Testing for Market Power in the Swedish Banking Oligopoly

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ABSTRACT

The purpose of this paper is to examine the degree and art of competition in a domestic bank market. It is the first attempt to use the oligopoly model developed in Oxenstierna (1998) in empirical research. A quasi multi-product (loans and deposits) banking application of that paper's basic game theoretic model is developed, allowing for asymmetries in cost levels and two different types of product differentiation. The model is then solved for different theoretical equilibria. The model has enough structure for direct use in the empirical application - in this case in an analysis of competition in the Swedish bank oligopoly. All market parameters are derived from estimating *n* bank-specific demand equations and an aggregate market demand equation for each market. Since all behavioural equations are provided in the theoretical model there is no need for econometrical estimation of bank-level conduct. Results show that there was significant market power in both the loan market and the deposit market, although with a strongly time-varying pattern. The overall picture of conduct, is that pricing policies are less competitive in the deposit market. The economic cost level constitutes a bottom level for pricing policies in the loan market, and attempts to establish higher spreads are not sustainable in the long run. It was also possible to evaluate the conduct of individual banks. Finally, welfare losses to the society from non-competitive pricing were calculated. They are around 1.1% of GDP as a yearly average during the sampling period (1989-97). The paper also analyses the empirical transmission of money market rates into loan and deposit rates, and finds evidence of significant stickiness mainly in the loan market.

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1 Introduction

The first purpose of this essay is to examine the degree and art of competition in a domestic bank market, where entry has not been free due to legal or economic entry barriers. The paper also aims at developing the new methodology for empirical work in the study of oligopoly markets set out in Oxenstierna (1998). A full-fledged asymmetric oligopoly model based on non-cooperative game theory is employed and its application is demonstrated in a quasi multi-product analysis of the Swedish banking markets (deposits and loans). Not only the market performance can be analysed over time, but also the conduct of individual banks. The individual banks' empirical conducts are related to an analytically deducted scale of game theoretic optimal conducts, and welfare consequences of the conducts found can be evaluated as quantified changes in consumer surpluses.

As pointed out by Berg and Kim (1994), any study of performance, or efficiency in scale or scope in banking, should preferably be based on an analysis of market structure and conduct. The reason for this is that inefficiencies have been shown to significantly dominate over economies of scale or scope in recent empirical studies of banking industries, see, e.g., Berger and Humphrey (1992). This implies that the latter are of secondary importance for economic policy in the field of banking. This study aims to advance the understanding of the importance of market structure and conduct in the banking industry, thus establishing a better basis for empirical studies of performance and efficiency.

Many authors, usually using a model formulation with conjectural variations in Cournot competition have modeled the hypothesis of oligopolistic interaction in banking.[1] In Oxenstierna (1998), motives are given for basing empirical industrial organisation research on a full-fledged game-theoretic model, as compared to conjectural variations models. The banking model developed in this paper reflects specific banking features in that it is a multi-product, asymmetric oligopoly model. It is concurrently asymmetric between banks in terms of their cost functions, and in two different types of product differentiation.

The advantage of this approach is that:

- The econometric work regarding estimation of the market's competitive structure is simplified in comparison to conjectural variations models: It only requires estimation of aggregate market parameters for a linear market demand function[2], and n firm-specific demand functions.[3] The behavioural equations

[1] The conjectural variation is defined as the reaction a firm conjectures about the output of its competitors if it was to change its own output.

[2] For the oligopsonistic market of deposits, the supply equation is estimated.

are all provided as different theoretically deducted game-theoretic equilibria, and require no estimation. With n firms in the market, only $(n + 1)$ parameters have to be estimated econometrically in order to completely define the market's competitive structure (assuming that the sizes of banks can be established by direct observation).

- Individual bank conduct is evaluated over time and related to different regimes. Individual conduct can differ between banks.
- Evaluations of welfare aspects are based on the concept of consumer surplus and are also provided for on firm level in the theoretical model. Welfare evaluations thus require no additional econometric work.

In section 2 of this essay a quasi multi-product model of oligopolistic competition in non-symmetric bank markets is elaborated, built on a base version of the oligopoly model worked out in Oxenstierna (1998). In section 3, a method for empirical application of the model in a domestic banking market is proposed, and applied in an analysis of on-balance sheet conduct and performance of Swedish banks. There is also a separate analysis of the empirical transmission of money market rates into loan and deposit rates. In section 4 some conclusions are drawn.

2 A Multi-product Asymmetric Oligopoly Banking Model

A model of the basic banking markets, deposits and loans, should first of all recognise the multi-product character of the bank's activities. The gross margin a bank earns has to be allocated in parts, each representing the opportunity cost of the asset or liability in question. One way of doing this is to peg the bank as a financial intermediary around an (internal) transfer interest rate, normally equal to the short-term money market interest rate or the interbank interest rate. This market rate then represents a market valuation of the opportunity cost of liquidity operating in the bank. Furthermore, the banking model should correctly handle the dual character of deposit liabilities. These are first of all an output, i.e. a product sold in a market. But they are also the major part of the funding, needed to sell loan products. The first aspect has implications for the specification of demand functions, and the second aspect affects the definition of cost functions and the method of their estimation (see further section 2.1).

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[3] In the specific case of banking, the banks' operating costs must also be disaggregated between the market for loans and the market for deposits. This is due to the multi-product character of banking, and the lack of disaggregated cost data from banks' annual reports. See further section 3.2.2.

Six fundamental assumptions referring to both markets alike are made in the model:

1. Banks are assumed to operate in markets that can be characterised as asymmetric oligopoly markets. Three types of asymmetry are considered; banks may differ in: *i.* The relative size of the market pertaining to each bank, reflecting a size component of product differentiation, *ii.* A relative price component of product differentiation, and *iii.* Banks' cost levels. All these asymmetries influence the strategic interaction.

2. Both types of output (deposit liabilities and loans) are assumed to be differentiated between the banks, i.e. customers do not perceive the services provided as homogenous.

3. The banks interact strategically when they make decisions about interest rate levels. In so doing, they are assumed to be profit maximisers according to the conditions given by the different market structures and conducts.

4. Banks are price takers in the money market and in the input markets.

5. There are no explicit demand interrelationships between the loan market and the deposit market. Any interaction between the two markets is transmitted only through the money market and the interest rate set there. Internally in each bank, there is a non-strategic opportunity cost relationship between the two markets, since the money market interest rate constitutes a common opportunity cost of liquidity.

6. There are no cost complementarities in the cost function, i.e. no economies of scope. The cost function is further assumed to be linear in the short term, i.e., $C_i(q_i) = c_i q_i$ within each period for each of the two markets.

Points 1, 2 and 3 indicate that we might encounter market power in the bank output markets. Assumptions 4, 5 and 6 make it possible to separate the analysis of the two output markets, except for the joint money market interest rate. Further comments to these assumptions and additional assumptions referring to the specific markets and the cost functions are made in the next section.

There are two possible sources of market power: Non-competitive conduct and/or product differentiation. In banking, the underlying product might seem to be homogenous ("money"), which could lead to a model formulation where market power is wrongly attributed to conduct, when it in fact stems from product differentiation. An empirical banking model should therefore test for product differentiation. Product differentiation includes such factors as the strength of the bank's brand name, the general character of the establishment, efficiency, and all the personal links that attach the customers. In so far as these and other intangible factors vary from bank to bank, the service provided in each case is differentiated from the customers' point of view. Banks also actively build relationships with customers in order to generate (private) information which is crucial to the bank in the loan market and is costly to duplicate by other banks (Diamond (1984), Boyd and Prescott (1986)), or in order to cross-sell products. Relationships tend to grow stronger over time (Petersen and Rajan (1994), Berger and Udell (1995)), although pricing conduct tend to shorten the life-length of the relationship (Greenbaum *et al.* (1989)). Also from the customer's point of view the relationship-building might have a value, in which case it will increase product differentiation.

2.1 The treatment of demand interrelationships

In the literature on multi-product oligopoly it has been observed that demand interrelationships and/or cost complementarities between the markets can give rise to strategic linkages across markets (Bulow, Geanakoplos and Klemperer, 1985). In banking, demand interrelationships may emanate from revenue economies of scope, meaning that customers can lower their transaction, transportation and search costs by consuming the various financial services jointly from the same bank. Such customer benefits will be observed either directly by a willingness to pay higher interest rates or fees for the jointly provided services, or indirectly by accepting lower interest rates on deposits. In this way, banks can increase their revenues, or lower their funding costs, by supplying their services jointly rather than separately.

Here the market interrelationships have been modelled differently, by abstracting from direct demand interrelationships for the two markets. Market interrelation takes place only through the interbank money market which establishes a joint opportunity cost for both markets, equal to the money market interest rate. There are two justifications for this simplifying assumption: *i.* empirical tests for cross-price relationships between the two markets are unable to establish any statistically significant existence of such effects in Swedish banking, either on any of the two aggregated markets, or for any of the five individual banks, see further section 3.2.3 and *Appendix 2*; *ii.* Berger et al. (1996) found no evidence of statistically significant revenue economies of scope in US banking for any of a number of various model specifications and data sets.[4]

[4] Berger *et al.* (1996) is the only known such study. Their modelling approach does not allow them to distinguish between the existence of market power and the existence of revenue economies of scope. The non-existence of the latter does not rule out market power in each separate market, only that market power is not exercised through extracting higher prices for joint production.

2.2 The Market Structures

In the previous sections the bank has been conceptualised as a financial intermediary, separating its decision-taking in the deposits and loans markets. Here this view will be pursued by building a model of the market structure where any interaction between the two markets is transmitted only through the exogenously given money market interest rate, p_M. The model is a static, differentiated goods oligopoly model, with asymmetries between banks in the levels of operating costs and product differentiation, where the latter has one relative size component and one relative price component.

Define p_i as the net interest rate charged for loans, $p_i \equiv p_i^{Loans} - p_M$, where p_M is the money market interest rate. Specifically, the deposit market interest rate is defined net of the money market interest rate: $\tilde{p}_i \equiv p_M - p_i^{Deposits}$. Let the amount of loans demanded from the i^{th} bank be given by:

$$L_i = s_i\left[\alpha - \beta\left(p_i + \gamma_i\left(p_i - \bar{p}\right)\right)\right], \tag{1}$$

and let the amount of deposits supplied to the i^{th} bank be given by:

$$D_i = \tilde{s}_i\left[\tilde{\alpha} - \tilde{\beta}\left(\tilde{p}_i + \tilde{\gamma}_i\left(\tilde{p}_i - \tilde{\bar{p}}\right)\right)\right], \tag{2}$$

where:

$\bar{p} = \sum_{j=1} s_j p_j$ is the weighted average loan interest rate of the n banks so that p_i - $\bar{p}$ is the deviation between own price and the weighted average price.

α, β are parameters for the linear aggregated market demand function for loans. α is the intercept and β is the slope. β is assumed to be positive, so that L_i is a negative function of p_i.

γ_i is an exogenous parameter that measures the level of substitutability for bank i (i.e. the degree of product differentiation) between its product and the products offered by the other banks in the market, as related to price differentials. By assumption, $\gamma_i > 0$.

s_i is an exogenous parameter for the relative size of the market of firm i. $0 < s_i < 1$ and $\Sigma s_j = 1$. As seen from (1), s_i is a shift parameter for the level of quantity demanded and represents a size component of product differentiation.

n is the number of banks in the market.

Variables and parameters with a tilde (~) on top are for the deposit market, and are defined in an analogous way to the loan market.

2.2.1 Theoretical equilibria and welfare effects

The full derivation of the different game theoretic equilibria for the basic market structures (1) and (2) in the model used here is provided in Oxenstierna (1998). The model is solved for different game-theoretic equilibria[5], which include both price-setting behaviour and quantity-setting behaviour. In this way any confusion whether banks are price-setters or quantity-setters is avoided. In empirical studies of the loan market, banks are often thought of as quantity setters.[6] In periods of rapid asset growth, e.g. like the second half of the 1980s in Sweden, banks seemed to compete for market shares by actively selling loans. Also, during periods of banking crisis characterised by a "credit crunch", banks seem to operate mainly as quantity setters. It is therefore clearly relevant to include the non-cooperative quantitative setting equilibrium in comparison with other equilibria. The only differences to the base model in Oxenstierna (1998) lie in the above given definitions of prices, which are calculated net of the money market interest rate, and in the definition of costs. For the loan market, the cost includes the opportunity cost of equity capital, as reflected in the capital adequacy ratio, so that total costs are the sum of operating costs allocated to loans, costs for expected loan losses, and equity costs. For the deposit market the costs include the operating costs allocated to deposits and the opportunity cost arising from reserve requirement on deposits. Firm-specific costs and the market interest rate level p_M will be reflected with a positive sign in the various optimal interest rate levels, that are given by the different market regimes.

2.2.2 Discussion of the model's aptness in the general banking context, and to the Swedish banking markets in particular

Prices are usually seen as the major instrument of transmitting information about market conditions or product quality. However, it is easy to find examples of markets where quantities, in the form of relative firm sizes or market shares, are of major importance in influencing consumers' choice. Retail banking markets seem to display that kind of consumer behaviour, where a bank's size signals confidence, or simply availability through branch networks to the customers and thus, seemingly, influence their very preferences. The model defined above is de-

[5] Nash equilibrium with respect to competition in prices, Nash equilibrium with respect to competition in quantities, the joint maximisation of profits (monopoly price and quantity), and competitive pricing. Also a best reply to the monopoly price is deducted, although this is not an equilibrium solution.

[6] See, e.g., Berg and Kim (1994) and Berg and Kim (1998). Berger et al. (1996) and Humphrey and Pulley (1997) take the opposite view.

signed to capture these effects by letting demand being influenced by relative firm size.

Recent methodological developments in the empirical study of oligopoly markets address the issue of product differentiation in detail. Berry (1994), develops a static oligopoly model where there is a range of observable product characteristics, as well as a range of unobservables.[7] In the study of service markets, like banking, and most product markets, rich data sets on product characteristics and on demand data (prices and quantities) related to these are rarely available. One of the few *observable* characteristics in official data sets that distinguishes retail banks in terms of product differentiation is their relative sizes. These are highly correlated to the size of the branch networks of Swedish banks, since all the five banks have nationwide coverage. They also offer very similar product sets to consumers. Furthermore, payments services that are offered to customers, such as giro systems and automatic teller machines, are not a distinguishing factor between Swedish banks, since they are provided by jointly owned organisations. For these reasons, the models and methods developed by Berry and others are not very suitable in a banking context, where the typical data set contains only prices, quantities and cost variables.

Another issue is whether the derived model is a suitable tool for testing competition in Swedish bank markets, apart from the fact that it accords well with the available data (prices, quantities, relative sizes, and costs). Some characteristics of Swedish banking might help to answer that question. The retail banking markets in Sweden are deregulated since 1985. The previous regulations comprised a limit on the total amount of lending; a liquidity quota that forced the banks to hold large amounts of government and housing bonds; and a regulation of lending rates (Englund, 1990). The abolishment of these regulations meant that the banks were free to decide both the composition of their balance sheets and their interest rates without interference from the Riksbank (the Swedish central bank). Until recently, entry to the bank market was severely restricted due to charter requirements. Only since 1994 a number of small "home-banks" have been established.

The Swedish banking system is highly concentrated with a concentration ratio for the five biggest firms of more than 86 percent in both markets. After a deep banking crisis in the beginning of the 1990s, there were five major Swedish banks, see *Table 1* in Oxenstierna (1999).[8] Each of them has nation-wide branch networks. Each of them can be characterised as a universal bank that offers a full

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[7] Vesala (1998) is the first known attempt to apply this modelling technique in a theoretical model to banking.

[8] Lately, they have become four, since Swedbank and Föreningsbanken decided to merge in Spring 1997. However, this event falls outside the sample period, which is from 1989:1 – 1997:2.

set of retail services for individuals and corporations, and a full set of wholesale services for major corporations. Another feature is that they all have centralised financial management and treasury functions. On basis of the business they do and how they operate, it would not be improper to characterise them all also as commercial banks, even though two of them have their roots in the long traditions of savings banks (Swedbank) and cooperative banks (Föreningsbanken). Additionally, there are fundamental asymmetries between the banks. The five major banks differ in market shares from about 10% (Föreningsbanken) to about 25% (Swedbank). Cost levels range from about 1.5% to about 3.2%, defined as operating costs./.total assets (figures from annual reports 1995).

Swedish banks operate with a spread between deposit and loan interest rates that is larger than economic costs, see *Fig. 1*. It is immediately evident from the figure that the dramatic changes in spread over time cannot be explained by changes in economic costs, since the latter are fairly constant during the sample period. This fact might indicate that banks exercise their market power. - Based on these short characteristics we can conclude that the particular game theory based oligopolistic model developed above might indeed be suitable for an analysis of competition in the Swedish banking markets.

3. Testing for Competition in the Swedish Banking Oligopoly

3.1 The method of empirical application

The model developed above can be used for a test of competition in a domestic banking market. The method of applying the model empirically comprises the following steps:

1. Obtain data on output volumes and interest rates, both regarding banks' interest rates and p_M, as well as bank cost data. See section 3.2.1.
2. Estimate the marginal costs, c_i and $\widetilde{c}_i$ respectively, from a multi-product cost function augmented with estimated equity costs and operating costs for expected loan losses. See section 3.2.2.
3. Estimate the loan market demand function, as well as the n firm-specific loan demand equations. With these, and the directly observed firm sizes, the product differentiation parameters γ_i as well as the market equation parameters α, β for (1) are calculated, i.e. all market demand parameters are determined. The process is replicated for the deposit market. We can specifically note that

since all behavioural equations are provided in the theoretical model there is no need for empirical estimation of bank-level conduct. See section 3.2.3.

4. Calculate the theoretical equilibria for all individual banks, using the estimated parameter values. See section 3.2.4.
5. Compare the observed prices with the theoretically predicted prices. Evaluate which conduct best describes the empirically observed behaviour, e.g. by constructing minimum-squared-error terms. See section 3.2.5 and 3.2.7.
6. Calculate welfare effects of deviations from efficient pricing using the estimated parameter values. See section 3.2.8.

3.2.1 Obtaining interest rate data. Determining p_M

Banking industry data are highly comparable because of the uniform regulatory and financial reporting requirements. Furthermore, the supervisory activities exercised by regulatory bodies give some assurance as to the quality and integrity of the data. The Riksbank collects balance sheet data and interest rate data from all Swedish banks on a quarterly basis.[9] Data were collected from 1989:1, and the last observation used here is from 1997:2. Each bank reports balance sheet volumes and interest rates for three categories of customers: Corporate customers (excluding loans to /from banks and other financial corporations), households (including entrepreneurs with one-person businesses), and other customers (includes municipalities). Each customer category has eight types of accounts. Each bank reports the current interest rate in percent on each account on the last day of the quarter. Thereafter, the interest rates are weighted according to the balance on each account. However, in this study, which is the first competition study utilising this data set, I will not exploit the richness of the full data set, but aggregate the base data into two products: Deposits and Loans, respectively. The calculation of interest rates for the aggregates are done with weighting according to the volumes, i.e. with the same method that is used when the base data are compiled. From this point of view, the aggregated interest rates are comparable between banks.

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[9] The data comprises only accounts denominated in the domestic currency and are published only as market averages for the five biggest banks. However, individual bank data have been made available for this study by the Riksbank, on the condition that the identity of individual banks must remain concealed. There was a change in methodology in the collection of interest rate data for deposits from 1993:4, causing a minor discontinuity. Further comments on the data set are in Oxenstierna (1999).

Interviews conducted with financial management officers verify that banks use a basket of short-term interest rates to calculate p_M, ranging from overnight rates to 3-month money market rates.[10] I have used the 3-month T-bill interest rate daily averages, compounded to quarterly averages, to calculate p_M.[11] Smoothing corrections of p_M were undertaken with a moving average process to adjust for apparent rigidities in the adaptation of banks' loan stocks and deposit stocks to rapidly changing market interest rates, see *Fig. 2*. The reason for this is that parts of stocks have long maturities, e.g. fixed interest rate loans. Especially during the banking crisis in 1991 - 1993 these rigidities in some quarters lead to an apparently unrealistic division of the total spread between loans and deposits.

3.2.2 Estimating marginal costs

There are six aspects of the treatment of costs that require special comments, since they will influence the specification of the functions to be estimated: *i.* the possibility that cost complementarities between the two markets can give rise to strategic linkages across markets; *ii.* the practice of cross-subsidisation of deposit related services; *iii.* that funding costs are likely to be influenced by market power in deposit markets; *iv.* the treatment of loan losses as part of operating costs; *v.* the necessity to include equity costs in the cost function; and *vi.* the possibility of rent sharing.

1. The assumption made above of the absence of cost complementarities is based on empirical cost studies of banks in various countries.[12] In Oxenstierna

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[10] Interviews conducted in two Swedish banks in November 1996 by the author. Interviews conducted by Bergendahl (1989, p 390) indicate that 3-month money market rates were the prevalent choice by that time in 11 major Swedish and UK banks.

[11] The Swedish interbank market started in 1980 when the first CDs were issued. In 1982 the first T-bills were issued, which was the first step in a development towards a market based funding of the state debt. A secondary market was established and in 1983 the formal regulations of interest rates were abolished in the money market. See Blomberg (1994). One reason for using the T-bill rate, is that it is less volatile than the interbank rates. Levels of 3-month T-bill rates and 3-month interbank rates are quite the same throughout the sampling period. The time series data were obtained from The Riksbank Statistical Yearbook.

[12] See Vesala (1993, App. 6) for an overview. The general finding of the listed studies is that there is no unanimous evidence of economies of scope. See also Clark (1996) for a contemporary empirical cost study. He specifically studies economies of scope, which are found to be insignificant regardless of bank size or relative efficiency of banks. In a recent application of the Bulow et al. (1985) model on the banking industry, Vesala (1995, Ch. 4) develops a multi-product conjectural variations duopoly banking model with cost complementarities but independent demand functions. In an empirical application on the Finnish banking industry he finds evidence of positive cost complementarities.

(1999), there was some evidence presented of slight dis-economies of scope (about –1.5 per cent) in the Swedish banking market, which is of special relevance here, since this paper utilises the same dataset as in that study.

2. One specific problem in banking studies is the treatment of costs in the analysis of the banks' fund-raising activities. It has been frequently observed that banks don't charge customers the real user costs for deposit related services, e.g. payments services and ancillary services. This was a behaviour that was encouraged by deposit interest rate ceilings set by regulatory authorities, common in many countries until recently. Berger and Humphrey (1992) call this practice "commingling of implicit revenues", which are difficult to disentangle in empirical research.[13] The practice of commingling has lead some researchers to estimate the deposit market parameters not on the basis of interest rates or interest paid, but on the basis of some quantitative proxy for the activity level, such as the volume of transactions, or the number of accounts.[14] The "commingling" problem is not necessarily a problem in the model approach used here, since it is a phenomenon connected with (sub-)optimising behaviour due to price regulation in deposit markets, whereas Swedish bank markets were unregulated in this respect during the period of investigation (1989-1997).

3. In general, when estimating cost functions, it is assumed that input markets are competitive, so that input prices are exogenous. We will assume that this is the case for labour costs and other operating costs. Those cost studies of banking industries, which define deposits as an *input*, often include also deposit interest costs as an input price. Since this paper intends to test for competition in the deposit market by separating the *output* market for deposit liabilities from the output market for loans, deposit interest rates will not be included in the estimated cost function.

4. Loan losses will here be treated as a normal feature of banking. In reference to the pricing of loans, this means that there is a perceived level of *expected* losses on loan assets, i.e. a *mean* asset risk, which is priced into the loan interest rate. This risk level is unique for each bank, and for each loan product marketed. Analytically it forms part of the operating costs for loans, and need not be included as a separate item in the statistical cost function since it is by

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[13] As noted by Fixler and Zieschang (1992), a 100% reserve requirement would force the bank to charge explicitly for its deposit related services. But the reserve requirement is usually a few percentage points, which means that the bank can lend on deposits and raise revenues. These revenues can be paid in the form of a deposit interest rate, or used to subsidise deposit-related operating costs.

[14] See, e.g., Berger, Hanweck, and Humphrey (1987); Suominen (1994); and Vesala (1995).

definition allocated to the loan output. As with other components of the operating cost, we will assume that the marginal cost of loan losses is bank-specific, and constant in the short run. Swedish banks allocate operating costs for loan losses as well as equity costs only between loan products[15], therefore they will be subsequently added to the estimated operating costs for loans. This procedure reduces the number of parameters to be estimated and thus helps to remedy problems caused by a lack of data, since there are only 33 observations per bank.

5. An estimate of equity costs is needed, i.e. the risk premium to investors for running the bank as such. This risk premium is an opportunity cost of capital and reflects the risk of *unexpected* losses on assets as a *variance* of asset risk, e.g. measured as a variance of asset pricing. Equity costs will also not need to be included as a separate item in the statistical cost function, since both the banking practice and the banks' regulators define the amount of equity as related only to the amount of loans. The calculated equity costs will consequently also be added to the estimated loan cost function in a subsequent step.[16]

6. Rents earned because of market power leading to high intermediation margins, i.e. high spread between deposit and lending interest rates, do not necessarily imply a high profitability as measured by some accounting based ratio like return on equity. A high spread might well be accompanied by a low operating efficiency or rent sharing with labour, which would result in excess staffing or excess wages, both leading to high operating costs. In the empirical application to the five Swedish banks below, I will therefore estimate operating costs individually, assuming only that there is a common technology in the banking industry.

Considering these remarks, the task is here to determine marginal costs for the different products. In order to do so, a translog cost function is estimated for the inputs that are not already allocated among the outputs. The ordinary translog cost function developed by Christensen, Jorgenson and Lau (1973) is a second order Taylor expansion series in output quantities and input prices. Using this

[15] The regulatory practice of allocating equity costs only among loan products is confirmed also as a banking practice in Matten (1996) as well as in interviews conducted by the author with financial management officers in two major Swedish banks.

[16] See Oxenstierna (1999), where the capital *asset pricing* model (CAPM) is used as a way to measure the risk premium for investors in bank equity, *r*, by evaluating a total opportunity cost of equity, $p_M + \beta_i(r_M - p_M)$. β_i is the stock market beta for the bank's stock, p_M is the risk-free market return for assets of the same duration as the bank's stock and r_M is the return to the aggregate market portfolio of stocks. See Clark (1996) for another empirical application.

methodology, the cost structure of multi-product banks can be modelled with maximum flexibility, giving explicit recognition to each of the outputs. A translog statistical cost function was hence specified in accordance with the specifications made above:

$$\ln OC = \alpha_0 + \sum_{i=1}^{3}\alpha_i \ln q_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{ij} \ln q_i \ln q_j + \sum_{i=1}^{3}\sum_{k=1}^{2}\delta_{ik} \ln q_i \ln w_k + \sum_{k=1}^{2}\beta_k \ln w_k + \frac{1}{2}\sum_{k=1}^{2}\sum_{l=1}^{2}\beta_{kl} \ln w_k \ln w_l + \varepsilon \quad (3)$$

where OC is operating cost, *i* and *j* are output indices for the three outputs, *k* and *l* are input indices for the two inputs and ε is the error term. The two major cost items that are not allocated to either of the output quantities are labour costs and other operating costs[17].

The outputs are: *i.* loans in SEK, *ii.* deposits in SEK, and *iii.* other assets than loans in SEK ("securities"). Even though securities give rise to very low operating costs compared to other assets, they are included as a separate output for the following reasons: *i.* they constitute a considerable part of total assets, see *Table 1* in Oxenstierna (1999); *ii.* they contribute substantially to banks' earnings; *iii.* they have a critical role in managing financial risks which means that they can be expected to have a strong impact on economic costs, i.e. opportunity costs for equity capital. Off-balance sheet products are excluded from the outputs since there is a profound lack of data on them; they are only reported as a net revenue item in annual and quarterly reports. On the other hand, they comprise a substantial and increasingly important activity in Swedish banks, with revenues comparable in size with the net interest revenue from on-balance sheet products in later years. In order to approximate the marginal costs for on-balance products we have to estimate the cost function for the part of operating costs that are allocated to produce them. In the absence of data indicating otherwise, we will assume that off-balance sheet products command operating costs in the same proportion to revenues, as on-balance sheet products, i.e. a similar cost/revenue ratio. This would be the optimal resource allocation if banks use the same technology to produce both on- and off-balance sheet products. Hunter et al. (1990) and Hunter and Timme (1991) do similar ad hoc allocations of total costs.[18]

[17] Other operating costs (w_2) comprises rents, marketing costs, depreciation allowances and write-down of tangible and intangible fixed assets, IT costs, etc.

[18] For a further discussion on the output vector, see Oxenstierna (1999).

Symmetry requires that $\alpha_{ij} = \alpha_{ji}$ for all i and j, and $\beta_{kl} = \beta_{lk}$ for all k and l. The following homogeneity restrictions must be imposed on the cost function in order to get linear homogeneity in the input prices:

$$\sum_{k=1}^{2} \beta_k = 1; \quad \sum_{l=1}^{2} \beta_{kl} = 0, \forall k; \quad \sum_{k=1}^{2} \delta_{ik} = 0, \forall i.$$

Factor share equations for the two inputs are obtained by differentiating the cost function with respect to input prices, and using Shephard's lemma:

$$S_k = \sum_{i=1}^{3} \delta_{ik} \ln q_i + \beta_k + \sum_{l}^{2} \beta_{kl} \ln w_l \tag{4}$$

where S_k is the share of factor costs for input k of total costs OC.

The traditional statistical tests used for inference testing require the underlying time series to be stationary since regression with non-stationary time series can give spurious results. Testing for stationarity was done with the augmented Dickey-Fuller (*ADF*) test. Results are reported in *Table A2.1* from which it is evident that all series are I(1). All series were therefore differenced once and then brought back to their mean levels.[19]

After adding an error term to (3) and attaching the share equations, the full dual system is estimated with the iterative seemingly unrelated regression (*SUR*) technique. One of the share equations is omitted at the estimation since the system of share equations is singular because of the adding-up constraint, $\Sigma S_k = 1$. The estimated parameters and their standard errors and *t*-statistics are given in *Table A2.2*. Goodness-of-fit measurements for the cost equations are in *Table A2.3*. Marginal operating costs are derived from (3):

$$MOC_i \equiv \frac{\partial OC}{\partial q_i} = \frac{OC}{q_i}\left(\alpha_i + \sum_{j=1}^{3} \alpha_{ij} q_j + \sum_{k}^{2} \delta_{ik} \ln w_k \right) \tag{5}$$

The calculated marginal operating costs based on the obtained parameter estimates are reported as averages over time in *Table 1* and as time series in *Figures 3 – 6*. For the loan market, the marginal costs are augmented with normalised operating costs for *ex ante* loan losses from new loans, and with opportunity costs for equity capital, in accordance with the specifications made above. The methods of estimating these items are worked out in Oxenstierna (1999). Since that essay uses the same data set as this one, the numerical values for these items are taken from there. As expected, the operating cost allocated to other assets (q_3) is very low.

[19] As an alternative to the more simple technique of differencing, Berndt (1991, ch 9) proposes a vector autoregressive process specification in the presence of autocorrelation. This involves applying an autocovariance matrix to the cost function (4) as well as to the factor share equations (5). However, the singularity of the factor share system "imposes severe identificability and diagonality constraints on the autocovariance matrix" (p. 478), in essence that all equations in the whole system have the same lag coefficient for all lagged variables. Since this is "a very strong restriction" (op cit), I have refrained from using the VAR specification in this case.

A number of alternative estimations were also conducted to check the robustness of the results. (1) Excluding the third output from the cost function influenced the ensuing marginal cost estimates with less than plus 5% for the deposit market and had a negligible effect on the loan market estimates. (2) Excluding the cost share equations from estimation influenced the ensuing marginal cost estimates with between plus 5 to 10% for the two-output model, and with minus 5 to 10% for the three-output model. However, the significance of estimated parameters was lowered.

	Loan MOC, excl. pred. loan losses	Predicted MOC for loan losses	MEC for equity capital	**MEC for loans; sum of col. 2-4**	**MEC for deposits**	**MOC for other assets**
Bank 1	1.37	0.43	0.32	2.12	1.16	0.009
Bank 2	2.20	0.47	0.32	2.99	1.30	0.037
Bank 3	1.47	0.43	0.27	2.17	1.24	0.006
Bank 4	1.98	0.50	0.24	2.72	1.54	0.045
Bank 5	1.71	0.22	0.32	2.25	1.33	0.060

Table 1. Marginal costs reported as yearly averages over time in percent of the amount of total loans, total deposits, and other assets, respectively. MOC = marginal operating cost, MEC = marginal economic cost. Values in columns 2, 6 and 7 are calculated from (5) using the estimated parameter values from (3) and (4). Values in columns 3 and 4 are estimated in Oxenstierna (1999).

3.2.3 Estimating demand equations. Determining market parameters.

The first stage is to estimate the market demand equations for the two markets, loans and deposits.[20] The resulting estimates will allow us to determine the market equation parameters α *and* β for each of the markets.

When estimating loan demand and deposit liability demand functions from time series, we again test for stationarity of all variables with the *ADF* test. Results are reported in *Table A2.1*, from which it is evident that all series are I(1). Additionally, p_M and other series included in the estimates below are also all I(1).

[20] It should be noted, that I estimate demand equations and not demand elasticities. The reason is that time series data will yield time-dependent, unstable values for structural parameters if the parameter estimates from linear demand equations are used first to calculate elasticities and then to deduct parameter values for the theoretical model. The only alternative would be to estimate a constant elasticity function, but that would presuppose a specific functional form for market demand, which is not compatible with the linear form of the market demand equations (1) and (2).

Economic theory tells us that quantity is the dependent variable in the market demand relationship. This assumption was tested with the Granger causality test. For both the loan market and the deposit market, results are that we can reject the null hypothesis that the price does not Granger cause the market quantity. We are also unable to reject the reverse null hypothesis, that the market quantity does not Granger cause the market price, on the 5 per cent level of significance (*F* -test) for both markets.[21] Since it is clear from both economic theory and from these Granger causality tests that quantities are the dependent variables in both markets, I will follow the Engle and Granger (1987) two step method in order to establish co-integrating vectors and error correction mechanisms (*ECM*).[22]

Economic theory, and the model used here, defines the demand function as having quantity as the dependent variable and own-price as one of the independent variables. Apart from that, there is no theoretical prescription on how a single-market demand function might be constituted, for what reason it seems advisable to apply a "general to specific" modelling approach.[23] The general model is in an autoregressive distributed lag (*ADL*) form, where the dependent variable is a function of its own lagged values and the contemporary and lagged values of all explanatory variables. For a generalised demand function, we get the following *ADL*(*m,n:k*) formula, where *m,n* are the numbers of lags, *k* is the number of exogenous variables and the error term $u_t \sim \mathrm{IID}(0, \sigma^2)$:

$$q_t = \delta_0 + \sum_{i=1}^{m} \delta_i q_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{n} \delta_{ji} x_{j,t-i} + u \tag{6}$$

3.2.3.1 Estimation technique and results

In the current setting, the theoretical model in Oxenstierna (1998) defines four different equilibrium price equations (supply relationships), but does not provide any obvious link between them that can be used in the estimation. There is on the other hand no need to make a systems estimation of the demand equation and the

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[21] The tests were made with one lag for the deposit market and four lags for the loan market. There are 33 observations and the *F* statistics are 3.77 for the loan market and 7.13 for the deposit market.

[22] An alternative would be the more demanding Johansen (1989) method, built on the vector autoregressive (*VAR*) methodology, primarily designed for problems where there are no *a priori* exogenous variables.

[23] The general to specific modelling is proceeding from a fairly unrestricted dynamic model, which is subsequently tested and reduced in size by testing different restrictions, see Charemza and Deadman (1997).

price equation simultaneously, since all parameters that are needed to feed the theoretical model are defined either in the demand equation or in the exogenously determined *cost* equation.[24]

Demand parameters can be consistently estimated in the presence of unobserved demand factors via the use of traditional instrumental variables methods, such as the two stage least squares method (*TSLS*), or the generalised method of moments (*GMM*). Correlation between the price variable and the error term suggests the use of instruments for prices, assuming that the demand error is uncorrelated with the instrument. Demand is specified to have a nonzero disturbance, which is associated with unobserved determinants of demand that are correlated across consumers in the market. If these disturbances are known to the suppliers and the consumers (and if demand depends upon them, one expects this to be so), then equilibrium quantities and prices will depend upon the disturbances. The simultaneity problem and the need for alternatives to ordinary least squares estimation techniques arises from this relationship between the disturbance and price.

Predetermined (i.e. exogenous and lagged endogenous) variables and cost function variables are thus used as supply-shifting instruments for endogenous prices in order to identify demand. Additionally, it seems relevant to take into consideration the possibility that the market conduct has been changing during the sample period, since spread levels have displayed a specific pattern over time, cf. *Fig 1*. In order to control for this, I have added a Lerner index, lagged one period, as a proxy for changes in the market conduct, to the list of instrument variables.[25]

The **loan** market *ADL* structure was tested with $m, n = 5$ and the following extensive range of candidates for exogenous variables: the own-price (p^L, which is net of the money market rate), the deposit market net interest rate, the short-term money market rate (p^M), the bond market rate for 5-year government bonds (p^{obl}), the GDP (Y), the stock market index, the consumer price index, and household

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[24] However, it might be possible to estimate a simple mark-up supply relationship simultaneously with the demand equation, in order to improve the significance of demand parameter estimates. But since estimates obtained from estimating the demand equations separately are highly significant for all 12 equations, this has been deemed not necessary.

[25] The Lerner index is defined as $(p - MC)/p$. All estimations were also executed without the lagged Lerner index as instrument variable. Results were not much influenced: The value of the estimated price parameter declined with 2% for the loan market and increased with 3% for the deposit market. Another attempt to control for changes in conduct was made by including a market concentration variable (CR5) as an instrument variable. This had a negligible effect on the estimates. Also the level of credit losses were tried as an instrument variable, the idea being that non-normal credit losses during the banking crisis would influence conduct. Also this had a negligible effect on the estimates.

debts as a percentage of disposable income (*Z*). The latter variable captures the fact that households lowered their debt levels from around 140% debt to disposable income in 1989, down to 85% in 1996, i.e. a deep change of preferences for having debt. The lowered household debt levels during the 1990s are due to some abstruse structural changes taking place in the early 1990's (see Berg, 1997), with *i.* a tax reform that together with other factors raised loan rates after tax with ca seven percentage points from 1990 to 1995, *ii.* a "credit crunch" during the banking crisis in 1991–3, *iii.* worsened economic outlooks for households, and *iv.* demographical changes. The stock of household debt thus diminished from 990 billion SEK in 1989 to 730 billion SEK in 1996.[26] The debt level was in 1997 back at the ratio it had before the great expansion of credits commencing in the middle of the 1980's.

Non-financial firms also show a declining trend of bank loans as a proportion of their total debt, from around 39% in 1989 to around 29% in 1997. This trend largely reflects the "credit crunch" during the banking crisis, including write-offs of bad debt. The decline entirely affects the credit lines to corporations, whereas fixed amount loans display a stable growth. There is a steady trend in banks' loan portfolios towards more of corporate loans (from 20% of total loans in 1989 to 45% in 1997), whereas corporate credits are declining somewhat (from 15% of total loans in 1989 to 11% in 1997). Nedersjö (1995) notes that large credit-worthy corporations increasingly have raised financial capital directly on the financial markets, leaving banks with a larger share of comparatively smaller and possibly riskier corporations in their loan portfolios. She suggests that this could explain the increasing (loan) interest rate spread from 1989-1994, since corporate credits command a somewhat higher interest rate than corporate loans. However, there are no data available on the size distribution of banks' corporate loan portfolios. The interest rate spread is also on the same level in 1997 as it was in 1989, see *Fig. 1*. I conclude that it is unlikely that structural changes in banks' corporate loan portfolios are an important factor in explaining the loan pricing conduct during the sampling period.

Estimation was done with *TSLS* on variables in levels. Predetermined variables were included based on the analysis of variance (*ANOVA*) technique. The following *ADL* structure resulted, with all parameters being significant on the 1% level, except p^{obl}, which is significant on the 5% level (with t-statistics in parentheses):

[26] Data for this and for the household savings ratio used in the deposit equation below were obtained from Nationalräkenskaperna and Finansräkenskaperna. A thorough statistical and econometrical analysis of these trends is found in Berg (1997).

$$L_t = 226 + 0.553L_{t-2} - 25.4p_t^L + 2.38p_t^{obl} - 7.11p_t^M + 32.5Z_t \quad (7)$$
$$(5.45) \quad (6.84) \quad (-5.75) \quad (2.18) \quad (-8.22) \quad (5.48)$$
$$R^2=0.92,\ R^2_{adj} = 0.91,\ DW = 1.77$$

The **deposit** demand function was tested in a similar fashion, with *m,n=5* and the following candidates for exogenous variables: the money market rate minus the own-price (p^D), the loan market interest rate, the short-term money market rate (p^M), the bond market rate for 5-year government bonds (p^{obl}), the GDP (Y), the stock market index (*AFGX*), the consumer price index (*KPI*), and the household savings ratio (savings as a percentage of disposable income, X). The latter increases from –5 per cent in 1989 to +8 per cent in 1992, and declines from 1995. The increase in savings is largely due to the factors discussed above that caused the amount of household debt to decline dramatically.

Estimation was done with *TSLS* on variables in levels, using predetermined variables, cost function variables and the lagged Lerner index as instruments. Predetermined variables were included based on *ANOVA* analysis, after which the following *ADL* structure resulted, with the price variable being significant on the 1% level (with t-statistics in parentheses):

$$D_t = 146 + 0.552D_{t-1} - 34.9p_t^D + 4.38p_{t-1}^M + 3.11p_{t-5}^{obl}$$
$$(1.20) \quad (2.44) \quad (-2.81) \quad (1.15) \quad (1.78)$$
$$- 0.0200AFGX_{t-1} + 4.01X_t + 0.000341Y_{t-3} \quad (8)$$
$$(-1.24) \quad (1.67) \quad (2.67)$$

$$R^2=0.93,\ R^2_{adj} = 0.91,\ DW = 2.51$$

It should be noted, that it was not possible to establish significant cross price effects with the other market for any of the two markets.

3.2.2 Co-integrating vectors and individual bank markets

The concept of co-integration makes it possible to formulate the existence of an equilibrium, or stationary, relationship among time-series, although each of them is individually non-stationary. Time series containing unit roots are said to be co-integrated if there exists a linear combination of them that lacks a unit root. As a consequence, testing for co-integration is to test for a unit root in the residuals of equations (7) and (8), respectively, rather than in the constituting time series taken by themselves, i.e. the residuals have to be stationary. The hypothesis of no co-integration could be rejected for both equations, with *ADF* t-values significant on the 10 percent level.

The co-integrating vector for each of the two equations can now be calculated by taking expectations of all variables, which is the same as equating each variable with all of its lags.[27] The long run coefficients can then be calculated from the estimated coefficients, see Banerjee *et al.* (1993, Ch 2). The resulting co-integrating vectors are, for the loan market:

$$L = 505 - 56.7p^L + 5.32p^{obl} - 15.9p^M + 72.6Z \tag{9}$$

and for the deposit market:

$$D = 326 - 77.8\, p^D + 9.77\, p^M + 6.93\, p^{obl} \tag{10}$$
$$+ 8.92\, X - 0.0446\, AFGX + 0.000761Y$$

The co-integrating vectors (9) and (10) directly yield the market parameters α and β for each of the two markets, respectively. The next step is therefore to determine the product differentiation parameters γ_i. These are established in the same way as for the aggregated markets; by estimating *ADL* equations with instrumental variables' techniques, and calculating co-integrating vectors for individual banks. The resulting equations and co-integrating vectors are reported in *Appendix 2*. Again, it was not possible to establish significant cross price effects between any of the banks and individual competitors. The reason for this is evidently that the weighted average cross price effect (which was always included in the estimations due to the way the market model (1) is defined) uniformly dominates individual cross price effects between bank *i* and any bank *j*.

In order to empirically deduct the γ_i parameters, we first need to rewrite the estimated co-integrating vectors. These are in the form (see *Appendix 2*):

$L_i = \hat{\delta}_{i0} + \hat{\delta}_{i1} p_i + \hat{\delta}_{i2} \overline{p} + \sum_{j=3}^{k} \hat{\delta}_{ij} x_j + u_i$, which translates into:

$$L_i = \hat{\delta}_{i0} + \left(\hat{\delta}_{i1} + \hat{\delta}_{i2}\right) p_i - \hat{\delta}_{i2}\left(p_i - \overline{p}\right) + \sum_{j=3}^{k} \hat{\delta}_{ij} x_j + u_i \tag{11}$$

We note that we can rewrite (1) as a statistical function on the following form:

[27] The Granger representation theorem (Engle and Granger, 1987) proves that a co-integrated system of variables can be represented in three isomorphic forms: the *VAR*, the *ECM*, and the moving-average forms. Here we are pursuing the first step in their two-step procedure, where the parameters of the co-integrating vector are estimated by running the *TSLS* regression in the levels of the variables. In the second step, the obtained parameters are used in the *ECM* form, see section 3.2.6. Phillips and Loretan (1991) show that there are several alternatives how to estimate the long run relationship, one of them the *ADL* approach used here. An *ECM* is simply a linear transformation of the *ADL*, see Banerjee *et al.* (1990) and Banerjee *et al.* (1993).

$$L_i = \hat{s}_i\hat{\alpha} - \hat{s}_i\hat{\beta}p_i + \hat{s}_i\hat{\beta}\gamma_i(p_i - \overline{p}) + \varepsilon_i, \tag{12}$$

where $\varepsilon_i = \sum_{j=3}^{k}\hat{\delta}_{ij}x_j + u_i$. The size parameters, $\hat{s}_i$, which are considered to be exogenous in the short run, are in this case determined by direct observation of lagged market shares. We can then solve for the γ_i values in (12) by equating the corresponding factors from (11) and (12): $\hat{s}_i\hat{\beta}\gamma_i = \hat{\delta}_{i2}$. This procedure yields γ_i parameters that are time-stable except for the influence from s_i.[28]

	Loans, calculated parameters	**Deposits, calculated parameters**	**Loan elasticities, averages over time**	**Deposit elasticities, averages over time**
Market	α = 505 β = 56.7	α = 326 β = 77.8	-0.40	-0.51
Bank 1	γ_1 = 2.4 (0.27)	γ_1 = 2.2 (0.13)	-0.90 (0.20)	-1.2 (0.46)
Bank 2	γ_2 = 2.3 (0.25)	γ_2 = 0.91 (0.046)	-1.2 (0.32)	-0.88 (0.22)
Bank 3	γ_3 = 2.2 (0.31)	γ_3 = 0.89 (0.078)	-1.2 (0.34)	-0.86 (0.28)
Bank 4	γ_4 = 1.6 (0.19)	γ_4 = 1.5 (0.079)	-0.87 (0.21)	-1.0 (0.26)
Bank 5	γ_5 = 1.2 (0.090)	γ_5 = 1.7 (0.050)	-1.1 (0.29)	-1.3 (0.31)

Table 2. Calculated market parameters for the two aggregated markets, and the individual banks. Deposit elasticities are transformed into demand elasticities since they are estimated net of the money market rate. Elasticities and γ_i values are averages for the sample period, 89:1-97:2. Standard deviations in parentheses.

As an additional check, long run market elasticities are calculated from the cointegrating vectors (9) and (10). For individual bank markets, the own price elasticity is deducted from (1):

$$\varepsilon_{ii} = -\frac{p_i}{L_i}s_i\beta\left(1 + \gamma_i\left(1 - s_i\right)\right), \tag{13}$$

[28] In comparison, the alternative method where parameter values would be determined from elasticities, yields less stable values since elasticities have higher standard deviations over time, (e.g., the γ_i values would vary not only with s_i but also with the ratio L_i/p_i if they were deducted from (13)). See footnote 20.

and is calculated by insertion of the estimated parameters, see *Table 2*.[29]

Elasticity measures are bound to be imprecise and to vary between different specifications.[30] Elasticities are in reality a function of time, so that, *a priori*, a longer interval between observations has a higher elasticity.[31]

3.2.4 Calculation of the theoretical equilibria

With all market parameters determined, see *Table 2,* the next task is to evaluate which of the different game-theoretical equilibria (see Oxenstierna (1998), expressions (13), (16) or (18)) for each of the two markets, that best conforms to the actual behaviour of each bank. The needed inputs are the calculated parameter values, α, β, $\gamma_{i,}$ s_i and the average costs (which are equal to marginal costs due to the assumption of short-term (within the period) constant returns to scale). Computations are done for each bank in each quarter. Results are reported in *Figures 3 - 4* for the loan market, and in *Figures 5 - 6* for the deposit market. This is a positive analysis, where observed prices are gauging the explanatory power of the different theoretical market regimes, as represented by the various calculated equilibrium prices, ranging from marginal economic cost pricing to monopoly pricing.

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[29] To my knowledge, there are no prior estimates of bank market elasticities on Swedish data. The elasticities are of the same magnitude as internationally reported elasticities. Berg and Kim (1998) report the following disaggregate loan market elasticities for Norwegian banks for the period 1988-91: Retail loans: -0.90; corporate loans: -0.86. No elasticities are reported for individual banks. Vesala (1995) reports the following elasticities from Finnish bank markets: Loan market demand elasticity: -0.55. Individual banks' own demand elasticities range from -1.45 to -4.14. Deposit market supply elasticity: 0.17. Individual banks own supply elasticities range from: 0.28 to 0.61.

[30] Edgerton *et al.* (1996, ch 6) study imprecision in elasticity estimates due to specification error (structural variation) by comparing the results from non-dynamic and dynamic versions of the same type of model applied on the same time series data set. They find that the model choice leads to big and statistically significant effects, where differences are in excess of the model consistent variations for nearly all goods estimated. This raises doubt on previous bank market studies that have not taken the time structure of bank markets into explicit consideration. Only one previous study is known to have done so, Swank (1995).

[31] This is also what Assarsson (1996) finds when estimating elasticities for different goods and services on Scandinavian countries' household data, using an *ECM* variant of a dynamic almost ideal demand system. The precision of estimated elasticity is also substantially influenced by the choice of model, and by the choice of estimation method. All these sources of variations cause Edgerton (*op. cit.* p 166) to conclude that, in general, an interval of ±0.25 is the minimum level of uncertainty of elasticity measures on individual Swedish consumption goods.

3.2.5 Evaluating the conduct in the markets

Because of the large amount of data, I will evaluate conduct mainly from inspecting the figures. Starting with the overall markets (*Fig 1,* which summarises events in the two markets by adding their observed prices, their estimated costs and their theoretically deducted prices, respectively), it is evident from the graphed total spread compared to the total economic costs, that the Swedish banking markets have gone through a period of less competitive conduct. The total spread at the beginning of 1989 of about 5% increased to about 6.5% in 1992-93, but has since then sunk back to about 4.7% in the beginning of 1997, whereas costs have been fairly constant throughout the period. The major explanation for the increase in spread is most likely to be the profound banking crisis in Sweden, which gave banks an opportunity to exercise their market power. The banking crisis, which had its main impact during 1991-3, was mainly a property lending credit risk phenomenon, but, evidently, deposit customers had to pay the major part of the price for it, since the overall increase in spread was due mainly to an increased spread on the deposit market during the crisis, (compare *Fig. 3* and *Fig. 5*). Apparently, market power was greater on the deposit side during that period. Also, there was a profound shift of propensities to loan and to save during the period so that households and firms lowered their debt levels substantially by saving for amortising (Berg, 1997). This changed banks from being "asset-driven" to being "liability-driven" (Matten 1996), i.e. they got large excess deposit volumes. These were difficult to place at the higher margins that private sector loans command, which in turn might have had a negative impact on the degree of competition in the deposit market.

In order to analyse the market conduct in more detail, I have divided the sampling period into five sub-periods, see *Figures 3, 5, 7* and *8*. During the ***first*** period, which is the "pre-crisis" period, 89:1 – 91:1, spreads are increasing in the deposit market and declining in the loan market. The probable reason for this is that banks faced a strong decline in loan demand, see *Fig. 8*, which causes competition to increase. The decline in loan demand is caused by a combination of lowered household and corporate debt levels and an increase in households' savings ratio from –5% of disposable incomes in 88:4 to around zero in 91:1 (Statistics Sweden, BNP/kvartal). The increase in savings does, however, not turn up as bank deposits, but is evidently used to amortise bank loans (*Fig. 8*). It is therefore difficult to explain the big increase in deposit spread (+0.7 percentage points) during the pre-crisis period with exogenous factors. One hypothesis is that banks shifted their market power from the loan market, where competition was increasing due to a declining demand, to the deposit market, where demand was constant in real terms. As regards the interest rate levels, see *Fig. 5*, they are best explained by the hypothesis of Nash equilibrium with respect to quantities (henceforth called NE(q)) for deposits in 89:1, increasing above the monopoly price level in 91:1. The loan market rates, on the other hand, declined down to the marginal economic cost (MEC) level in 91:1, see *Fig. 3*.

The ***second*** period represents the deep banking crisis from 91:2 – 92:4. During this period the exogenous trends of changing savings and loans behaviour continue, making banks increasingly liability-driven. Together with large write-offs of bad debts, this gives banks excess deposits of around 50 Bn SEK. Since excess deposits have to be placed at lower interest rates than commercial loans, there is a dis-incentive for competition for deposits, which is the likely explanation for the increased spread in the deposit market with another 0.5 percentage point. In the second half of this period, however, the strong increase in demand for deposit liabilities abate (*Fig. 8*), and the spread level stabilises (*Fig. 5*) above the monopoly price. This high price level can be explained by the fact that banks got large volumes of excess deposits (*Fig. 7*), so that they became increasingly liability-driven and less competitive in their pricing of deposit services. In the loan market, there is a continued strong decline in loan demand, which keeps pricing competitive and prices are kept down to near the economic cost level (*Fig. 3*). Economic cost levels are stable in each of the two markets throughout both the first two periods.

The ***third*** period, 93:1 – 94:2 depicts the resolution of the banking crisis.[32] The savings quota is now stabilised at a record high of around 8% of disposable income. Loan demand measured as loan stocks related to household disposable income continue to decline down to 1.5 in 94:2 (from 2.5 at its peak in 1989). The bulk of bad debt write-offs also occurred during this period, so that overall loan demand dropped dramatically, see *Fig. 8*. These factors taken together meant that banks built up excess deposits on the level of 150 Bn SEK, see *Fig. 7*. Deposit spread drops from 4.1% down to 2.3%, which is close to the NE(q) level. This can to a minor part be explained by the continued decline in economic costs on the deposit side, see *Fig. 5*. On the other hand, loan economic costs increase due to rising equity costs, see *Fig. 3*, which is part of the explanation for the quickly increasing loan rates, from the MEC level in 92:1, up towards the level corresponding to the Nash equilibrium with respect to competition in prices (henceforth NE(p)) in 93:4. However, the dramatic shifts in market power between markets should mainly be understood as a short-term adjustment, as will be elucidated in the next section.

The ***fourth*** period, 94:3 – 96:1, is a revival period for the loan markets. Finally, loan demand picks up and the savings ratio starts to drop, which together make

[32] Already in mid-1993 the large banks and the stock market felt that the crisis was contained. For example, S-E-Banken's shares reached their pre-crisis level in August 1993, and a new emission of stocks doubling the share capital was successfully placed. Also Handelsbanken and Swedbank made big emissions of new stocks at the same time.

excess deposits decline somewhat, see *Figures 7* and *8*. Loan spread decreases down to the marginal economic cost level (*Fig. 3*), without any plausible exogenous explanation, except that the increase in period *III* was a short-term adaptive phenomenon which is slowly corrected in period *IV* (see the next section for a further elaboration of this). One possible endogenous explanation might be that banks started to compete for loan market shares again after surviving the crisis. Also, a number of small new low-cost banks were established during this period, which influenced the competitiveness of the retail markets, mainly the deposit market. In the deposit market, spreads are again increasing, from the NE(q) level to the monopoly price level, (*Fig. 5*). This is particularly noticeable since marginal costs for providing deposit liability services are declining rapidly.

In the ***fifth*** period, 96:2 – 97:2, there is a return to the familiar pattern from period *III*. The savings ratio continues to drop, which, together with the ever increased competition from newly established niche banks, might explain the significant drop of the deposit spread to below the NE(p) level, (*Fig. 5*). There is, however, a mirror-imaged pattern in the loan market. Loan demand continues to grow (*Figures 7 - 8*), and banks are able to raise the loan spread from the MEC level halfway up towards the NE(p) level, (*Fig. 3*). Also in this period, there is a strong decline in market interest rates, with three percentage points, (See *Fig. 3* in Oxenstierna (1999)). The alternative hypotheses proposed and tested with the *ECM* estimations in the next section explains the conduct in periods *III* and *V* primarily as short-term adjustments.

The overall picture of bank conduct during all the five periods in both markets, is that the economic cost level constitutes a bottom level for pricing policies, and that attempts to establish higher spreads are not sustainable in the long run in the loan market. In the deposit market, the huge amounts of excess deposits gives small incentives for price competition, so that average spreads over the entire period are best explained by the hypothesis of monopoly pricing.

3.2.6 Transmission of money market rates into loan and deposit rates

One important monetary policy issue with regard to the relation between money market interest rates and the banking markets, is how efficiently the money market rates are passed through to the loan and deposit market rates. These two markets display price stickiness, as evidenced primarily through periods *III* to *V*, when the relative spread levels between the markets are distorted due to rapidly falling money market rates, see *Fig. 2, 3* and *5*. For these reasons it is of some interest to investigate the patterns of price stickiness.

Price stickiness can be explained by menu costs arising from the activity of changing prices, as in Rotemberg and Saloner (1987) or, in a banking application, in Hannan and Berger (1991). They explain the often observed phenomenon of greater price rigidity in a monopoly than in an oligopoly, by a proposition that higher price elasticities increases the incentives to alter prices in response to changing marginal costs. In this case, the Swedish banking markets should be equally sticky, since elasticities are of the same size in both markets. But as will be demonstrated below, the loan market is significantly more sticky than the deposit market, which calls for other explanations than menu costs.

By carrying out *ECM* estimations, some further light can be shed on the issue of short-term adjustments. Following Bårdsen (1989), we can hence rewrite the *ADL* in (6) as an *ECM*, without imposing any restrictions on the model:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{m-1} \alpha_i^* \Delta y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{n-1} \beta_{ji}^* \Delta x_{j,t-i} + \alpha_m^* ECT + u_t , \tag{14}$$

where $\alpha_m^* = \sum_{i=1}^{m} \alpha_i - 1$, $\beta_{jn}^* = \sum_{i=0}^{n} \beta_{ji}$ and where the error correction term (ECT^j) for the j^{th} equation is defined as:

$$ECT^j = y_{t-m} - \sum_{j=1}^{k} \theta_j x_{j,t-n} \text{ , with } \theta_j = \frac{-\beta_{jn}^*}{\alpha_m^*} .$$

For the loan market we obtain:

$$ECT^L = L_{t-2} + 56.7 p_t^L - 5.32 p_t^{obl} + 15.9 p_t^M - 72.6 Z_t$$

and for the deposit market:

$$\begin{aligned} ECT^D = {} & D_{t-1} + 77.8 p_t^D - 9.77 p_{t-1}^M - 6.93 p_{t-5}^{obl} \\ & + 0.0446 AFGX_{t-1} - 8.92 X_t - 0.000761 Y_{t-3} \end{aligned}$$

The *ECT* series were then tested for stationarity with the *ADF* test. The hypothesis of stationarity could not be rejected for any of the two series, on the 5% level for ECT^L and on the 1% level for ECT^D, i.e. all elements of the *ECM*s are I(0). The *ECM*s (14) are then estimated with *OLS*, yielding the following results for the loan market (with t-statistics in parentheses):

$$\begin{aligned} \Delta L = {} & 55.0 - 3.72 \Delta p^L + 0.0262 \Delta p^{obl} - 0.617 \Delta p^M + 65.2 \Delta Z - 0.104 ECT^L \\ & (2.68) \quad (-0.72) \quad (0.021) \quad (-0.36) \quad (6.55) \quad (-2.51) \end{aligned} \tag{15}$$

$R^2 = 0.75$, $R^2_{adj} = 0.70$, $DW = 2.23$

For the deposit market we get:

$$\Delta D = 161 + 23.3\Delta p^{D} - 1.45\Delta p^{M} + 1.14\Delta p^{obl} - 0.000206\Delta GDP -$$
$$(4.38)\ (2.08)\quad (-0.53)\quad (0.50)\qquad (-2.02)$$
$$2.06\Delta X - 0.00525\Delta AFGX - 0.484 ECT^{D} \qquad (16)$$
$$(-0.47)\quad (-0.25)\qquad\quad (-4.15)$$
$$R^2 = 0.64,\ R^2_{adj} = 0.50,\ DW = 2.19$$

As expected, the *ECT* parameters are negative. The *ECT* parameter also has an economic interpretation: In general, it measures a variable's speed of adjustment back to the equilibrium level (Johansen (1989, p 16), quoted in Charemza and Deadman (1997)) which in this case is the number of quarters it takes to return to the long-run equilibrium after the occurrence of a disturbance. Thus it gives completing information on short-run behaviour. For the loan market the value is almost 10 quarters and for the deposit market it is about 2 quarters. The difference between the two markets indicates that banks' loan stocks are slower to adapt to changing market interest rate conditions than deposit stocks.

One important factor in both periods *III* and*V* is that money market rate levels dropped significantly, see *Fig. 2*. Since loan stocks and deposit stocks are likely to adapt with different speeds to dramatic shifts in interest rate levels, this could also explain the shift in net spreads between the two markets as a short-term dynamic phenomenon. Rapidly falling loan interest rates induce some customers with fixed interest rate loans to renegotiate their loans. When interest rates go down, not all loans are renegotiated, so that banks continue to earn the high rates on not renegotiated loans, causing net loan spread to increase.[33] Similarly, some part of the deposit stock is fixed rate, so that banks will continue to pay high interest rates on such deposits, causing net deposit spread to decrease. Another factor that is likely to influence these short-term adaptations is the slope of the yield curve, which was negative during the third period, see *Fig. 2.* and tilts throughout periods *III – V*. As far as loan rates follow long-term market rates instead of the assumed short-term rates, the transmission of money market rates will not be complete. Banks can also absorb changes in money market rates when they determine their own reference rates (p_M). However, the impression is that there has been an increase over time in the usage of short-term rates as reference rates in lending, which would facilitate an improved pass-through of the market rates.

The pattern of dramatic shifts in observed price conduct between the two markets in periods *III* through *V* (*Figures 3 – 6*) seems to support the proposition made above, that it mainly should be understood as a short-term phenomenon due to

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[33] When a customer renegotiates or cancels a fixed interest loan, a one-time compounded interest income effect for the bank occurs. Such effects are not recorded in the Riksbank loan interest rate statistics, since it registers the current rates on all loans.

differing adjustment speeds in the stocks of loans and the stocks of deposits, respectively. The greatly increased spread on loans in these two periods (*Fig. 3*) must therefore be seen in conjunction with the corresponding reduction in spread on deposits (*Fig. 5*), with overall spread declining in both periods (*Fig. 1*). The redistribution of spreads between the two markets thus seems to be mainly a fictitious phenomenon related to short-term adjustments in a volatile money market interest rate environment.

3.2.7 Evaluating the conduct of individual banks

It is possible to evaluate the conduct also of individual banks over time, and to compare them in terms of cost levels, pricing strategies, development of market shares, etc. However, such an evaluation would inevitably provide the means for revealing the identity of the individual banks. Therefore, due to the secrecy of the Riksbank data set (cf. footnote 9), observations on the conduct of individual banks will here be restricted to looking at only one sample bank in each market. Starting with the sample bank in the loan market in *Fig. 4*, we see a bank that has higher economic costs than the average throughout the period. Further, it has a slightly more aggressive pricing policy than average until 95:2, after which its prices are on par with the average. The pricing policy until 95:2 was not rewarded with increasing market shares, which are on the same level at the end of 1994 as in 1989 (the dip in market shares during 92:2 – 93:3 might be due to reporting irregularities during the banking crisis). From the beginning of 1995 this bank has falling market shares, which, at least in part, might be attributable to the change in pricing policy.

Turning to the sample bank in the deposit market (*Fig. 6*), this bank has a cost level development that is very close to the average bank throughout the period. Until 92:3 it has a higher price level than average, and faces a slow decline in market shares. From 92:4 it changes to a more aggressive pricing policy and restores the market share in 93:4. In 1994, it switches back to its previous, less aggressive pricing policy with interest rates ca 0.3% above the average, and starts to lose market shares again.

All five banks display similar patterns of conduct as the sample bank. There are no real outliers, as evidenced by the estimated costs and elasticities in *Tables 1 – 2*.

3.2.8 Evaluating the performance in the markets

Performance is evaluated by inserting observed prices, estimated costs and market parameters into equation (37) in Oxenstierna (1998) for each quarter and each market. This yields a measure of the welfare loss from non-competitive pricing. In *Table 3,* the calculated yearly averages are disclosed for each of the two markets as well as totals.

	Loans	Deposits	Total	% of GDP
1989	1339	10649	11987	1.0%
1990	1706	16646	18352	1.3%
1991	1528	17318	18846	1.3%
1992	2337	25751	28088	1.9%
1993	5352	13551	18903	1.3%
1994	4555	6888	11443	0.7%
1995	2312	11482	13794	0.8%
1996	4150	5443	9593	0.6%

Table 3. Calculated welfare losses from non-competitive pricing in Swedish bank markets. Values in SEK millions.

The welfare losses as a percent of GDP increase from about one percent in 1989 up to almost two percent in 1992, adding to the accounting costs of the banking crisis. Welfare losses are then declining, and continue to do so in 1997. The average welfare loss to society over the period 1989 – 1996 was 1.1% of GDP. The conclusion above, regarding the shift of market power between markets, is again confirmed. The deposit market is comparatively less competitive through 1995 as a combined effect of strongly increasing demand for deposit liabilities and a lack of competition during the banking crisis. From 1996, the picture is reversed, with increasing demand for loans and increasing competition for deposits, together shifting the bulk of welfare losses over to the loan market. However, this change is, again, likely to reflect a short-term adaptation in stocks of deposits and loans to rapidly declining market interest rates, as elucidated in section 3.2.6. Overall, the deposit market has much larger welfare losses than the loan market.

4 Conclusions

In this essay an asymmetric oligopoly model for multi-product banking is developed, based on the possibility to separate a bank's activities in the deposit and loan markets. This requires absence of economies of scope and that there are no demand interrelationships between the markets. These assumptions correspond with empirical evidence on the Swedish banking markets. As an alternative to the prevailing conjectural variations models in Cournot competition, the full-fledged game-theoretic model with two types of product differentiation from Oxenstierna (1998) is employed to represent the market structures. This model's range of different game-theoretic equilibria are then used in a positive analysis, where observed prices are gauging the explanatory power of the different theoretical models. Furthermore, the model allows for an evaluation of welfare effects, based on the calculation of consumer surpluses. Any deviation from efficient pricing is evaluated on the individual bank level.

It appears that the model developed in Oxenstierna (1998) is well suited for an empirical analysis. The "structural richness" of the theoretical model simplifies the econometric work, due to the method developed for empirical application of the model, where the central econometric task consists of a straightforward estimation of demand equations: All market demand parameters for the n asymmetric banks are derived from estimating n bank-specific demand equations and an aggregated market demand for each market. Since all behavioural equations are provided in the theoretical model, there is no need for empirical estimation of bank-level conduct.

The model was applied to the Swedish banking oligopoly. Results show that there is significant market power mainly in the deposit market, although with a strongly time-varying pattern. The loan market is found to be more competitive, but also displays strong time variations. In order to further analyse the short-term volatility in conduct that is found, an error correction mechanism is deducted and estimated. This reveals different short-term behaviour in the stocks of deposits and loans, respectively. This result sheds some light on the monetary transmission mechanisms in the Swedish banking system, where evidence is found of significant stickiness mainly in the loan market. Overall, conduct is declining from the NE(p) level at the end of 1993, down towards the competitive price level at the end of the period, see *Fig. 1*.

Summing up events in the **loan market** (*Fig. 3*), net spread ($p - p_M$ – *economic costs*) was rising from around zero in 1990/1 to a peak in the beginning of 1994, but banks were unable to compensate themselves for the increasing equity costs, causing net spread to fall back to zero in 1995, then increasing to about 0.75% at the end of the period. Conduct is on average best explained by the hypothesis of marginal economic cost pricing on average for the whole period, although the post crisis period (*III*) offered spread levels approaching the NE(p) level. The overall picture of bank conduct during all the five periods in the loan market, is that the economic cost level constitutes a bottom level for pricing policies, and that attempts to establish higher spreads are not sustainable in the long run.

There were profound structural changes in savings behaviour during the sample period, making banks increasingly liability-driven, which to a large extent explains short-term changes in pricing levels. The influence of these structural changes are most evident in the **deposit market** (*Fig. 5*), where the average conduct in the market is best explained by the hypothesis of NE(q) prices at the begin of the period, but rapidly increasing until 93:2 so that net prices ($p_M - p$) are above the monopoly price. Thereafter, net spread falls rapidly down to the NE(q) level at the end of 1993. It subsequently reverts to the monopoly price level until the end of 1995. After that, it starts to fall, so that it is below the NE(p) price in 97:2. It is clear that the persistent large volumes of excess deposits (around 150 Bn SEK from 1994 and onwards, *Fig. 7*) have a detrimental effect on the degree of competition. Cost levels are increasing until the begin of 1994, and thereafter falling, so that they are one percentage point lower in 97:2 than at the peak level.

It is also possible to follow the conduct and relative pricing strategies of individual banks. Finally, welfare losses to the society from non-competitive pricing were calculated. The average level throughout the period 1989 – 1996 corresponds to ca 1.1% of GDP, mainly stemming from the deposit market, although there was a strong increase in welfare loss levels due to non-competitive pricing during the banking crisis, peaking at almost two percent of GDP in 1992. After that, welfare losses are persistently declining, and are less than one percent of GDP in 1997.

Appendix 1
Tables with results from estimations

Variable	Market	Bank 1	Bank 2	Bank 3	Bank4	Bank5
w_1, level		1.1	2.8†	1.1	1.4	1.5
w_1, 1st difference		5.2**	6.0**	3.3**	3.3**	4.5**
w_2, level		3.0	1.4	0.7	2.5	1.3
w_2, 1st difference		5.4**	5.0**	4.2**	4.2**	4.0**
C, level		1.9	0.26	1.3	1.1	0.45
C, 1st difference		4.7**	6.4**	3.0**	3.6*	2.6*
p_L, level	1.8	2.1	1.8	2.3	1.6	0.36
p_L, 1st difference	5.3**	5.9**	5.8**	6.4**	5.5**	4.8**
L, level	1.2	2.9	2.1	2.2	2.2	1.7
L, 1st difference	6.9**	5.6**	7.5**	5.4**	6.1**	3.4**
p_D, level	1.8	2.0	0.77	2.0	1.7	1.7
p_D, 1st difference	4.5**	4.6**	4.0**	5.4**	5.0**	4.6**
D, level	2.3	2.8	2.1	2.7	2.1	2.2
D, 1st difference	5.9**	7.7**	4.7**	4.0**	7.3**	5.1**

Table A1.1 Augmented Dickey-Fuller (*ADF*) tests: Absolute t-ratios. L is loans, D is deposits, p_i are the respective interest rates net of the (smoothed) 3-month money market rate. † , * and ** denotes significance at the 10%, 5% and 1%-levels respectively, based on MacKinnon critical values. A constant and a time trend have been included in the *ADF* regressions, if significant. All 1st differences are significant on the 1% level.

Pooled SUR Parameter	Variable	Coefficient	S.E.	t-ratio	Prob.>|t|
α_1	ln q_1	0.25**	0.012	21.0	0.0000
α_2	ln q_2	0.28**	0.018	15.4	0.0000
α_3	ln q_3	0.0062	0.0052	1.19	0.2351
α_{11}	ln q_1 ln q_1	0.38*	0.16	2.44	0.0153
α_{12}	ln q_1 ln q_2	-0.53*	0.25	-2.08	0.0382
α_{13}	ln q_1 ln q_3	-0.12†	0.075	-1.66	0.0981
α_{22}	ln q_2 ln q_2	0.38*	0.16	2.43	0.0153
α_{23}	ln q_2 ln q_3	-0.40*	0.18	-2.53	0.0118
α_{33}	ln q_3 ln q_3	-0.020*	0.0094	-2.08	0.0384
δ_{11}	ln q_1 ln w_1	-0.19**	0.011	-17.7	0.0000
$\delta_{12} = -\delta_{11}$	ln q_1 ln w_2	0.19**	0.011	17.7	0.0000
δ_{21}	ln q_2 lnw_1	-0.25**	0.017	-14.3	0.0000
$\delta_{22} = -\delta_{21}$	ln q_2 lnw_2	0.25**	0.017	14.3	0.0000
δ_{31}	ln q_3 lnw_1	0.0093	0.0058	1.60	0.1116
$\delta_{32} = -\delta_{31}$	ln q_3 lnw_2	-0.0093	0.0058	-1.60	0.1116
β_1	lnw_1	0.47**	0.0076	62.1	0.0000
$\beta_2 = -\beta_1$	lnw_2	-0.47**	0.0076	-62.1	0.0000
β_{11}	lnw_1 lnw_1	0.47**	0.0080	59.5	0.0000
$\beta_{12} = \beta_{21} = -\beta_{11}$	lnw_1 lnw_2	-0.47**	0.0080	-59.5	0.0000
$\beta_{22} = \beta_{11}$	lnw_2 lnw_2	0.47**	0.0080	59.5	0.0000

Table A1.2 Cost function parameter estimates. † , * and ** denotes significance at the 10%, 5% and 1%-levels respectively

	Equation	**R^2**	**Adjusted R^2**	**Standard error**	**DW-statistic**
Bank 1	Operating Cost	0.97	0.95	0.012	1.88
	Cosh share 1	0.93	0.92	0.0083	2.20
Bank 2	Operating Cost	0.94	0.90	0.023	2.64
	Cosh share 1	0.87	0.84	0.023	1.77
Bank 3	Operating Cost	0.88	0.78	0.011	2.12
	Cosh share 1	0.81	0.78	0.0098	1.78
Bank 4	Operating Cost	0.84	0.73	0.028	2.02
	Cosh share 1	0.34	0.21	0.024	2.09
Bank 5	Operating Cost	0.93	0.87	0.015	1.55
	Cosh share 1	0.94	0.92	0.012	1.23

Table A1.3. Goodness-of-fit measures for the estimated cost functions.

Appendix 2 Estimated *ADL* structures and co-integrating vectors for individual banks

Estimation was done with *TSLS* on variables in levels, using predetermined (i.e. exogenous and lagged endogenous) variables, cost function variables and the lagged Lerner index as instruments (variable definitions are in section 3.2.3 except *p bar*, which is the weighted average market price). Predetermined variables were included on the basis of the analysis of variance (*ANOVA*) technique. Specifically, it should be noted that none of the estimated equations had significant own-market cross-price parameters to other individual banks' prices, but that all of them had significant parameters to the weighted average market price. In no case were across market parameters significant, neither to other individual banks nor to the across market weighted average market price. The reason for this is evidently that the weighted average cross price effect (which was always included in the estimations due to the way the market model (1) is defined) uniformly dominates individual cross price effects between bank *i* and any bank *j*.

Individual loan markets

The following *ADL* structures resulted (*t* – statistics in parentheses), with goodness-of-fit measures and calculated co-integrating vectors (CV) in the loan markets:

Bank 1

$$L_t = 0.819L_{t-1} - 7.77p_t^L + 5.16\overline{p}_t^L + 0.0719KPI_{t-4}$$

(6.29) (−1.70) (1.30) (1.55)

R^2=0.85, R^2_{adj} = 0.83, DW = 1.84

CV: $L = -42.8p + 28.4\overline{p} + 0.396KPI$

Bank 2

$$L_t = 0.682L_{t-1} - 10.8p_t^L + 9.09\overline{p}_{t-1}^L + 12.8Z_{t-3} + 0.399KPI_{t-2} - 0.000119Y_{t-5} - 43.9$$

(3.78) (−2.66) (2.21) (1.91) (3.04) (−2.93) (−1.15)

R^2 =0.84, R^2_{adj} = 0.80, DW = 2.17

CV: $L = 138 - 34.0p + 28.6\overline{p} + 40.3Z + 1.25KPI - 0.000374Y$

Bank 3

$$L_t = 0.489L_{t-1} - 9.44p_t^L - 4.09p_{t-1}^L + 12.4\overline{p}_t^L + 13.8Z_t$$

(5.27) (−1.27) (−2.72) (1.12) (3.41)

$$-1.79p_{t-5}^{obl} + 0.104KPI_{t-3} - 0.0000363Y_{t-2}$$

(−3.37) (1.95) (1.16)

R^2=0.95, R^2_{adj} = 0.94, DW = 2.21

CV: $L = -26.5p + 24.2\overline{p} - 3.50p^{obl} + 27.0Z + 0.204KPI + 0.0000710Y$

Bank 4

$$L_t = 0.497L_{t-2} - 16.8p_t^L - 2.24p_{t-2}^L + 11.9\overline{p}_t^L + 21.5Z_t + 0.0000257Y_{t-2} + 19.8$$

(7.00) (−2.01) (−1.07) (1.62) (11.2) (1.05) (1.39)

R^2=0.97, R^2_{adj} = 0.97, DW = 1.79

CV: $L = 39.4 - 37.8p + 23.7\overline{p} + 42.6Z + 0.0000510Y$

Bank 5

$$L_t = 0.769L_{t-1} - 3.34p_t^L + 1.79\overline{p}_{t-1}^L + 5.83Z_t + 0.0607KPI_t - 0.295p_{t-4}^M - 0.420p^{obl}$$ R^2

(5.05) (−1.66) (1.36) (2.95) (1.44) (−3.58)

=0.95, R^2_{adj} = 0.94, DW = 2.09

CV: $L = -14.5p + 7.75\overline{p} + 25.2Z + 0.263KPI - 1.28p^M - 1.82p^{obl}$

Individual deposit markets

The following *ADL* structures ($t-$ statistics in parentheses) with goodness-of-fit measures and calculated co-integrating vectors (CV) resulted in the deposit markets:

Bank 1

$$D_t = -30.9 p^D_{t-1} + 30.8 \overline{p}^D_{t-1} + 1.28 X_{t-1} - 1.93 p^{obl}_{t-2} + 3.14 p^M_{t-2} + 0.0192 AFGX + 33.2$$

(−1.42) (1.39) (1.38) (1.42) (1.63) (3.88) (1.61)

R^2=0.93, R^2_{adj} = 0.92, DW = 1.70

CV: $D_t = -30.9 p + 30.8 \overline{p} + 1.28 X - 1.93 p^{obl} + 3.14 p^M + 0.0192 AFGX + 33.2$

Bank 2

$$D_t = -0.375 D_{t-2} - 36.6 p^D_t + 27.1 \overline{p}^D_t + 1.47 p^M_t + 2.54 X_{t-1} + 206.9$$

(−1.80) (−2.56) (1.94) (1.32) (5.81) (6.38)

R^2=0.78, R^2_{adj} = 0.73, DW = 1.81

CV: $D_t = -26.6 p + 19.7 \overline{p} + 1.07 p^M + 1.85 X + 151$

Bank 3

$$D_t = 0.392 D_{t-1} - 14.9 p^D_t + 7.25 \overline{p}^D_{t-1} + 1.34 p^M_{t-3} + 0.254 KPI_{t-3} + 0.00490 AFGX_{t-3}$$

(2.05) (−2.72) (1.22) (2.00) (2.83) (1.08)

R^2= 0.92, R^2_{adj} = 0.91, DW = 1.86

CV: $D_t = -24.6 p + 11.9 \overline{p} + 2.21 p^M + 0.00805 AFGX + 0.417 KPI$

Bank 4

$$D_t = 0.422 D_{t-2} - 17.3 p^D_t + 17.4 \overline{p}^D_t + 1.37 X_{t-2} + 1.04 p^{obl}_{t-5} + 58.9$$

(2.65) (−1.82) (1.65) (4.80) (2.95) (2.84)

R^2=0.89, R^2_{adj} = 0.86, DW = 2.45

CV: $D_t = -29.9 p + 30.0 \overline{p} + 2.36 X + 1.79 p^{obl} + 102$

Bank 5

$$D_t = 0.432 D_{t-1} - 7.26 p^D_{t-2} + 8.35 \overline{p}^D_{t-2} + 0.669 X_{t-1} + 0.00483 AFGX_{t-3} + 20.3$$

(3.47) (−1.28) (1.48) (2.89) (2.88) (3.11)

R^2=0.92, R^2_{adj} = 0.91, DW = 1.60

CV: $D_t = -12.8 p + 14.7 \overline{p} + 1.18 X + 0.00850 AFGX + 35.8$

References

Assarsson, B., **1996**, in Edgerton *et al.: The Econometrics of Demand Systems. With Applications to Food Demand in the Nordic Countries*, Kluwer Academic Publishers

Banerjee, A., Galbraith, J.W. and Dolado, J.J., **1990**, *Dynamic Specification and Linear Transformations of the Autoregressive-Distributed Lag Model,* Oxford Bulletin of Economics and Statistics, 52:1, 95-104

Banerjee, A., Dolado, J.J., Galbraith, J.W.,and Hendry, D.F., **1993**, *Co-integration, error correction, and the econometric analysis of non-stationary data*, Oxford University Press

Bårdsen, G., **1989**, *Estimation of Long Run Coefficients in Error Correction Models,* Oxford Bulletin of Economics and Statistics, 51:2, 345-350

Berg, L., **1997**, *Hushållens skulder och förmögenhet – En analys av hushållens skuldsättning med utblick till år 2000*, Nordbanken, Ekonomiska sekretariatet, Stockholm

Berg, S.A. and Kim, M., **1994**, *Oligopolistic Interdependence and the Structure of Production in Banking: An Empirical Evaluation*, Journal of Money, Credit, and Banking, 26:2

Berg, S.A. and Kim, M., **1998**, *Banks as Multioutput Oligopolies: An Empirical Evaluation of the Retail and Corporate Banking Markets*, Journal of Money, Credit, and Banking, 30:2

Bergendahl, Göran, **1989**, *The management of assets and liabilities in banks: Principles and applications*, Revue de la Banque, 6/1989.

Berger, A.N., Hanweck, G.A., and Humphrey, D.B., **1987,** *Competitive Viability in Banking,* Journal of Monetary Economics 20

Berger, A.N. and Humphrey, D.B., **1992**, *Measurement and Efficiency Issues in Commercial Banking*, in Griliches, Zvi, (ed), *Output Measurement in the Services Sectors*, The University of Chicago Press, 1992.

Berger, A. N., Humphrey, D. B., and Pulley, L.B., **1996,** *Do consumers pay for one-stop banking? Evidence from an alternative revenue function,* Journal of Banking and Finance, 20, 1601-1621

Berger, A.N. and G. Udell, **1995**, *Relationship Lending and Lines of Credit in Small Firm Finance*, Journal of Business, 68, 351-382.

Berndt, E.R., 1991, The Practice of Econometrics: Classic and Contemporary, Addison-Wesley Publishing Company, Inc.

Berry, S.T., **1994,** *Estimating discrete-choice models of product differentiation*, RAND Journal of Economics, 25:2, 242-262

Blomberg, Erik, **1994**, *Banking*, in *EEA and the Financial Services Sectors in Sweden*, Sveriges Riksbank Occasional Paper, 9.

Boyd, J. and E. Prescott, **1986**, *Financial Intermediary-coalitions*, Journal of Economic Theory, 38, 211-232.

Bulow, J.I., Geanakoplos, J.D., and Klemperer, P.D., **1985**, *Multimarket Oligopoly: Strategic Substitutes and Complements*, Journal of Political Economy, 93:3.

Charemza, W.W. and Deadman, D.F., **1997**, *New Directions in Econometric Practice. General to Specific Modelling, Cointegration and Vector Autoregresseion*, 2nd edition, Edward Elgar Publishing Ltd.

Christensen, L.R., D.E. Jorgenson and L.J. Lau, **1973**, *Transcendental logarithmic production frontiers,* Review of Economics and Statistics 55, 28-45.

Clark, Jeffrey A., **1996**, *Economic Cost, Scale Efficiency, and Competitive Viability in Banking*, Journal of Money, Credit, and Banking, 28:3, 342-364.

Diamond, D., **1984**, *Financial Intermediation and Delegated Monitoring*, Review of Economic Studies, 51, 393-414.

Edgerton, D.L, B. Assarsson, A. Hummelmose, I.P. Laurila, K. Rickertsen, P.H. Vale, **1996**, *The Econometrics of Demand Systems. With Applications to Food Demand in the Nordic Countries*, Kluwer Academic Publishers.

Englund, Peter, **1990**, *Financial Deregulation in Sweden*, European Economic Review 34: 385-393.

Engle, R.F. and C.W.J. Granger, **1987,** *Co-integration and Error Correction: Representation, Estimation and Testing,* Econometrica, Vol 55, 251-276

Fama, Eugene F., **1985**, *What's Different About Banks?,* Journal of Monetary Economics, 15, 29-39.

Feenstra, Robert C. and James A. Levinsohn, **1995**, *Estimating Markups and Market Conduct with Multidimensional Product Attributes,* Review of Economic Studies, 62, 19-52.

Fixler, Dennis J. and Zieschang, Kimberly D., **1992**, *User Costs, Shadow Prices, and the Real Output of Banks*, in Griliches, Zvi,(ed), *Output Measurement in the Services Sectors*, The University of Chicago Press, 1992.

Friedman, James W., **1986**, *Game Theory with Applications to Economics*, Oxford University Press, New York.

Greenbaum, S.I., G. Kanatas and I. Venezia, **1989**, *Equilibrium Loan Pricing under the Bank-Client Relationship*, Journal of Banking and Finance, 13, 221-235

Hannan, T. and A. Berger, **1991**, *The Rigidity of Prices: Evidence from the Banking Industry*, American Economic Review, 81:4, 938-945.

Hunter, W.C., S.G Timme, and W.K Yang, **1990**, *An Examination of Cost Subadditivity and Multiproduct Production in Large U.S. Banks,* Journal of Money, Credit, and Banking, Vol. 22:4, 504-525.

Hunter, W.C. and S.G. Timme, **1991**, *Technological Change in Large U.S. Commercial Banks,* Journal of Business, vol. 64:3, 339-362.

Johansen, S., **1989**, *Likelihood Based Inference in Cointegrated Vector Autoregressive Models,* Cento Interuniversitario di Econometria (CIDE), Bologna.

Matten, Chris, **1996**, *Managing Bank Capital: Capital Allocation and Performance Measurement,* John Wiley & Sons, Chichester.

Nedersjö, Anna-Karin, **1995**, *Bankernas räntor och Riksbankens ränteanalys*, Penning- & Valutapolitik 1995:1, 37-47.

Oxenstierna, Gabriel C., **1998**, *An Asymmetric Oligopoly Model and a Method for its Empirical Application*, Journal of Economics, Vol.67 (1998), No.1, pp 39-61.

Oxenstierna, Gabriel C., **1999**, *Market Power in the Swedish Banking Oligopoly: A Game-theoretic Model of Competition Applied to the Five Big Swedish Banks 1989-97,* Essay 2*: Do Swedish Banks Enjoy Economies of Scale or Economies of Scope?* , Akademitryck, Stockholm

Petersen, M. and R. Rajan, **1994**, *Benefits of Firm-Creditor Relationships: Evidence from Small Business Data*, Journal of Finance, 49, 3-37.

Phillips, P.C.B. and M. Loretan, **1991**, *Estimating Long-run Economic Equilibria,* Review of Economic Studies, Vol 58:3, 407-436.

Pulley, L.B. and Humphrey, D.B., 1993, *The Role of Fixed Costs and Cost Complementarities in Determining Scope Economies and the Cost of Narrow Banking Proposals*, Journal of Business, 66:3.

Rotemberg, J. and G. Saloner, **1987**, *The Relative Rigidity of Monopoly Pricing*, American Economic Review, 77, 917-926.

Shaffer, Sherrill, **1994**, *Structure, Conduct, Performance, and Welfare*, Review of Industrial Organization, 9: 435-450.

Shapiro, Carl, **1989**, *Theories of Oligopoly Behaviour,* in Handbook of Industrial Economics, Elsevier, Amsterdam.

Suominen, Matti, **1994**, *Measuring Competition in Banking: A Two-Product Model*, Scandinavian Journal of Economics, 96:1.

Swank, Job, **1995**, *Oligopoly in loan and deposit markets: An econometric application to the Netherlands*, De Economist 143:3, 353-366.

Tirole, Jean, **1989**, *The Theory of Industrial Organization,* The MIT Press, Cambridge, Ma.

Vesala, Jukka, **1993**, *Retail Banking in European Financial Integration*, Bank of Finland D:77, Helsinki 1993.

Vesala, Jukka, **1995**, *Testing for Competition in Banking: Behavioral Evidence from Finland*, Bank of Finland Studies E:1, Helsinki 1995.

Vesala, Jukka, **1998**, *Technological Transformation and Nonbank Competition in a Model of Retail Banking Oligopoly*, Bank of Finland Discussion Papers 8/98.

Statistical references

Föreningsbanken, Gotabanken, Handelsbanken, Nordbanken, S-E-banken, Swedbank: *Annual Reports* and *Quarterly Reports*.

The Riksbank, *Statistical Yearbook*, Stockholm 1990 - 1996.

SOS, *Bankerna*, Statistics Sweden, Stockholm, 1988 - 1996.

Finansräkenskaperna, Financial accounts, yearly accounts, Statistics Sweden, series K11 SM.

Finansräkenskaperna, Financial accounts, quarterly accounts, Statistics Sweden, series K17 SM.

Nationalräkenskaperna, National accounts, quarterly accounts, Statistics Sweden.

Nationalräkenskaperna, National accounts, yearly accounts, Statistics Sweden, series N10 SM.

Finansmarknaden del I and *del II*, Financial markets part I and part II, quarterly accounts, Statistics Sweden, series K18 SM.