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Housing loan rate margins in Finland

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Abstract

This paper examines how housing loan rates are determined, using data on new housing loans in Finland. Finland is an example of a bank-based euro area country where the majority of loans are granted at variable rates. The paper extends the earlier interest rate pass-through literature by taking explicitly into account the changing of lending rate margins. A standard lending rate pass-through model, empirically specified as an error-correction model, is extended with variables predicted by a theoretical bank interest rate setting model. The results show that, since the mid-1990s, short-run movements in housing loan rates can be largely explained by changes in money market rates, and that long-run developments have also been affected by less volatile cost and credit risk factors. The roles of loan competition and capital regulation are also considered, but these effects are more difficult to identify empirically.

Keywords: housing loan, lending rate, lending rate margin, error-correction model

JEL classification numbers: G21, E43

Asuntolainamarginaalit Suomessa

Suomen Pankin keskustelualoitteita 10/2010

Hanna Putkuri
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä työssä tarkastellaan uusien asuntolainojen korkojen määräytymistä Suomessa, jossa rahoitusjärjestelmä on pankkikeskeinen ja lainat ovat valtaosin vaihtuvakorkoisia. Tutkimus laajentaa aiempaa korkojen läpimenoa koskevaa kirjallisuutta ottamalla lainamarginaalien muuttumisen eksplisiittisesti huomioon. Virheenkorjausmallina esitettyä tavanomaista lainakorkomallia täydennetään muuttujilla, jotka johdetaan pankkikorkojen määräytymistä kuvaavasta teoreettisesta mallista. Tulosten mukaan asuntolainakorkojen lyhyen aikavälin vaihtelu selittyy lähinnä markkinakorkojen muutoksilla, kun taas pitkällä aikavälillä – 1990-luvun puolivälistä alkaen – myös vähemmän vaihtelevat kustannus- ja riskitekijät ovat vaikuttaneet korkojen kehitykseen. Työssä tarkastellaan myös pankkien välisen lainakilpailun ja vakavaraisuussääntelyn vaikutuksia, mutta niitä on vaikeampi identifioida empiirisesti.

Avainsanat: asuntolaina, lainakorko, lainamarginaali, virheenkorjausmalli

JEL-luokittelu: G21, E43

Contents

1 Introduction

The impact of changes in market interest rates on bank lending rates, further on spending and financing decisions, and finally on inflation and economic growth is a key channel of monetary policy transmission. This is particularly true for countries with bank-based financial systems and the majority of bank loans granted at variable rates.

The euro area is generally considered as an example of a bank-based financial system, while Finland stands out with roughly 90% of outstanding loans to the public being tied to variable rates. Moreover, as to housing finance, close to 95% of housing loans in Finland have variable interest rates and they are for the most part granted by domestic deposit banks. This general picture is also supported by empirical evidence showing that the interest rate channel plays a substantial role in monetary transmission in almost all euro area countries and a predominant role in Finland and a few other countries (Angeloni et al, 2003). Given these findings, the lending rate pass-through is likely to be an important mechanism in the Finnish economy in general and the housing market in particular.

Recently, the bank interest rate pass-through has drawn increasing attention due to the exceptionally strong and rapid decrease in money market rates since the start of the global financial crisis in autumn 2008. During the first year of the crisis, the ECB main refinancing rate was lowered by 3.25 percentage points to a historically low level of 1%. At the same time, the 12-month Euribor decreased by almost 4 percentage points from 5.25% in October 2008, on average, to 1.26% in September 2009. Over the same period, the average interest rate on new housing loans in Finland decreased by 3.4 percentage points to as low as 2.12%, among the lowest in the euro area.

The degree to and the speed at which bank interest rates respond to changes in market interest rates are key factors of the monetary transmission mechanism. A body of literature has shown that the response of bank lending rates is sluggish and incomplete in the short run, while in the long run the pass-through can be less than, equal to or even more than one-to-one. The sensitivity of lending rates to changes in market interest rates has been interpreted to reflect various cyclical, structural and institutional factors but most often it is taken to indicate the degree of competition between banks.

A question that has been less explored in the interest rate pass-through literature is the determination of bank lending rate margins. The same factors that affect the degree and speed of pass-through of market interest rates may also directly influence the level of lending rate margins. During the past decade and a half, the difference between the interest rate on new housing loans and the 12-month money market rate, traditionally the most common reference rate in Finland, has trended down from the level of 2 percentage points to less than 0.5 at

the lowest. The emergence of the global financial crisis and the economic depression in Finland finally reversed this trend.

Against this background, my purpose in this paper is to examine the housing loan rate pass-through in Finland and, in specific, to distinguish between the pass-through of market interest rates and changes in the determinants of lending rate margins. The key determinants – operating costs, credit risk, market power, and the minimum capital requirements – are derived from an extended version of the oligopolistic Monti-Klein model of banks' interest rate setting behaviour. When omitted in the empirical analysis, changes in these cyclical and structural factors may show up either as a high or low degree of pass-through of market interest rates, while the determination of margins remains a black box.

The key result of the paper is that, since the mid-1990s, short-run movements in the Finnish housing loan rates are largely explained by changes in market interest rates, and that long-run developments are also affected by less volatile cyclical and structural factors. Two easily measured variables, the ratio of banks' administrative expenses to total assets and the unemployment rate, combine to capture changes in the average lending rate margin. Given these two additional factors, the pass-through from market interest rates to housing loan rates is found to be sluggish in the short run but complete in the long run. The latter finding is in line with the fact that most of the housing loans in Finland are tied to variable interest rates, while the former, by and large, reflects the fact that in the short run borrowers can affect the degree and speed of pass-through by choosing between different reference rates, ie money market rates and more sticky prime rates, depending on the direction of market rates.

The evidence on the roles of loan market competition and capital adequacy regulation is less robust or statistically insignificant. The result may in part be caused by a lack of relevant indicators for changes in these two factors. The loan market concentration, as measured by the Herfindahl-Hirschman index, is often used as a proxy for the degree of competition, but here the variable is not significant in the preferred final model. The same is true for a smooth dummy variable attempting to capture the adjustment towards lower capital requirements of housing loans along with Basel II.

The rest of the paper is organised as follows. Section 2 summarises relevant literature on the two issues in focus: bank lending rate pass-through and determinants of bank interest margins. Section 3 lays the theoretical foundation of the paper by extending an oligopolistic Monti-Klein model of banks' interest rate setting behaviour. Section 4 describes the empirical approach of the paper and the data and variables used. The section also reports the key estimation results. Finally, section 5 concludes.

2 Related literature

There are two closely related strands of literature that both analyse the determination of bank interest rates. One examines the pass-through of market interest rates to bank lending and deposit rates, while the other analyses the determinants of bank interest margins. My focus is on the pass-through of market interest rates to bank lending rates (section 2.1) and the factors determining the margin between the two (section 2.2), in particular in the case of housing lending in Finland (section 2.3).[1]

2.1 Bank lending rate pass-through

The pass-through of market interest rates to bank lending rates has been studied from two different perspectives. First, according to the traditional money view of monetary transmission, interest rates are the key channel through which monetary policy affects investment and financing decisions and further inflation and economic growth. From this monetary policy perspective, the key research question is the degree and speed at which changes in policy rates are passed on to market interest rates and further to lending and deposit rates.

Second, in the industrial organisation literature, banks are seen as profit-maximising firms that set lending and deposit rates in proportion to their marginal costs, approximated by market interest rates. According to this cost-of-funds approach, the extent to which changes in market interest rates are passed through to bank interest rates reflects, first and foremost, the market structure of the banking system and the intensity of competition between banks.

The general finding in the literature is that the response of bank lending rates to changes in market interest rates is sluggish and incomplete in the short run. Cottarelli and Kourelis (1994) were among the first to estimate the extent to which and the speed at which bank lending rates respond to changes in money market rates. They found the response to be sticky but quite different across countries, particularly in the short run, and explained this heterogeneity by structural differences in the national financial systems. Since then, a body of literature has emerged providing further evidence of and explanations for the sluggish lending rate pass-through. Yet there is no consensus on whether the pass-through is complete in the long run. The results vary across types of loans, countries and time periods analysed.[2]

[1] There is also a body of literature on the stickiness of deposit rates, many spurred by the seminal papers by Hannan and Berger (1991) and Neumark and Sharpe (1992), but further details on the dynamics of deposit rates are beyond the scope of this paper.
[2] For a survey, see eg de Bondt (2005).

Previous studies have also found heterogeneity in the degree and speed of pass-through across retail market segments and between banks within a single country. Corporate loan rates typically respond more quickly than housing and consumer loan rates (eg de Bondt, 2005, Kok Sørensen and Werner, 2006). Furthermore, banks with the largest market shares price their loans least competitively, supporting a relative market power hypothesis, while well-capitalized and highly liquid banks are least responsive to changing market conditions, as predicted by a bank lending channel (de Graeve et al, 2007).

Moreover, the response of bank lending rates to changes in market interest rates can be asymmetric with respect to the interest rate cycle (eg Gropp et al, 2007), but competition between banks reduces this asymmetry by limiting banks' ability to smooth interest rate margins (Mojon, 2000). A distinction can also be made between bank lending rates below or above their equilibrium levels (Sander and Kleimeier, 2004) and between expected and unexpected monetary policy shocks (Kleimeier and Sander, 2006).

The evidence is mixed on whether the degree and speed of pass-through has increased in the euro area since the adoption of the single monetary policy. Marotta (2009) finds structural breaks in the corporate lending rate pass-through but is cautious in associating them to the introduction of the euro. In fact, he finds that the pass-through has become more incomplete, possibly due to reduced competition and higher risk premiums, the latter in accordance with Basel II.

2.2 Bank interest margins

Bank interest margins have been modelled using two different frameworks, a firm-theoretical model by Klein (1971) and Monti (1972) and a dynamic dealership model by Ho and Saunders (1981). The former approach treats banks as risk-neutral profit-maximising firms, while the latter views them as risk-averse dealers. The Monti-Klein model is discussed and extended in the theoretical part of the paper (section 3), while the latter strand of literature is briefly reviewed here.

The seminal paper by Ho and Saunders (1981) shows both theoretically and empirically that the difference (spread) between lending and deposit rates results, first and foremost, from the transactions uncertainty of banks and depends on the following four factors: the degree of risk aversion, the size of bank transactions, the structure of the banking market, and the variance of lending and deposit rates. McShane and Sharpe (1985) show broadly similar evidence but argue that the key interest rate risk is related to the volatility of money market rates. Furthermore, Allen (1988) extends the Ho-Saunders model by considering different types of

loans with interdependent demands and shows that bank interest margins may be reduced as a result of cross-elasticities of demand.

Later extensions of the models have shown that bank interest rate margins may also depend on the default risk (Angbazo, 1997), regulation (Saunders and Schumacher, 2000), operating costs and the degree of bank competition (Maudos and Fernández de Guevara, 2004, Maudos and Solís, 2009), the presence of foreign banks (Martinez Peria and Mody, 2004), the degree of specialisation (Carbó Valverde and Rodríguez Fernández, 2007) and diversication (Lepetit et al, 2008), and macroeconomic fundamentals (Barnea and Kim, 2007, Juselius et al, 2009).

2.3 Evidence on Finnish housing loan rates

Previous empirical evidence on the housing loan rate pass-through in Finland originates from cross-country studies that focus mainly on the heterogeneity between countries as to the degree and speed of the pass-through. The existing studies differ in terms of time periods, specifications and estimation methods used, but the results generally indicate that in Finland the pass-through from money market rates to housing loan rates is relatively high and rapid in the European comparison. The key findings are discussed below (see table 1 for a summary).

Donnay and Degryse (2001), de Bondt et al (2005), Kleimeier and Sander (2006) and Sander and Kleimeier (2006) all find that in Finland the degree of immediate and short-run pass-through of money market rates to housing loan rates is among the highest in the euro area. For example, Donnay and Degryse estimate that the one-month pass-through is 0.18 percentage points, which is at the higher end of the range of 0.02–0.19 in other sample countries. The studies that analyse also the long-run dynamics typically find that the pass-through is, by and large, complete in the long term.

Based on the existing evidence, it also seems that the pass-through has accelerated over time in that the speed of adjustment is the higher, the more recent data is used. Moreover, the estimated speed of adjustment seems to depend on which market interest rate is used in the analysis. Kok Sørensen and Werner (2006) advocate using a compounded market interest that has the same maturity structure as the outstanding stock of loans, but at the same time they note that this approach may underestimate the true speed of adjustment in countries where the majority of loans are granted at variable rates. For example in Finland, the estimated speed of adjustment is higher, when a short-term market rate is used instead of a compounded rate.

The determinants of bank lending rate margins have not been widely studied using Finnish data. A standard pass-through model assumes a constant margin, though in the case of Finland it seems not to be the case, in particular in the long term. According to Kauko (2005), in 1993–2003, the squeeze in the margin between the interest rate on new loans to the public and the money market rate can be explained by the decrease in the number of bankruptcies, reflecting lower credit risk, and by the EMU membership which reduced interest rate risk and possibly increased competition.

Table 1. **Previous evidence on housing loan rate pass-through in Finland**

			Impact in the short run			Impact in the long run	
	Time period	Model	Short-term rate	Long-term rate	Speed of adjust-ment*	Short-term rate	Long-term rate
Donnay – Degryse (2001)	92M01–00M05	SVAR	0.18[b,g] 0.39[b,i]				
de Bondt et al (2005)	94M04–02M12	ECM	0.38[b,h]	0.08[e,h]	-0.05	0.54	0.52
	99M01–02M12	ECM	0.39[b,h]	0.18[e,h]	-0.08	0.99	
Kleimeier – Sander (2006)	99M01–03M05	STD	0.57[a,g] 0.61[a,i]			1.07	
Sander – Kleimeier (2006)	98M01–03M09	ECM*	0.36[a,f]			0.98	
Kok Sørensen – Werner (2006)	99M01–04M06	ECM	n.a.		-0.10	1.16[c]	
	99M01–04M06	ECM	n.a.		-0.20	1.08[d]	
	03M01–05M01	ECM	n.a.		-0.34	1.09[b]	

SVAR denotes a structural vector autoregressive model, ECM an error-correction model, STD a standard first-difference model, and ECM* an error-correction model with a momentum threshold autoregressive (M-TAR) error-correction term.
Pass-through from (a) 1-month money market rate, (b) 3-month money market rate, (c) weighted average of short- and long-term market rates, (d) most correlated market rate, or (e) 10-year government bond yield, and the impact (f) immediately, (g) after one month, (h) after two months, or (i) after three months. n.a. indicates no multiplier was reported in the paper.
* Speed of adjustment to long-run equilibrium.

3 Theoretical model

In the theoretical part of the paper, I take an industrial organisation approach to banking by applying an oligopolistic extension of the Monti-Klein model. The model builds on the role of banks as profit-maximising firms, while abstracting from the economics of information. The original model of a monopolistic bank was put forward in the seminal papers by Klein (1971) and Monti (1972), but later on the model has been extended and tested in several ways in the literature.[3]

I take a static Freixas-Rochet (2008) version of the model as a starting point and extend it by adding a simple bank capital requirement and by introducing credit risk in line with Wong (1997) and Corvoisier and Gropp (2002) (section 3.1). The profit-maximising behaviour of a representative bank is analysed under Cournot competition between a finite number of banks (section 3.2). Finally, the optimal bank lending rate is derived from the loan market equilibrium condition (section 3.3). Particular attention is paid to the impact of various cost and risk factors and the degree of competition on the equilibrium lending rate.

3.1 Basic set-up and assumptions

There are three types of agents: banks, the central bank and private borrowers (eg households). The banking industry is oligopolistic with N banks, indexed by $n = 1, \ldots, N$. A representative bank n is a financial intermediary that takes deposits (D_n), grants loans (L_n) and holds equity capital (K_n).[4] The remaining net assets or liabilities (M_n) the bank either lends or borrows in the interbank money market. By the balance sheet identity, the bank's total assets and liabilities are equal

$$L_n + M_n = D_n + K_n \tag{3.1}$$

The money market rate (r_M) is set by the central bank, and bank n takes it as given. Assuming that the cost of holding capital (r_K) is higher than the risk-free market rate of return, the bank holds its capital at the minimum regulatory level of k per cent of loans, required by the central bank

$$K_n = kL_n \tag{3.2}$$

[3] See eg Sealey (1980), Zarruk (1989), Zarruk and Madura (1992), Wong (1997), Corvoisier and Gropp (2002) and Gropp et al (2007).
[4] Cash reserves are ignored, because they do not affect the optimal lending rate.

All banks use the same technology, represented by a strictly increasing cost function

$$C_n(L,D) = C(L,D) = \gamma_L L_n + \gamma_D D_n \text{ (for all n)} \tag{3.3}$$

in which parameters γ_L and γ_D, treated here as constants, denote the separable marginal costs of managing loans and deposits, respectively

$$\gamma_L \equiv \frac{\partial C(L,D)}{\partial L} \text{ and } \gamma_D \equiv \frac{\partial C(L,D)}{\partial D} \text{ with } \frac{\partial C^2(L,D)}{\partial L \partial D} = \frac{\partial C^2(L,D)}{\partial D \partial L} = 0 \tag{3.4}$$

Banks have some degree of market power in the imperfectly competitive loan and deposit markets. Banks face a downward-sloping demand for loans $L(r_L)$ and an upward-sloping supply of deposits $D(r_D)$. L and D denote the total amount of loans and deposits and r_L and r_D the corresponding lending and deposit rates.

Banks face credit risk, measured by parameter $\mu(\mu \in [0,1])$. The parameter is the same for all banks and it can be interpreted either as a proportion of non-performing loans at the end of the period (Wong, 1997) or as a default probability of loans (Corvoisier and Gropp, 2002).

3.2 Profit-maximisation

In a static Cournot game, banks compete through quantities both in the loan and deposit markets, choosing their actions simultaneously and independently. Given the quantity choices, the lending and deposit rates adjust accordingly to the levels $r_L(L)$ and $r_D(D)$ that clear the markets. Here, $r_L(L) = L^{-1}(r_L)$ and $r_D(D) = D^{-1}(r_D)$ denote the inverse demand and supply functions (with $r'_L(L) < 0$ and $r'_D(L) > 0$ at all $L, D \geq 0$).

Bank n chooses L_n and D_n to maximise its expected end-of-period profit, taking the volumes of loans and deposits of other N-1 banks as given. The profit function of the bank is equal to the expected net interest income less capital costs and operating expenses

$$\max_{L_n, D_n} E\pi_n(L_n, D_n) = (1-\mu) r_L(L) L_n + r_M M_n - r_D(D) D_n - r_K K_n - C(L_n, D_n) \tag{3.5}$$

subject to the balance sheet constraint (3.1). By expressing M_n, K_n and $C(L_n, D_n)$ in terms of (3.1), (3.2) and (3.3) respectively, the objective function (3.5) can be rewritten as

$$E\pi_n = ((1-\mu)r_L(L) - r_M)L_n - (r_D(D) - r_M)D_n - (r_K - r_M)kL_n - \gamma_L L_n - \gamma_D D_n \quad (3.6)$$

A Cournot-Nash equilibrium of the banking industry is an N-tuple of vectors $(L_n^*, D_n^*)_{n=1,\ldots,N}$ such that for every n, (L_n^*, D_n^*) solves the decision problem defined by function (3.5). Assuming that the profit function is strictly concave in L_n and D_n and twice differentiable, the first-order conditions for the profit-maximisation of bank n are given by the following marginal revenue and cost functions

$$\begin{cases} \dfrac{\partial E\pi_n}{\partial L_n} = (1-\mu)r_L(L^*) - (r_M + (r_K - r_M)k + \gamma_L) + (1-\mu)r_L'(L^*)L_n^* = 0 \\ \dfrac{\partial E\pi_n}{\partial D_n} = r_M - (r_D(D^*) + \gamma_D) - r_D'(D^*)D_n^* = 0 \end{cases} \quad (3.7a,b)$$

The first two terms on the right hand side of equations (3.7a) and (3.7b) describe the profitability of an extra unit of loans and deposits, respectively, while the third term represents the effect of this extra unit on the profitability of loans and deposits already 'produced'. Under separability (3.4), the equilibrium of the loan market (3.7a) is independent of the equilibrium of the deposit market (3.7b). For the purpose of this study, it is enough to focus on the optimal volume of loans (L_n^*)

$$L_n^* = \frac{(r_M + (r_K - r_M)k + \gamma_L) - (1-\mu)r_L(L^*)}{(1-\mu)r_L'(L^*)} \quad (3.8)$$

Since equation (3.8) is independent of n, there is a unique symmetric equilibrium, in which each bank chooses $L_n^* = L^*/N$. Consequently, the equilibrium condition (3.8) can be rewritten in the form in which for each bank the expected marginal revenue from lending L^*/N equals the total marginal cost of funding, holding capital and managing the stock of loans

$$(1-\mu)\left(r_L'(L^*)\frac{L^*}{N} + r_L(L^*)\right) = r_M + (r_K - r_M)k + \gamma_L \quad (3.9)$$

By rearranging and introducing the price (here, lending rate) elasticity of demand for loans ($\varepsilon_L(r_L)$), the condition (3.9) can be rewritten in the Lerner index form (price minus marginal cost divided by price)

$$\frac{(1-\mu)r_L^*(L)-(r_M+(r_K-r_M)k+\gamma_L)}{(1-\mu)r_L^*(L)}=\frac{1}{N\varepsilon_L(r_L^*)} \tag{3.10}$$

in which the inverse of the price elasticity is equal to the quantity elasticity of inverse demand for loans ($\phi_L(L)$)

$$\frac{1}{\varepsilon_L(r_L)}=\phi_L(L)=-\frac{r_L'(L)L}{r_L(L)} \tag{3.11}$$

According to equation (3.10), the higher is the number of banks or the higher is the interest rate elasticity of demand for loans, the lower is the market power of the bank, and the lower the Lerner index.

3.3 Equilibrium lending rate

Finally, equation (3.10) can be rewritten to give a more straightforward formula for the equilibrium lending rate

$$\begin{aligned} r_L^*(L) &= \frac{1}{1-\mu}\frac{1}{1-\frac{1}{N\varepsilon_L(r_L^*)}}(r_M+(r_K-r_M)k+\gamma_L) \\ &= \frac{1}{1-\mu}\frac{1}{1-\frac{1}{N\varepsilon_L(r_L^*)}}((1-k)r_M+kr_K+\gamma_L) \\ &= \beta_0+\beta_1 r_M, \end{aligned} \tag{3.12}$$

where $\beta_0=\frac{1}{1-\mu}\frac{1}{1-\frac{1}{N\varepsilon_L(r_L^*)}}(kr_K+\gamma_L)$ and $\beta_1=\frac{1}{1-\mu}\frac{1}{1-\frac{1}{N\varepsilon_L(r_L^*)}}(1-k)$.

According to this model, the sensitivity (β_1) of the optimal lending rate to changes in the money market rate depends positively on the level of credit risk (μ) and the market power of banks (inverse of N and ε_L) and negatively on the required capital-to-loans ratio (k). The margin (β_0) depends, in addition, positively on the operating costs (γ_L) and the cost of capital (r_K). Given the assumptions made, the key comparative statics of the model can also be summarised as follows (see also table 2): The lending rate is the higher, the higher the funding costs or operating expenses are, or the higher the credit risk, market power or bank capital requirement is.

Table 2. **Comparative statics of the theoretical model**

Effect on the optimal lending rate (r_L^*)		
Deposit rate	r_D	0
Money market rate	r_M	+
Cost of capital	r_K	+
Marginal cost of managing loans	γ_L	+
Probability of default	μ	+
Number of banks	N	–
Price elasticity of demand for loans	ε_L	–
Minimum capital-to-loans ratio	k	+

In the Freixas-Rochet (2008) benchmark case, where the elasticity (ε_L) is assumed to remain constant and there is no credit risk ($\mu = 0$) nor bank capital requirements ($k = 0$), the sensitivity of the lending rate to changes in the money market rate depends only on the number of banks, interpreted to reflect the degree of competition.

4 Empirical model

In the empirical part of the paper, I test some of the key predictions of the theoretical model by estimating a model for the average interest rate on new housing loans in Finland. Taking a macro-level approach and treating the banking sector as a single decision maker omits differences between banks. The main interest in this paper is, however, on the role of long-run developments in macro-level factors such as the market cost of funding, changes in the operating costs (eg due to technological change), credit risk, banking competition and the regulatory environment.

The variables of the empirical lending rate model are motivated (in section 4.1) by the preceding theoretical model. The static nature of the theoretical model gives, however, little guidance on the dynamics of the empirical specification. Therefore, I start the analysis by first describing the data and testing the variables for their order of integration (section 4.2). I find the variables integrated of order one, which is a prerequisite for testing whether the levels of the series are cointegrated. Cointegration is found, which means that the nonstationary series form a stationary linear combination that can be interpreted as a long-run equilibrium relationship between the variables (section 4.3). Finally, the model is estimated in the error-correction form, in which the short-run dynamics of the variables are influenced by the deviation from the long-run equilibrium (section 4.4).

4.1 Implications of the theoretical model and empirical specifications

The oligopolistic Monti-Klein model presents a very simplified approach to banking, yet, as advocated by Freixas and Rochet (2008), it provides several conclusions that can be tested empirically. Most of the interest rate pass-through studies estimate the equilibrium lending rate ($r^*_{L,t}$) by applying the last specification of equation (3.12), assuming a constant margin or markup (β_0) over the market interest rate ($r_{M,t}$) and an iid error term (u_t) at each time period t

$$r^*_{L,t} = \beta_0 + \beta_1 r_{M,t} + u_t \tag{4.1}$$

The advantage of the model is its intuitive interpretability as a simple marginal cost pricing model (eg Rousseas, 1985, and de Bondt, 2005), in which the marginal funding costs are approximated by the relevant market interest rate.

Given the theoretical background, the size of the pass-through coefficient (β_1) is usually interpreted in terms of banks' market power. Incomplete pass-through ($\beta_1 < 1$) is taken as a sign of imperfect competition (or inelastic demand for loans), whereas complete pass-through ($\beta_1 = 1$) is in line with perfect competition (or fully elastic demand for loans). The case of over-shooting pass-through ($\beta_1 > 1$) is usually attributed to credit risk (de Bondt, 2005).

In the theoretical model, there are no costs to banks of changing their lending and deposits rates. However, due to such adjustment costs, banks do not in practice set their interest rates equal to their equilibrium levels in every period. Furthermore, borrowers can either accelerate or decelerate the pass-through by choosing between different reference rates, depending on whether market interest rates are decreasing or increasing. In the empirical model, rigidities in the price setting are introduced through partial adjustment according to a mechanism

$$r_{L,t} - r_{L,t-1} = \gamma(r^*_{L,t} - r_{L,t-1}) + v_t \tag{4.2}$$

in which the adjustment parameter $\gamma (0 < \gamma < 1)$ indicates the proportion of the deviation from the equilibrium that can be corrected in one period (eg Davidson and MacKinnon, 1993). Solving equation (4.2) for $r_{L,t}$ and substituting (4.1) for ($r^*_{L,t}$) yields an autoregressive distributed lag model

$$r_{L,t} = \alpha_0 + \alpha_1 r_{M,t} + \alpha_2 r_{L,t-1} + \varepsilon_t \tag{4.3}$$

in which $\alpha_0 = \gamma\beta_0$, $\alpha_1 = \gamma\beta_1$, $\alpha_2 = 1-\gamma$, and $\varepsilon_t = \gamma u_t + v_t$. Equation (4.3) can also be written in the error-correction form

$$\Delta r_{L,t} = \alpha_1 \Delta r_{M,t} - \gamma(r_{L,t-1} - (\beta_0 + \beta_1 r_{M,t-1})) + \varepsilon_t \quad (4.4)$$

in which $\gamma = 1 - \alpha_2$, $\beta_0 = \frac{\alpha_0}{\gamma}$ and $\beta_1 = \frac{\alpha_1}{\gamma}$. The model discriminates between the short-run dynamics (first-difference terms denoted by Δ) and the adjustment towards the long-run equilibrium (in levels).

I follow this widely applied modelling approach but test whether the standard pass-through model (4.1) can be improved by extending it with variables suggested by the theoretical model. In specific, I test whether changes in the key determinants of lending rate margins should be better accounted for when assessing the extent to and the speed at which lending rates respond to changes in market interest rates, in particular in the long term.

4.2 Variables and data description

Based on the theoretical model presented in section 3, bank lending rates are affected by the following five factors: (1) market interest rate level, (2) banks' operating costs, (3) credit risk faced by the banks, (4) banks' market power, and (5) banks' minimum capital requirements. In the empirical part of the paper, I define the variables as follows (see table 3 for a summary).

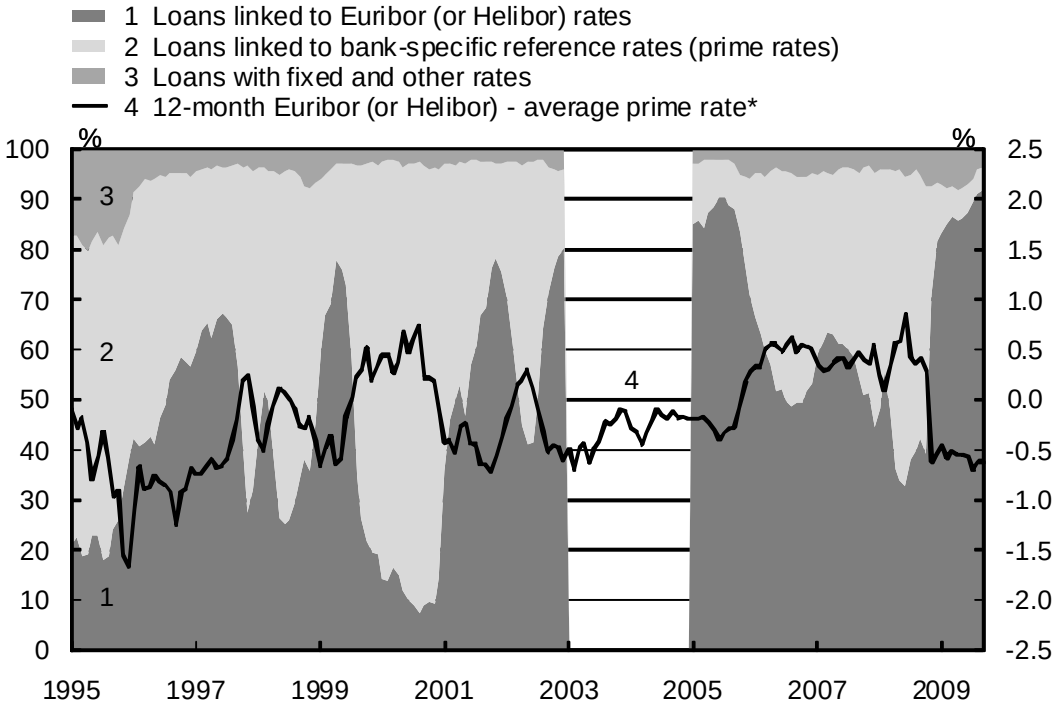
First of all, I concentrate on the new housing lending in Finland. The key variable of interest is the average interest rate (HLRATE) on new housing loans to households by the Finnish monetary financial institutions. The housing finance in Finland is dominated by deposit banks, while specialised mortgage credit banks still play a relatively minor role.

Focusing on one country and one type of loans can be reasoned by substantial differences in the characteristics of loans both across countries and by different purposes of loans. Mortgage interest rates still differ across countries both in terms of levels and changes, and these differences can be partly explained by differences in the national demand and supply conditions and country-specific institutional factors (Kok Sørensen and Lichtenberger, 2007). According to the ECB (2009), one of the key differences relates to the typical interest rate linkage of loans.

Finland stands out as one of the few euro area countries, where more than 90% of new housing loans are typically granted at variable rates. From January 1995 to September 2009, approximately 58% of new housing loans in Finland were linked to money market rates (Helibor prior to 1999 and Euribor from 1999 onwards), 37% to bank-specific reference rates (called prime rates) and only less than 5% to fixed or other rates. Nevertheless, the relative shares of money market

and prime rate linkages in new housing loans can vary considerably from a month to another (figure 1). Prime rates tend to become more popular in times of rising market interest rates, while the use of interbank rates typically increases when market interest rates are decreasing. This regularity is related to the fact that prime rates usually follow money market rates with a short lag, while households typically choose the one that is lower at the time of raising a loan.

Figure 1. **New housing loans in Finland, by interest rate linkage**



Data on interest rate linkages was not collected in 2003 and 2004.
* Average of prime rates of three largest banks in Finland.
Source: Bank of Finland.

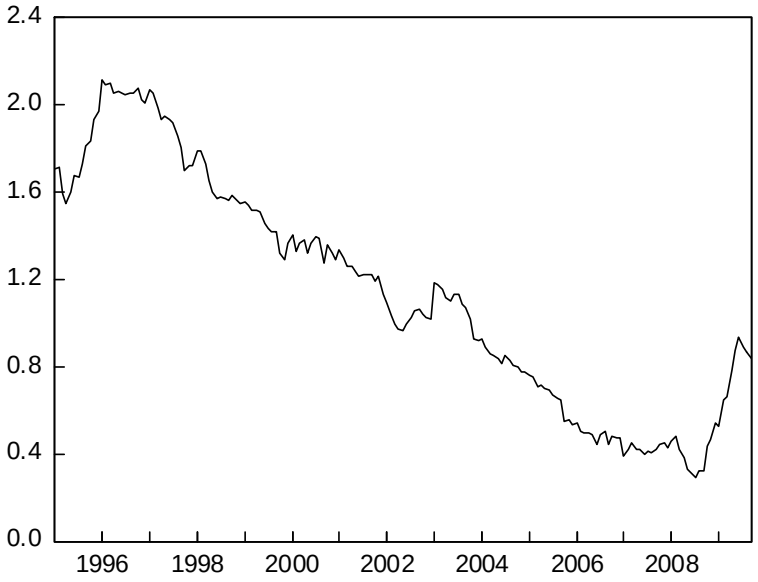
As to the market interest rate level, I focus on the 12-month money market rate (MRATE), which has been the single most common reference rate for housing loans since the mid-1990s.[5] In the previous studies, the selection of comparable market interest rates has usually been made on the basis of correlation (eg de Bondt, 2005) or by matching maturities (Kok Sørensen and Werner, 2006).

The difference between the average housing loan rate and the 12-month money market rate (HLRATE-MRATE) can be used as a rough proxy for the

[5] There is some anecdotal evidence that the average interest rate fixation period among new housing loans has shortened since the strong drop in money market rates in autumn 2008, as households have increasingly re-linked their loans to shorter-term market rates, in particular to the 3-month Euribor rate.

average housing loan rate margin. A better estimate of the margin can, however, be obtained by replacing MRATE by the weighted average of key reference rates among the new loans. Figure 2 depicts the difference between the housing loan rate and the weighted average of two variable reference rates, namely the 12-month money market rate and the average prime rate of the three largest banks operating in Finland.[6] In the short term, the difference seems to be influenced mainly by the volatility of key reference rates, whereas in the long term it may also reflect changes in the underlying determinants of margins: banks' operating costs, risks related to lending, competition between banks and regulation. The proxy for the margin has narrowed for the most of the period considered, but the deepening of the global financial crisis in 2008 finally reversed this trend.

Figure 2. **Proxy for the housing loan rate margin***



* Interest rate on new housing loans minus weighted average of variable reference rates.
Sources: Bank of Finland, Reuters and calculations by the author.

Developments in banks' operating costs can be captured by the ratio of administrative expenses to average total assets (COST). Other operating expenses are excluded due to some significant non-recurrent items that are difficult to remove from the data. Over the period considered, the cost-to-assets ratio has trended down in line with the decrease in the number of bank branches and the declining employee-to-branch ratio. This development is related to extensive

[6] Due to the lack of data on the shares of different interest rate linkages in 2003 and 2004, weights in 2003M01–2004M12 are replaced by the average of weights in 2002M12 and 2005M01.

technological and structural changes that the Finnish banking sector has undergone since the depression and the severe banking crisis of the early 1990s. Furthermore, the rise in total assets (the denominator of the indicator) reflects a significant increase in the average size of loans, which has in part compensated banks for the decrease in the margins in percentage terms.

Risks related to household lending are generally contingent on the development of interest rates, income and housing prices but the combined effect of the risks is difficult to gauge. For example, during the current financial and economic crisis, market interest rates have fallen to historically low levels, easing the debt servicing burden of those with variable rate loans. At the same time, the labour market conditions have deteriorated and increased households' income uncertainty. In the empirical analysis, I emphasize the income-related risks and use the unemployment rate as a macro-level proxy for the riskiness of housing lending (RISK). The use of this indicator is also supported by its high correlation with the share of aggregate nonperforming loans in total loans of the Finnish banking sector since the mid-1990s.[7] Nevertheless, housing loans are typically well-secured by borrowers' residential property, and banks' losses on household lending have so far been very small, even during the banking crisis of the early 1990s.

There are no direct measures for the degree of competition in housing finance but different market concentration ratios and indexes are often used as indicators for competition in retail banking (eg Carbó et al, 2009). The Herfindahl-Hirschman index (HHI) is one of the most widely-used measures, and it is calculated as the sum of the squared market shares of the banks operating in the market. Basically, the higher is the index, the higher is the degree of concentration, the more the banks have market power, and the lower is the intensity of competition between banks.

According to the Herfindahl-Hirschman index, the Finnish bank loan market is highly concentrated but, more importantly, the degree of concentration has decreased as compared to the mid-1990s. Based on anecdotal evidence, bank competition has been rather intense over the past years, in particular in housing lending. The stamp duty on new bank loans was abolished in Finland in April 1998, which made it less costly for customers to renegotiate loan contracts and to switch from a bank to another. There is also some anecdotal evidence of cross-subsidisation in that narrow housing loan rate margins have been used to attract loan customers and to induce them to buy other banking services as well.

The pricing of bank loans can also be affected by regulatory changes. Along with the implementation of the New Basel Capital Accord (Basel II) in the beginning of 2007, the risk-weight of residential mortgage lending decreased to

[7] Data on nonperforming household or housing loans are not available for the corresponding time period.

35% from the former 50%. Consequently, banks need to hold less capital against their housing loans. Banks most likely adjusted their loan pricing up front, after the change in the risk-weight was first published in April 2003 (Basel Committee on Banking Supervision, 2003). Consequently, a smooth dummy variable (CAP) is constructed in an attempt to capture the gradual change in pricing. The variable takes the value of zero up to March 2003 and the value of one from January 2007 onwards, and increases linearly between the two points in time.

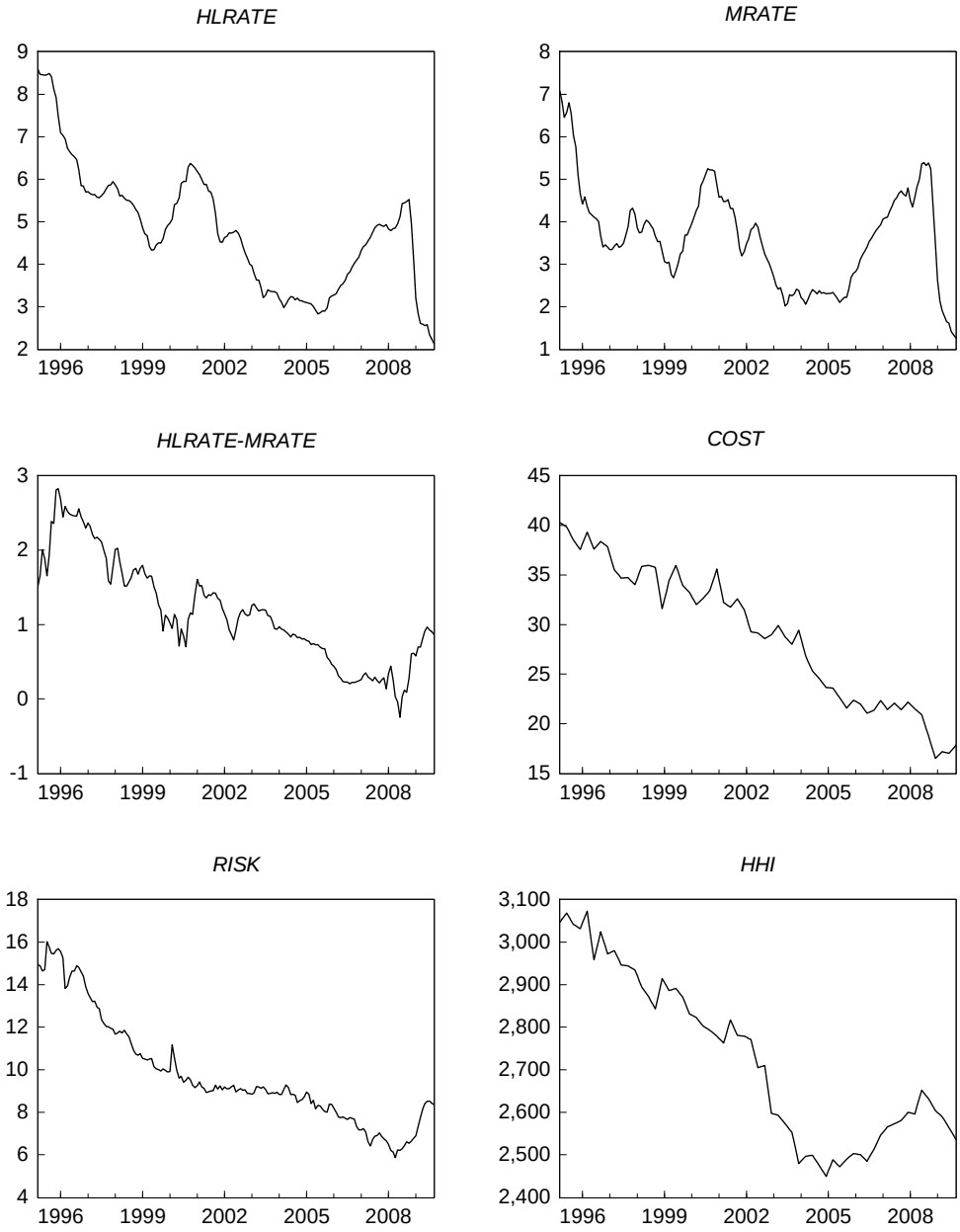
Table 3. **Variable description and expected impact on the dependent variable**

Variable	Notation	Description	Expected impact	Data source(s)
Housing loan rate	HLRATE	Average interest rate on new housing loans to households by Finnish MFIs, %	Dependent variable	Bank of Finland (BoF)
Market interest rate	MRATE	12-month Euribor (Helibor prior to 1999), %	+	BoF and Reuters
Operating costs	COST	Finnish banks' administrative expenses per average total assets, interpolated from quarterly data, %	+	Financial Supervisory Authority (FIN-FSA)
Credit risk	RISK	Unemployment rate, seasonally adjusted, %	+	Statistics Finland
Banking competition	HHI	Herfindahl-Hirschman index for claims on the public and public sector entities, inter-polated from quarterly data, divided by 100.	+	FIN-FSA
Bank capital requirements	CAP	Dummy for banks' adjustment to Basel II framework	-	Constructed by author

The data covers the period from March 1995 to September 2009, as shown in figure 3. The beginning of the sample is restricted to the mid-1990s for two reasons. First and foremost, there is prior evidence that the behaviour of Finnish banks as interest rate setters seems to have changed permanently and fundamentally during the banking crisis of the early 1990s (Kauko, 1995). Second, the banking data used in constructing COST and HHI variables is readily available only since the first quarter of 1995.[8]

[8] The Finnish banking group data covers the following deposit banks and banking groups: individual commercial banks, total of savings banks, total of member banks of the amalgamation of the cooperative banks, and total of local cooperative banks.

Figure 3. **Variables**



Notation: HLRATE = interest rate on new housing loans (%), MRATE = 12-month money market rate (%), COST = banks' administrative expenses as a percentage of average total assets (%), RISK = unemployment rate (%), HHI = Herfindahl-Hirschman index for total lending.

According to the augmented Dickey-Fuller (ADF) test, all five time series (HLRATE, MRATE, COST, RISK, HHI) are found to be integrated of order one, I(1), using a test equation that contains an intercept but no trend as suggested by Hamilton (1994).[9] According to this result, shocks can have permanent effects on the variables, unlike in the case of stationary, I(0), variables.

Interestingly, the difference between the housing loan rate and the 12-month money market rate (HLRATE-MRATE) is also an I(1) variable. This finding also suggests that it is not reasonable to treat the margin as constant when modelling the lending rate pass-through over the long term.

4.3 Long-run equilibrium relationship

In what follows, nonstationary variables are tested for cointegration by using two different approaches, the OLS-based Engle-Granger (1987) method and the maximum likelihood (ML) based Johansen (1991, 1995) procedure. One of the key differences between the approaches is that the Johansen VAR procedure treats all variables as potentially endogenous, while the Engle-Granger single-equation method requires making an a priori restriction that only one of the variables is endogenous. In this section, I first use the Engle-Granger method by taking all variables but the housing loan rate as exogenous. The model has a very intuitive interpretation as an extended marginal cost pricing model. Finally, I compare the results with those of the corresponding Johansen test.

To apply the Engle-Granger two-step test method, I first estimate the possible long-run equilibrium relationship as a static regression between the variables (step 1) and then test the residual for its order of integration using the ADF test and MacKinnon (1991) critical values (step 2). To enable coefficient testing based on standard errors, I also estimate a Stock-Watson (1993) dynamic OLS (DOLS) version of the model, which corrects for potential endogeneity and small sample biases.

As a benchmark, I first estimate a standard long-run model in which the margin between the housing loan rate (HLRATE) and the 12-month money market rate (MRATE) is assumed to remain constant (β_0) in the long term. This assumption is commonly made in the empirical interest rate pass-through literature. Table 4 summarises the estimation results of both OLS (Model 1) and DOLS (Model 1') regressions[10]

$$\mathrm{HLRATE}_t = \beta_0 + \beta_1 \mathrm{MRATE}_t + \varepsilon_t \qquad \text{(Model 1)}$$

[9] The null hypothesis of a unit root in the first differences of the series can be rejected at the 5 per cent significance level. The detailed results of the ADF tests are reported in the appendix.
[10] One lead and lag in the DOLS model were chosen based on information criteria.

and

$$\begin{aligned} HLRATE_t = {} & \beta_0 + \beta_1 MRATE_t \\ & + \beta_2 \Delta MRATE_{t-1} + \beta_3 \Delta MRATE_t + \beta_4 \Delta MRATE_{t+1} + \varepsilon_t \end{aligned} \qquad \text{(Model 1')}$$

The pass-through coefficient (β_1) of the DOLS model (Model 1') is not significantly different from one, implying a complete long-run pass-through. The residual (ε_t) of the more parsimonious OLS model (Model 1) is, however, tested to be nonstationary, which indicates that no cointegration between the two interest rates is found and the regression results of the first step may be spurious (for detailed test results, see appendix). This finding supports the notion, suggested both by theory and descriptive data, that it may not be reasonable to treat the housing loan rate margin as constant over time.

To take better into account the changing of the margin, I extend the model with the four key variables (COST, RISK, HHI and CAP) suggested by the theoretical model. Again, the model is estimated using OLS (Model 2) and DOLS (Model 2') to allow both the residual and coefficient testing

$$\begin{aligned} HLRATE_t = {} & \beta_0 + \beta_1 MRATE_t \\ & + \beta_2 COST_t + \beta_3 RISK_t + \beta_4 HHI_t + \beta_5 CAP_t + \varepsilon_t \end{aligned} \qquad \text{(Model 2)}$$

and

$$\begin{aligned} HLRATE_t = {} & \beta_0 + \beta_1 MRATE_t \\ & + \beta_2 COST_t + \beta_3 RISK_t + \beta_4 HHI_t + \beta_5 CAP_t \\ & + \beta_6 \Delta MRATE_{t-1} + \beta_7 \Delta MRATE_t + \beta_8 \Delta MRATE_{t+1} \\ & + \beta_9 \Delta COST_{t-1} + \beta_{10} \Delta COST_t + \beta_{11} \Delta COST_{t+1} \\ & + \beta_{12} \Delta RISK_{t-1} + \beta_{13} \Delta RISK_t + \beta_{14} \Delta RISK_{t+1} \\ & + \beta_{15} \Delta HHI_{t-1} + \beta_{16} \Delta HHI_t + \beta_{17} \Delta HHI_{t+1} \\ & + \beta_{18} \Delta CAP_{t-1} + \beta_{19} \Delta CAP_t + \beta_{20} \Delta CAP_{t+1} + \varepsilon_t \end{aligned} \qquad \text{(Model 2')}$$

According to the results, the extended OLS model (Model 2) has a stationary residual, indicating that the estimated model can be interpreted as a long-run equilibrium relationship. As expected, the higher is the cost ratio, the risk level or the degree of market concentration, the higher is the housing loan rate.

The long-run pass-through coefficient of the money market rate is significantly less than one, implying that the pass-through of the money market rate to the housing loan rate is less than complete in the long term (Model 2'). The finding may reflect measurement errors or omitted factors, such as banking competition not fully captured by the HHI variable.

The dummy variable (CAP) trying to describe banks' gradual adjustment to the Basel II framework did not have sufficient statistical significance, so the variable is excluded from the preferred long-run models (Models 2 and 2' reported in table 4).

Table 4. **Results of Engle-Granger two-step cointegration test**

Step 1:	Dependent variable: HLRATE			
	Standard long-run relationship		Extended long-run relationship	
	Model 1	Model 1'	Model 2	Model 2'
Constant	0.85	0.73 [0.25]***	-4.30	-3.44 [0.31]***
MRATE	1.08	1.11 [0.08]***	0.80	0.84 [0.01]***
COST			0.02	0.03 [0.00]***
RISK			0.14	0.13 [0.01]***
HHI			0.16	0.11 [0.02]***
ΔMRATE(-1)		-0.78 [0.41]*		-0.22 [0.07]***
ΔMRATE		-0.59 [0.28]**		-0.38 [0.08]***
ΔMRATE(+1)		0.12 [0.41]		-0.12 [0.07]
ΔCOST(-1)				-0.01 [0.03]
ΔCOST				-0.04 [0.04]
ΔCOST(+1)				0.03 [0.03]
ΔRISK(-1)				-0.09 [0.04]**
ΔRISK				-0.14 [0.04]***
ΔRISK(+1)				0.00 [0.04]
ΔHHI(-1)				-0.03 [0.12]
ΔHHI				-0.04 [0.14]
ΔHHI(+1)				0.15 [0.12]
Adjusted R^2	0.77	0.77	0.98	0.99
SEE	0.70	0.66	0.19	0.14
DW	0.04	0.05	0.36	0.42
Method	OLS	DOLS	OLS	DOLS
Sample	1995M03–2009M09	1995M05–2009M08	1995M03–2009M09	1995M05–2009M08
Step 2: Residual I(d)	I(1) → No cointegration		I(0) → Cointegration	

Estimated models are of the form: (1) $HLRATE_t = \beta_0 + \beta_1 MRATE_t + \varepsilon_t$, (2) DOLS version of (1), (3) $HLRATE_t = \beta_0 + \beta_1 MRATE_t + \beta_2 COST_t + \beta_3 RISK_t + \beta_4 HHI_t + \varepsilon_t$, (4) DOLS version of (3), in which HLRATE denotes the interest rate on new housing loans, MRATE the 12-month money market rate, COST the banking sector's administrative-cost-to-assets ratio, RISK the unemploy-ment rate, HHI the Herfindahl-Hirschman index for total lending (divided by 100), and Δ is the difference operator.

*** Coefficient statistically significant at the 1% level, ** 5% level, * 10% level using Newey-West heteroskedasticity and autocorrelation consistent standard errors [in square brackets].

I(d) denotes integration of order d based on MacKinnon (1991) critical values (see appendix).

The Johansen test shows evidence in favour of one cointegrating vector both in the two-variable case (HLRATE, MRATE) and among the extended set of variables (HLRATE, MRATE, COST, RISK, HHI). Both the trace test and maximum eigenvalue test reject the null hypothesis of no cointegration, while the hypothesis of one cointegration vector cannot be rejected (see appendix).

To sum up, I find the evidence of cointegration strong enough to estimate the housing loan rate model in the error-correction form. Based on the long-run equilibrium regressions, the extended set of variables is needed to capture not only the pass-through of market interest rates but also the changing of the lending rate margin.

4.4 Error-correction model

Analogously to testing for cointegration, the error-correction model can be estimated using two different techniques, the Engle-Granger method for single-equation error-correction models (ECMs) and the Johansen system approach for vector error-correction models (VECMs).

Starting with the Engle-Granger method, the model can be written in the form, in which the short-run dynamics between the variables (first-difference terms) are estimated with the lagged residual (ECT) of the long-run equilibrium regression as an additional explanatory variable

$$\begin{aligned}\Delta HLRATE_t = {} & \alpha_0 + \alpha_1 \Delta HLRATE_{t-1} + \alpha_2 \Delta MRATE_t + \alpha_3 \Delta COST_t \\ & + \alpha_4 \Delta RISK_t + \alpha_5 \Delta HHI_t + \gamma ECT_t + \varepsilon_t\end{aligned} \qquad \text{(ECM 1)}$$

Here, the lagged residual, also called an error correction term, is equal to $HLRATE_{t-1}-(\beta_0 + \beta_1 MRATE_{t-1} + \beta_2 COST_{t-1} + \beta_3 RISK_{t-1} + \beta_4 HHI_{t-1})$, which is calculated using the parameters of Model 2 reported in section 4.3. The coefficient (γ) of the error-correction term measures the speed at which the housing loan rate adjusts towards its long-run equilibrium level.

According to the OLS estimation (ECM 1 in table 5), short-run movements in the housing loan rate (ΔHLRATE) can be largely explained by the past change in the lending rate, the change in the money market rate (ΔMRATE) and the past deviation from the equilibrium (ECT), while changes in the operating costs (ΔCOST), credit risk (ΔRISK) and concentration (ΔHHI) do not play any statistically significant role in the short term. The coefficient of the error-correction term is negative and highly significant supporting the error-correction representation. Furthermore, the absolute value of the coefficient is rather large (0.23) in the light of international evidence, implying a high speed of adjustment in Finland.

The corresponding model can also be estimated using the Johansen system approach. I start with a specification in which the cointegrating equation is of the same form as above and there are no model restrictions[11]

$$\begin{aligned}\Delta HLRATE_t = {} & \alpha_0 + \alpha_1 \Delta HLRATE_{t-1} + \alpha_2 \Delta MRATE_{t-1} + \alpha_3 \Delta COST_{t-1} \\ & + \alpha_4 \Delta RISK_{t-1} + \alpha_5 \Delta HHI_{t-1} + \gamma(HLRATE_{t-1} - \beta_0 \\ & - \beta_1 MRATE_{t-1} - \beta_2 COST_{t-1} - \beta_3 RISK_{t-1} - \beta_4 HHI_{t-1}) \\ & + \varepsilon_t\end{aligned} \qquad \text{(VECM 1)}$$

The number of lags is determined empirically by the general-to-specific approach. I end up with only one lag after starting with four lags and by dropping the ones (and any higher ones) that are not jointly significant by the Wald test and the ones for which the ΔMRATE term has a negative coefficient.

According to the maximum likelihood estimation, the short-run dynamics of the housing loan rate are again largely explained by the money market rate, while the long-run equilibrium level depends also on the cost ratio and the riskiness of lending (VECM 1 in table 5). The degree of competition, as measured by the Herfindahl-Hirschman index, is not statistically significant in the cointegrating equation.

Secondly, I drop the insignificant HHI variable, re-estimate the model and test three of the remaining variables (MRATE, COST and RISK) for weak exogeneity with respect to the cointegrating vector

$$\begin{aligned}\Delta HLRATE_t = {} & \alpha_0 + \alpha_1 \Delta HLRATE_{t-1} + \alpha_2 \Delta MRATE_{t-1} + \alpha_3 \Delta COST_{t-1} \\ & + \alpha_4 \Delta RISK_{t-1} + \gamma(HLRATE_{t-1} - \beta_0 - \beta_1 MRATE_{t-1} \\ & - \beta_2 COST_{t-1} - \beta_3 RISK_{t-1}) + \varepsilon_t\end{aligned} \qquad \text{(VECM 2)}$$

According to the likelihood ratio (LR) test, the zero restrictions imposed on the adjustment coefficients of the models for ΔMRATE, ΔCOST and ΔRISK (ie coefficients corresponding to γ in VECM 2) cannot be rejected. Thus, variables other than HLRATE can be treated as weakly exogenous (VECM 2 in table 5). These restrictions imply that when there is a deviation from the long-run equilibrium, it is only the housing loan rate that adjusts to restore the equilibrium.

Thirdly, I impose weak exogeneity of MRATE, COST and RISK and at the same time test whether the coefficient of MRATE can be restricted to one in the cointegrating vector ($\beta_1 = 1$)

[11] Models for ΔMRATE, ΔCOST, ΔRISK and ΔHHI are not reported here.

$$\Delta HLRATE_t = \alpha_0 + \alpha_1 \Delta HLRATE_{t-1} + \alpha_2 \Delta MRATE_{t-1} + \alpha_3 \Delta COST_{t-1} + \alpha_4 \Delta RISK_{t-1} + \gamma(HLRATE_{t-1} - \beta_0 - MRATE_{t-1} - \beta_2 COST_{t-1} - \beta_3 RISK_{t-1}) + \varepsilon_t \quad \text{(VECM 3)}$$

Again, the restrictions cannot be rejected, suggesting that the pass-through of MRATE can be considered as complete in the long run (VECM 3 in table 5).

Table 5. **Results of Engle-Granger error-correction model and Johansen vector error-correction model**

Dependent variable: ΔHLRATE				
	ECM 1	VECM 1	VECM 2	VECM 3
Constant	-0.01 [0.01]**	-0.01 [0.01]	-0.02 [0.01]*	-0.02 [0.01]*
ΔHLRATE(-1)	0.26 [0.04]***	0.12 [0.08]	0.11 [0.08]	0.11 [0.08]
ΔMRATE	0.45 [0.06]***			
ΔMRATE(-1)		0.43 [0.07]***	0.43 [0.07]***	0.45 [0.07]***
ΔCOST(-1)		0.02 [0.02]	0.02 [0.02]	0.02 [0.02]
ΔRISK(-1)		0.01 [0.03]	0.00 [0.03]	0.01 [0.03]
ΔHHI(-1)		0.05 [0.07]		
ECT	-0.23 [0.05]***	-0.16 [0.04]***	-0.18 [0.03]***	-0.17 [0.03]***
Cointegrating equations				
	Model 2	CE 1	CE 2	CE 3
Constant	-4.30	-2.15	-1.41	-1.48
MRATE	0.80	0.95 [0.03]***	0.96 [0.03]***	1 [imposed]
COST	0.02	0.03 [0.01]***	0.03 [0.01]***	0.03 [0.01]***
RISK	0.14	0.17 [0.03]***	0.18 [0.02]***	0.18 [0.03]***
HHI	0.16	0.04 [0.04]		
Coefficient restrictions	None	None	Exogeneity[1]	Exogeneity[1], pass-through[2]
LR test prob.			0.54	0.51
Adjusted R^2	0.79	0.61	0.61	0.60
SEE	0.08	0.10	0.10	0.10
DW	1.99			
Approach	Engle-Granger	Johansen	Johansen	Johansen
Method	OLS	ML	ML	ML
Sample	1995M05–2009M09	1995M05-2009M09	1995M05-2009M09	1995M05-2009M09

HLRATE denotes the interest rate on new housing loans, MRATE the 12-month money market rate, COST the banking sector's administrative-cost-to-assets ratio, RISK the unemployment rate, HHI the Herfindahl-Hirschman index for total lending, ECT the error-correction term, and Δ the difference operator.

*** Coefficient statistically significant at the 1% level, ** 5% level, * 10% level using Newey-West heteroskedasticity and autocorrelation consistent standard errors [in square brackets].

[1]Weak exogeneity of MRATE, COST and RISK. [2]Complete long-run pass-through of MRATE.

The estimated speed of adjustment (γ) varies slightly between the models (from 0.16 in VECM 1 to 0.23 in ECM 1), but in any case it can be regarded as relatively high. For example, according to last model (VECM 3), it takes less than six months ($\approx 1/0.17$) for a deviation from the long-run equilibrium to be corrected. The sluggishness of the adjustment may, by and large, reflect the fact that in the short run borrowers can affect the degree and speed of pass-through by choosing between different reference rates, ie money market rates and more sticky prime rates, depending on the direction of market rates.

To sum up, short-run movements in the average interest rate on new housing loans in Finland can be largely explained by changes in money market rates, while in the long run developments are also affected by less volatile cyclical and structural factors. Over the period considered, the ratio of banks' administrative expenses to total assets and the unemployment rate combine to capture the changing of the average lending rate margin.

5 Conclusions

This paper has examined how housing loan rates are determined, using Finnish data. Finland is an example of a bank-based euro area country where the majority of loans are granted at variable rates. The paper extends the earlier interest rate pass-through literature by taking explicitly into account the changing of lending rate margins. A standard lending rate model, specified as an error-correction model, is extended with variables predicted by a theoretical bank interest rate setting model. The empirical results show that, since the mid-1990s, short-run movements in housing loan rates can be largely explained by changes in money market rates, and that long-run developments have also been affected by less volatile cost and credit risk factors. The roles of loan competition and capital regulation are also considered, but the effects are more difficult to identify.

The pass-through of market interest rates to bank lending rates is one of the key channels of monetary transmission. In the case of new housing loans in Finland, the estimated speed of adjustment is rather high, which enhances the effectiveness of monetary policy. On the negative side, the rapid pass-through may weaken financial stability by increasing the volatility of housing markets. Historically, housing prices in Finland have been highly volatile in the international comparison (eg ECB, 2003, and IMF, 2004), but the role of short interest rate fixation periods has not yet been explored. Furthermore, due to the high share of variable-rate loans in Finland, changes in market interest rates pass through to interest rates of most of the outstanding loans as well. This mechanism makes the future interest expenses uncertain and increases risks borne by the borrowers.

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Appendix

Results of unit root tests and cointegration tests

Table A1. **Results of ADF unit root tests**

		Prob.*	I(d)**
Interest rate on new housing loans	HLRATE	0.25	I(1)
	ΔHLRATE	0.00	
12-month money market rate	MRATE	0.06	I(1)
	ΔMRATE	0.00	
Housing loan rate margin (proxy)	HLRATE-MLRATE	0.68	I(1)
	Δ(HLRATE-MLRATE)	0.00	
Banks' administrative-cost-to-assets ratio	COST	0.93	I(1)
	ΔCOST	0.00	
Unemployment rate	RISK	0.24	I(1)
	ΔRISK	0.00	
Herfindahl-Hirschman index for lending	HHI	0.57	I(1)
	ΔHHI	0.04	

Null hypothesis: Variable has a unit root. Time period: 1995M03–2009M09.
* MacKinnon one-sided p-values. ** Order of integration at the 5% significance level.
Test equation includes a constant. Lag length is determined automatically based on SIC.

Table A2. **Results of ADF unit root tests**

	Test statistic		Critical value*	I(d)**
Residual of model (1)	-1.53	>	-3.37	I(1)
Residual of model (3)	-4.47	<	-4.16	I(0)

Null hypothesis: Variable has a unit root. Time period: 1995M03–2009M09.
* MacKinnon critical value at the 5% significance level.
Test equation includes no constant. Lag length is determined automatically based on SIC.

Table A3. **Results of Johansen cointegration tests**

Number of cointegrating	Trace test		Maximum eigenvalue test	
equations	Test statistic	Prob.*	Test statistic	Prob.*
None	18.30	0.02	16.30	0.02
At most 1	2.00	0.16	2.00	0.16

Null hypothesis: There is a hypothesised number of cointegrating equations.
Series: HLRATE and MRATE. Lags: 1. Time period: 1995M05–2009M09.
* MacKinnon-Haug-Michelis p-values.
Both tests indicate 1 cointegrating equation at the 5% significance level.

Table A4. **Results of Johansen cointegration tests**

Number of cointegrating equations	Trace test		Maximum eigenvalue test	
	Test statistic	Prob.*	Test statistic	Prob.*
None	77.10	0.01	38.28	0.01
At most 1	38.83	0.27	20.86	0.28
At most 2	17.96	0.57	8.68	0.86
At most 3	9.28	0.34	7.23	0.46
At most 4	2.06	0.15	2.06	0.15

Null hypothesis: There is a hypothesised number of cointegrating equations.
Series: HLRATE, MRATE, COST, RISK and HHI. Lags: 1. Time period: 1995M05–2009M09.
* MacKinnon-Haug-Michelis p-values.
Both tests indicate 1 cointegrating equation at the 5% significance level.

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