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Measuring competition in the UK deposit-taking sector

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Abstract

We use a new regulatory dataset to measure the intensity competition in the UK deposit-taking sector. The novelty of this study is two-fold. First, the dataset allows us to explore trends in competition intensity over an extended, 24-year period from 1989 to 2013 using data for UK-regulated firms which encompasses a wider range of firms than for previous studies. Second, we take a portmanteau approach and estimate a number of different performance-based competition measures common in the literature to support conclusions on the intensity of competition over the period. Our estimates of the Lerner index, the Panzar-Rosse H-statistic and the Boone indicator suggest that competition intensity was strong at the beginning of our sample, but became less intense in the early 2000s. However, the deposit-taker business model bundles together activities in several markets simultaneously, so strong competition in some markets can be offset by the extraction of market rents in others. Importantly, competition intensity decreased (and the ability of UK deposit-takers to extract market rents from customers increased) in the period immediately ahead of the financial crisis (2003–07).

Key words: Competition, banks, deposit-takers.

JEL classification: D22, D24, G21, L11, N20.

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1 Introduction

Accurate measures of competition intensity are important in understanding the influence of the banking industry in the wider economy. Anti-competitive practices and other market failures in banking can have negative consequences for productive efficiency and the cost of finance (Goddard and Wilson, 2004) with implications for consumer welfare and economic growth. Recent studies focus on the way competition can reduce systemic risk (e.g. Schaeck et al., 2009) for which measures of competition are key.

The objective of this paper is to use data on UK banks and building societies (collectively 'deposit takers') to investigate the intensity of competition in this sector over a relatively long time period and using different measurement techniques. Past empirical studies using UK data were more narrowly focussed on: industry structure (concentration) and competition intensity; specific (and generally limited) time periods; and/or on individual product types or services offered. For example, Logan (2004) studied concentration in UK bank loans and deposits for the period 1990-2004 and found that concentration in lending increased over the period but is generally more concentrated than retail deposits. Matthews et al. (2007) constructs two (non-structural) measures of competition intensity using an unbalanced panel of 12 large UK bank groups over the period 1980-2003. Using these measures they find that competition in core banking businesses was the same throughout the 1990s as it was in the 1980s and that generally that UK banks are monopolistically competitive. Schaeck and Cihák (2010) measure competition intensity for the period 1995-2005 using a sample of UK and European banks and find that competition between UK banks decreased over the period. Casu and Girardone (2009) use data for 79 UK banks (from a total sample of 2,701 European banks) to study competition and find that competition in the UK improved between 2002 and 2005 although the authors note that there is no evidence of increased competitive pressures across Europe as a whole. Finally, Weill (2013) constructs competition measures for European banks including 56 UK banks over the period 2002-2008 and finds that competition intensity peaked in 2003 and declined for the remainder of the sample period.

The novelty of this work is two-fold. First we use a new UK regulatory dataset of 127 deposit takers covering 24 years from 1989 to 2013. This is a broad dataset covering a period which straddles a number of UK economic cycles and includes the 2008 financial crisis and its aftermath. Second, to draw firm conclusions about the intensity of competition, we take a portmanteau approach by estimating all common measures used in the literature, rather than using a smaller sub-set of measures. We then compare the outcome of these measures with observed trends in the UK deposit-taking sector to explore how competition intensity has evolved over time, in particular since the significant reforms enacted in the 1980s and the periods immediately before and after the financial crisis.

This paper proceeds as follows. We review aspects of the literature relevant to this study in section 2. Section 3 reviews and discusses the intuition behind the measures of competition we use in this study. In section 4, we briefly discuss the new regulatory data and highlight the key issues and limitations of using

this data. We then present our econometric results for the measures of competition in section 5 and reconcile these outcomes with the recent history of the UK deposit-taking sector in section 6. Section 7 concludes.

2 Literature review

The structure-conduct-performance (SCP) hypothesis developed by Bain (1951) states that the industry structure determines the competitive conduct and performance of firms within that market. Under this hypothesis, more concentrated industries will be less competitive as the opportunities for collusion improve. The major structural changes in asset composition and market shares of banks and building societies that occurred in the UK following the 'big bang' deregulation of the 1970s and 1980s (Davis and Richardson (2010))[1] should therefore have signalled changes in the competitive landscape. However, Logan (2004) shows inconsistencies in outcomes for competition between UK banks: between 1989 and 2003 concentration in lending, as measured by the Herfindahl-Hirschman Index (HHI), increased (a decline in competition under SCP) while deposit concentration remained unchanged (no change in competition under SCP). However, many studies highlight that SCP-based measures fail to consider how firms compete in the markets so they tend to be poor estimates of the intensity of competition (e.g. Claessens and Laeven (2004)).

Another issue with UK banks during the period of our study is the effect the 1980s deregulation had on reducing entry barriers to banking services. In addition, the 1993 Second Banking Coordination Directive aimed to reduce formal barriers to entry in the EU, allowing European banks to operate in different markets. This increased competition, especially in non-traditional non-interest bearing products, increased efficiency and consolidation (Casu and Girardone, 2006). There is a well-established link between competition and efficiency where more efficient firms outperform less efficient ones, thereby gaining market share (Suarez and Perotti (2002); Degryse and Ongena (2008)) and driving overall industry efficiency up (Schaeck and Cihák (2014)).

Contestable markets theory, now ascendant in the literature, focusses on the influence of both existing incumbents and potential competitors rather than just incumbents on which concentration ratios are focussed (see Baumol et al. (1982)). This theory rejects the mechanistic link from structure to conduct and performance, an outcome borne out in more recent studies of the banking industry (e.g. Bikker et al (2014))[2]. These empirical studies of firm behaviour measure competition directly from performance-based data, such as revenues and costs (e.g. Matthews et al. (2007); Berger et al. (2009); Schaeck and Cihák (2010, 2012 and 2014)). The approaches used in this strand of the literature measure the departure of firms' performance with respect to the outcomes expected under perfect competition. Liu et al. (2013)

[1] Figure 1 in Davies and Richardson (2010) shows the wave of consolidation among large UK banks and building societies, but also shows that the four largest UK groups account for a smaller share of deposit-taking and lending services in 2010 than they did in 1960.
[2] Bikker et al. (2014) note that the empirical banking literature shows that concentration is generally a poor measure of competition given that some studies find that competitive conduct is more intense than the industry structure suggests while others find that market power is greater than industry structure suggests. As the authors note, "Since the mismatch can run in either direction, concentration is an extremely unreliable measure of performance."

discuss a range of performance-based measures highlighting that they require careful interpretation to assess competition and, ideally, a variety of such indicators should be used.

One performance-based measure frequently used in empirical work is the Lerner index (Lerner (1934)). Market power is proxied by the price mark-up over marginal cost. This measure remains popular and has been used in several recent empirical banking sector studies (e.g. Fernández de Guevara et al. (2007); Berger et al. (2009); Casu and Girardone (2009); Coccorese (2014)). Another indicator is the Panzar-Rosse H-Statistic which has been widely used in empirical banking studies (e.g. Claessens and Laeven (2004); Casu and Girardone (2006); Carbó et al. (2009); Schaeck et al. (2009); Schaeck and Cihák (2012)). The popularity of this indicator lies in its theoretical foundation of profit-maximising equilibrium conditions and its simple econometric setup based on easily available firm-level data (Bikker et al. (2012)). In addition, the H-statistic does not require a narrow market definition which is useful when considering bank business models spanning overlapping markets (Shaffer (2004)). A more recent development is the Boone indicator that looks at profits and measures of efficiency in competitive industries (Boone (2008)). This is an increasingly popular approach as it requires simple and easily available firm-level data (e.g. Schaeck and Cihák (2010, 2014); van Leuvensteijn et al. (2011)) and does not need observations on all firms in a market[3] (Boone (2008)).

These performance-based measures are not only theoretically more sound than structural measures but are driven by individual firm behaviour and do not generally require defining a narrow geographic market (Casu and Girardone (2006)). However, there are some caveats when interpreting these measures. The Lerner index assumes that firms are profit maximising but firms do not always operate with perfect technical and allocative efficiency. Koetter et al. (2012) develop adjusted versions of the index to address this problem. The Lerner index is measured with error because output prices and marginal costs are unobservable and are often estimated from total cost empirical models (Kumbhakar et al. (2012)). Another problem is that the average mark-up across all firms may not capture the degree of product substitutability making difficult to assess changes in competition (Vives (2008)). When measuring firms' mark-ups it is also important to take into account changes in efficiency. This is because firms may fail to minimise their costs introducing an error to empirical measures of the price-cost mark-up (Kumbhakar et al., 2012). New techniques to estimate mark-ups based on the stochastic frontier theory can overcome such limitations. Empirical tests using banking sector data show that these efficiency-corrected measures are highly correlated with return on assets (Coccorese, 2014).

Similarly, the H-statistic also requires careful interpretation. The H-statistic requires additional information about costs and market equilibrium to infer the degree of competition (Bikker et al. (2012)). A joint test of competitive conduct and equilibrium can address some of those problems. However, the test narrows the applicability of the revenue H-statistic to only those periods where the market is in a long-run equilibrium (Shaffer (1982)). More recent research demonstrates that the H-statistic can be

[3] The theory underlying the Boone indicator is about the relative profit difference between any three firms. Consequently, some measure of the intensity of competition is possible without observations for all firms in the industry.

sensitive to the way the test is specified, in particular when scaling the regression variables. Bikker et al. (2012) discuss how this problem affects many of the past studies using this technique and explain how to interpret the results in each case. Finally, there are cases when the H-Statistic can fail in which the Lerner index becomes a better indicator of market power (Spierdijk and Shaffer (2015)). Given the novelty of the Boone indicator in the literature, there is less exploration of outcomes than for the H-statistic. One limitation is that the Boone indicator is distorted where firms are not competing to maximise (short-term) profits but rather seek to build market share or where firm outputs are increasingly heterogeneous (van Leuvensteijn et al (2011)).

Table 2.1 below presents a summary of recent empirical studies using the measures discussed above. These studies use a range of methodologies and data, cover UK and non-UK banks and focus on the pre-crisis period.

Most studies include more than one performance-based measure, or combine them with a market concentration index. For example, Matthews et al. (2007) described UK banks as monopolistically competitive based on data from 1980 to 2000. The authors found that competition on core balance sheet activities was the same in the 1990s and 2000s as it was in the 1980s based on estimates of the H-statistic and Lerner index. In contrast, they found that competition in non-core balance sheet activities worsened significantly during the 1990s.

Table 2.1: Recent estimates of competition measures

Study	Region	# UK Banks[1]	Period under study	Measures[2]	Periodicity of estimates
Berger et al (2009)	World	43	2007	HHI, L	Average for period
Bikker et al (2012)	World	73	1994–2004	PRH	Average for period
Carbó et al (2009)	EU	58	1995–2001	HHI, L, PRH	Average for period
Casu and Girardone(2006)[3]	EU	63	1997–2003	CR, PRH	Average for period
Casu and Girardone(2009)	EU	73	2000–2005	L	Annual
Claessens and Laeven(2004)	World	106	1994–2001	PRH	Average for period
Coccorese(2014)	World	116	1994–2012	L	Annual
Fernández de Guevara et al (2007)	EU	45	1993–2000	L	Annual
Goddard and Wilson (2009)	G7	166	2001–2007	PRH	Average for period
Logan(2004)	UK	357	1989–2003	CR, HHI	Annual
Matthews et al (2007)	UK	11	1980–2004	PRH, L	Average for sub-periods
Schaeck and Cihák (2010)	EU	–	1995–2005	B	Annual
Schaeck and Cihák (2012)	EU	43	1999–2005	PRH	Average for period
Schaeck and Cihák (2014)	EU	43	1995–2005	B	Annual
Schaeck et al (2009)	World	–	1998–2005	PRH	Average for period
Weill (2013)	EU	56	2002–2008	L, PRH	Annual
van Leuvensteijn et al (2011)	EU + G2	140	1992–2004	B	Annual

Source: Authors

Notes:
[1] Total number of UK banks reported in the study
[2] Measure(s) of competition used in the study. CR = concentration ratios; HHI = Herfindahl-Hirschman Index; L = Lerner index; PRH = Panzar-Rosse H-statistic; B = Boone indicator
[3] Casu and Girardone (2006) contains a similar table for earlier studies of competition in the banking sector

Fernández de Guevara et al (2007) found that the EU deregulation process did not improve competitive conditions for the period 1993-2000. Their estimate of the Lerner index for the UK shows that market power increased in the late 1990s and early 2000s. Carbó et al. (2009) compared the HHI with the Lerner index for the UK and found these measures are strongly and positively correlated over the period 1995-2001. Girardone and Casu (2006) concluded that the EU financial market is monopolistic competitive based on their study of EU banks for the period 1997-2003. The authors also found that the UK has a low competition score (as measured by the H-statistic) in spite of having a large number of banks compared to other European countries. In addition, they suggest that the banks with highest inefficiencies and costs might also generate the greatest profits in Europe. In a separate study, Girardone and Casu (2009) estimated the Lerner index for a number of European countries over the period 1999-2005 and found that market power in the UK as measured by the Lerner index fell slightly in both 2004 and 2005. They also found that this trend was accompanied by a fall in efficiency from 2000-2005. This is consistent with their main findings that more market power in Europe does not lead to higher inefficiencies.

Schaeck and Cihák (2014) estimated the Boone indicator for several European countries for the period 1995-2005 and found that competition in the UK fell steadily over the period (and consistent with estimates of the Boone indicator for the UK over the period 1994-2004 by van Leuvensteijn (2011)). The authors found that competition improved between 1998 and 2001 but subsequently fell steadily until 2004. The authors concluded that the UK had one of the least competitive banking sectors amongst developed countries. In a separate study, Schaeck and Cihák (2012) estimated the H-Statistic for the UK over the period 1999 to 2005 and found that small banks in the UK were more competitive than large banks over the same period.

Overall these studies suggest that the best representation for UK banks is one of monopolistic competition with firms enjoying some market power. The results also suggest that since the year 2000 competition intensity in the UK deteriorated.

3 Review of measures used in this study

In this section, we review the measures from the literature that we use in this study to understand trends in competition. We begin with a measure of industry concentration, the HHI and then discuss three performance-based measures: the Lerner index, the Panzar-Rosse H-statistic, and the Boone indicator.

3.1 The Herfindahl-Hirschman Index (HHI)

The HHI is constructed directly from the data and is generally straightforward to calculate. The HHI calculates concentration as the sum of the square of each firms' share in an industry or market, that is:

$$HHI = \sum_{i=1}^{N} s_i^2 \tag{1}$$

where s_i is the share of firm i in the market and N is the total number of firms. As firm share is calculated on a scale between 0 and 100, the HHI ranges from close to zero (a very large number of firms with very small market shares) to a maximum value of 10,000, in which a single firm holds a monopoly.

The HHI provides background on industrial sectors and/or markets, although it tells us little about the intensity of competition. Competition authorities in the UK (and elsewhere) make use of the HHI as an indicator of the *likelihood* that there could be a competition issue worthy of investigation. For example, an industry with an HHI of greater than 1000 is considered concentrated (and potentially worth of investigating) while an HHI of greater than 2000 is considered highly concentrated (Competition Commission (2014)). Competition authorities also use the HHI to signal whether merger activity warrants investigation under competition powers. A horizontal merger generating an increase in the HHI of less than 250 in a concentrated market is not likely to give cause for concern while in a highly concentrated market, an increase in the HHI of less than 150 is not likely to give cause for concern (Competition Commission and Office of Fair Trading (2010)). More generally, any event that generates increases in the HHI as noted above could also be worthy of investigation. There are a number of mergers in our dataset so these reference points are worth noting.

3.2 The Lerner Index

The Lerner index is a measure of price-cost margin and is premised on the outcomes that: in perfect competition the output price (equal to marginal revenue) equals marginal cost (i.e. economic profits should be zero); and in a quantity-setting, Cournot static oligopoly model price rises above marginal cost as firm market power increases. Consequently, divergence of measured price-cost margin from zero should be an indicator of market power (Lerner (1934)).

3.2.1 The standard approach

Under the standard approach used in the literature, the aggregate Lerner index (L) is computed as:

$$L = \frac{P - MC}{P} \tag{2}$$

where P is the output price and MC is the marginal cost, aggregated for all firms.

For the financial sector, the difficulty in measuring prices of output goods and marginal costs is particularly acute. Deposit takers are involved in multiple activities, some of which can be defined as both outputs and inputs[4]. We take the approach common in the literature that deposit-takers predominantly have an intermediation role and that deposits are an input to the production of other products (such as loans). In line with the empirical literature we take a single output approach (Berger et al. (2009), Fernández de Guevara et al. (2007)), defining output price P from equation (2) as interest and

[4] For example, Berger and Humphrey (1997) propose a 'production approach' to banking, where deposits are a product providing services to customers while Freixas and Rochet (1998) propose an 'intermediation approach' in which deposits are an intermediate input in the production of loans.

non-interest income (revenue associated with total output) per unit of total output proxied by total assets. We also consider total loans as a single output alternative (Kick and Prieto (2013), Coccorese (2014)) on the basis that credit intermediation is the main activity for banks.

Marginal cost MC is not directly observable for a particular firm or for individual products supplied by a firm. Empirically, standard estimates of the Lerner index are therefore derived by estimating the parameters of a total cost function from individual firm data and deriving the marginal costs from the equation parameters. For deposit-taking firms, the Lerner index is commonly calculated by assuming a total cost function of the form:

$$\begin{aligned}\ln(C_{i,t}) = \alpha_0 + \alpha_1 \ln Q_{i,t} + \frac{\alpha_2}{2}(\ln Q_{i,t})^2 + \sum_{j=1}^{3} \beta_j \ln(W_{j,i,t}) \\ + \frac{1}{2}\sum_{k=1}^{3}\sum_{j=1}^{3} \alpha_{kj} \ln W_{k,i,t} \ln W_{j,i,t} + \sum_{j=1}^{3} \delta_j \ln(W_{j,i,t}).\ln Q_{i,t} + \lambda_1 E_{i,t} \\ + \frac{\lambda_2}{2} E_{i,t}^2 + \theta_1 T + \theta_2 T^2 + \sum_{j=1}^{3} \lambda_j T \ln(W_{j,i,t}) + \Phi' X_{i,t} + \varepsilon_{i,t}\end{aligned} \quad (3)$$

where $C_{i,t}$ is total cost (or expenses) for bank i at time t, $Q_{i,t}$ is total assets, a proxy for bank output[5], $W_{j,i,t}$ are input prices reflecting labour costs (W_1), physical capital (W_2) and funding costs (W_3), $E_{i,t}$ is bank capital, T is a time trend and $X_{i,t}$ contains a number of control variables which may impact on the firm production technology (e.g., period fixed effects, as in Berger et al. (2009)). The α, β, δ, λ, θ and Φ in equation (3) are parameters to be estimated from data (see section 5 for detail).

The measure of marginal cost used in the calculation of the Lerner index is then derived from the estimates in equation (3) as:

$$MC_{i,t} = \frac{\partial C_{i,t}}{\partial Q_{i,t}} = \left(\alpha_1 + \alpha_2 \ln Q_{i,t} + \sum_{j=1}^{3} \delta_j \ln(W_{j,i,t})\right)\frac{C_{i,t}}{Q_{i,t}} \quad (4)$$

3.2.2 The stochastic frontier approach

We also construct an alternative estimate of the Lerner index following Kumbhakar et al. (2012). This alternative estimate is based on the observation that, as price must be greater than marginal cost, the relationship between price, marginal cost and output can be written as[6]:

$$\frac{P_{i,t}Q_{i,t}}{C_{i,t}} = \frac{\partial\, ln\, C_{i,t}}{\partial\, ln\, Q_{i,t}} + u_{i,t}, \qquad u_{i,t} \geq 0 \quad (5)$$

[5] Most studies use total assets as an output measure as income by type of bank activity is not always be available. See, for example, Fernández de Guevara et al. (2007), Berger et al. (2009) or Weill (2013). As a robustness check of our results we use total loans as a proxy for output in section 5.2.

[6] If $P \geq MC$ then $P.\left(\frac{Q}{C}\right) \geq MC\left(\frac{Q}{C}\right) = \left(\frac{\partial C}{\partial Q}\right)\left(\frac{Q}{C}\right) = \frac{\partial \ln C}{\partial \ln Q}$. See Kumbhakar et al (2012) for details.

where $P_{i,t}Q_{i,t}/C_{i,t}$ is the ratio of total revenue ($P_{i,t}Q_{i,t}$) to total costs and $u_{i,t}$ is a measure of the markup applied by the firm over marginal cost.

Assuming a total cost function similar in form to that in equation (3), the mark-up $u_{i,t}$ can be estimated directly from the following relationship using the stochastic frontier methodology:

$$RC_{i,t} = \gamma_1 + 2\gamma_2 \ln Q_{i,t} + \sum_{j=1}^{3} \mu_j \ln(W_{j,i,t}) + \rho T + \eta E_{i,t} + u_{i,t} + v_{i,t} \quad (6)$$

where $RC_{i,t}$ is the ratio of total revenue to total cost and $v_{i,t}$ is the error term. One advantage of this approach is that it does not require a separate estimate of output prices as for the standard Lerner index in equation (2). However, it requires an additional behavioural assumption for the mark-up term $u_{i,t}$ which can only be positive and is restricted to be the positive half of a normal distribution.[7] The error term $v_{i,t}$ is a two-sided random process that does not reflect market power but rather uncertainty on the part of the firm when pricing their products. Kumbhakar et al. (2012) then show that the Lerner index can be calculated using the relationship between the estimated one-sided mark-up ($\hat{u}$) and the elasticity of total cost to output ($\mathrm{E}_{TC,Q}$) as follows:

$$L = \frac{\hat{u}}{\mathrm{E}_{TC,Q} + \hat{u}} \quad (7)$$

where the elasticity of total cost to output term ($\mathrm{E}_{TC,Q}$) is derived from the deterministic element of equation (6) as follows:

$$\mathrm{E}_{TC,Q} = \hat{\gamma}_1 + 2\hat{\gamma}_2 \ln Q_{i,t} + \sum_{j=1}^{3} \hat{\mu}_j \ln(W_{j,i,t}) + \hat{\rho} T + \hat{\eta}\, E_{i,t} \quad (8)$$

3.3 The Panzar-Rosse H-statistic

The Panzar-Rosse H-statistic considers the transmission of input costs through to firms' revenues as estimated by the sum of the elasticities of revenue to the underlying input prices. Weak pass-through of costs to revenues is interpreted as a greater exercise of market power, while full pass-through is indicative of highly competitive markets. To understand the intuition behind the H-statistic, it is useful to consider the two extremes cases of perfect competition and monopoly.

Under perfect competition, each firm in equilibrium earns zero economic profits. Costs are homogeneous of degree one in input prices, so any change in input prices induces an equal change in marginal costs. A

[7] Together, the mark-up term $u_{i,t}$ and the error term $v_{i,t}$ make up the compound error term as commonly set out in the stochastic frontier literature. We follow the suggestion in Kumbhakar et al (2012) and assume that $u \sim N^{+}(0, \sigma_u^2)$ and $v \sim N(0, \sigma_v^2)$ where N^{+} is the normal distribution truncated at zero from below.

sustained increase in input costs will generate negative economic profits in the short term. To restore zero economic profits, some firms exit the market, reducing aggregate supply and raising output prices such that remaining firms' revenues exactly offset the increase. The elasticity of firms' revenue to costs will therefore be unity in the perfect competition case.

In contrast, a monopolist sets prices in the market where demand is elastic as this is where marginal revenue is positive.[8] The monopolist responds to an increase in input costs by reducing production and so total revenue falls as demand is elastic and the resulting increase in price is not sufficient to offset the reduction in the output. The elasticity of the monopolists revenue to costs is therefore negative. Intermediate values for the H-statistic reflect varying degrees of monopolistic competition with the intensity of competition diminishing as values move from one (perfect competition) towards zero (increasingly imperfect / monopolistic competition) (see Rosse and Panzar (1977) and Panzar and Rosse (1987)). The H-statistic will be negative for a perfect monopoly, although in practical terms the index generally varies between one (strong competition) and zero (weak competition).

The H-statistic is derived from a fixed effects panel regression of the following form:

$$\ln(TR_{i,t}) = \alpha + \sum_{j=1}^{J} \beta_j \ln(C_{j,i,t}) + \theta' X_{i,t} + \eta_{i,t} \tag{9}$$

where $TR_{i,t}$ is the total revenue for firm i at time t, $C_{j,i,t}$ is input cost factor j and $X_{i,t}$ is a vector of exogenous control variables. The H-statistic itself is calculated as the sum of the coefficients on each factor cost, i.e.

$$H = \sum_{j=1}^{J} \beta_j \tag{10}$$

3.4 The Boone Indicator

The intuition behind the Boone indicator relies on the so-called 'output-reallocation effect': more efficient firms are able to expand their output at lower cost than less-efficient firms when competition intensity increases, leading to higher profits for more efficient firms. As competition becomes more intense, less-efficient firms become increasingly unprofitable and leave the market, leaving more efficient firms able to expand output and profitability – hence output is reallocated to more efficient

[8] Total Revenue is equal to price times quantity, $TR = P \times Q$. Marginal revenue can be derived using the product rule as $MR = \frac{\partial(PQ)}{\partial Q} = P + Q\frac{\partial P}{\partial Q} = P\left[1 + \frac{\partial P}{\partial Q}\frac{Q}{P}\right]$. The elasticity of demand is defined as $\mathrm{E}_D = \frac{\partial Q}{\partial P}\frac{P}{Q}$, so marginal revenue becomes $MR = P\left[1 + \frac{1}{\mathrm{E}_D}\right]$. Demand is elastic where $-\infty < \mathrm{E}_D < -1$ which implies a positive marginal revenue, while inelastic demand (where $-1 < E^D < 0$) implies negative values for marginal revenue. A monopolist will always set production on the elastic part of the demand curve where marginal revenue is positive.

firms when competition intensity increases. An increase in competition intensity can arise from either greater interaction between incumbent firms or lower barriers to entry.

Formally, Boone (2008) describes this effect as follows: for any three firms in a market with levels of efficiency n, n', and n'' such that $n'' > n' > n$, an increase in the intensity of competition benefits the most efficient firms such that the profit difference between the most and least efficient firms $\big(\pi(n'') - \pi(n)\big)$ rises faster than the profit difference between a less efficient firm and the least efficient firm $\big(\pi(n') - \pi(n)\big)$ and the ratio $[\pi(n'') - \pi(n)]/[\pi(n') - \pi(n)]$ increases. Boone demonstrates that this relationship between efficiency and output is consistent with a broad set of models of competition.[9]

Empirically, the measures of profits and efficiency are determined as follows. First, profits are defined in terms of total revenues and variable costs (see Boone (2008) for discussion of variable definitions). Efficiency is measured in terms of average variable costs, defined as variable cost scaled by revenue derived directly from current activity, such as interest and fees, foreign exchange and investment income received.

In practice, the Boone indicator is estimated as the time fixed effects coefficient on variable costs using an equation of the form:[10]

$$\pi_{i,t} = \alpha + \beta_t \ln(c_{i,t}) + \Phi X_{i,t} + \eta_{i,t} \tag{11}$$

where $\pi_{i,t}$ are the variable profits, $c_{i,t}$ are average variable costs and $X_{i,t}$ are control variables for each firm i at period t. The Boone indicator is the estimated coefficient β_t derived for each period t, allowing comparisons through time.

3.5 Interpretation of performance-based measures

The performance-based measures provide us with different perspectives on the divergence of outcomes from what we would expect in perfectly competitive markets. Each measure has a different theoretical foundation, focussing on a different aspect of competition outcomes. Table 3.1 sets out the key characteristics of each of the measures we consider in this study.

The theoretical outcomes for perfect competition against which these measures are benchmarked are generally those that arise in the absence of market failures, such as information asymmetries and externalities. These market failures tend to raise entry and exit barriers, introduce sunk costs and limit the propagation of production technologies. Moreover, these same market failures can also be sources of financial instability when present in the deposit-taking sector. In this sense, the perfect competition outcomes embedded within the performance-based measures we consider are not necessarily aligned with a particular outcome for financial stability.

[9] Models include, but are not limited to, competition based on quantities (Cournot) and price (Bertrand). See Boone (2008).
[10] See Boone et al. (2007) for details.

Table 3.1: Characteristics of measures of competition intensity

Measure	Theoretical Range	Value at perfect competition	Direction indicating increasing intensity of competition	Concept underpinning perfect competition outcome
Lerner index	0 to 1	0	↓	Economic profits driven towards zero
H-Statistic[1]	0 to 1	1	↑	Full pass-through of costs to revenue
Boone indicator[2]	-∞ to 0	-∞	↓	Output reallocated to more efficient firms

Notes:
[1] The H-statistic can take on negative values for a pure monopoly but for practical purposes is bound between 0 and 1
[2] Under perfect competition, the elasticity of profit to costs is negative infinity as any increase in costs drives firms to exit the market. In practice, estimates of the Boone indicator will be negative, with values approaching zero as competition intensity decreases.

4 Data for the UK regulated deposit taking sector

We use a newly-compiled dataset of the UK deposit-taking sector in this study (de-Ramon et al. (2016a)). The dataset is drawn from regulatory reports generated by a number of different agencies[11] to produce a large, unbalanced panel dataset that includes all UK-regulated deposit takers. Deposit takers include two distinct business models: banks and building societies. Banks are incorporated and have freedom to undertake a wide range of activities (including non-financial business); building societies have a mutual ownership structure and have restricted funding and lending requirements.[12] The data are reported on a semi-annual basis for the period 1989 to 2013 and includes firms' balance sheet and profit and loss data.

We also focus on firms that undertake traditional financial intermediation roles – that is transforming deposits into loans (regardless of whether deposits or loans are from the household or corporate sectors).

Table 4.1: Regulated firms by business models

	Number of:	
	firms	**observations**
By business model		
Banks	105	2967
Building societies	21	545
By activity		
Traditional model[1]	74	2080
Non-traditional model	27	551
Mixed model[2]	25	881
– proportion of traditional activity[3]		55%
Total	126	3512

Source: Bank of England, Authors' calculations

Notes:
[1] The traditional model is defined where firms loan-to-assets ratio is greater than 10% and a deposit-to-assets ratio is greater than 20%
[2] Firms that operated under both traditional and non-traditional models at different points in the sample
[3] Average proportion of observations for which mixed model firms operated under the traditional model

[11] Regulatory data were collected by three different agencies – the Bank of England, the Financial Services Authority (FSA) and the Financial Conduct Authority (FCA) – over the period 1989-2013. In addition, there were a number of changes to the data collected resulting from changes to the regulatory regime, in particular the move from Basel I to Basel II, which needed to be reconciled.
[12] Building societies are owned by their deposit holders (members), 75% of business assets must be loans fully secured on residential property and 50% of the funds (liabilities) must be held by members.

We have excluded those firms that either do not fund their activities significantly with deposits or use their funding to provide loans.[13] The excluded firms are largely focussed on trading activities or other financial market products, and in general are not competing with the more traditional role of financial intermediation. Where firms have a 'mixed model', using both traditional and non-traditional models at different points in time, we have excluded only those observations where the non-traditional model was dominant. Table 4.1 above provides a summary of the types of firms in the data.

Table 4.2: Selected data[1]

	Mean	Standard deviation	Median	Minimum	Maximum
Key variables					
Total expenses (£ mn)	1609.8	5243.7	199.3	0.8	62527.5
Input costs					
(i) Staff costs (£ mn)	333.8	1437.5	33.9	0.1	14761.5
– ratio to total assets (%)	1.631	3.110	0.941	0.030	54.894
(ii) Physical capital (£ mn)	342.8	1430.8	25.9	0.3	15283.2
– ratio to total fixed assets (%)	340.9	1349.0	126.9	1.3	37194.5
(iii) Funding costs (£ mn)	934.7	2789.0	123.8	0.1	34009.0
– ratio to total deposits (%)	5.686	5.639	4.904	0.060	159.711
Total revenue (£ mn)	2056.4	7023.7	248.8	1.0	91521.4
– ratio to total expenses (%)	124.8	18.8	120.6	16.6	235.8
– ratio to total assets (%)	8.582	6.530	7.418	0.239	111.154
Variable profits (£ mn)	449.9	1963.5	38.4	-336.1	34778.5
– ratio to total assets (%)	0.599	1.055	0.489	-14.303	9.223
Variable costs (£ mn)	1272.9	4011.7	169.9	0.4	61674.5
– ratio to total revenue (%)	66.89	13.19	69.16	34.59	89.13
Control variables[2]					
Total assets (£ mn)	47734	203137	3474	1.7	1925711
Average risk weight (%)	56.08	19.22	52.20	3.88	136.13
Provisions to assets ratio (%)	1.401	3.622	0.655	0.003	53.060
Tier 1 to total capital ratio (%)	83.23	21.25	81.83	34.12	237.62
Total loans to assets ratio (%)	53.82	26.12	58.40	0.00	99.33
Non-financial deposits to total deposits ratio (%)	73.94	26.86	82.76	0.00	100.00
Non-earning assets to total assets ratio (%)	2.593	4.718	0.899	0.001	82.688

Source: Bank of England, Authors' calculations

Notes:
[1] Data are for firms with traditional model defined where loan-to-assets ratio is greater than 10% and deposit-to-assets ratio is greater than 20%[2] The bank-level control variables are used in the regressions to estimate the different indicators. These variables represent additional costs (e.g. Tier 1 to total capital ratio) or attitudes to risk (average risk weight of provisions to assets ratio) (see Leon (2014)).

Table 4.2 above sets out summary statistics of key variables from the dataset used for the estimates in this study. These statistics demonstrate clearly the varied scope of firms in our dataset: total assets range in value from £1½ million to £1.9 trillion with a median value of £3½ billion. Measures of input prices (staff costs to total assets ratio, fixed investment costs to total fixed assets, funding costs to total deposit ratios) are less skewed than for the cost data (staff costs, physical capital, funding costs). The capital strategies of firms vary considerably: the ratio of tier 1 capital to total capital (a measure of the quality of deposit-takers' capital) has a mean value of 83.2% and median of 81.8%, but ranges from 34.1% to

[13] We exclude those firms that have a loan-to-assets ratio of less than 10% and a deposit-to-assets ratio less than 20%, consistent with other studies focussed on competition between deposit takers.

237.6%. Ratios greater than 100% mean that firms hold Tier 1 instruments that are not eligible (i.e. exceed the maximum allowed) to meet regulatory requirements, suggesting some firms hold considerably more Tier 1 capital than is strictly necessary. Differences are also evident in: the portfolios of deposit-takers as shown by average risks weights (range 3.9% to 136.1%, median 52.2%); and loss performance as shown by provisions (range 0.003% to 53.1% of assets, median 0.7% of assets).

It is worth highlighting three other properties of this dataset that are pertinent for our estimates.

Competition between business models. Financial intermediation activities by UK firms comprise business models that tie together products and services across a number of markets. These markets include deposits, corporate bonds and equity on the liabilities side of their balance sheets, and loans to both the household (unsecured loans, such as personal loans and credit cards, and mortgages) and corporate market segments on the assets side. Banks' business models bundle deposit taking and lending with payment services to households, corporates and other financial firms in diverse ways. In contrast to competition data on homogenous industries, the bank-level data we use relate to the competition among somewhat heterogeneous business models.

There are different potential sources of competition from outside the deposit-taking sector in each of these potential markets, for example money market funds, non-bank securitisers, peer-to-peer lenders (P2P) (although not significant in our sample period) and new technology firms competing on payments services. That said, none of these competitors are able to tie together markets in the same way deposit takers[14] do, such as with the provision of overdraft facilities / credit lines (loans) with current accounts (deposits). The continued ability of the deposit taking business model to expand in size and remain profitable over the time frame of this study (and the inability of other business models to completely disintermediate the deposit-taking business model) suggest an overall equilibrium across markets must exist in which deposit takers compete effectively with other business models. Nevertheless, the extent of competition from non-deposit takers has been significant in some markets in which deposit takers operate, in particular the market for retail mortgages which is not explicitly taken into account here.

In practical terms, we are constrained by the limitations of the data on deposit-takers' balance sheets and profit and loss statements. Funding on the liability side of deposit-taker's balance sheets is fungible, making any direct matching of funding costs on the liability side of a deposit-taker's balance sheet with outputs on the asset side of the balance sheet (i.e. loans) arbitrary[15] and any measures including non-deposit taking firms as part of the sample would be sensitive to this assumption.

Group consolidated versus solo level data. Regulatory data for deposit takers are collected on both a group-consolidated and solo basis for UK regulated firms. Solo level data reflect both the operations of

[14] As deposit-taking is a regulated activity in the UK, no firms outside our deposit-taker population can replicate this business model.
[15] We note here that pricing practices of deposit takers will influence this outcome. Some banks may directly link sources of funding to products, but other do not. Unfortunately information on deposit takers' pricing strategies and how they may change over time is not available.

stand-alone firms and of subsidiary-level entities within a wider group, including operations within a narrow geographic definition of the UK. In contrast, the group consolidated data include all global exposures for the group. Using solo data would allow us to focus on the operations within the clearly defined UK geographic boundary. However, groups operating in the UK use their global operations to source funding (deposit or wholesale) and otherwise provide competitive advantage to firms.[16] Omitting global operations would exclude this information from the data. One additional advantage of using group consolidated data is that we can avoid distorting measures of competition when coordination by solo-level firms within the same group means that these firms may not compete with each other. We have consistently used group consolidated data throughout which means that the data include both UK domestic and international exposures.

Treatment of mergers. In the regulatory data base, deposit-takers that merge can continue to report data for both entities, using one entity as the merged group and the other as a solo entity, or report both entities on a solo basis and submit data for a third entity as the group.[17] We use the group consolidated data from the point at which the merger is effective and exclude subsidiaries that are included within the group but that continue to report solo data. As with the use of group consolidated data noted above, this can avoid any distortion of competition measures where coordination within the group might affect individual firm behaviour. It is possible that some information on competitive conduct could be excluded where the influence of group decisions does not immediately affect the conduct of newly acquired subsidiaries. Even so, it is not possible to determine subsequently when any influence might be exerted by group management so we use group data from the date of the merger.

5 Empirical results

In this section, we estimate the indicators discussed in section 3 based on the individual deposit-taker data available in our dataset. Appendix 1 provides a brief description of the data used for each indicator. All performance-based measures are derived from parameters estimated from panel regressions.

5.1 The Herfindahl-Hirschman Index (HHI)

We calculate the HHI shown in equation (1) using data on total assets for traditional model deposit takers. Figure 5.1 below shows the progression of the HHI over the sample.

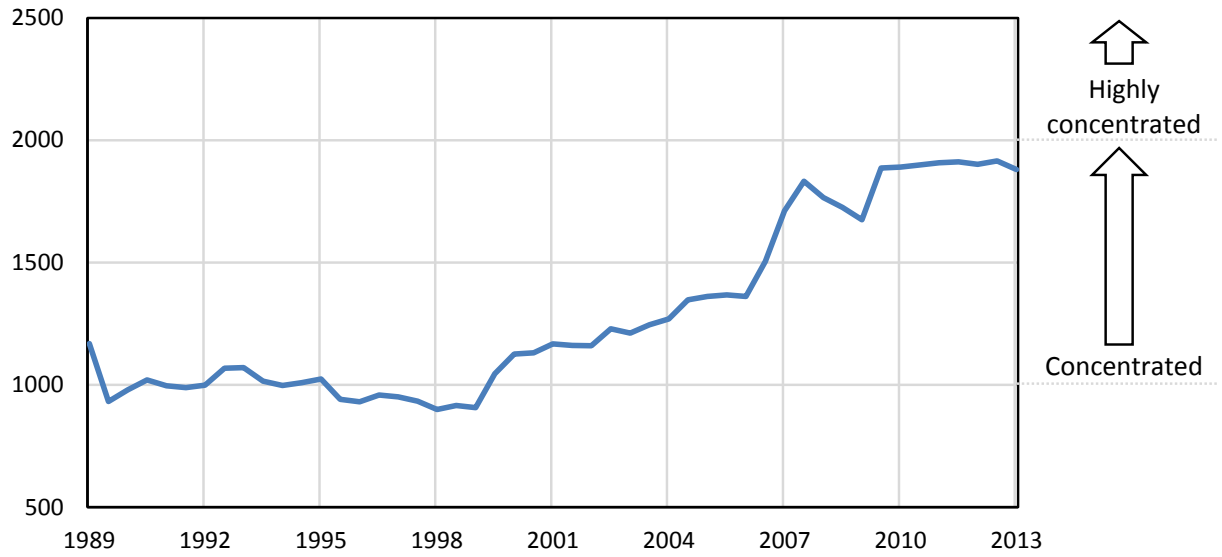
The value of the HHI for total assets indicates that the deposit taking sector is on the border of being concentrated over the first decade of the sample. Mergers in 2000 (Barclays and Woolwich Building Society; Royal Bank of Scotland and National Westminster Bank) saw the HHI move from 907 at the end of 1999 to 1,130 by end 2000. Concentration then continued to rise steadily reflecting both faster growth by larger banks and the ongoing absorption of smaller banks. The purchase by RBS of the ABN

[16] The potential advantages include: using the size of the global balance sheet to provide lending to large, multinational corporates across multiple jurisdictions; greater diversification of profits leading to more opportunities for cross-subsidisation of national businesses (deep pockets); and greater scope for development and propagation of innovative products.

[17] Firms were given discretion as to which entities reported group consolidated data and whether to continue to report solo data for each subsidiary entity following a merger.

AMRO businesses in 2007 saw the HHI rise by 470 points from 1,362 in 2006 to 1,832 in mid-2008, an increase of more than three times the 150 point increase that competition authorities note could give rise to concerns about competition in an already concentrated market (i.e. a market with a $HHI > 1{,}000$). Lastly, the merger of Lloyds Banking Group and HBOS, along with Barclays purchase of Standard Life Bank, increased the HHI by 213 points to 1,887 in the first half of 2010. Concentration subsequently remained high at around 1,900, close to the 2,000 threshold for a highly concentrated industry.

Figure 5.1: Herfindahl-Hirschman Index – Total Assets[1]



Source: Bank of England, Authors' calculations

Notes:
[1] For deposit-takers using traditional finance model

However, the implications of this measure of the HHI for competition are not clear for a number of reasons: the HHI provides no indication of the contestability of the sector; the use of group data means expansion into non-UK markets can distort the measure; and total assets are not representative of any particular market in which deposit-takers operate. We calculate the HHI for deposits, total loans, mortgages and unsecured loans in Figure A2.1 of Appendix 2 and find a similar pattern for deposits and total loans (reflecting the selection of the traditional financing model). However, concentration in the unsecured loans sector is considerably higher than for total loans, while concentration in mortgages remained considerably lower than for assets until 2009, after which the increase in concentration reflects a number of mergers (most notably the merger of Lloyds and HBOS in late 2008).

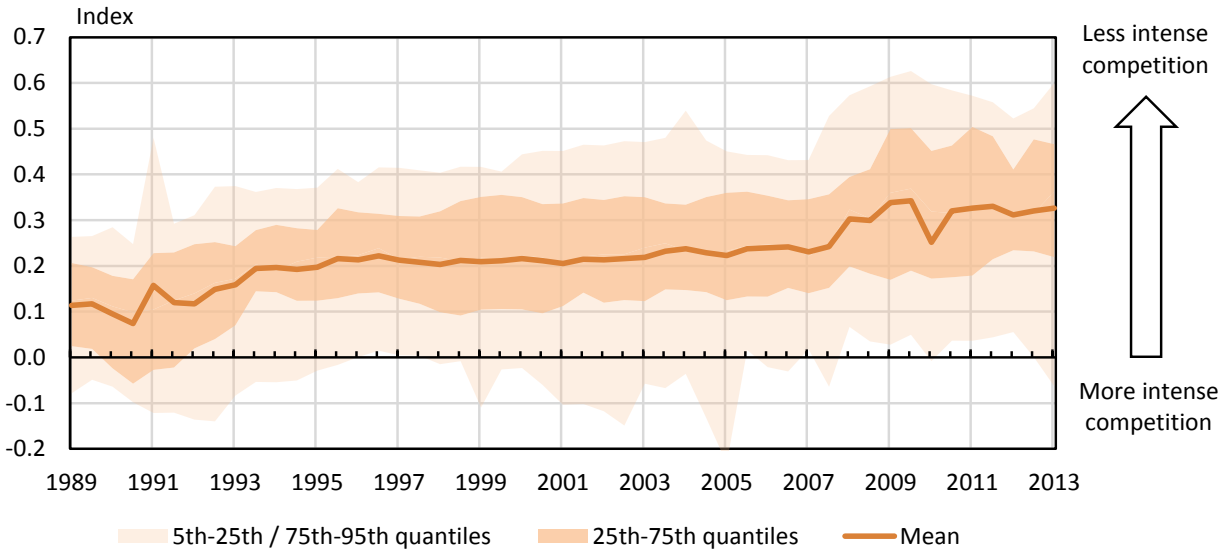
5.2 The Lerner Index

We follow Berger et al. (2009) to estimate the marginal cost and output price for the standard approach to the Lerner index (discussed in section 3.2.1) and follow Kumbhakar et al. (2012) to measure the Lerner index indirectly using the stochastic frontier approach (see section 3.2.2). We estimate a third version of the index using the standard approach which is a market power proxy for credit provision only and excludes other services provided by banks (Kick and Prieto (2013) and Coccorese (2014)). Finally,

we provide additional robustness tests by estimating Lerner indices over data sub-periods to help ensure average cost function parameters are well behaved.

The total cost function in equation (3) is estimated using a panel regression with fixed cross-section effects and clustered errors to allow for intragroup effects.[18] We use total wage and operational expenses as well as interest paid[19] by firms to measure total costs ($C_{i,t}$ in equation (3)). For input prices we proxy: staff costs ($W_{1,i,t}$) using the ratio of annual personnel expenses to total assets; physical capital ($W_{2,i,t}$) using the ratio of other operational expenses (non-interest, non-labour) to fixed assets; and average firm funding rate ($W_{3,i,t}$) using the ratio of interest expense to total deposits. We proxy total output ($Q_{i,t}$) by using total assets and use the ratio of total revenue to total assets to proxy banks' output price (P in equation (2)). To ensure linear homogeneity in the input costs, we divide total costs and input prices by the average firm funding rate $W_{3,i,t}$. The Lerner index is calculated for each bank and we take the mean as the aggregate measure. Figure 5.2 shows the evolution of the average Lerner index among all banks and the range measured by the 5th, 25th, 75th and 95th quantiles.[20]

Figure 5.2: Lerner index – standard calculation



Source: Author's calculations

Figure 5.2 shows that the Lerner index increases steadily over the period, with the average moving from 0.1 in 1989 to just over 0.3 in 2009 at the height of the financial crisis and remains mostly above 0.3 until the end of the sample. The index is stable within a range of 0.21 and 0.24 between 1997 and 2007 suggesting that market power did not change significantly over an extended period of time, although we note that margins were, on average, higher over the second half of this period. Between 1998 and 2007

[18] Estimating the Lerner index using other permutations (e.g. time fixed effects) produces similar results.
[19] We include interest paid as part of total costs as this is consistent with the assumption that firms are financial intermediaries and deposits and bond liabilities are inputs (and not outputs). See discussion in section 3.2.1
[20] The Lerner index is calculated for each firm using the estimated relationship. The central estimate of the Lerner index is calculated as the average for all firms at each point in time. The quantiles correspond to the distribution of Lerner index calculations for each firm.

the values of the index taken by different banks (the quantile range) widens with respect to earlier periods. After the 2008 financial crisis the range widens even further and the average increases.

To check the robustness of the estimated parameters in the marginal cost function, we re-estimate the Lerner index over four sub-periods.[21] The sub-periods are between 6 and 8 years long, overlap slightly and coincide with significant changes in the UK financial and regulatory infrastructure (as described in de-Ramon et al. (2016a) and de-Ramon et al. (2016b)): (1) 1989 to 1996 which covers the first Basel accord; (2) 1996 to 2002 which includes the introduction of the market risk amendment to the Basel accord, increased trading assets and ends with the bursting of the 'dot-com' bubble; (3) 2002 to 2008 which begins with the creation of HBOS and ends with the onset of the financial crisis; and (4) 2008 to 2013 which includes the post-crisis industry consolidation and subsequent contraction in economic activity.

Figure A2.2 in Appendix 2 shows estimates for each of the four sub-periods along with our central, full sample estimate. We note that the full sample estimate is contained within the 25-75% quantile range of all the sub-period estimates (and coincides exactly with the sub-period (3) estimate). Moreover, while the estimates in sub-periods (1), (2) and (4) do not coincide with the level of the full sample estimate, the patterns within sub-periods (1) and (2) are the same – that is, market-power increases over time. Sub-period (4) also broadly moves in line with the full-sample estimates, although market power starts to decline at the end of this sub-period. One trend to highlight is the drop from 0.29 to 0.21 in the estimated index between sub-periods (2) and (3). This change is difficult to interpret as different cost function parameters are estimated for each period and thus different values are predicted for the same data point (e.g. 2002). We could argue that average market power fell as production technology changed between the two sub-periods. However, the trend between 2002 and 2007 is one of increasing market power with the Lerner index back at 0.3 by the end of the period. We can conjecture that the estimates in sub-periods exaggerate underlying changes in technology which are better integrated in the whole period estimates. Alternatively, the differences in the level could simply reflect noise in the data.

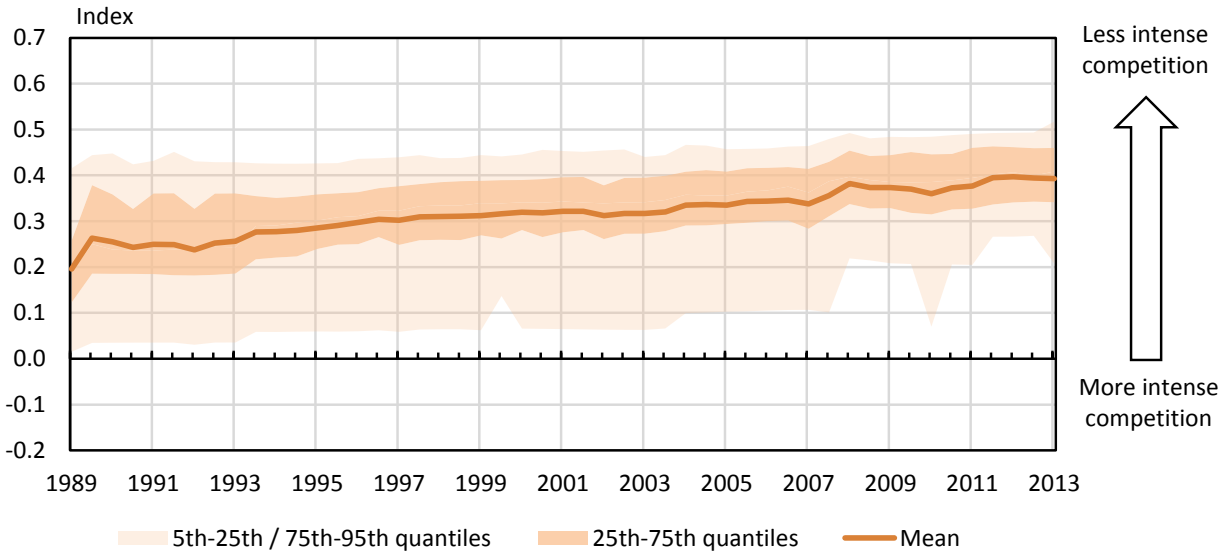
We implement further robustness tests on these results following Berger et al. (2009) by adding year fixed effects and robust standard errors to capture the specificities of each firm through time. In addition, following Matthews et al. (2007) we add environmental variables and period dummies to the regression to control for other factors that may evolve over time and affect the cost function parameters. In general, the alternative Lerner index estimates follow a similar trend and increase over the whole period and the conclusion that market power increased steadily over the period remains.

We now estimate the Lerner index using the stochastic frontier approach (discussed in section 3.2.2) using: the ratio of total revenue to total costs ($RC_{i,t}$) as the dependent variable and as regressors we use total assets as a measure of output and input prices for labour, funding and fixed capital as before.[22] The

[21] Other sub-periods investigated included fixed four and six year averages. The conclusions drawn were the same in all cases.
[22] We do not need a proxy for the output price P under this approach.

results in Figure 5.3 below show that industry margins rose steadily through the period. We note in particular that there is a clear increase in the index over the 4 year period leading up to the financial crisis, with the index rising from 0.32 in the first half of 2003 to 0.36 in the first half of 2008.

Figure 5.3: The Lerner Index – stochastic frontier approach



Source: Author's calculations

As a check on our results, we also estimated an alternative formulation of the Lerner index using the standard estimation methodology. For this estimate, we narrowed the measure of bank output by constructing a mark-up proxy for competition in credit provision only (i.e. excluding other bank services), following Kick and Prieto (2013) and Coccorese (2014). We assume that the appropriate measure of output for the total cost function is total loans and that the price of output is only interest and fee income per loan.[23] The corresponding Lerner index is shown in Figure A2.3 in Appendix 2 and shows two peaks in 1994 and 2004 and two troughs in 2001 and 2008. Otherwise the average index remains fairly stable over the period within a range of 0.39-0.47. The pre-crisis period (2005 to 2008) shows a narrowing of the range of mark-up values suggesting fewer deposit takers were able to maintain higher margins. These results, in combination with the estimates of the Lerner index for all activities, suggest that competition in credit provision was relatively stable and saw periods of stronger competition even as the overall market power of deposit takers increased over the period 1989-2013. This observation is consistent with Matthews et al. (2007) who find that competition in the non-interest element of banking weakened between 1991 and 2004 implying that British banks altered their business models to increase their collective market power.

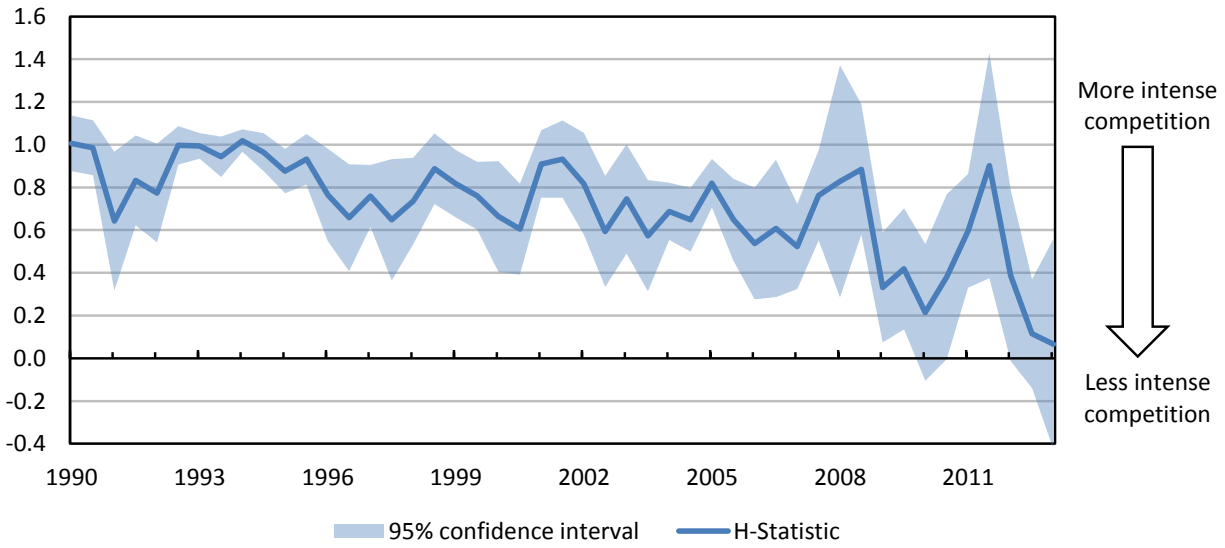
[23] These results need to be interpreted with caution. As the data do not distinguish between loan and non-loan based fee income, the price of output includes some fee income that is not derived from loan products and so may overstate the true price of loans at different points of time.

5.3 The Panzar-Rosse H-statistic

We estimate the Panzar-Rosse H-statistic using an unscaled measure of total revenues[24] ($TR_{i,t}$ in equation (9)), following the methodology set out in Bikker et al. (2012)[25]. The key financial sector costs for the regression are labour, physical capital and funding,[26] defined as above in the Lerner index calculations. We also included a number of firm-specific factors as control variables that reflect deposit-taker behaviour and risk profile: average risk weights, the ratio of provisions to assets, the ratio of tier 1 to total capital, the ratio of loans to assets, the ratio of non-financial deposits to total deposits, the ratio of non-earning assets to total assets and UK real GDP growth. Finally, we include firm specific and time specific fixed effects. We used a panel regression with fixed time effects and clustered errors (to allow for intragroup effects) to estimate the H-statistic at each point in our time series.

Figure 5.4 below shows the central estimates of the H-statistic using rolling fixed time panels of two data periods (one year), with the outcome shown in the second period, and including the 95% confidence interval. Figure 5.4 suggests that there was very strong competition between UK banks up to 1994 but that market power subsequently increased over time bringing the H-statistic significantly below one.

Figure 5.4: Panzar-Rosse H-statistic – rolling period estimates



Source: Author's calculations

However, the H-statistic needs to be estimated where there is a long-run competitive equilibrium if estimates are to be valid. Shaffer (1982) shows that, where there is a long-run competitive market

[24] The choice of control variables $X_{i,t}$ in equation (9) usually includes some measure of assets which, in effect, acts as a scaling variable for total revenues $TR_{i,t}$. Bikker et al. (2012) review many studies and demonstrate that using a scaled revenue specification yields inconsistent measures of the H-statistic.

[25] Bikker et al. (2012) estimate the Panzar-Rosse index for a number of countries between 1994 and 2004 including bank specific effects. For the UK their preferred estimate is significantly below 1 but they also find that UK firms are not in long term equilibrium through the whole of that period.

[26] This choice is in line with past Panzar-Rosse applications to banking, for example Bikker et al. (2012), Goddard and Wilson (2009) or Shaffer (2004).

equilibrium the return on assets should be equalised across firms regardless of input costs.[27] We follow the test formulated by Shaffer to establish periods when the market was in long-run equilibrium. The test is performed by substituting the ratio of total net income to total assets (a measure of return on assets) for total revenue in equation (9) and calculating the modified H-statistic, H^{ROA}, as before. Where we cannot reject the hypothesis that $H^{ROA} = 0$, there is a long-run competitive equilibrium and measures of the H-statistic are valid.[28]

We use rolling time windows of varying size to determine the long-run equilibrium sub-periods within our full sample. The strategy is first to construct the stability test for rolling four-year periods – for example, using all data between 1989 and 1992, then all data between 1990 and 1993, etc. – then increase the size of the window by adding an additional time period and note in which sub-periods and for which window size we reject the long-run equilibrium hypothesis. At the end of the process we were left with the largest possible windows that do not reject long-run equilibrium. We then estimate the H-statistic for each of these periods.

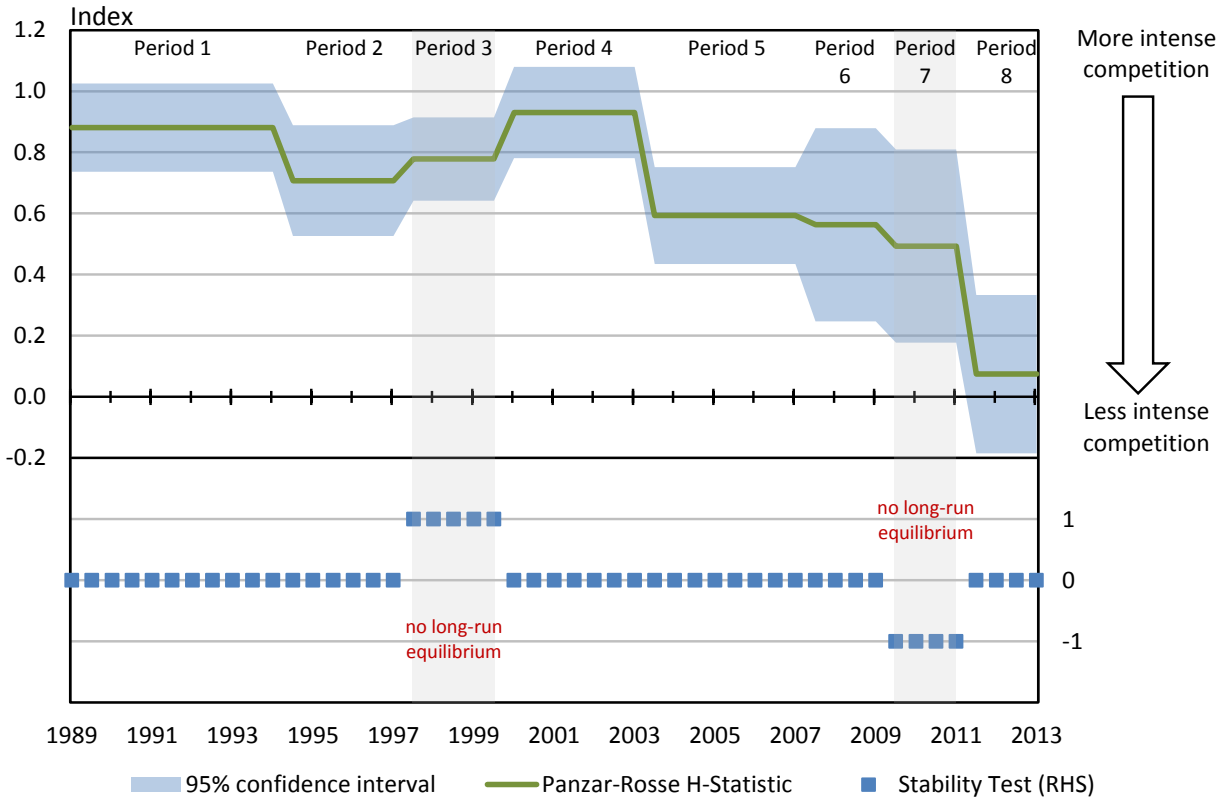
This process yields eight separate periods: two separate periods of disequilibrium, the first from 1998 to 2000 ($H^{ROA} > 0$) and the second from 2010 to 2011 ($H^{ROA} < 0$); and six periods where long-run equilibrium is present (1989 to 1994, 1995 to 1997, 2000 to 2003, 2004 to 2007, 2008 to 2009 and 2012 to 2013). The periods of disequilibrium may reflect two disruptive influences in the UK financial sector: the cluster of building society demutualisations in the mid-1990s, and the immediate aftermath of the 2008 global financial crisis.

Figure 5.5 below shows our estimates of the H-statistic including the 95% confidence interval and the outcome of the stability test for the eight periods identified. We find that the value of the H-statistic is not statistically different from one for much of the period from 1989 to 2003, excluding only the two years from 1995 to 1997 (and ignoring the disequilibrium period 1998-2000). We then find that the H-statistic moves to a much lower level for the period 2004 to 2009 and lower again for the period 2012-2013 to be statistically no different from zero (again ignoring the disequilibrium period 2010-2011). Note also that the 95% confidence interval widens substantially at the end of the sample, most likely reflecting volatility around the time of the financial crisis. One final observation is that the move lower in the H-statistic in the period 2004-2008 suggests that competition intensity between deposit takers declined prior to the financial crisis, consistent with the findings from the Lerner index.

[27] Bikker et al. (2012) estimate the H-statistic for a number of countries for the period 1994 to 2004 including bank specific effects. For the UK, their preferred estimate is significantly below 1 but they also find that UK firms are not in long-run equilibrium throughout the estimation period

[28] The stability test is a two-sided t-test and H^{ROA} can take negative and positive values. Shaffer (1982) notes that, when $H^{ROA} < 0$, an increase in input prices reduces return on assets with the implication that, in the short run, the firm it cannot immediately pass on higher costs. Where $H^{ROA} > 0$, an increase input prices *increases* return on assets. Shaffer postulates that this may arise if demand pull factors forces the firm to bid up the price of inputs, although this explanation remains conjecture.

Figure 5.5: Panzar-Rosse H-statistic and stability test



Source: Author's calculations

5.4 The Boone indicator

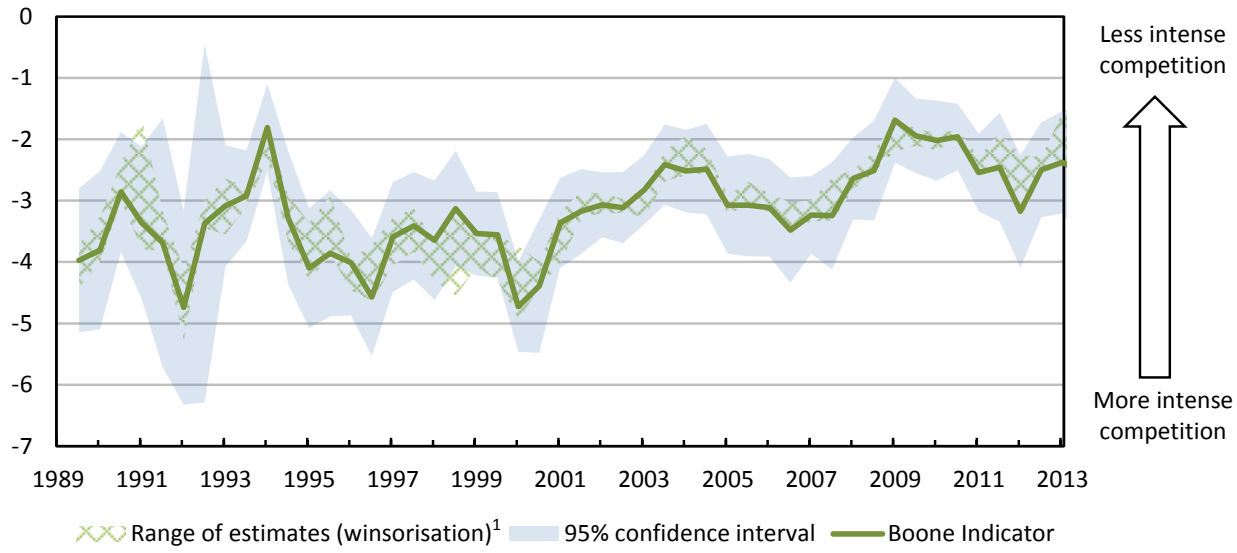
The approach we follow for estimating the Boone indicator is that of Schaeck and Cihák (2014). We use a panel regression with fixed bank-specific effects, robust errors and allowing for intra-group clustering. Profits ($\pi_{i,t}$ in equation (11)) are measured as total operating profits reported by deposit takers scaled by total assets. Costs ($c_{i,t}$ in equation (11)) are measured as variable costs scaled by interest received and income from foreign exchange, investment, fees and other sources. We use similar bank-specific controls as those used for the H-statistic, including average risk weights, the ratio of provisions to assets, the ratio of tier 1 to total capital, the ratio of loans to assets, the ratio of non-financial deposits to total deposits, the ratio of non-earning assets to total assets and UK real GDP growth. To estimate the Boone indicator over the sample, we construct a dummy variable for each time period and include it and the interaction with costs in the estimation. The Boone indicator is extracted as the coefficient in each time period of the interaction variable. Finally, we exclude the largest regression outliers using a standard winsorisation process.[29]

The final estimates for the Boone indicator are shown in Figure 5.6 below. We include in the chart the 95% confidence interval which is relatively stable in size across the entire period. The Boone indicator is

[29] We calculate the fitted values from the estimated model and exclude observations less that are less than the 1st or greater than the 99th percentile of the distribution. This process is undertaken iteratively. Our central estimate involves two iterations of the winsorisation process.

more volatile than the other measures, but nevertheless shows a pattern of less intense competition (exercise of greater market power) from the early 2000s through to end of the period. As a further robustness check, we also show how the winsorisation process changes the central estimates. Successively removing the outliers does not substantially change the estimate, but does has the effect of making the overall upward trend in the Boone indicator more pronounced, particularly over the last decade of the sample where the winsorisation tends to result in higher estimates of the Boone indicator (hatched area in Figure 5.6).

Figure 5.6: Boone Indicator



Source: Author's calculations

Notes:
[1] Hatched area shows the range of winsorised estimates for the Boone indicator, where data points generating largest errors are sequentially removed. The range shows the maximum and minimum estimates for up to 20 iterations of the winsorisation process.

We implement a further robustness check for the Boone indicator using an alternative sub-sample. Following van Leuvensteijn (2011) we restrict the firms in our sample to exclude firms that lend less than 50% of their balance sheet.[30] This alternative statistic reflects the reallocation of profits from less to more efficient banks that compete more directly on loans. The estimation results are shown in Figure A2.4 of Appendix 2 and show a clear trend over time towards less intense competition. Looking at sub-periods, the Boone indicator for lenders during the first half of the 1990s was around -5 suggesting that competition was more intense than in any other period. After 1994 there is a sudden shift towards less intense competition but it is a stable period until 2001 with a value of around -4. Subsequently, the indicator trends towards less intense competition until 2005 with a slight rebound before the financial crisis. In the final period the indicator shifts again towards less intense competition settling around a value of -2.

[30] This is a more restrictive assumption than our definition of firms using the traditional model, which excludes firms with lending of less than 20% on their balance sheets

5.5 Comparison across competition indicators

Table 5.1 below shows the average value for each of the competition measures for the eight periods derived for the H-statistic.

Table 5.1: Combined measures of competition intensity[1]

	Lerner index[2]			Boone	*Note*:
	Standard	Efficiency[3]	H-Statistic[4]	indicator[5]	HHI[6]
Period 1 (1989–1994)	0.14	0.25	0.88	-3.36	1021
Period 2 (1995–1997)	0.21	0.29	0.71	-3.90	969
Period 3 (1998–2000)[7]	0.21	0.31	0.78	-3.46	971
Period 4 (2000–2003)	0.21	0.32	0.93	-3.52	1154
Period 5 (2004–2007)	0.23	0.34	0.59	-2.92	1396
Period 6 (2008–2009)	0.30	0.37	0.56	-2.52	1749
Period 7 (2010–2011)[7]	0.31	0.37	0.49	-2.12	1896
Period 8 (2012-2013)	0.32	0.39	0.07	-2.63	1898

Source: Bank of England, Authors' calculations

Notes:
[1] Periods are derived from the Panzar-Rosse H-statistic stability test used for calculating the long-run equilibrium sub-periods
[2] Lower values of the Lerner index indicate greater competition intensity
[3] Efficiency adjusted measure of the Lerner index
[4] Higher values of the H-statistic indicate greater competition intensity
[5] Lower values of the Boone indicator indicate greater competition intensity
[6] HHI for total assets.
[7] Periods where the stability test associated with the H-statistic indicates that there is no long-run competitive equilibrium

Estimates of the H-statistic show that, at the beginning of the sample, competition intensity was strong in periods 1 through 4. This is supported by the more negative values for the Boone indicator. The Lerner index suggests competition was more intense early in Period 1. However, periods five and six (highlighted in the table) show a distinct reduction in the intensity of competition from earlier periods across all measures.[31] Most pertinently, this includes the four years immediately prior to the 2008 financial crisis (period 5, from 2004 to 2007) and the period of the crisis itself (period 6, from 2008 to 2009). There is less consensus between the measures for the periods after the crisis (periods 7 and 8, from 2010 to 2013) most likely reflecting the considerable economic uncertainty and regulatory change undertaken over these periods.

Table 5.2: Boone Indicator – tests for statistical difference between periods[1,2,3]

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period 1 (1989–1994)	–	0.920	0.664	0.632	0.100	0.032**	0.001***	0.005***
Period 2 (1995–1997)	–	–	0.341	0.428	0.021**	0.004***	0.000***	0.000***
Period 3 (1998–2000)	–	–	–	0.945	0.052*	0.018***	0.000***	0.002***
Period 4 (2000–2003)	–	–	–	–	0.015**	0.003***	0.000***	0.000***
Period 5 (2004–2007)	–	–	–	–		0.296	0.001***	0.021**
Period 6 (2008–2009)	–	–	–	–	–	–	0.013**	0.125
Period 7 (2010–2011)	–	–	–	–	–	–	–	0.502
Period 8 (2012-2013)	–	–	–	–	–	–	–	–

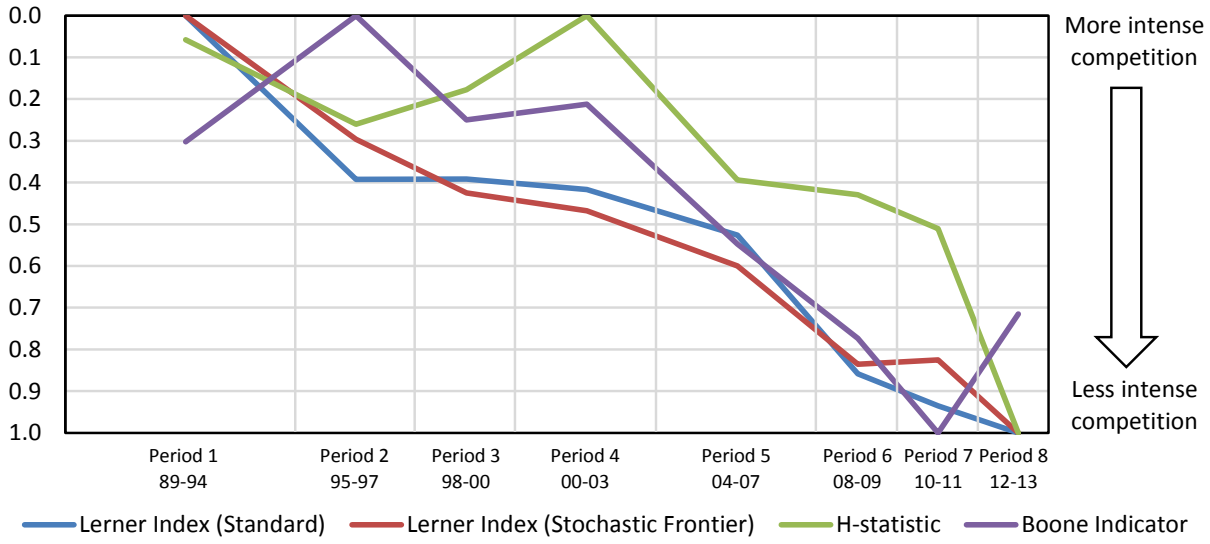
Source: Bank of England, Authors' calculations

Notes:
[1] Periods are derived from the Panzar-Rosse H-statistic stability test used for calculating the long-run equilibrium sub-periods
[2] Asterisks indicate probability from hypothesis test H_0: $Period\ i \neq Period\ j$ for $i \neq j$ where $p < 0.1$ = *; $p < 0.05$ = **; $p < 0.01$ = ***
[3] Test are Wald tests of composite linear hypotheses on the Boone regression estimated parameters and variance-covariance matrix.

[31] We discuss the possibility of intense competition in credit provision as suggested by the Lerner index on loans in section 5.2

We can quantify the statistical significance of these differences for some measures. From our estimates of the H-statistic in section 5.3 we know that during periods 1 and 4 the statistic is not significantly different from one (the perfect competition outcome), but significantly different from one during periods 5, 6 and 8 (with period 8 being statistically indistinguishable from zero). Table 5.2 above shows statistical tests based on the Boone indicator for periods 1 to 8 identified for the H-statistic. The table reports the probability from a Wald test of the hypothesis that one period (denoted in rows) is statistically different from another period (in columns). The table shows that the average Boone indicator estimated for periods 1 to 4 (1989-2003) is statistically different from those of periods 5 to 8 (2004-13). The estimated average Boone indicators for periods 1 to 4 are not-statistically different from each other and most differences in consecutive periods are not statistically different from zero. However, period 5 (2004-07) is significantly different from 4 (2000-03) and period 8 (2012-13) is significantly different from period 7 (2010-11).

Figure 5.7: Combined measures of competition[1,2]



Source: Author's calculations

Notes:
[1] Periods are derived from the Panzar-Rosse H-statistic stability test used for calculating the long-run equilibrium sub-periods
[2] Measures are normalised such that zero corresponds to the most competition intensity and one the least competition intensity for each measure

Figure 5.7 above provides a visual representation of the combined outcomes of the four performance-based measures. All measures are normalised such that values lie between zero and one[32] with zero indicating the value where competition intensity for each measure is at its maximum and one indicating the value where competition intensity is at its minimum over the sample. The eight periods correspond to

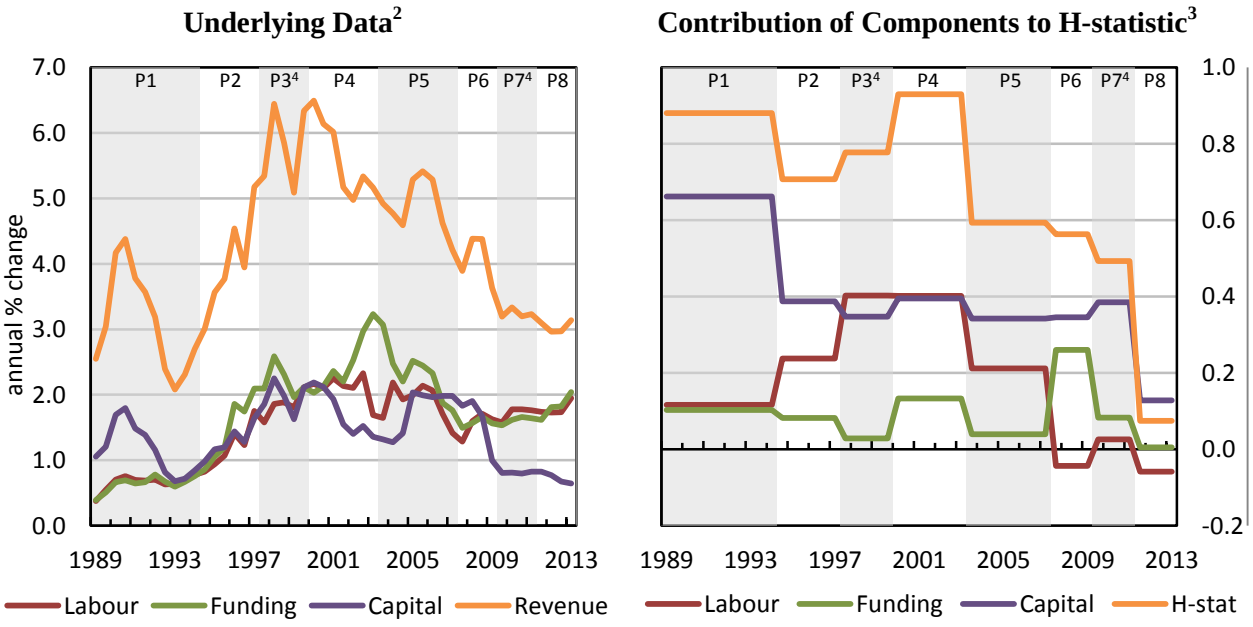
[32] The measures are normalised using the formula $x_{norm} = [x - x_{min}]/[x_{max} - x_{min}]$ where x_{norm} is the normalised value, x is the average value of the measure in each sub-period, x_{min} is the minimum value of the averages for the sub-periods and x_{max} is the maximum average value.

the long-run equilibrium sub-periods calculated for the H-statistic[33] (as noted in section 5.3). On this scale, the consistent trend towards less intense competition in general over the entire period is clear.[34]

5.6 Intuition behind the measures

To gain some intuition into these movements, we first look at the input costs used in construction of the H-Statistic. The three input costs used (labour, fixed capital and funding) along with the measure of revenue are shown on the left hand side of Figure 5.8, while the contributions of each input cost to the H-statistic are shown on the right hand side. We need to be careful in interpreting these measures. In Period 1, the pattern of rising and falling fixed capital costs are clearly reflected in the revenues, in line with the outcome for strong competition as measured by the H-Statistic (set out in section 3.3 above). Increases in input costs are also reflected in revenues in Period 2. However, the relationship between revenue and fixed capital costs falls further than would be expected under the strong competition model. Moreover, while period 4 saw a return to the strong relationship between movements in input costs and revenue, the reduction in labour costs towards the end of period 5 and rebound in period 6 are not being reflected in movements in revenue. Trends in funding costs appear to be driving revenues to a greater extend in period 6, but by period 8 the relationship between input costs and revenues appears to have broken down almost completely.

Figure 5.8: Input costs for H-statistic[1]



Source: Bank of England, Author's calculations

Notes:
[1] Periods in the chart are derived from the stability test used in calculating the H-statistic
[2] Chart shows the annual percentage change for each data series (revenue and input costs) used to estimate the H-statistic
[3] The Labour, Funding and Capital series in the chart show the estimated coefficients on input costs generated by estimating equation (9). The H-stat series shows the H-statistic, which is the sum of the estimate input cost coefficients.
[4] The stability test for the H-statistic found that there was no long-run equilibrium in periods 3 and 7

[33] As the H-statistic is not valid for periods 3 and 7, any average that partially included these periods will also be invalid. The average of other measures of competition are valid for these sub-periods.
[34] A similar pattern is observed when the sample is split up into equal periods of three years (eight sub-periods) and four years (six sub-periods) although, as noted above, averages for the H-statistic are not valid for averages that include the periods 1998-2000 or 2010-2011

For the Boone indicator, we can look at the relationship between average variable costs and profits. Average variable costs, as a proxy for the efficiency of firms, should drive profits to a greater extent where competition is strong. A simple cross-sectional regression of profits (dependent variable) on average variable costs will generate a steep, negatively sloped line where competition is intense while the slope of the line will become increasingly shallow as competition intensity is reduced. Figure A2.5 divides our dataset into six equal periods[35] and shows the relative profits and costs for each firm in these periods and a line showing the fitted regression line between the two variables.[36] The relationship between relative profits and costs gets weaker in the later periods indicating that less efficient (more costly) firms are increasingly able to sustain profits. Figure A2.6 shows that both total assets and income rose more sharply than profits and variable costs over the period, which has the effect of lowering the mean value of relative profits and costs over time at a similar rate.

6 General Discussion

The empirical outcomes above raise a number of questions, in particular about why the intensity of competition in the deposit-taking sector diminished in general throughout the period. We also observe that competition intensity was *decreasing* in the period immediately ahead of the 2008 financial crisis, although competition was strong during other periods of financial instability (e.g. during the small-banks crisis of the early 1990s). The historical context of trends in the UK financial markets helps to make sense of these trends.

Trends in deposit-taking business prior to 1989. The UK deposit taking landscape at the end the 1970s was dominated by two business models, clearing banks and building societies which, in effect, operated in separate market segments. In retail markets, building societies were the dominant source of savings accounts and mortgages: building societies' deposits accounted for 33% of all financial assets of the household sector versus 24% for bank deposits[37] at the end of the 1970s, but around 80% of the stock of mortgages throughout the decade (Callen and Lomax (1990)). The banks were more focussed on providing payment services including credit cards, non-interest bearing deposits, corporate lending and foreign currency business in the Euromarkets.

The lack of competition between banks and building societies in UK domestic retail markets was linked to regulatory restrictions on banks' ability to lend in domestic markets, the so-called 'corset'[38] (Fforde (1983)). These restrictions helped building societies operate an effective cartel arrangement setting interest rates for loans and deposits (such arrangements in the banking sector had been abolished a decade earlier – see Callen and Lomax (1990)). The regulatory environment that helped limit

[35] Similar outcomes are observed when splitting the sample into four and eight equal periods.
[36] The lines are derived by regressing relative profits on a constant and relative costs and is analogous, but not equal, to our estimates of the Boone Indicator as the regression does not include the additional controls noted in equation 11.
[37] Remaining household sector financial assets were held in National Savings (8.1%), Gilts (8.9%) and Unit Trusts, Ordinary and Preference Shares (29.8%). See Callen and Lomax (1990)
[38] The supplementary special deposits scheme (otherwise known as the 'corset') imposed penalties where a bank's interest-bearing eligible liabilities (IBELs) grew faster than a rate prescribed by the Bank of England.

competition between these two business models was then effectively reset in the 1980s with the 1979 Banking Act, the 1986 'big bang' reforms of the stock market which allowed (and encouraged) foreign bank entry and the 1986 Building Society Act (and subsequent amendments). By the end of the 1980s, increased competition due to this deregulation had blurred the roles of banks and larger building societies and facilitated an increase in mergers (Callen and Lomax (1990)).

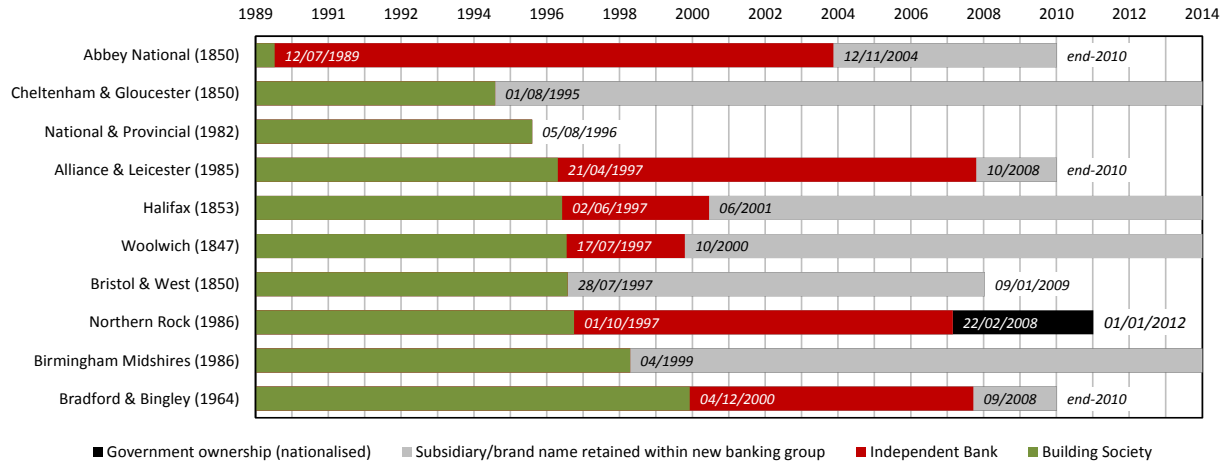
The change in the regulatory environment added to the trends that were already emerging thanks to developments in information technology. By the beginning of the 1980s, banks were already taking advantage of advances in server technology to centralise both transactions, which allowed customers to use any branch of a bank (previously customers were tied to their local branch) and credit decisions (loans to customers) that previously were undertaken by managers at the branch level (Bátiz-Lazo and Wood (2002)). Building societies moved later to take advantage of information technology, but this reflected the clearing banks' ability to utilise their own existing technology infrastructure and experience of their payment system operations. Competition from the banking sector also broke down the building societies' quasi-cartel arrangements on interest rates by the middle of the 1980s (Callen and Lomax (1990)).

Period of consolidation from 1989 to the early 2000s. By the start of the 1990s, banks and building societies were competing strongly with each other in UK retail markets, and our estimates suggest that few (if any) supernormal profits were being made. Credit worthiness of customers could now be assessed more efficiently and consistently across a banks' entire branch network given data on individuals. This freed firms from the need to have senior loan officers in each branch. The freedom provided by the banking reforms to expand the number of products that could be sold, the greater flexibility in the roles of staff at branches freed from making credit risk decisions, and the introduction of server technology that allowed branches to become sales points for a wide number of products, drove competition through the 1990s. Building societies were also forced to respond to the increase in competition from banks. The 1986 Building Societies Act provided building societies the freedom to expand the number of products they could sell and to convert into public companies for the first time. Demutualisations of building societies were popular as conversion to a bank allowed greater access to wholesale funding. Moreover, demutualisations provided deposit holders with large one-off financial gains as they became shareholders in the new entity and generated high returns for managers who were now running large incorporated business (with remuneration to go along with it).

The number of conversions to public company status were limited at the turn of the decade and only Abbey National took early advantage (in 1989, see Figure 6.1). Callen and Lomax (1990) noted that trends driven by the blurring of roles of banks and building societies and an increase in mergers in response to the intense competition from the banking sector, "…should not…be exaggerated since, for the most part, societies remain separate financial entities with a distinctive nature". This distinctive nature was not enough to prevent a wave of demutualisations from occurring in the mid-1990s. The

timing of the demutualisations reflected a number of factors. While idiosyncratic factors held back some, the housing market crisis that began in 1989 and lasted over the first half the next decade delayed a number of demutualisations until around the mid-1990s. The impact that the housing market crash had on the building society sector was substantial: provision and losses measured as a percentage of assets rose from 0.02% in 1988 to 0.76% in 1992, while the percentage of mortgages that were in arrears rose from 0.87% in 1988 to 11.2% at the peak in 1992, falling back to 3.7% by 1996.[39]

Figure 6.1: Building Society demutualisations



Source: Building Society Association

In parallel with the mergers and demutualisation of building societies, there were a number of key mergers and/or takeovers of banks in this period, most notably: HSBC and Midland Bank (1992); Lloyds and TSB (1995); Abbey National and National and Provincial[40] (1996); Birmingham Midshires and Halifax (1999); Barclays and Woolwich (2000); Royal Bank of Scotland and NatWest (2000); and Bank of Scotland and Halifax to form HBOS (2001). Demutualisation was not the only strategy available to building societies to improve competitiveness. Although most of the largest societies converted to banks, Nationwide epitomised the alternative strategy, first developing a 'poison pill' strategy in the form of charitable assignment (to deter carpetbaggers and retain building society status)[41] and consolidating with a number of other building societies to attain size. Nationwide's decision to allow other societies to adopt the 'charitable assignment defence' effectively ended the desire for further demutualisation in the sector from the late 1990s onwards.

While building societies were the key source of competition in retail markets, banks were also facing strong competition in corporate lending and Eurocurrency markets from international banks and non-

[39] Source: Annual reports of the Building Societies Commission 1986-2001 and Building Societies Annual Statistical Tables (2008) published by the FSA.
[40] Abbey National first launched a bid to take over the National & Provincial Building Society in 1995. National & Provincial eventually agreed and demutualised on 5 August 1996 to allow the takeover by Abbey National to proceed.
[41] Charitable assignment is an agreement signed by members of the society which would assign any members' windfall benefits from demutualisation to a charity run by the Society. This agreement was designed to prevent 'carpet baggers' from opening deposit accounts opportunistically, then forcing the building society to demutualise in order to make windfall gains.

bank financial firms. Competition in Eurocurrency markets came primarily from US banks looking to avoid domestic regulatory restrictions, while the rise of London as a centre of such business also attracted banks from around the world looking to compete for the same business. The direct response to changes in regulations was not the only influence on the deposit taking sector. The deregulatory mood set in the 1980s brought with it additional changes to the regulatory approach. There was a desire by authorities for British banks to be able to compete effectively with (predominantly) American investment banks, in particular for loans to large industrial conglomerates (Centre for Policy Studies (2006)). Moreover, the prevailing mood was that larger banks would provide some protection against the likelihood of future financial crisis (Sinclair (2000)).

The outcome of this period of firm consolidation and growth was to increase the concentration of the sector across a number of markets (see Figure A2.1 in Appendix 2). Notably, over the first half of the 2000s the increase in concentration of the deposit and unsecured loan market segments was significant, with the HHI moving above the critical 1000 value indicating a concentrated market (the largest moves driven by the creation of HBOS from the Halifax and Bank of Scotland merger). The mortgage market remained less concentrated in this period with the HHI remaining below 1000, perhaps reflecting the extent of competition from outside the deposit-taking sector.

One episode in this period of strong competition between banks and building societies is worth noting. The increasing intensity of competition in retail financial markets contributed to the small banks crisis of the early 1990s. A number of small banks failed over the early 1990s and required intervention from the Bank of England to provide liquidity assistance (see Balluck et. al. (2016)). The underlying cause of these failures is complex and intense competition is likely to have contributed, although the crisis appears ultimately to have been precipitated by over-exposure to wholesale funding (a strategic mismatch of asset and liability maturities) and the UK recession and housing market crash.

Post-millennium, pre-crisis period. While the 1990s were characterised by strong competition, the consolidation in the deposit taking sector driven by this competition was largely complete by the early part of the new millennium (the formation of HBOS in 2001 was the last large merger of UK deposit takers until the aftermath of the 2008 crisis). A new equilibrium appears to have been reached, one in which deposit-takers ability to extract market rents from customers was enhanced. This is clearly demonstrated by the estimates of the H-statistic, Boone indicator and the standard and efficiency-adjusted Lerner indexes for all deposit taking business which show a reduction in the intensity of competition from 2004 onwards (see Table 5.1 above). The Cruikshank Review[42], launched in response to the increase in scale of banks in the UK and published in 2000, found that competition was not effective in a number of markets, in particular money transmission and services to personal customers and small and medium sized businesses.

[42] The Review of Banking Services in the UK, led by Don Cruikshank, was published on 20 March, 2000.

While the ability of deposit takers to extract market rents from consumers appears to be enhanced in this period, there is evidence that competition in some markets was more intense, as suggested by the Lerner index for total lending (see Figure A2.3). In the mortgage market, deposit takers were subject to strong competition from a number of non-bank competitors and evidence suggests that margins were generally low. That said, the PPI mis-selling scandal[43] which erupted in this period demonstrates how the bundling of products can boost overall profitability even as competition in the market for one of the bundled products (i.e. mortgages) is intense.[44]

The crisis and post-crisis period. The ability of the banks to extract market rents seems to have continued over the crisis and into the post-crisis period, although the H-statistic stability test suggests a period of disequilibrium around the time of the crisis. The immediate impact of the crisis led to further (forced) consolidation in the sector: HBOS was folded into Lloyds Banking group; Bradford and Bingley and Northern Rock were dismembered and partly nationalised (the non-nationalised businesses were taken over by Santander in and Virgin Money, respectively).

Our estimates of competition intensity are less definitive in this period: the standard Lerner index is the same on average for the period 2010-2013 as it was for the period 2004-2007; the efficiency-adjusted Lerner index and the H-statistic show reduced competition for the same period while the Boone indicator suggests that competition intensity increased somewhat in 2012-2013 (see Table 5.1). That our measures may show some divergence in this period is perhaps not surprising. Deposit-takers have been subject to considerable regulatory change and the resulting uncertainty (of both firms' business prospects and the final regulatory regime) and the unwillingness or inability of new firms to enter the market may have diminished competitive effort.

7 Conclusion

The measures of competition intensity calculated in this study suggest that the firms in our dataset are able to extract market rents and earn positive economic profits. The H-statistic, Boone indicator and Lerner indexes indicate that firms, while initially experiencing a period of more intense competition, were increasingly able to extract market rents from customers in the period leading up to the financial crisis and in the post-crisis period.

We performed direct tests of the departure from the 'perfect competition' outcomes of UK deposit takers using performance-based measures of competition. Our results indicate that, along with increasing concentration, there was an overall trend of increasing market power / falling competition intensity over the sample from 1989-2013. We note that care needs to be taken when interpreting the performance-

[43] Payment Protection Insurance (PPI) is a form of insurance that covers mortgage (or other interest) payments in the event of a borrower's loss of income (e.g. because of unemployment). Banks were found to have mis-sold PPI to customers. Banks were estimated to have made profits after tax of £1.4 billion from the sale of PPI in 2006 (see Competition Commission Market investigation into payment protection insurance, available here: http://webarchive.nationalarchives.gov.uk/20140402141250/http://www.competition-commission.org.uk/assets/competitioncommission/docs/pdf/non-inquiry/rep_pub/reports/2009/fulltext/542.pdf)

[44] The deposit-taking business model effectively ties together a number of markets so it is not possible from our dataset to effectively disentangle firms' activities in a way that would allow us to assess competition in individual markets.

based measures, pointing out where the theory and data are ambiguous. In particular, these indicators are less useful in assessing the statistical significance of small movements in competition, especially during small or consecutive time intervals.

The ability to earn supernormal profits by these firms does not necessarily imply that competition is low in all markets in which these firms supply products. The performance based measures can be adapted to study competition at a more granular level, e.g. for specific markets such as unsecured loans or mortgages. The differences in the measured price-cost margin for all firm activities (as measured by the Lerner index) versus an inspection of interest rates on individual lending activities suggests that the intensity of competition is higher for some deposit takers' lending activities (and most likely strongest in the market for mortgages than other loans) than for other sources of income (including sales from bundled products, advice and 'investment banking' activities). Using a loan- specialised Boone indicator we show that the competition among those banks may have been more intense during certain periods but also find an overall decreasing trend in competition over time. These more granular estimates are sensitive to a number of assumptions, caveats and uncertainties. We recommend using a battery of indicators also considering the structure of the specific market and existing barriers.

Many studies focus on the number of firms participating in specific financial services markets to proxy the short-term evolution of competition. We show that these structure measures may not be adequate to identify competition outcomes in the UK. In particular, they may not provide a good indicator of how competition affects efficiency and financial stability due to the complexity of the banking business and the many sources of income (and risk). The performance-based measures of competition offer alternative methodologies that take into account the interaction between firm efficiency and competition.

It is also important to complement empirical studies with a good understanding of the regulatory, structural and technological constraints that drive competition. We show that UK policy initiatives easing those constraints led to mixed long-term outcomes. For example, lifting barriers between banks and building societies and promoting European banks to compete in a single financial market did not deliver improvements in competition overall within the UK banking sector. Due to the complex nature of deposit taking businesses and the possibility of increased market share through consolidation, monitoring the impact on competition over the long term seems a worthwhile objective. In addition, changes in competition due to prudential policy may be important for the long-term prospects of financial stability (e.g. an enlarged non-bank sector as a result of capital and funding requirements on regulated banks).

The measures we have calculated also suggest that the relationship between competition in those markets in which deposit takers participate and financial stability is not straightforward. Our results suggest that intense competition in some markets can coexist with an increasing ability of firms to extract market rents when operating across multiple markets. Moreover, our estimated measures of competition intensity suggest periods in which financial instability coincides with both stronger (i.e. early 1990s small banks crisis) and weaker (i.e. 2008 financial crisis) competition.

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Appendix 1

Table A1.1: Data and assumptions used in regressions[1]

Indicator	Version	Perfect competition outcome	Model assumptions	Dependent variable	Explanatory variables	Environ-mental factors	Reference
Lerner index	Standard price-cost margin measure	Output price convergence with marginal cost	Output mix and price, translog cost function, homogeneity	Total Cost	Cost input prices, core Tier 1 capital, total assets	For robustness checks	Casu and Girardone (2009)
	Mark-up adjusted price-cost margin measure	Output price convergence with marginal cost after considering efficiency of each firm	Output mix, translog cost function, homogeneity, half-normal efficiency distribution	Revenue to total cost ratio (revenue per each pound spent)	Input prices, core Tier 1 capital, total assets	For robustness checks	Kumbhakar et al. (2012) Coccorese (2014)
Panzar-Rosse H-statistic	H statistic of market power	No pricing market-power	Translog cost function	Total Revenue (unscaled)	Input prices	For robustness checks	Bikker et al. (2012)
	Test of competitive market equilibrium	Profits correlated with input prices under perfect competition	Translog production function	Profits (return on assets)	Input prices	Yes, for robustness checks	Bikker et al. (2012)
Boone indicator		Competition increases profit share of most efficient firms	Linear relationship	Profits (return on assets)	Efficiency (proxied by total cost to total revenue ratio)	Yes	Schaeck and Cihák, (2010)

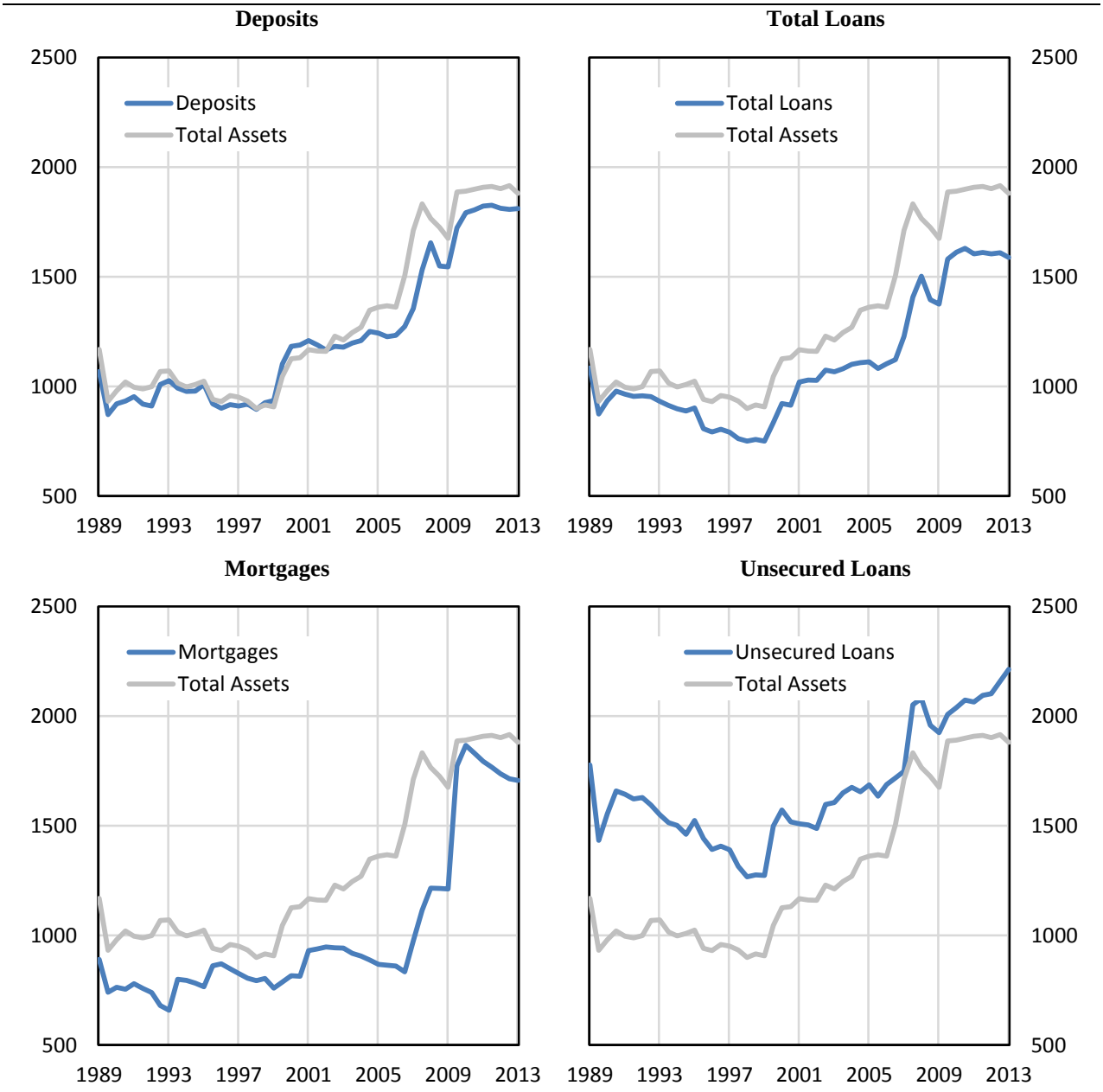
Source: Authors

Note(s):

[1] All five empirical measures are transformation of fixed effects panel regression parameters; fully loaded regressions (time and bank fixed effects) were also implemented. The data panel consists of banking group data regarding UK and non-UK balance sheet exposures and income account information. Environmental factors are: average risk weight, provision ratio, Tier 1 capital ratio, loan to assets ratio retail deposit ratio of liabilities other non-earning assets ratio, group size, GDP growth, period dummies.

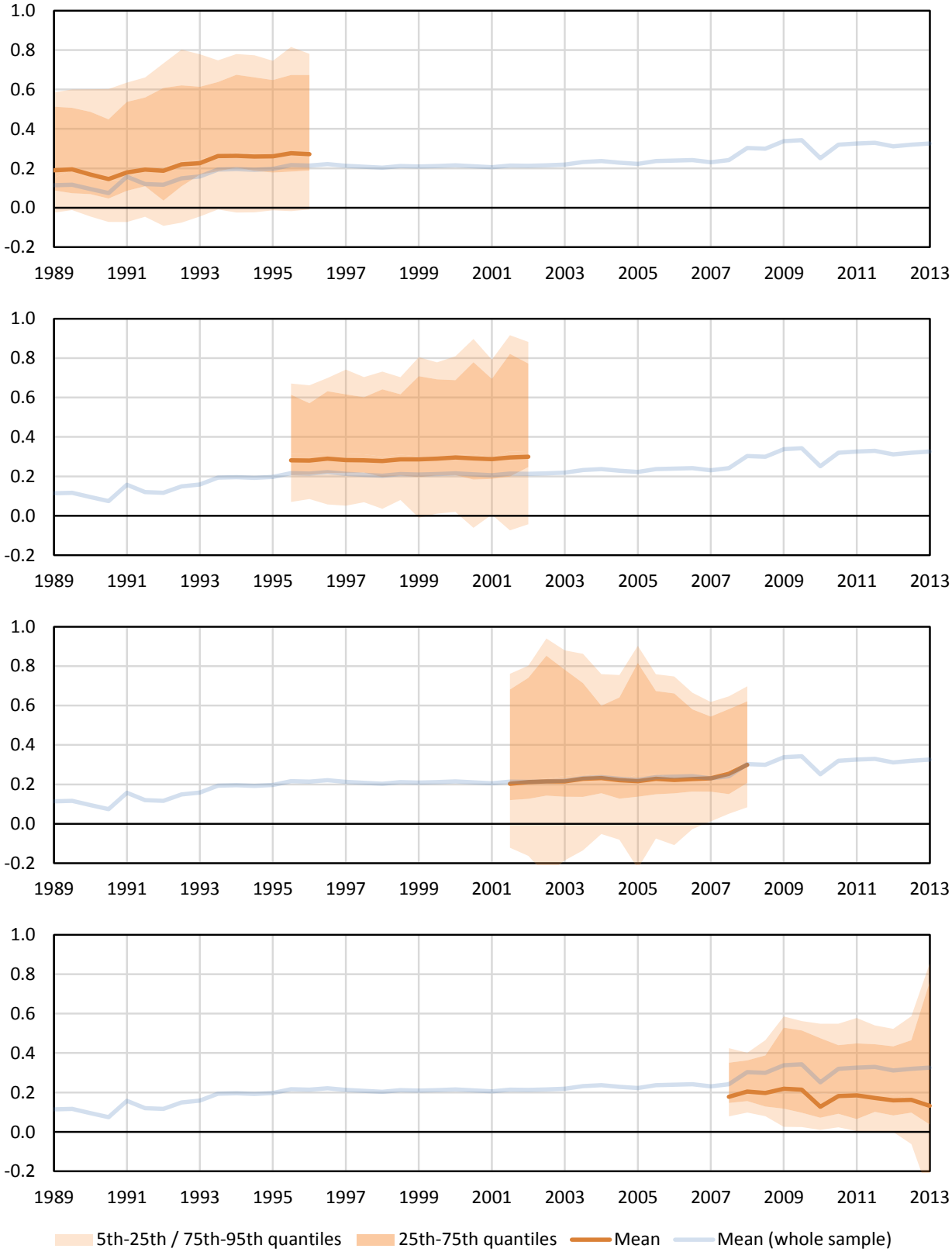
Appendix 2

Figure A2.1: Herfindahl-Hirschman Index of individual sectors – traditional banking model



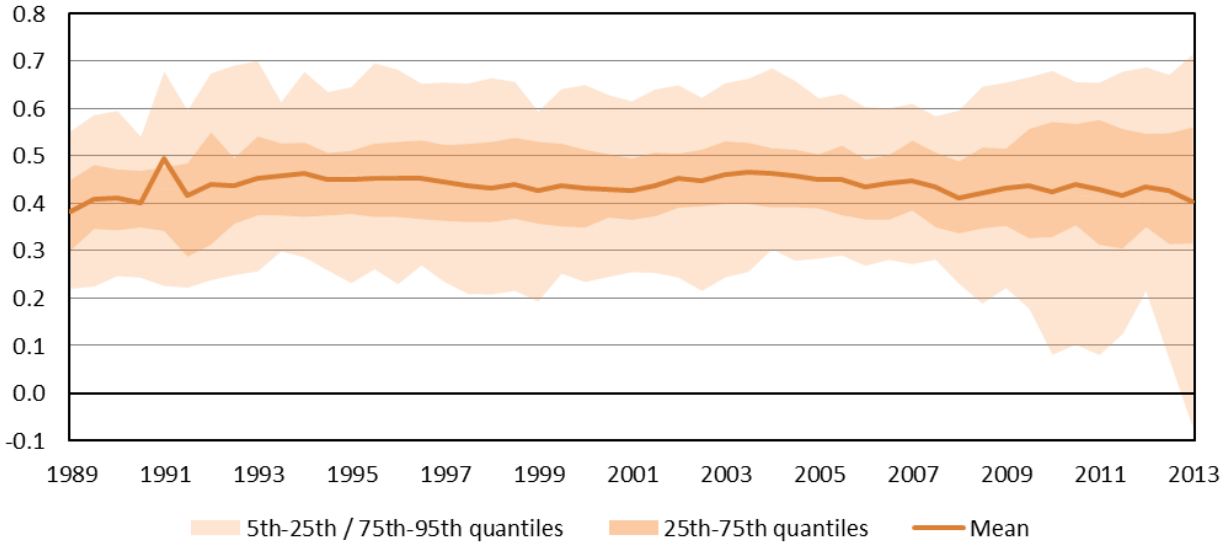
Source: Bank of England, Authors' calculations

Figure A2.2: Estimation of Lerner index over sub-samples



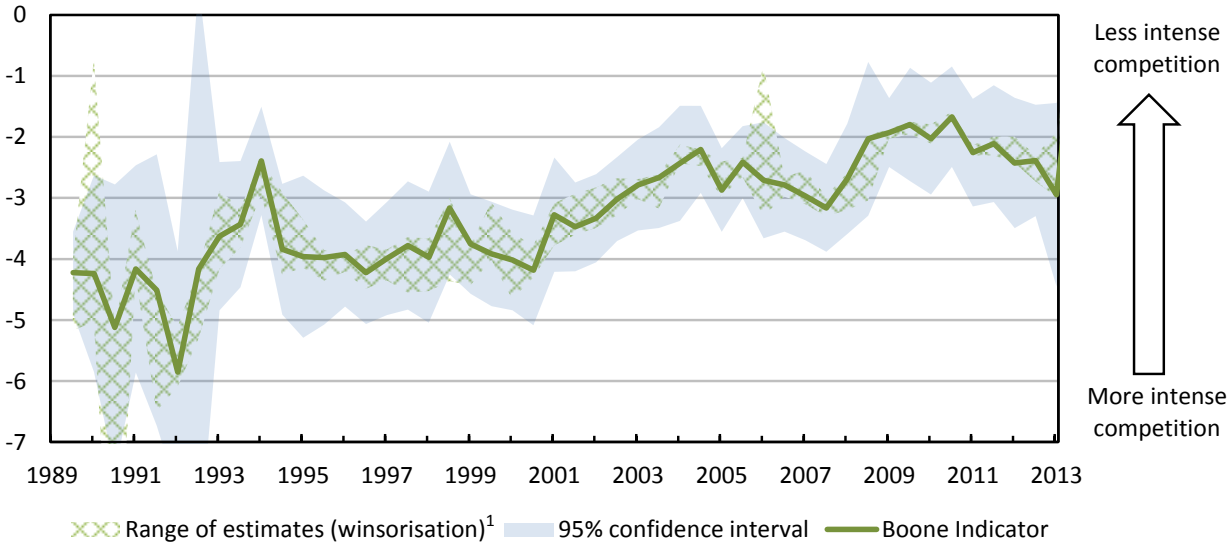
Source: Bank of England, Authors' calculations

Figure A2.3: Lerner Index for Total Loans



Source: Bank of England, Authors' calculations

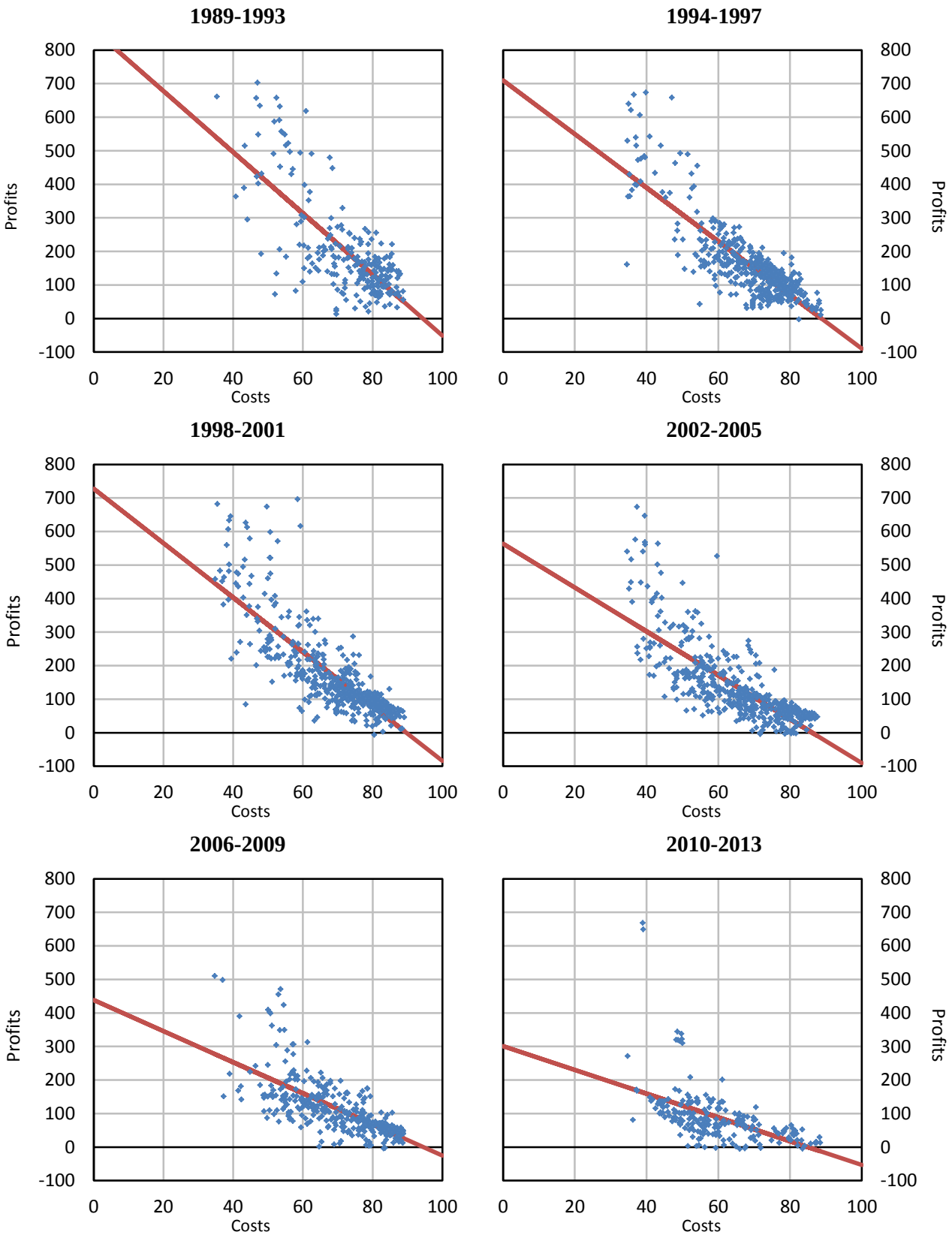
Figure A2.4: Boone indicator for Total Loans



Source: Bank of England, Authors' calculations

Notes:
[1] Hatched area shows the range of winsorised estimates for the Boone indicator, where data points generating largest errors are sequentially removed. The range shows the maximum and minimum estimates for up to 20 iterations of the winsorisation process.

Figure A2.5: Relationship between average variable costs and profits[1] in six consecutive periods[2]



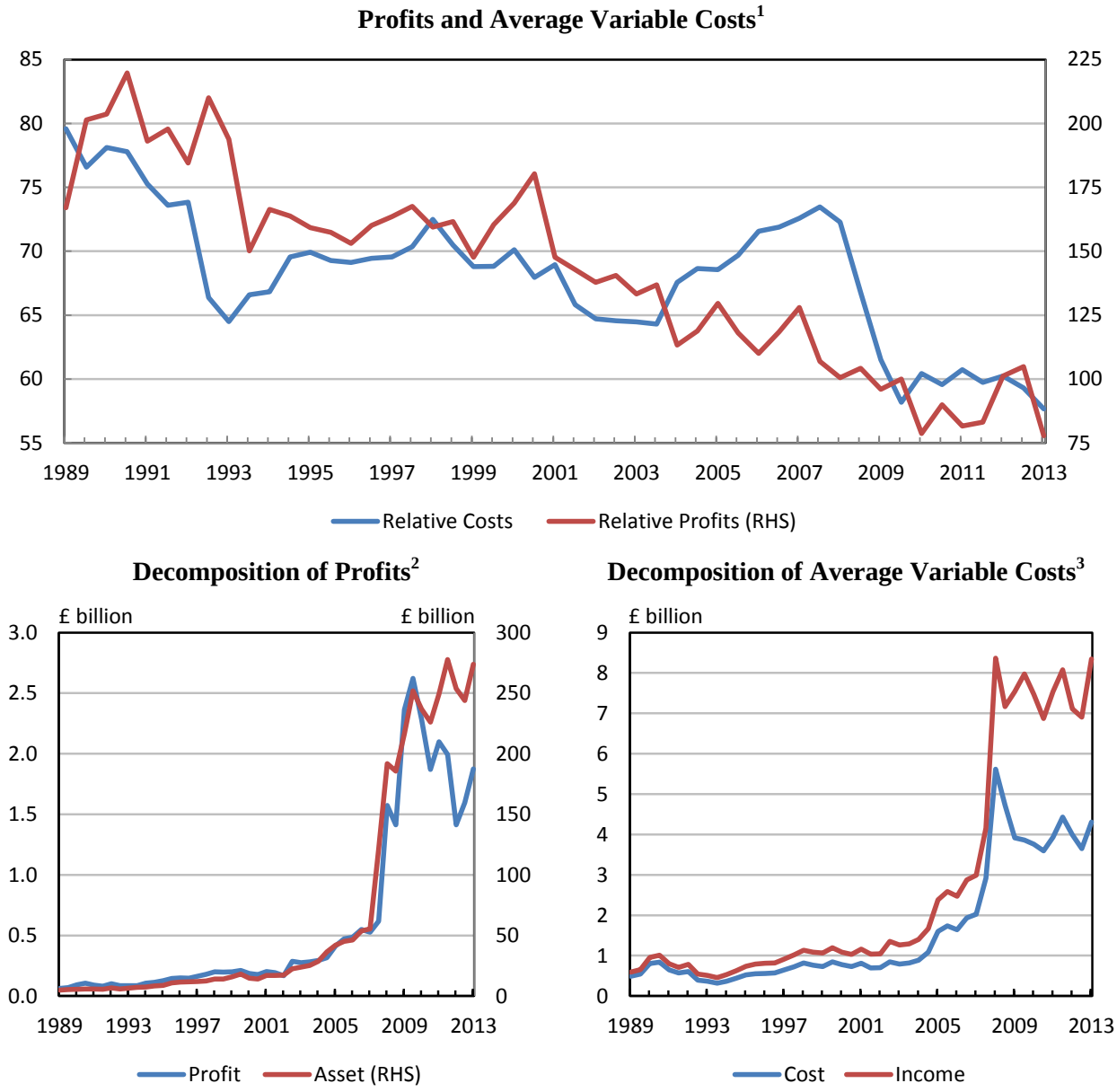
Source: Bank of England

Notes:

[1] Diamonds show the individual bank variable profit and variable cost data within each period noted. The line shows fitted values for profits from a simple linear regression of variable profits on variable costs

2 The dataset was divided into six equal periods of four years (the first period includes an additional year). As the number of banks change over time, the number of data points within each period will differ.

Figure A2.6: Decomposition of profit and average variable cost measures used to estimate the Boone Indicator



Source: Bank of England, Author's calculations

Notes:

[1] Relative profits are the profits before tax of each firm divided by the value of total assets. Relative costs are total costs for each firm divided by income generated from intermediation activities. Graph shows the mean of all firms' data at each point in time.

[2] Total profits are defined as above.

[3] Total costs are defined as above. Income is derived as revenue generated from interest received, foreign exchange commission and trading income, fees received and other operating income