1} = 1$, while the second vector is normalized on household debt, i.e. $\beta_{d,2} = 1$. Moreover, exact identification is achieved in two steps. First, we exclude the housing turnover from the housing price equation, i.e. $\beta_{th,1} = 0$, and second, we assume that housing prices and housing stock have the same effect on household debt, i.e. $\beta_{ph,2} = \beta_{h,2}$. In addition, no structural trend break occurs in the housing price equation, that is, we set $\beta_{sb,1} = 0$. As a result, the cointegration matrix is given by

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \alpha_{2,ph} & \alpha_{2,d} \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & \beta_{R,1} & 0 & \beta_{h,1} & \beta_{t,1} & 0 \\ \beta_{h,2} & 1 & \beta_{yh,2} & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & \beta_{t,2} & \beta_{sb,2} \end{pmatrix}. \tag{4.7}
$$

Equation (4.7) represents the cointegration of our baseline model. The estimated coefficients are found in panel 0 in table 4.2.

The first restriction (panel 1) we impose is omitting the real after-tax interest rate from the housing price vector, i.e. $\beta_{R,1} = 0$. Hence, the cointegration matrix corresponding to panel 1 takes the form

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \alpha_{2,ph} & \alpha_{2,d} \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & \beta_{t,1} & 0 \\ \beta_{h,2} & 1 & \beta_{yh,2} & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & \beta_{t,2} & \beta_{sb,2} \end{pmatrix}. \tag{4.8}
$$

The second restriction (panel 2) is to drop real disposable income from the debt equation, i.e. $\beta_{yh,2} = 0$. The cointegration matrix is then given by

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \\ \alpha_{2,ph} & \alpha_{2,d} \\ \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & \beta_{t,1} & 0 \\ \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & \beta_{t,2} & \beta_{sb,2} \end{pmatrix}. \tag{4.9}
$$

The third imposed restriction (panel 3) is that there is no effect of disequilibrium in the housing market on household debt, i.e. $\alpha_{2,ph} = 0$. Equation (4.10) shows the corresponding cointegration matrix:

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \\ 0 & \alpha_{2,d} \\ \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & \beta_{t,1} & 0 \\ \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & \beta_{t,2} & \beta_{sb,2} \end{pmatrix}. \tag{4.10}
$$

In the next step (panel 4), we exclude the trend from both vectors, i.e. $\beta_{t,1} = \beta_{t,2} = 0$. The cointegration matrix turns into

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \\ 0 & \alpha_{2,d} \\ \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & 0 & 0 \\ \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & 0 & \beta_{sb,2} \end{pmatrix}. \tag{4.11}
$$

Fifth, we assume that there is no structural trend break in the debt equation, i.e. $\beta_{sb,2} = 0$. The corresponding cointegration is then given by

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ \\ 0 & \alpha_{2,d} \\ \\ \alpha_{3,ph} & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & 0 & 0 \\ \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & 0 & 0 \end{pmatrix}. \tag{4.12}
$$

Finally, we assume no effect of disequilibrium in the housing market on real disposable income, i.e. $\alpha_{3,ph} = 0$. Equation (4.13) represents the final cointegration matrix given by

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ 0 & \alpha_{2,d} \\ 0 & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & 0 & 0 \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & 0 & 0 \end{pmatrix}. \tag{4.13}
$$

4.3.6 Results

Table 4.2 and 4.3 summarize the development when imposing the restrictions above. We report both the alpha[10] and beta coefficients as well as their standard errors (in parenthesis). In each panel, we report a likelihood ratio (LR) test which tests the restrictions from panel i to panel $i-1$ on the one hand, and a LR test which tests all the restrictions in panel i to the model without any restrictions on the other hand.

In general, we considered the t-values ex-ante for choosing new restrictions and checked their validity ex-post with LR tests. The restrictions imposed in panel 2 and 3, however, are the result of following Anundsen and Jansen' approach. The restriction in panel 2 is justified by the LR test, whereas the restriction in panel 3 is rejected by the LR test. Nonetheless, the result of the likelihood ratio test in the final specification indicates that also this restriction is valid.

Panel 6 reports the final specification which slightly differs from Anundsen and Jansen. While they imposed weak exogeneity of disposable income, we chose only one restriction, namely that disequilibrium in the housing market does not affect disposable income.

All the coefficients are significant and have the expected sign. The long run effects on housing prices can be summarized as follows:

---

[10]The alpha coefficients are reported in Appendix E.

- A 1% increase in real household debt increases real housing prices by 1.44%.

- A 1% increase in real disposable income leads to a 2.53% increase in housing prices.

- A 1% increase in the housing stock lowers real housing prices by 5.06%.

The long run effects on household debt are:

- A 1% increase in real housing prices leads to a rise in real household debt by 0.75%.

- A 1 percentage point increase in the real after-tax interest rate decreases real household debt by 1.36%.

- A 1% increase in the housing turnover increases real household debt by 0.19%.

- A 1% increase in the housing stock leads to a 0.75% increase in real household debt.

The main point of re-estimating this particular model was to find evidence of the existence of a financial accelerator between housing prices and credit, as well as to ensure that the model can be used for our further analysis. As noted above, our estimation produces meaningful and significant results. In addition, the positive coefficients for real household debt in the housing price equation and for real housing prices in the household debt equation show that there is a financial accelerator at work.

Consequently, this model is well-suited for our further analysis.

β	**Panel 0** $\beta_{sb,1} = 0$		**Panel 1** $\beta_{R,1} = 0$		**Panel 2** $\beta_{yh,2} = 0$		**Panel 3** $\alpha_{2,ph} = 0$	
	ph	d	ph	d	ph	d	ph	d
ph	-	0.84 *** $_{(-)}$	-	1.01 *** $_{(-)}$	-	0.61 *** $_{(-)}$	-	0.72 *** $_{(-)}$
d	0.30 $_{(0.61)}$	-	0.37 $_{(0.37)}$	-	1.68 *** $_{(0.05)}$	-	1.50 *** $_{(0.19)}$	-
yh	-0.43 $_{(1.05)}$	-3.21 *** $_{(0.76)}$	0.73 $_{(0.72)}$	-3.57 *** $_{(0.77)}$	0.45 *** $_{(0.10)}$	-	1.38 *** $_{(0.37)}$	-
R	1.43 $_{(1.16)}$	0.08 $_{(0.66)}$	-	0.79 *** $_{(0.34)}$	-	-0.07 ** $_{(0.03)}$	-	-0.43 ** $_{(0.17)}$
th	-	0.003 $_{(0.06)}$	-	-0.01 $_{(0.06)}$	-	0.001 $_{(0.01)}$	-	0.03 $_{(0.03)}$
h	-7.11 * $_{(3.38)}$	0.84 *** $_{(0.10)}$	4.13 * $_{(2.07)}$	1.01 *** $_{(0.10)}$	-1.55 *** $_{(0.27)}$	0.61 *** $_{(0.01)}$	-2.89 ** $_{(1.09)}$	0.72 *** $_{(0.05)}$
$trend$	-0.03 *** $_{(0.01)}$	0.02 $_{(0.004)}$	-0.02 * $_{(0.01)}$	0.02 *** $_{(0.004)}$	-0.01 *** $_{(0.001)}$	0.01 *** $_{(0.001)}$	-0.005 $_{(0.003)}$	0.005 *** $_{(0.001)}$
struc. break	-	0.01 $_{(0.003)}$	-	0.01 *** $_{(0.003)}$	-	-0.001 *** $_{(0.0003)}$	-	-0.002 * $_{(0.001)}$
Observations	$n = 110$		$n = 110$		$n = 110$		$n = 110$	
Log-likelihood:	1034.8721		1034.4828		1032.6011		1030.2054	
LR test[11]:	-		$\chi^2(1) = 0.78$ [0.38]		$\chi^2(1) = 3.76$ [0.05]		$\chi^2(1) = 4.79$ [0.03]	
LR test[12]:	$\chi^2(1) = 1.07$ [0.30]		$\chi^2(2) = 1.85$ [0.40]		$\chi^2(3) = 5.61$ [0.13]		$\chi^2(4) = 10.41$ [0.03]	

TABLE 4.2: General-to-specific modelling: Panel 0, 1, 2, 3. Standard errors are reported in parenthesis. Significance: p-value ≤ 0.01: ***, p-value ≤ 0.05: **, p-value ≤ 0.1: *. Estimation period: 1986 Q4 – 2013 Q3.

[11] Likelihood ratio test of restrictions from panel i to panel $i-1$.
[12] Likelihood ratio test of restrictions from panel i to the model without restrictions.

β	Panel 4 $\beta_{t,1} = \beta_{t,2} = 0$		Panel 5 $\beta_{sb,2} = 0$		Panel 6 $\alpha_{3,ph} = 0$	
	ph	d	ph	d	ph	d
ph	-	0.98 *** (−)	-	0.78 *** (−)	-	0.75 *** (−)
d	1.24 *** (0.18)	-	1.39 *** (0.25)	-	1.44 *** (0.27)	-
yh	1.86 *** (0.37)	-	2.28 *** (0.53)	-	2.53 *** (0.58)	-
R	-	−0.82 ** (0.34)	-	−1.14 ** (0.49)	-	−1.36 ** (0.57)
th	-	0.09 * (0.05)	-	0.15 ** (0.06)	-	0.19 *** (0.07)
h	−3.68 *** (0.82)	0.98 *** (0.09)	−4.64 *** (1.20)	0.78 *** (0.04)	−5.09 *** (1.29)	0.75 *** (0.05)
trend	-	-	-	-	-	-
struc. break	-	−0.003 (0.002)	-	-	-	-
Observations	$n = 110$		$n = 110$		$n = 110$	
Log-likelihood:	1028.4506		1028.1424		1027.9882	
LR test[13]:	$\chi^2(2) = 3.51\ [0.17]$		$\chi^2(1) = 0.62\ [0.43]$		$\chi^2(1) = 0.31\ [0.58]$	
LR test[14]:	$\chi^2(6) = 13.92\ [0.03]$		$\chi^2(7) = 14.53\ [0.04]$		$\chi^2(8) = 14.84\ [0.06]$	

TABLE 4.3: General-to-specific modelling: Panel 4, 5, 6. Standard errors are reported in parenthesis. Significance: p-value ≤ 0.01: ***, p-value ≤ 0.05: **, p-value ≤ 0.1: *. Estimation period: 1986 Q4 – 2013 Q3.

[13]Likelihood ratio test of restrictions from panel i to panel $i - 1$.
[14]Likelihood ratio test of restrictions from panel i to the model without restrictions.

4.3.7 Comparison with Anundsen and Jansen's estimation

Table 4.4 compares our findings with the results in the original article by Anundsen and Jansen (2013). Even though we use a longer time period, revised data and impose slightly different restrictions, all the coefficients have the same signs. Some of the estimates hardly differ in their values, e.g. household debt and housing stock in the debt equation, while the difference is greater in other variables, e.g. real disposable income and housing stock in the housing prices equation. Furthermore, all beta coefficients are significant in our estimation, while this was not the case in Anundsen and Jansen's estimation. They reported an insignificant coefficient for the real after-tax interest rate, and this coefficient was twice as big as our estimate measured in absolute terms. Nonetheless, the similar results represent a further justification of our model choice.

	Heer and Lund 1986 Q4 – 2013 Q3		Anundsen and Jansen 1986 Q4 – 2008 Q4	
β	ph	d	ph	d
ph	-	0.75 (−)	-	0.76 (−)
d	1.44 (0.27)	-	0.98 (0.19)	-
yh	2.53 (0.58)	-	1.69 (0.63)	-
R	-	−1.36 (0.57)	-	−2.74 (1.79)
th	-	0.19 (0.07)	-	0.28 (0.15)
h	−5.09 (1.29)	0.75 (0.05)	−3.03 (1.15)	0.76 (0.16)
α	ph	d	ph	d
ph	−0.30 (0.05)	−0.26 (0.06)	−0.24 (0.04)	−0.10 (0.03)
d	-	−0.05 (0.03)	-	−0.04 (0.01)
yh	-	0.11 (0.03)	-	-

TABLE 4.4: Comparison with Anundsen and Jansen's estimation.

5 Effect of LTV restrictions on aggregate household debt

In this chapter, we analyze the effect of the LTV restrictions imposed in March 2010 and December 2011 on aggregate household debt. Intuitively, the LTV restrictions should prevent households with limited equity — mostly young people — from obtaining or increasing mortgages, while the wealthier households should remain unaffected. Thus, the hypothesis is that

the LTV restrictions dampen aggregate real household debt.

This chapter is structured as following: In section 5.1, we explain the methodology and derive the extended model specification. In section 5.2, we present the estimation results, which we discuss in section 5.3.

5.1 Empirical model

In order to analyze the effect of the LTV restrictions, we extend the model from the previous chapter by introducing dummy variables which are restricted to lie in the cointegration space. In this way, we are able to investigate the long run effect of the LTV restrictions. We further assume that the LTV restrictions directly affect household debt. In addition, housing prices are indirectly affected through a change in credit. As a consequence, the dummy variables only enter the debt equation. Empirically, we handle this issue by imposing restrictions on the beta parameters of the dummy variables in the housing price equation.

Furthermore, we apply two different approaches. Firstly, we assume that both LTV restrictions have the same effect on household debt (subsection 5.1.1) and secondly, we distinguish between the two LTV restrictions and allow them to have a different impact on household debt (subsection 5.1.2). The first case can be seen as a natural experiment, where we compare household debt before and after a policy change, while the latter also analyzes the effect of tightening the LTV restrictions..

5.1.1 No distinction between LTV restrictions

In this case, we do not distinguish between the LTV restriction from March 2010 (max 90% LTV) and December 2011 (max 85% LTV). Hence, we introduce a dummy variable which takes the value 1 for the period 2010 Q2 – 2013 Q3 and 0 otherwise:

$$
LTV_t = \begin{cases} 1 & \text{if } t \geq 2010 \ Q2, \\ 0 & \text{if } t < 2010 \ Q2. \end{cases} \tag{5.1}
$$

The cointegration matrix is then given by

$$
\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ 0 & \alpha_{2,d} \\ 0 & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & 0 & 0 & 0 \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & 0 & 0 & \beta_{L,2} \end{pmatrix}, \tag{5.2}
$$

where $\beta_{L,2}$ denotes the long-run effect of introducing LTV restrictions on household debt.

5.1.2 Distinction between LTV restrictions

In this set-up, we allow the LTV restriction from March 2010 (max 90% LTV) and December 2011 (max 85% LTV) to have different impacts on household debt. Hence, we introduce two dummy variables:

$$LTV2010_t = \begin{cases} 1 & \text{if } 2010 \ Q2 \leq t \leq 2011 \ Q4, \\ 0 & \text{otherwise,} \end{cases} \tag{5.3}$$

and

$$LTV2012_t = \begin{cases} 1 & \text{if } t \geq 2012 \ Q1, \\ 0 & \text{otherwise,} \end{cases} \tag{5.4}$$

The corresponding cointegration matrix is then given by

$$\Pi = \begin{pmatrix} \alpha_{1,ph} & \alpha_{1,d} \\ 0 & \alpha_{2,d} \\ 0 & \alpha_{3,d} \end{pmatrix} \begin{pmatrix} 1 & \beta_{d,1} & \beta_{yh,1} & 0 & 0 & \beta_{h,1} & 0 & 0 & 0 & 0 \\ \beta_{h,2} & 1 & 0 & \beta_{R,2} & \beta_{th,2} & \beta_{h,2} & 0 & 0 & \beta_{L1,2} & \beta_{L2,2} \end{pmatrix}, \tag{5.5}$$

where $\beta_{L1,2}$ and $\beta_{L2,2}$ reveal the long-run effect of the LTV restriction of 90% and 85%, respectively.

5.2 Results

Table 5.1 summarizes the estimation results when imposing dummy variables according to the specification given in equation (5.2) and (5.5).

β	LTV		LTV 2010/2011	
	ph	d	ph	d
LTV	-	-0.01 (0.03)	-	-
$LTV2010$	-	-	-	0.001 (0.04)
$LTV2012$	-	-	-	-0.01 (0.04)
ph	-	0.76 *** $(-)$	-	0.76 *** $(-)$
d	1.45 *** (0.27)	-	1.43 *** (0.28)	-
yh	2.52 *** (0.60)	-	2.61 *** (0.62)	-
R	-	-1.33 ** (0.57)	-	-1.31 ** (0.60)
th	-	0.18 ** (0.07)	-	0.19 ** (0.07)
h	-5.08 *** (1.30)	0.76 *** (0.06)	-4.21 *** (1.33)	0.76 *** (0.06)
α	ph	d	ph	d
ph	-0.30 *** (0.05)	-0.26 *** (0.06)	-0.29 *** (0.05)	-0.25 *** (0.06)
d	-	-0.05 * (0.03)	-	-0.05 * (0.03)
yh	-	0.11 *** (0.03)	-	0.11 *** (0.03)
Observations	$n = 110$		$n = 110$	
Log-likelihood:	1028.0082		1028.0806	
LR test[1]:	$\chi^2(9) = 19.06$ [0.02]		$\chi^2(10) = 21.32$ [0.02]	

TABLE 5.1: Effect of LTV restrictions on aggregate household debt. Standard errors are reported in parenthesis. Significance: p-value ≤ 0.01: ***, p-value ≤ 0.05: **, p-value ≤ 0.1: *. Estimation period: 1986 Q4 – 2013 Q3.

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[1]Log likelihood ratio test of restrictions from panel i to the model without restrictions.

First of all, in the specification which does not distinguish between the two LTV restrictions, the estimated coefficient has the expected negative sign, but is not significant. In addition, the coefficient is rather small. Secondly, when distinguishing between the LTV restrictions of 90% and 85%, the estimated effects differ in signs. In addition, they are insignificant and negligible from an economic point of view. Lastly, we note that the coefficients of the control variables are fairly stable in both specifications, that is, they hardly change in value and are still significant.

5.3 Discussion

As seen in the previous section, it turns out that the LTV restrictions appear to have failed to dampen real household debt on an aggregate level. These results are in line with the findings of Igan and Kang (2011), who did not find a negative link between tightening macroprudential tools and credit growth among households in South Korea, despite their initial expectations. On the contrary, Wong et al. (2011) found that LTV restrictions had a dampening effect on household leverage in Hong Kong. However, as mentioned earlier in this thesis, both of these models ignored the bi-directional causality between household debt and housing prices, and may therefore suffer from endogeneity problems.

The question is why the LTV restrictions apparently have failed to dampen the aggregate household debt in Norway. More specifically, what can explain the insignificant result in our model? The insignificant result may stem from three different sources. Firstly, the restrictions are expected to constrain debt for particularly the younger part of the population, while the older households may not be affected at all. If the LTV restrictions have prevented young people from entering the credit market, the aggregated effect of this reduction may have been — at least partly — offset by increased debt among older age groups. Secondly, there are ways to avoid the LTV restrictions. As a result, the young people may still have been able to enter the credit market, thus leaving aggregate household debt unaffected. Thirdly, our model may suffer from an omitted variable bias since we do not control for variables such as population growth or the degree of centralization.

The LTV restrictions are assumed to have had the intended reduction in household debt for the young group. However, the old generation may have supported the young generation by directly buying dwellings for them. Hence, the fall in debt for the young generation was counteracted by a rise in the old generation's debt. Another explanation is that parents and their children could have chosen to jointly invest in a dwelling. In this case, we would expect to see a slight decrease in the younger generation's debt, while the older generation's debt increases a bit more relative to the situation without LTV restrictions. Finally, the habit of holding debt might have changed among old people, implying that the fall in the young generation's debt has been offset by the old generation's growth in debt. More specifically, the older generation may have used the increase in their wealth for buying even more expensive houses on the one hand, that is, they increased their mortgages, or they increased their existing loans to finance greater consumption expenditures on the other hand. The latter effect is discussed in Mian and Sufi (2011) and is described as home equity-based borrowing. Even though the last reason is not linked to the LTV restrictions, it might be a reason for the insignificant effect of the LTV restrictions on aggregate household debt.

The second hypothesis is that there are ways to avoid the LTV restrictions. The high growth in housing prices the last two decades has led to a strong increase in net worth for the older generations participating in the housing market. A higher level of wealth and the opportunity to increase existing loans based on an increased value of collateral, give rise to several opportunities in supporting the younger generation. Firstly, they can finance the amount of capital required to meet the LTV restrictions through an advance in inheritance or private loans. Secondly, the older generation can serve as guarantors. Yet another option to counter the LTV restrictions may have been the State Housing Bank, which has granted loans to people originally subject to the LTV restrictions. As a matter of fact, the amount of start-up loans has increased from 3.4 billion NOK to 7 billion NOK over the time period from 2007 to 2013. Thus, the State Housing Bank's lending practices may have undermined the policy requirement and even counteracted it. As a consequence, young people have still been able to enter the credit market after the introduction of the LTV restrictions, and this may explain why there is no significant fall in aggregate household debt.

Another explanation is that the insignificant results may be due to an underspecified model. For instance, we did not control for population growth due to the lack of quarterly data prior to 1997 Q4. All else equal, a larger population will be expected to hold a higher level of aggregate debt. As a matter of fact, numbers from Statistics Norway show that the average population growth in the years before 2010 was lower than in the period from 2010–2013[2]. This increase partly stems from an increase in net immigration[3]. Thus, a potential effect from the LTV restrictions on aggregate debt may be disguised by an increased population.

Another omitted variable which may have an impact on aggregated household debt is the increasing urbanization in Norway. When people move to urban areas, they usually pay a higher price for dwellings than in the districts, and are thus expected to increase their mortgages. According to Statistics Norway, the number of inhabitants in urban settlements increased by 60 000, or 1.5% in 2011 (Statistics Norway, 2012). In addition, almost 90% of the growth in the population of Norway in 2011 took place in the urban settlements. As before, not taking increasing urbanization into account may disguise the effect of the LTV restrictions on aggregate household debt.

In general, the insignificant results may be due to a combination of the reasons given above. The central question which arises is whether the LTV restrictions have had a different impact on household debt across age groups. We will therefore use a different model in the next chapter in order to find evidence for this hypothesis.

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[2]Annual population growth rate (calculated based on numbers from Statistics Norway): 0.66% on average in 1987–2009 and 1.27% on average in 2010–2013.

[3]Annual net immigration (calculated based on numbers from Statistics Norway): 22,000 on average in 1999–2009 and 44,000 on average in 2010–2012.

6 Effect of LTV restrictions on household debt across age groups

Following the discussion in section 5.3, one possible reason for the insignificant effect of the LTV restrictions on aggregate household debt was that the distribution of debt across age groups might have changed. More precisely, our hypothesis is that

> **the LTV restrictions cause the older group to accumulate debt faster, while the younger and poorer group is kept off the credit market to some extent, and accumulates debt slower.**

In order to find evidence supporting this hypothesis, we build a simple single-equation model in section 6.2 which differs from the previous model due to the lack of quarterly data. The estimation results are summarized and discussed in section 6.3.

6.1 Data set

In order to investigate the effect of the LTV restrictions on household debt across age groups, we use a panel data set with slightly different variables for household debt and income, as the previously used variables are only available on aggregate levels[1]. These two variables are divided by the number of persons in each group in order to control for population growth and demographic changes. The variables thus enter the regression on

---

[1]See appendix A.2. Note that we replace disposable income with income, since disposable income was not available for each group.

per capita form. Both variables are provided by Statistics Norway and are measured on a yearly frequency. The data set starts in 1993 and ends in 2012.

The original data set distinguishes between 6 age groups. To simplify the interpretation of the results, we reduce the number of age groups and distinguish only between young and old. The young group consists of persons from age 17 to 44 years, while the old group contains all persons of age 45 years or older.

Group index i	Dummy variable	Age
1	-	17-44
2	*old*	45+

TABLE 6.1: Age groups.

6.2 Model specification and methodology

6.2.1 Age group model

Our starting point is the theoretical debt equation introduced in section 4.1,

$$D_t = g(PH_t, YH_t, R_t, TH_t, H_t), \tag{6.1}$$

which together with the housing price equation determines the relationship between housing prices and household debt. Since we do not have enough observations to apply the previous model, we have to change the empirical specification and use a single equation for debt only. Moreover, we consider only short run effects with this particular model.

Firstly, we introduce a dummy variable for the older generation:

$$old_i = \begin{cases} 1 & \text{if } i = 2, \\ 0 & \text{otherwise,} \end{cases} \tag{6.2}$$

where i is the group index defined in table 6.1.

Secondly, we define dummy variables for the LTV restriction in March 2010,

$$LTV1_t = \begin{cases} 1 & \text{if } 2010 \leq t \leq 2011, \\ 0 & \text{otherwise,} \end{cases} \tag{6.3}$$

and in December 2011,

$$LTV2_t = \begin{cases} 1 & \text{if } t = 2012, \\ 0 & \text{otherwise,} \end{cases} \tag{6.4}$$

as well as a dummy variable when not distinguishing between the two LTV restrictions:

$$LTV_t = \begin{cases} 1 & \text{if } t \geq 2010, \\ 0 & \text{otherwise.} \end{cases} \tag{6.5}$$

Thirdly, we assume that the housing stock has no impact on household debt in the short run. Consequently, we are left with the following exogenous variables: real housing prices, real income, real after-tax interest rate and housing turnover. Note the difference between this single-equation model and the previous model: While we have to treat housing prices and income as exogenous in this particular model, they are endogenous in the previous model.

Finally, we include a trend variable t. Hence, our Age group model is given by:

$$debt_{it} = \beta_0 + \alpha_0 t + \beta_1 ph_t + \beta_2 inc_{it} + \beta_3 R_t + \beta_4 th_t + a_i + u_{it}, \qquad (6.6)$$

where real household debt, *debt*, and real income, *inc*, vary both over time and between groups, while the control variables real housing prices, *ph*, real after-tax interest rate, *R*, and housing turnover, *th*, vary only over time, but not between groups. The error term u_{it} is assumed to be uncorrelated with the exogenous variables, while the variable a_i denotes fixed effects, which vary between groups, but are constant over time. Further, we rewrite equation (6.6) as a 1. difference equation:

$$\Delta debt_{it} = \alpha_0 + \beta_1 \Delta ph_t + \beta_2 \Delta inc_{it} + \beta_3 \Delta R_t + \beta_4 \Delta th_t + u_{it}. \qquad (6.7)$$

Note that both the constant term and the fixed effects have disappeared. Further, the new constant term is the coefficient in front of the trend variable in equation (6.6).

In the next step, we include the dummy variables for the LTV restrictions. Moreover, we allow the two groups to have a different trend in household debt before and after the LTV restrictions by including the group dummy variable old_i as well as interaction terms. Hence, when we do not distinguish between the two LTV restrictions, the equation takes the form

$$\begin{aligned} \Delta debt_{it} = \alpha_0 + \delta_0 old_i + \beta_1 \Delta ph_t + \beta_2 \Delta inc_{it} + \beta_3 \Delta R_t + \beta_4 \Delta th_t \\ + \delta_1 LTV_t + \gamma_1 LTV_t \cdot old_i + u_{it}. \end{aligned} \qquad (6.8)$$

When we do distinguish between the two LTV restrictions, the model is given by

$$
\begin{aligned}
\Delta debt_{it} &= \alpha_0 + \delta_0 old_i + \beta_1 \Delta ph_t + \beta_2 \Delta inc_{it} + \beta_3 \Delta R_t + \beta_4 \Delta th_t \\
&\quad + \delta_1 LTV1_t + \phi_1 LTV1_t \cdot old_i + \delta_2 LTV2_t + \phi_2 LTV2_t \cdot old_i + u_{it}.
\end{aligned}
\tag{6.9}
$$

6.2.2 Methodology

Equation (6.8) and (6.9) will be estimated using pooled Ordinary Least Squares (OLS).

Moreover, equation (6.8) and (6.9) have been specified such that we can apply the difference-in-difference method. This particular method works as follows: First, we compute the difference in household debt between the two age groups before and after the introduction of the LTV restrictions, and second, we compute the difference of these two differences. If this number is equal or close to zero, then the LTV restrictions have no different impact on household debt between young and old. Alternatively, we could compute the difference between before and after the LTV restrictions for the young group as well as for the old group, and then compute the difference of those differences. In either case, the difference-in-difference estimator is the same.

Particularly, the model specification given by equation (6.8) allows the different groups to have different levels of debt everything else equal. Moreover, the effect of the LTV restrictions is allowed to differ between the two age groups. More precisely, the difference in debt between old and young before the LTV restrictions is given by $(\beta_0 + \delta_0) - \beta_0 = \delta_0$ and after the LTV restrictions the difference between old and young is measured by $(\beta_0 + \delta_0 + \delta_1 + \gamma_1) - (\beta_0 + \delta_1) = \delta_0 + \gamma_1$. The difference-in-difference estimator is then computed to be $(\delta_0 + \gamma_1) - \delta_0 = \gamma_1$, i.e. the coefficient in front of the interaction term of the dummy variables *LTV* and *old*. In other words, the coefficient γ_1 shows the different impact of the LTV restrictions on household debt for the old generation when using the young generation as reference group.

	LTV	
	before	after
young	β_0	$\beta_0 + \delta_1$
old	$\beta_0 + \delta_0$	$\beta_0 + \delta_0 + \delta_1 + \gamma_1$
diff	$(\beta_0 + \delta_0) - \beta_0 = \boldsymbol{\delta_0}$	$(\beta_0 + \delta_0 + \delta_1 + \gamma_1) - (\beta_0 + \delta_1) = \boldsymbol{\delta_0 + \gamma_1}$
diff-in-diff	-	$(\delta_0 + \gamma_1) - \delta_0 = \boldsymbol{\gamma_1}$

TABLE 6.2: Difference-in-difference estimator when not distinguishing between the two LTV restrictions.

In an analogous manner, the coefficients ϕ_1 and ϕ_2 denote the difference-in-difference estimators for the LTV restrictions from March 2010 and December 2011, respectively, when distinguishing between the two LTV restrictions (equation (6.9)).

6.3 Results

Table 6.3 summarizes the estimation results for the Age group model. Residual diagnostics show that the model does not suffer from serial correlation of first order, nor does it from serial correlation of second order. Since the number of observations is rather low, the results should be handled with care.

The control variables are highly significant and have the expected signs. The exception is the real after-tax interest rate, which is highly significant, but instead of having the expected negative impact on real household debt, its effect is estimated to be positive. As argued in chapter 4, this might be due to the fact that there is a cointegrated relationship between household debt and housing prices. As a consequence, the single-equation model may suffer from an endogeneity problem, which means that OLS estimation may give biased and inconsistent estimates.

		LTV		LTV 2010/2011	
	Panel 1 $\Delta debt$	Panel 2 $\Delta debt$	Panel 3 $\Delta debt$	Panel 4 $\Delta debt$	Panel 5 $\Delta debt$
old	-	-	0.009 *** (0.0001)	-	0.009 *** (0.00002)
LTV	-	−0.014 *** (0.005)	−0.021 *** (0.0003)	-	-
$LTV \cdot old$	-	-	0.013 *** (0.0002)	-	-
$LTV1$	-	-	-	−0.023 *** (0.007)	−0.032 *** (0.002)
$LTV1 \cdot old$	-	-	-	-	0.015 *** (0.0001)
$LTV2$	-	-	-	−0.001 (0.002)	−0.005 *** (0.001)
$LTV2 \cdot old$	-	-	-	-	0.009 *** (0.0001)
Δph	0.187 *** (0.004)	0.166 *** (0.004)	0.157 *** (0.002)	0.151 *** (0.006)	0.141 *** (0.004)
Δinc	0.146 *** (0.038)	0.127 *** (0.019)	0.093 *** (0.012)	0.109 *** (0.012)	0.074 *** (0.004)
ΔR	0.412 *** (0.038)	0.525 *** (0.081)	0.547 *** (0.084)	0.712 *** (0.126)	0.742 *** (0.132)
Δth	0.001 (0.004)	0.017 *** (0.001)	0.021 *** (0.0001)	0.034 *** (0.004)	0.039 *** (0.003)
constant	0.037 *** (0.005)	0.041 *** (0.003)	0.037 *** (0.0001)	0.042 *** (0.003)	0.039 *** (0.0004)
Observations	$n = 38$	$n = 38$	$n = 38$	$n = 38$	$n = 38$
R^2:	0.1285	0.1582	0.1977	0.1736	0.2149
AR(1) test[2]:	1.394 [0.163]	1.372 [0.170]	1.371 [0.170]	1.361 [0.173]	1.356 [0.175]
AR(2) test[3]:	1.388 [0.165]	1.347 [0.178]	1.358 [0.175]	1.341 [0.180]	1.344 [0.179]

TABLE 6.3: Results Age group model. Robust standard errors are reported in parenthesis. Significance: p-value $\leq$ 0.01: ***, p-value $\leq$ 0.05: **, p-value $\leq$ 0.1: *. Estimation period: 1994 – 2012.

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[2]AR(1) test: Testing the null of no serial correlation of first order. Test statistics: $N(0,1)$. p-values are reported in brackets.

[3]AR(2) test: Testing the null of no serial correlation of second order. Test statistics: $N(0,1)$. p-values are reported in brackets.

Considering table 6.3, our prime interest is directed towards the dummy variables and their interaction terms.

First, panel 2 and 4 show the results when we do not allow for differences across age groups. Then, real household debt is estimated to increase around 4% when there is no change in the control variables. Moreover, the LTV restrictions are estimated to have a dampening effect on real household debt. More precisely, when we do not distinguish between the two LTV restrictions, the estimated growth rate is 1.4% lower after the LTV restrictions. Then again, when we distinguish between the two LTV restrictions, the growth rate is 2.3% lower after the LTV restriction in March 2010 on the one hand, and 0.1% lower after the LTV restriction in December 2011 on the other hand. The latter effect is not only small from an economic point of view, but also insignificant.

Second, panel 3 and 5 show the results when we allow for differences across age groups. Generally, when there is no change in fundamentals, real household debt is estimated to increase with around 4% for the young generation, while the growth rate is slightly higher for the old generation (around 5%). Moreover, the LTV restrictions are estimated to have a negative impact on real household debt for the young generation, while the impact is less negative or even positive (LTV in 2011) for the old generation. The isolated effect on each age group's growth rate in real household debt is summarized in table 6.4.

	LTV	LTV 2010	LTV 2011
young	−0.021	−0.032	−0.005
old	−0.008	−0.017	0.004

TABLE 6.4: Estimated effect of LTV restrictions on each age group's growth rate in real household debt.

Finally, in order to determine whether the impact on the young and old is different, we compute the difference-in-difference estimator in table 6.5.

	LTV		LTV 2010		LTV 2011	
	before	after	before	after	before	after
young	0.037	0.016	0.039	0.007	0.039	0.034
old	0.046	0.038	0.048	0.031	0.048	0.052
diff	0.009	0.022	0.009	0.024	0.009	0.018
diff-in-diff	-	**0.013**	-	**0.015**	-	**0.009**

TABLE 6.5: Estimated difference-in-difference estimator for LTV, LTV 2010 and LTV 2011.

In the case where we do not distinguish between the two LTV restrictions, the difference between the young and old group's growth rate in real household debt before the LTV restrictions is estimated to be 0.9 percentage points, while the difference after the imposition is 2.2 percentage points. Hence, the difference-in-difference estimator is $\hat{\gamma}_1 = 0.013$, that is, the reduction in household debt for the older group is 1.3 percentage points less than for the younger group, which means that the gap between the old and young group's growth rate has increased.

When we make a distinction between the two LTV restrictions, the gap between the growth rates is still 0.9 percentage points before the LTV imposition, even though the estimated growth rates are slightly higher. After the LTV restriction in 2010, the gap has increased to 2.4 percentage points, which in turn has resulted in a difference-in-difference estimator equal to $\hat{\phi}_1 = 0.015$. Analogously, the difference-in-difference estimator for the LTV restriction in 2011 is estimated to be $\hat{\phi}_2 = 0.009$, that is, the gap between the two growth rates has widened by 0.9 percentage points.

Generally, the results indicate that the impact of the LTV restrictions is indeed different across age groups. While there is a strong decrease in the young generation's growth rate, the older generation has reacted less to these measures, and even accumulated debt slightly faster after the LTV restriction in 2011. Hence, the results confirm our hypothesis to some extent. While the effect on the young group is negative as expected, the old generation's growth rate has only increased after the tighter restriction in 2011.

7 Conclusion

The purpose of this thesis was to examine the effect of the loan-to-value (LTV) restrictions introduced in March 2010 and December 2011 on Norwegian household debt.

After many years with high growth in household debt, Norway is among the countries with the highest debt-to-income ratio worldwide. Several economists have pointed out that such a high accumulation of household debt threatens financial stability and has severe implications from a macroeconomic perspective. As a result, the FSA have introduced a LTV restriction of 90% in 2010 and lowered it to 85% in 2011. The main goal of these restrictions was to dampen the growth of household debt and housing prices.

Firstly, we re-estimated a model introduced by Anundsen and Jansen (2013) with an extended data set, and found a cointegrated relationship between housing prices and household debt. Moreover, the results indicate that there is indeed a financial accelerator at work, that is, there are self-reinforcing effects between housing prices and credit in the long run. These results are in line with the findings in Anundsen and Jansen (2013), Fitzpatrick and McQuinn (2007), and Gimeno and Martinez-Carrascal (2010). Consequently, it is crucial to take this bi-directional causality between housing prices and credit into account when analyzing the effect of LTV restrictions.

Secondly, in order to analyze the question of interest, we extended the benchmark model by including dummy variables for the LTV restrictions in 2010 and 2012. Our findings indicate that the LTV restrictions have failed to have a significant effect on aggregate household debt. Hence, the results are in contrast with the evidence from similar studies such as Wong et al. (2011) and Price (2014), but in line with the study from Igan and Kang (2011). The insignificant result cried for explanation and we outlined three different causes. Firstly, the LTV restrictions may have failed to prevent a sufficient amount of

people from entering the credit market due to (grand)parent financing and start-up loans from the State Housing Bank. Secondly, a potential decline in the younger generation's debt may have been counteracted by a rise in the older generation's debt. Finally, our model may suffer from omitted variable bias since we did not control for variables such as population growth and urbanization due to the lack of quarterly data.

Thirdly, in order to substantiate our hypotheses, we derived a single-equation model which allowed us to study the impact of the LTV restrictions on household debt across age groups. In this particular model, we controlled for population growth as well as demographic changes. As expected, the results indicate that the LTV restrictions had a dampening effect on the growth in debt among the young. Then again, the impact on debt among the elderly is less clear. The estimates revealed a slight reduction in growth in debt after the LTV restriction in 2010, whereas debt was estimated to grow faster again after the tightening of the LTV restriction. Causality is not that clear in this case, and the increased growth rate may be the result of (grand)parent financing and/or a change in the willingness of holding debt among the elderly.

In general, we conclude that the LTV restrictions are likely to increase financial stability through decreasing the speed of debt accumulation among young people, who hold over 60% of total household debt. However, they seem to have failed the initial aim of dampening the aggregate amount of household debt, which still remains a threat to the Norwegian economy. LTV restrictions can therefore be seen as a valuable tool for reducing the accumulation of debt among the most sensitive group. They may, however, have limited power to dampen household debt on an aggregate level.

Our study has two main shortcomings. Firstly, the number of observations after the introduction of the LTV restrictions is relatively low. Secondly, the model used to analyze the effect on aggregate household debt may suffer from omitted variables, while the Age group model does not take the cointegrated relationship between housing prices and household debt into account. In this context, further research is needed. New and more reliable evidence may be provided by including potential omitted variables as well as applying a richer data set. In addition, a cross-section analysis between countries may allow to isolate the effect of LTV restrictions and will probably produce more precise estimates.

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A   Appendix: Data definitions

A.1   Data used in the Housing prices and debt model

All data are seasonally unadjusted and measured on a quarterly basis. Except for the interest rate all variables are transformed to log scale in the empirical analysis.

Variable	Data description	Source
pc	The consumption deflator in the National Accounts.	Statistics Norway
ph	Hedonic housing price index measuring average housing prices in Norway ($PBOL$). The housing price index is deflated by pc.	Statistics Norway
d	Total amount of outstanding gross household debt ($BG300$). Deflated by pc.	Statistics Norway
yh	Households' disposable income ($RD300$), excluding equity income ($RAM300$). Deflated by pc.	Statistics Norway
h	Real housing stock measured in fixed prices ($K83$). Measures the total stock of housing in Norway and is calculated according to the perpetual inventory method.	Statistics Norway
th	The housing turnover measures the number of housing transactions.	Statistics Norway
i	Nominal interest rate paid by households on loans in private financial institutions ($RENPF300$).	Statistics Norway
p	Consumer price index (KPI).	Statistics Norway
π	Annual inflation rate ($\pi = \Delta_4 p$).	Statistics Norway
τ	Capital tax rate ($TRTMNW$). After a tax reform in 1992, τ has been constant at 0.28.	Statistics Norway
R	Real annual after-tax interest rate ($R = 4i \cdot (1-\tau) - \pi$).	Statistics Norway

TABLE A.1: Data used in the Housing prices and debt model.

A.2 Data used in the Age group model

All data are measured on a yearly basis. Except for the interest rate all variables are transformed to log scale in the empirical analysis.

Variable	Data description	Source
pc	The consumption deflator in the National Accounts.	Statistics Norway
ph	Hedonic housing price index measuring average housing prices in Norway ($PBOL$). The housing price index is deflated by pc.	Statistics Norway
N	Number of residents 17 years and older (tax statistics).	Statistics Norway
$debt$	Real household debt per capita. Gross household debt (tax statistics) divided by N and deflated by pc.	Statistics Norway
inc	Real income per capita. Gross income (tax statistics) divided by N and deflated by pc.	Statistics Norway
th	The housing turnover measures the number of housing transactions.	Statistics Norway
i	Nominal interest rate paid by households on loans in private financial institutions ($RENPF300$).	Statistics Norway
p	Consumer price index (KPI).	Statistics Norway
π	Annual inflation rate ($\pi = \Delta_4 p$).	Statistics Norway
τ	Capital tax rate ($TRTMNW$). After a tax reform in 1992, τ has been constant at 0.28.	Statistics Norway
R	Real annual after-tax interest rate ($R = 4i \cdot (1 - \tau) - \pi$).	Statistics Norway

TABLE A.2: Data used in the Age group model.

B Appendix: Stationarity tests

B.1 Real housing prices
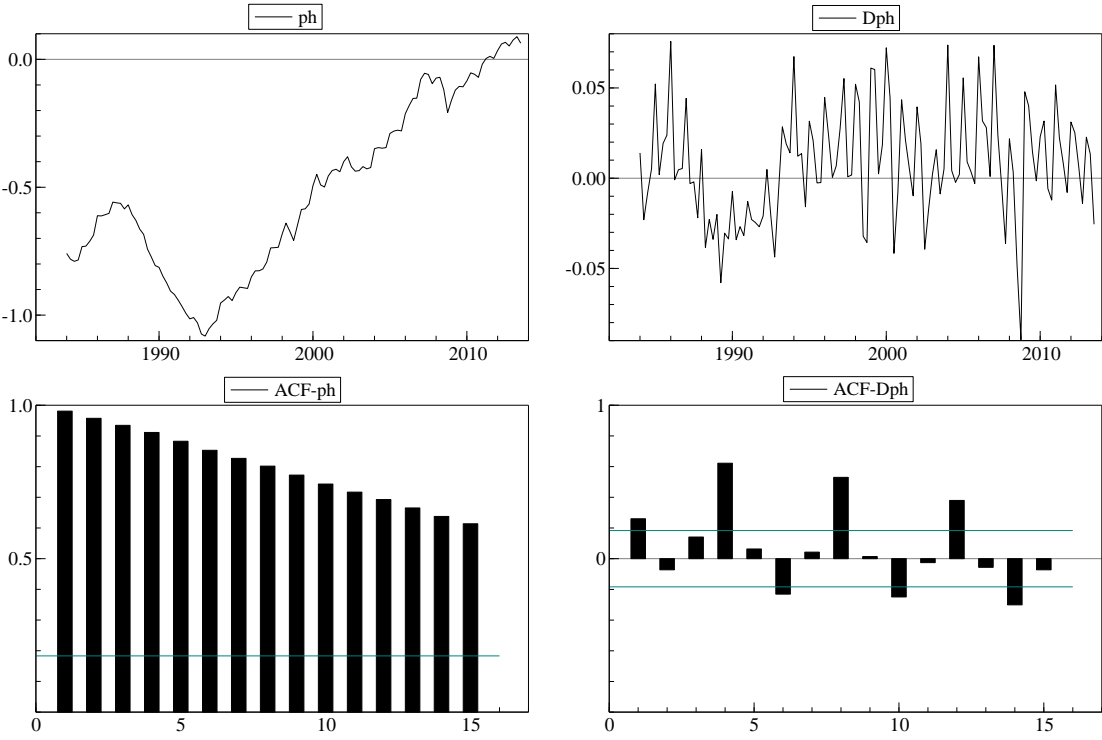
FIGURE B.1: Time series and ACF function (1984 Q1 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
ph	5	yes	yes	yes	1.546	-2.845	-3.45
Δph	4	yes	no	yes	1.539	-3.260	-2.89

TABLE B.1: ADF test (1986 Q2 – 2013 Q3).

B.2   Real household debt
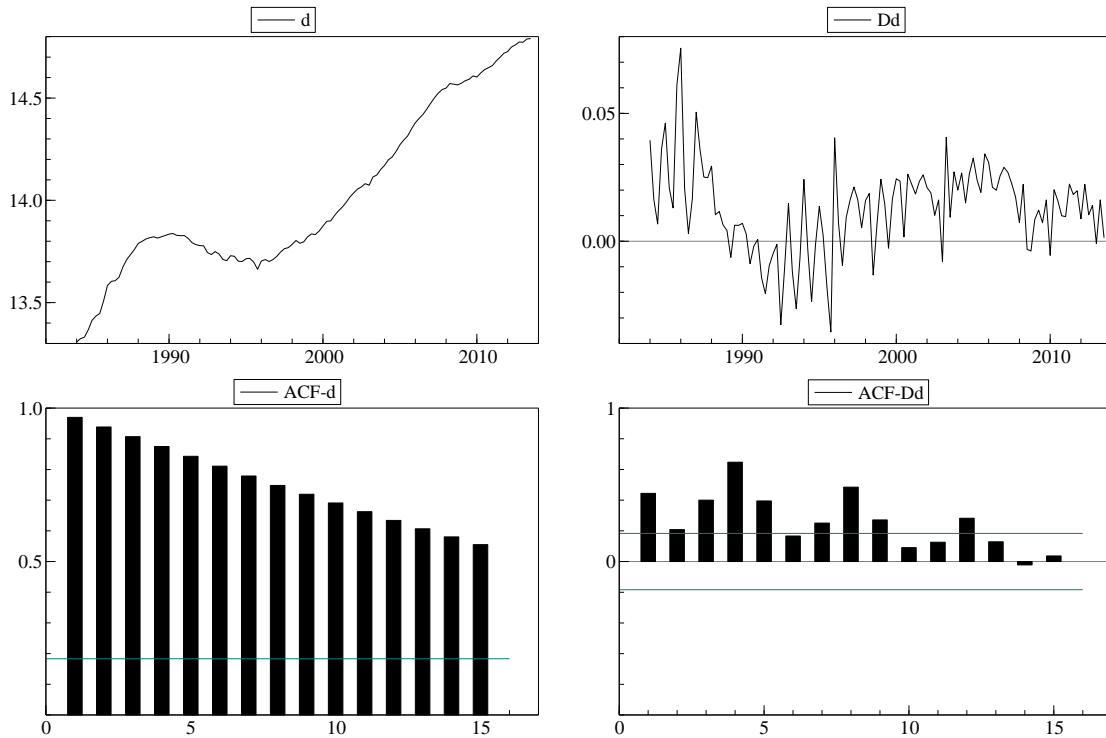
FIGURE B.2: Time series and ACF function (1984 Q1 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
d	4	yes	yes	no	2.280	-2.702	-3.45
Δd	3	yes	no	no	2.286	-2.944	-2.89

TABLE B.2: ADF test (1986 Q2 – 2013 Q3).

B.3 Real disposable income
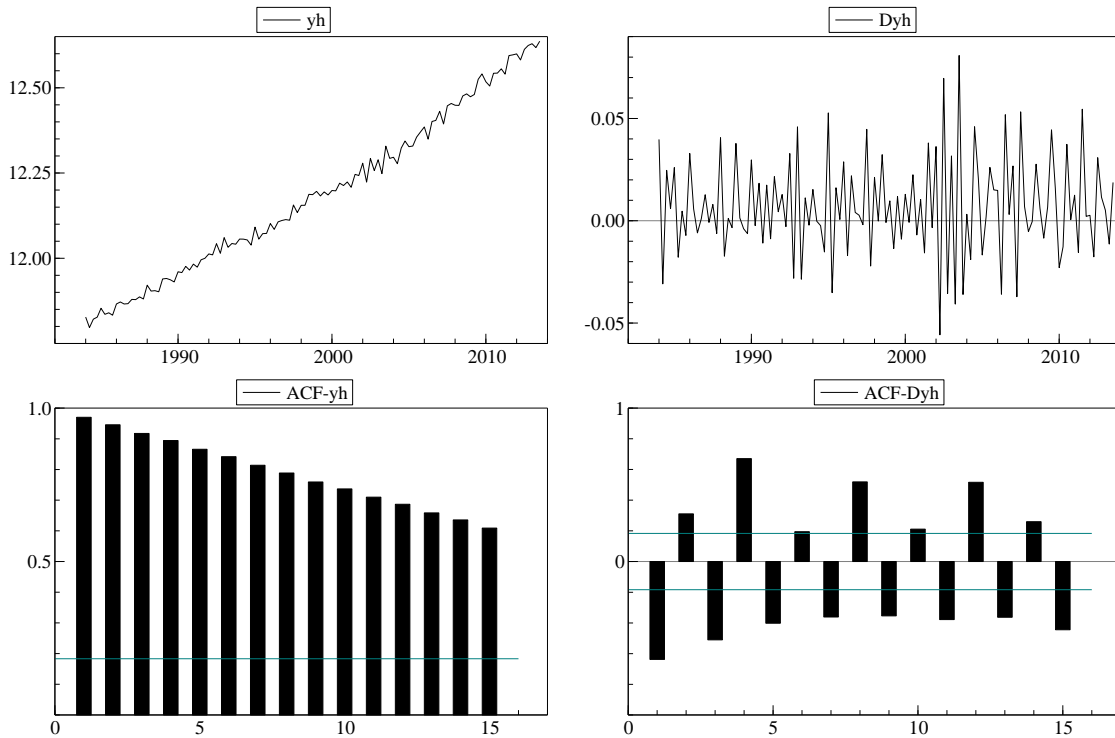
FIGURE B.3: Time series and ACF function (1984 Q1 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
yh	5	yes	yes	yes	1.984	-0.766	-3.45
Δyh	4	yes	no	yes	2.015	-5.061	-2.89

TABLE B.3: ADF test (1986 Q2 – 2013 Q3).

B.4   Real after-tax interest rate
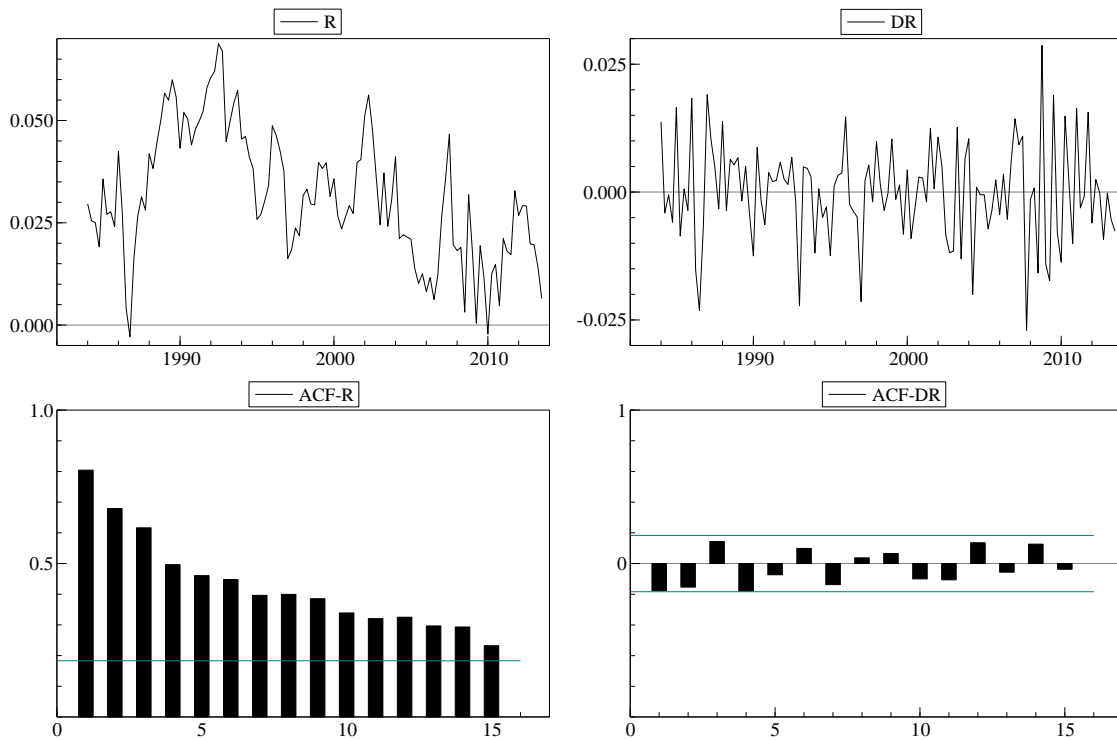
FIGURE B.4: Time series and ACF function (1984 Q1 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
R	4	yes	yes	no	1.841	-2.847	-3.45
ΔR	3	yes	no	no	1.858	-6.848	-2.89

TABLE B.4: ADF test (1986 Q2 – 2013 Q3).

B.5   Housing turnover
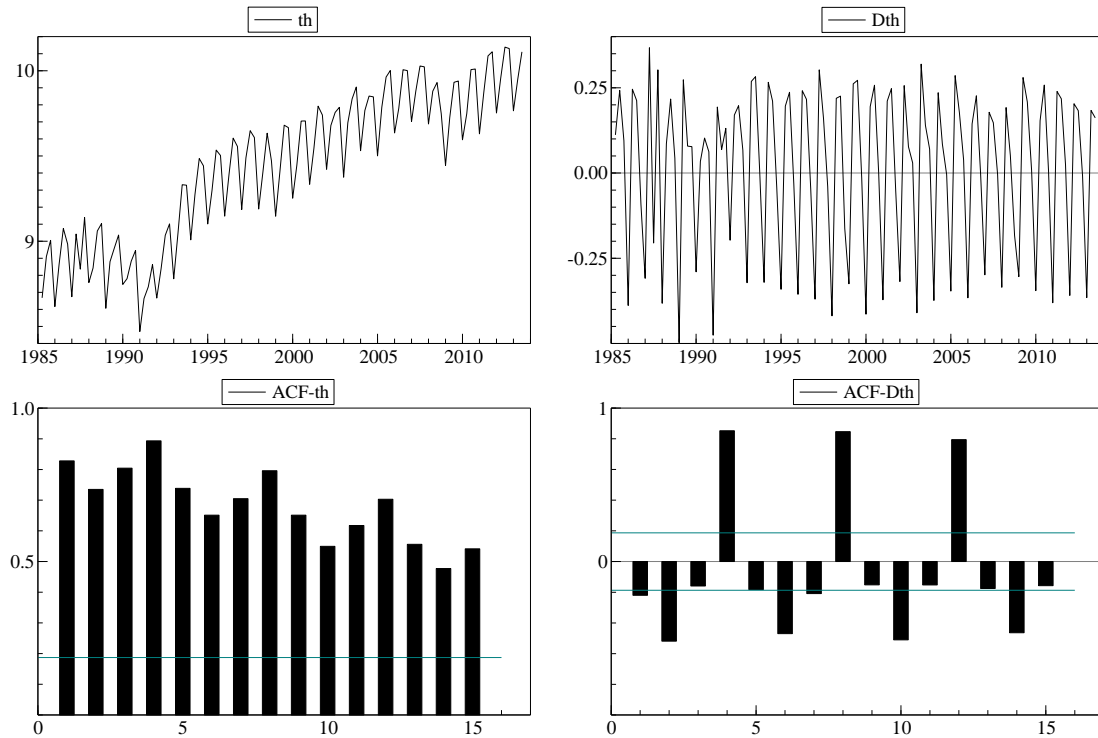
FIGURE B.5: Time series and ACF function (1985 Q2 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
th	2	yes	yes	yes	2.137	-1.810	-3.45
Δth	1	yes	no	yes	2.221	-10.09	-2.89

TABLE B.5: ADF test (1987 Q2 – 2013 Q3).

B.6   Real housing stock
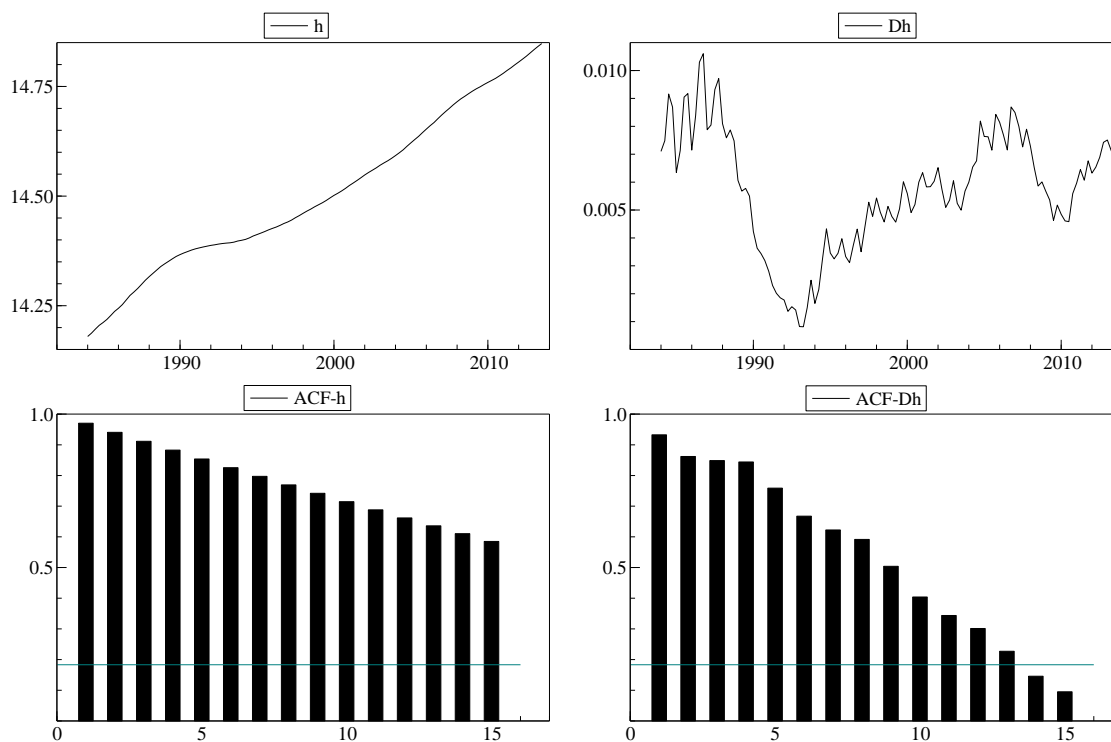
FIGURE B.6: Time series and ACF function (1984 Q1 – 2013 Q3).

Variable	Lags	Constant	Trend	Season	DW	t-adf	Crit. value 5%
h	5	yes	yes	no	1.833	-1.603	-3.45
Δh	4	yes	no	no	1.850	-2.634	-2.89
$\Delta^2 h$	3	yes	no	no	1.839	-2.942	-2.89

TABLE B.6: ADF test (1986 Q2 – 2013 Q3).

C Appendix: Lag length tests

Table C.1 and C.2 show the results of the lag reduction tests for the exogenous variables in the unrestricted VARX.

- Endogenous variables: Real housing prices, real household debt, real disposable income.

- Restricted variables: Real after-tax interest rate, housing turnover, housing stock, deterministic trend and a dummy variable for the structural break in the time series for real household debt.

- Unrestricted variables: Constant and centered seasonal dummies.

C.1 Lag reduction test: Information criteria

Lags	log likelihood	SC	HQ	AIC
7	1054.7704	-13.550	-15.888	-16.977
6	1050.1381	-13.724	-15.673	-17.003
5	1045.4042	-13.897	-15.757	-17.026
4	1039.9761	-14.056	-15.828	-17.037
3	1031.4725	-14.159	-15.842	-16.990
2	1029.3262	-14.379	-15.974	-17.062
1	1023.2662	-14.527	-16.033	-17.060
0	1017.3948	$\mathbf{-14.679}$	$\mathbf{-16.096}$	$\mathbf{-17.063}$

TABLE C.1: Lag reduction test: Information criteria (1986 Q4 – 2013 Q3).

C.2 Lag reduction test: F-test and LR test

Tests of lag reduction	F-test, LR test	F-statistic	p-value
7 to 6	$\chi^2(6)$	9.265	[0.1592]
7 to 5	$\chi^2(12)$	18.732	[0.0952]
7 to 4	$\chi^2(18)$	29.589	[0.0416]
7 to 3	$\chi^2(24)$	46.596	[0.0038]
7 to 2	$\chi^2(30)$	50.888	[0.0100]
7 to 1	$\chi^2(36)$	63.008	[0.0035]
7 to 0	$\chi^2(42)$	74.751	[0.0014]
6 to 5	F(6,124)	0.9260	[0.4788]
6 to 4	F(12,164)	1.0095	[0.4425]
6 to 3	F(18,175)	1.2699	[0.2127]
6 to 2	F(24,180)	1.0684	[0.3841]
6 to 1	F(30,182)	1.1249	[0.3108]
6 to 0	F(36,183)	1.1638	[0.2565]
5 to 4	F(6,128)	1.0996	[0.3662]
5 to 3	F(12,169)	1.4478	[0.1489]
5 to 2	F(18,181)	1.1194	[0.3366]
5 to 1	F(24,186)	1.1781	[0.2668]
5 to 0	F(30,188)	1.2147	[0.2174]
4 to 3	F(6,132)	1.8022	[0.1034]
4 to 2	F(12,174)	1.1280	[0.3403]
4 to 1	F(18,187)	1.2021	[0.2628]
4 to 0	F(24,192)	1.2409	[0.2114]
3 to 2	F(6,136)	0.4550	[0.8404]
3 to 1	F(12,180)	0.8878	[0.5605]
3 to 0	F(18,192)	1.0343	[0.4234]
2 to 1	F(6,140)	1.3467	[0.2405]
2 to 0	F(12,185)	1.3464	[0.1957]
1 to 0	F(6,144)	1.3409	[0.2428]

TABLE C.2: Lag reduction test: F-test, LR test (1986 Q4 – 2013 Q3).

D Appendix: Structural break

This appendix explains the specification of the dummy variables used for controlling the structural break occured in the debt statistics in 1995 Q4. We adopt an approach proposed by Johansen et al. (2000), where we allow for both a structural break in the (restricted) trend variable as well as in the (unrestricted) constant term.

D.1 Specification of dummy variables regarding a structural break

Our initial model is given by

$$
\Delta Y_t = \alpha \begin{pmatrix} \beta \\ \gamma \end{pmatrix}' \begin{pmatrix} Y_{t-1} \\ X_{t-1} \\ t \end{pmatrix} + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + \sum_{i=0}^{q-1} \Psi_i \Delta X_{t-i} + \Phi \begin{pmatrix} \mu \\ CS1_t \\ CS2_t \\ CS3_t \end{pmatrix} + \varepsilon_t, \qquad \text{(D.1)}
$$

where Y is a 3×1 vector of the endogenous variables, X is a 3×1 vector of the exogenous variables, t is the deterministic trend variable with the according parameter γ, $\mu = 1$ is the constant term, $CS1$, $CS2$ and $CS3$ are centered seasonal dummies, and ε is a 3×1 vector of the error term.

First, we divide our sample into two subsamples. Let

$$1986 \ Q3 = T_0 < T_1 < T_2 = 2013 \ Q3, \tag{D.2}$$

where $T_1 = 1995 \ Q3$ is the last observation in period 1.

Second, let

$$D_{2,t} = \begin{cases} 1 & \text{if } t = T_1, \\ 0 & \text{otherwise,} \end{cases} \quad \text{for } t = ..., -1, 0, 1, ... \tag{D.3}$$

so $D_{2,t-i}$ is an indicator function of the ith observation in the 2nd period; that is, $D_{2,t-i} = 1$ if $t = T_1 + i$.

Third,

$$E_{2,t} = \sum_{i=k+1}^{T_2 - T_1} D_{2,t-i} = \begin{cases} 1 & \text{for } T_1 + k + 1 \leq t \leq T_2, \\ 0 & \text{otherwise,} \end{cases} \tag{D.4}$$

is the effective sample of the 2nd period. It is convenient to gather the sample dummies and the drift parameters for the different sample periods

$$E_t = (1, E_{2,t})', \quad \mu = (\mu_1, \mu_2) = (1, 1), \quad \gamma = (\gamma_1', \gamma_2')', \tag{D.5}$$

of dimensions (2×1), (3×2), (2×2), respectively. The model equation becomes

$$\Delta Y_t = \alpha \begin{pmatrix} \beta \\ \gamma \end{pmatrix}' \begin{pmatrix} Y_{t-1} \\ X_{t-1} \\ t \cdot E_t \end{pmatrix} + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + \sum_{i=0}^{q-1} \Psi_i \Delta X_{t-i} + \Phi \begin{pmatrix} \mu \cdot E_t \\ CS1_t \\ CS2_t \\ CS3_t \end{pmatrix} \tag{D.6}$$

$$+ \sum_{i=1}^{p} \kappa_{2,i} D_{2,t-i} + \varepsilon_t,$$

where the observations $Y_{T_1+1}, ..., Y_{T_1+p}$ are held fixed as initial observations. Note, that the effect of the dummy variables $D_{2,t-1}, ..., D_{2,t-p}$ corresponding to the observations $X_{T_2+1}, ..., X_{T_2+p}$ is to render the corresponding residuals zero, thereby essentially eliminating the corresponding factors from the likelihood function, and hence the conditional likelihood function given the initial values in each period.

E Appendix: Adjustment coefficients

$n = 110$	Panel 0		Panel 1		Panel 2	
α	ph	d	ph	d	ph	d
ph	0.19 *** (0.05)	0.25 *** (0.08)	0.29 *** (0.09)	0.32 *** (0.09)	−2.08 *** (0.61)	−3.32 *** (0.96)
d	−0.03 (0.03)	−0.01 (0.05)	−0.02 (0.05)	−0.10 * (0.05)	0.88 ** (0.35)	1.33 ** (0.55)
yh	−0.09 *** (0.03)	−0.02 (0.05)	−0.19 *** (0.06)	−0.10 (0.06)	0.39 (0.40)	0.76 (0.62)

$n = 110$	Panel 3		Panel 4		Panel 5	
α	ph	d	ph	d	ph	d
ph	−0.76 *** (0.13)	−0.92 *** (0.16)	−0.51 *** (0.02)	−0.42 *** (0.01)	−0.33 *** (0.06)	−0.29 *** (0.06)
d	-	−0.05 (0.03)	-	−0.04 *** (0.01)	-	−0.05 (0.03)
yh	0.10 (0.10)	0.25 * (0.12)	0.12 (0.07)	0.19 *** (0.06)	0.03 (0.05)	0.13 *** (0.05)

$n = 110$	Panel 6			
α	ph	d		
ph	−0.30 *** (0.05)	−0.26 *** (0.06)		
d	-	−0.05 * (0.03)		
yh	-	0.11 *** (0.03)		

TABLE E.1: General-to-specific modelling: Adjustment coefficients. Standard errors are reported in parenthesis. Significance: p-value ≤ 0.01: ***, p-value ≤ 0.05: **, p-value ≤ 0.1: *. Estimation period: 1986 Q4 – 2013 Q3.

F Appendix: Guidelines

F.1 Guidelines for prudent residential mortgage lending practices issued by the FSA

1. **Thoroughgoing process**. Before granting or increasing a home mortgage loan, the bank must have accurate information on borrowers' income and overall debt (including joint debt in a housing cooperative), normally by obtaining tax assessment data on current salary or other income, and on the property to be mortgaged, based on a prudent valuation.

2. **Sufficient debt servicing capacity**. The bank should have in place procedures for calculating borrowers' capacity to repay their mortgages with a basis in income, expenses, servicing of overall debt in the form of interest and instalments (liquidity surplus) and the consequences of an interest rate increase; see point 8. Where the borrower is shown to incur a liquidity deficit in the event of an interest rate increase, the loan should as a rule not be granted, and the borrower should in all such cases be dissuaded from taking up the loan.

3. **Loan-to-Value ratio**. The bank must have in place procedures for assessing collateral and the borrowers' aggregate mortgage debt to ensure a margin relative to property value. A mortgage loan may not normally exceed 85 per cent of the property's market value, where the loan-to-value ratio includes all loans secured on the property. It would also be natural to take the borrowers' overall equity capital situation into consideration when determining the loan-to-value ratio.

4. **Additional collateral**. In the event of deviation from the norms in points 2, 3, 6 and 7, either additional formal security in other property or an assurance of personal security for parts of the loan (surety/guarantee) must be available or the bank must have conducted a special prudential assessment. Criteria for prudential assessments should be established by the board of directors of the banks concerned.

5. **Instalments**. Mortgage loans exceeding 70 per cent of property value should normally not require payment of instalments from the first due date, thereby building up a more reassuring safety buffer.

6. **Debt servicing capacity for home equity credit lines**. Home equity credit lines can pose an increased risk for banks, and guidelines must clarify which customer groups are eligible for such facilities. Banks' guidelines must state that when a borrowers' liquidity surplus is assessed, account should be taken of the fact that debt servicing capacity may be significantly impaired during the period of credit due to income reduction upon retirement etc. Where the borrower is required to repay the loan in full upon expiry of the period of credit, banks should, when calculating the borrower's liquidity surplus, include interest and instalment payments as if the credit has been granted as a repayment loan.

7. **Loan-to-value ratio for home equity credit lines**. Granting of home equity credit lines must be based on a prudential assessment, and the loan should normally not exceed 70 per cent of the property's market value. Assessments should draw a distinction between mortgage loans where repayment in full is required after expiry of the period of credit and loans continuing for the borrower's lifetime.

8. **Consequences of an increase in interest rates**. When assessing a borrower's ability to pay and possible dissuasion from taking out a mortgage, the bank must make allowance for an interest rate increase of at least 5 percentage points from the current level. It is important to make the borrower clearly aware of this. The bank should in all cases make clear the consequences of choosing between a fixed rate and a variable rate mortgage.

9. **Handling of deviations**. Where the bank finds cause to deviate from its internal guidelines based on these minimum requirements, the decision to do so must be taken at a higher level than normally authorized to grant home mortgage loans.

10. **Reporting**. Each quarter a report shall be submitted to the bank's board of directors or — in the case of foreign branches — the management, on compliance with the guidelines for prudent home financing in which deviations from the guidelines are identified and reported. Finanstilsynet will monitor compliance by reviewing institutions' replies to a questionnaire included in the home loan surveys, at ordinary on-site inspections and thematic inspections of Norwegian institutions, and at meetings with foreign branches. Finanstilsynet will also be entitled to inspect the reports submitted to the board of directors or management.