THE SWEDISH HOUSING MORTGAGE REFORM'S IMPACT ON HOUSE PRICES:

A STUDY OF THE DEVELOPMENT OF SCANDINAVIAN HOUSE PRICES FOLLOWING THE 85 PERCENT MORTGAGE CAP IN SWEDEN

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Abstract

The Swedish house prices have grown steadily for years, even throughout the recent financial crisis. During 2011, house prices started to decline. An extensive body of research has identified a connection between deregulations of credit markets and increasing house prices. In this study we examine if the opposite holds, that is, if the mortgage cap implemented by the Swedish Financial Supervisory Authority on October 1st, 2010 has triggered the decline in house prices. We carry out our study by implementing two quasi-experiment methods on the Scandinavian countries; one difference-in-difference estimation and one regression discontinuity design. We use two sets of panel data covering regions in the treatment group (Sweden) and control groups (Norway and Denmark). Our regression and graphical results provide some evidence that the mortgage cap has contributed to the decline in Swedish house prices. Due to the complexity of the housing market, it is difficult to credibly ascribe the house price decline entirely to the mortgage cap per se.

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CONTENTS

1 INTRODUCTION

The last century's dynamic and vividly fluctuating economy has raised an interest to investigate what factors ensure financial stability. Changing housing markets have proven to greatly impact a nation's economy, all the way down to individual households. Maintaining healthy levels of house price developments and household indebtedness has historically been a major concern in the struggle to sustain a nation's economic stability, both in Sweden and internationally.

An important part of financial institutions' responsibilities today is to closely monitor the development of the residential market, in particular the factors affecting house prices. Individual households have become more dependent on the market price for their house since property represents both the vast majority of the households' debt as well as the majority of the households' accumulated wealth.

Household's access to credit is one factor affecting how the housing market develops. In the past 20 years, Sweden has experienced a rapid and aggressive increase of household debt. Households' total indebtedness in relation to income has grown from 90 percent in the mid 1990's to 170 percent in 2010 (Johansson et al., (2011)). Meanwhile, the most critical fact is that the fraction house mortgage-to-total household debt is the fastest growing in Sweden out of several Western countries (BKN, (2011)[1]. The ratio has increased by 18 percentage points during the last decade and today, household mortgages constitute 90 percent of total debt (FI, (2012)). Adelino et al. (2012) as well as Glick and Lansing (2010) suggest that an increase in households' access to credit leads to an increase in house prices. To the best of our knowledge, research covering the effect on house prices from a *restriction* in access to credit is limited. Figure 1 in the appendix[2] illustrates long-term trends in house price indices and household indebtedness for the Scandinavian countries.

Our interest in this topic is further enhanced by the peculiar reaction of Swedish house prices to the recent financial crisis. A distinguishing aspect of the Swedish housing market is that house prices were relatively unaffected by the crisis and prices continued to grow steadily during 2008 and onward. The relatively calm reaction by the Swedish housing market was also one of the most important reasons to why Sweden did not suffer to the same extent as other countries in the crisis (Jansson and Persson, (2011)). During 1995 through 2010, Swedish house prices increased by 144 percent in real terms (Englund, (2011)), but in 2011 house prices began to drop. Figure 2 illustrates a change in trend, and the house price index and the consumer price index are converging. This is far from the long-term trend, where the house price index lies far above the consumer price index. The indications that house prices now have turned downward is supported by quarterly reports from Statistics Sweden and various broker agencies (Mäklarstatistik, (2012)).

With the recent financial crisis leaving Sweden's housing market relatively unaffected, and despite the growing household leverage, why are we experiencing a downward sloping trend in house prices right now? Should not this trend has started earlier and what is triggering the price

[1] BKN includes Denmark, Finland, France, Ireland, Netherlands, Spain, Great Britain, Sweden, Germany and the US in their analysis.
[2] All figures and tables are enclosed in the appendix.

decline? In the same way as mortgage deregulations have coincided with increasing house prices, policy interventions by governments have been the latest fashion in order to establish stable markets (Andrews, (2010)).

In this paper we examine whether the 2010 Swedish mortgage cap reform has contributed to the negative house price growth during 2011. The mortgage cap is a limit on new loans undertaken and was introduced by the Swedish Financial Supervisory Authority[3] (FI) on October 1st, 2010. The public recommendation regarding a mortgage cap regulates that new mortgages cannot exceed 85 percent of the loan-to-value (LTV) ratio of the market value of the property when buying a new home. The aim of the regulation was to ensure an effective consumer protection and to make sure that high mortgage was not used as a competitive advantage when fighting for customers in the banking sector. FI stated that the limit on the LTV ratio would not impact the price of houses. However, key concerns of public policy implementations are the extent to which the policies actually fulfil their anticipated objectives and whether the policies cause any unintended spill-over effects.

The effect on new mortgage following the policy is clear and consistent; new loans undertaken have dropped for the first time since 2002, and 14 percent of new loans have been taken at precisely 85 percent of the market value of the property, indicating that the mortgage cap has had desired effect (FI, (2012)). Nevertheless, the authority has not presented a follow up on the effects on house prices.

Our investigation relies on an understanding of how factors affecting household indebtedness influence house price growth. Firstly, the country specific mortgage interest rate and the planned rate path will greatly affect households' decisions regarding house mortgage. Secondly, the development of house prices has been most rapid in countries with the greatest accessibility of choosing a variable interest rate over a fixed rate (BKN, (2011)). Further, the access to credit is also impacted by the required amortization of the loan, the size of the down payment, the availability to housing equity withdrawals, as well as tax advantages on interest rate payments (BKN, (2011)). Mortgage regulations will greatly impact a household's access to credit, and a more deregulated market makes it easier to buy your own house without risking your own equity.

The impact of deregulated mortgage markets on house prices becomes more apparent during financial crises. Glick and Lansing (2010) explain that the width and depth of economic downturns are largely connected to growing household indebtedness and rising house prices. Further, Geanakopolos (2010) argues that two leverage cycles enhanced each other in the US during the recent financial crisis; the financial market and the house market. Accordingly, the upsurge in house prices was a consequence of the credit market expansion, and new, more leveraged borrowers entered the housing market, which drove prices up even further. Mian and Sufi (2009a) showed that the American counties that experienced the largest increase in household indebtedness were the same ones that also experienced the largest increase in house prices before the housing bubble burst. Further, Glick and Lansing (2010) showed that countries that were hit most severely during the last recession were those which had experienced the largest increase in household indebtedness before the crisis.

[3] Swedish: Finansinspektionen. Hereinafter referred to as FI.

During the financial crisis, the decline in value for American properties caused turmoil in the financial sector, which quickly developed into a full-scale global economic crisis. This makes it even more obvious that a crucial part of the financial institutions' responsibilities are to monitor household's leverage. There exist big incentives to control household indebtedness levels in order to maintain the stability of an economy, a reason to why governmental regulations in the area have become more common.

We aim to investigate whether a more restricted mortgage policy will reduce households' ability to pay for residential property, thus causing a decline in house price growth. We hypothesize that the mortgage cap has caused a negative effect on Swedish house prices. This follows from previous research claiming that easier access to credit will increase house prices, and we expect that the opposite would hold for a restriction in access to credit.

Our strategy to estimate the effect on house prices that arises from the more restricted mortgage regulation relies on two quasi-experiment approaches in which an exogenous event (the change in the Swedish government regulation) changes the environment for Swedish individuals, households, cities, and regions. In the meantime, the Swedish policy implementation leaves the other Scandinavian countries unaffected. We apply our strategy using a difference-in-difference method and test whether regions affected by the treatment (policy implementation) have experienced larger declines in house prices than regions that are unaffected by the treatment. For graphical illustrations we apply a regression discontinuity design on borders. We show how house price growth and the supply of new listings of houses to the market have developed over time and investigate whether there seem to be different trends after the policy implementation compared to before.

A quasi-experiment should not be seen as a true randomized experiment, but rather will the treatment group and the control group occur as a *result* of the change in policy. Therefore, we use Sweden as a treatment group (affected by the Swedish mortgage cap), and other Nordic countries – more specifically Norway and Denmark – as control groups[4]. Norway and Denmark constitute suitable control groups since they apply similar mortgage legislations as Sweden, which is important since the level of regulation will have a substantial impact on the developments of house prices. Table 1 displays the variations of the mortgage legislations in the Scandinavian countries. Further, these countries are alike in several micro- and macroeconomic aspects. We find it reasonable to assume that the Scandinavian countries react more similarly to other exogenous factors than other European countries. Since different reactions between the countries could disrupt the validity of the investigation, it is of importance that the control and treatment groups differ as little as possible.

For our results to be in line with our hypothesis, we expect to see a decrease in Swedish house prices after the policy has been implemented. Meanwhile, in a perfectly theoretical scenario, the Norwegian and Danish house prices remain unchanged from the previous trend. The housing

[4] We have investigated the alternative to include Finland as a control group. For the chosen empirical strategy, Finland does not serve as an equally good control group as Norway and Denmark. The Swedish-Finish border is short and price index is available for few regions, hence it is not suitable for the purpose of RD design.

market is dynamic, and due to other exogenous events there could be changes in Norwegian and Danish house prices during the time period of our study.

We measure house prices using regional house price indices covering owner-occupied one-family houses from the national statistics bureaus, available on a quarterly basis. The indices are based on actual transactions and are constructed using a hedonic approach with a purchase price coefficient controlling for variations in house characteristics.

Our results present us with negative coefficients for the treatment variable in both the Norwegian and the Danish samples. For the Norwegian sample, we find that the policy caused house prices on the Swedish side of the border to devalue 1.6 percentage points more than in the Norwegian regions. The Danish sample results also indicates that Swedish house prices seemed to devalue between 1.2 and 1.5 percentage points due to the policy implementation. The Danish results are somewhat robust for the applied macroeconomic controls, which could enhance that the policy impacted Swedish house prices negatively.

The graphical results from the regression discontinuity design present us with some indications that the implementation of the Swedish policy has caused the Swedish housing market to decline. The Norwegian sample indicates that the activity on the Swedish market has decreased compared to the Norwegian. The Danish sample fluctuates throughout the whole sample period and it is hard to address the variations in house price growth to the implementation of the Swedish policy. However, the results indicate that there exists a greater difference in the growth after the policy implementation than before, which would enhance our results.

Our findings are not as evident as previous research on how changes in leverage legislation and restraints in households' access to credit can impact house prices. Mian and Sufi (2009b) have successfully explained how credit supply shocks can cause an increase in house prices. Further Lilienfeld-Toal and Mookherjee (2011) show that the 2005 BAPCA reform (Bankruptcy Abuse Prevention and Consumer Protection Act) in the US played an important role in triggering the reversals of the house price growth. In opposite to the above research, Mäklarstatistik (2011) has reported that the policy in itself is not an explanatory factor of the recent downturn in house prices.

From the results we cannot explicitly state that more restricted leverage legislations will impact house prices negatively. However, in line with our results, Mian and Sufi (2009a) also argue that it is hard to relate their results as a consequence of one most important single factor, or even factors, because of the highly joint interaction across markets in the economy, and especially in the dynamic housing market.

The remainder of this paper is organized as follows. Section 2 provides a short background to mortgage caps implemented in the Scandinavian countries. Section 3 presents the variables of interest and descriptions of the data in our Norwegian and Danish samples. Section 4 describes the empirical strategy implemented; the difference-in-difference method and the regression discontinuity design. In section 5 we present regression and graphical results and analyze whether the mortgage cap had an impact on Swedish house prices. Finally, section 6 concludes our findings, discusses possible weaknesses and provides suggestions for further research.

2 MORTGAGE CAPS IN SCANDINAVIA

The widespread mortgage market deregulations during the 1980's increased households' capacity to pay for housing. Ellis (2008) argues that an initially high LTV ratio on new mortgages was one of the explanations to why the US mortgage market collapsed in August 2007, and to why the house prices dropped so drastically. In the aftermaths of the crisis, governments have become increasingly more aware of the negative effects of deregulated credit markets. Public policy interventions in housing markets are now widespread, though these differ considerably across countries.

Due to different legal systems, there exist no minimum requirements for the mortgage markets among the European Union member states. FI introduced the 85 percent limit on mortgage cap on October 1st, 2010, which only holds for the Swedish financial market and households. The equivalent directive was issued in March 2010 in Norway, and the 2003 Mortgage-Credit Loans and Mortgage-Credit Bonds Act regulated the Danish market. This implies that all Scandinavian countries now have implemented regulations for the initial down-payment of a house, and they only differ in terms of the time of implementation and the required LTV ratio of the market value of the property. Sweden was the last country to implement the regulations in October 2010.

Table 1 presents a comparison between the countries in aspects that will affect household indebtedness to a great extent. Combined, we can conclude that after Sweden's implementation of the mortgage cap, the Scandinavian countries resemble in most variables that affects household's indebtedness and willingness to undertake a loan, and thus in mortgage factors that affect housing prices.

2.1 SWEDEN

In 2009, more than 50 percent of the Swedish households had a house mortgage that exceeded the disposable income by five times (FI, (2010)). One year after the implementation of the mortgage cap, the fraction had decreased to 30 percent (FI, (2012)). In 2009, 18 percent of the households had a LTV ratio above 85 percent. This fraction has decreased to 9 percent after the implementation of the mortgage cap (FI, (2012)).

Before FI introduced the mortgage cap, the banks and lending institutes had no recommendations on how to decide upon new loans (Karlsson, (2012)). However, most companies applied internal recommendations that were similar among them, and the rules spanned from 75 percent to 95 percent of the market value of the property. Many companies also applied two different parts of the loan; 75 percent to 85 percent of the value of the property was considered the bottom part of the loan[5] and the amount that exceeded the bottom loan was considered the top part of the loan[6]. The top-loan was considered more risky and required regulated repayments and had a higher interest rate (FI, (2010)). Typically, companies assigned the same loan terms to households regardless of the characteristics and the geographical settlement of the house.

[5] Swedish: Bottenlån
[6] Swedish: Topplån

The new mortgage cap did not postulate a direct regulation, but a public recommendation gives the companies the freedom to use other methods than the one suggested in order to fulfil the mandatory, common aim. However, it is important to stress that there are actually loans being undertaken above 85 percent of the value of the property. This would indicate that the response on the market is somewhat ambiguous.

2.2 NORWAY

In Norway, growth in house prices has followed the same path as the increase in household indebtedness (Finanstilsynet, (2012)). Finanstilsynet (equivalent to the Swedish FI) is responsible for supervising the financial market. Following the mortgage market during recent years they have concluded that the "unhealthy" lending environment has swelled. Households' debt amounted to two times the disposable income at the end of 2011, and debt has been increasing the last years (SSB, (2012a)). From 2004 to 2009, the number of households with an outstanding debt three times as large as disposable income increased from around 20 percent to 30 percent (Finanstilsynet, (2012)).

Finanstilsynet issued guidelines for restriction on residential mortgage lending in March 2010 in order to restrain household debt growth. The new regulation imposed that new loans undertaken should not exceed 90 percent of the market value of the house. In contrast to the Swedish FI, the Norwegian central bank actually stated that a restriction in households' access to mortgage credit could prove to curb house price growth (NB, (2010)). However, little evidence has shown that the Norwegian mortgage cap has had the desired effects on lending. A study carried out by Finanstilsynet during 2011 showed that 26 percent of the households had a LTV ratio that exceeded 90 percent, compared to 21 percent in 2010. In December 2011, Finanstilsynet issued new guidelines for prudent lending, this time lowering the ceiling to 85 percent. It is important to stress that we have restricted our research period from the second quarter of 2010 to the fourth quarter of 2011 in order to include only the period in which the 90 percent mortgage cap was applicable.

2.3 DENMARK

Denmark has the highest household indebtedness among the Scandinavian countries, and also in relation to other European countries (BKN, (2011)). Denmark has experienced a rapid increase in households' debt-to-income ratio during the last years. In 2011, house mortgage as a percentage of disposable income exceeded 250 percent, and the total debt as a percentage of disposable income exceeded 300 percent. Further, house mortgage as a percentage of GDP was around 120 percent (BKN, (2011)). The rapid increase in indebtedness could in part be explained by the easy access to credit.

The mortgage banks are supervised by the Danish Financial Supervisory Authority, Finanstilsynet, (equivalent to the Swedish FI). The Mortgage-Credit Loans And Mortgage-Credit Bonds Act regulates the Danish mortgage market and provides favorable agreements once a household becomes eligible to undertake a mortgage. However, a large segment of the population will not be granted a loan since the regulations for credit worthiness are strict. You

cannot obtain a loan if you for example have a poor credit record or if you are not able make a 20 percent down payment of the value of the property.

3 DATA

Our investigation is based on two sets of panel data where we follow the same geographical regions over time. Hence, the observations are not randomly drawn; instead the main idea is that we want to examine the regions along the Swedish border. The Norwegian sample investigates rural areas, whereas the Danish sample investigates urban areas. The data covering the border between Sweden and Norway consists of 11 Swedish regions and 16 Norwegian regions. Since the Swedish regions altogether cover a greater area, the fewer number of regions does not affect comparability. The Sweden-Denmark comparison includes 11 Danish regions and 9 Swedish regions. Figure 3 presents maps which illustrate the included regions. A corresponding list of regions is presented in Table 2.

It is of great importance for our methods that our control groups are unaffected by the Swedish treatment (the change in regulation) and is not subject to other changes during the investigation's time horizon. The Danish sample covers a longer time horizon since, to the best of our knowledge, there are no other exogenous events related to the housing market to take into consideration. The Norwegian sample's time horizon had to be reduced to adjust it for changes in Norwegian mortgage legislations. Hence, the Danish dataset contains more observations and gains some greater validity. The Danish sample covers 18 quarters; 2007 quarter 3 through 2011 quarter 4. The Norwegian sample covers 6 quarters; 2010 quarter 2 through 2011 quarter 3. The Danish sample consists of 360 observations and the Norwegian sample consists of 162 observations.

House price indices on a regional and quarterly basis, covering owner-occupied one-family houses[7], are collected from Statistics Sweden (SCB), Statistics Denmark (DST) and Statistics Norway (SSB). These are governmental organizations, which certify the high validity of the statistics[8]. Our dependent variable is structured as the growth in house price index of each region. The Norwegian index is constructed using the widely accepted hedonic method[9], which controls for geographical location and individual characteristic of the houses. The Swedish and Danish indices are constructed according to a closely related framework to the hedonic method and represent unweighted mean values of the ratio between the actual selling price over the taxed assessed value[10] of the house. This method also controls for individual characteristic of a house. The differences in how the indices are constructed are not expected to affect comparability.

[7] The price index used in this thesis does not cover the condominium market, which does not allow us to comment nor discuss the implications on this market.
[8] The house price indices are based on the best possible coverage of sales and they are systematically developed over time.
[9] The hedonic method is used in many countries when constructing house price indices (Englund, (2011)). However, indices can still be subject to biases. As discussed by Lilienfeld-Toal and Mookherjee (2011), an index can be subject to bias if certain houses with low quality were sold more often after the reform than before the reform.
[10] Swedish: Taxeringsvärde

The main restriction in our datasets is the limited availability of house price indices, which restraints us from carrying out our investigation on more narrow geographical regions. For all countries, the most detailed house price index is available at a regional level at the national statistics bureaus. For municipality or zip-code level one can only obtain actual selling prices, and in rural areas the sample would be too small and varying in order to qualify for a representative median house price.

The number of new listings of houses has been collected on a regional basis from Hemnet Statistics for the Swedish data, from finn.no for the Norwegian data and from Realkreditrådet for the Danish data. We compute the number on new listings per capita to control for populations size and we use the variable as an approximation for the relative supply in the region[11] (Mian, A., Sufi, A. and Trebbi, F., (2011)). An obvious drawback with the Swedish and Norwegian statistics is that these sources do not cover all the transactions in the market. Furthermore, data on new listings can be biased, given that the same house can be listed more than once if the house is not sold on the first try. The Danish new listings do not suffer from these drawbacks since the data is collected from an official database where all publicly registered sales are included.

We supplement our data with macroeconomic control variables which are firmly established to influence house price developments (BKN, (2009))[12]. It is important to clarify that our explanatory variables do not directly control for differences in house characteristics; this is instead already controlled for by using a house price index based on a purchase price coefficient. The GDP growth and unemployment rates are collected from SCB, SSB, and DST. For all three countries, the GDP growth rates are calculated according to the EU-standard National Accounts (Eurostat, (2011), SCB, (2012b), SSB, (2012c), DST, (2012b)). This ensures that the variables are perfectly comparable across the countries. Further, we control for mortgage interest rates since they will greatly affect a household's willingness to undertake a loan in order to buy a house. For example, low interest rates will decrease interest payments, making households less reluctant to undertake a loan. Lending institutes do not seem to account for differences in geographical area nor individual characteristics of the house when deciding upon loans to credit takers (FI, (2010)). Therefore, we have applied the same mortgage interest rate on all regions in each country. The mortgage interest rates are collected from SSB, DST, and Swedbank Hypotek for Sweden. Figure 4 presents the development in mortgage interest rates for the Scandinavian countries during the past decade.

[11] Other factors than new listings, for example the total stock of houses for sale, could serve as an approximation of supply. Our choice to use new listings is in line with the method of Mian, Sufi and Trebbi (2011) and is also guided by the availability of data.

[12] According to BKN (2009), the correlation between house price growth and unemployment rate developments as well as correlation with the interest rate is proven to be negative and high. These variables are critical factors to explain the short term house price developments. Since we cover a short time span, these are important factors to include as explanatory variables. One variable often considered to have an impact is disposable income. According to BKN (2009), the correlation between the growth in real disposable income and house price growth is low; a correlation coefficient of only 0.25. Hence, we do not include disposable income as an explanatory variable.

4 EMPIRICAL STRATEGY

The investigation of this thesis is carried out by applying two methods commonly applied to quasi-experiments – a difference-in-difference estimation and a regression discontinuity (RD) design. The difference-in-difference method is known to be successful in addressing the effectiveness of the implementation of a certain policy and we implement it to investigate whether the mortgage cap could have had an effect on Swedish house prices. The RD design has gained momentum and is complementing regular natural experiment evaluation strategies, for example difference-in-difference and instrumental variables (Ashenfelter O., Card, D., (2011)). We use the RD design approach to produce graphical illustrations of a boundary discontinuity design, where we compare a variable's development on either side of a national border over time[13]. In this section, we will explain the rationale behind our applications and the technicalities of the methods.

4.1 DIFFERENCE-IN-DIFFERENCE

The difference-in-difference method originates from Ashenfelter and Card (1985) and is established as one of the most common methods when investigating program effects. In a difference-in-difference setting you have two groups; the treatment group and the control group, and two time periods; before and after the policy. The difference-in-difference design aims to estimate the effect from the policy by investigating whether the difference between the control and the treatment group is changed before, compared to after, the implementation of the policy. The total effect of the policy on the house prices is called the treatment effect. The following formula presents the underlying reasoning of the size of the treatment effect:

$$\hat{\delta}_T = \underbrace{(\bar{y}_{2,T} - \bar{y}_{2,C})}_{\text{Difference between the treatment and control groups } \textit{after} \text{ the policy}} - \underbrace{(\bar{y}_{1,T} - \bar{y}_{1,C})}_{\text{Difference between the treatment and control groups } \textit{before} \text{ the policy}}$$

The method is carried out twice, once for the Sweden-Norway comparison and once for the Sweden-Denmark comparison. The method is directly applicable to both sets of data; the procedure, definitions, and assumptions do not differ. Sweden is the treatment group in each run and the control group is either Norway or Denmark. The choice of control group is one of the problematic aspects of this method since the control group must be unaffected by the treatment as well as constant in respect to other exogenous factors. Multiple ordinary least squares (OLS) regressions are carried out and the results, which then are to be interpreted and analyzed, are reported both quantitatively and graphically.

[13] It is important to clarify that we do not implement a full RD design approach. According to Nichols (2007), there are five key assumptions and tests to carry out in order to verify casual inference, which validate the applicability of an RD design. These assumptions have not been tested. Instead, this thesis implements the RD design for the purpose of the favorable graphical presentations.

4.2 DIFFERENCE-IN-DIFFERENCE REGRESSION SPECIFICATION

The following difference-in-difference regression set-up is applied in our investigation:

$$house\ price\ \ index\ growth_{t,i} = \beta_0 + \delta_1 Policy + \delta_2 Swe + \delta_3 PolicySwe +$$

$$\beta_1 X_{1,\,t,\,i} + \beta_2 X_{2,t,\,i} + \beta_3 X_{3,t,\,i} + time\_dummies + \varepsilon_{t,\,i}$$

The regression is defined by the following variables. *House price index growth*$_{t,i}$ is the growth in house price index at time *t* in region *i*. *Policy* is a time dummy with a value of one if time is after the policy and zero otherwise. *Swe* is a dummy with a value of one for Sweden and zero otherwise. This variable's coefficient captures any differences between the treatment and control group prior to the policy implementation. *PolicySwe* is an interaction term with a value of one if it corresponds to the treatment group after the policy and zero otherwise. The estimated coefficient of this variable, $\widehat{\delta_3}$, is the difference-in-difference estimator and explains the effect of the policy on the dependent variable. We chose macroeconomic control variables with the aim to eliminate the effect these factor have on house price developments. $X_{1,t,i}$ is the *unemployment rate* at time *t* in region *i*. $X_{2,t,i}$ is the *growth in GDP* at time *t* in region *i*. $X_{3,t,i}$ is the *mortgage interest rate* at time *t* in region *i*. We include time dummies for each cross-section in order to control for time fixed effects (FE). Lastly, we have the idiosyncratic error term, $\varepsilon_{t,\,i}$. It represents unobserved, time-varying factors which affect the dependent variable. As explained in the data section, the time horizon *t* is longer for the Danish sample compared to the Norwegian sample.

It is likely that endogeneity[14] is a major issue with our regression specification. FE aim to exploit within-group variations over time and hence account for unobservable factors which have an impact on the dependent variable. Including FE decreases the risk of endogeneity and thereby increases the possibility to accurately assess the independent variables' impact on the dependent variable (Wooldridge, (2009)). We control for time FE with the intention to eliminate time trends and how the demand and supply of houses fluctuate between quarters. We also control for region FE in order to eliminate the impact from region specific factors, such as the existence of major cities and the location. Further, we correct for heteroskedasticity in all regressions by using robust standard errors.

4.3 REGRESSION DISCONTINUITY DESIGN

Already in 1960, Thistlethwaite and Campbell introduced the RD design, a casual inference evaluation approach. Only in the late 1990's did the design and its favorable way of displaying results graphically catch researchers' attention. There are several major advantages which are boosting the RD design's momentum. It provides vastly credible and transparent estimations of program effects and can be used in a wide range of economically important contexts. Further, the design requires milder assumptions compared to other non-experimental approaches (Hahn et al., (2001)). Our RD design extracts the casual effect of the policy by utilizing a given exogenous threshold. The threshold determines when the assignment variable (growth in house price index and new listings per capita) becomes subject to treatment. By comparing

[14] Regression results become biased due to endogeneity when one or several of the explanatory variables are correlated with the error term, often due to an omitted variable.

observations that lie closely on each side of the threshold, the local treatment effect can be estimated in settings where randomization would be unfeasible.

We have carried out the RD design through a graphical presentation of discontinuities in geography. This is in line with Black (1999) and Bayer et al. (2007), who applied the geographical RD design to study house prices on both sides of school attendance boundaries in order to investigate the value of attending different schools. We implement the RD design on national borders in order to examine the growth in house prices, as well as the development in number of new listings per capita. Our forcing variable is the border classification and the threshold is defined by the national borders. The basis of our strategy to identify the effect of the policy on the dependent variables relies on different regions being appointed different values depending on the proximity to the border. This provides the advantage that we can investigate the local impact by the policy on different regions, both close to the border and as one goes further into the country. Table 3 illustrates the regions applied in the RD design approach.

In order to examine the effect of the mortgage cap we compare discontinuity in the treatment and control groups over time[15]. We aim to investigate whether there exists continuity between the countries at the threshold in the time periods before the event, and discontinuity after, which would imply that the trends change after the policy implementation.

5 EMPIRICAL RESULTS

In this section we will present the results from our difference-in-difference and RD design investigations. We start by presenting descriptive statistics for both of our datasets, followed by the results from the difference-in-difference study and the graphical interpretation from our RD design. Finally, a discussion regarding our results concludes. We continually refer to the Norwegian dataset as Panel A, and the Danish dataset as Panel B.

5.1 DESCRIPTIVE STATISTICS

Table 3 reports summary statistics for our two datasets. Panel A presents data for Sweden and Norway separately in order to compare price growth mean and other variables before and after the policy implementation. For Sweden, the average quarterly growth in house prices before the policy was 1 percent, which decreased to 0.4 percent after the policy. The corresponding average growth for Norway was 1 percent before, which increased to 2 percent after.

Table 3, Panel B presents equivalent data for the Danish dataset. Here, the Swedish average quarterly house price growth before the policy was 1.15 percent, which decreased to -0.71 percent after the policy. The corresponding Danish average growth was -1.05 percent before, which decreased to -1.76 percent after. Note that we investigate different Swedish regions in the datasets, and hence the two Swedish means are not identical.

[15] To ease interpretation, we call the two sides of the threshold in a RD graph "treatment group" and "control group", similarly as in a difference-in-difference estimation. Normally, in an RD design, one refers to the two sides as the treated and untreated observations of the assignment variable (y-axis variable) (Lee and Lemieux, (2009)). Hence, the "treatment group" corresponds to the treated segment of the assignment variable (Sweden), and the "control group" corresponds to the untreated segment (Norway and Denmark).

Our additional dependent variable in the RD design, new listings per capita, shows opposite trends in the two dataset. In the Norwegian sample, the relative number of new houses put on the market dropped by 5 percent in Sweden after the reform, while it decreased by a smaller percentage, 4 percent, in Norway after the reform. The outcome is different in the Sweden-Denmark comparison. The relative number of new Swedish houses increased by 5 percent after the policy, whereas the Danish corresponding numbers show a decrease of 9 percent.

5.2 DIFFERENCE-IN-DIFFERENCE

5.2.1 SWEDEN/NORWAY

Table 4 reports the results from the difference-in-difference regressions, where the growth in house price index is regressed on our explanatory variables. The first column illustrates the naive difference-in-difference set up, where the coefficient of interest, *SwePolicy,* explains the treatment effect. It confirms that house prices on the Swedish side of the border appeared to devalue 1.6 percentage points due to the implementation of the policy. This is statistically significant at a 5 percent level. When controlling for time FE on a quarterly basis (column 2), the treatment effect is still statistically significant, but now at a 1 percent level, and the explanatory power of the model has increased from 0.077 to 0.372. This implies that different time trends capture a major part of the model. When controlling for regional FE in column 5 and 6, the variable explaining Sweden before is dropped due to perfect collinearity[16]. Region FE does not seem to contribute to the model as much as time FE since the explanatory power of the models including region FE is sizably smaller.

When using a full set of macro controls in columns 3 through 6 the treatment effect is positive, but since the effect is not statistically different from zero, it cannot be argued that it explains the effect of the policy. The levels on which the control variables help to explain the model varies between column 3 through 6. The mortgage interest rate has a negative coefficient and is statistically significant in the majority of the models. This is intuitive since a high interest rate would cause a decrease in house price growth. Growth in GPD does not seem to explain the price development in any of the models. The fact that the GDP is insignificant in all models is surprising. One possible explanation to why GDP does not seem to explain the house price growth, despite the regional proximity, may be that there exist great differences in country specific aspects. For example, Norwegian GDP relies heavily on exports and production of petroleum, which is not present in the Swedish context. Hence, GDP may not impact house prices in the same way in the countries. Further, the unemployment rates help explain the model in column 3 and 4, but the coefficients are positive, which is highly remarkable. Intuitively, if unemployment goes up, both demand and supply could be affected; purchasing power decreases (demand) and people may be forced to sell their homes (supply), which would lead to a decline in house price growth. The results are not in line with this reasoning, which also could be detected back to differences in country specific aspects. This will be further developed in the discussion section.

[16] Perfect collinearity is not surprising since all Swedish regions sum to 1, i.e. the intercept of all Swedish before dummy variables will equal one.

Continuing to the graphical illustrations of our difference-in-difference method, Figure 5, Panel A, illustrates both the quarterly growth rates in absolute values as well as the means of Sweden and Norway before and after the policy. The average quarterly growth is positive and almost identical for Sweden and Norway before the policy change[17]. The results clearly show that after the policy implementation, Sweden had a lower growth rate than Norway. Sweden had on average experienced a growth of 0.4 percent per quarter after the policy, which corresponds to a decrease of 0.6 percentage points. Norway, on the other hand, experienced an increase of 1 percentage point, up to almost 2 percent average quarterly growth rate. The difference between Norway and Sweden after the policy is apparent and sizable. Before the event the difference between the countries' average growth rates was negligible, while the results after show a substantial difference of 1.53 percentage points. Thus, the graphical illustration of our difference-in-difference shows that Swedish house price growth has declined to a greater extent than Norwegian prices after the policy. This is an indication that the policy impacted Swedish house prices negatively.

5.2.2 SWEDEN/DENMARK

Table 4, Panel B, reports the regression results for the Danish dataset. Column 1 reports a negative treatment effect which is almost significant at the five percent level (P-value 0.055). The results suggest that the drop in growth was 1.2 percentage points larger in Sweden than in Denmark. However, we cannot infer the results to the policy because of the low statistical significance. When adding controls for time FE (column 2) on a quarterly basis the treatment effect remains negative and becomes significant at the five percent level. One important aspect is that the explanatory power, R^2, increases from 0.134 to 0.568. As in the Norwegian dataset, time trends seem to absorb a large part of the model and enhance the result that the Swedish growth has declined to a larger extent than the Danish growth.

When adding controls for time and regional FE in column 4 through 6, the results vary in several aspects. The treatment effect is negative and significant at the 0.1 percent level when controlling for regional FE, suggesting that regional heterogeneity exists to a great extent. However, the explanatory power of the model is not as high as when controlling for time FE. Similarly to the Norwegian sample, the variable representing Sweden before is dropped due to perfect collinearity. In the columns 4 through 6, the explanatory power varies between 0.272 and 0.569. Time FE seem to explain a vast part of the variations in explanatory power compared to the regional differences.

Column 3 through 6 add control variables on a macro level. In column 3 and 5, the treatment effect is negative to a larger extent than in the naïve models. The results suggest that Swedish house prices devalued 1.5 percentages points due to the implementation of the policy. These results are statistically significant at the five percent level (column 3), and at the 0.1 percent level (column 5). The levels on which our control variables help explain the models vary. The only significant control variable is the development of GDP. The coefficient is positive for two of the regressions, which is expected since an increase in GDP would imply that the economy is doing

[17] The mean growth rates presented in the difference-in-difference graphs correspond to the mean values in the summary statistics, Table 2.

well, thus impacting the house prices positively. Regarding our other control variables, the negative coefficients for mortgage interest rate suggests that a higher interest rate causes a decrease in house price growth. Even though this follows our intuition, we cannot draw any conclusions since the coefficients are insignificant. A distinguishing feature in recent years has been the distinct conditions of interest rates. Our data set covers a time period where the mortgage interest rates have been historically low (see Figure 3), and the atypical financial environment may explain why the control variable does not seem to impact house price growth. Nor does the control variable for unemployment rate seem to impact our model; the results are insignificant for all regressions and indicate both negative and positive impacts on the house price growth.

Figure 5, Panel B, shows the graphical illustration of the difference-in-difference method. Denmark had a negative average quarterly growth rate of 1.05 percent during the period 2007-2010, while Sweden had a positive average growth rate of 1.15 percent per quarter in the same period. Both countries experienced a drop in the average quarterly house price growth after the fourth quarter of 2010, but the decrease in Sweden was larger; 1.86 percentage points for Sweden compared to 0.72 percentage points for Denmark. Worth noting is that Denmark experienced an average decline in house prices throughout the whole study and Sweden experienced a positive growth in house prices before the policy was implemented, and a negative growth afterward. The graphical results enhances our regression results that the policy has impacted Swedish house prices negatively.

There exists a seasonal trend in house prices, which is expected since the indices are based on actual transactions. The graph's absolute values indicate that house prices drop in the last months of the year and during the summer. This strengthens the above discussion regarding the models' explanatory powers, where we argue that time FE seem to absorb a major part of the model.

5.3 GRAPHICAL ILLUSTRATIONS IN RD SETTING

5.3.1 SWEDEN/NORWAY

In Figure 6, Panel A, the left-hand side column shows RD graphs illustrating the average house price index growth and the right-hand column shows new listings per capita. The plots before the policy represent the average, quarterly growth during 2010 quarter 2 and 3, and the plots after the policy represent the average, quarterly growth for the quarters following the reform.

The top-left graph indicates continuity since the countries have approximately the same average house price growth at the threshold. In the bottom-left graph, the distance between the lines has increased considerably, showing a discontinuity. Thus, there is some evidence that the implementation of the policy has had negative effects on the Swedish house price growth. Also, the Swedish growth rate decreases as one goes further away from the border, indicating a disproportional effect on regions.

The top-right graph shows that Norway had a higher number of new listings per capita before the policy compared to Sweden. The same holds for the bottom-right graph, where Norway still

had a higher number of new listings after the policy. However, the difference between the countries is larger after the policy. We do not see a clear shift from continuity before to discontinuity after. Hence, we only find weak indications that the policy would have impacted supply negatively. The graphs of new listings both before and after the policy illustrate horizontal trends as one moves further from the border, indicating that there is no evidence that the policy would affect the housing market disproportionally within a country.

5.3.2 SWEDEN/DENMARK

The RD design results are presented in Figure 6, Panel B. Graphs are presented on a yearly basis from 2008 to 2011. In contrast to the Norwegian structure, this set-up allows for a more thorough comparison over time.

The results regarding both the house price growth and new listings show that the Swedish values are continually rather stable, whereas the Danish values fluctuate vividly during the period. In the house price growth column, we see discontinuity at the threshold in all years except for 2010. In 2010, which mainly consists of quarters before the policy implementation, we find continuity. After the policy was implemented, we once again see discontinuity. We also see that Sweden has dropped from a positive house price growth to a negative development. However, this is not convincing enough to allow us to draw any conclusions regarding a possible treatment effect.

The Danish RD results do not illustrate a clear discontinuity effect as a result of the policy implementation, but rather, there appears to be co-movement between the Danish house price growth and new listings per capita. The co-movement could be referred back to a standard supply and demand reasoning of housing; when supply of new listings increases, the house prices should decrease. When studying the Danish developments in both variables between the years, one can see that as supply goes down, the house price growth tend to increase, and the opposite also holds. This is true for all years but 2010. Continuing this reasoning of standard supply and demand on the Swedish results, we would expect to see a stable price growth in 2008 through 2010 since the supply of new houses on the market is stable. The basic supply-demand application seems to hold for the years prior to the policy implementation, but for 2011 the number of new listings on the market decreases slightly, implying that the house price should increase somewhat. On the contrary, we see a significant drop in Swedish house prices. This is an indication that market conditions in Sweden after the policy implementation respond in other ways than expected, while the results for Denmark is in line with expectations. Thus, this could be a sign that the policy implementation had an effect on Swedish house price growth.

However, to the above, we have to add one remark. We cannot exclude that the change in new listings originated from the policy implementation. The results clearly show that market factors do not react in the way they should after the policy was implemented, but whether this behavior could be assigned to the policy would require an investigation of drivers of supply. This falls outside the scope of this thesis.

5.3.3 SENSITIVITY TEST OF GRAPHICAL RD DESIGN

To explore the robustness of our RD graphs, we have investigated three various bandwidths[18]. We have studied the results from one default bandwidth, one half of the default and twice the default as recommended by Nichols (2007). Since the trends in all graphs coincide, we can conclude that the default bandwidth give the accurate results. Our graphs also ensure that the bandwidth satisfies the following condition; the width should be wide enough to minimize noise while also being narrow enough to ensure that the observations are comparable close enough on each side of the cut-off point (Lee and Lemieux, (2009)). Further, it would have been possible to confirm the strength of the chosen width even more if our datasets consisted of a larger number of data points.

5.4 DISCUSSION OF THE RESULTS

The results presented above indicate some ambiguous findings. The varying levels of significance of the coefficients as well as the impact from control variables raise some issues, which are further developed in this section.

Two important aspects regarding the setting come to mind when analyzing our results. Firstly, our datasets differ in some important aspects. The data covers different time periods, where the Danish dataset covers a longer period. Hence, we are able to more thoroughly follow the effect over time and the difference-in-difference estimation may be more valid due to the larger number of observations. The reason for not covering a longer time period for the Norwegian dataset is that a comparable mortgage cap was implemented in the first quarter of 2010, and revised it in the fourth quarter of 2011. Because of the chosen method, our control group needs to be unaffected by the Swedish treatment and by other exogenous factors during the investigation's time period. However, this raises a second critical point, namely that Sweden was the last country to implement a ceiling on new mortgage undertaken. Hence, the countries do not differ considerably in legislation, but rather in the timing of the implementation. Thus, no control group is entirely neutral to a mortgage cap, and especially the Norwegian sample results could be influenced by the fact that their mortgage cap was introduced in such close connection to the Swedish counterpart. We have considered other control groups when applying the difference-in-difference method, but for the RD design implementation we are dependent on the border proximity as a forcing variable, thus cutting us out of options of other control groups.

When applying a quasi-experiment approach, exogenous factors which are difficult to control for always exist. Individual characteristics and locations of regions, cities and households of the treatments or control groups could interact with the treatment effect and give biased results. The complexity of the housing market makes it difficult to control for all factors that determine the behavior of the market. Our results give ambiguous answers to what macro variables actually contribute to the models applied in this thesis. One of the reasons for this could be found by exploring the differences among the Scandinavian countries. Firstly, Norway is not part of the

[18] A bandwidth is a smoothing parameter (the width of a bin) for the regression discontinuity estimator. The optimal bandwidth depends on unknown functionals of the distribution of the data. (Imbens, G., and Kalyanaraman, K., (2010)). The optimal bandwidth is used to minimize mean squared errors (MSE). Often, smaller bandwidths produce lower bias and higher variance. A larger bandwidth can cause the linear regression to be a less accurate approximation (Nichols, (2007)).

European Union, thus experiencing greater independence. Secondly, the size of the countries, the demographic settings, and the utilization of natural resources differ a lot and give rise to different reactions to changes in the surrounding environment. Differences in legislation and welfare care can for example explain why the unemployment rate is statistically significant and positive for Norway, while negative and insignificant for Denmark. Thirdly, the financial turmoil affected house prices in the Scandinavian countries in different ways.

5.4.1 DISCUSSION SPECIFIC TO THE RD DESIGN

One important feature to discuss regarding the RD results is whether the border classification can serve as a suitable forcing variable. One benefit with the regional boundaries is that they are unchanging, meaning that we can follow the effect over time. This does, however, make it reasonable to question the randomization of the boundaries. It is highly likely that, on an individual basis, households are not indifferent whether to live in Norway or Sweden. Nor is it reasonable to think that the national borders have been defined randomly or that it is determined by chance what side of the border a house ends up on, implying that borders are endogenous. This limitation regarding the effectiveness of applying an RD design to boundaries has been discussed in great detail by Black (1999). This is one of the reasons to why we have chosen to complement our RD design with the difference-in-difference method.

By comparing the development of regions close to the border we would prefer the data points to share similar characteristics in terms of physical and sociographic attributes. This is, however, unlikely to be satisfied in our analysis since the regions cover big geographical areas and since some regions are located far from the border. One of the reasons to why the graphical illustrations do not show the expected outcome for the Danish sample can be that the regions do not share the same neighborhood attributes in the sense of socioeconomic, political and geographical characteristics. Black (1999) argues that it is possible to overestimate the value of a treatment if one does not control for neighborhood characteristics. A more detailed sample at zip-code levels would have given us the possibility to more closely control for neighborhood characteristics, as well as the opportunity to more thoroughly study the development of house prices as one goes further from the border. Researchers applying the RD design have often chosen houses that are situated within 0.15-0.35 miles of the threshold (Black, (1999)), which is far from our chosen border classification. By choosing houses close to the border, one would be able to eliminate the majority of other variables that could affect house price growth, thus any discontinuity found could be assigned to which side of the border a house is located on. However, due to the unavailability of data, we have used house price indices on a regional basis, and hence we cannot infer that our results depend solely on the policy in itself or other characteristics of the regions.

It is also important to stress that all things differing between the countries, other than the treatment effect, could impact the results, why the discussion above regarding the different macro variables between the groups will also prove to be important in the RD setting.

6 CONCLUSION

This thesis investigates the impact on Swedish house prices by the mortgage cap introduced by FI on October 1st, 2010. Based on our difference-in-difference and RD design analyses, we find some evidence that the mortgage cap has contributed to the decline in Swedish house prices. However, the ambiguous results make it difficult to credibly ascribe the detected house price decline to the policy per se.

Our results are in line with our expectations that Sweden has experienced a larger drop in house prices after the policy implementation compared to Norway and Denmark. The treatment effects are similar in the Sweden-Norway and Sweden-Denmark difference-in-difference comparisons. The coefficients measuring the treatment effect indicate that the policy has had a negative impact on house price growth and it is statistically significant. The regression results are, however, not completely robust for additional macroeconomic control variables. The Danish results are the most successful in verifying our hypothesis since the treatment effect is negative, more coefficients are significant, the explanatory power is larger and the time horizon of the comparison is longer.

Since our results show that the policy only had a small effect on house prices, the mortgage cap may be successful in decreasing the size of household's mortgage loans while having small spill-over effect on the housing market. These indications could prove to be valuable for policy makers' future interventions on the mortgage market.

We add one valuable dimension to our study by investigating the treatment effect from a RD design perspective. In the Sweden-Norway comparison, we find a clear discontinuity at the threshold in house price growth after the policy. Based on the Sweden-Norway investigation, this is some evidence in line with our hypothesis that Swedish house prices were negatively impacted by the policy. The discontinuity developments are not as evident in the Sweden-Denmark comparisons, but there are some indications that the policy could have impacted the Swedish house market to act differently. Although the graphical results do not present us with strong evidence that the policy has had an impact, the RD design is a powerful tool for the purpose of this thesis.

Perhaps the most intuitive explanation of the ambiguous results is that the policy change implemented by FI on October 1st, 2010 was not introduced strongly and convincingly enough. If the policy was not able to convince banks and households that the access to credit had been restricted, the market would not respond in an efficient way, hence leaving the effect of the policy out. This is in line with FI's conclusions about the mortgage cap, as well as Mäklarstatistik's report during 2011.

Even though difference-in-difference investigations and RD designs are reputable methods to analyze policy effects, they may contain weaknesses which can help explain why we cannot convincingly conclude that the policy contributed to the decline in house prices. The endogeneity problem of boundaries in a geographical RD design could be overcome by excluding regions that appear to have borders defined under the influence of for example

neighbourhoods or rivers. Further, one needs to ask; what characteristics differ between Sweden, Norway, and Denmark beside the defined treatment effect? Macro- and microeconomic differences may vary widely between regions or exogenous factors outside our scope may have affected our control groups during the investigation's time horizon.

The somewhat ambivalent results from our different methods open up for further studies to focus on the effects by leverage-restricting policy implementations on house prices in Sweden. The housing market is an intricate market wherein different factors interacts and affects the prices. A key success factor for future analyses would be to carry out the investigation on more detailed geographical levels, such as zip-codes. This would also provide the advantage of an increase in the size of the dataset. For example, the real estate price index is only available on regional data, where a more detailed level would enhance the understanding on the Swedish housing market. Furthermore, a new register for residential condominiums is under development and will become a valuable resource in the future in order to follow the development for individual homes over a longer period.

Future investigations applying a RD design on the Swedish housing market could prove to be highly successful. Both the Swedish housing market as such, and the effects of policy implementations, are interesting fields of study and the opportunities to explore the Swedish housing market in the light of applied RD designs are immense.

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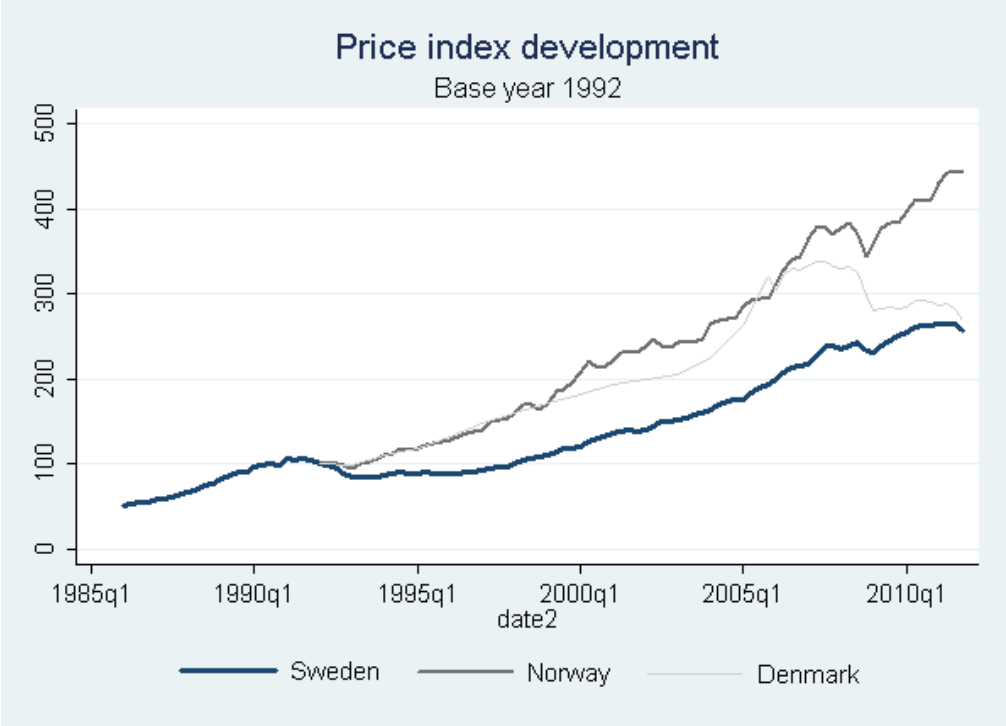
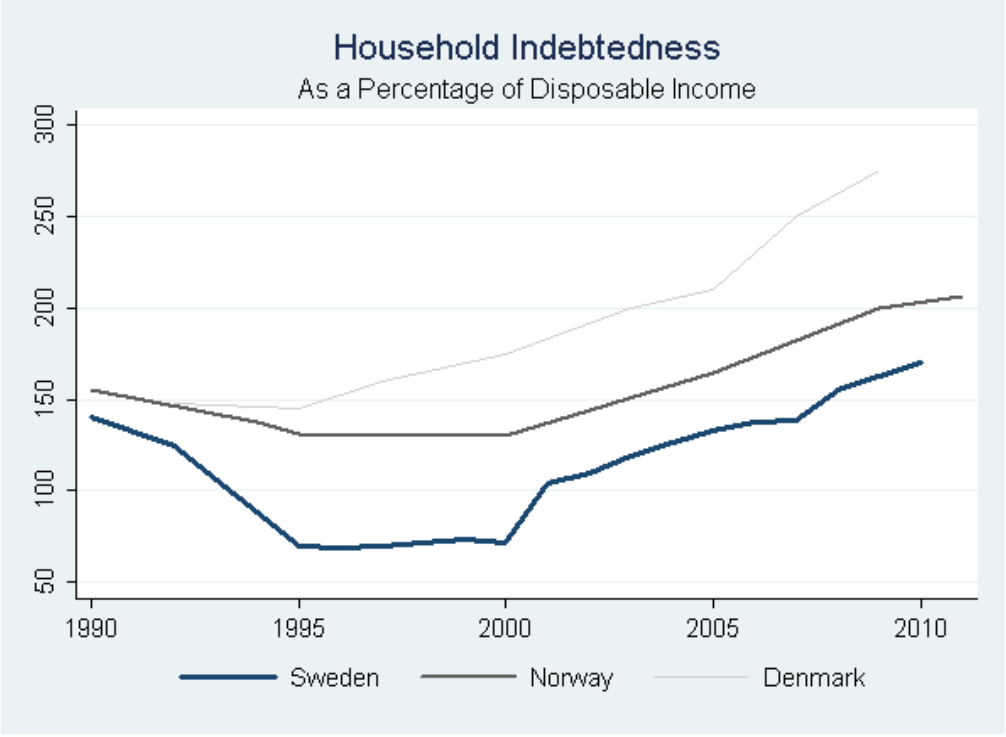
8 APPENDIX

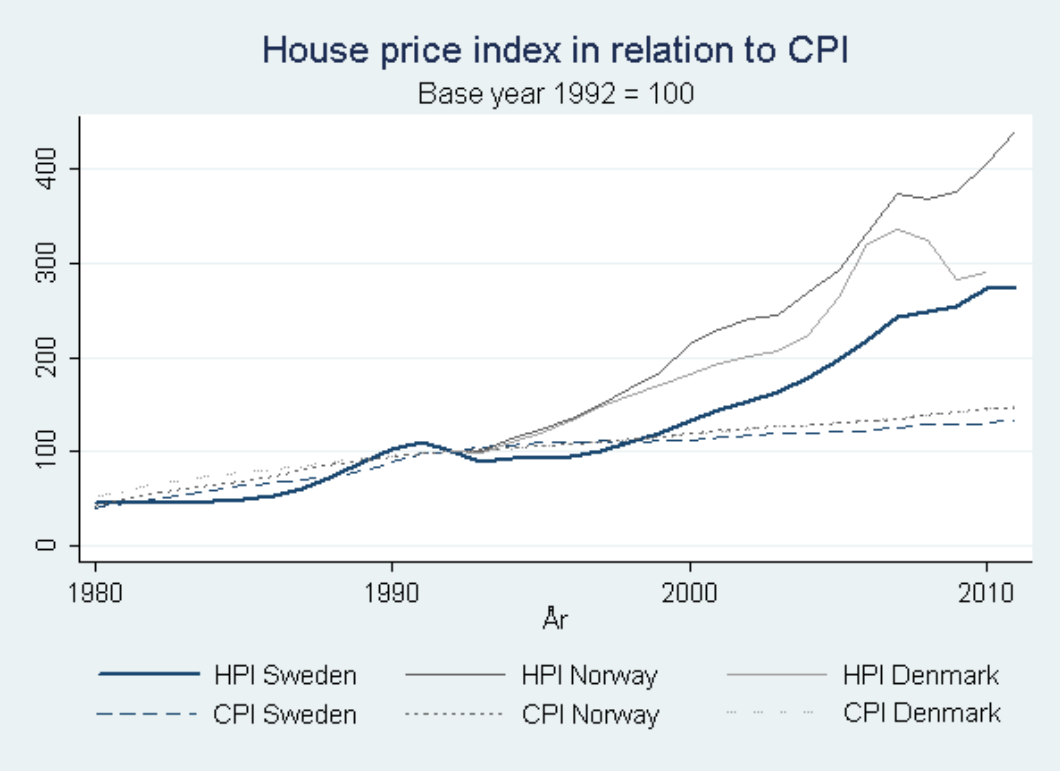
Figure 1: House Price Index and Household Indebtedness Developments Over Time

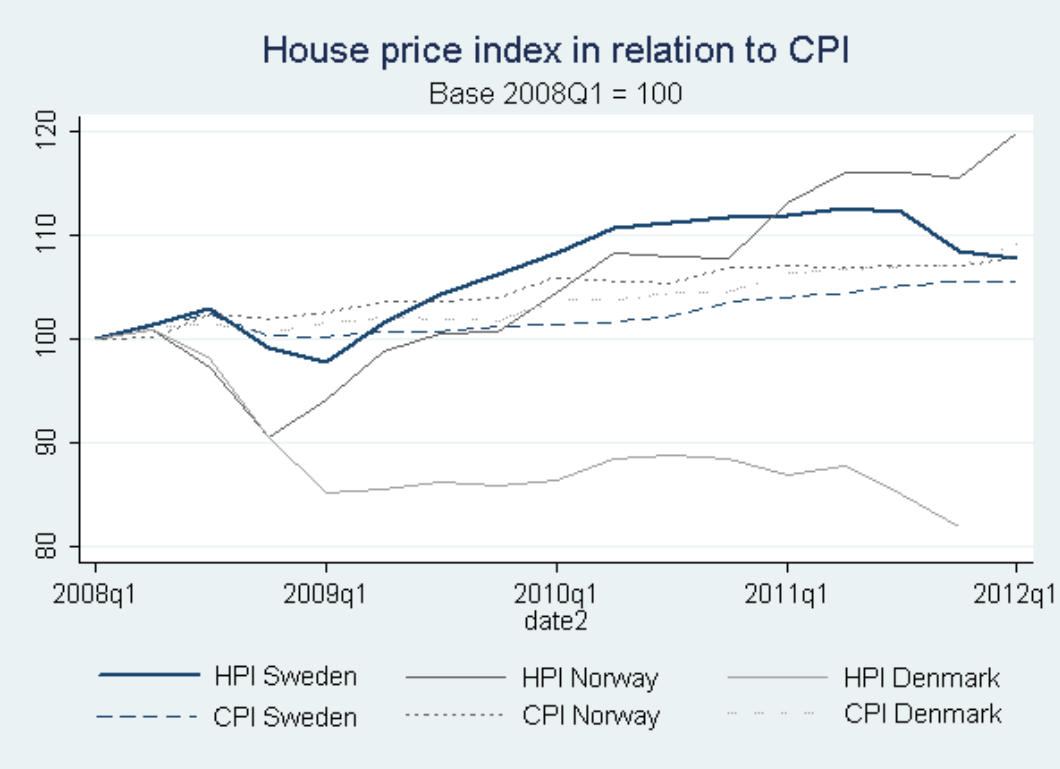




The top graph shows the house price index development for the Scandinavian countries, and the bottom graph shows the corresponding development over time in household indebtedness. All data has been collected from the national statistics bureaus.

Figure 2: Consumer Price Index in Relation to House Price Index



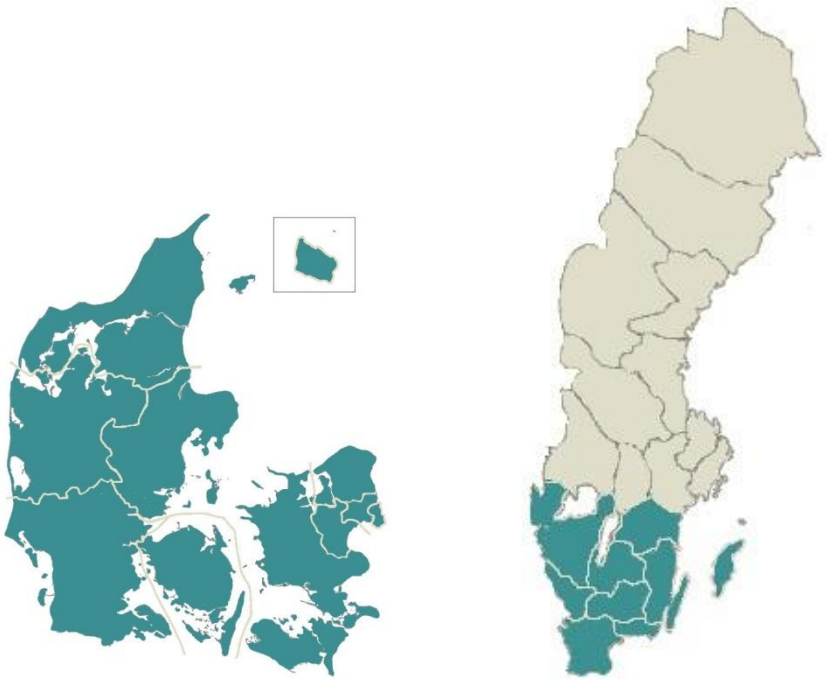


The figures show the relation between consumer price index and house price index for the three countries, where the top graph illustrates the long term trend of the two indices. The bottom graph illustrates the short term trend between 2008 and 2011. Compared to the long term trend, HPI and CPI are now converging. All data is collected from the national statistics bureaus.

Figure 3: Maps Presenting the Analyzed Regions

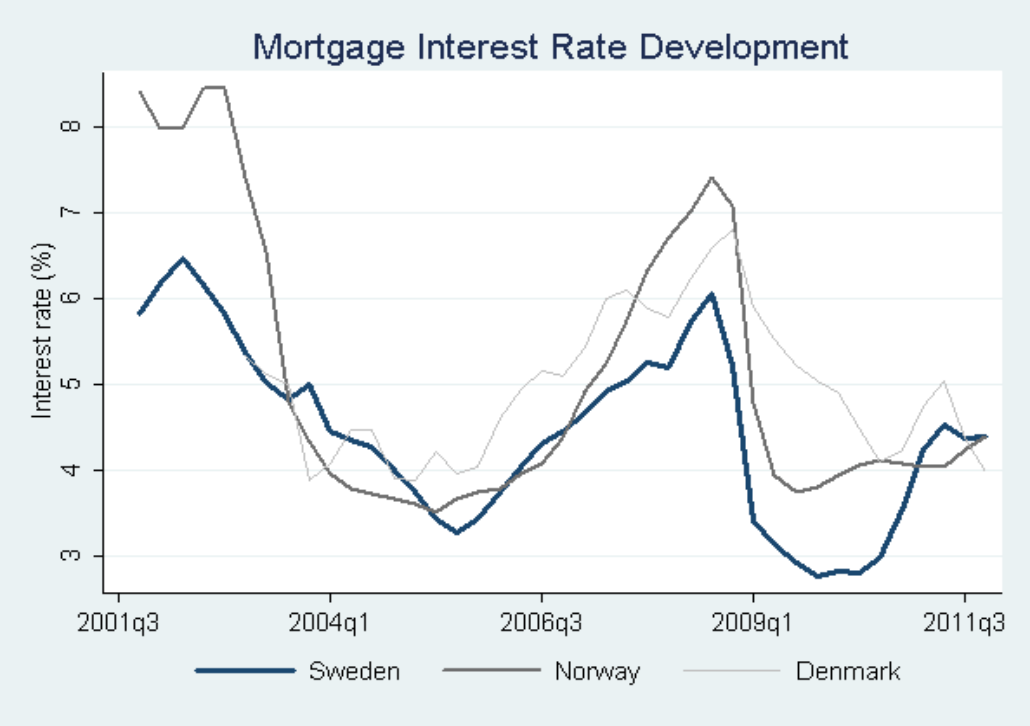
Panel A: Sweden / Norway

Panel B: Sweden / Denmark



The shaded areas in the two panels illustrate the regions which have been included in our datasets. The two datasets have different characteristics. For the Norwegian dataset displayed in Panel A, rural regions are used to test whether the policy have had any effect on house price growth. The Danish dataset instead focus on urban areas, displayed in Panel B. Observe that the total area of Denmark is 43 094 km^2 and the total area of Sweden is 449 964 km^2.

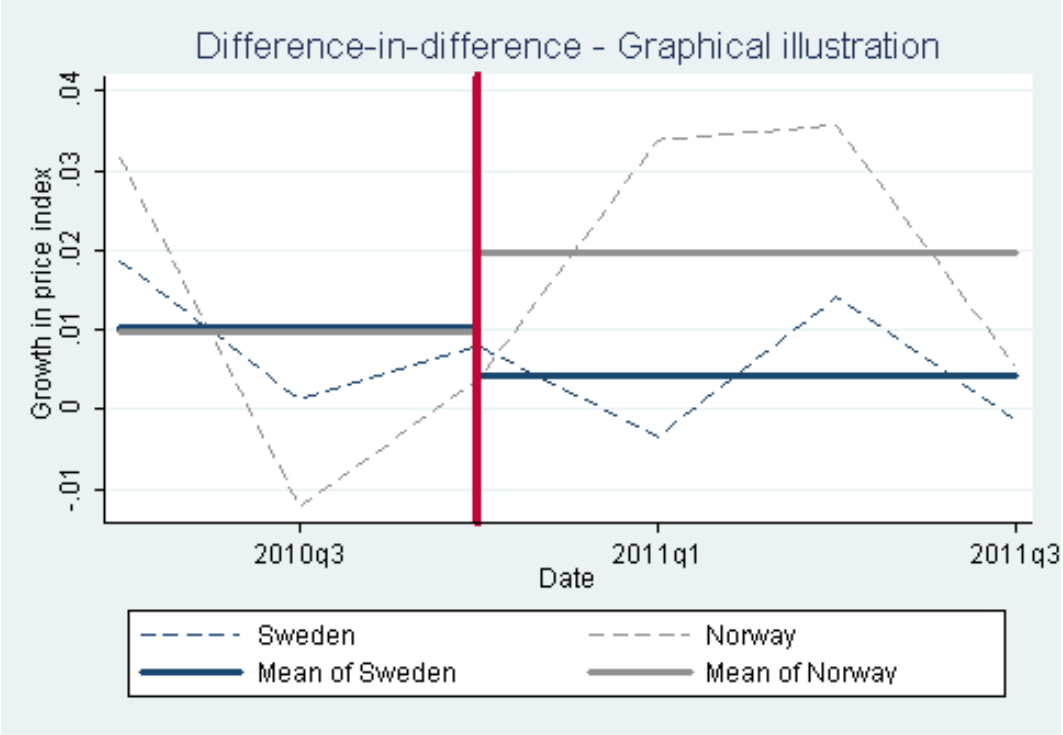
Figure 4: Mortgage Interest Rate Development



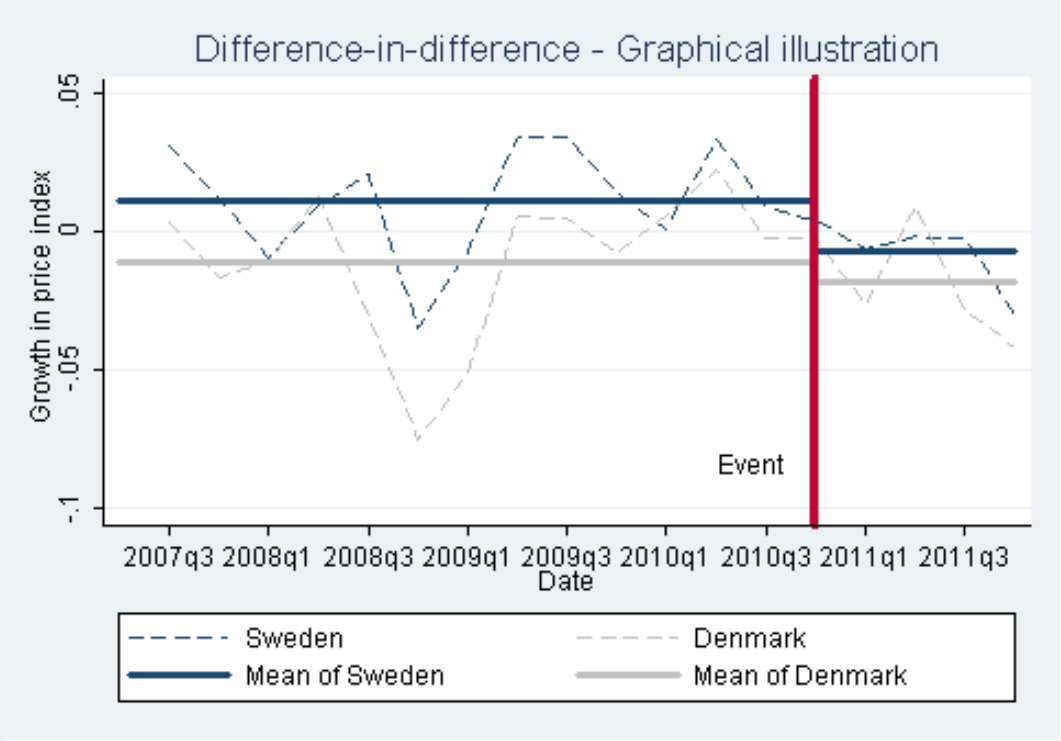
The graph presents the quarterly developments of the Scandinavian countries' mortgage interest rates between 2001 and 2011. The development of the interest mortgage rate depends on the repo-rate set by the central banks. For Norway, data for mortgage interest rate has been collected from Statistics Norway with banks as lending institutions, household as sector, and mortgage with property as collateral as mortgage type. For Denmark, data have been collected on mortgage-credit institutes on outstanding lending from Statistics Denmark with housing as item and household as sector. For Sweden, the mortgage interest rate has been calculated as a mortgage basket of data from Swedbank Hypotek, where the mortgage interest basket consists of equally big parts of the average 5-year interest rate, 3-year average interest, and 3-months average interest rate. Swedbank does not explicitly present the ratio for loans with flexible or fixed interest rate. Hence, the Swedish mortgage interest rate basket has been constructed manually.

Figure 5: Graphical Illustrations of Difference-In-Difference Results

Panel A: Sweden / Norway



Panel B: Sweden / Denmark

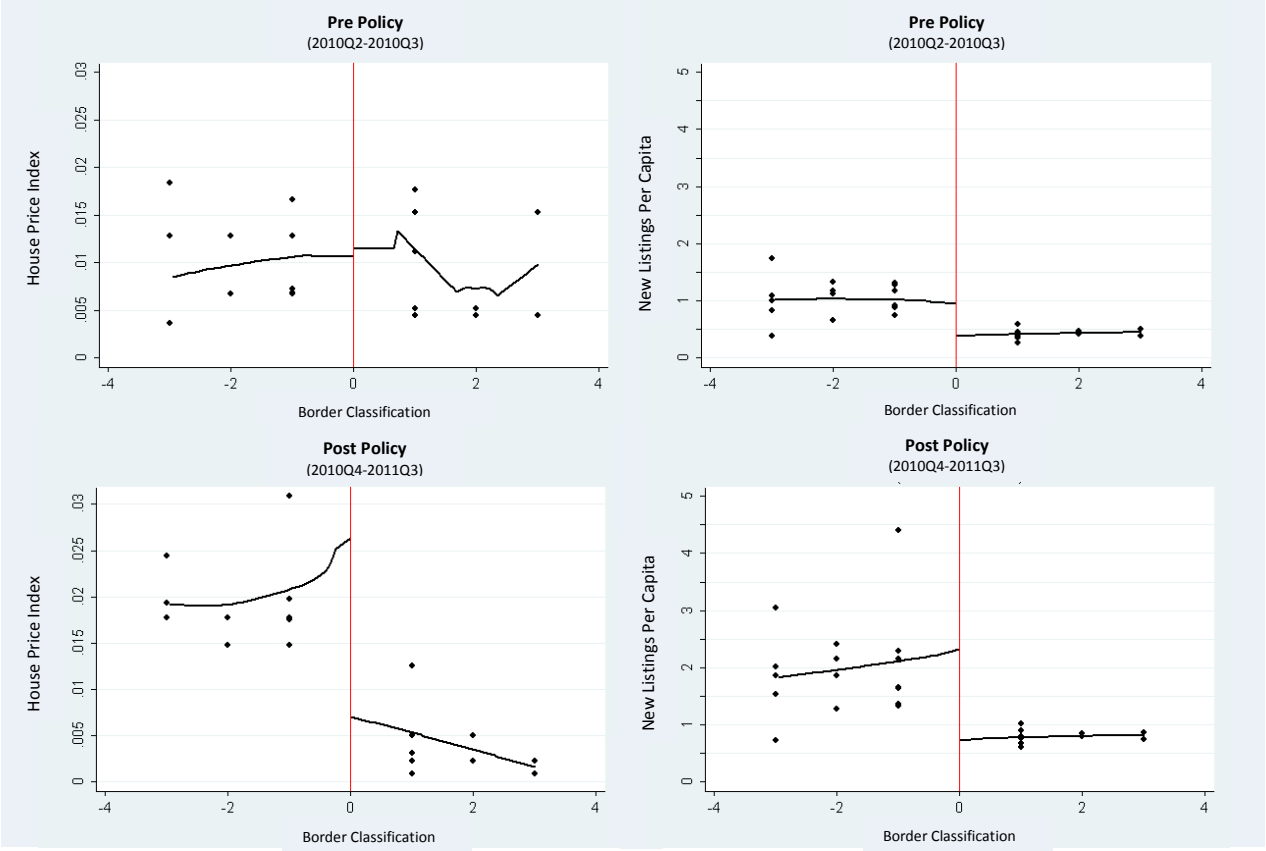


These panels display the graphical illustrations of the applied difference-in-difference method.

Figure 6: Graphical Illustrations of Regression Discontinuity Design Results

Panel A: Sweden / Norway

House Price Index Growth | New Listings Per Capita

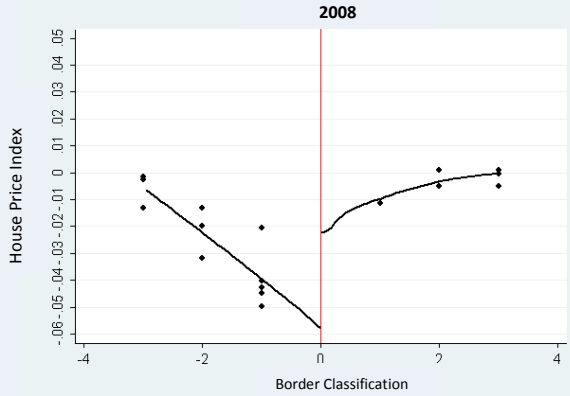


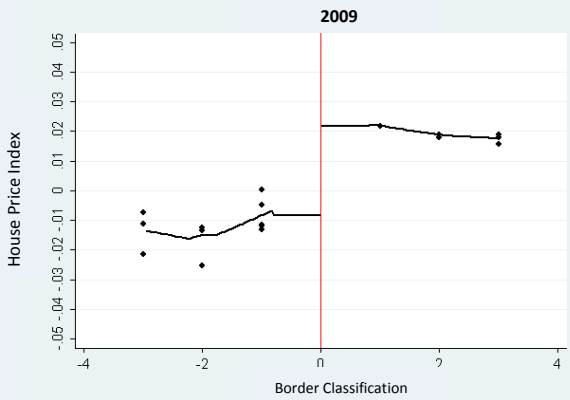
These panels include the graphical results from the RD implementation. Growth in house price index is displayed in the left-hand column, while the graphs for new listings per capita are presented in the right-hand column. We analyze the impact of the change in policy by comparing the development over time; each graph presents different time periods. We generate the graphs by implementing a RD design approach that estimates a kernel-weighted local polynomial smoothing on both sides of the threshold. The border classification is positive for the Swedish regions and negative for the control groups. The border is defined as 0. Note that the new listing per capita is displayed in hundredths (1/100). For Panel A, we collapse the mean of the assignment variable before and after the policy implementation due to a short time-span. Panel B displays the average values during 2008 through 2011 in order to follow the development over time.

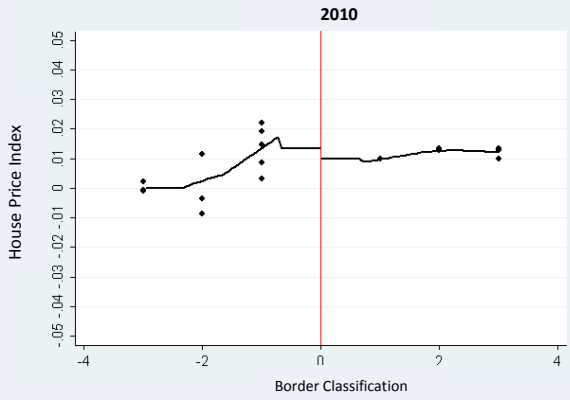
Figure 6: Graphical Illustrations of Regression Discontinuity Design Results

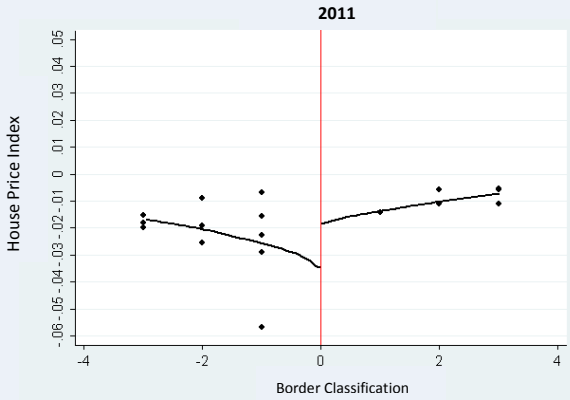
Panel B: Sweden / Denmark

House Price Index Growth

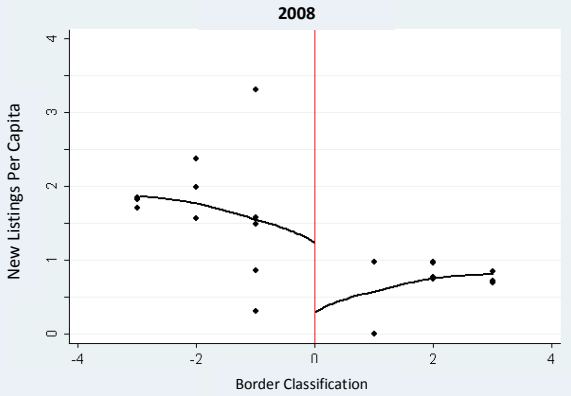


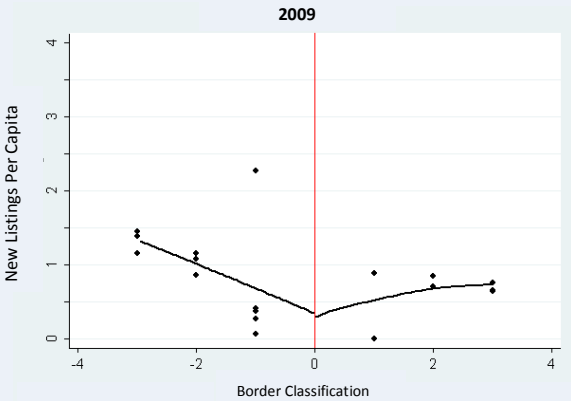


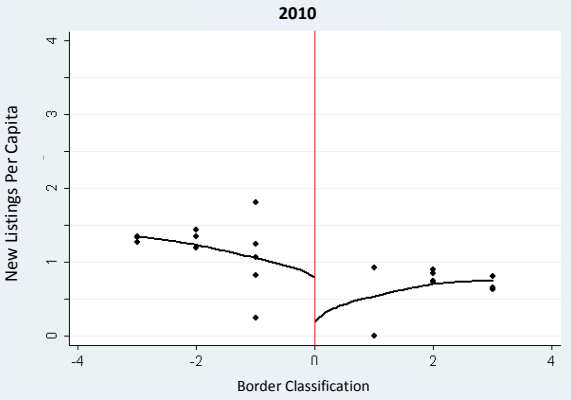




New Listings Per Capita







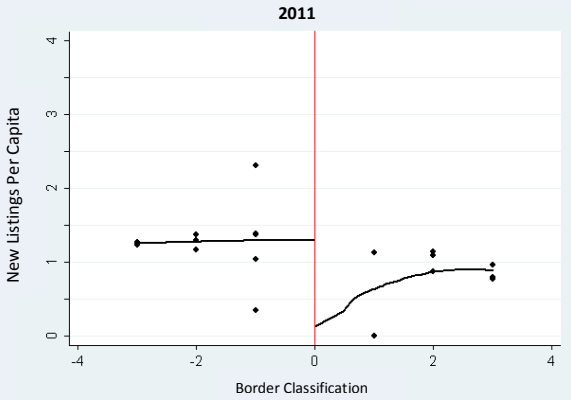


Table 1: Mortgage Regulation in Sweden, Norway, and Denmark

	Sweden	Norway	Denmark
Mortgage cap (loan-to-value)	85%	90%*	80%
Type of interest (majority)	Variable	Variable	Variable
Withdraw of equity	Yes	Yes	Yes
Tax advantages	Yes (33 %)	Yes	Yes (30%)
Amortization-free loans	Allowed, and very common	Allowed for a restricted period	Allowed, and very common

*Norway introduced the 90 percent ceiling on the loan-to-value ratio in March, 2010. However, new recommendations which limit the ratio to 85 percent were introduced in December 2011. Our sample period only includes the 90 percent mortgage cap.

This table presents the mortgage regulation situations in Sweden, Norway and Denmark during our sample periods. The time horizons of our samples are adjusted to ensure that these levels of mortgage caps are consistent throughout the whole period. The table shows that the countries are similar in all mortgage legislative aspects but the level of the mortgage cap, which strengthens the argument that these are suitable treatment and control groups.

Table 2: Region List and Border Classification

Panel A: Sweden / Norway

SWEDEN		NORWAY	
Region	**Border classification**	**Region**	**Border classification**
Västra Götaland	1	Ostfold	-1
Värmland	1	Akershus	-1
Västmanland	1	Hedmark	-1
Dalarna	1	Sor-Trondelag	-1
Jämtland	1	Nord-Trondelag	-1
Västerbotten	1	Nordland	-1
Norrbotten	1	Troms	-1
Örebro län	2	Oppland	-2
Västernorrland	2	Lillehammer	-2
Östergötland	3	Buskerud	-2
Gävleborg	3	Vestfold	-2
		Telemark	-3
		Hordaland	-3
		Sogn	-3
		Romsdal	-3
		Trondheim	-3
11 regions		16 regions	

Panel B: Sweden / Denmark

SWEDEN		DENMARK	
Region	**Border classification**	**Region**	**Border classification**
Blenkinge	1	København by	-1
Skåne	1	Københavns omegn	-1
Jönköping	2	Nordsjælland	-1
Kronoberg	2	Bornholm	-1
Kalmar	2	Østsjælland	-1
Halland	2	Vest- og Sydsjælland	-2
Östergötland	3	Fyn	-2
Gotland	3	Østjylland	-2
Västra Götaland	3	Sydjylland	-3
		Vestjylland	-3
		Nordjylland	-3
9 regions		11 regions	

This table presents a list of the analyzed geographical regions and each region's appointed border classification value. Swedish regions (treatment group) are appointed positive values between 1 and 3 depending on their geographical location. Regions along the border have a value of 1. Regions one step further into the country have a value of 2. Regions furthest from the border are appointed a value of 3. The Norwegian and Danish regions (control groups) are appointed values according to the same methodology, but are given negative values.

Table 3: Summary Statistics

Panel A: Sweden / Norway

	All				Pre policy				Post policy			
Sweden	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
House price index growth	0.0062	0.0157	-0.0217	0.0428	0.0099	0.0181	-0.0205	0.0428	0.0043	0.0142	-0.0217	0.0297
New listing (#)	774	816	108	4487	806	803	149	3694	758	831	108	4487
New listing per capita	0.0020	0.0007	0.0009	0.0037	0.0021	0.0005	0.0012	0.0032	0.0020	0.0008	0.0009	0.0037
Mortgage interest rate	0.0374	0.0068	0.0280	0.0452	0.0290	0.0010	0.0280	0.0299	0.0417	0.0038	0.0354	0.0452
GDP growth	0.0128	0.0058	0.0040	0.0200	0.0165	0.0036	0.0130	0.0200	0.0110	0.0059	0.0040	0.0200
Unemployment rate	0.0867	0.0145	0.0510	0.1310	0.0951	0.0156	0.0730	0.1310	0.0825	0.0121	0.0510	0.1090
Population (#)	386,166	386,697	126,259	1,589,016	385,598	391,338	126,584	1,578,516	386,450	388,906	126,259	1,589,016
Year/quarter	2011/1	n/a	2010/2	2011/3	2010/3	n/a	2010/2	2010/3	2011/2	n/a	2010/4	2011/3
Observations	66				22				44			

Norway	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
House price index growth	0.0163	0.0263	-0.0280	0.0670	0.0097	0.0248	-0.0201	0.0533	0.0196	0.0266	-0.0280	0.0670
New listing (#)	1281	1306	96	8325	1234	891	145	4120	1304	1476	96	8325
New listing per capita	0.0050	0.0023	0.0012	0.0153	0.0051	0.0017	0.0016	0.0094	0.0049	0.0025	0.0012	0.0153
Mortgage interest rate	0.0410	0.0007	0.0404	0.0424	0.0409	0.0004	0.0405	0.0412	0.0410	0.0008	0.0404	0.0424
GDP growth	0.0033	0.0161	-0.0250	0.0280	-0.0105	0.0147	-0.0250	0.0040	0.0103	0.0118	-0.0040	0.0280
Unemployment rate	0.0270	0.0041	0.0190	0.0380	0.0276	0.0036	0.0220	0.0350	0.0267	0.0043	0.0190	0.0380
Population (#)	231,817	125,348	26,381	545,653	230,561	125,521	26,381	536,499	232,445	126,250	26,381	545,653
Year/quarter	2011/1	n/a	2010/2	2011/3	2010/3	n/a	2010/2	2010/3	2011/2	n/a	2010/4	2011/3
Observations	96				32				64			

These tables present summary statistics for our two datasets, stating mean, standard deviation, minimum and maximum values. Each panel presents each country's statistics for three groups; the full sample as well as two groups sorted by the observations before and after the policy implementation on October 1st, 2010. All data is collected on a quarterly basis. The number of observations in each sample is indicated.

House price index growth is the house price development per region including one-family homes, excluding condominiums. It is collected from Statistics Sweden (SCB), Statistics Norway (SSB), and Statistics Denmark (DST). The number of new listings per region is divided by population per region to calculate new listings per capita. New listings are collected from hemnet.se, finn.se, and realkreditraadet.dk. The population per region is collected from SCB, SSB, and DST. All regions of a country are appointed the same, national mortgage interest rate, collected from Swedbank Hypotek, SSB and DST. All regions in each country are appointed the same GDP growth, collected from SCB, SSB and DST. The unemployment rate is collected on a regional basis from SCB, SSB and DST. The Swedish unemployment rates are conducted according the EU-standard Labor Force Survey (LFS) and all countries' GDP rates according to the EU-standard National Accounts. Each sample's time period is presented in year/quarter format. The mean of the time period is rounded upward when two quarters represent the median. Standard deviation is redundant for the time variable.

Table 3: Summary Statistics

Panel B: Sweden / Denmark

	All				Pre policy				Post policy			
Sweden	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
House price index growth	0.0064	0.0232	-0.0422	0.0554	0.0115	0.0235	-0.0375	0.0554	-0.0071	0.0162	-0.0422	0.0258
New listing (#)	1024	1083	53	4781	1002	1037	73	3832	1073	1189	53	4781
New listing per capita	0.0021	0.0007	0.0009	0.0044	0.0021	0.0006	0.0013	0.0034	0.0022	0.0009	0.0009	0.0044
Mortgage interest rate	0.0413	0.0107	0.0276	0.0605	0.0409	0.0125	0.0276	0.0605	0.0421	0.0035	0.0354	0.0452
GDP growth	0.0025	0.0156	-0.0390	0.0230	0.0009	0.0170	-0.0390	0.0230	0.0066	0.0103	-0.0110	0.0200
Unemployment rate	0.0724	0.0182	0.0360	0.1310	0.0719	0.0198	0.0360	0.1310	0.0737	0.0132	0.0390	0.1040
Population (#)	497,608	499,447	56,955	1,590,604	495,427	497,228	56,955	1,578,516	503,281	510,785	57,203	1,590,604
Year/quarter	2009/4	n/a	2007/3	2011/4	2009/1	n/a	2007/3	2010/3	2011/2	n/a	2010/4	2011/4
Observations	162				117				45			
Denmark	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
House price index growth	-0.0125	0.0332	-0.1384	0.0765	-0.0105	0.0338	-0.1111	0.0747	-0.0176	0.0312	-0.1384	0.0765
New listing (#)	1544	1080	49	4957	1590	1092	49	4574	1416	1045	97	4957
New listing per capita	0.0033	0.0020	-0.0001	0.0113	0.0034	0.0020	-0.0001	0.0096	0.0031	0.0020	0.0004	0.0113
Mortgage interest rate	0.0527	0.0084	0.0398	0.0679	0.0558	0.0077	0.0410	0.0679	0.0447	0.0037	0.0398	0.0503
GDP growth	0.0039	0.0158	-0.0310	0.0220	0.0049	0.0182	-0.0310	0.0220	0.0014	0.0053	-0.0050	0.0080
Unemployment rate	0.0488	0.0192	0.0153	0.1053	0.0440	0.0189	0.0153	0.1053	0.0624	0.0122	0.0430	0.1023
Population (#)	502,335	210,616	41,406	839,710	500,887	209,611	41,949	833,122	506,390	215,301	41,406	839,710
Year/quarter	2009/4	n/a	2007/3	2011/4	2009/1	n/a	2007/3	2010/3	2011/2	n/a	2010/4	2011/4
Observations	198				143				55			

Table 4: Regression Results: Policy Effect on House Price Growth

Panel A: Sweden / Norway

	(1)	(2)	(3)	(4)	(5)	(6)
	growth	growth	growth	growth	growth	growth
Swe	0.0002	0.0002	-0.0422**	-0.0309		
	(0.97)	(0.96)	(0.00)	(0.33)		
Policy	0.0099	0.0156***	0.0087	0.0064	0.0087	0.0083
	(0.07)	(0.00)	(0.21)	(0.65)	(0.07)	(0.55)
SwePolicy	-0.0155*	-0.0156**	0.0095	0.0321	0.0116	0.0262
	(0.03)	(0.01)	(0.31)	(0.24)	(0.33)	(0.20)
Unemployment rate			0.3274*	-0.2631	0.4596*	-0.3707
			(0.03)	(0.15)	(0.05)	(0.10)
GDPgrowth			0.0861	0.4098	0.0911	0.3354
			(0.69)	(0.34)	(0.72)	(0.46)
Mortgage interest rate			-1.5102*	-3.1829*	-1.5381	-2.9718*
			(0.01)	(0.01)	(0.07)	(0.01)
Constant	0.0097*	-0.0068*	0.0633*	0.1396*	0.0398	0.1240*
	(0.03)	(0.02)	(0.01)	(0.01)	(0.16)	(0.01)
FE	no	no	no	no	region	region
Time FE	no	quarter	no	quarter	no	quarter
R^2	0.077	0.372	0.113	0.417	0.079	0.403
N	162	162	162	162	162	162

* p<0.05, ** p<0.01, *** p<0.001, meaning coefficient statistically different from zero at the 5%, 1% and 0.1% confidence level, respectively.

These tables present coefficient estimates for six specifications of regressions on growth in house price index. P-value in parentheses. Inclusion of unit fixed effects and/or time fixed effects are indicated for each regression. Standard errors are heteroskedasticity-robust and clustered at region level. The regression specification of column (1) and (2) is $y = \beta_0+\delta_1 Policy + \delta_2 Swe + \delta_3 SwePolicy + \varepsilon$. Column (3) through (6) includes additional control variables. The regression specification follows: $y = \beta_0+\delta_1 Policy + \delta_2 Swe + \delta_3 SwePolicy$ + unemployment rate + GDP growth + mortgage interest rate + ε. Policy is a time dummy which equals one before the policy and zero otherwise. Swe is a dummy which equals one if the index corresponds to Sweden before the policy and zero otherwise. SwePolicy is an interaction term which equals one if the index corresponds to Sweden after the policy. The SwePolicy coefficient represents the difference-in-difference estimator and measures the policy's total effect on Sweden. Swe is dropped due to collinearity whenever unit fixed effects are controlled for.

Table 4: Regression Results: Policy Effect on House Price Growth

Panel B: Sweden / Denmark

	(1)	(2)	(3)	(4)	(5)	(6)
	growth	growth	growth	growth	growth	growth
Swe	0.0220***	0.0220***	0.0193***	0.0186**		
	(0.00)	(0.00)	(0.00)	(0.01)		
Policy	-0.0071	-0.0098	-0.0084	-0.0152	-0.0090**	-0.0353**
	(0.16)	(0.16)	(0.12)	(0.19)	(0.00)	(0.00)
SwePolicy	-0.0116	-0.0116*	-0.0146*	-0.0087	-0.0144***	-0.0084
	(0.06)	(0.02)	(0.02)	(0.27)	(0.00)	(0.28)
Unemployment rate			0.0934	-0.0116	0.2168	0.0088
			(0.44)	(0.92)	(0.09)	(0.96)
GDPgrowth			0.7899***	0.0148	0.7959***	0.0134
			(0.00)	(0.94)	(0.00)	(0.95)
Mortgage Interest rate			-0.2191	-0.2611	-0.0673	-0.2545
			(0.30)	(0.51)	(0.58)	(0.43)
Constant	-0.0105***	0.0061	-0.0063	0.0227	-0.0121	0.0128
	(0.00)	(0.07)	(0.70)	(0.41)	(0.28)	(0.51)
FE	no	no	no	no	region	region
Time FE	no	quarter	no	quarter	no	quarter
R^2	0.134	0.568	0.333	0.569	0.272	0.533
N	360	360	360	360	360	360

* p<0.05, ** p<0.01, *** p<0.001, meaning coefficient statistically different from zero at the 5%, 1% and 0.1% confidence level, respectively.