DEPOSIT INTEREST RATE RIGIDITY AND ASYMMETRY

- A STUDY ON THE SWEDISH BANKING MARKET

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This thesis examines price rigidity and asymmetry in the deposit interest rate setting on the Swedish banking market. We investigate if these patterns can be related to market concentration measured by the Herfindahl-Hirschman index. We apply an error-correction framework to estimate the degree of pass-through of money market interest rate changes to deposit interest rates. Our results indicate an incomplete pass-through in the long-run, which implies that the banking market is not fully efficient. As expected, the pass-through is even more incomplete in the short-run with values between 0.3–0.45. We find evidence of price asymmetry i.e. banks are more reluctant to raise deposit interest rates when the money market rate increases than decrease the deposit interest rates when the money market rate is falling. Finally, when dividing our time-period into three sub-periods, according to HHI-level, we see an indication of a relationship between market concentration and price rigidity and asymmetry.

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Master Thesis in International Economics
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Presentation Date: 25/1 - 2006
Presentation Time: 10.15-12.00 room 542

Acknowledgements:
We would like to thank our tutor Richard Friberg for helpful advice throughout the thesis.

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1. INTRODUCTION

Many industrialized countries operate their monetary policy through market-oriented instruments with the aim to influence the short-term interest rates, which in turn influences the banks retail interest rates.[1] In traditional macro economic theory the pace and symmetry at which prices adjust to changes in market conditions affect the efficiency of the economy, as price deviations from an equilibrium setting causes misallocation costs. In the retail bank industry the flexibility of deposit interest rate adjustments to changes in the money market rates is one of the determinants of the effectiveness of the interest rate channel of the monetary policy transmission mechanism. In other words, a more complete pass-through of market interest rates to retail bank interest rates, in a relatively short horizon, facilitates a more efficient monetary policy with lower misallocation costs, hence moving the economy closer to equilibrium. The effectiveness of the monetary policy is essential in order to be able to influence the future path of spending and inflation in the economy.

A focal task by retail banks is to collect savings in the form of deposits and thereafter lend it out for investments. For the market to be perfectly efficient, in equilibrium, the interest rate paid on the deposit accounts would equal interest gained on their investments less the cost the bank has of doing business i.e. transaction costs. However, in the real world this assumption barely holds, as all major banks have presented large profits during the last years, implying that prices are not justified by their costs. Thus, the interest rate setting on deposit accounts by banks will have an impact on the behavior of deposit holders; how much they decide to save on deposit accounts, and thereby also affect financial stability and the country's overall economic activity.

[1] They do so by determining the conditions that keep the supply and demand in the market of bank reserves in equilibrium. Borio, (1997)

Earlier studies in other countries indicate that price rigidity exists in deposit interest rate settings by banks (e.g. Hannan and Berger, 1991 and De Bondt, 2002). The price rigidity on bank retail deposit accounts has several possible explanations; it can be caused by menu costs, market structure or the result of collusive behavior by banks. Price stickiness in retail interest rates leads to misallocation costs that are not beneficial for the society. On these premises we find it important to highlight price rigidity at this time, particularly bearing in mind that the Swedish economy has been booming in recent years with the consequence of increases in the Swedish money market rate. An incomplete pass-through of the money market rate to the deposit interest rates may result in great benefits for the banks at the expense of the deposit holders, especially when the money market rate is increasing.

Moreover, price rigidity i.e. an incomplete pass-through of changes in the money market rate to the deposit interest rate is an important feature of our paper. Here we assume that adjustments towards the long-run equilibrium are symmetric, which implies that the adjustment speed is exactly the same for interest rate increases as for decreases. However, previous research shows that asymmetries exist in the adjustment process towards equilibrium and consequently we try to find evidence for this phenomenon in the Swedish banking industry. Banks could profit by decreasing the interest rate paid on deposit accounts more rapidly when the market rates are adjusted downwards than they raise interest rates at times when adjustments are being made upwards.

In contrast to previous papers in this field we find indications of increased pass-through, i.e. less price rigidity in recent years. This may be the result of increased competition arising from new entrants on the Swedish banking market, both from domestic and foreign firms. The Herfindahl-Hirschman index reflects this statement as it shows a decline in market concentration of the major banks in the last five years. Additionally, increased pass-through in

recent years may be the result of technological innovations, leading to decreased information and switching costs for deposit holders.

The main contribution of our thesis is that no extensive research within this field has been applied on the Swedish banking industry. More advantageous is that we use real data collected from one of the major Swedish banks and it covers an extensive time-period from 1993 to 2006. We also address the issue of price asymmetry in the price setting behavior by banks. Additionally, we investigate the relationship between market concentration and the degree of pass-through and asymmetry. Finally, we are able to get more accurate findings since we use bank deposit interest rates with the same maturity as the money market rate.

1.1 Purpose

The purpose of the thesis is to:

- *Investigate the pass-through effect of changes in the money market rate to retail deposit interest rates in the Swedish banking market.*
- *Search for evidence of price asymmetries in the price setting behavior by Swedish banks.*
- *Determine whether a relationship exists between market concentration and the degree of pass-through by dividing the data into different time-periods.*

We examine these issues using monthly data on deposit interest rates from a single bank, using an Error-Correction framework.

1.2 Disposition

The paper is structured in the following way. Section 2 provides a theoretical background on the monetary transmission mechanism and how price rigidity, asymmetries and market concentration creates disequilibrium in deposit

interest rate settings by banks. Section 3 describes the statistical data and explains the selection of the variables used in the models. In section 4 the Error-correction model is presented and the connection to economic theory is explained. Section 5 presents and discusses the results. Section 6 concludes our findings and recommendations on issues to be addressed in subsequent research are presented.

2. THEORY

2.1 Monetary policy and the Transmission mechanism

As stated in the paper by Romer and Romer (1994), monetary policy matters and will have a real effect on the economic activity. From 1994 and onwards the Swedish Central bank's main objective has been to "maintain price stability" with the target to keep the annual increase in Consumer Price Index, CPI close to 2 percent, with a permissible fluctuation of +/- 1 percent.[2] To carry out the monetary policy the Central Bank use their key instrument, the so called "repo rate". Adjustments in the repo rate take place at pre-announced monetary policy meetings. For a successful implementation of monetary policy it is fundamental that its effect on the rest of the economy is both predictable and effective. Changes in the repo rate directly affect the money market rates (short term interest rates), as it affects the shortest market rate, the rate at which the banks participating in the central payment system can borrow and lend from the central bank overnight. Consequently, the long-term interest rates, the exchange rates, asset prices and the quantity of money are affected. As the money market rates affect both loan and deposit interest rates in banks, it alters individuals' disposable income and thereby their propensity to save and/or consume, in the end affecting both total demand within the economy and the inflation rate. An important property for the reliability and efficiency of monetary policy is the flexibility of money market- and retail interest rates, how fast, and to what extent the financial institutions pass-through a change in the money market rate to the retail rate to their customers. The process that describes how changes in monetary policy affect other parts of the economy is called the Transmission Mechanism of monetary policy.

The transmission mechanism operates through various channels, affecting different variables and different markets, at various speed and intensity. The

[2] www.riksbanken.se

literature, for example the paper by Woodford and Walsh (2003) describes three main channels of the monetary policy transmission mechanism; the *interest rate channel*, the *credit channel* and the *exchange rate channel*. In this paper we focus on the interest rate channel, which describes how the changes in the repo rate affect the inflation through affecting the total demand for goods and services.

There are three key ways at which interest rates influences the real economy. The first component is the reaction of companies and households to changes in relative costs of alternative credit and deposit possibilities, i.e. *the substitution effect*. Secondly, changes in interest rates alter the costs and incomes of all economic agents and thus, their net income, i.e. the *income effect*. Finally, it alters the value of real and financial assets and, consequently, the wealth of companies and households.

The degree at which changes in central bank interest rates are passed through to changes in banks lending- and saving rates thereby to a great extent determines the strength of these effects. Thus, the effectiveness of monetary policy depends on the degree and speed at which the banks retail interest rates adjust to changes in policy-controlled interest rates. Banks decisions regarding interest rates on saving accounts influence household consumption, as higher deposit interest rates will make it more attractive to postpone consumption in favor of increased savings. Several papers, for example the paper by Hofmann and Mizen (2002), investigate the relationship between monetary policy changes and the response on both bank loan- and deposit interest rates.

2.1.1 The effective interest channel

According to Loayza and Schimdt-Hebbel (2002) the monetary transmission mechanism and the interest rate channel effectiveness depends on the market structure of the economic system in question, for example if the financial

structure incorporates a variety of financial institutions or if it comprises mainly of major banks. In a well-diversified market, with many institutions and products, monetary policy changes will be translated to changes in the market interest rates and other financial prices quicker, than in settings with few financial institutions that can exert some kind of monopoly power in the setting of interest rate independent of the central bank. [3] This will be further explained in the section about price rigidity.

2.1.2 Monetary Policy and forecasting

As the effect of monetary policy decisions is exerted with a lag, the Central Bank must be forward looking and base their monetary policy decisions on forecasts of future inflation developments. The lag at which the policy change affects the rest of economy depends on the business cycle, expectations and credibility of the Central Bank. If future inflation is forecasted to be higher than optimal, the Central Bank usually raises the repo rate, and if it is below the inflation target the repo rate is decreased. If a change in the repo rate is expected by the general public, interest rate changes will start the adjustment process before the actual adjustment has taken place.[4]

2.1 Price Rigidity and asymmetry

2.2.1 Price Rigidity

The paper by Neumark and Sharpe (1992) explains that if banks were operating in a perfectly competitive environment they would pay an interest rate on deposits equivalent to the rate of return that they earn on loans less the different transaction services i.e. the cost of doing business A more detailed

[3] Loayza and Schimdt-Hebbel, (2002) also conclude that in diverse settings the most important channels of the monetary transmission mechanism is the interest rate-, asset price- and the exchange rate channel versus the credit channel in less developed areas.
[4] Sveriges riksbank, Penningpolitiken I Sverige, (2006)

explanation is that banks take savings in the form of deposits and subsequently lend them out for investments, an efficient market would imply that the interest paid to deposit holders would equal the marginal cost of capital less the transaction costs. The marginal cost facing banks is assumed to be the money market rate as this could be a proxy for a bank's cost of funding. If the bank market would be completely efficient, and perfect competition would prevail, the response to a change in market rates would be direct and there would be a complete pass-through of adjustment in money market rates to subsequent changes in a bank's retail rates. In the real world, this is barely the case and therefore not prevailing for the Swedish banking industry. Several theoretical arguments have been put forward to explain the sluggishness of retail interest rates. These explanations include tacit collusion between financial institutions, dynamic price discrimination that relies on consumer habit, menu costs and market structure.

An explanation is that banks operating in more concentrated markets, and especially for deposit interest rate markets, earn more on the business of investing deposits. This in turn would lead banks in more concentrated markets to be more tempted to pay lower deposit interest rates on the accounts. Evidence of this can for example be found in the paper by Hannan and Berger (1989).

Another possible explanation for price rigidity on deposits i.e. why the interest rate on deposits is not constantly updated with every movement of the t-bill rate or money market rate, is presented by Flannery (1982). He argues that consumers may find it pricey to constantly seek for the best interest rate and hence change bank accordingly, often referred as switching costs. Flannery furthermore explains that price rigidity might be due to the costs faced by banks for adjusting the deposit interest rate to changes in the money market rate, so called menu costs. The conclusion according to Flannery is that it is beneficial both for banks and consumers to implement pricing practices that follow the market rate on average. This explanation means that, even in the

existence of competitive pricing, depositors earns the marginal rate of return averaged over some horizon.

A final explanation, which has obtained extensive research for price rigidity on deposits, is one, which proposes that interest rate sluggishness may be related to the prevailing market structure. This explanation implies that concentrated markets show greater price rigidity on deposit interest rates. The relationship between concentration and price rigidity will be further explained in section 2.2.2 Market concentration.

2.2.2 Price asymmetry

When searching for evidence of price rigidity in the deposit interest rate setting we assume that market adjustment towards equilibrium is symmetric i.e. the adjustment speed towards the long run equilibrium is exactly the same for interest rate increases as for decreases. However, previous studies show evidence that asymmetries exist in the adjustment process for deposit interest rates. Both Hannan and Berger (1991), Neumark and Sharpe (1992), De Graeve et al. (2004) and Lago-Gonzalez and Salas-Fumas (2005) present evidence of asymmetries in the case of deposits interest rates. Moreover, Neumark and Sharpe (1992) and Moore et al. (1990) also finds that bank deposit interest rates are more slowly to adjust to market interest rates at times when the deposit interest rate is lower than the equilibrium interest rate, than at times when it is above equilibrium interest rate. However interestingly, a recent study by Berstein and Fuentes (2003) present a somewhat different finding, they found no evidence or only weak signs of asymmetries on the Chilean deposit accounts.

In the empirical literature we find several explanations for price asymmetries in deposit interest rates. One explanation argues that it is important to emphasize that asymmetries in bank interest rates are often more prominent in cases not

favorably to the customers i.e. banks are more sluggish to adjust interest rates upwards on deposits and vice versa on loans at times when the money market rate increases. This is for example found by Hannan and Berger (1991) and called the kinked-supply explanation[5]. This explanation is commonly accepted when the competition on the deposit market is rather low. However, another economic literature by Hofmann and Mizen (2002) argues that when the competition on the market is high banks are more reluctant to adjust deposit rates downwards since doing it will be on the expense of losing customers. This possible explanation of asymmetry in deposit interest rates relies on the differences in the costs of adjusting prices upward or downwards.

Another explanation presented amongst others by Gonzalez and Fumás (2005) for price asymmetry is the one of bank collusion and collusive price arrangements. If all banks collude, they all wants to profit maximize and hence adjust their interest rate accordingly. However since banks are operating in an imperfect environment with inadequate information and different believes about future economic conditions collusion between the parties may be difficult to maintain. The result is that adjustments in the interest rate by banks will be avoided to the greatest extent possible since it will be considered as cheating by the other banks. The adjustment will only appear when all banks realize that the change is a reaction to changing economic conditions. If this theory of interest rate asymmetry is applicable, then interest rate increases may be more interpreted as cheating from the collusion than interest rate decreases because of the fact that the expected cost of a collusive breakdown should be greater for deposit rate increases than decreases.

A final explanation concerns the timing of depositors' reactions to changes in the price of the deposit interest rate. If there is a lag between the price change and the depositors' responses to them, this lag will be an additional cost on a

[5] The kinked supply explanation means that the supply curve of deposits is assumed to be flatter for interest rate increases than decreases, i.e. more customers are expected to switch bank to receive a higher interest rate than the ones switching as to escape an interest rate decrease. (Hannan and Berger, 1991, p.941)

deposit interest rate increase. This can be explained by the fact that the extra interest is paid out to depositors before the full reaction of the depositors is realized. This explanation also implies more price rigidity for increases in the deposit interest rate than for decreases.

2.2.3 Market Concentration

A traditional approach is to investigate the relationship between concentration and pricing behavior based on the structure-conduct-performance paradigm Bain (1951), which suggests a direct connection between market concentration and performance. The hypothesis is that less competition on a market (fewer and larger firms) is associated with higher markups. Several empirical studies have also shown a direct relationship with market concentration and market power in the banking industry. As mentioned previously Neumark and Sharpe (1992) finds that banks in concentrated markets skim off surpluses on market interest rate movements in both directions by being slower to raise interest rates on deposit in case of an increase than to reduce them in case of declining rates.

Many studies have examined if the structure of the market has an impact on the degree of price rigidity and price asymmetry. The hypothesis is that companies in more concentrated market have more market power and are therefore able to react slower to changes in the market rate as consumer will be less prone to change bank. Evidence for this has also been found by for example by William E. Jackson (1997). He examines the speed of adjustment across low, medium and highly concentrated markets and finds that the adjustment speed is slower for low and high concentrated market than for the medium group.

Hutchinson (1995) finds that the spread between deposit interest rates and treasury bills varies considerably over time. A paper by Rosen (2002) concludes

that bank interest rates tend to be less responsive to changes in the marginal cost (market interest rates) when the price – cost margin is already large than when it is small.

Another way to view the positive correlation between concentration and profits is according to the efficient-structure paradigm. Here profits reflect lower costs arising from more efficient companies rather than non-competitive pricing, a perspective hypothesized by Peltzman (1977) studying manufacturing industries. This perspective has been proposed to be applicable also for the banking industry, and was examined in a study by Hannan and Berger (1989). However, their findings supported the structure-performance paradigm proposed by Bain in (1951). A later paper by Hannan and Berger (1994) also oppose the efficient-structure paradigm as their study find strong evidence that banks in more concentrated markets exhibits lower operating efficiency.[6] Furthermore, they find that the operating cost relating to market concentration appears to be several times higher than the social loss arising from non-competitive pricing of bank outputs as measured by the welfare triangle.[7]

Another approach to analyze the competitive behavior of firms is based on microeconomic foundations and assumes that a bank set its equilibrium price and quantities as to maximize profit based on cost considerations and the degree of competition on the market. The degree of competition in the market on the other hand is determined by demand conditions and characteristics of interaction between firms. This view is shared by Hannan (1994) who finds that price rigidity varies with the responsiveness to a price change likely to be exhibited by customers and furthermore that asymmetry seems to be greater in markets were the quantity response to changes in deposit rates are smaller.

[6] Market power that increases concentration allows companies to be less cost efficient without exiting the industry.

[7] It might suggest that antitrust and merger policies should consider more of the implications of cost efficiencies of impeding mergers. The cost economies often claimed might be offset with the reduced market pressure to minimize costs.

3. THE DATA

The data used in our analysis is based on data collected from actual savings accounts at one of the major banks in Sweden. The time period covered in our study is from January 1993 to February 2006 and consists of monthly observations. The paper covers three topics related to deposit interest rate setting behavior by Swedish banks. The first section estimates the degree of long- and short-term pass-through within an Error-Correction Mechanism framework (ECM). In the second part we search for evidence of price asymmetries using two alternative approaches. Finally we divide our time series into three sub samples to investigate a possible relationship between market concentration and market imperfections.

3.1 Deposit interest rates

The data consists of all interest rate changes made on three different saving accounts; for amounts SEK 0-100', SEK 100'-250' and > 250'. The time-period covered is January 1993 to February 2006. On all the accounts 4 withdrawals per year are allowed without charge[8]. The 0-100' account contains 36 interest rate change decisions, the 100'-250' account covers 40 interest change decisions and the > 250' account 41 changes. When comparing the date at which adjustments in the interest rate has been made at the major Swedish banks we observe that they all seem to adjust their interest rates within the same period of time. The last adjustment to deposit interest rates was made for all the major banks[9] between 1 November 2003 and 7 November 2006. We therefore conjecture that the patterns we document can be representative for the market as a whole. Furthermore, the data illustrate both increase and decrease decisions, which enable us to investigate the existence of price asymmetries in the Swedish banking industry. Our data contains approximately

[8] On this cause we consider the maturity on our saving accounts to be 3 months.
[9] Swedbank, Nordea, Handelsbanken and SEB

8 upward price adjustments in respective accounts. This imbalance of up- and downward interest rate adjustment must be taken under consideration when analyzing the results from our regressions, especially when estimating the asymmetry effect. The few upward interest rate changes are due to the prevailing macroeconomic conditions at the time-period covered. At the start of our examined time-period, year 1993, interest rates were very high and have since then steadily decreased over time.

When selecting the period of study we wanted to focus on a period with similar market conditions, without any large macro economic shocks influencing the deposit interest rates. The reason for starting our study in 1993 is that the Swedish economy during the prior years experienced a dramatic financial crisis. The financial crisis caused interest rates to become very volatile and rise to exceptionally high values in 1992, when the Swedish central bank was struggling to defend the krona. On this cause we find the interest rates during that particular period not to be representative and hence decided not to include them in our study. Another reason for starting our study in year 1993 is that the Swedish central bank at this time changed their monetary policy target, and introduced an inflation target of 2 percent.[10]

3.2 Treasury-bill rate as independent variable

The explanatory variables included in our study are the 3 months Treasury-bill rate and lagged variables of both the Treasury bill and the dependent variable (deposit interest rate). In our study we investigate the relationship between the money market rate and the deposit interest rate. Therefore, the Treasury bill with a maturity of three months has been chosen to be consistent with the maturity on the saving accounts considered in our study. The T-bill rate is collected from the Swedish Central Bank and consists of monthly observations, recorded at the end of each month. The monetary policy rate is not included in

[10] www.riksbanken.se

our study as an explanatory variable but included in our figures to further visualize the transmission mechanism. The difference between the monetary policy rate and the Treasury bill rate is that the former is set by the Central Bank and the latter is determined in the market. In Sweden, the Treasury-bill rate closely follows the monetary policy rate set by the Central Bank. There are two explanations for us not including the repo rate as an explanatory variable in our study. Firstly, as the monetary policy rate and the Treasury bill rate are highly correlated we consider it not necessary to include both variables in our model. Secondly, we consider the Treasury bill to be more appropriate to be seen as the rate at which the banks can invest its deposit amounts and consequently earn profit.

3.3 The interest rate gap

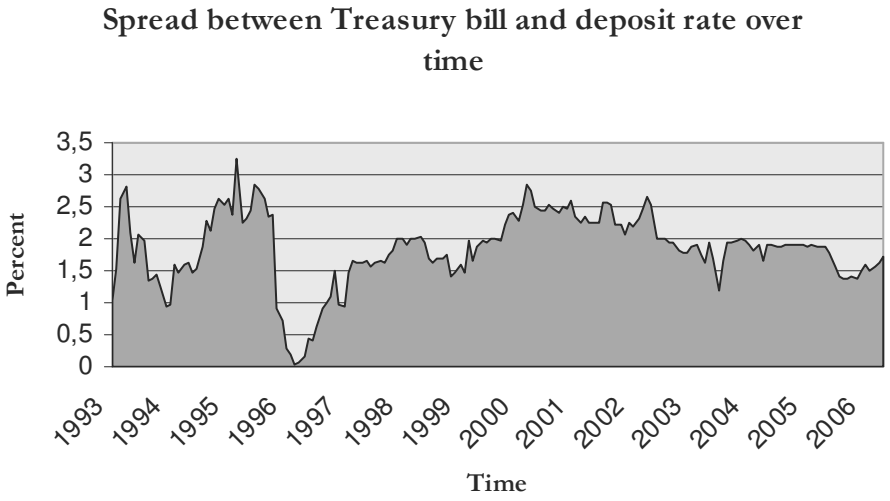

Figure 1. The graph shows the interest gap between the Swedish T-bill rate and the deposit interest rate between 1993 and 2006.

Another way to look at our data is to examine the interest rate spread, the interest rate difference between the Treasury-bill (money market rate) and the deposit interest rates. As we discern from figure 1 the spread has varied over time and shows a more volatile pattern in the early years. The reason for the

sudden drop in the beginning of 1996 was a pronounced improved inflation picture during the summer and autumn of 1995, arising from the strengthening of the krona and the activity slowdown imminent from the economic downturn in continental Europe. The repo rate was lowered from 8.91% to 4.10% during 1996. The spread increased again at the end of 1996 as the inflation had decreased dramatically and averaged 0.8% during 1996, which is below the Swedish central bank's tolerance interval according to Gröttheim and Berg (1998).[11] Between the years 2000 and 2003 the spread show consistent high values. A possible explanation is that during these years a lot of mergers occurred on the Swedish banking market with a higher market concentration as a consequence, facilitating the banks' power to set interest rates. In recent years, as a more competitive market has emerged, the spread has become more stable just below two percent, which might be an indication of a more normal spread.

3.4 Time Dummies

Time dummies are included in the linear model to allow for time effects that change slowly over time and affect interest rates in the same direction. Examples are factors such as market deregulation, inflation and/or other external factors such as macro economic shocks hitting the economy. Twelve dummy variables, one for each year excluding 1993, which is treated as a base year, were created. The dummy variables takes the value of one for observations during the respective years and zero otherwise.

3.5 HHI- concentration index in relation with interest rates

The Herfindahl-Hirschman index, HHI is a measure for determining market concentration. The U.S. department of justice uses the concentration index

[11] The krona weakens because of a combination of cyclical factors, credibility effects and short-run market reactions.

with the main purposes of antitrust enforcement. The HHI is calculated by summing the squares of the percentage market shares held by each respective company in the market. The HHI obtain values between 0 and 10 000, in monopoly the index would be 10 000 while in perfect competition the index would equal to zero. A HHI with a value below 1000 is regarded as a competitive market while a HHI above 1800 is regarded as a highly concentrated market[12].

A positive trait of HHI is that it reflects both the market share distribution of the top firms and the composition of the rest of the firms in the market.[13] Since a few dominating banks and several small ones characterize the Swedish bank structure, we consider the HHI index as an adequate measure as it takes market asymmetries into consideration.

In our analysis we have calculated the HHI regarding deposit interest rates for the Swedish banking sector between 1993 and 2005. All existing banks each year have been taken into consideration when calculating the market concentration. Data on deposit volumes has been collected from Svenska Bankföreningen. The single banks deposit volume divided by total deposit volume on the market has been applied as a measure for calculating the HHI. The HHI results for respective year in our study can be illustrated by the following diagram;

[12] U.S. Department of Justice, Horizontal Merger Guidelines, 1997
http://www.usdoj.gov/atr/public/guidelines/hmg.htm#15
[13] Ibid

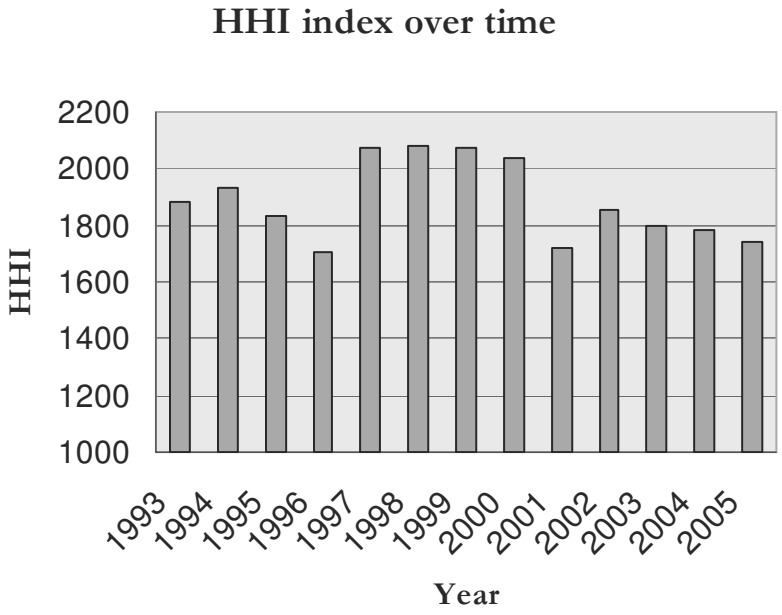

Figure 2. The diagram presents the level of concentration on the deposit market for the Swedish banking industry from 1993 to 2005.

The HHI indicates the Swedish banking deposit market as being moderately and even highly concentrated the whole time period. This implies that the four largest banks in Sweden have been dominating actors on the market and has contained an oligopoly position over time. In *figure 2* we are able to conceive three clearly defined episodes with similar HHI values. The first episode extends from year 1993 to 1996, the second episode from 1997 to 2000, and the third from 2001 to 2005. The prominent rise in HHI starting year 1997 and continuing until year 2000 can be explained by bank mergers creating larger players on the market. In recent years HHI has decreased which may be a result of new actors entrancing the market and reducing the major banks' dominant position.

4. THE ERROR-CORRECTION FRAMEWORK

The Error-correction mechanism (ECM) was first espoused by Sargan (1984). Engle and Granger made a more popularised description of the model with its correction for disequilibrium. The error-correction model is suitable in this type of framework since it combines a long-run equilibrium relationship with a short-run adjustment process. According to Engle and Granger (1987) the error-correction model is estimated in a two-step procedure. In the first step the general linear regression model (equation 1) are estimated and the residuals are saved. Secondly, the residual obtained from the linear model are incorporated in the ECM model (*equation 2 and equation 3*) as an error-correction term.

4.1 The linear regression

By estimating the following linear regression model we find the long-run pass-through:

$$DepositR_t = \beta_0 + \beta_1 \sum_1^{13} tDummy + \beta_2 MMR_t + \mu \qquad \textit{(Equation 1)}$$

*Deposit*R represents the interest rate on the different deposit accounts, the variable *tDummy* represents the yearly dummies and the variable *MM*R represents the money market interest rate. According to theory *equation 1* should hold in the long run, but in the short run however, there might be disequilibrium. This disequilibrium is represented by the error term estimated from the linear model.

- **The error correction term, μ_{t-1}, $(Deposit_{t-1} - \beta_0 - \beta_1 \sum_1^{13} tDummy - \beta_2 MMR_{t-1})$**

The residuals obtained from the linear model (equation 1) are here called the error correction term. The implication of the error correction term in our study is that it represents how far the deposit interest rate on the saving accounts is from its long run equilibrium value. If the error correction equals zero, it implies that the model is already at its long run equilibrium and the long run pass-through effect of money market rates to deposit interest rates has been attained. On the other hand if the error correction term is positive, it implies that the deposit rate is above its equilibrium value and the opposite holds when the deposit rate is below its equilibrium value and μ_{t-1} is negative.

4.2 The ECM-model

For the ECM to be applicable, the variables must be co-integrated as stated in the Granger Representation Theorem. The error-correction model in our thesis consists of one or three explanatory variables, an error-correction term and an adjustment parameter. The two final ECM models used in our study are presented in the following equations:

$$\Delta Deposit_t = a_1 \Delta MMR_t + a_2 (Deposit_{t-1} - \beta_0 - \beta_1 \sum_1^{13} tDummy - \beta_2 MMR_{t-1}) \quad \textit{(Equation 2)}$$

$$\Delta Deposit_t = a_1 \Delta MMR_t + a_2 (Deposit_{t-1} - \beta_0 - \beta_1 \sum_1^{13} tDummy - \beta_2 MMR_{t-1}) + a_3 \Delta MMR_{t-1} + a_4 \Delta Deposit_{t-1} \quad \textit{(Equation 3)}$$

Table 1. Description of the variables included in the Error-Correction model.

Variable	Description
$\Delta Deposit$	Deposit account differential from period t-1 to period t.
ΔMMR_t	Money market rate (t-bill rate) differential from period t-1 to period t
Additional variables in equation 2	
ΔMMR_{t-1}	Money market differential from period t-2 to period t-1
$\Delta \text{Deposit}_{t-1}$	Deposit account differential from period t-2 to period t.-1

* Year dummies are included in the regression

- **The Short term parameter, α_1**

The coefficient of the money market differential, a_1, reflects short-term dynamics of movements in the money market rate, in other words the short-term pass-through. Earlier studies have found this value to be between 0.25 and 0.40, which indicates a relatively slow speed of adjustment. [14]

In the ECM *equation 3* we have also included lagged variables of both the deposit rate and the money market rate. This has been done as we assume that the adjustment process takes more than a month to complete and therefore lagged variables of both the deposit rate and the money market rate to have an impact on the independent variable. By including these parameters we can compare and find the most suitable model and hence findings regarding interest rate pass-through and asymmetries on the Swedish banking market. By expanding our model we hope to find improved significance and higher R^2.

[14] De Bondt studying the Euro-area found the short run pass-through to be 0.354 between the years 1996 to 2001 and Nuemark and Sharpe found the pass-through in the US market to be 0.25 between the years 1983 to 1989.

- **The adjustment parameter, α_2**

The error correction terms coefficient, a_2, also called the adjustment parameter, describes how quick the adjustment speed is towards the equilibrium interest rate. The closer the value of a_2 is to -1, the quicker the adjustment speed is. The coefficient is expected to be negative as to restore the equilibrium. If so a_2 μ_{t-1} will consequently be negative at times when μ_{t-1} is above equilibrium causing the deposit rate to fall in the next session, and positive when μ_{t-1} a is below its equilibrium value causing the deposit rate to rise in the next period. This relationship between the value of a_2 and the deposit rate implies that the value of a_2 (the error term coefficient) determines how long it takes to re-establish the equilibrium.

- **Calculating the mean number of months to reach final pass-through**

In order to estimate the mean number of months it takes for the money market interest rate to be fully passed through to the deposit interest rates the following formula is calculated:

$(1- a_1)/a_2$. *(Equation 4)*

In previous research the mean number of months to reach complete pass-through has typically been between 3 to 10 months. A study by Angeloni and Ehrmann (2003) on the Swedish banking market between 1999 and 2002 found the mean number of months to reach complete pass-through to be 1 month. This was by far the fastest among the countries included in the study. According to a working paper done by ECB the speed of adjustment has increased since the introduction of the euro. This study find that the adjustment speed on deposits redeemable at notice of up to three months is 4 to 6 months. If this also would affect countries outside the Euro-area, it would imply that we should find a faster pass-through in recent years.

4.3 The asymmetry model

Two alternative approaches to measure the asymmetry between interest increases and decreases have been chosen in our study. In the first approach we use the adjustment parameter a_2 to capture asymmetry. In this way we want capture pass-through differences between times when deposit interest rate is above or below the equilibrium value. Two dummy variables are created, one where negative values of the adjustment parameter takes the value of one and others zero (NegDummy), and the other where positive and zero values takes the value of one and other zero (PosDummy).

$$\Delta Deposit_t = a_1 \Delta MMR_t + a_2(Deposit_{t-1} - \beta_0 - \beta_1 \sum_1^{13} tDummy - \beta_2 MMR_{t-1}) + a_3 NegDummy_t + a_4 PosDummy_t \qquad \textit{(Equation 5)}$$

In the second approach we use the same model as *equation 5* but the dummy variables now correspond to negative and positive T-bill differentials. In this case the dummy variables illustrate the differences in pass-through between increases (PosDummy) and decreases (NegDummy) in the money market rate.

4.4 The concentration model

To be able to capture potential differences arising from changes in the competitive environment we divide our statistical data into three sub-periods according to similarities in HHI-concentration index. We then re-estimate the linear regression model for these sub-periods, see *equation 1*.

4.5 Stationarity and co integration

One essential feature of the error-correction framework is that the variables included in the error-correction model can be estimated more efficiently if the

time-series are stationary or non-stationary, but co-integrated. The consequence is that the error-correction term and the variables presented in first difference are less likely to be collinear. The concept of error-correction is thereby closely related to that of co integration and was first proposed by Engle and Granger in (1987) who discovered that it is possible for a linear combination of integrated variables to be stationary. Moreover, when two variables are co-integrated, for example deposit interest rates and the money market rate as in our study; there is a long-term equilibrium relationship between them. However, in the short-run the variables may be in disequilibrium. Therefore, in our regression the error-term is the "equilibrium error" and its coefficient measures the adjustment speed toward equilibrium.

Before estimating the final model in an error-correction framework we must determine whether there exists a long-run equilibrium relationship between our variables i.e. if they are co-integrated. To be able to test for co-integration, we must start by examine if all variables are individually integrated. In the first step we conduct Dickey-Fuller tests to see if our variables contain a unit root. The result of the stationarity tests is that all variables fail to reject the hypothesis of a unit root, which means that they are non-stationary. When examining an autocorrelation-graph for each unit root test we conclude that our residuals are positively autocorrelated with the first lag of the variable. In the next step we perform an Augmented Dickey-Fuller (ADF) tests, including one lag, to test for stationarity. Neither in this case can we reject the null hypothesis that the time series contains a unit root. However, at this moment the autocorrelation-graphs show no signs of autocorrelation and therefore we draw the conclusion that our time series are non-stationary. The next step before checking for co-integration is to transform our variables to first differences, in a so called Difference Stationary Process, to see whether our variables becomes stationary. The tests indicate that all time series becomes stationary.

The final step is to conduct an Engle-Granger Augmented Dickey-Fuller (EG-ADF) test for co-integration with the null hypothesis of no co-integration

against the alternate of co-integration between the variables. Including the appropriate lag-length we conclude that our regression model is stationary and there exists a long-run relationship between the variables. It is the residuals from the co-integrated equilibrium relationship that should be stationary.

5. RESULTS

5.1 A graphical illustration

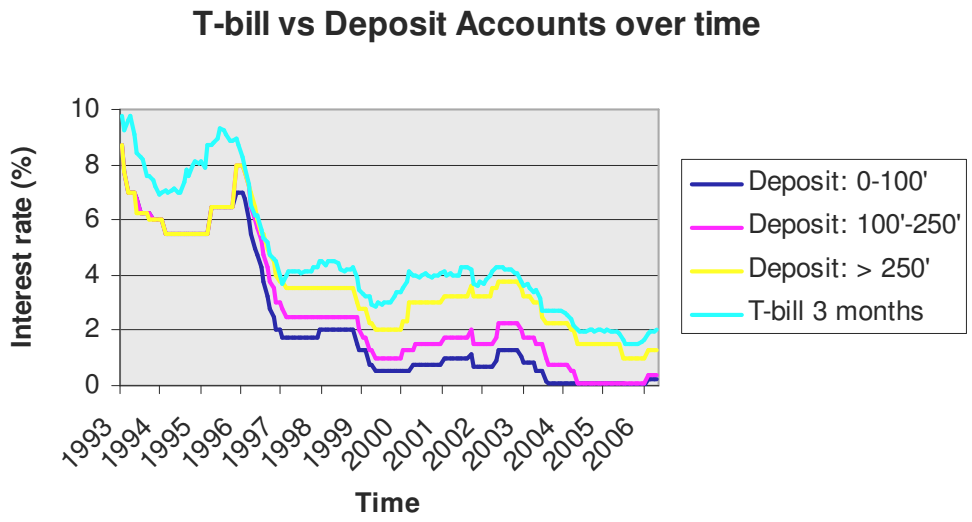

Figure 3. The figure shows the T-bill vs. deposit interest rates relationship from 1993 to 2006.

By graphically illustrating the relationship between our examined deposit accounts over time and the Swedish 3 months t-bill rate we distinguish that the deposit accounts to a large extent follows the same pattern as the T-bill rate. However, as expected, there is a clear gap between the deposit interest rates and the t-bill, in addition we observe a displacement of the timing for changing the deposit interest rates according to changes in the T-bill rate. This finding, without any further investigations, indicates an incomplete pass-through within the Swedish banking industry. Moreover in the figure we see a tendency to asymmetric effects. An example of this is that during the years 1997 to 1998 the t-bill rate increased with approximately 80 p.p. while the deposit interest rate stayed flat, except for the 0-100' account, which had a slight increase towards the end of the year by 25 p.p. On the other hand for t-bill decreases, the adjustment speed seems to be much quicker, as for example we can

conceive this phenomenon between the years 1993 to 1994, 1996 to 1997 and the end of 1998 until the beginning of 1999.

5.2 Results from the error-correction models

Following the graphical assessment of our variables we continue by presenting the results on the pass-through and asymmetry effects from the error correction model estimations.

5.2.1 Long-term pass-through

The results for the long-term pass-through effect on the saving accounts were all significant and showed somewhat analogous results, with variations between 0.795 and 0.889. This is inline with previous economic research within this field and indicates an incomplete pass-through of changes in the money market rates to deposit interest rates over the years included in our study. The finding of incomplete pass-through, present evidence of price rigidity on the Swedish banking industry. One possible explanation for this phenomenon could be the fact that individuals are facing so called switching costs, and are therefore more reluctant to change to another bank although it would be beneficial. Another explanation might be the menu costs faced by banks making it costly for them to constantly update their deposit interest rates. The standard error of the regression varies between 0.035 and 0.040 basis points for saving accounts redeemable at notice up to three months.

Table 2. The table present results of the long-run pass-through on all saving accounts included in the study.

Saving Accounts	SEK 0-100'		SEK 100'-250'		SEK > 250'	
Variable	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Constant	-0.379	0.263	-0.762	0.031	-0.029	0.924
T-bill	0.843	0.000	0.889	0.000	0.795	0.000
Adj. R-square	0.987		0.984		0.981	

* Year dummies are included in the regression

5.2.2 Short-term pass-through

The short-term pass-through results estimated in the ECM-framework varies between 0.333 and 0.425 with the highest pass-through for the account 0-100'. This implies that 42.5% of the money market change is immediately passed-through to the saving account 0–100'. Earlier studies, for example by De Bondt (2002), show somewhat similar results. The adjustment parameter reflects the adjustment speed towards equilibrium and in our study the two first accounts in the table both show values around 0.250 while the third account show an obviously higher value of 0.394. This indicates that the adjustment speed is faster on deposit accounts holding larger amounts. One way to interpret this finding is that banks might be more caring towards high income/wealthy customers as these customers are more profitable to the banks and therefore more important to keep. All adjustment parameters have a negative sign, which is in accordance with theory. By looking at the significance of the adjustment parameter we conceive that there exists a long run relationship between the money market rate and the deposit interest rate, i.e. they are co-integrated.[15] To conclude, all coefficients were significant and the signs are inline with economic theory.

[15] ECB working paper nr 126., p. 10

Table 3. Results on the short-term pass-through for the saving accounts.

Saving Accounts Variable	SEK 0-100' Coefficient	P-value	SEK 100'-250' Coefficient	P-value	SEK > 250' Coefficient	P-value
Constant	-0.031	0.035	-0.035	0.043	-0.028	0.093
Adjustment parameter$_{t-1}$ (residual)	-0.242	0.000	-0.281	0.000	-0.394	0.000
T-bill differential	0.425	0.000	0.333	0.000	0.369	0.000
Adj. R-square	0.266		0.192			

By including lags in our model the results appear strikingly different. The immediate pass-through declines considerably for all accounts, indicating a slower immediate pass-through effect. During the same month as the adjustment is made the pass-through lies between 0.173 and 0.283.[16] The adjustment in the deposit interest rate also reflects changes made in the money market rate during the previous month, in our sample ranging from 0.358 to 0.516[17], which indicates that the pass-through in the past month is even greater than the immediate pass-through. Adding this up the pass-through after two months falls out to be between 0.605 and 0.693[18]. The adjustment parameter decreases radically when including one lag, which can be interpreted as the speed towards equilibrium becomes slower. However these results must be considered with caution since the significance of the coefficients is noticeably lower.

[16] When including lags of the independent variable in the model, the pass-through is calculated as follows: α_1 / 1- α_4, where α_1 is the money market differential and α_4 is the lagged deposit interest differential.
[17] ibid
[18] When including lags of the independent variable in the model, the pass-through is calculated as follows: $\alpha_1 + \alpha_3$ / 1- α_4, where α_1 is the money market differential, α_3 the lagged money market differential and α_4 is the lagged deposit interest differential.

Table 4. Results on the short-term pass-through for the saving accounts with lagged independent variables.

Saving Accounts with lag Variable	SEK 0-100'		SEK 100'-250'		SEK > 250'	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Constant	-0.011	0.332	-0.009	0.544	-0.011	0.481
T-bill differential	0.243	0.000	0.144	0.050	0.232	0.002
$T\text{-bill}_{t-1}$ differential	0.352	0.000	0.428	0.000	0.335	0.000
$Deposit_{t-1}$ differential	0.142	0.030	0.171	0.010	0.063[19]	0.352
Adjustment $parameter_{t-1}$ (residual)	-0.069	0.206	-0.082	0.204	-0.199	0.011
R-square	0.378		0.329			

5.3 Asymmetry

If the banking industry would be completely competitive we would expect to neither find any signs of pass-through sluggishness nor any asymmetry effects. However our previous findings of incomplete pass-through indicate that the Swedish banks are experiencing some kind of market power, which could have an effect on the interest rate setting behavior by banks. Signs of asymmetry were first documented in the well-known paper by Hannan and Berger (1991). On the other hand recent papers by Heffernan (1997) and Hofmann & Mizen (2002) find no strong evidence of asymmetry in the price setting of interest rates.

The results from our study indicate that asymmetry exists in the adjustment parameter ≥ 0 on all accounts and all coefficients are significant. When comparing the adjustment speed for positive disequilibrium's' with the symmetric model, where no consideration is given to potential asymmetries, the results appear quite different. For example in table 3 the adjustment

[19] When excluded from the model the other variables showed similar coefficient values.

parameter on the saving account 0-100' has the coefficient of -0.242 compared to the asymmetric model where the positive adjustment parameter for the same account has the coefficient of -0.570, a difference of 0.228. The result can be interpreted as; when the deposit rate is above its long run equilibrium level, the adjustment speed towards equilibrium is faster than in cases when interest rates are below equilibrium. Also the coefficient for the adjustment parameter < 0 indicates asymmetry but no clear conclusion can be drawn since the coefficients are insignificant (except for the account > 250' which is significant on the 10 % level).

Table 5. Results of the asymmetry effects from the adjustment parameter approach.

Saving Accounts	**SEK 0-100'**		**SEK 100'-250'**		**SEK > 250'**	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Constant	0.026	0.213	0.023	0.353	0.004	0.856
T-bill differential	0.381	0.000	0.284	0.000	0.352	0.000
Adj. parameter ≥ 0	-0.570	0.000	-0.590	0.000	-0.574	0.000
Adj. parameter < 0	0.024	0.779	-0.007	0.949	-0.206	0.100
R-square	0.321		0.235		0.274	

When instead estimating the asymmetry effect using t-bill differentials instead of the adjustment parameters we find similar results. A decrease in the t-bill interest rate appears to have a much greater impact on the deposit interest rate than a t-bill increase. Also in this case adjustments in the t-bill rate leading to deposit rate decreases turns out to be significant while t-bill rate increases are not. One explanation for the insignificance might be the few observations of interest rate increases during the time-period covered. Furthermore comparing these results with the result from the symmetric model in table 3 the existence of asymmetry is even more emphasized.

Table 6. Results of the asymmetry effects from the T-bill differential approach.

Saving Accounts Variable	SEK 0-100'		SEK 100'-250'		SEK > 250'	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Constant	0.027	0.138	0.016	0.453	0.019	0.379
Adj. parameter$_{t-1}$	-0.235	0.000	-0.263	0.000	-0.381	0.000
T-bill differential ≥ 0	-0.148	0.253	-0.177	0.264	-0.093	0.543
T-bill differential < 0	0.724	0.000	0.601	0.000	0.609	0.000
Adj. R-square	0.361		0.250		0.310	

5.4 The impact of market concentration on pass-through and asymmetry

To investigate whether market concentration in the banking industry affects the degree of pass-through to deposit interest rates we divided our time period in to three different sub samples, characterized by similar concentration ratios (HHI)[20]. The results from these regressions show strong indications of a relationship between market concentration and the degree of pass-through. The degree of pass-through was found to be lowest during the period between 1997 and 2000 when the concentration ratio showed the highest values, while it was markedly higher during the preceding and following years.

[20] Only the 0-100' saving account were considered when estimating the relationship between pass-through and market concentration as we expect to find similar results for all accounts.

Table 7. Long-run pass-through comparison between three time-periods, on the 0-100' account.

Saving Accounts	**SEK 0-100'**					
Period	**1993 – 1996**		**1997 – 2000**		**2001 - 2005**	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Constant	-1.496	0.068	0.318	0.363	-1.373	0.001
T-bill	0.976	0.000	0.269	0.019	0.766	0.000
Adj. R square	0.762		0.935		0.938	

Testing for differences in asymmetry among our sub samples and relating it to the concentration levels, we discern that the asymmetry seem to have diminished in recent years. It could be discussed whether this could be due to increased competition on the banking market. The number of joint-stock banks and foreign banks has increased from 15 to 50 from year 1990 to 2004. This increase is mainly due to the entry of so called "niche banks" on the Swedish banking market, reorganization from pure saving banks (Sparbanker) to joint-stock banks and finally the entrance of several foreign branches, consequently reducing the banks market power.[21] Another explanation for the decrease in asymmetry is related to the theory of switching costs and information costs facing individuals. It seems reasonable to assume that bank customers of today have easier access to information regarding offers from different banks. In addition the growth of internet banking implies that having a retail bank outlet close by should be less important for the choice of bank. For these reasons one may expect consumers to be more open to switch banks.

[21] Banker i Sverige: Faktablad om svensk bankmarknad, Svenska bankföreningen, 2005

Table 8. Asymmetry comparisons between three time-periods, on the 0-100' account.

Saving Accounts	**SEK 0-100'**					
Period	**1993 – 1996**		**1997 - 2000**		**2001 - 2005**	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Constant	0.031	0.725	0.035	0.095	-0.021	0.461
T-bill differential	0.307	0.053	0.098	0.242	0.238	0.059
Adj. parameter ≥ 0	-0.612	0.032	-0.699	0.000	-0.333	0.042
Adj. parameter < 0	0.037	0.867	0.114	0.435	-0.442	0.017
R-square	0.137		0.559		0.292	

6. CONCLUSION

In this paper our main purpose was to examine sluggishness in pass-through of market interest rates, with comparable maturity, to interest rates on Swedish banks' saving accounts. Furthermore we aimed to investigate the possibility that banks tend to be more reluctant to raise deposit rates than to decrease them, in other words if there exists price asymmetry in the interest rate setting by banks. Finally, we search for evidence of a relationship between the degree of concentration and interest rate sluggishness.

To carry out the task we applied the error correction framework, including Treasury bill rate differentials and the error correction term as independent variables. In an alternative model we also included lagged differentials of the interest rates on both the Treasury bill and deposit interest rate in order to find the appropriate lag-length. The results indicate that the interest rate pass-through on the Swedish retail banking market is not complete in the long-run, and that it takes approximately 4 months to reach the long-run pass-through.

Two alternative models are used to measure the asymmetry. In the first approach we applied the error correction term to estimate the differences in pass-through effect between times when the interest rate is above or below its long run equilibrium value. In the second approach we compared the pass-through effect of increases and decreases in the money market rate with the long-rung general pass-through effect. Our findings suggest that Sweden, in similarity with other countries, exhibits asymmetry in the interest rate price setting. When the t-bill rate is decreasing, alternatively the deposit interest rate is above its long-run equilibrium level, the pass-through effect is found to be significantly higher than the average pass-through. For t-bill rate increases the pass-through effect to saving accounts are smaller than the average pass-through but this effect is not statistical significant.

In the final section we used sub samples for three different time-periods to investigate the relationship between market concentration and the degree of long-run pass-through. Our results indicate that this correlation exists, as the pass-through effect is found to be highest during the years with the lowest concentration indexes.

Our findings have implications both for the Swedish overall financial system as well as from a micro or consumer perspective. According to macro economic theory and the transmission mechanism the pass-through of changes in the market interest rates to bank's interest rates should be complete, for the economy to be in equilibrium. When in equilibrium, an economy's monetary policy is efficient in its ability to control inflation, as effects of changes in the base rate are more easily predictable. Our findings imply that the transmission mechanism is not fully efficient because of misallocation costs. From a micro perspective not complete pass-through and asymmetry imply losses for the consumers due to inadequate competition on the Swedish banking market.

However, our finding show that the pass-through has increased over the last years at the same time as the concentration level has decreased. One possible explanation may be that the Swedish banks are today operating in a more competitive environment where the entrance of "nische" banks and foreign branches possess a prominent role. This new environment and the fact that customers today are faced with less information costs because of technology advancements forces the banks to be more customers oriented.

As both domestic and foreign branches have entered the Swedish banking industry in recent years and challenged the existent dominant actors a suggestion for further research within this field is whether this increased competition will have a prominent effect on the degree of deposit interest rate pass-through in the future. We furthermore find it interesting to do a similar research as in our thesis but instead of focusing on the deposit interest rate apply it on the banks' loan interest rates. Finally, we believe it would be

intriguing to compare the interest rate rigidity of the larger banks with the one of the smaller, so called "nische" banks, to see if any differences exist between them.

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