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Impact of bank competition on the interest rate pass-through in the euro area

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Abstract

This paper analyses the impact of loan market competition on the interest rates applied by euro area banks to loans during the 1994-2004 period, using a novel measure of competition called the Boone indicator. We find evidence that stronger competition implies significantly lower spreads between bank and market interest rates for most loan market products, in line with expectations. This result implies that stronger competition causes both lower bank interest rates and a stronger pass-through of market rate changes into bank rates. Evidence of the latter is also presented by our error correction model for bank rates. Further, banks compensate income losses from increased loan market competition by offering lower deposit rates. Our findings with respect to the loan market rates have important monetary policy implications, as they suggest that measures to promote competition in the European banking sector are likely to render the monetary policy transmission mechanism more effective.

JEL codes: C23, D4, E50, G21, L10

Key words: Monetary transmission, competition, bank lending and funding, interest rate spreads, error-correction model.

1. Introduction

This paper discusses the effects of bank competition on bank loan interest rates, and their responses to changes in market rates, as well as on deposit rates. Given the prominent role of the banking sector in the euro area's financial system, it is of significant importance for the European Central Bank (ECB) to monitor the degree of competitive behaviour in the euro area bank loan market. A more competitive banking market is expected to drive down bank loan rates, adding to the welfare of households and enterprises in a financially stable environment. This is particularly true for competitive edges resulting from efficiency gains. At the same time, competition may increase instability through two channels: by exacerbating both the problem of depositor (investor) coordination on the liability side and the risk of panics; and by increasing incentives to take risks, and thus raising the probability of failure (Vives, 2010). Further, in a more competitive market, changes in the ECB's main policy rates is assumed to pass through more strongly and more quickly into banking rates, enhancing the monetary policy transmission mechanism.

This study extends the existing empirical evidence, which suggests that the degree of bank competition has a significant effect on both the level of bank rates and the pass-through of market rates to bank rates. It assesses the impact of monetary policy actions, via changes in market interest rates, on bank interest rates. Understanding this pass-through mechanism is crucially important to central banks. Most studies that analyse the relationship between competition and banks' pricing behaviour apply a concentration index such as the Herfindahl-Hirschman index (HHI) as a measure of competition. However, we question the suitability of such indices as measures of competition. Where the traditional interpretation is that concentration erodes competition, concentration and competition may instead increase simultaneously where competition forces consolidation. For example, in a market where inefficient banking firms are taken over by efficient peers, strengthened competition may go hand in hand with an increased concentration ratio. In addition, the HHI suffers from a serious weakness in that it does not distinguish between small and large countries. In small countries, the concentration ratio is likely to be higher, precisely because the economy is small.

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2 The main innovation of our paper is that it applies a new measure of competition called the Boone
3 indicator (see also Boone, 2001 and 2008; Bikker and Van Leuvensteijn, 2008; Van Leuvensteijn *et*
4 *al.*, 2011). The basic notion underlying this indicator is that in a competitive market, the more efficient
5 companies are likely to have bigger market shares. Hence, the stronger the impact of efficiency on
6 market shares, the stronger competition will be. Further, by analysing how this efficiency-market share
7 relationship changes over time, our approach provides a measure which can be employed to assess
8 how changes in competition affect the cost of borrowing for both households and enterprises, and how
9 they affect the pass-through of policy rates into bank lending rates.

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21 Our study also contributes to the pass-through literature in the sense that it uses a newly-constructed
22 data set on bank lending rates for eight euro area countries covering the period from January 1994 to
23 December 2004. These data cover a longer period and are based on more harmonised principles than
24 those used by previous pass-through studies for the euro area.¹ The dataset regards Austria, Belgium,
25 France, Germany, Italy, the Netherlands, Portugal and Spain.² We consider four types of loan products:
26 mortgage loans, consumer loans and both short-term and long-term loans to enterprises as well as two
27 types of savings: time deposits and current-account deposits.³ We apply recently developed dynamic
28 panel estimates of the pass-through model. Our approach is closely related to that of Kok Sørensen and
29 Werner (2006), on which it expands by directly linking the degree of competition to the pass-through
30 estimates.

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45 Against this background, we test the following three hypotheses:

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49 I) Loan interest rates are lower in more competitive loan markets than in less competitive loan
50 markets. Similarly, deposit interest rates are higher in more competitive banking markets than in
51 less competitive markets.
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60 ¹ Except Kok Sorensen and Werner (2006), who used a nearly identical data set. This is the first time the data set
has been published in a journal article.

² For other euro area countries we have insufficient data to estimate the Boone indicator.

³ Enterprises comprise the entire population of non-financial corporations.

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2 II) Long-run responses of bank interest rates to the corresponding market rates are stronger in more
3 competitive markets than in less competitive markets
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6 III) Bank interest rates in more competitive markets adjust faster to changes in market interest rates
7 than in less competitive markets.
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12 We find that stronger competition implies significantly lower interest rate spreads for most loan market
13 products, as we expected. This result implies that the more fiercely banks compete with each other, the
14 lower bank interest rates will be and the more strongly market rates will be passed through. We find
15 evidence of stronger pass-through in our error correction model of bank interest rates. Furthermore, in
16 more competitive markets, corporate lending rates respond more rapidly to changes in market interest
17 rates. Finally, we observe for the two deposit categories, that stronger competition in the loan market
18 increases the (negative) spread between bank and market rates significantly. Apparently, banks
19 compensate income losses due to stronger loan market competition by offering lower deposit rates.
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32 The structure of this paper is as follows. Section 2 discusses the literature on competition and bank
33 interest rate pass-through. Section 3 describes the Boone indicator of competition and provides country
34 estimates of this indicator. Section 4 presents the employed interest rate pass-through model of the
35 error-correction type and explains the use of panel unit root and cointegration tests. Section 5
36 introduces the bank and market interest rate data and investigates their properties. Empirical evidence
37 on competition and the bank interest rate pass-through based on the spread model and the error-
38 correction model equations is shown in Section 6. Finally, Section 7 summarises and concludes.
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50 **2. Literature on competition and monetary transmission**

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54 According to the seminal papers by Klein (1971) and Monti (1972) on banks' interest rate setting
55 behaviour, banks can wield a degree of market pricing power in determining loan interest rates. The
56 Monti-Klein model demonstrates that interest rates on bank products with lower demand elasticities
57 are priced less competitively. Hence both the levels of bank interest rates and their changes over time
58 are expected to depend on the degree of competition. With respect to the level of bank interest rates,
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2 Maudos and Fernández de Guevara (2004) show that an increase in banks' market power (*i.e.* a
3
4 reduction in competitive pressure) results in higher net interest margins.⁴ In addition, Corvoisier and
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6 Gropp (2002) explain the difference between bank retail interest rates and money market rates from
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8 bank's product-specific concentration indices. They find that in concentrated markets, retail lending
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10 rates are substantially higher.
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15 Regarding the effect of competition on the way banks adjust their lending rates, both Cottarelli and
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17 Kourelis (1994) and Borio and Fritz (1995) find, in a cross-country analysis, a significant effect of
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19 constrained competition on the monetary transmission mechanism. Thus lending rates tend to be
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21 stickier when banks operate in a less competitive environment, due to, *inter alia*, the existence of
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23 barriers to entry. This finding was confirmed in an Italian setting by Cottarelli *et al.* (1995). Reflecting
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25 the existence of bank market power and collusive behaviour as well as potential switching costs for
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27 bank customers (or other factors affecting demand elasticities), the degree of price stickiness is likely
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29 to be asymmetric over the (monetary policy) interest rate cycle.⁵ Against this background, Mojon
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31 (2001) tests for the impact of banking competition on the transmission process related to euro area
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33 bank lending rates, using an index of deregulation constructed by Gual (1999). He finds that higher
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35 competition tends to put pressure on banks to adjust lending rates more quickly when money market
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37 rates are decreasing. Furthermore, higher competition tends to reduce the ability of banks to increase
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39 lending rates (although not significantly), when money market rates are moving up.⁶ Similar findings
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41 of asymmetric pass-through effects have been found by Scholnick (1996), Heinemann and Schüler
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43 (2002), Sander and Kleimeier (2002, 2004) and Kuan-Min and Thanh-Binh Nguyen (2010).⁷
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50 ⁴ Of course, competition is not the only factor determining the level of bank interest rates. Factors such as credit
51 and interest rate risk, banks' degree of risk aversion, operating costs and efficiency are also likely to impact on
52 bank margins. See, for example, Maudos and Fernández de Guevara (2004).

53 ⁵ See, for example, Newark and Sharpe (1992) and Mester and Saunders (1985) for empirical evidence of
54 asymmetric interest rate pass-through effects among US banks.

55 ⁶ In addition to bank competition, switching costs and other interest rate adjustment costs, bank rate rigidity may
56 also be due to credit risk factors. For example, in a situation of credit rationing banks may decide to leave
57 lending rates unchanged and to limit the supply of loans instead; see, for example, Winker (1999). Banks may
58 also choose to provide their borrowers with 'implicit interest rate insurance' by smoothing bank loan rates over
59 the cycle; see Berger and Udell (1992). Finally, sometimes banks give customers an interest rate option for a
60 given period. These banks have to recoup the costs of their options which may reduce the speed of the interest
rate pass through for outstanding borrowers.

⁷ Sander and Kleimeier (2002, 2004) differ from other studies in that they also model the severity of the
interest rate shock (rather than merely its direction). This approach aims to take into account menu cost
arguments implying that banks tend to pass on changes in market rates of a minimum size only.

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2 Moreover, De Bondt (2005) argues that stronger competition from other banks and from capital
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4 markets has helped to speed up the adjustment of interest rates to changes in market rates by banks in
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6 the euro area.
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10 A number of country-specific studies also provide evidence of sluggish pass-through from market rates
11 into bank rates when competition is weak. For example, Heffernan (1997) finds that British banks'
12 interest rate adjustment behaviour is compatible with imperfect competition whereas Weth (2002), by
13 using various proxies for bank market power, provides evidence of sluggish and asymmetric pass-
14 through among German banks. De Graeve *et al.* (2004) estimate the determinants of the interest rate
15 pass-through behaviour of Belgian banks and find that banks with more market power pursue a less
16 competitive pricing policy. In a microeconomic analysis of Spanish banks, Lago-González and Salas-
17 Fumás (2005) provide evidence that a mixture of price adjustment costs and bank market power causes
18 price rigidity and asymmetric pass-through. The impact on interest rates will have wider implications
19 for the development of output and prices as shown, for example, for Ireland by Bredin and O'Reilly
20 (2004). In a cross-country study, Kok Sørensen and Werner (2006) show that differences in the pass-
21 through process across the euro area countries may to some extent be explained by national differences
22 in bank competition. Finally, in another euro area based study, Gropp *et al.* (2007) provide evidence
23 that the level of banking competition has a positive impact on the degree of bank interest rate pass-
24 through using the H-statistic.
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46 **3. The Boone indicator**

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50 The Boone indicator assumes that more efficient firms (that is, firms with lower marginal costs) will
51 gain higher market shares or profits, and that this effect will be stronger the fiercer competition in that
52 market is. In order to support this intuitive market characteristic, Boone develops a broad set of
53 theoretical models (see Boone, 2000, 2001, 2004 and 2008, Boone *et al.*, 2004, and CPB, 2000). Using
54 the same data as Genesove and Mullin (1998), Boone and Van Leuvensteijn (2010) show that this
55 indicator is able to identify different regimes of competition empirically. We use one of Boone's
56 theoretical models to explain the Boone indicator and to examine its properties compared to common
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measures such as the HHI and the price-cost margin (PCM). Following Boone *et al.* (2004), and replacing ‘firms’ by ‘banks’, we consider a banking industry where each bank i produces one product q_i (or portfolio of banking products), which faces a demand curve of the form:

$$p(q_i, q_{j \neq i}) = a - b q_i - d \sum_{j \neq i} q_j \quad (1)$$

and has constant marginal costs mc_i . This bank maximizes profits $\pi_i = (p_i - mc_i) q_i$ by choosing the optimal output level q_i . We assume that $a > mc_i$ and $0 < d \leq b$. The first-order condition for a Cournot-Nash equilibrium can then be written as:

$$a - 2b q_i - d \sum_{j \neq i} q_j - mc_i = 0 \quad (2)$$

Where N banks produce positive output levels, we can solve the N first-order conditions (2), yielding:

$$q_i(c_i) = [(2b/d - 1)a - (2b/d + N - 1)mc_i + \sum_j mc_j] / [(2b + d(N - 1))(2b/d - 1)] \quad (3)$$

We define profits π_i as variable profits excluding entry costs ε . Hence in equilibrium, a bank enters the banking industry if, and only if, $\pi_i \geq \varepsilon$. Note that Equation (3) provides a relationship between output and marginal costs. It follows from $\pi_i = (p_i - mc_i) q_i$ that profits depend on marginal costs in a quadratic way. Competition in this market increases as the produced (portfolios of) services of the various banks become closer substitutes, that is, as d increases (with d kept below b). Further, competition increases when entry costs ε decline. Boone *et al.* (2004) prove that market shares of more efficient banks (that is, with lower marginal costs mc) increase both under regimes of stronger substitution and amid lower entry costs.

3.1 The empirical Boone indicator model

Equation (3) supports the use of the following model for market share, defined as $s_i = q_i / \sum_j q_j$:

$$\ln(ms_{it}) = \alpha + \beta_t \ln(mc_{it}) + \sum_{t=1, \dots, (T-1)} \gamma_t d_t + \varepsilon_{it} \quad (4)$$

1 where α , β_i and γ are parameters, ms_{it} denotes the market share of bank i in year t , mc_{it} stands for the
2 marginal costs of the respective bank, d_t is a time dummy and ε_{it} an error term. The parameter of
3 interest, β_i , is expected to have a negative sign, because relatively efficient banks will gain higher
4 market shares. Equation (4) has been specified in log-linear terms in order to deal with
5 heteroskedasticity. Moreover, this specification implies that β_i is an elasticity, which facilitates its
6 interpretation, particularly across countries.⁸ We will refer to β_i as the Boone indicator in year t . Boone
7 shows that when differences in performance in terms of market shares are increasingly determined by
8 marginal cost differences, this indicates increased competition. The Boone indicator requires data of
9 fairly homogeneous products.

10 An advantage of the Boone indicator is that it is linked more directly to competition than frequently
11 used but often misleading measures such as the Herfindahl-Hirschman Index (HHI) and other
12 concentration indices. The standard intuition of the HHI is based on a Cournot model with symmetric
13 banks, where a relaxation of entry barriers reduces the HHI. However, where banks differ in
14 efficiency, an increase in competition reallocates output to the more efficient banks that already had
15 higher output levels. Hence, the increase in competition raises the HHI.⁹ In order to estimate the Boone
16 indicator from Equation (4), we will use the data described in the next subsection.

17 3.2 Data on euro area banks

18 Our first empirical analysis is the estimation of the Boone indicator model, following Equation (4).
19 The Boone indicator model uses annual BankScope data of banks from eight euro area countries
20 during 1992-2004.¹⁰ This model is based on marginal costs which are derived from a translog cost
21 function with output components and input prices (see the Appendix). In order to exclude irrelevant
22 and unreliable observations, banks are only incorporated in our sample if they fulfil the following
23 conditions: total assets, loans, deposits, equity and 'other non-interest income' must be positive; the
24 deposits-to-assets ratio and loans-to-assets ratio must be less than 0.98 and 1, respectively; the income-
25 to-assets ratio must be below 0.20; the personnel expenses-to-assets and other expenses-to-assets ratios

⁸ The few existing empirical studies based on the Boone indicator have all used a log linear relationship. See, for example, Bikker and Van Leuvensteijn (2008).

⁹ For other arguments against the HHI, see our 'Introduction'.

1 must be between 0.05% and 5%; and, finally, the equity-to-assets ratio must be between 0.01 and 0.50.
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 4 These conditions are set to capture, for each variable, the range between the 5% and 95% percentile in
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 6 order to reduce outliers. As a result, our final data set totals 520 commercial banks, 1,506 cooperative
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 8 banks, 699 savings banks, 28 specialized governmental credit institutions (*Landesbanken*) and 62 real
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 10 estate banks (see Table 3.1).
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15 **Table 3.1. Total number of banks by country and by type (over the period 1992-2004)**

Country	Commercial banks	Cooperative banks	Real estate banks	Savings banks	Specialised governmental credit institutions	Total
AT	52	54	10	65	0	181
BE	24	6	0	5	0	35
DE	130	867	44	501	28	1570
ES	61	17	0	43	0	121
FR	115	83	2	30	0	230
IT	105	476	1	52	0	634
NL	24	1	4	1	0	30
PT	9	2	1	2	0	14
<i>Total</i>	<i>520</i>	<i>1506</i>	<i>62</i>	<i>699</i>	<i>28</i>	<i>2815</i>

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 29 *Note:* Country name abbreviations are for, respectively, Austria, Belgium, Germany, Spain, France, Italy, the Netherlands and Portugal.
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33 Table 3.2 provides a short description of the model variables. To grasp the relative magnitude of the
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 35 key variables, such as costs, loans, security investment and other services, we present them as shares of
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 37 corresponding balance-sheet items. Total costs are defined as total expenses. They vary, as country
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 39 averages, between 6.3% and 8.6% of total assets, whereas market shares in the loan market vary
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 41 between 0.06% and 5.8%. Across countries, loans and securities are in the ranges of, respectively,
 42
 43 35%-60% and 4%-37% of total assets. One of the output components we distinguish is other services.
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 45 For lack of direct observations, this variable is proxied by non-interest income. Non-interest income
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 47 ranges from 12%-20% of total income. Wage rates are proxied as the ratio of personnel expenses and
 48
 49 total assets, since for many banks the number of staff is not available. Wages vary across countries
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 51 between 0.9% and 1.7% of total assets. The input price of capital is proxied by the ratio of other
 52
 53 expenses and fixed assets. Finally, interest rates are proxied as interest expenses divided by total
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 55 funding and range from 3.2% to 5.9%.
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¹⁰ See also Van Leuvensteijn *et al.* (2011) who use a similar approach.

Table 3.2. Mean values of key variables for various countries (1992-2004)

Country Code	Boone model		Translog cost function					
	Average loans market shares in %	Total costs as % of total assets	Loans as % of total assets	Securities as % of total assets	Other services as % of total income	Other expenses as % of fixed assets	Wages as % of total assets	Interest expenses as % of total funding
AT	0.87	6.34	56	22	20	229	1.4	3.2
BE	2.27	6.49	35	37	16	594	1.0	4.5
DE	0.06	6.44	60	22	12	227	1.5	3.7
ES	0.98	6.63	58	14	16	167	1.5	4.1
FR	0.41	7.42	54	4	20	537	1.5	4.8
IT	0.22	6.67	53	26	16	261	1.7	3.5
NL	3.02	6.59	54	15	13	340	0.9	5.4
PT	5.83	8.62	52	8	18	191	1.3	5.9

3.3 Estimation results for the Boone indicator

Table 3.3 shows the country estimates of the time dependent Boone indicator based on the dataset described above, across countries and over time, usually 1994–2004, depending on the country. The results are based on Equation (4). The estimations are carried out using the Generalized Moment Method (GMM) with one-, two- or three-year lagged values of the explanatory variable, marginal costs, or average costs as instrument variables.¹¹ To test for overidentification of the instruments, we apply the Hansen J-test to the GMM (Hayashi, 2000). The joint null hypothesis is that the instruments are valid as such, *i.e.* uncorrelated with the error term. Under the null hypothesis, the test statistic is chi-squared distributed with the number of degrees of freedom equal to the number of overidentification restrictions. A rejection would cast doubt on the validity of the instruments. Furthermore, the Anderson canonical correlation likelihood ratio is used to test for the relevance of excluded instrument variables (Hayashi, 2000). The null hypothesis of this test is that the matrix of reduced-form coefficients has rank $K-1$, where K is the number of regressors, meaning that the equation is underidentified. Under the null hypothesis of underidentification, the statistic is chi-squared distributed with $L-K+1$ degrees of freedom, where L is the number of instruments (whether included in the equation or excluded from it). This statistic provides a measure of instrument relevance, and rejection of the null hypothesis indicates that the model is identified. We use kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations. The bandwidth in the estimation is set at two periods and the Newey-West kernel is applied. Where the instruments are

¹¹ Generalized Moment Method (GMM) is used to correct for endogeneity between market shares and marginal costs using different moment conditions.

Table 3.3. Boone indicator estimates over time and across euro-area countries

	Germany ¹⁾		France		Italy		
	β_t	<i>z-value</i>	β_t	<i>z-value</i>	β_t	<i>z-value</i>	
1993						-5.90	-1.18
1994						** -7.25	-3.24
1995	-4.47	-1.40	** -1.28	-3.36	** -4.51	-3.53	
1996	** -7.09	-2.92	** -1.28	-3.56	** -5.58	-3.98	
1997	** -4.64	-3.41	** -1.11	-3.55	** -5.89	-4.08	
1998	** -5.10	-3.97	* -0.79	-1.99	** -4.60	-6.08	
1999	** -2.60	-4.04	* -0.7	-2.30	** -4.05	-4.39	
2000	** -2.50	-4.60	-0.46	-1.34	** -3.32	-4.39	
2001	** -3.31	-7.02	-0.68	-1.67	** -2.66	-3.62	
2002	** -4.53	-4.71	-0.40	-0.78	-1.59	-1.82	
2003	** -2.73	-5.62	0.27	0.39	** -2.42	-3.69	
2004	** -2.66	-4.15	0.10	0.12	** -1.81	-2.79	
F-test	10.70		5.01		13.23		
Anderson canon corr. LR-test	185.20		1023.66		300.34		
Hansen J-test (p-value)	0.00		19.69 (0.48)		0.00		
Number of observations	14 534		918		4 918		
	Spain		Netherlands		Belgium		
	β_t	<i>z-value</i>	β_t	<i>z-value</i>	β_t	<i>z-value</i>	
1993	* -4.21	-2.49					
1994	* -4.80	-2.28	-1.92	-1.42			
1995	-5.20	-1.92	* -4.42	-2.42	-1.48	-1.59	
1996	-9.61	-0.67	** -2.09	-2.58	** -1.74	-2.93	
1997	-4.36	-1.78	-3.57	-1.70	** -2.02	-3.78	
1998	-5.40	-0.86	1.04	0.38	** -1.98	-3.19	
1999	* -5.46	-2.21	-1.44	-0.85	** -2.62	-4.65	
2000	-3.44	-1.93	** -3.26	-3.00	** -3.41	-6.10	
2001	** -4.38	-2.55	** -3.91	-4.71	** -3.00	-4.51	
2002	* -3.88	-2.09	* -2.45	-2.44	** -3.42	-4.34	
2003	-3.42	-1.20	-2.22	-1.80	** -2.79	-3.18	
2004	** -2.69	-5.62	** -3.09	-2.85	** -3.12	-4.02	
F-test	3.33		3.90		6.35		
Anderson canon corr. LR-test	38.78		31.71		178.10		
Hansen J-test (p-value)	0.00		20.5 (0.039)		8.34 (0.60)		
Number of observations	1 015		241		269		
	Austria		Portugal				
	β_t	<i>z-value</i>	β_t	<i>z-value</i>			
1994	11.2	1.01	0.05	0.05			
1995	-4.03	-0.94	1.57	0.91			
1996	* -2.31	-1.93	0.09	0.16			
1997	4.25	0.93	-0.04	-0.08			
1998	-0.91	-0.52	-0.55	-0.76			
1999	-2.98	-0.73	-1.51	-1.40			
2000	-2.31	-0.50	** -2.43	-4.03			
2001	-0.96	-1.30	** -1.92	-3.77			
2002	* -1.49	-1.97	** -2.16	-7.33			
2003	** -1.26	-3.52	* -1.74	-2.05			
2004	** -2.99	-2.23	-1.53	-1.69			
F-test	2.21		3.94				
Anderson canon corr. LR-test	28.89		77.92				
Hansen J-test, (p-value)	9.308 (0.59)		11.71 (0.38)				
Number of observations	988		134				

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2 *Notes:* This table presents GMM estimates of Equation (4). For Italy and Spain, 2SLS has been used where the equation is
3 exactly identified, so that the Hansen J-test equals 0.00. Asterisks indicate 95% (*) and 99% (**) levels of confidence.
4 Coefficients of time dummies are not shown.
5

6
7 overidentified, 2SLS is used instead of GMM. For this 2SLS estimator, Sargan's statistic is used
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9 instead of the Hansen J-test.
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13 Over the sample period, the Boone indicator for Belgium, Germany, and Italy is highly significant,
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15 except for one or two years, suggesting stronger loan market competition than elsewhere in the euro
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17 area.¹² The Dutch and Spanish loan markets take up an intermediate position with significant Boone
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19 indicators for at least a number of years. For France, the degree of competition declined over the years,
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21 where the reverse development is observed for Austria and Portugal. If, for each country, we had
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23 estimated only one beta for the full-sample period instead of annual ones (that is, $\beta_t = \beta$ for all t), we
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25 would have obtained significant values for all countries except Portugal, reflecting a certain degree of
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27 competition across the entire area (see Van Leuvensteijn *et al.*, 2011). For a number of countries, the
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29 Boone indicator has positive values, though not significantly different from zero, which indicates low
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31 levels of competition. These Boone indicator estimates enable us to analyse the impact of competition
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33 on the interest rate pass-through, using a model described in the next section.
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39 **4. The specification of the interest rate pass-through model**

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44 Our analysis of the pass-through of market interest rates to bank rates takes into account that economic
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46 variables may be non-stationary.¹³ The relationship between non-stationary but cointegrated variables
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48 should preferably be analysed using an error-correction model (ECM), by which the long-run co-
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50 movement of the variables may be disentangled from the short-run adjustment towards the
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52 equilibrium.¹⁴ Accordingly, most of the pass-through studies conducted in recent years apply an ECM,
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54 which allows testing for both the long-run equilibrium pass-through of bank rates to changes in market
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57
58 ¹² Most likely, the favourable result for Germany hinges in part on the special structure of its banking system,
59 being built on three pillars, *i.e.* commercial banks, publicly-owned savings banks and cooperative banks (see
60 Hackethal, 2004).

¹³ In order to avoid spurious results, see Granger and Newbold (1974).

rates and the speed of adjustment towards the equilibrium.¹⁵ Using a panel-econometric approach, we test for the impact of banking competition – measured by the Boone indicator – on the long-run equilibrium of market rate pass-through.

4.1. The error-correction model

If bank interest rates and their corresponding market rates are cointegrated, the error-correction framework is the most appropriate model. We propose the following two model equations for each of the six considered product related bank interest rates,¹⁶ which will be used to test the three hypotheses as developed in the introduction:

$$BR_{i,t} = \zeta BI_{i,t} + \eta_i MR_{i,t} + \theta BI_{i,t} MR_{i,t} + \kappa_i D_i + u_{i,t} \quad (5.a)$$

$$\Delta BR_{i,t} = \lambda_i u_{i,t-1} + \mu_i \Delta MR_{i,t} + \xi BI_{i,t} \Delta MR_{i,t} + v_{i,t} \quad (5.b)$$

where i refers to countries ($i=1, \dots, N$) and t to months ($t=1, \dots, T$). Equation (5.a) reflects the long-run equilibrium pass-through, while Equation (5.b) presents the short-term adjustments of bank interest rates to their long-run equilibrium. We first discuss the long-run effects of Equation (5.a) because the short-run effects of Equation (5.b) depend on the error term $u_{i,t}$ of Equation (5.a). BR represents bank interest rates (loan rates or deposit rates) and ΔBR is the monthly change in bank interest rates. $BI_{i,t}$ is the Boone indicator of country i at time t . To simplify interpretation, the Boone indicator is redefined in positive terms, where an increase in the Boone indicator reflects stronger competition, so that $BI = -\beta$.¹⁷ For each of the six considered interest rates, we include the market rates in the various countries separately ($\eta_i MR_{i,t}$ and $\mu_i \Delta MR_{i,t}$, respectively, in the long and the short run), in order to

¹⁴ An error correction model is a dynamical system in which the deviation of the current state from its long-run relationship will be fed into its short-run dynamics. This provides a coherent framework for the analysis of interest rate dynamics.

¹⁵ See, for example, Mojon (2001), De Bondt (2002, 2005), Sander and Kleimeier (2004), and Kok Sørensen and Werner (2006).

¹⁶ *Viz.*, four types of loan products (mortgage loans, consumer loans and short and long-term loans to enterprises) and two types of deposits (time deposits and current-account deposits).

¹⁷ As the model of interest rates is based on monthly data, while we have annual estimates of the Boone indicator, we construct monthly competition estimates $-BI_{i,t}$ as follows. We place the annual Boone indicator

observe country-specific effects. The market rates, $MR_{i,t}$, are multiplied by the Boone indicator ($\theta BI_{i,t}MR_{i,t}$ and $\zeta BI_{i,t}\Delta MR_{i,t}$, respectively, for the long and the short run), in order to capture the (overall) impact of competition on the pass-through. Furthermore, we account for country effects in the long-run model by using country dummies (D_i). The short-run model includes the error correction term ($\lambda_i u_{i,t-1}$), the effects of competition on short-term adjustments in market rates ($\zeta BI_{i,t}\Delta MR_{i,t}$) for all countries simultaneously and the change in the market rate for each country separately ($\mu_i \Delta MR_{i,t}$). Alternatively, Equations (5.a) and (5.b) can be extended by a risk measure to capture the risk premium in bank interest rates.

In Equations (5.a) and (5.b), we estimate euroarea wide (panel) parameters for the various competition effects (ζ , θ and ξ), because competition is supposed to change only gradually over time and the estimated Boone indicator appears to vary insufficiently over time to capture reliable country-specific competition effects. The other parameters (η_i , μ_i and λ_i) remain country-specific, unless their equality across all countries considered should pass a Wald test.

The three hypotheses to be tested are, expressed in the parameters of Equations (5.a) and (5.b):

- I) Loan interest rates are lower in more competitive loan markets than in less competitive loan markets, that is, $H_0: \zeta + \theta MR_{i,t} < 0$ and $H_1: \zeta + \theta MR_{i,t} \geq 0$.¹⁸ Similarly, deposit rates are higher in more competitive markets than in less competitive ones (hence, $H_0: \zeta + \theta MR_{i,t} > 0$ and $H_1: \zeta + \theta MR_{i,t} \leq 0$).
- II) In more competitive markets, long-run loan and deposit rates respond more strongly to the corresponding market rates than in less competitive markets, or: $H_0: \theta > 0$ and $H_1: \theta \leq 0$.
- III) Bank interest rates in more competitive markets adjust more quickly in the short run to changes in market rates than in less competitive markets, so: $H_0: \xi > 0$ and $H_1: \xi \leq 0$.

As our Boone indicator measures competition in the loan market, the competition effect on the deposit rate pass-through may be less reliable. Loan market competition may have a positive impact on deposit

estimate in June of the respective year and then interpolating on a monthly basis between these values using 12-month moving averages.

¹⁸ Note that competition causes a downward shift in the level of bank interest rates (that is, $\zeta < 0$) as well as a change in the relationship between market rates and bank rates (expressed by $\theta MR_{i,t}$).

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2 markets too, implying $\zeta + \theta MR_{i,t} > 0$. Alternatively, banks may try to compensate for strong loan market
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4 competition by exploiting their market power in the deposit market, in which case $\zeta + \theta MR_{i,t} < 0$. This
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6 would assume that banks act as price makers in the deposit market and as price takers in the loan
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8 market.
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11 As a simpler, alternative modelling approach, we also consider that in Equation (5.a) the pass-through
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13 effect may be immediate and complete, that is, we assume that $\eta_i = 1$ and $\theta = 0$, so that the bank's
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15 interest rate spread, $(BR_{i,t} - MR_{i,t})$, is explained by competition only – measured as the Boone indicator,
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17 $BI_{i,t}$ – and fixed effects (that is, country dummies, D_i , and monthly dummies, D_t):
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$$(BR_{i,t} - MR_{i,t}) = \zeta BI_{i,t} + \kappa_i D_i + \psi_t D_t + u_{i,t} \quad (6)$$

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28 Using this interest rate spread model, the first hypothesis ('Loan interest rates are lower in more
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30 competitive loan markets than in less competitive loan markets') is reformulated as $H_0: \zeta < 0$ and $H_1:$
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32 $\zeta \geq 0$.
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37 4.2. Unit root and panel cointegration tests

38 *Unit root tests*

39
40 The pass-through of interest rates can only be specified as an error correction framework if the
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42 variables are non-stationary and a long-term relationship between the variables is established.
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44 Therefore, as a first preparatory step, we investigate the unit root properties of the variables and verify
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46 through a cointegration test in the next section whether a long-term relationship is established between
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48 the variables.¹⁹ We apply two types of tests based on two different null hypotheses. The Im, Pesaran
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50 and Shin (2003) test (referred to as IPS test) is a panel version of the Augmented Dickey Fuller (ADF)
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52 test on unit roots. It is based on the following regression equation:
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¹⁹ Unit root tests analyse whether a time series variable is non-stationary over time. For a survey of panel unit root tests, see Banerjee (1999). For a more detailed description and application to a similar set of data, see also Kok Sørensen and Werner (2006).

$$\Delta Y_{i,t} = \alpha_i + \rho_i Y_{i,t-1} + \sum_{j=1}^{p_j} \tau_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \quad (7)$$

where Y stands for BR , MR , BI , and $BI \times MR$, i refers to countries ($i=1, \dots, N$) and t points to months ($t=1, \dots, T$). The autoregressive parameter ρ_i is estimated for each country separately, which allows for a large degree of heterogeneity. The null hypothesis is, $H_0: \rho_i=0$ for all i , against the alternative hypothesis $H_1: \rho_i < 0$ for some countries. The test statistic Z_{t_bar} of the IPS test is constructed by cross-section-averaging the individual t -statistics for ρ_i . Rejection of the null hypothesis indicates stationariness.

As a cross-check, we add results based on Hadri's (2000) test, which is a panel version of the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, testing the null hypothesis of stationarity. The model underlying the Hadri test can be written as:

$$Y_{i,t} = \alpha_i + \sum_{\tau=1}^t u_{i,\tau} + \varepsilon_{i,t} \quad (8)$$

with Y as above. The time series $Y_{i,t}$ are broken down into two components, a random walk component $\sum_{\tau} u_{i,\tau}$ and a stationary component $\varepsilon_{i,t}$. The test statistic Z_{τ} is based on the ratio of the variances $\sigma_u^2 / \sigma_{\varepsilon}^2$. The null hypothesis of the test assumes that this ratio is zero, implying that the interest rate contains no random walk component. By contrast, rejection of the null hypothesis indicates the presence of unit root behaviour in the variable under investigation. Both panel series test statistics are asymptotically normal.

Cointegration tests

The second preliminary step tests for cointegration using panel cointegration tests by Pedroni (1999, 2004), which are based on the following regression model for each product-related bank interest rate:

$$BR_{i,t} = \omega BI_{i,t} + \psi_{i,1} MR_{i,t} + \psi_{i,2} BI_{i,t} MR_{i,t} + \nu_{i,t} \quad (9)$$

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4 The long-run coefficients $\psi_{i,j}$ ($j = 1, 2$) may be different across the euro area countries. We use the
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6 group mean panel version of the Pedroni test. The null hypothesis of this test assumes a unit root in the
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8 residuals of the cointegration regression, which implies absence of cointegration. The alternative
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10 hypothesis assumes a root less than one, but allows for different roots across the euroarea countries.²⁰
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12 We use three different types of test statistics: an ADF type which is similar to the ADF statistic used in
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14 univariate unit root tests, a nonparametric Phillips-Perron (PP) version, and a version which is based
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16 directly on the autoregressive coefficient (ρ -test). These tests will be applied to the bank and market
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18 interest data described in the next section.
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24 **5. Bank and market interest rate data and their properties**

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28 Our retail bank interest rates are from the ECB's monthly MFI Interest Rate (MIR) statistics, which
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30 have been compiled on a harmonised basis across all euro area countries since January 2003. For the
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32 period prior to January 2003, the series have been extended backwards to January 1994 using the non-
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34 harmonised national retail interest rate (NRIR) statistics compiled by the national central banks of the
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36 (later) Eurosystem.²¹ The MIR statistics consist of more detailed breakdowns than the NRIR statistics,
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38 particularly with respect to the size of loans and the rate fixation periods. In order to link the two sets
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40 of statistics, the MIR series have been aggregated (using new business volumes as weights) to the
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42 broader product categories of the NRIR statistics, which include rates on (i) mortgage loans, (ii)
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44 consumer loans, (iii) short-term loans to non-financial corporations (≤ 1 year), (iv) long-term loans to
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46 non-financial corporations (> 1 year), (v) current-account deposits, and (vi) time deposits.²² The
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48
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53 ²⁰ In the panel versions of the tests the alternative hypothesis assumes a root which is less than one, but is
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55 identical across the countries. Hence, the group mean versions allow for stronger heterogeneity. As a result, we
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57 focus on the test's group mean version.

58 ²¹ For some bank products in some countries, it is not possible (due to insufficient data availability) to extend
59
60 interest rates series all the way back to 1994. Therefore, unbalanced samples were used for some bank products.

²² The two series have been linked in January 2003 with a parallel level shift of the series prior to this date. The
level shift was based on the average monthly difference between the NRIR and MIR series for the period from
January 2003 to September 2003 for which observations for both definitions were available. In contrast to Kok
Sørensen and Werner (2006), we use new business weights (applying monthly averages observed in the January
2003 – June 2004 period to smoothe out undue volatility) to aggregate the MIR categories to the NRIR. We
believe this captures the differences across countries more precisely in terms of initial rate fixation periods and
also corresponds better to the new business rate nature of the NRIR statistics.

sample period covers 147 monthly observations ranging from January 1994 to March 2006 (used until the end of 2004).

Table 5.1. Availability of four bank interest rates and corresponding market rates with equivalent fixation periods

	Mortgage loans	Consumer loans	Short-term enterprise loans	Long-term enterprise loans	Current account deposits	Time deposits
AT	April 1995 3M MR	April 1995 3M MR	April 1995 3M MR		April 1995 3M MR	April 1995 3M MR
BE	Jan. 1994 3M MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Jan. 1994 5Y MR		Jan. 1994 3M MR
DE	Jan. 1994 10Y MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Nov. 1996 5Y MR		Jan. 1994 3M MR
ES	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR
FR	Jan. 1994 10Y MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Jan. 1994 5Y MR		Jan. 1994 3M MR
IT	Jan. 1995 3M MR		Jan. 1994 3M MR	Jan. 1995 3M MR	Jan. 1994 3M MR	Feb. 1995 3M MR
NL	Jan. 1994 10Y MR		Jan. 1994 3M MR		Jan. 1994 3M MR	Jan. 1994 3M MR
PT	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR			Jan. 1994 3M MR

Sources: ECB and Bloomberg.

Note: Date indicates: 'available since'; '3M MR' is the 3-month money market rate (MR). '5Y MR' and '10Y MR' are the 5-year and 10-year government bond yields, all applying in the respective countries.

We select market rates which correspond most closely to these bank interest rates in terms of the rate-fixation period. Hence, a three-month money market rate is selected to correspond with bank rates that are either floating or fixed for short periods (below one year), while longer-term government bond yields are paired with long-term fixed bank rates.²³ Table 5.1 presents the data availability of bank interest rates in each country together with the corresponding market rates for each product category. Note that there is strong variation in rate fixation periods across both products and countries. For instance, in many euro-area countries the predominant fixation period for mortgages is rather short, proxied by three months (see ECB, 2006). In Germany and France, however, the typical fixation period on consumer loans is quite long, approximated here by five years.

²³ The market rates have been chosen to best match bank interest rates on the basis of information from the Methodological Notes for the NRIR statistics and from the volume weights of the MIR statistics.

Table 5.2. Summary statistics of four bank interest rates in % (1994-2004)

	AT	BE	DE	ES	FR	IT	NL	PT
<i>Mortgage rates</i>								
Average	5.6	5.9	6.4	6.6	6.1	7.0	5.7	7.6
Standard deviation	1.0	1.2	1.1	2.7	1.5	3.2	1.0	3.5
Maximum	7.9	8.8	9.1	11.5	8.9	13.0	8.0	14.5
Minimum	3.8	3.8	4.5	3.1	3.9	3.7	3.8	3.4
<i>Consumer lending rates</i>								
Average	6.6	8.1	7.5	10.4	8.8			13.1
Standard deviation	1.1	0.5	1.0	2.8	1.7			3.6
Maximum	9.5	9.1	10.2	16.2	12.1			19.6
Minimum	5.0	7.3	6.3	7.1	6.2			8.6
<i>Rates on short-term loans to enterprises</i>								
Average	4.8	4.6	4.0	5.9	4.5	6.7	4.2	8.8
Standard deviation	1.0	1.1	0.7	2.2	1.5	2.8	1.0	3.8
Maximum	7.2	7.6	5.8	10.5	7.8	11.7	6.5	16.8
Minimum	2.9	2.9	3.1	3.2	2.6	3.3	2.8	4.4
<i>Rates on long-term loans to enterprises</i>								
Average		5.1	5.2	5.7	5.9	6.3		
Standard deviation		1.1	0.5	2.4	1.4	2.7		
Maximum		8.2	6.1	10.4	8.8	11.8		
Minimum		3.4	4.2	3.0	4.0	3.1		
<i>Current account deposit rates</i>								
Average	1.3			1.8		2.6	1.7	
Standard deviation	0.2			1.2		1.8	0.3	
Maximum	1.7			4.6		5.7	2.0	
Minimum	1.0			0.5		0.7	1.1	
<i>Time deposit rates</i>								
Average	3.5	3.4	4.4	3.8	4.0	3.3	4.1	3.4
Standard deviation	1.0	0.9	2.1	1.3	2.3	0.9	2.2	0.8
Maximum	6.3	5.4	8.9	8.0	9.1	5.4	8.7	5.1
Minimum	1.9	2.0	1.9	2.0	1.6	2.0	1.8	2.0

Table 5.2 shows summary statistics of the bank interest rate data. Bank interest rates differ substantially across countries, across products and, of course, over time. On average, over the 1994-2004 period, mortgage rates and consumer lending rates were highest in Portugal and lowest in Austria. Average rates on short-term loans to enterprises, were highest in Portugal and lowest in Germany, whereas the rates on long-term loans to enterprises were highest in Italy and lowest in Belgium. On the deposit side, current-account deposit rates were lowest in Austria and lowest in Italy, while time deposit rates were lowest in Italy and highest in Germany.

Table 5.3 details the market interest rates for the considered countries. We find that Italy has, on average, the highest three-month money market rate and the Netherlands the lowest. The same picture emerges for the 5-year government bond yield. The minima for the three-month money market rates

Table 5.3. Summary statistics of three market rates in % (1994-2004)

	AT	BE	DE	ES	FR	IT	NL	PT
<i>3-month money market rate</i>								
Average	3.6	3.6	3.6	4.9	3.9	5.4	3.5	5.3
Standard deviation	0.9	1.1	1.0	2.3	1.4	2.8	1.0	2.9
Maximum	5.5	7.0	5.9	9.7	8.1	11.0	5.4	12.7
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
<i>5-year government bond yield</i>								
Average	4.7	4.8	4.5	5.7	4.8	6.1	4.6	5.9
Standard deviation	1.1	1.2	1.0	2.6	1.3	2.9	1.1	2.7
Maximum	7.3	8.0	7.1	12.2	7.9	13.4	7.3	12.2
Minimum	2.8	2.9	2.8	2.7	2.7	2.9	2.8	2.7
<i>10-year government bond yield</i>								
Average			5.2		5.4		5.3	
Standard deviation			1.0		1.2		1.0	
Maximum			7.6		8.2		7.7	
Minimum			3.6		3.6		3.6	

Table 5.4. Summary statistics of four bank rate spreads in % (1994-2004)²⁴

	AT	BE	DE	ES	FR	IT	NL	PT
<i>Mortgage rates</i>								
Average	2.1	2.2	1.8	1.6	1.3	1.9	1.1	2.2
Standard deviation	0.6	0.6	0.3	0.5	0.7	0.7	0.2	1.0
Maximum	3.6	3.5	2.4	2.9	3.8	3.7	1.7	4.5
Minimum	0.8	0.3	1.0	0.8	0.1	0.7	0.6	0.5
<i>Consumer lending rates</i>								
Average	3.2	4.2	3.1	5.5	4.0			7.7
Standard deviation	0.7	0.9	0.8	0.6	0.9			1.3
Maximum	5.1	6.5	5.2	7.2	7.0			10.2
Minimum	2.1	2.6	1.4	4.2	2.3			4.4
<i>Rates on short-term loans to enterprises</i>								
Average	1.3	1.0	0.5	1.0	0.6	1.3	0.7	3.4
Standard deviation	0.6	0.2	0.6	0.2	0.8	0.5	0.3	1.1
Maximum	2.9	1.5	1.6	2.0	2.8	2.5	1.3	6.7
Minimum	0.4	0.4	-0.4	0.5	-1.8	-0.4	-0.1	1.9
<i>Rates on long-term loans to enterprises</i>								
Average		0.4	1.1	0.9	1.1	1.3		
Standard deviation		0.4	0.2	0.4	0.7	0.4		
Maximum		1.2	1.8	1.8	2.2	3.3		
Minimum		-0.3	0.5	0.1	-0.4	-0.5		
<i>Current-account deposit rates</i>								
Average	-2.0			-2.9		-2.7	-1.7	
Standard deviation	0.7			1.2		1.1	0.8	
Maximum	-1.0			-1.4		-1.3	-0.8	
Minimum	-3.8			-5.9		-6.0	-3.5	
<i>Time deposit rates</i>								
Average	-0.4	-0.1	-0.2	-0.5	-0.1	-0.9	-0.2	-1.1
Standard deviation	0.4	0.2	0.2	0.3	0.1	0.5	0.4	0.9
Maximum	0.6	0.2	0.2	0.1	0.2	-0.2	0.6	-0.1
Minimum	-1.5	-0.7	-0.6	-1.1	-0.3	-2.6	-1.1	-4.7

²⁴ Spreads are based on bank rates and market rates of equivalent maturities and are sometimes negative due to a mismatch between the maturity of the loans and the corresponding market rate.

and the yields on government bonds with, respectively, a 5-year and a 10-year fixation period are very similar across all countries: these minima were reached after the introduction of the euro in 1999.

Table 5.4 presents the spreads between the various bank and market rates. Spreads on deposits are negative as, on these products, the market rates exceed the bank lending rates. On average, the spreads are quite narrow, ranging from 0.5% to 2.0%, with the notable exception of consumer loans, where bank interest rates often include very high risk premiums.

5.1 Unit roots and cointegration

Table 5.5 reports the panel unit root tests for the bank and market interest rate series of the considered eight euro area countries simultaneously. The IPS test on the null hypothesis of a unit root cannot be rejected at the 5% significance level for either the bank rates or the market rates, indicating non-stationary interest rates. This result for the interest rates has been confirmed by the Hadri test results.

Table 5.5. Panel unit root tests on model variables applied to all countries

	Im, Pesaran and Shin (IPS) test		Hadri test	
	$Z_{t_bar}^a$	<i>p-value</i>	Z_{τ}	<i>p-value</i>
H_0	Non-stationarity		Stationarity	
	<i>Boone indicator</i>			
Boone indicator	-2.16	0.02	10.67	0.00
	<i>Bank interest rates</i>			
Mortgage loans	0.98	0.84	18.78	0.00
Consumer loans	-0.89	0.19	16.59	0.00
Short-term loans to enterprises	-0.68	0.25	18.83	0.00
Long-term loans to enterprises	0.40	0.66	13.10	0.00
Current account deposits	1.64	0.95	13.86	0.00
Time deposits	-0.72	0.24	16.03	0.00
	<i>Market interest rates^a</i>			
Mortgage loans	0.04	0.52	17.08	0.00
Consumer loans	0.34	0.64	15.21	0.00
Short-term loans to enterprises	-0.68	0.25	17.23	0.00
Long-term loans to enterprises	0.94	0.83	13.39	0.00
Current account deposits	0.38	0.65	12.60	0.00
Time deposits	-1.56	0.06	16.46	0.00
	<i>Boone indicator times market interest rates^b</i>			
Mortgage loans	-2.16	0.01	15.76	0.00
Consumer loans	-1.88	0.03	12.64	0.00
Short-term loans to enterprises	-1.44	0.08	17.46	0.00
Long-term loans to enterprises	-1.38	0.08	13.74	0.00
Current account deposits	-1.60	0.06	12.65	0.00
Time deposits	-2.46	0.01	15.70	0.00

^a Market rates are approximated according to Table 5.1; ^b The test statistics are explained in Section 4.2.

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2 For the Boone indicator and the interaction variables of the Boone indicator and market interest rates,
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4 the evidence is mixed. The IPS tests indicate stationarity for the Boone indicator and interaction terms
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6 with three out of six interest rates, while the Hadri test clearly rejects stationarity for all terms. Where
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8 the evidence is mixed, we accept non-stationarity for the Boone indicator and the cross-terms, since
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10 the majority of test results indicate this. We also apply the panel unit root tests to the first differences
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12 in interest rates, the Boone indicator and the interaction terms to test on second-order non-stationarity.
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14 In all cases, the test results reject $I(2)$ and, hence, support the conclusion that the interest rate series are
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16 integrated of order 1, so that $I(1)$ holds. Given these findings, we proceed to test for cointegration
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18 between bank interest rates and the corresponding market rates.
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24 Table 5.6 shows the results for Pedroni's three panel cointegration tests as applied to the long-run
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26 models of the six bank rates.²⁵ For all bank rates except that on consumer loans and current-account
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28 deposits, the null hypothesis of no cointegration was rejected for two out of three tests, indicating a
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30 long-run equilibrium relationship between bank rates, market rates and the Boone indicator. For bank
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32 rates on consumer loans and current-account deposits, the null hypothesis of no cointegration cannot
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34 be rejected. Apparently, our sample is too short to detect a long-run relationship, also given the fact
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36 that changes in expected default rates may hide a stable long-run relationship.²⁶ A shortcoming for the
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38 interest rates on consumer loans might be that the consumer loan rate data are too highly aggregated.
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40 As many other country studies find evidence of co-integration,²⁷ and economic theory also expects it,
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42 we continue with the reservation that the results of the errorcorrection models for consumer loans and
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44 current-account deposits have to be interpreted with caution.²⁸
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56 ²⁵ P-values of the various test statistics were derived using the standard normal distribution, which is a valid
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58 assumption for cointegration tests; see Pedroni (1999).

59 ²⁶ For six countries, we have consumer loan rates available only for the twelfth months after January 2003.

60 ²⁷ *E.g.* US (indirectly): Berger and Hannan (1991), Mester and Saunders (1995); euro studies: DeBondt (2005);
Sander and Kleimeier (2004); UK: Heffernan (1997), Hofmann and Mizen (2004); Belgium: De Graeve, De
Jonghe, and Vander Vennet (2007); Ireland: Bredin *et al.* (2001).

²⁸ Estimations in first differences of bank consumer loan rates reveal that competition does not have a significant
effect on changes in the lending rates, in line with the results of Table 6.5.

Table 5.6. Pedroni cointegration tests on the six long-run bank interest rates models

Bank interest rates	Group mean panel cointegration tests ^a		
	ρ -statistic	PP-statistic	ADF-statistic
Mortgage loans	-3.19 (0.00)	-3.56 (0.00)	-0.07 (0.53)
Consumers loans	0.73 (0.77)	0.19 (0.57)	0.05 (0.52)
Short-term loans to enterprises	-5.79 (0.00)	-4.75 (0.00)	-1.50 (0.07)
Long-term loans to enterprises	-2.68 (0.00)	-2.91 (0.00)	-0.75 (0.22)
Current-account deposits	1.14 (0.87)	1.29 (0.90)	0.66 (0.75)
Time deposits	-8.28 (0.00)	-7.08 (0.00)	-0.43 (0.33)

Note: The null hypothesis of this test assumes absence of cointegration; ^a P-values in parentheses.

6. Empirical evidence on competition and the bank interest rate pass-through

In Section 5 the results of the IPS test on unit roots were mixed for the Boone indicator, while some interaction terms and the cointegration tests also had ambiguous results for consumer loans and current-account deposits. Therefore, as a first investigation into the impact of competition on the bank interest rate pass-through, we now analyse the effect of competition on the various bank loan interest rate spreads. We test the hypothesis that bank interest rate spreads are lower in more competitive markets using Equation (6). We also test whether the coefficient of competition, κ , is significantly negative. The results in Table 6.1 show that competition significantly reduces the bank rate spread for three out of four loan products, namely for mortgages, consumer loans and short-term loans to enterprises. No significant effect is found for rates on long-term loans to enterprises. The Boone indicator's coefficient shows that competition tends to keep bank loan rates more closely in line with the corresponding market rates (implying that they are lower), which confirms the first hypothesis.²⁹

For the two deposit categories, stronger competition in the loan market causes the (negative) spread between bank and market rates to widen significantly. Hence, deposit rates are lower the stronger competition in the loan market is. Apparently, competition is heavier in the loan market than in the deposit markets, so that banks under competitive pressure compensate their decline in loan market income by lowering their deposit rates.

²⁹ A re-estimation of Equation (6) with the distance to default for, respectively, mortgage, consumer loans and loans to firms using ECB data suggests no substantial change in the parameter of the Boone-indicator. This lack of change appears for each of the four types of loans. Unfortunately, the level of default tends to decrease the lending rates instead of increasing it (as one would expect). Apparently, this indicates an underpricing of default risk in the period 1999-2002, see for instance Pavlov and Wachter (2006). Inclusion of GDP to capture the business cycle did not change this result. Hence, inclusion of risk does not improve (nor significantly changes) our relationship between competition and the interest rate pass through.

Table 6.1. Effect of competition on the spreads between bank and market lending rates

	Mortgage loans		Consumer loans		Short term loans to enterprises	
	<i>coefficient</i>	<i>z-value</i> ¹⁾	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>
Boone indicator	-0.030	** -2.12	-0.075	*** -3.03	-0.128	*** -6.72
Constant	1.357	*** 5.54	5.818	*** 16.91	.736	*** 3.02
Country dummies ²⁾	$\chi^2(7)=498$		$\chi^2(5)=3095$		$\chi^2(7)=911$	
Monthly dummies ²⁾	$\chi^2(119)=693$		$\chi^2(119)=766$		$\chi^2(119)=223$	
R-squared, centred	0.687		0.907		0.793	
Number of observations	957		717		957	
	Long term loans to enterprises		Current account (sight) deposits		Time deposits	
	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>
Boone indicator	0.003	0.15	-0.154	*** -8.26	-0.036	*** -3.06
Constant	1.114	*** 4.26	-3.496	*** -12.30	-0.655	*** -2.80
Country dummies	$\chi^2(4)=240$		$\chi^2(3)=141$		$\chi^2(7)=640$	
Monthly dummies	$\chi^2(119)=1084$		$\chi^2(119)=1499$		$\chi^2(119)=389$	
R-squared, centred	0.670		0.832		0.691	
Number of observations	578		477		956	

Notes: Two and three asterisks indicate confidence levels of 95% and 99%, respectively. The *z-value* indicates whether the coefficient differs significantly from 0 under the normal distribution with mean zero and standard deviation one.

¹⁾ Chi-squared distributed Wald tests on H_0 'all country dummy coefficients are zero' and 'all monthly time dummy coefficients are zero', respectively. These null hypotheses are rejected for all loan and deposit types.

Table 6.2 presents the estimated long-run relationship of the error-correction model (ECM) presented in Section 4.1, in order to test the three hypotheses mentioned in that section.³⁰ When tested, one single EU-wide coefficient for market rates was rejected in favour of separate country-specific parameters for market rates. The ECM explains bank interest rates from the Boone indicator and the market rates, see Equation (5.a). It should be noted that the impact of market rates on bank interest rates is highly significant for all four interest rates considered and in all eight euro area countries. Moreover, in line with the existing literature, we find that the country-specific long-run pass-through coefficients (η_i) differ considerably across product categories (and across countries), with the final adjustment of bank interest rates to changes in market rates being highest for mortgage loans, short-term loans to enterprises and time deposits.³¹

³⁰ We use Newey-West's kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations to correct for heteroskedasticity and autocorrelation, with the bandwidth set on two periods.

³¹ See also Mojon (2001), De Bondt (2005) and Kok Sørensen and Werner (2006).

Table 6.2. Estimates of the long-run models for the six bank interest rates

	Mortgage loans		Consumer loans		Short-term loans to enterprises	
	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>
Boone indicator (ζ)	-0.198	***-3.32	-0.196	** -2.39	-0.153	** -3.39
Market rate AT (η)	0.843	*** 8.02	0.824	*** 6.15	0.937	*** 8.76
Market rate BE	0.913	*** 12.26	1.000	*** 5.98	0.892	*** 23.05
Market rate DE	0.923	*** 14.88	0.312	** 2.41	0.325	*** 6.22
Market rate ES	0.777	*** 10.89	0.785	*** 7.63	0.725	*** 10.90
Market rate FR	0.989	*** 12.85	1.093	*** 13.38	0.877	*** 13.04
Market rate IT	0.870	*** 16.07			0.807	*** 16.90
Market rate NL	0.784	*** 18.11			0.879	*** 20.11
Market rate PT	1.274	*** 24.63	1.336	*** 23.06	1.344	*** 37.41
Market rate*Boone ind. (θ)	0.053	*** 4.29	0.057	*** 3.21	0.039	*** 3.47
Constant	1.951	*** 9.74	5.679	*** 11.21	2.813	*** 13.62
R-squared, centred	0.940		0.927		0.952	
Number of observations	957		717		957	
$\zeta + \theta MR_{i,t}$	0.034		0.055		0.002	
$\chi^2 H_0: \zeta + \theta MR_{i,t} = 0$ ¹⁾	2.92, p-value = 0.09		2.39, p-value = 0.12		0.01, p-value = 0.92	
	Long term loans to enterprises		Current account (sight) deposits		Time deposits	
	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>
Boone indicator (ζ)	-0.181	***-3.59	-0.146	***-5.75	-.001	-0.60
Market rate AT (η)			0.063	*** 2.28	0.616	*** 10.17
Market rate BE	0.808	*** 16.79			0.921	*** 39.45
Market rate DE	0.615	*** 11.48			0.894	*** 33.03
Market rate ES	0.691	*** 10.89	0.259	*** 6.75	0.925	*** 26.99
Market rate FR	0.982	*** 14.42			0.997	*** 137.37
Market rate IT	0.745	*** 18.84	0.433	*** 18.09	0.856	*** 26.99
Market rate NL			0.083	*** 2.19	0.831	*** 12.41
Market rate PT					0.798	*** 38.33
Market rate*Boone-ind. (θ)	0.046	*** 4.48	0.037	*** 5.86	-0.015	-0.60
Constant	2.591	*** 11.58	1.457	*** 10.43	0.302	** 3.15
R-squared, centred	0.956		0.966		0.972	
Number of observations	578		477		956	
$\zeta + \theta MR_{i,t}$	0.028		0.005		-0.024	
$\chi^2 H_0: \zeta + \theta MR_{i,t} = 0$ ¹⁾	2.26, p-value=0.13		0.53, p-value=0.47		4.29, p-value =0.04	

Notes: One, two and three asterisks indicate levels of confidence of 90%, 95% and 99%, respectively. Country dummies are included but not shown.

¹⁾ Chi-squared distributed Wald tests on $H_0: \zeta + \theta MR_{i,t} = 0$. The null hypothesis is not rejected for any loan type.

The first hypothesis to be tested with the ECM-model is: loan interest rates are lower in more competitive loan markets than in less competitive loan markets. Table 6.2 shows that the effect of the combined terms with the Boone indicator of competition is (slightly) positive for all four considered loan products. But the Chi-squared distributed Wald tests on $H_0: \zeta + \theta MR_{i,t} = 0$ also shows that the combined effects $\zeta + \theta MR_{i,t}$ are not significant at the 95% confidence level. Note that the level of bank rates is significantly lower under competition (that is, $\zeta < 0$), but that this effect is reduced by the cross term of market rates and indicator ($\theta MR_{i,t} BI_{i,t}$). This outcome does not confirm our earlier finding of

1 significantly lower loan market spreads under competition. Apparently, the simple spread model is a
2 more successful tool for observing the competition effect than the more complicated ECM.³²
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8 Furthermore, we find that stronger loan markets competition significantly reduces the interest rate on
9 current-account deposits, which is the more important source of funding, while no significant effect is
10 observed for time deposits. Our explanation is that loan market competition forces banks to reduce
11 interest expenses on funding. For current-account deposits, this is roughly in line with our finding
12 above of negative spreads on deposits that widen amid stronger loan market competition. The effects
13 of the combined terms with the Boone indicator of competition are not significant for the deposit rates
14 also.
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25 The second hypothesis applied to the ECM-model is: in more competitive markets, bank interest rates
26 show stronger long-run responses to the corresponding market rates than in less competitive markets.
27 Our results suggest that all four bank loan rates do indeed respond significantly more strongly to
28 market rates when competition is high, see the coefficient θ of the Boone indicator times market rate
29 term. Further, we find that the income loss of stronger competition in the loan market has been
30 compensated by lower interest rates on current accounts.³³ So we observe that competition does make
31 for stronger long-run loan bank rate responses to corresponding market rates, thereby contributing to a
32 more rapid pass-through. Therefore, the second hypothesis has been accepted.
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45 The third hypothesis related to the ECM-model is: in the short run, more competitive markets adjust
46 faster to changes in market interest rates than less competitive markets. To test this hypothesis, we
47 estimate Equation (5.b). The results in Table 6.3 indicate that the immediate responses of banks'
48 interest rates on loans to changes in market rates do tend to be higher in more competitive markets (see
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³² Re-estimation with a risk measure, did not affect the estimation results of the ECM, see also footnote 29.

³³ As mentioned in Section 6.1, the estimated long-run relationship between, on the one hand, interest rates on consumer loans and current account deposits and, on the other hand, their corresponding market rates may be spurious owing to lack of a statistically significant cointegration relationships.

Table 6.3. The short-term ECM model of six bank interest rates^a

	Mortgage loans		Consumer loans		Short term loans to enterprises	
	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>
Δ Market rate AT (μ)	0.227	***3.15	0.203	*1.84	0.275	***3.41
Δ Market rate BE	0.207	*1.73	0.358	1.32	0.408	***2.49
Δ Market rate DE	0.511	***4.33	-0.267	-1.30	0.159	1.20
Δ Market rate ES	0.217	*1.75	0.041	0.10	0.573	***3.36
Δ Market rate FR	-0.025	-0.58	-0.005	-0.09	0.079	0.73
Δ Market rate IT	0.156	1.11			0.066	0.42
Δ Market rate NL	0.262	***2.79			0.464	***3.01
Δ Market rate PT	0.173	*1.88	0.001	0.00	0.159	0.87
Δ Market rate*Boone-ind. (ζ)	0.020	0.86	0.071	1.52	0.050	*1.66
Residual AT (-1) (λ)	-0.005	***-3.10	-0.004	***-2.89	-0.005	***-3.00
Residual BE (-1)	-0.007	** -2.20	-0.003	-1.09	-0.005	-1.52
Residual DE (-1)	-0.003	-1.56	-0.003	** -2.07	-0.001	-0.23
Residual ES (-1)	-0.006	***-2.80	-0.003	-0.86	-0.000	-0.03
Residual FR (-1)	-0.006	***-3.45	-0.004	***-3.25	-0.003	-0.44
Residual IT (-1)	-0.006	** -1.96			-0.004	* -1.64
Residual NL (-1)	-0.004	-1.63			-0.000	-0.10
Residual PT (-1)	-0.009	***-3.89	-0.006	-1.50	-0.011	** -2.28
R ² centred	0.19		0.03		0.19	
Number of observations	949		711		949	
	Long term loans to enterprises		Current account deposits		Time deposits	
	<i>coefficient</i>	<i>z-value</i>	<i>coefficient</i>	<i>z-value</i>	<i>Coefficient</i>	<i>z-value</i>
Δ Market rate AT (μ)			0.107	***3.05	0.229	***2.90
Δ Market rate BE	0.987	***6.97			0.532	***6.02
Δ Market rate DE	0.657	***3.56			0.587	***6.27
Δ Market rate ES	0.994	***3.67	0.374	***3.90	0.344	**2.09
Δ Market rate FR	0.162	1.47			0.972	***38.82
Δ Market rate IT	0.744	***3.34	0.312	***3.68	0.146	1.28
Δ Market rate NL			0.099	**2.45	0.463	***4.95
Δ Market rate PT					0.281	***3.37
Δ Market rate*Boone-ind. (ζ)	0.070	1.41	-0.033	** -2.47	0.020	0.92
Residual AT (-1) (λ)			-0.004	** -2.16	-0.004	* -1.69
Residual BE (-1)	0.001	0.31			-0.004	-1.58
Residual DE (-1)	-0.001	-0.80			-0.001	-0.64
Residual ES (-1)	-0.005	-1.51	-0.010	** -2.13	-0.006	** -2.03
Residual FR (-1)	-0.004	-1.36			0.000	0.24
Residual IT (-1)	-0.004	-1.33	-0.007	-1.41	-0.009	** -2.33
Residual NL (-1)			-0.003	** -2.18	-0.005	-1.46
Residual PT (-1)					-0.009	***-3.39
R ² centred	0.27		0.18		0.63	
Number of observations	573		473		948	

Note: One, two and three asterisks indicate a level of confidence of, respectively, 90%, 95% and 99%. ^a See Equation (5.b).

the ζ coefficient of the product term of changes in market rates and the Boone indicator, which is positive in Table 6.3 for all loan types).³⁴ However, this effect is statistically significant only for short-

³⁴ The null hypotheses of single EU-wide parameters for market interest rates and residuals in the short-run ECM model were rejected for most loan categories in favour of separate country-specific parameters.

1 term loans to enterprises, and than at the 10% level only. With respect to bank deposit rates, it is
2 remarkable that stronger competition on the loan market reduces (instead of increasing) the response of
3 the current-account deposit rate to market rates. This would point to the fact that banks are price takers
4 in the loan market and price makers in the deposit market. All in all, we have little if any evidence
5 supporting the third hypothesis.
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12 13 14 15 **7. Conclusion** 16 17

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19 This paper analyses the effects of competition on bank lending rates in four loan markets and on two
20 types of deposit rates. We measure competition by a novel approach, named the Boone indicator,
21 which allows the estimation of competition on separate submarkets for loans. Our results from a
22 simple interest rate spread model show that across eight euro area countries, bank interest rate spreads
23 on mortgage loans, consumer loans and short-term loans to enterprises are significantly lower in more
24 competitive markets. This result implies that bank loan rates are lower under stronger competition.
25 This may improve social welfare, but it may also result in more risky behaviour by the banks, causing
26 more financial instability and less social welfare. Furthermore, banks act as price makers in the deposit
27 market and as price takers in the loan market. Stronger loan market competition results in lower
28 offered deposit rates, at the cost of social welfare. However, these results are not confirmed by our
29 estimates with a more general, but also more complicated, error-correction model.
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45 Furthermore, empirical evidence for all loan categories considered suggests that the response of
46 banks' long-run loan interest rates to corresponding market rates is stronger in more competitive than
47 in less competitive loan markets. Finally, we observe that competition in loan markets does not
48 significantly reinforce the immediate response of bank interest rates to changes in corresponding
49 market rates. Summarizing, these results show that evidence exists that stronger loan market
50 competition reduces bank loan rates while changes in market rates are transmitted more strongly to
51 bank rates. These findings underline that bank competition has a substantial impact on the monetary
52 policy transmission mechanism. More loan market competition strengthens monetary policy
53 transmission in the euro area.
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Appendix: Calculations of marginal costs

In order to be able to calculate marginal costs, we estimate, for each country, a translog cost function (TCF) using individual bank observations. This function assumes that the technology of an individual bank can be described by a single one multiproduct production function. Under proper conditions, a dual cost function can be derived from such a production function, using output levels and factor prices as arguments. A TCF is a second-order Taylor expansion around the mean of a generic dual cost function with all variables appearing as logarithms. It is a flexible functional form that has proven to be an effective tool in explaining multiproduct bank services. Our TCF has different marginal costs for different types of banks, resulting in the following form:

$$\ln c_{it}^h = \alpha_0 + \sum_{h=1, \dots, (H-1)} \alpha_h d_i^h + \sum_{t=1, \dots, (T-1)} \gamma_t d_t + \sum_{h=1, \dots, H} \sum_{j=1, \dots, K} \delta_{jh} d_i^h \ln x_{ijt} \\ + \sum_{h=1, \dots, H} \sum_{j=1, \dots, K} \sum_{k=1, \dots, K} \epsilon_{jkh} d_i^h \ln x_{ijt} \ln x_{ikt} + v_{it} \quad (10)$$

where the dependent variable c_{it}^h reflects the production costs of bank i ($i = 1, \dots, N$) in year t ($t = 1, \dots, T$). The sub-index h ($h = 1, \dots, H$) refers to the type category of the bank (commercial, savings or cooperative bank). The variable d_i^h is a dummy variable, which is 1 if bank i is of type h and otherwise zero. Another dummy variable is d_t , which is 1 in year t and otherwise zero. The explanatory variables x_{ikt} represent three groups of variables ($k = 1, \dots, K$). The first group consists of (K_1) bank output components, such as loans, securities and other services (proxied by other income). The second group consists of (K_2) input prices, such as wage rates, deposit rates (as price of funding) and the price of other expenses (proxied as the ratio of other expenses to fixed assets). The third group consists of ($K - K_1 - K_2$) control variables (also called ‘netputs’), *e.g.* the equity ratio. In line with Berger and Mester (1997), the equity ratio corrects for differences in loan portfolio risk across banks. The coefficients α_h , δ_{jh} and ϵ_{jkh} , all vary with h , the bank type. The parameters γ_t are the coefficients of the time dummies and v_{it} is the error term.

Two standard properties of cost functions are linear homogeneity in the input prices and cost-exhaustion (see *e.g.* Beattie and Taylor, 1985, and Jorgenson, 1986). They impose the following restrictions on the parameters, assuming – without loss of generality – that the indices j and k of the

two sum terms in Equation (6) are equal to 1, 2 or 3, respectively, for wages, funding rates and prices of other expenses:

$$\delta_1 + \delta_2 + \delta_3 = 1, \epsilon_{1,k} + \epsilon_{2,k} + \epsilon_{3,k} = 0 \text{ for } k = 1, 2, 3, \text{ and } \epsilon_{k,1} + \epsilon_{k,2} + \epsilon_{k,3} = 0 \text{ for } k = 4, \dots, K \quad (11)$$

Equation (11) holds for each h . The first restriction stems from cost exhaustion, reflecting the fact that the sum of cost shares is equal to unity. In other words, the value of the three inputs is equal to total costs. Linear homogeneity in the input prices requires that the three linear input price elasticities (δ_i) add up to 1, whereas the squared and cross terms of all explanatory variables ($\epsilon_{i,j}$) add up to zero. Again without loss of generality, we also apply symmetry restrictions $\epsilon_{j,k} = \epsilon_{k,j}$ for $j, k = 1, \dots, K$.³⁵ As Equation (10) expresses that we assume different cost functions for each type of bank, the restrictions (11) likewise apply to each type of bank.

The marginal costs of output category $j = l$ (of loans) for bank i of category h in year t , mc_{ilt}^h are defined as:

$$mc_{ilt}^h = \partial c_{it}^h / \partial x_{ilt} = (c_{it}^h / x_{ilt}) \partial \ln c_{it}^h / \partial \ln x_{ilt} \quad (12)$$

The term $\partial \ln c_{it}^h / \partial \ln x_{ilt}$ is the first derivative of Equation (10) of costs to loans. We use the marginal costs of the output component ‘loans’ only (and not for the other K_j components) as we investigate the loan markets. We estimate a separate translog cost function for each individual sector in each individual country, allowing for differences in the production structure across bank types within a country. This leads to the following equation of the marginal costs for output category loans (l) for bank i in category h during year t :

$$mc_{ilt}^h = c_{it}^h / x_{ilt} (\delta_{lh} + 2 \epsilon_{llh} \ln x_{ilt} + \sum_{k=1, \dots, K; k \neq l} \epsilon_{lkh} \ln x_{ikt}) d_i^h \quad (13)$$

³⁵ The restrictions are imposed on Equation (10), so that the equation is reformulated in terms of a lower number of parameters.

Estimation results for marginal costs

We estimate a translog cost function for each separate country and take the first derivative of loans to obtain the marginal costs of lending.³⁶ As an example, Tabel A.1 presents estimation results of the translog cost function for Germany. Table A.2 shows the marginal costs estimates of loans, both across countries and over time. Marginal costs decline strongly over time, reflecting the significant decreases in funding rates during 1992–2004 and possibly also technological improvements. Germany, France and Spain have relatively high marginal costs compared to the Netherlands and Belgium. Apart from differences in funding rates, this may be explained also by lower efficiency in the former countries.

Table A.1. Estimates of the translog cost function for Germany

<i>Dependent variable: ln(costs)-ln(other expenses)</i>	Coefficient	t-value	P> t
<i>Outputs</i>			
ln(loans)_comm. banks	0.01	0.43	0.67
(ln(loans)) ² _comm. banks	0.08	45.14	0.00
ln(securities)_comm. banks	0.11	9.32	0.00
(ln(securities)) ² _comm. banks	0.04	39.84	0.00
ln(other services)_comm. banks	0.66	34.45	0.00
(ln(other services)) ² _comm. banks	0.06	24.31	0.00
ln(loans)_savings banks	-0.55	-5.16	0.00
(ln(loans)) ² _savings banks	0.21	20.25	0.00
ln(securities)_savings banks	0.60	10.79	0.00
(ln(securities)) ² _savings banks	0.05	24.39	0.00
ln(other services)_savings banks	0.92	7.93	0.00
(ln(other services)) ² _savings banks	0.07	5.73	0.00
ln(loans)_coop. banks	0.19	6.02	0.00
(ln(loans)) ² _coop. banks	0.11	26.79	0.00
ln(securities)_coop. banks	0.42	27.56	0.00
(ln(securities)) ² _coop. banks	0.04	42.97	0.00
ln(other services)_coop. banks	0.42	14.93	0.00
(ln(other services)) ² _coop. banks	0.05	13.86	0.00
<i>Input prices</i>			
ln(wage)-ln(other expenses)_comm. banks	-0.02	-0.78	0.44
(ln(wage) -ln(other expenses)) ² _comm. banks	0.12	26.00	0.00
ln(funding rate)-ln(other expenses)_comm. banks	0.85	28.35	0.00
(ln(funding rate)-ln(other expenses)) ² _comm. banks	0.15	22.66	0.00
ln(wage)-ln(other expenses)_savings banks	0.79	5.55	0.00
(ln(wage) -ln(other expenses)) ² _savings banks	0.06	2.18	0.03
ln(funding rate)-ln(other expenses)_savings banks	0.14	0.94	0.35
(ln(funding rate) -ln(other expenses)) ² _savings banks	0.08	2.91	0.00
ln(wage)-ln(other expenses)_coop. banks	0.15	4.16	0.00
(ln(wage) -ln(other expenses)) ² _coop. banks	0.65	15.58	0.00
ln(funding rate)-ln(other expenses)_coop. banks	0.09	15.26	0.00
(ln(funding rate) -ln(other expenses)) ² _coop. banks	0.10	12.40	0.00
<i>Cross-products between input prices</i>			
(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other expenses))_comm. banks	-0.27	-26.54	0.00

³⁶ See also Section 4.1 in Van Leuvensteijn *et al.* (2010).

1				
2	(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other	-0.15	-2.84	0.01
3	expenses))_savings banks			
4	(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other	-0.20	-14.82	0.00
5	expenses))_coop. banks			
6	<u>Cross-products between outputs</u>			
7	ln(loans) * ln(securities)_comm. banks	-0.03	-16.25	0.00
8	ln(loans) * ln(other services)_comm. banks	-0.10	-27.25	0.00
9	ln(securities) * ln(other services)_comm. banks	-0.03	-15.70	0.00
10	ln(loans) * ln(securities)_savings banks	-0.21	-20.79	0.00
11	ln(loans) * ln(other services)_savings banks	-0.21	-10.44	0.00
12	ln(securities) * ln(other services)_savings banks	0.08	7.58	0.00
13	ln(loans) * ln(securities)_coop. banks	-0.12	-34.04	0.00
14	ln(loans) * ln(other services)_coop. banks	-0.10	-15.55	0.00
15	ln(securities) * ln(other services)_coop. banks	0.03	9.17	0.00
16	<u>Cross-products between outputs and input prices</u>			
17	ln(loans)*(ln(wage)-ln(other expenses))_comm. banks	0.06	13.48	0.00
18	ln(loans)*(ln(funding rate)-ln(other expenses))_comm. banks	-0.04	-8.27	0.00
19	ln(loans)*(ln(wage)-ln(other expenses))_savings banks	0.00	-0.11	0.91
20	ln(loans)*(ln(funding rate)-ln(other expenses))_savings banks	0.02	0.78	0.44
21	ln(loans)*(ln(wage)-ln(other expenses))_coop. banks	0.10	11.44	0.00
22	ln(loans)*(ln(funding rate)-ln(other expenses))_coop. banks	-0.08	-8.09	0.00
23	ln(securities)*(ln(wage)-ln(other expenses))_comm. banks	0.03	11.11	0.00
24	ln(securities)*(ln(funding rate)-ln(other expenses))_comm. banks	-0.04	-10.00	0.00
25	ln(securities)*(ln(wage)-ln(other expenses))_savings banks	-0.10	-6.34	0.00
26	ln(securities)*(ln(funding rate)-ln(other expenses))_savings banks	0.06	3.88	0.00
27	ln(securities)*(ln(wage)-ln(other expenses))_coop. banks	-0.06	-14.28	0.00
28	ln(securities)*(ln(funding rate)-ln(other expenses))_coop. banks	0.05	10.49	0.00
29	ln(other services)*(ln(wage)-ln(other expenses))_comm. banks	-0.05	-9.36	0.00
30	ln(other services)*(ln(funding rate)-ln(other expenses))_comm. banks	0.04	6.74	0.00
31	ln(other services) *(ln(wage)-ln(other expenses))_savings banks	0.07	2.22	0.03
32	ln(other services)*(ln(funding rate)-ln(other expenses))_savings banks	-0.06	-1.89	0.06
33	ln(other services)*(ln(wage)-ln(other expenses))_coop. banks	-0.04	-4.48	0.00
34	ln(other services)*(ln(funding rate)-ln(other expenses))_coop. banks	0.03	2.79	0.01
35	<u>Control variables</u>			
36	ln(equity/assets)_comm. banks	-0.15	-4.26	0.00
37	ln(equity/assets) ² _comm. banks	0.01	1.96	0.05
38	ln(equity/assets)_savings banks	1.11	6.80	0.00
39	ln(equity/assets) ² _savings banks	0.21	7.86	0.00
40	ln(equity/assets)_coop. banks	0.51	10.03	0.00
41	ln(equity/assets) ² _coop. banks	0.10	11.86	0.00
42	dummy savings banks	2.63	6.12	0.00
43	dummy coop. banks	-0.15	-13.49	0.00
44	Intercept	3.07	48.08	0.00
45	Number of observations	19,551		
46	F(80, 19,470)	25,462.91		
47	Adjusted R-square	0.99		
48				

Notes: Coefficients of time dummies not shown.

¹⁾ 2SLS is used and the equation is exactly identified, so that the Hansen J-test equals 0.00.

²⁾ Estimated with the GMM.

Table A.2. Marginal cost estimates of loans across countries and over time (in %)

	AT	BE	DE	ES	FR	IT	NL	PT
1992	10.3	7.1	10.2	15.9	13.8	13.2	9.2	21.3
1993	9.4	6.9	9.4	17.2	13.4	12.0	8.1	18.8
1994	7.1	6.4	9.2	14.3	11.9	12.2	7.4	16.6
1995	7.3	5.8	8.9	15.4	11.7	11.8	7.1	15.4
1996	7.1	5.2	8.5	14.3	10.9	11.3	6.3	13.4
1997	6.1	4.6	7.4	11.7	10.9	9.7	6.4	12.3
1998	6.0	3.6	7.1	11.1	11.2	7.5	7.4	9.4
1999	5.5	3.2	6.4	8.8	10.0	6.7	6.4	6.1
2000	6.1	3.3	7.1	9.9	11.2	6.7	6.5	6.3
2001	6.1	3.1	7.3	9.6	11.7	6.6	6.4	5.9
2002	5.7	3.1	7.1	7.8	10.7	6.1	5.7	5.2
2003	5.5	2.7	6.4	5.9	8.9	5.3	4.9	5.3
2004	5.2	2.5	6.0	4.8	7.9	4.9	4.6	5.5