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To cite this article: Barbara Baarsma & Melvin Vooren (2018) Bank competition and the transmission of unconventional monetary policy in the euro area, European Competition Journal, 14:1, 174-193, DOI: [10.1080/17441056.2018.1463688](https://doi.org/10.1080/17441056.2018.1463688)

To link to this article: <https://doi.org/10.1080/17441056.2018.1463688>



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Published online: 23 Apr 2018.



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Bank competition and the transmission of unconventional monetary policy in the euro area

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ABSTRACT



We analyse the relation between bank competition and the transmission of unconventional monetary policy (UMP) for 14 European countries. We estimate an error-correction model to analyse the relation between the pass-through of UMP to long-term commercial interest rates and the level of competitiveness. We estimate this model for three different measures: the Herfindahl Index (HHI), the Boone indicator and the *H*-statistic. Our results indicate that bank concentration as measured by the HHI is not a good proxy of competitive conditions in the market, whereas the other two measures are more meaningful in this context. The pass-through of UMP is increasing in the degree of bank competition as measured by the Boone indicator and the *H*-statistic. The relationship between pass-through and the level of market concentration is less well defined, suggesting that competition and market concentration do not go hand in hand in the banking sector.

ARTICLE HISTORY Received 27 December 2017; Accepted 9 April 2018

KEYWORDS Bank competition; measurement of competition; euro area; unconventional monetary policy

1. Introduction

In March 2015, the European Central Bank (ECB) unfolded an extensive asset purchasing programme. This unconventional monetary policy (UMP) operates through lowering the marginal borrowing costs for commercial banks, which are then transmitted to firms and households through commercial interest rates that banks charge for business loans and mortgage loans. This paper empirically examines the importance of bank competition for the effectiveness of UMP.

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From a theoretical perspective, firms in less competitive markets do not transmit a decrease in marginal costs completely. For banks that are faced with regular cuts in interest rates this mechanism has been tested and confirmed.¹

In this paper, we provide empirical evidence that this holds for UMP as well. The marginal costs of commercial banks consist predominantly of the interest rates these banks have to pay on financial markets. As market interest rates are expected to decrease as a result of UMP, a more competitive banking environment is expected to promote a swifter and more complete transmission of the stimulating effects of UMP. We test this proposition by estimating an error-correction model (ECM) for a panel of 14 euro area countries, comprising the period 2009–2013. Doing so we link the degree of pass-through with the degree of bank competition.

As market concentration and market competition are two different concepts, concentration measures may not be a suitable proxy for competition. Claessens and Laeven² empirically show that the relation between these two indicators is not straightforward in the banking sector – i.e. concentration may increase while at the same time competition increases. We estimate the degree of bank competition directly by applying two measures: the Boone indicator³ and the *H*-statistic.⁴ Next, to estimating the degree of bank competition directly, we also estimate the Herfindahl–Hirschmann Index (HHI) as a measure for market concentration, and use it to determine the effects of banking market concentration on the transmission of UMP to see the difference with the direct competition measures.

Our results indicate that bank competition seems to enhance the intended stimulating effect of UMP, leading to lower commercial interest rates in the long run. Next to this, the estimation results suggest that banks seem to adjust their interest rates more rapidly in a competitive banking environment. This result indicates that competition improves the transmission of UMP. Regarding concentration, the effects are less clear-cut, confirming that concentration is not the same as competition in the banking sector.

¹This has been tested and confirmed by for example:

- KJ Kopecky and D Van Hoose, 'Imperfect Competition in Bank Retail Markets' (2012) 44(6) *Journal of Money Credit and Banking* 1185.
- M Van Leuvensteijn and others, 'Impact of Bank Competition on the Interest Rate Pass-Through in the Euro Area' (2013) 45(11) *Applied Economics* 1359.

²S Claessens and L Laeven, 'What Drives Bank Competition? Some International Evidence' (2004) 36(3) *Journal of Money, Credit, and Banking* 563.

³J Boone, 'A New Way to Measure Competition' (2008) 118(531) *Economic Journal* 1245.

⁴JC Panzar and JN Rosse, 'Testing for Monopoly Equilibrium' (1987) 35(4) *Journal of Industrial Economics* 443.

The remainder of this paper is structured as follows. In the next section, we give a brief overview of the developments of UMP over the past decades. Section 3 describes our data and methodology. In Section 4 we present our results, and we give the conclusion in Section 5.

2. Background

With nominal interest rates at their zero lower bound, central banks consider alternative forms of monetary policy. This zero lower bound for nominal interest rates had been reached by the Bank of Japan (BoJ) in the early 2000s. To combat the persisting deflation, the BoJ initiated a government bond-purchasing programme in March 2001. In this programme the BoJ purchased government bonds from the Japanese banking sector, striving to expand the amount of cash reserves in the banking sector. The idea was that by targeting a sufficient level of reserves, this would translate into an expansion of commercial lending into Japan's economy, driving up asset prices.⁵ Japanese inflation did however not increase sustainably since the first government bond-purchasing programme. After this, the BoJ committed to expand the asset purchase programme further, increasing the monetary base at an annual pace of 60–70 trillion yen in April 2013. Then, inflation started to increase. A year after BoJ's statement, inflation peaked at almost twice the target of 2% per year. As of 2017, Japanese inflation tumbled again, reaching 0.3% in December 2016.⁶

As a response to the 2008 financial crisis, the Federal Reserve (Fed) and the Bank of England (BoE) both adapted UMP. Both monetary authorities engaged in similar asset purchasing programmes, notwithstanding a minor difference. The BoE only purchased UK government bonds (gilts), while the Fed's programme not exclusively involved US Treasury Bills, but mortgage-backed securities as well. In practice, this difference is almost absent, since the Fed would solely purchase mortgage-backed securities backed by US government agencies.

2.1. The eurozone

In the European context the Target balances system, which stands for "Trans-European Automated Real-Time Gross Settlement Express Transfer", bears close resemblance to the UMP described in the preceding subsection.

⁵M Joyce and DSAVD Miles, 'Quantitative Easing and Unconventional Monetary Policy, an Introduction' (2012) 122(564) *The Economic Journal* F271.

⁶*ibid.*

These Target balances measure the total surplus or deficit each individual national central bank (NCB) has with the ECB, which parallels that country's current account balance with the other countries in the euro area.⁷

The monetary imbalances followed by the euro sovereign debt crisis, made countries in the eurozone vulnerable to budgetary shocks, as was the case in the Southern eurozone. When public debt is exchanged for the common currency, the exchanged liquidity can be invested unrestrictedly in other financial assets abroad, like Dutch or German bonds. This mechanism eventually dries up the monetary base in the affected countries. Because sovereign states do not have full control over the currency in which they issue their public debt, financial markets know that the government cannot guarantee that there will always be cash available to pay at the date their bonds mature.⁸

In this case, the outflow of liquidity becomes unsustainable, and many banks, particularly those in Greece, Ireland, Italy, Portugal and Spain (GIIPS), have suffered seriously. Capital flowed out of GIIPS countries mainly towards Dutch and German banks. These capital outflows resulted in Target deficits in the GIIPS countries, and Target surpluses in the other countries.⁹

To finance these Target deficits, the ECB supported extensive money creation by the NCBs in the GIIPS countries, at the expense of money creation in the countries with Target surpluses. The ECB ordered the NCBs of countries with Target surpluses to borrow and remove euro currency from circulation, in order to get "reprinted" by the NCBs of countries with Target deficits. By using this UMP mechanism, ECB passed the European Parliament. That allowed the ECB to aid the crisis countries, even before the European Financial Stability Facility (EFSF) and the European Financial Stability Mechanism (EFSM) came into existence. This money "reprinting" process is the mechanism is the focus of our analysis.

The Eurosystem unconventional monetary programme to purchase bonds on secondary markets, the ECB's Securities Markets Programme (SMP), came into effect in May 2010. This programme was replaced by another programme to purchase sovereign bonds in September 2012; the Outright Monetary Transactions (OMT) programme. Both programmes operated through the system of NCBs, as described above.

⁷HW Sinn and T Wollmershäuser, 'Target Loans, Current Account Balances and Capital Flows: The Ecb's Rescue Facility' (2012) 19(4) *International Tax and Public Finance* 468.

⁸For a complete analysis of the events, see P De Grauwe, 'The Governance of a Fragile Eurozone' (2012) 45 (3) *The Australian Economic Review* 255.

⁹Sinn and Wollmershäuser (n 7).

2.2. *The relationship with market structure*

UMP mainly operates through a reduction of the term premium on long-term financial assets, which consequently constitutes a decrease in the interest rates on these long-term assets. From this, it follows that commercial bank loan rates are very likely to decrease as a result of UMP. In an empirical study of the response of interest rates to UMP in the US and the UK, Christensen and Rudebusch¹⁰ conclude that long-term (>10 years) interest rates indeed declined as a result of UMP. Wright¹¹ comes to the same conclusion for the US although the effects die out fairly quickly in the succeeding months.

In the case of commercial interest rates, it is likely that market structure will also play a role in the transmission of UMP. Market structure is an important factor influencing banks' price-setting behaviour. In an uncompetitive market, banks might not adequately pass-through a reduction in a cost component, i.e. the interest rate on the financial market, to their commercial loan rates. This paper, therefore, addresses the question whether an uncompetitive banking market hinder the effectiveness of UMP because banks will not decrease their loan rates sufficiently fast?

The interest rate pass-through literature confirms that less competitive banking markets lead to less symmetric pass-through. Usually, the relation between commercial interest rates and market interest rates are modelled using Vector Autoregressive (VAR) models.¹² However, this literature only investigates the relation of competition and pass-through under normal circumstances. None of the aforementioned studies looked at the relation between bank competition and the pass-through of UMP to commercial interest rates. In addition, each of these studies focused merely on one single competition measure, whereas it is ambiguous what measure is the most suitable to measure competition in the

¹⁰JH Christensen and GD Rudebusch, 'The Response of Interest Rates to US and UK Quantitative Easing' (2012) 122(564) *The Economic Journal* F385.

¹¹JH Wright, 'What Does Monetary Policy Do to Long-Term Interest Rates at the Zero Lower Bound?' (2012) 122(564) *The Economic Journal* F447. Wright uses an identification through heteroskedasticity and high-frequency event-study analysis.

¹²This is done for example by:

- B Hofmann and P Mizen, 'Interest Rate Pass-Through and Monetary Transmission: Evidence from Individual Financial Institutions' Retail Rates' (2004) 71 *Economica* 99.
- H Sander and S Kleimeier, 'Convergence in Euro-Zone Retail Banking? What Interest Rate Pass-Through Tells Us About Monetary Policy Transmission, Competition and Integration' (2004) 23 *Journal of International Money and Finance* 461.
- GJ De Bondt, 'Interest Rate Pass-Through: Empirical Results for the Euro Area' (2005) 6(1) *German Economic Review* 37.
- S Kleimeier and H Sander, 'Expected Versus Unexpected Monetary Policy Impulses and Interest Rate Pass-Through in Euro-Zone Retail Banking Markets' (2006) 30 *Journal of Banking & Finance* 1839.
- Kopecky and Van Hoose (n 1).

banking sector. In the next section, we shed light on this question about measuring bank competition, and the model we use to answer the question on the importance of competition for the transmission of unconventional monetary policy.

3. Data and empirical model

3.1. Data and sample period

For our analysis, we exploit the Bankscope database, containing bank-level microdata of income statements, balance sheets and similar financial statements. This extensive database allows us to make accurate estimates of a variety of competition measures (see Section 3.2). The quality of the Bankscope database is endorsed by Bhattacharya.¹³ The sample period runs from 2009 to 2013. The rationale behind the selection of this sample period is that for the years before 2009, the Bankscope database is incomplete. Since this may lead to a bias, we omit those years. Also, not all banks have submitted their financial information for 2014 yet. Thus, for the same reason, we restrict the sample from 2009 to 2013. Another advantage of starting the observations from 2009 is the omission of the 2008 financial crisis. After all, the developments during that year could possibly have affected pass-through. Either way, UMP was absent in the euro area before the crisis, justifying the selected time frame.

3.2. Measuring bank competition

Bank competition can either be directly measured, or proxied for by a market concentration measure. Given the discourse on the question how to measure competition in the banking sector, we will do our analysis on the basis of three different measures, and use these different analyses as a robustness check. This subsection will provide an outline of the three different measures.

3.2.1. Panzar and Rosse: H-statistic

Before we can estimate the relationship between bank competition and the effects of UMP, we require an appropriate measure of competition. Panzar and Rosse¹⁴ introduced the *H*-statistic, a direct competition measure. In

¹³K Bhattacharya, 'How Good is the BankScope Database? A Cross-Validation Exercise with Correction Factors for Market Concentration Measures' (2003) BIS Working Papers No 133.

¹⁴Panzar and Rosse (n 4).

order to discriminate between monopolistic, oligopolistic and competitive market models, they developed a test statistic H . This H -statistic serves as a measure of competition, which is defined as the sum of the elasticities of the revenues with respect to the prices of the input factors:

$$H = \sum_{k=1}^m \frac{\partial R_i^*}{\partial w_{k_i}} \frac{w_{k_i}}{R_i^*}. \quad (1)$$

H is increasing in competition between values zero and one, while a negative value for H indicates a monopoly equilibrium. The banking market is perfectly competitive when H equals one. The competition measure H , as formulated in Equation (1), has been applied to the banking industry.¹⁵

Bikker and Haaf¹⁶ have applied the Panzar–Rosse approach to banks from 23 European and non-European countries over the period 1988 until 1998. For the analysis of the eurozone, we will need estimates of the H -statistic for the period 2009–2013. For our analysis, we have estimated the following model, based on the specification of Bikker and Haaf:

$$\begin{aligned} \ln INTR_i = & \beta_1 \ln AFR_i + \beta_2 \ln PPE_i + \beta_3 \ln PCE_i + \sum_{i=1} \gamma_i \ln BSF_i \\ & + \beta_4 \ln OI_i, \end{aligned} \quad (2)$$

where $INTR_i$ represents the ratio of total interest revenue to total assets, AFR_i represents the ratio of annual interest expenses to total funds (the average funding rate), PPE_i represents the ratio of personnel expenses to total assets and PCE_i represents the ratio of other expenses to fixed assets (the approximated cost of capital). BSF_i are bank fixed effects, and OI_i is the ratio of other income to total assets. Equation (2) implies that the H -statistic amounts to $(\beta_1 + \beta_2 + \beta_3)$.

3.2.2. Boone indicator

In empirical Industrial Organization, the price cost margin (PCM) is often used as an empirical approximation of the theoretical Lerner Index of market power (LI). The LI originates from the first order condition of a monopolist's profit maximization problem, price minus marginal costs, divided by price. Profits are maximized when the LI equates the inverse

¹⁵P Molyneux, D Lloyd-Williams and J Thornton, 'Competitive Conditions in European Banking' (1994) 18 Journal of Banking & Finance 445.

¹⁶JA Bikker and K Haaf, 'Competition, Concentration and their Relationship: An Empirical Analysis of the Banking Industry' (2002) 26(11) Journal of Banking & Finance 2191.

price elasticity of demand. The *LI* will be zero under perfect competition, since market demand will then be infinitely elastic. In the situation of a monopoly, it will approach one for any marginal costs larger than zero. Thus intuitively, the *LI* should be decreasing in the degree of competition.¹⁷

However, this measure has some theoretical robustness issues. More specifically, several theoretical papers have proposed models in which an increase in competition leads to a higher *PCM*, instead of lower margins.¹⁸ This irregularity has established the need of a more theoretically robust competition measure. Boone introduced one such measure, which he named Relative Profit Differences. We will further refer to this as the Boone indicator. The Boone indicator measures the elasticity of profits with respect to marginal costs, which is increasing in competition.

For each country *j*, we made yearly estimates of the Boone indicator, using average total costs (*ATC*) as a proxy for immeasurable marginal costs.¹⁹ The *ATC* of bank *i* in year *t* were calculated as total interest and non-interest expenses divided by total assets. Market shares (*ms*) were calculated with respect to total assets.

$$\ln ms_{ijt} = \alpha_{jt} + \beta_{jt} \ln ATC_{ijt}. \quad (3)$$

The estimated coefficient for β is referred to as the Boone indicator. Like Van Leuvensteijn et al.,²⁰ we use market shares instead of profits to estimate the Boone indicator, since economic profits are difficult to measure. The expected sign of β is negative, since a bank's market share is expected to decrease as a result of an increase of its marginal costs. This effect is supposed to be larger in more competitive markets, so that the absolute value of β will be larger.

3.2.3. Banking market concentration

The use of concentration markets can be disputed, as they may not be appropriate proxies for competition. An argument against the use of

¹⁷M. Van Leuvensteijn and others, 'A New Approach to Measuring Competition in the Loan Markets of the Euro Area' (2011) 43(23) *Applied Economics* 3155.

¹⁸This is done by example:

- RW Rosenthal, 'A Model in Which an Increase in the Number of Sellers Leads to a Higher Price' (1980) 48(6) *Econometrica* 1575.
- JE Stiglitz, 'Imperfect Information in the Product Market' in *Handbook of Industrial Organization* (Elsevier 1989) 769, vol. 1, book s 13.
- J Bulow and P Klemperer, 'Prices and the Winner's Curse' (2002) 33(1) *The RAND Journal of Economics* 1.

¹⁹Boone (n 3).

²⁰Van Leuvensteijn and others (n 17).

concentration measures, is that an increase in competition will likely induce a decrease in profit margins. This will put banks under pressure, forcing them to become more efficient. By prompting banks to make better use of scale efficiencies, this could constitute a wave of mergers and acquisitions. This process increases market concentration, while the actual degree of competition has increased. Studies have been done to estimate the relation between the degree of competition and various indices of concentration. These studies show contradictory results.

Claessens and Laeven²¹ found evidence that banking market concentration is positively instead of negatively correlated with the aforementioned H -statistic. Still, concentration measures are often used in the literature as a proxy for bank competition. One of the most often used concentration measures is the HHI, defined as the sum of all squared market shares.²²

The ECB has calculated the HHIs for various European countries. In their calculations, they made use of market shares on the basis of total bank assets. For our analysis, we also calculate the HHI's with market shares based on total bank assets.

3.2.4. Results for the three measures of competition

Table 1 presents the non-standardized Herfindahl indices, Boone indicators, and H -statistics for each year and each country. We can see that there is enough variation in the levels of competition within and across countries, allowing us to estimate an ECM of bank competition and interest rate pass-through.

The entire euro area has been incorporated in the analyses, provided that there was data available in the Bankscope database. Therefore, some euro zone countries have not been included. For instance, in the case of Italy, incomplete data rendered it impossible to estimate the H -statistics. For the sake of a full comparison between the results using the three different competition measures, we have omitted Italy from our analyses.

3.3. Assessing the scale and scope of UMP

The next stage is to obtain an appropriate measure the amount of UMP in each individual euro area state. The undisclosed nature of the Central Bank's

²¹Claessens and Laeven (n 2).

²²JA Bikker and K Haaf, 'Measures of Competition and Concentration in the Banking Industry: A Review of the Literature' (2002) 9 *Economic & Financial Modelling* 53.

Table 1. Results competition measure (non-standardized).

	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
			Austria					Belgium		
HHI	0.05	0.05	0.05	0.04	0.04	0.33	0.31	0.29	0.28	0.28
Boone	-0.9	-0.47	-0.51	-0.66	-0.25	-1.58	-1.3	-1.48	-1.12	-1.03
H-st.	0.48	0.29	0.81	0.78	1.72	0.56	0.89	0.54	1.12	0.53
n	216	222	218	213	189	24	25	25	21	19
			Germany					Estonia		
HHI	0.19	0.19	0.18	0.18	0.17	0.68	0.67	0.49	0.47	0.45
Boone	-1.29	-0.86	-1.17	-1.2	-0.91	-1.71	-2.15	-1.4	-1.25	-1.16
H-st.	0.69	0.31	0.48	0.47	0.39	0	1.81	0.85	1.7	1
n	1,594	1,621	1,642	1,614	1,559	4	5	7	7	7
			Spain					Finland		
HHI	0.07	0.07	0.11	0.19	0.23	0.5	0.55	0.6	0.54	0.53
Boone	0.21	-2.4	0.27	1.05	0.33	-2.3	-2.08	-1.76	-1.25	-1.38
H-st.	0.68	0.96	0.71	0.27	0.91	0.55	0.11	0.16	0.14	-0.27
n	116	109	101	76	57	8	11	16	27	25
			France					Greece		
HHI	0.26	0.26	0.27	0.25	0.26	0.15	0.16	0.22	0.22	0.24
Boone	-1.2	-1.09	-1.21	-0.63	-0.77	1.6	0.58	3.16	-2.08	-2.13
H-st.	0.45	0.16	0.14	0.79	0.2	0.52	0.37	-0.1	0.93	0.63
n	72	73	72	66	53	16	17	12	11	8
			Ireland					Luxembourg		
HHI	0.23	0.2	0.2	0.26	0.29	0.1	0.1	0.09	0.09	0.1
Boone	1.45	0.72	0.35	-1.62	-3.45	-0.37	-0.02	0.29	-0.09	-0.36
H-st.	1.05	-0.05	2.13	0.03	-0.04	0.87	0.85	1.05	0.96	1.04
n	8	10	9	7	6	45	43	40	38	32
			The Netherlands					Portugal		
HHI	0.21	0.27	0.27	0.28	0.28	0.49	0.49	0.41	0.42	0.35
Boone	0.22	1.02	-0.59	-0.56	0.33	1.26	0.24	0.89	1.72	-1.53
H-st.	0.3	0.37	0.45	0.41	0.69	1.11	1.39	0.21	0.62	0.69
n	24	23	23	26	24	15	17	17	17	17
			Slovenia					Slovakia		
HHI	0.35	0.33	0.33	0.33	0.33	0.32	0.3	0.3	0.31	0.4
Boone	-2.6	1.78	3.92	4	-0.82	-1.9	-2.42	-1.74	-2.24	-1.71
H-st.	0.55	5.11	1.28	0.05	0.05	1.02	3	1.31	2.03	0.83
n	9	8	8	7	7	9	9	9	8	7

Note: *n* indicates the number of banks active in that particular year.

investing behaviour makes it difficult to measure the scale and scope of UMP directly on a national level. One variable that we could use is the country-specific yield on long-term government bonds, assuming an inverse correlation of this variable with the magnitude of UMP. But since it is very much likely that other factors influence government bond yields as well – such as elections, speculation against the concerning government, or an increase in risk exposure – this variable is not appropriate as a measure for UMP.

In their analysis of the macroeconomic effects of UMP, Gambacorta, Hofmann and Peersman²³ used the total sum of central bank assets as a proxy for UMP. Saiki and Frost²⁴ took this variable as a fraction of nominal, seasonally adjusted GDP for their analysis of the relation between UMP and inequality in Japan. We will use the same variable in our analysis, that is the fraction of a NCB's total assets with respect to the concerning country's GDP:

$$UMP_{jt} = \frac{\text{Total Central Bank Assets}_{jt}}{GDP_{jt}}. \quad (4)$$

Larger countries tend to have larger central banks, and by adjusting for the size of their GDP, we give larger and smaller countries an equal weight in our analysis. We have retrieved total central bank assets on a yearly basis from the Bankscope database, which we subsequently interpolated on a quarterly basis using cubic spline interpolation. Seasonally adjusted GDP, computed at market prices following the output approach has been obtained on a quarterly basis from the OECD's statistical database. To get an indication of how UMP varies between countries, [Table 2\(a\)](#) provides summary statistics for our UMP variable for each country. [Table 2\(b,c\)](#) presents the summary statistics of interest rates on loans for house purchase and on loans to corporations, respectively. Both loans have an original maturity of over five years.

3.4. Empirical model

The pass-through of interest rates has been estimated before by Van Leuvensteijn et al.²⁵ in an ECM, which is the preferred specification to disentangle the short-run variations from the long-run co-movement of

²³L Gambacorta, B Hofmann and G Peersman, 'The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis' (2014) 46(4) *Journal of Money Credit and Banking* 615.

²⁴A Saiki and J Frost, 'Does Unconventional Monetary Policy Affect Inequality? Evidence from Japan' (2014) 46(36) *Applied Economics* 4445.

²⁵See Van Leuvensteijn and others (n 1) 1366–77, equations 5a,b.

Table 2. Summary statistics by country.

	Mean	St. dev.	Min	Max
<i>(a) UMP proxy</i>				
Austria	1.196	0.145	0.986	1.367
Belgium	1.039	0.203	0.779	1.352
Estonia	0.789	0.156	0.595	0.947
Finland	1.438	0.538	0.779	2.198
France	1.297	0.148	1.032	1.431
Germany	1.188	0.190	0.944	1.482
Greece	0.207	0.038	0.139	0.250
Ireland	3.716	0.834	2.441	5.151
Luxembourg	9.859	1.710	7.113	12.190
Netherlands	1.236	0.374	0.765	0.176
Portugal	2.397	0.449	1.409	2.875
Slovakia	1.438	0.125	1.192	1.571
Slovenia	1.159	0.169	0.941	1.420
Spain	1.332	0.526	0.728	2.101
<i>(b) Interest rates on loans for house purchase with an original maturity of over five years</i>				
Austria	3.023	0.435	2.407	3.807
Belgium	3.932	0.197	3.570	4.247
Estonia	2.494	0.473	1.807	3.157
Finland	1.961	0.354	1.447	2.497
France	3.899	0.179	3.557	4.230
Germany	4.458	0.271	3.983	4.863
Greece	3.534	0.320	3.030	3.973
Ireland	2.952	0.178	2.667	3.410
Luxembourg	2.279	0.091	2.103	2.463
Netherlands	4.702	0.091	4.500	4.787
Portugal	1.995	0.424	1.463	2.723
Slovakia	5.250	0.345	4.623	5.833
Slovenia	3.420	0.462	2.763	4.087
Spain	2.749	0.353	2.100	3.357
<i>(c) Interest rates on loans to corporations with an original maturity of over five years</i>				
Austria	2.727	0.280	2.363	3.203
Belgium	3.996	0.268	3.507	4.353
Estonia	2.854	0.381	2.373	3.463
Finland	2.192	0.343	1.743	2.763
France	3.425	0.186	3.070	3.773
Germany	3.693	0.282	3.247	4.017
Greece	4.714	0.392	4.003	5.343
Ireland	3.142	0.259	2.877	3.657
Luxembourg	3.067	0.342	2.520	3.453
Netherlands	3.632	0.210	3.353	3.953
Portugal	3.515	0.435	2.897	4.267
Slovakia	3.360	0.358	2.897	4.010
Slovenia	3.201	0.409	2.600	3.950
Spain	3.300	0.216	3.020	3.663

cointegrated, non-stationary variables. For a non-technical explanation of this model see the text box below. Our analysis builds upon the model specified by Van Leuvensteijn et al., in which we replaced the Boone indicator by the three measures introduced in Section 3.2, and the market rates by our proxy for UMP. In Equation (5a) we estimate the long-run relation. After that, we estimate the short-run effects in

Equation (5b).

$$BR_{it} = \zeta CM_{it} + \eta_i UMP_{it} + \theta CM_{it} UMP_{it} + \kappa D_i + u_{it}, \quad (5a)$$

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

Here, i refers to countries ($i = 1, 2, \dots, N$), and t refers to quarters ($t = 1, 2, \dots, T$). BR and ΔBR refer to long-term bank interest rates and quarterly change in these interest rates, respectively. UMP and ΔUMP represent the UMP proxy and quarterly difference. CM_{it} denotes the country-specific competition measure for the banking sector in quarter t . For the sake of comparability of the results, we have standardized all three competition measures to have a mean of zero and a standard deviation of one. We furthermore multiplied the Boone indicator by minus one, so that it is increasing in competition, like the H -statistic. This allows us to compare the results between the different measures.

ECMs are applied in the case of non-stationary, cointegrated time series.²⁶ Below we explain both these terms: non-stationary and cointegrated.

What is non-stationary? A time series variable is defined non-stationary when there is a correlation between the value in one period and the value in a preceding period. Or in other words, when the variable is not generated by a pure random process. Economic variables are often non-stationary; the value of an interest rate in one year is partially explained by the value of that interest rate in the preceding year.

What is cointegrated? When some linear combination of two or more non-stationary variables is stationary, these variables are called cointegrated. In this paper, we estimate the relationship between long-term bank interest rates and the degree of UMP. Both these time series variables are non-stationary. They are also cointegrated, because they have a long-run equilibrium relationship. The long-term bank interest rates are expected to decrease in the degree of UMP in the long run.

An ECM separates this long-run co-movement of variables from short-run deviations from this equilibrium relationship.²⁷ We apply this model because we are interested in the dynamics of the varying degrees of competition, which are short-run deviations from the equilibrium relationship. An ECM allows us to do this by filtering the long-run co-movement from the competition dynamics.

In the long-term model (5a), D_i represents country fixed effects. The short-term model (5b) includes the error-correction term $\lambda_i u_{i,t-1}$. The ECM will estimate the generic competition effects over the entire panel in the ζ , θ and ξ parameters, though the estimated parameters for η_i , μ_i and λ_i will remain country-specific.

The long-term interest rates that we use as outcome variables are obtained from the ECB's statistical data warehouse. We consider loans

²⁶CWJ Granger, 'Some Properties of Time Series Data and their Use in Econometric Model Specification' (1981) 16(1) *Journal of Econometrics* 121.

²⁷RF Engle and CWJ Granger, 'Co-Integration and Error Correction: Representation, Estimation, and Testing' (1987) 55(2) *Econometrica* 251.

for house purchase and loans to corporations, both with an original maturity of over five years. The reasoning behind this choice for these interest rates is that these apply to separate markets. The mortgage market is typically more standardized in terms of screening and regulation, while corporate loans are more tailored to the needs and riskiness of a particular corporation.²⁸ It is interesting to see whether the relation between competition and UMP pass-through differ in these two markets.

3.5. Unit root tests

Please recall from the text box above that non-stationarity means that there is a correlation between the value in one period and the value in a preceding period. With non-stationarity being a crucial assumption inherent to ECMs, we need to show whether these conditions are indeed met. We implement two statistical tests. The first test is a panel version of the Augmented Dickey–Fuller (ADF) unit root test, as introduced by Im, Pesaran and Shin (IPS),²⁹ further referred to as the IPS test. This test is based on the following regression model:

$$\Delta Y_{i,t} = \alpha_i + \rho_i Y_{i,t-1} + \sum_{j=1}^{p_j} \tau_{i,j} \Delta Y_{i,t-j} + \epsilon_{i,t}. \quad (6)$$

In the context of this paper, Y stands for the three competition measures introduced earlier, the proxy for UMP, the interaction between the competition measures and the proxy for UMP ($CM * UMP$), and the two investigated interest rates. Under the null hypothesis, all panels are non-stationary.

As a cross-check, we perform a second-panel unit root test, as introduced by Hadri.³⁰ In this test, all panels are stationary under the null hypothesis. The underlying regression model of the Hadri test is specified as follows, where Y stands for the same variables as in the IPS test:

$$Y_{it} = \alpha_i + \sum_{\tau=1}^t u_{i\tau} + \epsilon_{it}. \quad (7)$$

The results of both tests are displayed in [Table 3](#) and provide evidence to assume non-stationarity in all variables.

²⁸See for instance: S Greenbaum, A Thakor and A Boot, *Contemporary Financial Intermediation* (Academic Press/Elsevier 2016); WHJ Hassink and M van Leuvesteijn, 'Measuring Transparency in the Dutch Mortgage Market' (2007) 155(1) *De Economist* 23.

²⁹KS Im, MH Pesaran and Y Shin, 'Testing for Unit Roots in Heterogeneous Panels' (2003) 115(1) *Journal of Econometrics* 53.

³⁰K Hadri, 'Testing for Stationarity in Heterogeneous Panel Data' (2000) 3 *Econometrics Journal* 148.

Table 3. Results unit root tests.

	IPS test		Hadri test	
	H_0 : unit root		H_0 : stationarity	
	Zt-tilde-bar	p-Value	Z	p-Value
<i>UMP proxy</i>				
UMP	1.6158	0.9469	19.2457	0.0000***
Competition measures				
Herfindahl Index	3.3849	0.9996	29.854	0.0000***
Boone indicator	3.249	0.9994	17.9928	0.0000***
H-statistic	2.7686	0.9972	16.7848	0.0000***
<i>Market interest rates</i>				
House purchase	6.1175	1	22.0895	0.0000***
Corporations	3.5422	0.9998	13.7331	0.0000***
<i>CM * UMP proxy</i>				
Herfindahl Index	0.6753	0.7503	16.3916	0.0000***
Boone Indicator	3.7215	0.9999	20.8446	0.0000***
H-statistic	3.2029	0.9993	11.479	0.0000***

Note: *, ** and *** denote confidence levels of 90%, 95% and 99%, respectively.

3.6. Cubic spline interpolation

In order to match the frequencies of the observations, we have decided to interpolate all annual observations on a quarterly basis using cubic spline functions. Van Leuvensteijn et al.³¹ had to interpolate their estimates of the Boone indicator as well. They have interpolated yearly estimations of the Boone indicator on a monthly basis using 12-month rolling averages by placing each annual estimate on June of the respective year. Considering the fact that interpolated data are not real data, we will not proceed the same way as Van Leuvensteijn et al. did by interpolating on a monthly basis. Therefore, we decided to interpolate on a quarterly basis, using only two interpolated values instead of eleven values. In this manner, we can estimate the quarter-over-quarter pass-through, while minimizing the likelihood of spurious results. We have not performed interpolation on the outcome variable, as this would lead to spurious results.

4. Results

Table 4 presents the results of the long-run model. Our findings differ between the three measures used.

Considering the results respecting loans for house purchase, we observe that the sign of the ζ parameter in the Herfindahl model is negative at the 5% level, and that the coefficient in front of the $CM * UMP$ term (θ) is not

³¹Van Leuvensteijn and others (n 1).

Table 4. Results long-term model.

	Herfindahl Index		Boone indicator		H-statistic	
	Coefficient	z-Value	Coefficient	z-Value	Coefficient	z-Value
<i>Loans for house purchase with an original maturity of over five years</i>						
CM (ζ)	-0.801	-1.99**	-0.208	4.72***	-0.238	-2.06**
CM * UMP (θ)	0.309	0.80	-0.066	-1.84*	0.077	2.96**
UMP (η)	Included		Included		Included	
Country FE (κ)	Included		Included		Included	
R-sq, within	0.3664		0.4043		0.3759	
N	226		226		226	
<i>Loans to corporations with an original maturity of over five years</i>						
CM (ζ)	0.562	1.23	-0.055	0.52	-0.213	-2.25**
CM * UMP (θ)	-0.557	-1.56	-0.031	0.42	0.07	2.23**
UMP (η)	Included		Included		Included	
Country FE (κ)	Included		Included		Included	
R-sq, within	0.3087		0.3133		0.3159	
N	226		226		226	

Note: *, ** and *** denote confidence levels of 90%, 95% and 99%, respectively.

significantly different from zero. This suggests that in the long run, the effect of concentration as defined as the sum of all squared market shares (HHI) on this interest rate is negative. In other words, the interest rate decreases as the banking market becomes more concentrated.

Regarding the Boone indicator, that measures the (marginal) cost elasticity of profits, the results are not quite the same as with HHI. For the Boone indicator, the sign of the ζ coefficient negative, at a significance level of 1%. Since we multiplied the Boone indicator by minus one, this indicates that an increase in the level of competition decreases interest rates, and vice versa. So, in the long term, the estimate with the Boone indicator indicates that more intense competition will lead to a reduction in interest rates on mortgage loans and vice versa. The interaction between the Boone indicator and the size of the central bank's balance sheet relative to national income indicates that this competitive effect is decreasing as the magnitude of the monetary easing increases. This is clear from the sign in front of the θ parameter. Because the sign is negative, this implies that this effect dampens when the amount of UMP increases. This would imply that the competition effect is bigger for smaller levels of UMP. In addition, our results for the short-term model confirm that intensified bank competition increases the rate at which banks adjust their interest rates after cost decreases as a result of UMP.

With respect to the H-statistic, defined as the sum of the turnover elasticities of the prices of the production factors, we find a similar result for the long-run effect of competition on the long-term interest rate on loans for house purchase (the sign of ζ), yet at a significance level of 5%. Here,

the sign the θ parameter is positive, which implies the same dampening of the competition effect when the amount of UMP increases.

Because the Boone indicator and the H -statistics have a different scale the results cannot simply be compared. However, the fact that both measures indicate that more competition increases the effectiveness of UMP is an indication that this is a robust result.

Our findings suggest that market concentration is not the same as competition in the banking sector. Higher levels of market concentration tend to go hand in hand with lower bank interest rates. This difference between competitive and concentration measures can be explained by the fact that a more concentrated banking sector usually goes hand in hand with more financial stability. Some larger banks are generally more stable than many smaller banks. The lower interest rates found at the Herfindahl Index can then be explained by the increased financial stability, not by market concentration. This makes this index less suitable as a proxy for competition in the banking sector.

The competition effects on the interest rates on business loans are considerably smaller than on residential mortgages. We find no statistically significant effect of the Herfindahl Index on the interest rate on loans to corporations with an original maturity of more than five years. The same is true for the Boone indicator. For the H -statistic, we do find a (negative) effect ($p < 0.05$).

Market failures provide a possible explanation for these findings. Corporate loans are far less homogeneous than residential mortgages. In the corporate loans market, banks have to put much more effort in the screening of their potential customers, in contrast to residential mortgages, which are often warranted and generalized in schemes like the National Mortgage Guarantee (NHG) in the Netherlands. These information asymmetries may cause the market to work less well, and explain the small competition effects.

Barriers to entry may form another explanation for this effect. There are significant barriers to entry the European banking sector. Heavy regulations and limited switching behaviour of small and medium-sized enterprises (SMEs) are examples of barriers for potential entrants. The limited switching behaviour of SMEs makes it hard to win customers from incumbent banks. As such, it becomes difficult for potential entrants to reach the minimum efficient scale.

This limited switching behaviour can partly be explained by significant search and switching costs. There is little information available to SMEs about the interest rate they will eventually have to pay, as well as the

Table 5. Results short-term model.

	Herfindahl Index		Boone indicator		<i>H</i> -statistic	
	Coefficient	z-Value	Coefficient	z-Value	Coefficient	z-Value
<i>Loans for house purchase with an original maturity of over five years</i>						
<i>CM</i> * ΔUMP (ξ)	-0.801	-1.99**	-0.208	4.72***	-0.238	-2.06**
u_{t-1} (λ_i)	Included		Included		Included	
ΔUMP (μ_i)	Included		Included		Included	
<i>R</i> -sq, within	0.1882		0.1792		0.2096	
<i>N</i>	212		212		212	
<i>Loans to corporations with an original maturity of over five years</i>						
<i>CM</i> * ΔUMP (ξ)	0.433	0.74	0.066	0.111	0.100	0.122
u_{t-1} (λ_i)	Included		Included		Included	
ΔUMP (μ_i)	Included		Included		Included	
<i>R</i> -sq, within	0.2852		0.2850		0.2837	
<i>N</i>	212		212		212	

Note: *, ** and *** denote confidence levels of 90%, 95% and 99%, respectively.

acceptation criteria. This information will only be provided at the very end of a lengthy application process. Also, the switching costs induced by the lack of bank number portability contributes to the limited switching behaviour.

Table 5 presents the results of the short-run model for house purchase and loans to corporations, respectively. We find no statistically significant estimates for each of the three competition measures for both interest rates.

5. Conclusion and discussion

This paper aims to clarify the relation between the degree of competition in the banking sector and the effectiveness of UMP. We analyse the long- and short-run adjustments of two long-term commercial interest rates to changes in the size of the central bank's balance sheet to GDP ratio with an ECM, while accounting for the variance in the level of competitiveness. Given the wide amount of measures for banking sector competition, we estimate this model for three different measures, the Herfindahl Index, the Boone indicator and the *H*-statistic.

Based on the estimation results of our model, we find that the pass-through of unconventional monetary policy is increasing in the level of competition, as measured by the Boone indicator and the *H*-statistic, but that the effect of competition decreases in the level of UMP. After standardizing the scales of the Boone indicator and the *H*-statistic, we can see that the magnitude of the relations are roughly the same for both measures.

Yet, we find contradictory results regarding the effect of market concentration on the interest rates on long-term loans. Contrary to what one would expect, an increase in market concentration goes hand in hand with a decrease in long-term bank interest rates. This finding suggests that concentration and competition are not quite the same in the banking sector. This might be explained by the fact that more concentrated banking markets usually go together with more financial stability, because few larger banks are generally more stable than many smaller banks. Then, the lower interest rates are explained by increased financial stability, not by market concentration or competition. Claessens and Laeven³² argue that the Herfindahl Index is an unsuitable proxy for competition in the banking sector. On the basis of our results, we can conclude the same. The competition effects on the market for loans to corporations are much smaller than on the market for loans for house purchase. Because corporate loans are much more heterogeneous than residential mortgages, information asymmetries may play a larger role in this market. On the corporate loan market, banks must put much more effort in the screening of their potential customers. These information asymmetries may cause market failures, which could explain the smaller competition effect we find.

The results of the estimation of the short-run ECM do not provide statistically significant results. However, the signs of the effects suggest that more competitive banking markets emphasize the pass-through of the effects of UMP to bank interest rates. This indicates that an increase in competitiveness in the banking market enhances the monetary policy transmission mechanism in the euro area.

5.1. Policy recommendations

Our analysis indicates that unconventional central bank policy is not enough. In addition, effective competition policy is needed to ensure a competitive banking climate.

In 2015, the Dutch Central Bank has pleaded for more diversification in the Dutch banking sector, and stated it is important to reduce the market concentration. Our results suggest, however, that a decrease in market concentration does not necessarily lead to more competition. Shortly after the Dutch Central Bank made its statement, the Dutch Authority for Consumers and Markets stated that more competition on the

³²Claessens and Laeven (n 2).

market for financing for SMEs is necessary. We add to the statement that a more competitive banking market also has its drawbacks. For instance, a more competitive banking market may incentivise banks to take on more risks, leading to more instability in the financial system.

Our results show that it is worthwhile to pursue a competitive banking sector, as it enhanced the pass-through. In the light of the recent bond-purchasing programme by the ECB, it is important to take the level of bank competition into account, since an increase in bank competition can result in an amplification of the effects of this programme. In their country-specific recommendations, the European Commission should take the level of competition in the banking sector into account. Market concentration does not measure the level of competition in the banking sector, so these recommendations should be made on the basis of direct competition measures such as the Boone indicator and the *H*-statistic.

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Disclosure statement

No potential conflict of interest was reported by the authors.