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**Working Paper**

## Delivery networks and pricing behaviour in banking: An empirical investigation using Finnish data

Bank of Finland Discussion Papers, No. 18/1998

**Provided in Cooperation with:**

Bank of Finland, Helsinki

*Suggested Citation:* Vesala, Jukka (1998) : Delivery networks and pricing behaviour in banking: An empirical investigation using Finnish data, Bank of Finland Discussion Papers, No. 18/1998, ISBN 951-686-588-7, Bank of Finland, Helsinki,  
<https://nbn-resolving.de/urn:nbn:fi:bof-20140807217>

This Version is available at:

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# BANK OF FINLAND DISCUSSION PAPERS

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18/98

**Jukka Vesala**

Research Department  
19.8.1998

Delivery Networks and  
Pricing Behaviour in Banking:  
An Empirical Investigation Using Finnish Data

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The views expressed are those of the author and do not necessarily correspond to the views of the Bank of Finland

I wish to thank Pekka Ilmakunnas, Heikki Koskenkylä, David Mayes, Juha Tarkka and Jouko Vilmunen for their most helpful comments and suggestions. Remaining errors are however my own. Heli Tikkunen provided excellent research assistance, for which I am most grateful. I also wish to thank the Finnish Bankers' Association, especially Markku Hirvonen and Seppo Nihtilä, for letting me use their data and for sharing their information with me.

ISBN 951-686-588-7

ISSN 0785-3572

Suomen Pankin monistuskeskus  
Helsinki 1998

# Delivery Networks and Pricing Behaviour in Banking: An Empirical Investigation Using Finnish Data

Bank of Finland Discussion Papers 18/98

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## Abstract

The paper presents a method of measuring bank differentiation in terms of branch and ATM networks and uses the measures thus obtained to explain the pricing of deposits as well as corporate and household loans. Structural system models of demand and pricing equations are also estimated to separate network differentiation effects from collusion in loan and deposit rates. Pricing power due to network differentiation is found to exist mostly in household lending, while the benefits of differentiation are found to decrease trend-wise in all lending and deposit-taking activities. This result is in line with predictions concerning the technological transformation of services' delivery in banking. Differentiation is found to be the primary source of pricing power in lending, while collusion dominates in deposit-taking. Thus, European liberalization has greater potential to increase the contestability of the deposit market. Identified impacts of technological change imply more efficient pass-through of money market rate changes to loan and deposit rates in the future.

Keywords: banking, delivery networks, differentiation, collusion

# Jakeluverkostot ja hinnoittelu pankkitoiminnassa: Empiirinen tutkimus Suomen aineistolla

Suomen Pankin keskustelualoitteita 18/98

Jukka Vesala  
Tutkimusosasto

## Tiivistelmä

Tutkimuksessa kehitetään tapa mitata pankkien differentiaatiota jakeluverkostojen avulla ja käytetään näin saatuja mittareita selittävinä tekijöinä yritys- ja kotitalousluottojen sekä talletusten hinnoittelumalleissa. Kysyntä- ja hinnotteluyhtälöistä koostuvat systeemimallit estimoidaan myös, jotta voidaan erottaa toisistaan differentiaatio ja kolluusiokäyttäytyminen pankkien markkinavoiman selittäjinä. Tulosten mukaan jakeluverkostojen differentiaatio vaikuttaa eniten kotitalouksille suunnatussa luotonannossa, mutta differentiaation hyödyt pienenevät trendinomaisesti kaikessa luotonannossa ja talletustoiminnassa. Tämä on teorian mukainen tulos suhteessa teknisen kehityksen vaikutuksiin pankkitoiminnassa. Differentiaatio on tulosten valossa pääasiallinen syy pankkien markkinavoimaan luotonannossa, kun taas kolluusio talletustoiminnassa. Euroopan sisämarkkinaohjelmalla olisi siten suurimmat mahdollisuudet lisätä kilpailua talletusmarkkinoilla. Teknisen kehityksen myötä markkinakorkojen muutosten heijastuminen luotto- ja talletuskorkoihin voimistuu.

Asiasanat: pankkitoiminta, jakeluverkostot, differentiaatio, kolluusio

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# 1 Introduction

In a companion paper (Vesala 1998), I develop a model of retail banking competition that establishes a link between banks' pricing power and the extent to which they are (vertically) differentiated in terms of their branch and ATM networks. Furthermore, I demonstrate how the transformation of delivery technologies in banking reduces the pricing power and market share benefits banks realize from these 'physical' delivery networks. Technological transformation *reduces* and *equalizes* banks' markups in loan and deposit markets to the extent that it reduces the rates at which customers' utility declines as their accessibility to branches and ATMs worsens. As a result, competition in banking increases. New access options for banking services (eg PC and phone banking) and more extensive information on competing products and services make customers more mobile, and banks and nonbanks with small branch or ATM networks can compete on a more equal footing against banks with extensive networks.

In this paper, I estimate loan and deposit pricing equations using panel data on Finnish banks. Corporate and household credit markets are analysed separately. The pricing equations stem from the second stage of the theoretical model, ie short-run (SR) price competition with fixed delivery capacity. The aim of the estimations is to assess the effects of banks' *prevailing* differentiation in terms of their branch and ATM networks on their markups in loan and deposit markets and whether changes can be observed over time due to technological change. Finland provides a good opportunity for investigating empirically changes in the importance of branch and ATM networks as sources of pricing advantage, since the transformation of the delivery of banking services has already advanced quite far, particularly in the area of deposit-related activities. This paper presents a relatively simple empirical method of investigating these issues.

There is an identification problem if banks' pricing behaviour is other than noncooperative Bertrand-Nash behaviour, since the pricing power can then be due to either collusion or differentiation or both. Therefore, the aim is to be able to measure how much of banks' pricing power is due to differentiation in delivery networks after controlling for the possibility of cooperative behaviour or changes in it over time<sup>1</sup>. Conclusions about the potential effects of the European single market (deregulation, harmonization of banking regulations and free cross-border business activities) on banking competition and contestability are elementarily dependent on whether the primary source of banks' pricing power is network differentiation or collusion.

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<sup>1</sup> Econometric studies originating from Lee and Porter (1984) and Porter (1985) have confirmed that changes in firm conduct can take place over time, as predicted by theoretical oligopoly models. Namely, the Green and Porter (1984), Rotemberg and Saloner (1986) and the related regime-switch models predict periodic switches of oligopolistic conduct as a part of the cartel enforcement mechanism.

In the new empirical industrial organization (NEIO)<sup>2</sup> literature there are basically two approaches to the problem of measurement of cooperative conduct in product-differentiated industries (Bresnahan 1989). Either the elasticities of demand (including cross-elasticities) are carefully investigated to measure the degree of insulation of firms' demand from rivals' prices or an empirical model of competitive interaction is estimated. I adopt the latter approach because I wish to measure the contribution of cooperative conduct to banks' markups. This approach has also been applied quite extensively in recent times to various industries though, based on Bresnahan's (1989) and Slade's (1995) surveys of the literature, one can say that the majority of applications treat products as homogeneous across different firms. This methodology involves a simultaneous estimation of demand and pricing (supply) relations in order to be able to identify the parameters characterizing oligopolistic conduct.

Banking applications using the NEIO approach to measure competitive conduct include Spiller and Favaro (1984), Gelfand and Spiller (1987), Shaffer (1989), Hannan and Liang (1993), Neven and Röller (1994), Shaffer and DiSalvo (1994), Suominen (1994), Vesala (1995, ch. 4) and Berg and Kim (1998). None of these studies, however, discriminates between differentiation and oligopolistic coordination as sources of pricing power<sup>3</sup>.

Empirical work that investigates nonprice competition in banking is relatively scant. Mester (1987) and Calem and Nakamura (1994) examine the competitive effects of branching vs unit banking strategies in the US and find that branching tends to lead to more competitive outcomes because banks then become less geographically differentiated from each other. Schmid (1994) finds empirical support for the hypothesis that unconstrained nonprice competition in branch networks has resulted in Europe in over-branching from social standpoint. This result is in line with theoretical results indicating that a lack of price competition due to regulation or collusion supports competition in nonprice terms (eg Result 7 of Vesala 1998). Cerasi et al. (1997) study the impact of deregulation of banks' rate setting on branching in eight European countries and find that the increased price competition has lowered banks' branch network sizes, though branches still seem to give a competitive advantage over banks with smaller networks. These results are in line with the prediction that price competition reduces the size of the

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<sup>2</sup> NEIO literature, which has started to emerge in the early 1980s is fundamentally different from the previously predominant empirical method in the field, ie the structure-conduct-performance paradigm (SCPP), which tests whether firms have more market power in concentrated markets. In contrast, NEIO literature attempts to measure competitive behaviour directly and precisely by estimating empirical counterparts of theoretical oligopoly models. Bresnahan's (1989) survey summarizes the main criticism against the SCPP approach. Most importantly, the SCPP approach can not actually discriminate whether good performance is due to bad (pricing power) or good (efficiency) conduct. There is much literature on the validity of the SCPP in banking – especially from the US (Berger 1995 contains a summary). These studies usually find a positive relation between concentration or market share and profitability. However, these studies are plagued by the above methodological problem, as well as by severe identification and measurement problems as discussed eg in Vesala (1995, ch. 1).

<sup>3</sup> A related empirical literature uses the Panzar-Rosse (1987) methodology based on estimating the factor price elasticities of firms' revenue functions to make inferences about the appropriate model of competition for a particular industry. Banking applications of this methodology include Nathan and Neave (1989), Molyneux et al. (1992), Shaffer and DiSalvo (1994), and Bikker and Groeneveld (1998). This methodology is indirect, since it actually traces out the demand relation rather than the supply relation, which is actually affected by oligopolistic conduct. Moreover, interpretation of the results is not always clear in this methodology (Bresnahan 1989).

optimal branch network. Finally, Kim and Vale (1997) investigate the role of branches for competition in the Norwegian credit market and find that the branch network has clearly been used as a strategic nonprice variable in competition.<sup>4</sup>

Section 2 presents the derivation of the empirical pricing equations, and section 3 the adopted system models for identifying the coordination parameters. Section 4 describes the data and variables used in the estimations. Empirical implementation of the models and discussion of the results is the topic of section 5, and section 6 concludes by summarizing the main results and discussing the implications for future developments in banking conduct and competitiveness and for certain policy issues.

## 2 Empirical models of setting loan and deposit rates

### 2.1 Derivation of empirical pricing equations

For profit maximizing banks that invest excess funds from deposits in securities that earn the market rate of interest or issue securities to finance excess loans, the SR pricing equations for the loan and deposit markets are the first-order conditions for the oligopoly equilibria in the two markets. They represent optimal rate setting decisions given the level of ‘physical’ delivery capacity. I will analyse separately the corporate ( $m=1$ ) and household ( $m=2$ ) credit markets, since these two market segments are quite different in terms of products and lending procedures. The main interest is to examine whether the estimates of the ‘utility parameters’ that characterize the value of banks’ ‘physical’ delivery outlets for clients differ markedly across these two segments. This should be the case since the means and nature of informing the lender and the possibilities to ‘shop around’ for the best offers in the market should differ significantly. These two market segments also constitute a proxy for the retail credit market, which is the target of the theory. Nevertheless, empirical analyses will be carried out on the entire credit market as well.

Under noncooperative Bertrand-Nash competition, the pricing equations take the following form (Result 5 of Vesala 1998):

$$(1) \quad \begin{aligned} T_t^m(i_t, B_{1t}, C_t^{Lm}, N_t) &= i_t + C_t^{Lm} + K_t^m, \quad m = 1, 2 \\ R_t(i_t, B_{1t}, B_{2t}, C_t^D, N_t) &= i_t - C_t^D - \frac{H_t}{2}, \end{aligned}$$

where  $T^m$  and  $R$  are the column vectors of loan and deposit rates  $(t_1^m, \dots, t_N^m)'$  and  $(r_1, \dots, r_N)'$ ,  $B_1$  and  $B_2$  the column vectors of the numbers of branches and ATMs

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<sup>4</sup> There is also some empirical work on the effect of branching on service availability (eg Evanoff 1988) and on the determinants of banks’ branching decisions (eg Barros 1995). ATM network decisions have not been empirically assessed as far as I know. There are also quite many papers on the social desirability of branching regulations (Jayaratne and Strahan 1997 contains a summary) and on the cost efficiency effects of branching (Berger and Humphrey 1995 summarize the large international literature on the cost efficiency of banking firms).

$(b_{11}, \dots, b_{1N})'$  and  $(b_{21}, \dots, b_{2N})'$ , and  $C^{Lm}$  and  $C^D$  the column vectors of bank-specific SR marginal operating costs of corporate and household loan provision and deposit-taking activities,  $(c_1^{Lm}, \dots, c_N^{Lm})'$  and  $(c_1^D, \dots, c_N^D)'$ , as specified below.  $i$  denotes the money market interest rate and  $N$  the number of banks in the market. In the empirical analysis, the same banks operate in both the loan and deposit markets, which accords with Finnish banking structure. However, the panel data is unbalanced, so that  $N$  can vary over time.

$K^m$  and  $H$  represent the column vectors  $(K_1^m, \dots, K_N^m)'$  and  $(H_1, \dots, H_N)'$  of the *summary indices of banks' differentiation* with respect to their branch and ATM networks as defined by Results 1 and 3 of Vesala (1998), based on Feenstra's and Levinsohn's (1995) theory. These measures fully determine the semi-elasticities of the loan demand and deposit supply perceived by the banks with respect to their loan and deposit rates, so that the elasticities are the lower (ie pricing power the greater) the larger the values of these measures. The elements of the  $K$  and  $H/2$  vectors are also equal to the *absolute markups* that banks enjoy in loan and deposit markets over the money market rate and SR marginal operating costs. The *relative markups* (ie the *Lerner indices* of price competition intensity) equal  $K_i^m / t_i^m$  and  $H_i / 2r_i$ . The construction of the  $K$ - and  $H$ -indices is described in the next section.

I postulate that the bank-level SR operating cost functions with fixed delivery capacities are different for lending and deposit-taking activities, the difference being that ATMs are not part of the operating cost function for the lending activities. The cost functions are however defined to account for the multiproduct nature of banking by allowing for possible economies of scope between lending and deposit-taking. In turn, the marginal SR operating costs are postulated as linear in their arguments: fixed capacities, ie numbers of branches and ATMs (deposit costs only); activity levels, ie lending ( $L^m$ ) or deposit taking ( $D$ ) volumes, to control for increasing or decreasing returns to scale; 'cross-activity' levels to account for economies of scope; and  $k$  input prices ( $w_k$ )<sup>5</sup>, which may be bank-specific:

$$\begin{aligned}
 c_{it}^{Lm} &\equiv \frac{\partial C_{SRit}^{Lm}(L_{it}, D_{it} | b_{lit}, w_{ikt})}{\partial L_{it}^m} = \\
 &\beta_0^m + \lambda_i^{Lm} + \beta_1^m b_{lit} + \beta_2^m L_{it}^m + \beta_3^m D_{it} + \sum \beta_{4k}^m w_{ikt} + \varepsilon_t^{Lm} \\
 (2) \quad c_{it}^D &\equiv \frac{\partial C_{SRit}^D(L_{it}, D_{it} | b_{lit}, b_{2it}, w_{ikt})}{\partial D_{it}} = \\
 &\mu_0 + \lambda_i^D + \mu_{11} b_{lit} + \mu_{12} b_{2it} + \mu_2 D_{it} + \mu_3 L_{it} + \sum \mu_{4k} w_{ikt} + \varepsilon_t^D, L_{it} \\
 &= \sum^m L_{it}^m, i = 1, \dots, N_t, m = 1, 2
 \end{aligned}$$

<sup>5</sup> Estimates of marginal costs are needed in any NEIO assessment of oligopoly markups. Roberts and Samuelson (1988) develop a methodology to derive marginal cost estimates from an empirical cost function that is estimated together with factor-share equations to ensure parameter consistency. The estimates of the cost function parameters are then used to generate firm-specific estimates of marginal costs that are used as input in the estimation of the pricing equations. I adopt a different methodology, and estimate simultaneously the parameters of the cost function and the pricing relations, as in a banking application by Shaffer and DiSalvo (1994), since the simultaneous method is statistically preferred to the two-stage approach.

where the  $\lambda$ 's represent bank-specific components in the SR marginal operating costs that are not correlated with the other arguments, ie they represent the fixed effects in the panel estimation context. The fixed effects reflect cost efficiency differences across banks. Hence, a high  $\lambda$  may be due to overcapacity, waste or even extensive credit risk taking that increase costs relative to other banks. The random effects (the  $\varepsilon$ 's) reflect the production cost of unobservable service quality, which is not related to the size of banks' branch and ATM networks. These include the quality of all services associated with lending and deposit-taking, for example credit consultation, credit risk evaluation, and quality of payment transfers that have some value to banks' clients. The intercepts ( $\beta_0, \mu_0$ ) can be thought of representing the costs of producing a quality difference between banks' and nonbank providers' credit- and deposit- and payments-related services. That is, they capture the competitive benefits to the banking sector as a whole in terms of service quality vs any outside nonbank options for bank customers.

A quadratic functional form for the underlying SR cost functions is consistent with the above marginal cost functions.<sup>6</sup> This is a fairly flexible form, as it contains the arguments squared and cross-terms in addition to the linear terms, and is quite often applied in empirical research. For example, a linear marginal cost function was adopted by Bresnahan (1982) in his original test of competitive conduct.

It is important to allow for increasing or decreasing returns to scale by including activity levels as explanatory variables in the SR marginal operating cost functions. A fairly common practice in the literature is to use average variable costs or other constant proxies to specify marginal costs (see eg the airline application by Brander and Zhang 1993). This can obviously induce errors, since the slope of the marginal cost curve is ignored. Specifically, one could mismeasure the true price-marginal cost markup, and end up attributing what is

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<sup>6</sup> The quadratic SR operating cost function for the lending activities takes the following form:

$$\begin{aligned} C_{SRit}^L = & (\beta_0^m + \lambda_i^{Lm} + \beta_1^m b_{lit} + \beta_3^m D_{it} + \sum \beta_{4k}^m w_{ikt} + \varepsilon_t^{Lm}) L_{it}^m + \\ & (\beta_0^n + \lambda_i^{Ln} + \beta_1^n b_{lit} + \beta_3^n D_{it} + \sum \beta_{4k}^n w_{ikt} + \varepsilon_t^{Ln}) L_{it}^n + \\ & (\mu_0 + \lambda_i^D + \mu_{11} b_{lit} + \mu_{12} b_{2it} + \mu_3 L_{it} + \sum \mu_{4k} w_{ikt} + \varepsilon_t^D) D_{it} + \\ & \frac{1}{2} \beta_2^m L_{it}^{m2} + \frac{1}{2} \beta_2^n L_{it}^{n2} + \frac{1}{2} \mu_2 D_{it}^2 + \phi_1 b_{lit} + \sum \phi_{2k} w_{ikt} + \\ & \phi_3 b_{lit}^2 + \sum \phi_{4k} w_{ikt}^2 + \sum \phi_{5k} w_{ikt} b_{lit}, m, n = 1, 2, m \neq n \end{aligned}$$

The SR operating cost function for deposit-taking can be constructed in a similar fashion. To meet the requirements imposed by the theory, the cost function needs to be (i) concave, (ii) nondecreasing and (iii) homogeneous of degree one in input prices (eg Varian 1992). The last requirement is problematic, since the required parameter restrictions would be very complex. An alternative would be to adopt eg the often-applied translog form for the cost function, for which the theoretical parameter restrictions are much simpler. However, in my case the marginal cost functions need to be specified in linear form in order to solve the simultaneity problem as explained below and to obtain estimating equations that are in line with the underlying theory. In the literature, the theoretical cost function restrictions are often neglected altogether.

The long-run (LR) operating cost function for the lending activities is defined by,  $C_{LRit}^L = C_{SRit}^L + f_{li} b_{lit}$ , where  $f_{li}$  is bank  $i$ 's fixed cost of branch establishment. If there are constant returns to scale, the SR marginal operating cost curve is identical to the LR curve, where capacities are also allowed to change.

really the slope of the SR marginal cost curve to pricing power. Here, for example, if there are local decreasing returns to scale, then assuming constant returns to scale could account for the rejection of zero markups. Loan and deposit margins vs the money market rate could exceed average operating costs and yet still be close to marginal costs.<sup>7</sup>

The pricing equations take the following form, once the SR marginal operating costs (2) are inserted in (1):

$$\begin{aligned}
 T_t^m &= i_t + \beta_0^m + \Lambda \lambda^{Lm} + B_{1t} \beta_1^m + MT_t^m(K_t^m(B_{1t}, v^m, Z_t^m)) \\
 &\quad + L_t^m \beta_2^m + D_t \beta_3^m + W_t \beta_4^m + \varepsilon_t^{Lm}, m=1, 2 \\
 R_t &= i_t - \mu_0 - \Lambda \lambda^D - B_{1t} \mu_{11} - B_{2t} \mu_{12} - MR_t(H_t(B_{1t}, B_{2t}, \tau_1, \tau_2, \Xi_t)) \\
 &\quad - D_t \mu_2 - L_t \mu_3 - W_t \mu_4 - \varepsilon_t^D,
 \end{aligned}
 \tag{3}$$

where  $\Lambda$  is a matrix of firm dummies to generate the fixed effects in the SR marginal operating cost functions. The oligopoly markups  $MT^m$  and  $MR$  depend on the ‘physical’ delivery capacities; the parameters describing the rate at which customer utility decreases when access to ‘physical’ delivery outlets worsens ( $v^m$ , and  $\tau_1, \tau_2$ ); the loan and deposit rates adjusted for marginal utilities with respect to ‘physical’ delivery outlets and quality differences vs nonbank competitors. These ‘marginal utility-adjusted rates’ are the elements of the column vectors  $Z^m = (\zeta_1^m = t_1 - \eta_0^m - \eta_1^m b_{11}, \dots, \zeta_N^m)'$ , and  $\Xi = (\xi_1 = r_1 + \gamma_0 + \gamma_{11} b_{11} + \gamma_{12} b_{21}, \dots, \xi_N)$ . Lastly,  $W$  is the column vector of factor prices,  $(w_1, \dots, w_k)'$ , and  $\beta_4^m$  and  $\mu_4$  the respective row parameter vectors.

The above pricing equations entail a simultaneity problem, since the ‘marginal utility-adjusted rates’ appear on the RHS of the equations. However, if one defines the marginal cost and marginal utility parameters associated with the ‘physical’ delivery outlets as equal<sup>8</sup> ( $\eta_1^m = \beta_1^m, \gamma_{11} = \mu_{11}, \gamma_{12} = \mu_{12}$ ), as well as the marginal utilities and costs of the quality difference between banks’ and outside competitors’ services ( $\eta_0^m = \beta_0^m, \gamma_0 = \mu_0$ ), the ‘marginal utility-adjusted’ loan and deposit rates can be expressed as

<sup>7</sup> As regards banking applications of NEIO, possible deviations between marginal and average operating costs are explicitly addressed in Shaffer and DiSalvo (1994). Spiller and Favaro (1984) and Gelfand and Spiller (1987) ignore marginal operating costs altogether and simply use the market interest rate as a proxy for banks’ marginal costs.

<sup>8</sup> This assumption can be imposed without loss of generality. To demonstrate this, eg a borrower’s choice of preferred network density, given the quadratic utility function specification (see Vesala 1998), is based on the solution to:  $\max_{b_1 > 0} U(b_1, b^*, t) = \eta_0 + \eta_1 b_1 - (b_1 - b_1^*)^2 v - t(i, b_1)$ , s.t.  $t-i = \beta_0 + \beta_1 b_1$ . In this formulation, marginal costs are simply taken to be a function of delivery capacity, and it is assumed that a continuous choice is available for borrowers under marginal cost pricing. Then the first-order condition is:  $\eta_1 - 2v(b_1 - b_1^*) = \beta_1$ . Hence the optimal solution ( $b_1 = b_1^*$ ) implies that the respective marginal cost and utility parameters must be the same (see Feenstra and Levinsohn 1995).

$$\begin{aligned}
Z_t &= T_t - \beta_0^m - B_{1t}\beta_1^m = \\
(4) \quad i_t + \Lambda\lambda^{Lm} + MT_t^m(K_t^m(B_{1t}, v^m, Z_t^m)) + L_t\beta_2^m + D_t\beta_3^m + W_t\beta_4^m + \varepsilon_t^{Lm} \\
\Xi_t &= R_t + \mu_0 + B_{1t}\mu_{11} + B_{2t}\mu_{12} = \\
i_t - \Lambda\lambda^D - MR_t(H_t(B_{1t}, B_{2t}, \tau_1, \tau_2, \Xi)) - D_t\mu_2 - L_t\mu_3 + W_t\mu_4 - \varepsilon_t^D
\end{aligned}$$

which implicitly determines the ‘marginal utility-adjusted rates’ as a function of the model parameters  $(\Psi^m, \Phi)$  and arguments<sup>9</sup> ( $Z_t^m \equiv F^m(\Psi^m, B_{1t}, L_t, D_t, W_t)$  and  $\Xi_t \equiv G(\Phi, B_{1t}, B_{2t}, L_t, D_t, W_t)$ ). That is, the ‘marginal utility-adjusted’ rates are fully determined by bank-specific cost effects and redefined oligopoly markups,  $MT_t^{*m} \equiv K_t^{*m}(B_{1t}, v^m)$  and  $MR_t^* \equiv H_t^*(B_{1t}, B_{2t}, \tau_1, \tau_2)/2$ , which depend solely on differences in the sizes of branch and ATM networks and the associated ‘utility parameters’. Since they do not depend on loan and deposit rates, the simultaneity problem can be solved.<sup>10</sup> After substituting the redefined markups into (4), the loan and deposit rates appear only on the LHS.

I include period dummies, PD, in the estimating equations in order to control for the effects on banks’ markups of changes in deposit regulation regimes that occur within the sample period, and in order to separate the effects of liberalization from the effects of technological change. Loan rates were already practically free of regulation during this period. Furthermore, the time trend (t) is attached to the ‘utility parameters’ in order to investigate changes over time. Finally, the money market rate is included in the model, since in imperfectly competitive markets the pass-through of money market rate changes into banks’ loan and deposit rates can be significantly imperfect, and money market rate changes are reflected in banks’ margins vs the money market rate (eg Berger and Hannan 1991). As shown in the companion paper (Propositions 6.a and b of Vesala 1998), technological change should increase the pass-through of money market rate changes and reduce the impact of the interest rate level on margins. This implication will be tested in the estimations.

After rearranging (4), substituting the oligopoly markups  $MT^{*m}$  and  $MR^*$  into (4) to solve the simultaneity problem, and making all of the above mentioned additions, I obtain the following pricing equations, which are to be estimated:

$$\begin{aligned}
(5.1) \quad T_t^m - i_t &= \beta_0^m + PD_t\beta_0^{PDm} + \Lambda\lambda^{Lm} + K_t^{*m}(B_{1t}, v^m(t)) \\
&+ B_{1t}\beta_1^m(t) + L_t\beta_2^m + D_t\beta_3^m + W_t\beta_4^m + \beta_5^m(t)i_t + \varepsilon_t^{Lm}, m=1, 2
\end{aligned}$$

$$\begin{aligned}
(5.2) \quad i_t - R_t &= \mu_0 + PD_t\mu_0^{PD} + \Lambda\lambda^D + H_t^*(B_{1t}, B_{2t}, \tau_1(t), \tau_2(t))/2 \\
&+ B_{1t}\mu_{11}(t) + B_{2t}\mu_{12}(t) + D_t\mu_2 + L_t\mu_3 + W_t\mu_4 + \mu_5(t)i_t + \varepsilon_t^D
\end{aligned}$$

<sup>9</sup> This method of avoiding simultaneity bias is used in Feenstra and Levinsohn (1995)

<sup>10</sup> This approach also presumes that the semi-elasticities of perceived loan demand and deposit supply, which determine the respective markups, do not depend on the level of loan or deposit rates, whereas the elasticities do. Empirically, this formulation means imposing a more restrictive functional form.



## 2.2 Specification and properties of network differentiation indices

In (5.1) and (5.2) the *network differentiation indices* take the following form, as stipulated by the theoretical model (Results 1 and 3 of Vesala 1998):

$$\begin{aligned}
 K_{it}^{*m} &\equiv \left( \sum_{j \neq i} k_{ijt}^{*m} \right)^{-1} \equiv \left( \sum_{j \neq i} \frac{\frac{\rho_{jt}^m}{\sum_{j \neq i} \rho_{jt}^m}}{(b_{lit} - b_{ljt})^2 v^m} \right)^{-1} \equiv v^m \left( \sum_{j \neq i} k_{ijt}^{**m} \right)^{-1} \\
 &\equiv v^m K_{it}^{**}, \text{ for } b_{lit} > b_{ljt} \\
 H_{it}^* &\equiv \left( \sum_{j \neq i} h_{ijt}^* \right)^{-1} \equiv \left( \sum_{j \neq i} \frac{\frac{\delta_{jt}}{\sum_{j \neq i} \delta_{jt}}}{(b_{lit} - b_{ljt})^2 \tau_1 + (b_{2it} - b_{2jt})^2 \tau_2} \right)^{-1}, \\
 (6) \quad &\text{for } b_{lit} > b_{ljt} \text{ and } b_{2it} > b_{2jt},
 \end{aligned}$$

If  $b_{lit} \leq b_{ljt}$ , then  $k_{ijt}^{*m} = \varepsilon$ ; if  $b_{lit} \leq b_{ljt} \wedge b_{2it} \leq b_{2jt}$ , then  $h_{ijt}^* = \varepsilon$ ,  
 $i = 1, \dots, N_t, j \neq i = 1, \dots, (N+1)_t, b_{1N+1t} = 1, b_{2N+1t} = 0, m = 1, 2$ ,

where  $\rho^m$  and  $\delta$  represent market shares in the loan and deposit markets and are used as the weights in the calculation of differentiation indices. The larger the market shares of rivals to bank  $i$ , the smaller the value of its differentiation index. Hence, there is the typical positive relationship between a bank's market share and its pricing power, as in the standard, homogeneous product Cournot oligopoly model for symmetric firms, where the market price falls with the number of firms, ie with each firms' market share (eg Tirole 1990 ch. 5).

The key feature embedded in (6) is that banks are allowed gain competitive advantage vs other banks only if their networks are larger than those of the banks to which they are compared. When this is not the case, the respective part of the index is defined as a small number  $\varepsilon$ , in order to avoid division by zero. Addition of the  $(N+1)$ th term in the calculation of the  $K^*$ 's and the  $H^*$ 's captures the effect of the size of bank  $i$ 's networks independent of any comparison to other banks with 'physical' delivery networks. This corresponds to the competitive advantage vs the nonbank competitors outside the banking sector that do not have these networks.

The two-dimensional form of  $H^*$  produces technical problems, since the  $\tau$ -parameters cannot be factored out from the summation in the same way as the  $v^m$ -parameters to produce the indices  $K^{**}$ , as demonstrated in (6). As a result, the estimating equation would need to contain all 'cross-differences' in delivery networks among all  $(N-1)$  pairs of banks. To establish a more efficient estimating equation with respect to the use of the degrees of freedom, branches and ATMs

are treated as separate differentiation parameters to construct a one-dimensional indices<sup>11</sup>:

$$(7) \quad H_{it}^*/2 = \left( \sum_{j \neq i} \frac{\frac{\delta_{jt}}{\sum_{j \neq i} \delta_{jt}}}{(b_{lit} - b_{ljt})^2 \tau_1^*} \right)^{-1} + \left( \sum_{j \neq i} \frac{\frac{\delta_{jt}}{\sum_{j \neq i} \delta_{jt}}}{(b_{2it} - b_{2jt})^2 \tau_2^*} \right)^{-1} \equiv \tau_1^* \left( \sum_{j \neq i} h_{ijt}^{b1**} \right)^{-1} + \tau_2^* \left( \sum_{j \neq i} h_{ijt}^{b2**} \right)^{-1} \equiv \tau_1^* H_{lit}^{**} + \tau_2^* H_{2it}^{**},$$

which greatly simplifies the estimation. Once the  $\tau^*$ -parameters are estimated, the effect of this simplification on the value of the index can be assessed. This will be done in section 5.2 as regards the data on the Finnish banking industry.

The properties of the network differentiation indices are illustrated in the following by considering first symmetric and then asymmetric banking structures. Let there be  $N$  banks, of which  $M$  have equal-sized branch networks, and identical market shares.<sup>12</sup> The  $(N-M)$  other banks operate as unit banks with just a single branch office. Now after some manipulation, the expression for the one-dimensional differentiation index, which I denote *symmetry-equivalent differentiation index*  $KS^{**}$ , can be written as (subscripts  $t$  and  $m$  omitted)

$$(8.1) \quad KS_{i \in M}^{**} = \left( \frac{1}{\rho_{-i}} \left( (M-1)\rho_{-i}\varepsilon + \frac{\rho_F}{\left( \frac{b_T - (N-M)}{M} - 1 \right)^2} \right) \right)^{-1},$$

$$\rho_{-i} \equiv \sum_{j \neq i} \rho_j, \rho_F \equiv \sum_{k \notin M} \rho_k, i = 1, \dots, N, j, k = 1, \dots, N+1$$

where  $b_T$  symbolizes the total number of branches in the banking industry, and  $\rho_F$  the market share of the ‘fringe’, which is made up of the  $(N-M)$  unit banks and the nonbank competitor. We see that, for given  $b_T$  and  $N$ , the maximum value of the index obtains when the branch network is controlled by just one bank ( $M=1$ ) and other institutions make up the ‘fringe’. The *expression for the maximum value* equals  $(b_T - N)^2$ , as in this case  $\rho_{-i} = \rho_F$ . Further, for given  $b_T$ ,  $K^{**}$  is at its *maximum value* of  $(b_T - 1)^2$  when the only branch-bank is also the only bank ( $N=M=1$ ). However, with large  $b_T$  and small  $N$ , the maximum value is largely determined by  $b_T$ .<sup>13</sup>

<sup>11</sup> Another way would be to lump together branches and ATMs, and compute a one-dimensional differentiation measure. This would however presume that branches and ATMs are perfectly substitutable delivery channels, which should not be the case, since not all services can be offered through ATMs and ATMs offer more flexibility for customers as regards opening hours in particular.

<sup>12</sup> Hence the joint market share of the rival institutions to bank  $i$  ( $\rho_{-i}$ ) are the same for all  $M$  branch-banks.

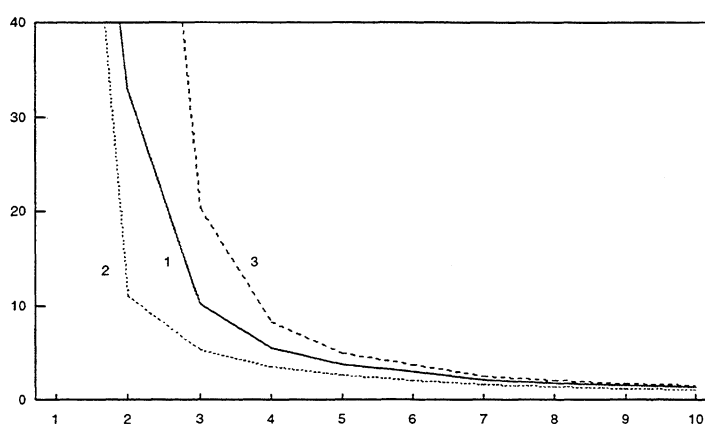
<sup>13</sup> Note that the value of the index is not defined when  $\rho_F = 0$ .

The index  $KS^{**}$  is highly *convex*, as illustrated in Figure 1. The value falls substantially, but at a decreasing rate, when there are more than one bank controlling the branch network ( $M > 1$ ). Hence the index allots a high reward for a monopoly position in the 'physical' delivery network. Symmetric branch-banks do not have a competitive advantage over other branch-banks, and their relative pricing power vs the 'fringe' falls with the number of branch-banks or with a decrease in the total number of branches.<sup>14</sup>

Figure 1.

**Illustration of symmetry-equivalent differentiation index,  $KS^{**}$ , (1) and (2) (horizontal axis  $M$ ), and asymmetric example (3) (horizontal axis  $M^*$ );**

(1) 0.1 market share of the 'fringe', (2) 0.9 market share of the 'fringe'. (3)  $x = 0.75$ . Figures drawn under the assumptions  $b_T = 1000$ ,  $N = 20$ ,  $\varepsilon = 0.1$ .



The convexity property of the  $KS^{**}$  index is maintained in the general cases of asymmetric branch-banks, which I study next. In the asymmetric cases, banks can have pricing power also vs other banks with branch networks. The value of the index is the larger, the greater the extent to which the bank in question controls the branch network as compared to its rivals. The effect of asymmetry on the index value is demonstrated in figure 1, where line (3) is drawn under the assumption that  $M^* (\geq 2)$  branch-banks possess 75 per cent of the network

<sup>14</sup> The  $KS^{**}$  index (or its sum over all banks) should actually be interpreted as a measure of concentration rather than differentiation, which takes into account both branches and market shares, since in the symmetric case branch-banks are not differentiated from each other as regards the scope of the branch network. The properties of  $KS^{**}$  resemble those of the conventional Herfindahl-index of market concentration (sum of the squared market shares) or individual firms' contribution to the index, as the latter are also strongly convex measures.

( $x=0.75$ ).<sup>15</sup> In the case where there is only one branch-bank ( $M^*=1$ ), there is of course no difference between the symmetric and asymmetric banking structures and hence the maximum of the index is always the same,  $(b_T - N)^2$ , regardless of any asymmetries in the banking sector.

It is possible to assess how much the calculated bank-specific differentiation indices,  $K_{it}^{**m}$ , deviate from the index value for the case where all banks are symmetric, ie where the index  $KS^{**}$  is calculated using the total number of branches and banks in the banking system in question (refer to equation (8.1)). The difference between the two indices ( $K_{it}^{**m} - KS_t^{**m} \equiv KD_{it}^{**m}$ ) constitutes a *measure of the differentiation of bank i vs other banks with branch networks*. In addition, the ratio ( $KD_{it}^{**m} / K_{it}^{**m}$ ) gives the percentage of bank i's pricing advantage that is due its branch-network exceeding its rivals' networks, ie due to its network differentiation against other branch-banks. The rest is due to the *network size effect*. These calculations are done for the Finnish banking industry in section 4.2. The estimates of bank-specific markups and their decompositions can be obtained by multiplying the  $K_{it}^{**}$  indices by the corresponding estimates of the  $v$ -parameters.

As a final point, note that the value of the differentiation index  $K^{**}$  is always positive for a bank that has more than one branch, while for unit banks the index value is at *minimum* value of zero. To see this, the index for the bank  $k$ , which has the smallest branch network among the branch-banks, can be expressed as

$$(8.2) \quad K_k^{**} = \rho_{-k} \left( \frac{(b_k - 1)^2}{(M^* - 1)\rho_{-k}\varepsilon(b_k - 1)^2 + \rho_F} \right)$$

where  $M^*$  stands for the number of branch-banks. We see now that the value of  $K_k^*$  is zero when  $b_k = 1$  (unit banks), and the differentiation index then obtains its minimum value of zero.

Given the maximum and minimum values, the differentiation indices could be scaled between 1 and 0 by dividing by the maximum,  $(b_T - N)^2$ .

<sup>15</sup> The value of the differentiation index takes the following form in the particular example of an asymmetric banking structure, where  $x$  per cent of the branch network is controlled by  $M^*$  banks:

$$KA_{i \in M}^{**} = \left( \frac{1}{\rho_{-i}} \left( \frac{(M^* - 1)\rho_{-i}\varepsilon + \rho_M}{(M - M^*) \left( \left( \frac{x(b_T - (N - M))}{M^*} - \frac{(1 - x)(b_T - (N - M))}{(M - M^*)} \right)^2 \right) + \frac{\rho_F}{\left( \frac{b_T - (N - M)}{M^*} - 1 \right)^2}} \right) \right)^{-1},$$

$$\rho_{-i} \equiv \sum_{j \neq i} \rho_j, \rho_M \equiv \sum_{k \in M, k \neq M^*} \rho_k, \rho_F \equiv \sum_{k \notin M} \rho_k, i = 1, \dots, N, j, k = 1, \dots, N+1$$

### 3 Identifying cooperative conduct

The empirical pricing equations (5.1) and (5.2) are based on the assumption of Bertrand-Nash behaviour on the part of banks. The aim of this section is to derive empirical system models consisting of demand and pricing relations that can be used to test the validity of the Bertrand-Nash restriction against alternative forms of conduct, and to estimate which part of banks' markups over marginal costs and the money market rate is due to differentiation in 'physical' delivery networks, and which to collusive conduct (anticompetitive price coordination among banks in setting their loan or deposit rates). Collusive behaviour may well be 'tacit', ie not based on an explicit cartel agreement.

The following first-order approximations of the loan demand and deposit supply relations for bank  $i$  can be obtained using the respective expressions for the 'own-' and 'cross-rate' semi-elasticities (Results 1, 2, 3 and 4 of Vesala 1998):

$$\begin{aligned}
 \ln L_t^m &= \alpha_0^{Lm} - \alpha_1^{LDm} \frac{(T_t^m - \eta_0^m - B_{1t} \eta_1^m)}{K_t^m} \\
 &\quad + \alpha_2^{LDm} \sum_{j \neq i} \frac{\rho_{jt}^m (t_{jt}^m - \eta_0^m - \eta_1^m b_{1jt})}{k_{ijt}^m}, \quad m = 1, 2 \\
 \ln D_{it} &= \alpha_0^D + \alpha_1^{DD} \frac{(R_t + \gamma_0 + B_{1t} \gamma_{11} + B_{2t} \gamma_{12})}{H_t / 2} \\
 &\quad - \alpha_2^{DD} \sum_{j \neq i} \frac{\delta_{jt} (r_{jt} + \gamma_0 + \gamma_{11} b_{1jt} + \gamma_{12} b_{2jt})}{h_{ijt} / 2}
 \end{aligned} \tag{9}$$

where the intercepts  $(\alpha_0^{Lm}, \alpha_0^D)$  capture the range of factors that affect the total size of the loan and deposit markets. The theory implies that the weighing parameters  $(\alpha_1^{LDm} = \alpha_2^{LDm} > 0, \alpha_1^{DD} = \alpha_2^{DD} > 0)$  be positive, and the same in absolute terms for 'own-' and 'cross-effects' in the loan demand and deposit supply relations. Namely, if the prices of all institutions rise in proportion, the individual demands should remain unaffected. This homogeneity implication of the theory will however be tested rather than imposed from the outset.

Based on (9), I am able to construct the following empirical demand equations to be estimated:

$$\begin{aligned}
 \ln L_t^m &= \alpha_0^{LDm} + YR \alpha_0^{YLDm} + \Lambda \lambda^{LDm} - \alpha_1^{LDm} \frac{(T_t^m - \beta_0^m - B_{1t} \beta_1^m(t))}{K_t^{*m}(B_{1t}, v^m(t))} \\
 &\quad + \alpha_2^{LDm} \frac{(T_t^{m-i} - \beta_0^m - B_{1t}^{-i} \beta_1^m(t))}{K_t^{*m-i}(B_{1t}^{-i}, v^m(t))} \\
 &\quad + X_t \alpha_3^{LDm} + (X_t \times T_t) \alpha_4^{LDm} + \varepsilon_t^{LDm}, \quad m = 1, 2
 \end{aligned} \tag{10.1}$$

$$\begin{aligned}
\ln D_t = & \alpha_0^{DD} + YR\alpha_0^{YDD} + \Lambda\lambda^{DD} + \alpha_1^{DD} \frac{(R_t + \mu_0 + B_{1t}\mu_{11}(t) + B_{2t}\mu_{12}(t))}{H_t^*(B_{1t}, B_{2t}, \tau_1(t), \tau_2(t))/2} \\
(11.1) \quad & - \alpha_2^{DD} \frac{(R_t^{-i} + \mu_0 + B_{1t}^{-i}\mu_{11}(t) + B_{2t}^{-i}\mu_{12}(t))}{H_t^{*-i}(B_{1t}^{-i}, B_{2t}^{-i}, \tau_1(t), \tau_2(t))/2} \\
& + Y_t\alpha_3^{DD} + (Y_t \times R_t)\alpha_4^{DD} + \varepsilon_t^{DD}
\end{aligned}$$

In (10.1) and (11.1), I approximate the effects of rivals' rates on bank i's loan demand and deposit supply with the averages  $(\rho^{-im}, \delta^{-i}, T^{-im}, R^{-i}, K^{*-im}, H^{*-i})$  for the rival institutions to bank i, instead of including all  $(N-1)$  ratios in the model.<sup>16</sup> Note that the loan demand and deposit supply relations have as arguments own and average rival 'marginal utility adjusted rates'. Cyclical variables that affect the total loan demand and deposit supply in a certain period  $t$  ( $X_t, Y_t$ ) are inserted in place of the original intercepts  $(\alpha_0^{Lm}, \alpha_0^D)$ . Year dummies (YR) are included to pick up unmodelled components of the error terms that are correlated with time, and firm dummies,  $\Lambda$  (fixed effects) those that are correlated with the characteristics of the institutions in the sample. Multiplicative terms  $(X_t \times T_t, Y_t \times R_t)$  are incorporated in the model, because the slopes of the loan demand and deposit supply functions need to depend on an exogenous variable in order to identify the oligopolistic coordination parameters, as discussed below. Finally, I have made the substitutions between the marginal utility and cost parameters and inserted the time trends, as before.

Now the semi-elasticities take the form

$$\begin{aligned}
\frac{\partial L_t^m}{\partial T_t^m L_t^m} = & -\frac{\alpha_1^{LDm}}{K_t^{*m}(B_{1t}, v^m(t))} + X_t \alpha_4^{LDm}, m = 1, 2 \\
(11) \quad & \frac{\partial D_t}{\partial R_t D_t} = \frac{\alpha_1^{DD}}{H_t^*(B_{1t}, B_{2t}, \tau_1(t), \tau_2(t))/2} + Y_t \alpha_4^{DD}.
\end{aligned}$$

The general first-order conditions for loan and deposit pricing equations are

$$\begin{aligned}
(12) \quad & L_t^m + (1 - \theta_L^m)(T_t^m - i_t - C_t^{Lm}) \frac{\partial L_t^m}{\partial T_t^m} = 0 \\
& -D_t + (1 - \theta_D)(i_t - R_t - C_t^D) \frac{\partial D_t}{\partial R_t} = 0, \theta_L = \frac{\partial t_{jt}}{\partial t_{it}}, \theta_D = \frac{\partial r_{jt}}{\partial r_{it}} \forall i, j,
\end{aligned}$$

since  $\frac{\partial L_{it}^m}{\partial t_{it}^m} = -\sum \frac{\partial L_{it}^m}{\partial t_{jt}^m}$  and  $\frac{\partial D_{it}}{\partial r_{it}} = -\sum \frac{\partial D_{it}}{\partial r_{jt}}$  according to the theoretical model (Vesala 1998). Parameters  $(\theta_L^m, \theta_D)$  correspond to the coordination parameters used in the NEIO analyses to identify the full range of different oligopolistic

<sup>16</sup> This corresponds to summarizing rivals' reaction curves into a single reaction curve for purposes of conducting comparative static analyses (Dixit 1986).

conduct. If parameters  $(\theta_L^m, \theta_D)$  can be identified, they can be interpreted as the degree of coordination among firms in the price-setting game. These parameters index all possible outcomes between noncooperative Bertrand-Nash behaviour and perfect collusion (joint profit maximization as in a monopoly firm).  $(\theta_L^m, \theta_D)$  equal to zero is consistent with Bertrand-Nash conduct and  $(\theta_L^m, \theta_D)$  equal to one with perfect collusion. The case of perfect collusion is not however nicely behaved, and I must set  $(0 \leq \theta_L^m, \theta_D < 1)$ .<sup>17</sup>

The first-order conditions that constitute the loan and deposit pricing equations (ie supply relations) are then equal to

$$(10.2) \quad T_t^m - i_t = PD_t \beta_0^{PDm} + C_t^{Lm}(t) + \frac{1}{1 - \theta_L^m(t)} \frac{1}{\frac{\alpha_1^{LDm}}{K_t^{*m}(B_{1t}, v^m(t))} - X_t \alpha_4^{LDm}} + \varepsilon_t^{LPm}$$

$$(11.2) \quad i_t - R_t = PD_t \mu_0^{PD} + C_t^D(t) + \frac{1}{1 - \theta_D(t)} \frac{1}{\frac{\alpha_1^{DD}}{H_t^*(B_{1t}, B_{2t}, \tau_1(t), \tau_2(t))/2} + Y_t \alpha_4^{DD}} + \varepsilon_t^{DP},$$

where  $C_t^{Lm}(t)$  and  $C_t^D(t)$  are the SR marginal operating costs as defined in (2) (including the time trends) and PD's the period dummies to control for the deposit regulation regimes.

Identification of the coordination parameters involves simultaneous estimation of the respective demand and supply relations, (10.1) and (10.2), and (11.1) and (11.2). I do not assess the extent of 'cross-market' cooperative conduct (as in Vesala 1995, ch. 4), which allows me to proceed by estimating the respective two-equation systems separately thus saving degrees of freedom. I do not allow for bank-specific variation in the coordination parameters. An extra benefit of the system estimations is that the simultaneous estimation forces the estimates of the 'utility parameters' to be consistent also with the loan demand and deposit supply relations derived from the theory.

The methodology for this kind of identification of the coordination parameter is originally developed in Bresnahan (1982). The idea is to let exogenous shifts in the demand relation shift firms' marginal revenue schedules, which in turn trace out the supply relation, and the equilibrium (here  $(L_t^*, T_t^*), (D_t^*, R_t^*)$ ) changes in a way that depends on the extent of oligopolistic coordination. Lau (1982) has shown that the necessary and sufficient condition for identification is that the demand relation be separable in at least one exogenous variable that is not an argument in the marginal cost function.<sup>18</sup>

<sup>17</sup> The problem of identifying perfect collusion arises here because of the functional forms adopted, and is not usually encountered in the literature.

<sup>18</sup> Shaffer (1989) represents an early application of this methodology to the assessment of competition in US banking, and Suominen (1994) to the Finnish banking industry.

Röller and Sickles (1998) argue that a simultaneous estimation of capacity setting and pricing equations would improve the efficiency of the estimates of the coordination parameters and eliminate any bias in them due to a *sequential strategic effect* of capacity on rivals' prices. The bias is upward if there is overinvestment in capacity due to this effect in the first stage of the game. Whenever the sequential strategic effect is zero, there is no need to specify the two-stage setup in order to measure pricing power.<sup>19</sup> Capacity setting has not typically been endogenized in related NEIO studies on competitive conduct in which coordination parameters are estimated.

In the theoretical formulation adopted here, however, there is a revenue effect of capacity only in the case that the capacity of bank  $i$  exceeds that of competitor bank  $j$  (See Appendix 3 of Vesala 1998). For any such pair, bank  $i$ 's decisions would have no effect on bank  $j$ 's prices, and the sequential strategic effect in question would not arise. Only *the direct effect of capacity on revenues* (through the differentiation indices) and *the direct effect of capacity decisions on the SR marginal cost* (included in (2)) need be considered.<sup>20</sup>

## 4 Data and empirical specifications

### 4.1 Data and variable operationalizations

The panel data set used in the estimations is unbalanced and contains information on nine different Finnish banks over an eleven-year period, 1986–1996, so that at minimum seven banks form each of the yearly cross-sections. Some data, eg corporate and household loan rates, are completely available only for 1990 onwards.

The data set covers almost entirely the Finnish banking sector. I treat cooperative and savings banks as single multibranch organizations, since this is the way they have actually operated with centralized control and marketing (eg common prime rates). Also a lot of official data used in this study are only collected for savings and cooperative banks as groups. Changes in the number of banks across cross-sections are due firstly to a merger of the two largest commercial banks in Finland (KOP and Unionbank) to form Merita-Bank in 1995

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<sup>19</sup> Röller and Sickles (1998) find in their study of conduct in the European airline industry that, when capacity setting is endogenized in the empirical model, the conclusions for product market competition are significantly different from those for the traditional approach in which only prices or quantities are strategic variables. Kim and Vale (1997) conclude that the traditional approach in banking studies, ie of treating branches as an exogenous variable, would result in misspecified empirical models of competitive conduct, which is in line with Röller's and Sickles' results.

<sup>20</sup> Here, the first-order conditions for the first stage of the game are independent of the coordination parameters, as only the size of the envisioned markup in the price setting subgame (stage two) matters, regardless of the composition of the markup. Naturally, this would not hold for many other empirical models of banks' rate setting, for which the bias indentified by Röller and Sickles (1998) could emerge. Additional restrictions for other parameters could be derived also here from the first-order conditions for capacity setting. This would however require estimating a complex model of six simultaneous equations, since the condition for branches includes both loan and deposit markups and the effects of loans and deposits on SR marginal operating costs.



and, secondly, to an entry of a small commercial bank, Interbank, in 1989. Branches of foreign banks are excluded from the sample, since they engage in very little retail banking activity in Finland.<sup>21</sup>

The panel data set is constructed on a quarterly basis. Yearly data would provide significantly less degrees of freedom, which would be a problem for the system estimations in particular. The data on branches and ATMs are available only on a yearly basis, so yearly data have been transformed into quarterly data by assuming that changes in banks' branch and ATM networks take place smoothly within each year. According to banks, this is a fairly good depiction of the actual changes in networks within a year, as plans to reduce or increase the number of outlets are carried out gradually. This is due inter alia to the need to smooth the use of internal resources within a year. Moreover, this data transformation should not significantly affect differences across banks in the cross-sectional dimension, which are of particular interest in this study.

Table 1 contains the variables that will be used in the estimations. The variables for the analysis of the entire credit market (T and L) include, in addition to the separately examined corporate and household lending, loans to financial institutions and public entities, which should be relatively independent of 'physical' delivery networks. Household and corporate lending have however constituted the bulk of bank lending. Only domestic currency-denominated items are included in the lending volumes and average rates. Foreign currency-denominated lending was quite significant in the early period until the end of the 1990s, but has since declined considerably, primarily due to heavy depreciation of the markka in the early 1990s. The deposit volume measure (D) contains all markka savings and demand deposits by the domestic public.

As to the branch capacity, post offices are available to Postipankki (Postal Bank), which is a government-owned commercial bank. However, post offices are generally used only by deposit clients, and in the baseline cases post offices are excluded from the loan market analysis but included in the deposit market analysis. I do not discriminate between branches by size, product range or other such information but treat them as homogeneous.

The numbers of ATMs, and the respective differentiation indices, comprise all ATMs available to each banks' clients, ie ATM compatibility agreements between banks are accounted for. This is the case since customer utility is the same regardless of whether he uses his own or other banks' ATMs, since banks have not charged any fees for using ATMs.

As regards cash dispensing ATMs that are used for cash withdrawals and account enquiries, there have been basically three developmental stages within the sample period: (1) a period of two competing networks ie that of commercial banks and that of the cooperative and savings banks (from 1986 to 1988 or 1989, when savings banks and then cooperative banks joined the commercial banks' network); (2) a fully compatible network (from 1989 to 1993); and (3) centralised ownership and management of compatible cash dispensers through a jointly-owned company, Automatia Ltd (from 1994 onward).

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<sup>21</sup> One of the foreign banks, Svenska Handelsbanken, is currently expanding its retail operations.

Table 1.

## Variables used in estimations

Variable	Operationalization
<i>Rates and volumes:</i>	
T	Average new lending rate
TB	Average new corporate lending rate (excl. financial institutions)
TH	Average new household lending rate
R	Average deposit rate
L	Volume of new lending
LB	Volume of new corporate lending (excl. financial institutions)
LH	Volume of new household lending
D	Volume of savings and demand deposits
All the above refer to items denominated in domestic currency	
<i>'Physical' delivery capacity:</i>	
B <sub>11</sub>	Number of branches, excl. post offices
B <sub>12</sub>	Number of branches, incl. post offices
B <sub>2</sub>	Number of ATMs in the network offered to clients
B <sub>2C</sub>	Number of cash dispensing ATMs in the network offered to clients
B <sub>2P</sub>	Number of payment ATMs in the network offered to clients
K <sup>**</sup>	Loan market differentiation index, excl. post offices
KB <sup>**</sup>	Corporate loan market branch network differentiation index, excl. post offices
KH <sup>**</sup>	Household loan market branch network differentiation index, excl. post offices
H <sub>1</sub> <sup>**</sup>	Deposit market branch network differentiation index, incl. post offices
H <sub>2</sub> <sup>**</sup>	Deposit market cash dispenser network differentiation index
H <sub>3</sub> <sup>**</sup>	Deposit market payment ATM network differentiation index
H <sub>4</sub> <sup>**</sup>	Deposit market total ATM network differentiation index (both cash dispensing and payment ATMs)
All differentiation indices exclude the $\nu$ - and $\tau$ -parameters.	
<i>Bank-specific input prices:</i>	
w <sub>1</sub>	Price of labour: total staff expenses per number of full time employees (deflated by CPI)
w <sub>2</sub>	Price of variable inputs: total nonstaff expenses per balance sheet total (deflated by CPI)
w <sub>3</sub>	Price of variable EDP inputs: total variable EDP expenses per balance sheet total (deflated by CPI)
<i>Industry-specific input prices:</i>	
w <sub>4</sub>	Real banking industry wage index
w <sub>5</sub>	Total industry nonstaff expenses per aggregate balance sheet total
w <sub>6</sub>	Total industry variable EDP expenses per aggregate balance sheet total
All input prices expressed as index 1990=100	
<i>Macroeconomic variables:</i>	
i	3 month money market rate (HELIBOR)
X, Y	Gross domestic product
<i>Period dummies:</i>	
PD <sub>1</sub> (1989–1990)	End of 'cartel' agreement for deposit rates (since January 1989)
PD <sub>2</sub> (1991–1996)	Withholding tax on deposit income (since January 1991)

\* R after these symbols signifies deflation by CPI

The first payment ATMs appeared in the late 1980s. They are significantly more advanced than the cash dispensers, since they can be used for a variety of payments and account transfers (but not for cash withdrawals). There was a phase of competing bank-specific payment ATM networks until 1993. In 1994 and 1995 there was universal compatibility, and in 1996 the largest bank, Merita, exited from the compatibility agreement.

In the absence of direct observations, it has become standard in banking cost studies to impute input prices from ratios of expenses for each input to the quantity of the corresponding input. Also here only the banking wage index represents a direct input price measure at the industry level. The quantity of labour input can be easily measured as the number of employees, while this is not the case with other (nonstaff) variable inputs.<sup>22</sup> Banks purchase increasingly many services needed in the production of banking services, notably EDP services from dedicated firms (outsourcing), and therefore balance sheet figures on materials and equipment do not correspond to actual input usage. Rents and leases entail the same problem. For this reason, I specify the prices for the other variable inputs as ratios of the corresponding expenses to balance sheet total, in order to circumvent the input quantity measurement problems and in order to control for the effect of the scale of operations.

Input price proxies based on total nonstaff expenses or EDP expenses are used as alternative specifications, as the latter are included in the former. Focusing on EDP expenses would cover an important part of variable nonstaff expenses, and avoid certain 'noise' items that are not related to the use of variable inputs, but some input usage would be excluded, which would matter particularly if banks' input mixes differ. The industry-specific input prices represent alternative specifications to the bank-specific prices. Their utilization assumes that banks act as price takers in homogeneous input markets and use the same kinds of inputs. Under the industry-level specification, the fixed effects in the SR marginal operating cost function also include bank-level differences in input prices, if they exist.

Finally, the period dummies control for the effects of changes in deposit rate regulation on banks' markups. Until the end of 1988 demand and savings deposit rates were subject to a cartel-like agreement as the interest income was tax exempt if at least two bank groups offered these deposits on similar conditions. Between January 1989 and 1991 tax exemption was determined by comparison to the Bank of Finland base rate. Since January 1991 a withholding tax has been levied on taxable deposits, which represents a significant deregulation of deposit rate setting. The maximum level of tax-exempt interest income has decreased over time with market interest rates, and is now 2 per cent annualized interest. Certain time deposits also were stipulated as tax-exempt during the sample period, since the last existing deposits of this type lost tax exemption at the end of 1997. In sum, indirect regulation of deposit rates through tax rulings existed (although to decreasing extent) during the sample period, and still do. The existence of tax exemption rules can restrict price competition, as will be discussed in section 5.3 and can generate biases in customer behaviour to the extent that depositors have preferences for tax-exempt deposit accounts.

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<sup>22</sup> There are some measurement problems concerning bank-specific input prices during 1994–1996 due to the restructuring of the sector with considerable reductions in the numbers of bank employees and branches. The data have been carefully handled to account for these changes.

## 4.2 Characterization of key variables

Table 2.a depicts the averages and standard deviations of the loan and deposit rates that constitute the dependent variables in the empirical pricing equations. Table 2.b gives the same information for the numbers of branches and ATMs and the respective differentiation indices, which are the key explanatory variables. The branch network differentiation indices are quite similar for corporate and household lending markets as well as for the deposit market, since banks' market shares in all three activities have been significantly correlated. Data on bank branches and ATMs were obtained from the Finnish Bankers' Association, and the rest from the Bank of Finland.

Table 2.a **Averages and standard deviations of loan and deposit rates and margins vs money market rate across banks**

	Market rate (i)	Avg new lending rate (T)			Avg deposit rate (R)		
		Avg	Std.dev	Avg margin (T-i)	Avg	Std.dev	Avg margin (i-R)
1986	12,6*	10,47	0,50	-2,13	4,43	0,59	8,17
1987	10,03	10,22	0,82	0,19	4,15	0,62	5,88
1988	9,97	10,70	0,30	0,73	4,74	0,86	5,23
1989	12,56	11,56	1,17	-1,00	5,29	0,84	7,27
1990	14,00	13,33	0,95	-0,66	6,37	0,73	7,62
1991	13,08	13,45	1,24	0,37	7,59	1,79	5,49
1992	13,25	13,58	0,71	0,33	7,98	1,51	5,27
1993	7,78	9,62	0,90	1,85	5,02	0,84	2,76
1994	5,35	7,32	0,86	1,98	3,12	0,47	2,23
1995	5,75	7,52	0,87	1,77	3,17	0,71	2,58
1996	3,63	5,59	1,02	1,97	2,22	0,41	1,40
Avg	9,81	10,45		0,64	4,98		4,83

	Avg new household lending rate			Avg new corporate lending rate		
	Avg	Std.dev	Avg margin (TH-i)	Avg	Std.dev	Avg margin (TB-i)
1989	11,28	1,17	-1,03	12,02	0,70	-0,35
1990	13,21	1,11	-0,53	13,66	1,22	-0,51
1991	13,68	0,56	0,55	12,80	2,66	-0,25
1992	13,74	0,80	0,72	13,13	1,23	-0,06
1993	10,20	0,97	2,68	9,36	0,50	1,64
1994	8,21	0,71	2,95	6,87	0,60	1,54
1995	8,17	0,62	2,48	7,32	0,63	1,59
1996	6,37	0,65	2,94	5,36	0,77	1,81
Avg	10,71		0,90	10,21		0,40

Table 2.b

**Averages and standard deviations of branches and ATMs and the respective differentiation indices across banks**

	Branches (excl. post offices) (B <sub>11</sub> )		Branches (incl. post offices) (B <sub>12</sub> )		Cash dispensing ATMs (B <sub>2C</sub> )		Payment ATMs (B <sub>2P</sub> )	
	Avg	Std.dev	Avg	Std.dev	Avg	Std.dev	Avg	Std.dev
1986	502	565	926	1064	358	249		
1987	504	561	923	1056	558	260		
1988	500	558	917	1053	1317	626	3	7
1989	432	540	793	1019	2300	929	11	21
1990	394	492	739	972	2479	1002	66	118
1991	364	458	488	501	2539	1026	97	153
1992	331	410	455	466	2546	1029	123	200
1993	268	324	386	454	2615	1056	921	763
1994	268	339	386	424	2474	999	1734	701
1995	276	375	409	454	2070	913	1844	813
1996	287	356	403	388	1965	866	876	423
Avg	374		621		2024		499	

	KB**		KH**		H <sub>1</sub> **		H <sub>2</sub> **		H <sub>3</sub> **	
	Avg	Std.dev	Agv	Std.dev	Agv	Std.dev	Agv	Std.dev	Agv	Std.dev
1986					6,11	6,87	3,33	1,60		
1987					6,11	6,87	3,33	1,59		
1988					6,11	6,87	2,26	0,41	2,52	6,68
1989	5,41	6,66	5,41	6,66	5,89	6,61	1,41	0,69	3,18	6,93
1990	5,42	6,58	5,41	6,51	5,04	6,40	1,46	0,59	4,37	7,28
1991	5,40	6,63	5,39	6,61	5,01	6,21	1,50	0,62	4,24	7,10
1992	5,43	6,63	5,42	6,65	5,09	6,31	1,46	0,59	4,39	7,20
1993	5,37	6,62	5,15	6,50	5,02	6,39	1,46	0,59	1,53	1,27
1994	5,43	6,66	5,42	6,65	5,04	6,35	1,46	0,59	1,44	0,58
1995	5,90	7,02	5,89	7,03	5,49	6,72	1,63	0,75	1,71	0,76
1996	6,80	7,24	6,81	7,23	5,50	6,73	1,92	0,94	4,57	6,85
Avg	5,54		5,50		5,49		1,86		3,19	

The theory proposes that technological transformation should reduce variability of the loan and deposit rates across banks, holding differences in banks' 'physical' delivery networks constant (Proposition 1 of Vesala 1998). The average number of branches has decreased over the sample period, reflecting restructuring in the banking industry, which has greatly reduced the total number of branches (Table 3). However, toward the end of the sample period, asymmetries in banks' networks (and market shares) have increased due to the restructuring and shrinking of the savings bank sector<sup>23</sup> and the Merita merger. The result of these tendencies is a decline in the average value of the branch network differentiation

<sup>23</sup> The savings bank sector was most severely affected by the dire banking problems in Finland in the early 1990s. In October 1993 around 80 per cent of savings banks' assets (and outlets) were sold to rival banks (merged into Savings Bank Finland in 1992), or transferred to an asset management company, Arsenal Ltd, to take care of the 'bad asset' problem.

indices until 1993 and a significant rise thereafter.<sup>24</sup> Also the standard deviation of the indices across banks increased toward the end of the sample period, which would work in the direction of increasing the variability of the rates, holding the technology levels ('utility parameters') constant.

However, the standard deviation of the household and corporate lending rates, which relate to the branch network, has tended to decrease during recent years compared to the levels at the end of the 1980s and early 1990s. The variability of the deposit rates increased markedly after the introduction of the withholding tax in 1991 but has since tended to decrease markedly. Hence the pricing power benefits stemming from branch networks seem to have decreased in both lending and deposit-taking, perhaps more visibly on the deposit side. Naturally, this is only preliminary and indicative evidence prior to the actual estimation of the empirical models. Due to compatibility, differences in the ATM network differentiation indices are almost nonexistent between banks for many years in the sample and hence would not produce variation in the deposit rates.<sup>25</sup>

Table 3. **Total numbers of branches and ATMs**

	Branches (excl. post offices)	Branches (incl. post offices)	Cash dispensing ATMs	Payment ATMs
1986	3507	6476	798	0
1987	3515	6457	1387	0
1988	3487	6413	1891	18
1989	3442	6335	2438	91
1990	3137	5908	2653	527
1991	2897	3897	2730	772
1992	2633	3633	2762	982
1993	2117	3080	2988	1474
1994	2126	2126	2827	1982
1995	1914	1914	2415	2151
1996	1708	1708	2292	2353
Avg	2771	4595	2098	863

<sup>24</sup> The network differentiation indices used in the estimations and reported in Table 2.b are slightly adjusted from the theoretical formula. Firstly, an upper limit is imposed, since the bank with the largest network would otherwise obtain a very high value, which distorts the estimations, particularly when the post offices are included. The upper limit is arbitrarily set at 20, which is around four times larger than the value of the second largest bank in terms of the delivery networks. Naturally, this procedure only affects the index value of the bank with the largest networks. Note that the particular choice of the upper limit affects the estimation results to some extent in quantitative terms. Secondly, in calculating the index, each banks' comparison to the 'nonbank' benchmark is unweighed by market share, since reliable data on nonbanks' market shares are very difficult to obtain.

<sup>25</sup> The total number of cash dispensing ATMs has already reached a peak in Finland and has started to decrease (Table 3). This would weaken the competitive position of the entire industry, though not that of banks against each other. The total number of payment ATMs is still increasing, and their utilization is growing heavily, based on Finnish Bankers' Association data.

Figure 2.

**Symmetry-equivalent branch network differentiation index  $KS^{**}$  for the Finnish banking industry;**  
 $N=7$ ,  $b_T = 2770$  (sample period averages) ( $\varepsilon=0.1$ ).

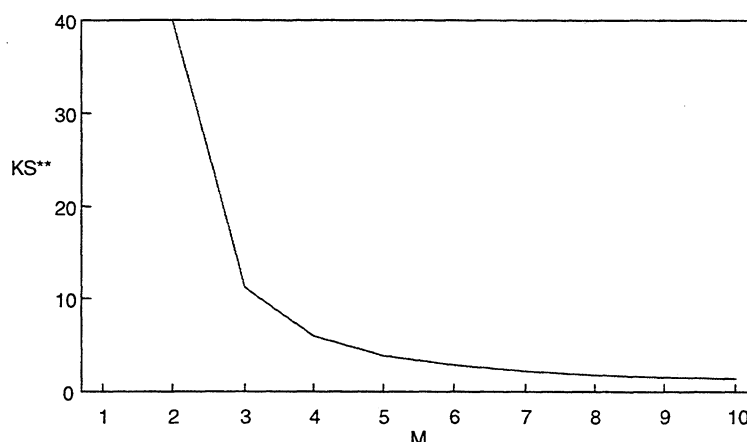


Figure 2 depicts the values of the *symmetry-equivalent branch network differentiation index*,  $KS^{**}$ , as defined in (8.1), given the sample period averages for total number of branches and banks in the Finnish banking industry. For  $M(=N)=7$  (all banks have a branch network),  $KS^{**}$  equals 2.26. Hence, the average difference,  $KD^{**}$ , between the average of the bank-specific  $K^{**}$ 's and  $KS^{**}$ , is 3.28 or 3.24 for the corporate or household lending markets respectively. Branch network differentiation vs other banks has thus represented, on average, around 60 per cent of the network differentiation index on the lending side, and around 40 per cent has been accounted for by the effect of the network size. A similar pattern emerges as regards branches and deposit-taking activities.<sup>26</sup>

As the average differentiation indices indicate (Table 2.b), banks' competitive standing vs. other banks in terms of delivery networks remained much the same until 1995 and 1996 when the Merita merger increased asymmetry in the Finnish banking system considerably. As a result, differentiation vs other banks constituted roughly 70 per cent of the average differentiation index values for lending and deposit-taking activities in 1996.

In case of payment ATMs,  $KS^{**}$  equals 2.71, and hence, on average over the sample period, only 0.49 or 15 per cent of the payment ATM network differentiation index,  $H_3^{**}$ , is allotted to differences among banks. The decision of Merita to exit from the common payment ATM network in 1996 resulted in a significant increase in the average value of the index, as well as average share of asymmetries between banks in the index. Due to extensive compatibility of cash-dispensing ATMs, the entire differentiation index is due to the network size effect, except for the years 1986, 1987 and 1988 when the networks of banks were not totally compatible.<sup>27</sup>

<sup>26</sup> For the median bank in the sample with respect to differentiation indices, the importance of differentiation vs other banks is somewhat lower than that implied by the average values of the indices.

<sup>27</sup> Even during 1986 and 1987, when the asymmetries between banks were strongest within the sample period, differentiation vs other banks only accounted for some 20 per cent of the average cash-dispensing ATM network differentiation index.

Banks' margins on loan and deposit rates vs the money market rate have correlated strongly with the level of market interest rates (Table 2.a). During the period of high rates, eg the early 1990s, loan margins were narrow and deposit margins wide. This demonstrates the stickiness of banks' rate setting vs the market rate changes. The negative margins on the lending side in 1989 and 1990 correspond to the years that were identified in Vesala (1995, ch. 3) in a switching regression model as periods in which a reversionary period in collusive conduct (price war) took place.

## 5 Empirical implementation and results

In the empirical estimations, the data set is handled as pooled cross-sections, since the cross-sectional variation is of primary interest, in addition to the changes in cross-sectional relations over time.

### 5.1 Loan pricing equations

In the analysis of the loan markets, equation (5.1) is estimated by OLS, including the fixed effects.<sup>28</sup> Table 4 reports the estimation results concerning the average new rates in corporate (TB) and household (TH) lending for the subperiod 1990Q1–1996Q4, as earlier data are not available. Table 5 gives the results for the entire credit market, both for the entire sample period, 1987Q1–1996Q4 (after adjusting the starting points), as well as the subperiod 1990Q1–1996Q4. GLS estimates were obtained to control for potential cross-sectional heteroscedasticity, but the estimates were unaffected by this change in estimation method.

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<sup>28</sup> This is often also referred to as the least squares dummy variable (LSDV) model (eg Greene 1993).



Table 4.

**OLS-fixed effects estimation results of (5.1);**  
**dependent variables: average new corporate (TB)**  
**and household lending rates (TH)**  
 (A) bank-specific factor prices, (B) industry-specific  
 factor prices

	TB 1990Q1– 1996Q4 (A)	TB 1990Q1– 1996Q4 (B)	TH 1990Q1– 1996Q4 (A)	TH 1990Q1– 1996Q4 (B)
Constant ( $\beta_0$ )	3.37**	1.60	3.95**	1.51
PD <sub>1</sub> ( $\beta_0^{PD}$ ) (1990)	-0.096	0.04	-0.71**	-0.47
B <sub>11</sub> ( $\beta_1$ )	0.0007	0.00037	-0.006**	-0.0042
Trend* B <sub>11</sub>	-2.27E-05	-2.65E-06	0.0003**	0.00024*
Wald test (prob value) <sup>1</sup>	(0.97)	(0.97)	(0.020)*	(0.066)
KB**/KH** (v)	0.13	0.12	0.36**	0.27*
Trend* KB**/KH**	-0.009	-0.0081	-0.019**	-0.016**
Wald test (prob value) <sup>1</sup>	(0.51)	(0.58)	(0.0010)**	(0.0049)**
LBR/LHR( $\beta_2$ ) <sup>2</sup>	-0.004**	-0.0037**	2.92E-05	-0.00057
DR( $\beta_2$ ) <sup>1</sup>	-2.94E-05	-2.10E-05	-8.30E-05	-1.26E-05
Bank-specific input prices (A):				
w <sub>1</sub> ( $\beta_{41}$ )	-0.0071*		5.47E-05	
w <sub>2</sub> ( $\beta_{42}$ )	0.00058		0.000143	
Wald test (prob value) <sup>1</sup>	(0.11)		(0.96)	
Industry-specific input prices (B):				
w <sub>4</sub> ( $\beta_{41}$ )		0.024		0.037
w <sub>5</sub> ( $\beta_{42}$ )		0.026*		0.026**
Wald test (prob value) <sup>1</sup>		(0.10)		(0.00030)**
i( $\beta_5$ )	-0.38**	-0.37**	-0.36**	-0.38**
Trend* i	0.0031	-0.0011	0.00093	-0.0016
R-squared	0.53	0.53	0.83	0.84
Adjusted R-squared	0.48	0.49	0.81	0.82
S.E. of regression	1.35	1.35	0.72	0.69
Sample observations	251	251	251	251
Absolute markup at sample mean				
KB*/KH*	0.71	0.67	1.98	1.49
Relative markup at sample mean				
KB*/TB KH*/TH	0.07	0.07	0.19	0.14
Wald test (prob value) <sup>1</sup>	(0.51)	(0.58)	(0.0010)**	(0.0049)**

\*\* significant at the 1 per cent level.

\* significant at the 5 per cent level.

Notes: 1) Wald test for rejecting the null hypothesis that the parameters in question could be restricted to zero.

2) Deflated by CPI.

Table 5.

**OLS-fixed effects estimation results of (5.1);**  
**dependent variable: average new lending rate (T)**  
 (A) bank-specific factor prices, (B) industry-specific factor prices

	1987Q1– 1996Q4 (A)	1990Q1– 1996Q4 (B)	1987Q1– 1996Q4 (A)	1990Q1– 1996Q4 (B)
Constant ( $\beta_0$ )	3.19**	3.87**	-3.24	0.50
PD <sub>1</sub> ( $\beta_0^{PD}$ ) (1989–1990)	-0.35*	-0.62*	0.17	-0.47
PD <sub>2</sub> ( $\beta_0^{PD}$ ) (1991–1996)	0.017		0.44	
B <sub>11</sub> ( $\beta_1$ )	-0.0024*	-0.0016	-0.0022*	-0.0014
Trend* B <sub>11</sub>	0.00013*	6.11E-05	0.00011*	6.63E-05
Wald test (prob value) <sup>1</sup>	(0.028)*	(0.72)	(0.063)	(0.82)
K** (v)	0.14*	0.19	0.11*	0.14
Trend* K**	-0.011**	-0.010	-0.0089**	-0.0085
Wald test (prob value) <sup>1</sup>	(0.0018)**	(0.19)	(0.011)*	(0.33)
LR( $\beta_2$ ) <sup>2</sup>	-4.81E-04**	-9.74E-04**	-4.44E-04**	-1.06E-03**
DR( $\beta_3$ ) <sup>1</sup>	-1.39E-05	-1.10E-05	-1.05E-05	-8.17E-07
Bank-specific input prices (A):				
w <sub>1</sub> ( $\beta_{41}$ )	-0.0042*	-0.0057**		
w <sub>2</sub> ( $\beta_{42}$ )	0.00035	0.00070		
Wald test (prob value) <sup>1</sup>	(0.058)	(0.021)*		
Industry-specific input prices (B):				
w <sub>4</sub> ( $\beta_{41}$ )			0.074**	0.020
w <sub>5</sub> ( $\beta_{42}$ )			0.031**	0.028**
Wald test (prob value) <sup>1</sup>			(0.000)**	(0.001)**
i( $\beta_5$ )	-0.36**	-0.30**	-0.33**	-0.29**
Trend* i	0.0041**	-0.00068	-0.0013	-0.0046
R-squared	0.73	0.73	0.74	0.74
Adjusted R-squared	0.71	0.70	0.73	0.71
S.E. of regression	0.80	0.84	0.78	0.83
Sample observations	359	251	359	251
Absolute markup at sample mean <sup>3</sup>	0.81	1.08	0.83	0.83
Relative markup at sample mean	0.08	0.10	0.08	0.08
Wald test (prob value) <sup>1</sup>	(0.0018)**	(0.18)	(0.063)	(0.82)

\*\* significant at the 1 per cent level.

\* significant at the 5 per cent level.

Notes: 1) Wald test for rejecting the null hypothesis that the parameters in question could be restricted to zero.

2) Deflated by CPI.

The results demonstrate quite significant differences between the corporate and household lending markets. Based on the estimates of the v-parameters, the importance of branch network differentiation has been much greater with respect to the pricing of household loans than corporate loans, and consequently banks have enjoyed wider markups in the former activities. The estimates of the v-

parameters, and thus also the markups are significantly different from zero, and Wald tests reject the exclusion of the differentiation indices in case of the household lending, while the significance tests fail to hold for corporate lending. The estimated absolute markups are around 2.5 times larger for household lending than corporate lending, amounting to some 1.5–2 percentage point at the sample mean. Corporate lending is found to be significantly more competitive, as the corresponding markup estimates are around 0.6–0.7 percentage point. These results suggest that, in effect, informational and other obstacles and costs of transacting with more distant lenders or with many lenders have been significantly lower for banks' corporate than household customers. Hence the mobility of banks' corporate customers is apparently greater than that of the household customers. The above results are quite robust over input-price specifications.

The effect of the time trend on the estimates of the  $v$ -parameters is negative in all cases, also in household lending. This is in line with the hypothesis that technological transformation is reducing banks' benefits from their branch networks in terms of pricing power. As a result, banks' markups fall. In household lending, the phone-banking options that all major Finnish banks have established may have been one significant contributor to this change, along with enhanced information on competing banks' offers through the Internet.

The results imply that a disproportionately large share of banks' profits has come from household lending compared to corporate lending, where markups have been narrower.<sup>29</sup> A narrowing of markups in these activities due to the transformation of banking would therefore put a particular strain on banks' future performance.

The results for the entire credit market are close to those obtained for the corporate lending market. This suggests that lending to entities other than households and corporations (basically financial institutions and central and local government) is similar to corporate lending in terms of the significance of physical delivery networks and competitiveness. The estimates of the  $v$ -parameter are significant for the entire period 1987Q1–1996Q4 indicating an average absolute markup of about 0.8 percentage point, but for the subperiod 1990Q1–1996Q1 the estimates are insignificant. Again, the time trend has a negative impact on the  $v$ -parameter estimates.

In case of household lending, as well as total lending, branching is found to lower the SR marginal operating cost. As changes in branch capacity shift the entire SR marginal operating cost curve, the results imply that increasing the number of branches has the effect of lowering the marginal operating cost at all output levels (lending volumes).<sup>30</sup> This suggests that lending has been the cheaper, the closer the bank has been to the customer. However, the impact of branching on the SR marginal operating cost is declining over time according to the estimates of the respective time trend coefficients, as should be the case under ongoing technological progress.

Tables 4 and 5 report unconstrained estimation results concerning the input price coefficients, where the theoretical nonnegativity requirements for a cost

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<sup>29</sup> This is actually a fairly common perception in Finland and other countries as well.

<sup>30</sup> Whether there are economies of scale related to branch expansion depends on properties of the LR cost function that I do not study here explicitly. Kim and Ben-Zion (1989) devise measures of the scale economies that account for output expansion with a given number of branches and expansion of output through branching.

function are not imposed a priori in the estimations. The coefficients always meet the nonnegativity requirement when the industry-specific input price proxies are adopted, and industry-level rises in input prices increase the SR marginal operating costs significantly for household and total lending. The negative coefficients for the bank-specific labour input price variables are disturbing. The negative coefficients might be explained by the fact that most banks strongly reduced their staffs toward the end of the sample period.<sup>31</sup> This restructuring has reduced costs, although the unit cost of labour has increased.<sup>32</sup> The coefficients of the bank-specific input prices are however insignificant when analysed in pairs, since the Wald tests support their joint exclusion from the model.<sup>33</sup>

There is evidence of increasing returns to scale, especially in corporate lending.<sup>34</sup> The coefficients of deposit volumes are negative, which points to economies of scope between lending and deposit-taking. However, these coefficients are very small and insignificant.

The level of the money market rate is significantly inversely related to banks' lending margins vs the money market rate. This confirms the significant stickiness of banks' loan rates with respect to movements in the market rate. The analysis in Vesala (1998) shows that technological transformation, in reducing the role of differentiation in terms of 'physical' delivery networks, should result in an increase in the pass-through of money market rate changes into banks' lending rates. In general, any effects that increase elasticity of loan demand would have this effect. Evidence of the increased pass-through over the sample period is however not robust across various model specifications. The coefficients of the respective time trends are also weakly significant, except in one case where significantly increased pass-through over the entire sample period is found.

The coefficients of the period dummies suggest that the implementation of withholding taxes on interest income in 1991 had the effect of increasing the lending margins to certain extent. This would imply that loan rates had previously been cross-subsidized from the deposit margins. The evidence on this is however quite weak.<sup>35</sup> The period 1989–1990, following the break-up of the deposit cartel

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<sup>31</sup> Total number of bank employees fell from the peak of around 52 000 in 1989 to less than 30 000 at the end of 1996. Staff reductions have continued thereafter.

<sup>32</sup> All models are quite robust with respect to the choice between all nonstaff inputs or just EDP inputs. The former specifications are reported, since in the lending activities the broad approach, which includes all operating inputs, seems more plausible than the narrow one.

<sup>33</sup> Formally, the Wald tests imply that the restriction of setting the coefficients of the bank-specific input prices to zero could be imposed without significantly affecting the performance of the model.

<sup>34</sup> Econometric evidence from estimating cost or profit functions or other related analysis has not typically found significant evidence of economies of scale in banking (see Berger and Humphrey 1995). However, technological IT development should result in increased scale economies, since it lowers the relative share of the variable cost component and increases the share of fixed and investment costs in the banking business (eg Humphrey 1994). Studies using more recent data tend to point to larger scale economies than before. Berger and Mester (1997) attribute this to technological change.

<sup>35</sup> Chiappori et al (1995), using a spatial model of banking competition, show that cross-subsidization is possible when deposit rates are regulated and tying-up of borrowers as depositors occurs.

agreement, coincides with a potential price war in Finnish banking (Vesala 1995, ch. 3), and the current results provide additional evidence of this shift in conduct.

Finally, the fixed effects are significant and account for a large share of the SR marginal operating costs. The fixed effects are larger and more significant, when industry- rather than bank-specific input prices are adhered to, since they then capture differences in input prices across banks, in addition to efficiency differences. Individual banks' coefficients have a priori-predicted signs based on their cost structures and lending policies.

The model fits significantly better for the pricing of the household lending than corporate lending. The main reason is that the key explanatory variables are found to be less significant for corporate lending.<sup>36</sup>

## 5.2 Deposit pricing equations

The deposit pricing equation (5.2) is estimated by OLS including the fixed effects, and the results are collected in Table 6 for the entire sample period 1987Q1–1996Q4 and the subperiod 1990Q1–1996Q4 to facilitate comparison with the credit market analysis. Only the models with bank-specific input price proxies are presented, since models with industry-specific input prices produce inconsistent results; notably the input price coefficients are always negative. Model fit is also significantly worse when industry-specific input prices are used. The narrow specification of the price for nonstaff operating inputs (EDP expenses only) produces a significantly higher fit than the broad specification, and so, I report the former results. The estimates of the key parameters are, however, quite robust with respect to specification of input prices: bank- or industry-specific,  $w_2$  or  $w_3$ . As regards the payment and account keeping services ancillary to deposit-taking, EDP represents a key input, whose importance has increased strongly over time. Again, GLS made no difference as regards the parameter estimates.

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<sup>36</sup> The estimation results concerning loan pricing are quite robust with respect to the inclusion of post offices within banks' branch network, but the fit is significantly higher than in the (a priori more plausible) case of excluding them. Use of yearly data produces qualitatively the same results, as it should, although somewhat lower estimates of the  $v$ -parameters are obtained.

Table 6.

**OLS-fixed effects estimation results of (5.2);  
dependent variable: deposit rate (R)**

	1987Q1–1996Q4	1990Q1–1996Q4
Constant ( $\mu_0$ )	–0.36	–0.47
$PD_1(\mu_0^{PD})$ (1989–1990)	0.62**	0.41*
$PD_2(\mu_0^{PD})$ (1991–1996)	–0.03	
$B_{12}(\mu_{11})$	–0.00069*	0.0015**
Trend* $B_1$	3.98E–05**	–0.00011**
Wald test (prob value) <sup>1</sup>	(0.010)*	(0.000)
$B_2(\mu_{12})$	–0.00074**	–0.00094**
Trend* $B_2$	3.77E–05**	5.10E–05**
Wald test (prob value) <sup>1</sup>	(0.000)**	(0.000)**
$H_1^*(\tau_1^*)$	0.084*	0.0023
Trend* $H_1^*$	–0.0043*	1.94E–05
Wald test (prob value) <sup>1</sup>	(0.0066)**	(0.97)
$H_4^*(\tau_2^*)$	0.14	0.11
Trend* $H_4^*$	–0.0026	–0.0015
ICD* $H_4^*$	–0.27*	–0.094
Wald test (prob value) <sup>1</sup>	(0.010)*	(0.38)
$DR(\beta_2)^2$	2.45E–06	–2.57E–05**
$DR(\beta_3)^2$	–3.03E–04**	–1.71E–04
Bank-specific input prices:		
$w_1(\beta_{41})$	–0.0018	–0.0056**
$w_3(\beta_{42})$	2.24E–05	0.00062*
Wald test (prob value) <sup>1</sup>	(0.33)	(0.000)**
$i(\beta_{32})$	0.97**	0.97**
Trend*i	–0.016**	–0.015**
R-squared	0.96	0.97
Adjusted R-squared	0.95	0.97
S.E. of regression	0.50	0.42
Sample observations	359	251
Absolute markup at sample mean $H^*$	0.75	0.22
Relative markup at sample mean $H^*/(i-R)$	0.17	0.06
Wald test (prob value) <sup>1</sup>	(0.000)**	(0.661)

\*\* significant at the 1 per cent level.

\* significant at the 5 per cent level.

Notes: 1) Wald test for rejecting the null hypothesis that the parameters in question could be restricted to zero.

2) Deflated by CPI.

The results imply that the significance of branch network differentiation has been lower in deposit-taking than in household lending. The estimated  $\tau_1^*$ -parameter is only about a third of the size of the corresponding  $v^2$ -parameter. Moreover, the time trend has a significant negative impact on  $\tau_1^*$ , and for the latter subperiod its estimate is not significantly different from zero. These results are consistent with the hypothesis that technological transformation has already proceeded farther on

the deposit than on the lending side. In Finland branches have apparently already lost significance to deposit customers to a considerable extent. Most transactions are currently effected via ATMs or remote banking, and branches are quite seldom visited.<sup>37</sup> One cannot however rule out the possibility that government interference in deposit rate setting through tax rules has in general reduced the impact of network differentiation on deposit rates.

As to differentiation in ATM networks, taking into account both cash dispensers and payment ATMs, the estimated  $\tau_2^*$ -parameter is somewhat larger than the  $\tau_1^*$ -parameter. However, the former estimates are not significant. The impact of the time trend on  $\tau_2^*$  is negative but not significant either. A dummy variable, ICD, is included in the model to assess the effect of ATM compatibility. It is defined as one for the period 1987Q1–1992Q4, when significant incompatibilities existed in the ATM networks, and zero otherwise. The negative and significant sign of that coefficient indicates that compatibility actually increased banks' pricing power due to improved service quality. If cash dispensers and payment ATMs are analysed separately ( $H_2^{**}$  and  $H_3^{**}$  are both inserted in the model), cash dispensers turn out to have a diminishing impact on pricing power while payment ATMs have increased their impact over time. This reflects the fact that the use of cash dispensers seems to have become saturated in contrast to the use of payment ATMs.

The estimated markups at the sample mean for the latter subperiod are only about a third of the estimate for the entire period. Around 70 per cent of the markups result from branch network differentiation, as the values of the ATM-network differentiation indices are considerably smaller due to compatibility than the values of the branch network differentiation indices.

I can now calculate what the value of the theoretical, two-dimensional differentiation index  $H_{it}^*(\tau_1^*, \tau_2^*)$  would be for each bank and for each year using the estimated  $\tau^*$ -parameters from the model where the one-dimensional simplification (7) was adhered to ( $\tau_1^* = 0.084$ ,  $\tau_2^* = 0.14$ ). This figure can then be compared to the sum  $2(\tau_1^* H_{1it}^{**} + \tau_2^* H_{2it}^{**}) \equiv H_{it}^{**}$ , which is the one-dimensional approximation. I calculated the difference  $H_{it}^*(\tau_1^*, \tau_2^*) - H_{it}^{**}$  for two banks and for all years, and in each case the difference is positive and almost identically always slightly below 30 per cent of the value of  $H_{it}^*(\tau_1^*, \tau_2^*)$ . This experiment suggests that the one-dimensional approximation underestimates the theoretical two-dimensional index by about a fourth to a third. Hence the estimates of the  $\tau$ -parameters from the complex model, where the two-dimensional specification is used, should be smaller in absolute magnitude than the reported estimates of the  $\tau^*$ -parameters.

Both branches and ATMs have the effect of shifting the SR marginal cost curve downward, but this effect diminishes over time. The coefficient of branches is however unstable over time, as the estimate for the latter subperiod demonstrates. Unconstrained estimation again produces a negative coefficient for

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<sup>37</sup> Based on Finnish Bankers' Association data, the share of ATM bill payments has increased from less than 1 per cent to roughly 30 per cent of all household bill payments between 1990 and 1996 and that of PC payments from 0.5 to 6 per cent over the same period. Currently, roughly 30 per cent of banks' private customers have made either PC or phone-banking contracts to effect transactions. Most cash for transactions purposes is nowadays withdrawn from cash-dispensing ATMs rather than over-the-counter at bank branches.

the bank-specific labour input price variable. Finally, there is again a slight indication of economies of scale and scope.

The impact of the level of the money market rate on banks' deposit margins is significant and very large, and deposit rates exhibit much stronger stickiness vs money market rate changes than the loan rates. Weaker price competition, as discussed in the next section (ie lower perceived price elasticities), would account for this difference. However, the sensitivity of the deposit rates has significantly increased, particularly in the latter subperiod, which is marked by deposit rate setting that is freer of tax exemption rules. According to the theory, this is what we should observe under ongoing technological transformation.

Since deposit rates are stickier than lending rates, an upward movement in the money market rate widens banks' margins between lending and deposit rates, *ceteris paribus*. This rather peculiar feature in international comparison has characterized Finnish banking in recent years. However, based on the estimation results here, this effect should be diminishing in the future.

The empirical pricing model fits deposit rates better than lending rates, and the R-squared figures are quite high.<sup>38</sup> Fixed SR marginal operating cost effects are again significant and account for a large share of the marginal costs.

### 5.3 System estimation to identify coordination parameters

The systems of demand and pricing equations (10.1) and (10.2), and (11.1) and (11.2) are estimated by nonlinear three stage least squares (3SLS), including the fixed effects and yearly dummies in the demand relations. The results are reported in Tables 7 and 8 for corporate and household lending and for deposit markets respectively.<sup>39</sup>

Before interpreting the results, some waivers are in order. It turned out that the system models fit poorly for the early period of the data, which exhibits a strong lending boom and an apparent price war (Vesala 1995, ch.3). Also deposit rates were strongly regulated via tax rules. The demand-side models based on first-order approximations may not be flexible or rich enough to predict demand for this peculiar period. The difficulties materialize in a lack of convergence of the estimates and failure of the parameter estimates to pass the consistency checks described below. For these reasons, I report the results only for the subperiod of more liberalized deposit rate setting, 1991Q1–1996Q4, for which the results are quite in line with the consistency checks, especially as regards the loan market results.

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<sup>38</sup> The estimation results concerning deposit pricing are quite robust with respect to the exclusion of post offices, though their exclusion produces somewhat lower estimates of the  $\tau^*$ -parameters. The fit is now worse when post offices are excluded, which is in line with a priori reasoning. Use of yearly data results in quite similar estimates eg of the  $\tau^*$ -parameters.

<sup>39</sup> Due to weak convergence of the estimates, the unrestricted model versions (conducted not restricted to Bertrand-Nash) had to be estimated by first fixing the values of  $(\alpha_1^{LDm}, \alpha_1^{DD})$  to those obtained from estimating restricted (conducted restricted to Bertrand-Nash) versions of the models.



Table 7.

**3SLS-fixed effects system estimation results of loan demand (10.1) and pricing equations (10.2); dependent variables:  $\ln(LB)$ ,  $TB$  and  $\ln(LH)$ ,  $TH$ ; 1991Q1–1996Q4**

	$\ln(LB)$ , $TB$	$\ln(LH)$ , $TH$
$\alpha_1^{LD}$	0.0187	0.00241
Restricted $v$ (Bertrand-Nash conduct)	0.123**	0.278**
Trend $KB^{**}/KH^{**}$	-0.0020**	-0.116**
Unrestricted $v$ (general oligopoly conduct)	0.117**	0.229**
Trend $KB^{**}/KH^{**}$	-0.0017**	-0.012**
$\theta_L$ (whole period)	0.025	0.166
$X(\alpha_3^{LD})$	0.0394**	0.0202
$X \times TB / X \times TH(\alpha_4^{LD})$	-0.0021**	-0.0013**
Unrestricted models:		
R-squared $\ln(LB)$ -/ $\ln(LH)$ -equation	0.753	0.922
Adjusted R-squared $\ln(LB)$ -/ $\ln(LH)$ -equation	0.722	0.912
R-squared $TB$ -/ $TH$ -equation	0.472	0.820
Adjusted R-squared $TB$ -/ $TH$ -equation	0.404	0.799
Sample observations	215	215
'Own-rate' price elasticity of demand at sample mean	-2.419	-1.249
'Cross-rate' price elasticity at sample mean	0.151	0.0185

\*\* significant at the 1 per cent level.

\* significant at the 5 per cent level.

Table 8.

**3SLS-fixed effects system estimation results of  
deposit supply (11.1) and pricing equations (11.2);  
dependent variables:  $\ln(D)$  and  $R$ ; 1991Q1–1996Q4**

$\alpha_1^{DD}$	-0.0013
Restricted $\tau_1^*$ (Bertrand-Nash conduct)	0.020**
Trend* $H_{11}^*$	-0.0006**
Unrestricted $\tau_1^*$ (general oligopoly conduct)	-0.026
Restricted $\tau_2^*$ (Bertrand-Nash conduct)	-0.045**
Trend* $H_4^*$	0.0017**
Unrestricted $\tau_1^*$ (general oligopoly conduct)	-0.059
$\theta_D$ (whole period)	0.789
$\theta_D$ (1991–1994)	0.571
$\theta_D$ (1995–1996)	0.894
$Y(\alpha_3^{DD})$	0.0015
$Y \times R(\alpha_4^{DD})$	0.0026**
Unrestricted models:	
R-squared ( $\ln(D)$ )	0.961
Adjusted R-squared ( $\ln(D)$ )	0.954
R-squared ( $R$ )	0.950
Adjusted R-squared ( $R$ )	0.941
Sample observations	215
'Own-rate' price elasticity of demand at sample mean	1.255
'Cross-rate' price elasticity at sample mean	0.0511

\*\* significant at the 1 per cent level.

\* significant at the 5 per cent level.

Since a considerable amount of structure has been imposed in the system models, there are a number of conditions that need to be satisfied for the results to be consistent with the theory, but which conditions have not been imposed a priori on the estimations. The purpose of the consistency checks is thus to investigate whether the 'data accept or reject the models', ie whether the theory is supported by the data.

First, based on the estimation results, the 'own-rate' and 'cross-rate' price elasticities have all the expected signs, except the cross-rate elasticity of deposit demand.<sup>40</sup> Since there is product differentiation in the model, according to the well-know result, firms should be pricing in the elastic parts of their demand schedules (eg Panzar and Rosse 1987). All models satisfy this condition at the sample mean. The absolute value of the estimated price elasticity is highest for corporate loans at the sample mean (around 2.4), while being significantly lower

<sup>40</sup> The signs of the  $\alpha_4^{LD}$ -parameters are negative, and those of the  $\alpha_1^{LD}$ -parameters positive, all consistent with theory. The estimate of  $\alpha_4^{DD}$  is positive, as it should be, while the sign of  $\alpha_1^{DD}$  is inconsistently negative. These parameters characterize the 'own-rate' price elasticities as defined in (11).

for household lending and deposit supply (both around 1.2). This is consistent with earlier results for the keenest competition in corporate lending. In addition, the 'cross-rate' price elasticities are lower in absolute value than the 'own-rate' elasticities, which is a plausible result. This means that changing own loan and deposit rates has a bigger impact on the demand for loans and supply of deposits than changes in rivals' rates. Finally, Wald-tests maintain the restrictions imposed by the theory that ( $\alpha_1^{LDm} = \alpha_2^{LDm}$ ,  $m = 1, 2$  and  $\alpha_1^{DD} = \alpha_2^{DD}$ ).

The results imply much lower degree of oligopolistic price coordination among banks in lending than deposit taking activities. However, the estimates of the coordination parameters are never significant as single parameters, but the Wald test rejects the exclusion of the entire set of coefficients that determine the elasticities and conduct parameters in all cases. Furthermore, barring the uncertainties in mind, the results indicate that the degree of coordination has been higher in household than in corporate lending. The estimated conduct parameter is however only 0.17, even for household lending, which implies that roughly 80 per cent of banks' pricing power has been due to differentiation and only 20 per cent to collusion. In corporate lending, the point estimate of the coordination parameter is close to zero and practically all of the (weak) pricing power is attributed to differentiation.

These results mean that the unrestricted estimates of the v-parameters are close to the restricted estimates forcing conduct to be Bertrand-Nash and that the estimates from the loan pricing equations are not significantly biased due to this restriction. Inserting yearly dummy variables to assess changes in the value of the coordination parameters over time in lending activities indicates that significant changes do not occur during the sample period. That is, there is no clear indication of a regime shift in oligopolistic conduct during this period.

On the deposit side, the situation is reversed. According to the results, banks' pricing power has resulted mainly from price coordination during the sub-sample period 1991Q1–1996Q4 reported in Table 8. The results even point to increased coordination toward the end of the sample period when concentration in the Finnish banking system increased due to the Merita merger and restructuring of the savings banks, but this result should be viewed with caution due to the weak significance of the respective coefficients.

The above results are in line with the findings in Vesala (1995 ch. 4) indicating that price coordination has been significantly higher in deposit-taking than in lending. They also are broadly in agreement with Suominen's (1994) results of 4–56 per cent use of monopoly power in the loan market and 18–100 per cent in the deposit market. He uses aggregate time series data (1986–1989) on the Finnish banking industry and bases his analysis on a two-product quantity setting model that incorporates linear demand and marginal cost functions. Suominen's analysis is a two-product extension of Bresnahan's (1982) test of competition or Shaffer's (1989) application of Bresnahan's test to the US banking industry.<sup>41</sup>

The findings here suggest that price competition among banks in setting deposit rates has not been highly effective in Finland in recent years on average. I think that the indirect regulation of deposit pricing via the taxation rules is the

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<sup>41</sup> The range for the estimated use of monopoly power in Suominen (1994) is due to the use of various instrumental variables-methods to correct simultaneous-equation biases in the OLS-estimates. The use of instrumental variables seems however questionable, as he notices, since the sample size is quite small.

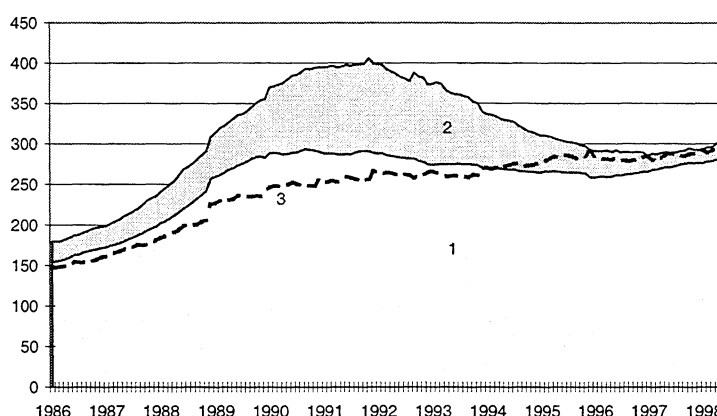
primary explanation, because these rules still seem to strongly guide banks in setting deposit rates. It can be envisioned that the highest tax-exempt deposit rate serves as a 'focal price' for banks in pricing deposits, which supports the emergence of apparently quite strong price coordination. Since deposit account types have been quite homogeneous across banks, the existence of such a 'focal price' could become quite decisive. The highest tax exempt deposit rate would be a natural deposit rate for banks to expect of rival banks' offers. There is no such obvious 'focal price'<sup>42</sup> for the pricing of especially corporate loans that require close credit risk evaluation, ie a lot of customer-specific judgement.

Secondly, the result of the smaller extent of price coordination among banks in lending can be explained, at least to some extent, by the stronger effect of delivery network differentiation on lending than on deposit-taking, as already found in the estimations of the pricing equations. In the extreme case, when firms are completely differentiated from each other, there is no real price competition anyway and the problem of collusive conduct does not arise at all. In general, the perceived heterogeneity of firms constitutes a factor that reduces the likelihood of price coordination (eg Tirole 1990, ch. 6), as the lack of a 'focal price'.

Thirdly, the introduction of the withholding tax in 1991 opened up new possibilities to compete over customers via offering higher-yielding taxable deposit accounts. Changes in these deposit rates represent moves that can be quickly executed. In fact, the existence of this kind of a feasible and credible reserve for keen competition has the effect of deepening collusion.<sup>43</sup>

Figure 3.

**Finnish bank's total loans (markka- and foreign currency-denominated) and total deposits, 1986–1998**



- 1 Total markka-denominated loans
- 2 Total foreign currency loans
- 3 Total markka-denominated deposits

<sup>42</sup> In general, the existence of a 'focal price', on which it would be natural for oligopolists to coordinate, is found in the theoretical industrial organization literature to support the emergence of price collusion (eg Tirole 1990, ch. 6).

<sup>43</sup> A general result from the standard models of infinitely repeated games is that anything that makes more competitive behaviour more feasible or credible (like unlimited capacities or other options to engage in fierce competition) actually promote collusion. Namely, very tight competition is reserved to punish defectors from 'tacit' collusion, and collusion is the stronger the more severe the punishment from defection. Shapiro (1989) calls this the 'topsy-turvy' principle of 'tacit' collusion. He states that all general factors that are found to deepen collusion are in line with this principle.

Finally, the subsample period from 1991Q1 to 1996Q4 has been characterized by a potential oversupply of bank credit in Finland. As Figure 3 shows, banks in Finland have not, on the aggregate, needed additional deposit funding to finance their lending activities, since their deposit base has exceeded the value of their loan books as regards the domestic currency-denominated items. In other words, banks could have met increasing demand for loans without having to resort to new and more expensive funding sources than deposits. This situation could explain in part why price competition in markka deposits has been seemingly weak (holding the effect of network differentiation constant).

Parameter estimates from system models restricted to Bertrand–Nash conduct are generally quite consistent with the results from estimating the pricing equations individually, which supports the consistency and robustness of the estimates. As to the results obtainable only from the system estimations, the demand for corporate loans has been found to be the most, and deposit supply the least, dependent on the cyclical position of the economy, the demand for household loans being the intermediate case. These results are quite reasonable, since corporate investments that are to a large extent financed by bank loans are the most variable component of GDP, and the elements of private consumption are not as variable as investments.

The demand-side equations actually fit quite well the data. Deposit pricing relations again have the best fit and the corporate loan pricing relations the worst. The coefficients of the year dummies are significant in the demand relations, as they pick up the unmodelled components that are correlated with time.

## 6 Conclusion

The purpose of this paper was to estimate empirical models characterizing the pricing of loans and deposits in order to examine the effects of banks' differentiation in terms of branch and ATM networks on their markups, and changes in this relation over time. To this end, a relatively simple way to measure the extent of network differentiation was presented. System models of loan and deposit demand and pricing relations were also estimated in order to separate network differentiation effects from collusion in prices. The empirical models were constructed according to the theory presented in Vesala (1998), and in the first instance, the empirical results obtained from the Finnish banking system (1986Q1–1996Q4) provide support to the theory as a suitable description of the pricing of loans and deposits. The demand relations based on the theory fit the data satisfactorily in the subperiod 1991Q1–1996Q4, while the models do not seem to be flexible enough to predict loan demand or deposit supply for the earlier subperiod, 1986Q1–1990Q4, due to the extraordinarily strong boom in bank lending and other peculiarities associated with this period.

The results indicate that pricing power due to branch network differentiation has existed mostly in household lending, where banks have enjoyed substantially wider markups than in corporate lending. However, in line with the predictions concerning the effects of the technological change, ie the reducing of customers' utility cost of weakened access to branches, this pricing advantage was found to be diminishing over time in all lending and deposit-taking activities.

Branch network differentiation was found to generate a significantly smaller pricing advantage with respect to deposits than household loans, which indicates

that technological transformation has advanced farther in the former activities. ATM network differentiation was found to contribute less to banks' markups on the deposit side than branch network differentiation, but the effect of the time trend was ambiguous: cash dispensers losing significance and payment ATMs increasing in importance. The indices characterising differentiation are mostly due to differences across banks, as regards branches, while the network size effect is relatively more important as regards ATMs, due to the compatibility agreements among banks. The network size effect captures the competitive advantage to all banks due to total ATM network size.

Deposit margins vs the money market rate have been strongly affected by the level of the market rate, much more so than the lending margins. This stickiness is likely due to the still existing control of deposit rates through tax exemption rules, and significant price coordination among banks, while the determination of the lending rates has been fully deregulated over the sample period.

The estimation of the price coordination parameters revealed that oligopolistic price coordination has been quite insignificant in the lending activities, implying that banks have engaged in effective price competition. Thus in lending, differentiation, rather than collusion is found to be the primary source of pricing power. Quite the contrary is found with respect to deposit pricing. This means that the importance of branching has still been lower than that implied by the results from the pricing models.

Coordination in deposit pricing has probably been supported by the stickiness caused by tax rules and an apparent oversupply of credit during the later subperiod (1991Q1–1996Q4) covered by the system estimations. The highest tax-exempt deposit rate seems to serve as a 'focal price' for banks' coordinating. Finally, the empirical results concerning the decomposition of the sources of banks' pricing power into differentiation and collusion support the general industrial organization theory in that the two sources are mutually exclusive. The greater the differentiation, the less likely the collusion. Lending is found here to exhibit more effective differentiation and a low degree of collusion and deposit-taking little differentiation and strong collusion.

The apparent differences in conduct between the Finnish loan and deposit markets, where market concentrations are approximately the same, illustrates the general problems with using only concentration as an indicator or predictor of competitive behaviour, as in the traditional SCPP-approach, which predicts extensive price coordination in concentrated markets. Other influences like product differentiation, demand conditions etc may be more significant in actual oligopolistic markets and the NEIO-approach to analyse conduct directly is thus more appropriate. In fact, the evidence of weak price coordination in the Finnish loan markets in spite of high market concentration provides evidence against the SCPP-approach. Focusing only on market concentration may thus generate biased conclusions eg for competition policy purposes.

What do the empirical results presented here imply for Finland as regards the potential effects of European liberalization, namely harmonized banking regulations, free cross-border banking within the single market, and the adoption of the single currency. All these factors increase the possibilities and likelihood of foreign banks increasing their operations in Finland and strengthen their competitive pressure on Finnish banks. The results imply that most benefits for customers would come from the elimination of cost differences on the lending side, rather than from reductions in the scope of collusive conduct among Finnish banks. Only more cost efficient lenders could undercut the domestic banks. On the

deposit side, in contrast, consumer benefits could be obtained also from reduced possibilities for the incumbent domestic banks to exercise collusion without attracting foreign competition. That is, the contestability of the Finnish deposit market would likely increase in the future due to pro-competitive developments in Europe.

The need for extensive branching, and the sunk costs related to incumbent banks' existing branch networks have been traditionally regarded as the most important barriers for banks as regards entry into new markets. Building up a branch network or acquiring a branch-bank in a target country are considered much more expensive entry methods than entry via establishment of one or a few branches. The results concerning the importance of branching indicate that Finnish deposit customers no longer place much value on 'physical' delivery outlets and hence the latter entry method could be successfully used by foreign or domestic bank or nonbank entrants into the Finnish banking market. Hence, entry barriers to the Finnish deposit (and asset management) market may not be very high, and substantial increases in competition and contestability might be achieved, which would generate significant customer benefits.

On the lending side, household lending was found to exhibit attractive markups for new entrants, but branching still seems to deliver an important, albeit diminishing competitive edge. Hence household lending would be the most difficult area for new entrants, and increases in competition and contestability would likely be realized more slowly than in the case of the deposit market. Corporate lending seems to be already quite competitive, which naturally restricts the scope of further customer benefits through increased competition.

There are several other implications of the findings given the results presented in Vesala (1998). First, the declining value of network differentiation due to technological change would result in customer benefits even without new entry or changes in the contestability of the banking markets, unless banks succeed in differentiating in some novel aspects of service quality. Regaining pricing power might be difficult through any means in the liberalized environment with free cross-border banking and increasing nonbank competition. Diminishing variability of loan and deposit rates across banks would be another result of the technological development, as is already visible in the data. Moreover, lower markups for banks would result in a lower optimal number of branches, thus causing continuous pressure to restructure branch networks. This restructuring trend is already observable in many countries.

In terms of policy implications, the results indicate that the pass-through of money market rates to lending rates should increase in the future, which would increase the efficiency of monetary policy. In a cross-country comparison, differences in the bank differentiation and in the stance of banking technologies would result in varying pass-through across countries. In the framework of the single monetary policy in the EMU, these differences would cause the monetary policy to have varying effects on the real economy. These differences will however diminish if competitive conditions and technologies converge within the single currency area.

The finding here of more rapid effects of technological transformation on deposits than on lending indicates that the loan rates would in the future become relatively stickier vs money market rate changes than would deposit rates. Moreover, if this feature continues to hold, deposit rate changes, eg due to further deregulation, would over time have weaker effects on lending rates.

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