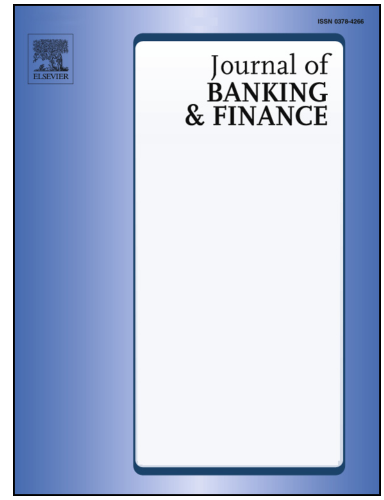

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Assessing Bank Competition for Consumer Loans

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Abstract

Based on frontier analysis, we derive inferences of bank consumer loan competition from estimating a revenue-cost 'competitive efficiency' (CE) frontier. The competitiveness of the $400 billion U.S. bank consumer loan market is then assessed by comparing results from our frontier CE measure with other competition measures, such as HHI, Lerner Index, and H-Statistic. These measures are weakly related to one another and only half of them identify banks with the highest loan price as also being the least competitive. This is the opposite of what is expected. Using the frontier CE measure, the most and least competitive banks are not located in the most populous states and the largest banks are underrepresented. Overall, the HHI should not be used to indicate competition.

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1 Introduction.

Bank loans generate more than half of all U.S. bank revenues and differ between business and consumer loans in both size and borrower sophistication. Consumers are viewed as less informed in financial matters and so are the focus of most state and federal legislation, as well as regulatory concern. Consumer loans in this paper comprise loans to individuals for household, family, and other personal expenditures—a $400 billion dollar market. Concerns about financial services offered to consumers, including all types of consumer loans, led Congress to establish the Consumer Financial Protection Bureau (CFPB) when it passed the 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act. Identifying and correcting potentially unfair or anticompetitive behavior may ultimately increase consumer welfare and raise total economic surplus.

This paper's principal contribution is methodological and takes the form of proposing a new competition measure—our Competitive Efficiency (CE) measure—that is based on frontier analysis. This measure looks at an individual bank's loan spread-to-cost ratio and "statistically subtract" influences that are unrelated to output market competition—such as factor prices, productivity, scale of operation, bank-specific risk—leaving an estimate of the unexplained portion of the loan spread-to-cost ratio across banks. Once the influence of normal error on this residual is removed, we are left with the presumed average effect of competition on the loan spread-to-cost ratio. This value is then used to form a relative index across banks which defines the "competitive efficiency" frontier. The theoretic framework that underlies our frontier approach to measuring competition borrows from Boone (2008a) who derived a robust competition measure based on relative profit differences.

Competition policy that has had some success in more oligopolistic industries than banking, has been to identify and later look more closely at manufactured products where prices seem to be "too high" according to some mark-up measure (e.g., Lerner Index) or remain very stable even though costs are fluctuating or major material input costs are falling (e.g., H-Statistic). The use of the HHI by banking regulators to limit market concentration through mergers and acquisitions is an example of attempting to prevent implicit price collusion (local price leadership) and maintain a competitive environment that will keep prices from becoming "too high" via market power or price collusion. For antitrust authorities it is important to know which competition measure may best reflect the price conduct aspect of bank competition for consumer loans. Using our frontier CE measure, we focus on trying to identify banks with relatively higher consumer loan prices—after controlling for cost and productivity differences—and report information on their market characteristics, such as where they are located, the income level in their markets, the degree of branch ownership concentration, and other descriptives.[1]

[1]Banking regulators and consumer non-profits tend to focus their attention on consumer complaints, which largely deal with the seeming unfairness of or inadequate information on charges associated with particular banking services. Some very recent examples relate to unclear or misleading statements in lending documents (CFPB, 2013c), the existence of certain credit card fees and retroactive interest charges (Agarwal, et al., 2014), and the (largely) past practice of ordering account overdraft events so as to maximize the number of separate overdrafts an account holder pays for (CFPB, 2013b). However, not much data on consumer complaints is available.

In this paper, we estimate and compare our frontier CE measure with five, more or less, standard competition measures—HHI, H-Statistic, Lerner Index, an inefficiency-adjusted Lerner Index (L), and a Mark-up. In addition, we analyze the ability of all these six competition measures to actually identify banks with relatively low versus high loan output prices. This is often viewed as a useful indicator of the strength versus weakness of market competition so that the greater the match, the greater the possible accuracy of the measure. As a first screening device, this type of bank-level information may be helpful for antitrust authorities when it comes to assessing the competitive conditions of a specific banking market and the banks operating in it. European regulators have similar concerns about lack of competition and high prices for banking services (European Commission, 2007; Liikanen report, 2012).

Our analysis shows that these competition measures, while often significantly statistically related to each other for US banks, are only weakly economically related to one another. Measured by adjusted R-squared, 16 out of the 21 bivariate correlations among our competition measures are less than .10 while all correlations with HHI are .01 or less. Thus, the competition indicators appear to measure different aspects of competition. Overall, given the poor performance but still widely used HHI in identifying bank competition, it would be useful for antitrust authorities to obtain a "second opinion" by computing an additional competition indicator—our frontier CE measure may be a good candidate to adequately assess the price conduct aspect of loan competition.

The remainder is as follows. Based on a theoretic model of the banking industry, in Section 2 we define and estimate our frontier CE measure using quarterly data on 2,644 U.S. banks making consumer loans over 2008-2010—a period of financial stress for both banks and many consumers. Section 3 describes the other five competition measures and illustrates the degree to which each competition measure generally, and at their frequency tails, are related to one another. Characteristics of the most and least competitive banks for each competition measure are outlined in Section 4. This illustrates how the average loan price, bank profitability, and industry asset share vary when moving from most to least competitive institutions for each competition measure. For some measures, price and profitability falls (rather than rises) as we move from the most competitive to the least competitive banks, not an encouraging result. Section 5 looks at the association of each measure with consumer loan price conduct that would give a first indication about potentially competitive versus anticompetitive behavior. Our frontier CE measure is then used in Section 6 to show which states appear to have the greatest concentration of most/least competitive banks and note the average per capita income level of the communities they serve. Section 7 presents our conclusions and their implication for policy.

2 A New Measure: Competitive Efficiency Frontier.

Using a different methodology based on efficient frontier analysis, it is possible to derive inferences of bank consumer loan competition from estimating a revenue-cost competition frontier. We also suggest that standard competition measures incompletely adjust for important cost/productivity differences among banks and incorporate these additional cost influences into our analysis (Bolt and Humphrey, 2010 and 2015). The theoretic framework that underlies our frontier approach to measuring competition borrows both from Boone (2008a,b) who derived a robust competition measure based on relative profit differences, and Maudos and Fernandez de Guevara (2004) and Uchida and Tsutsui (2005), who analyzed key factors that drive optimal interest rate spreads in a model of bank competition. But first we turn to the data.

2.1 Data.

We use quarterly data on 2,644 U.S. banks making consumer loans over 2008-2010. Our analysis is restricted to banks with $100 million or more in assets in 2010 which accounted for 89% of the types of consumer loans we cover. Consumer loans in this paper comprise personal loans, student loans, auto loans, and other installment loans or revolving credit plans. Data are not available to separate these different types of consumer loans across banks. We exclude loans secured by real estate (mortgages) and credit card loans (as Visa, MasterCard, and other issuer organizations, rather than individual banks, set credit card interchange fees by type of merchant). Deposit account overdrafts are not classified as a consumer loan. The final sample includes 380 large banks each with assets over $1 billion and 2,264 banks with assets between $100 million and $1 billion.[2]

Note that we focus on competition among banks for consumer loans rather than on competition among all suppliers of consumer loans. Studies have shown that bank consumer loans are markedly less expensive than payday loans, pawn shop loans, or auto title loans (Caskey, 2005; Stegman, 2007). Suppliers of non-bank consumer loans justify their higher price by noting the higher credit risk and nonpayment experience they incur and, as a result, suggest they do not make excessive profits given the risks they face. This has found some support in the empirical literature (Flannery and Samolyk, 2005; Skiba and Tobacman, 2007). Non-bank lenders also argue that were it not for them, the low income and risky loan market segment would not generally be served by banks. From this perspective, the bank and non-bank consumer loan markets are essentially segmented by borrower risk. In addition, data on costs, profitability and prices of consumer loans for non-banks are not available to be compared with regularly reported bank consumer loan data.

The bank data we use come from the Call Reports during 2008-2010. These data are only provided at the aggregate bank level. We match the Call Report data with information about the locations of bank branches and deposits held by each bank using the FDIC's Summary of Deposits. Only bank deposits data is available at the individual branch level. This allows us to calculate an HHI's for each Metropolitan Statistical Area (MSA) and a deposit-based weighted HHI for each individual bank.[3]

[2] Various screens were applied to eliminate shell banks, special purpose banks, banks with no loans, or no deposits, or no full time employees, etc., or that contained variables beyond five standard deviations from the mean and are clearly unrepresentative of the banking industry in general. Although there are some 3,800 small banks with assets less than $100 million, they were excluded from the analysis as they only accounted for 11% of consumer loans and their mean size was less than that of a single branch office of a large bank.

[3] MSA refers to both the larger (urban) standard MSAs as well as the smaller (rural) non-MSA

Banks may compete for loans locally, but they can operate in multiple markets. However, interest rate data are only available at the aggregate bank level. This implies that interest rates are not known in every market a bank operates in. But to the extent that banks operate in multiple markets, they usually have the bulk of their deposits in a single market (Rosen, 2007). In our sample, the median bank has branches in only two MSAs out of 956. Although the billion dollar banks have a broader geographical representation, the median billion dollar bank in our sample has branches in only four MSAs and operates in only 1 state out of 50. Even at the 99th percentile, the average billion dollar bank has offices in only 26 states.

While only a minority of banks operates in multiple markets, those banks own a disproportionate share of total assets and hence have a large impact on competitive efficiency of the U.S. banking sector. Implicitly we are assuming that banks set the same interest rates in all markets. However, this assumption is consistent with earlier evidence that multimarket banks tend to set uniform interest rates at their markets in the same states (Radecki, 1998; Hannan and Prager, 2004; Rosen, 2007). Hannan and Prager (2009) find as well that large multimarket banks tend to be less sensitive to local market conditions with respect to pricing than the smaller single-market banks.[4] Consequently, in assessing loan competition across banks, we take the view that a bank's potential competitors are located mainly in the MSAs that a given bank has a branch in. So, our competition measure—as well as the Lerner index and H-Statistic—is defined on aggregate bank level (and not on a local market level), reflecting the "average" across all branches of the various markets each bank has at least one branch in. Our frontier CE measure aims to tie aggregate "excess" loan revenues with an overall lack of competitive efficiency for an individual bank relative to other banks.

Finally, good data on potential cross-subsidization between bank services and products are not readily available. Carbo and Rodriguez (2007) argue that income from non-interest bank activities may influence net interest margins through possible cross-subsidization effects and Lepetit et al. (2008) also find that banks may charge lower rates on loans—so that credit risk is underpriced—if they are able to obtain high fees from other services and customers. Hence, cross-subsidization may affect competitive conditions in a market. However, in a recent paper by Abedifar, Molyneux, and Tarazi (2014), the authors find little empirical evidence that cross-subsidization between traditional intermediation and non-interest income activities has played an important role in U.S. banking markets during and after the financial crisis, which is exactly our sample period.

2.2 Theoretic Framework.

Our approach to measuring competition is similar to that developed by Boone (2008a), whose aim was to determine competition based on a firm's relative profits. In Boone

counties covered in the FDIC's annual Summary of Deposits. The U.S currently counts 956 MSAs, and a local banking market is usually defined by one of these MSAs.

[4]Hannan and Prager (2004) document that multimarket banks tend to offer lower (deposit) interest rates than single-market banks operating in the same market. However, Rosen (2007) finds that as multimarket bank presence increases in local markets, the more similar the banks in a market become in size, the higher the interest rates.

(2008a) competition is determined by subtracting a firm's variable costs from its revenues, giving a return to fixed inputs plus extra revenues associated with the degree of relative competition. Excess revenues may either be generated due to a lack of competition or due to high efficiency levels. Within a general model of Cournot competition, Boone analyzes the impact of increased competition on firms' output, prices, profit, and market shares.

In particular, following Uchida and Tsutsui (2005), consider a banking industry where each bank i, $i = 1, ..., N$, attracts d_i deposits and makes loans q_i (for simplicity, investing in government bonds is ignored). Since our main focus is on bank loan competition, we abstract from considerations on the liabilities side of the bank's balance sheet and assume that banks have unlimited access to an inelastic supply of deposits at a (fixed) rate r^d. The profit of bank i is

$$\pi_i = p(q_i, q_{-i})q_i - r^d d_i - C_i(q_i, d_i; n_i),$$

where $p(q_i, q_{-i})$ is the inverse demand curve for loans, C_i the operating cost function, and n_i the efficiency level of bank i. Banks are identical except for their efficiency level n_i, where higher n_i denotes higher efficiency implying (weakly) lower marginal cost. Assume a linear demand curve for loans

$$p(q_i, q_{-i}) = a - bq_i - d\sum_{j\neq i} q_j.$$

The bank's problem is

$$\max_{\{q_i, d_i\}} \ \pi_i \quad s.t. \quad q_i = d_i.$$

Substituting $q_i = d_i$ and writing $\tilde{C}_i(q_i; n_i) = C_i(q_i, q_i; n_i)$, the first-order conditions are

$$a - bq_i - d\sum_{j\neq i} q_j - r^d - \partial\tilde{C}_i/\partial q_i = 0.$$

In a Cournot-Nash equilibrium, these conditions determine the optimal loan quantities q_i^* and prices p_i^*. In particular, it follows:

$$q_i^* = \frac{(2b/d - 1)(a - r^d) - (2b/d + N - 1)\partial\tilde{C}_i/\partial q_i + \sum_{j=1}^N \partial\tilde{C}_j/\partial q_j}{(2b + d(N-1))(2b/d - 1)}.$$

Boone (2008a) shows that equilibrium prices and loan quantities in this Cournot setting can actually be written as $p_i^*(n_i, \bar{N})$ and $q_i^*(n_i, \bar{N})$ where $\bar{N}$ is an aggregate efficiency index which is a function of the efficiency levels $n_1, ..., n_N$, with N the number of banks that enter the market (so that $\pi_i^*(n_i, \bar{N}) \geq f_i$, where f_i denotes the entry cost).[5] In Boone's framework, competition measurement centers around variable profit

$$\pi_i^*(n_i, \bar{N}) = p_i^*(n_i, \bar{N})q_i^*(n_i, \bar{N}) - r_i^d d_i^* - C_i(q_i^*(n_i, \bar{N}), d_i^*; n_i),$$

with $d_i^* = q_i^*$. Under constant marginal cost, Van Leuvensteijn et al. (2011) show that

[5]Boone (2008a) assumes $\partial\tilde{C}_i/\partial q_i = 1/n_i$.

optimal variable profits are quadratic in marginal costs.

Following Boone (2008a), consider three banks with different efficiency levels, so that $n_2 > n_1 > n_0$, and calculate the "distance" to the least efficient bank, $\Delta_2 = \pi^*(n_2, \bar{N}) - \pi^*(n_0, \bar{N}) > 0$ and $\Delta_1 = \pi^*(n_1, \bar{N}) - \pi^*(n_0, \bar{N}) > 0$. Increased competition—through entry (change in f), market conduct (change in b and/or d), or regulation—reallocates output from less efficient to more efficient banks which raises Δ_2 relative to Δ_1. Hence, this output reallocation effect depends on the level of competition itself. Denoting θ the level of competition, we may write $\Delta_1(\theta)$ and $\Delta_2(\theta)$. Defining his measure of Relative Profit Differences (RPD) as RPD(θ)=$\Delta_2(\theta)/\Delta_1(\theta)$, Boone proves that $\partial \mathrm{RPD}/\partial\theta > 0$. This result holds for a broad set of models (Boone 2008b).

The intuition for Boone's relative profits measure is that in a more competitive industry firms are punished more harshly for being inefficient since their costs are higher. In a more competitive industry, the most efficient firm gains more relative to less efficient firms, so its relative profits and market share increase relative to those "lagging" firms. Since this output reallocation effect is a general feature of more intense competition, RPD is a robust measure of competition and, from a theoretical point of view, more robust than the price-cost margin of a Lerner Index or H-Statistic.

Profits from bank loans are just loan revenues minus costs. While total revenues are reported for loans, quantities and operating costs are not. Our approach to measuring Boone's RPD involves first forming a ratio of unit loan revenues minus unit funding cost (i.e. loan spread) all divided by each bank's overall operating cost. Second, influences on this ratio that are unrelated to output market competition but yet drive optimal interest spreads—such as factor prices, productivity, scale of operation, bank-specific risk, etc.—are then "statistically subtracted" leaving an estimate of the unexplained portion of the loan spread-to-cost ratio across banks. Interestingly, using a theoretic model of bank intermediation in credit markets, Maudos and Fernandez de Guevara (2004) have identified these influences such as cost, productivity, size, and risk as key determinants of the interest margin (see also Carbo and Rodriguez, 2007). Third, the influence of normal error on this residual is removed and we are left with the presumed average effect of competition on the loan spread-to-cost ratio. This value is then used to form a relative index across banks that we maintain reflects Boone's RPD. The larger the distance from the frontier, the less "competitive efficient" the bank is.

2.3 Empirical Implementation.

In simple terms, profits = f (competition, costs). As profits are simply revenues minus costs, profit differences across banks can be alternatively measured as the "mark-up" ratio of revenue to costs and, if all explicit costs are included, an estimate of relative competition can be obtained from: revenue/costs - f (costs) = g (competition). Here g (competition) represents the *unexplained mark-up* over cost and includes a normal return on equity which is not explicitly specified in the model. Our revenue/cost ratio is the inverse of the popular Cost Income Ratio used in banking or revenue/cost = (interest revenue - interest expense + fee income)/(labor + capital + other non-interest expense). Banks with a lower input cost per unit of output revenue raised are (by definition) more profitable. This approach is similar to using a Lerner-type Index expressed as the ratio P_o/MC, replacing MC with AC, and multiplying by a ratio of output and input quantities Q_o/Q_i giving: $(P_o * Q_o/AC * Q_i)$ which equals a revenue/cost ratio.[6]

If the productivity of inputs Q_i differs across banks then input prices (reflected in AC) will not reflect their true cost to the bank. Observed input cost $AC * Q_i$ will be higher for banks with greater productivity making them appear more competitive than they are as the observed spread $P_o - MC$ or $P_o - AC$ will be lower. The productivity variables we specify have been important in reducing cost inefficiency to low levels in both stochastic and linear programming frontier models (Carbó, Humphrey, and Lopez del Paso, 2007).[7] Specifically, labor (L) is more productive and real labor costs are lower when there are fewer employees (line, back office, and management) per branch office (BR). As well, capital productivity is improved when a bank produces more deposits (DEP) per branch office. Banks differ in their staffing arrangements (L/BR) to meet their daily peak load for teller window transactions, back office transaction processing, and in their layers of management. Some banks operate in-store or supermarket branches where the staffing level is about half that of a stand-alone office (Radecki, Wenninger, and Orlow, 1996). In addition, in-store and stand-alone branches located in higher income areas (suburban versus central city or rural) generate more deposits per office, raising the deposit/branch ratio (DEP/BR) as well as generating a greater demand for other banking services (adding to revenue). Importantly, branch locations in high income areas are limited and in-store branch contracts with supermarket chains are exclusive within states or metropolitan areas so these productivity/cost differences can be relatively persistent.[8] In sum, a high labor/branch ratio and a low deposit/branch ratio suggests cost inefficiency that rolls over into profit inefficiencies relative to other banks.

In estimating the competition frontier, we use the composed error Distribution Free Approach (DFA) in Berger (1993).[9] In a composed error framework, the DFA model illustrated in (1) relates the ratio of consumer loan revenues, net of funding expenses, to overall operating costs. Specifically, it attempts to explain the variation across banks in the ratio of unit consumer loan revenues ($PCLOAN$) minus unit deposit cost ($PDEP$) divided by overall operating cost (OC), comprised of labor, physical capital, and materials expense. Although operating cost is not allocated to the various banking services in the reported data, we do specify variables to explain the overall level and variation of operating cost among banks which, in turn, influence the effect of operating cost on consumer loans and other banking services.

[6]Expressing the Lerner Index as a mark-up percentage $(P_o - MC)/P_o$, a spread $P_o - MC$ or a ratio P_o/MC should give the much the same ranking of bank competition. This is also the case when average cost AC replaces marginal cost since MC is uniquely tied to AC by the slope of the supply curve (or scale economies). We do not have separate information on Q_o/Q_i, only the reported revenue/cost result.

[7]Berger and Mester (1997) and Frei, Harker, and Hunter (2000) have also shown productivity influences to be a primary determinant of previously unexplained bank cost inefficiency.

[8]The capital cost of an in-store branch is only about one-fifth of a conventional branch (Radecki, Wenninger, and Orlow, 1996).

[9]Two other frontier approaches exist: Data Envelopment Analysis (DEA) which uses linear programming and the composed error Stochastic Frontier Approach (SFA). We prefer the DFA because when no restrictions are placed on the resulting distribution of estimated efficiency, it is not a half-normal distribution as assumed in the SFA. Also, each constraint added in DEA raises measured efficiency even when, in a regression framework, the added variable may be insignificant.

$$\ln((PCLOAN - PDEP)/OC) = R(\ln Q, \ln P, \ln X, \ln Z) + \ln e + \ln u. \quad (1)$$

The total residual ($\ln e + \ln u$) in (1) reflects the unexplained portion of the net revenue-operating cost dependent variable remaining after output (Q), input cost (P), productivity (X), and risk (Z) have been accounted for (see the Appendix for the exact specification). Here $\ln e$ represents the value of random error while our maintained hypothesis is that $\ln u$ represents the effect of competition on revenues. The DFA concept assumes that $\ln e$ will average to a value close to zero while the average of $\ln u$ will reflect the average effect of competition ($\ln \bar{u}$).[10] The bank with the lowest average residual ($\ln \bar{u}_{\min}$) is also the bank where the variation in underlying cost and productivity explains the greatest amount of the variation in revenues relative to operating costs, reflecting the strongest effect of market discipline on the revenue/cost ratio through competition. This minimum value defines the competition frontier and the relative competition efficiency (CE_i) of all the other i banks in the sample is determined in (2) by their dispersion from this frontier:

$$CE_i = \exp(\ln \bar{u}_i - \ln \bar{u}_{\min}) - 1 = (\bar{u}_i/\bar{u}_{\min}) - 1 \quad (2)$$

If $CE_i = 2.0$, then $\bar{u}_i$ is two times larger than $\bar{u}_{\min}$ so the unexplained portion of $(PCLOAN - PDEP)/OC$ is two times larger than $((PCLOAN - PDEP)/OC)_{\min}$. This difference reflects the unspecified influence of competition. Thus the larger is CE_i, the weaker is the ability of market competition to restrain revenues, relative to costs, so CE is similar to inefficiency in a cost frontier. Unlike the L measure above, we do not incorporate profit inefficiency from either a standard or alternative profit function. We focus on how well–or poorly–the competition measures are related to relatively high prices for that is what the consumer pays. If high prices lead to high profits then focusing on high prices will identify banks that do both. We see no reason to penalize those that achieve relatively high profits without having high prices, for example by controlling better their costs or being located in SMSAs with higher than average growth or income which affects the demand for consumer loans.

Although we account for the output level of consumer loans, factor prices, factor productivity, risk, scale effects, and the stage of the business cycle, it is still possible that we have excluded some important cost influence from the estimated frontier model shown in the Appendix. Even so, our statistical fit across six two-quarter panel estimations averaged .86, suggesting that there is not much left to be explained by unreported and excluded differences in cost.[11] Indeed, if all costs have been included, this suggests that 14% of the variation in $(PCLOAN - PDEP)/OC$ reflects the in-

[10] DeYoung (1997) has suggested that 6 separate cross-section estimations may be needed for random error in the composed error term to achieve an average value close to zero. Our composed error terms are averaged over 6 cross-section estimations of two quarters each.

[11] While a fixed effects approach would likely improve the statistical fit, the time and bank-specific dummy variables can not discriminate between excluded cost effects (which we would like to include) and the excluded effect of competition on revenues (which we wish to exclude and keep in the residual). The Lerner Index has a similar problem when applied to the entire bank as it excludes around 35% of revenue generated by banking output when estimating marginal cost in a cost function as output associated with non-interest income is not reported.

fluence from (unobserved) competition. If all costs have not been included, then the influence of competition is smaller than 14% and we have overestimated, rather than underestimated, the influence of a lack of competition.

As seen in Table 1, the average consumer loan CE value for 2,644 banks is 9.6, which reflects the fact that the mean bank experienced a level of averaged unexplained residuals from (1) across six cross-section regressions that were 9.6 times the level of those for the bank whose averaged residuals were lowest (and hence define the competition efficiency frontier). This is a relative measure so if the minimum residual is small, the CE value can still appear to be large as an index.

3 Other Measures of Consumer Loan Competition.

In this section five other competition measures are defined and estimated. Overall, these measures are only weakly related to one another, suggesting that they measure different aspects of competition.

3.1 Market Concentration Measure: HHI.

Regulators rely on the Herfindahl-Hirschman Index (HHI) because they believe it to be predictive of higher prices if mergers or acquisitions occur where market concentration exceeds a certain level. It is also simple to compute.[12] While the sum of squared market shares only reflects the potential for anticompetitive or collusive behavior leading to higher prices and/or greater profits, stock market event studies of proposed mergers have indeed supported that view (e.g., Warren-Boulton and Dalkir, 2001). In practice, the HHI is augmented with additional market information (U.S. Department of Justice, 2010). Importantly, and unlike other measures of market competition, a post-merger/acquisition HHI can be determined and inferences drawn as to likelihood of post-merger price increases if the merger goes through. The other measures are solely ex post, not also ex ante as is the HHI. Even so, the focus on market shares does not account for how these shares may have been achieved—through lower costs or by anticompetitive behavior. If lower costs and/or greater cost efficiency have been an important reason for some banks in achieving a relatively high HHI, this will overstate the apparent lack of competition that exists currently. It can also overstate the potential anticompetitive effects of a bank merger, for example as suggested by an event study, if the merger/acquisition is perceived to lead to important cost reductions which could be the main reason behind a favorable event study result.

This possibility, originally raised by Demsetz (1973), led to the efficient structure controversy and the finding that cost efficiency (measured from a cost frontier) and the HHI are about equally important in explaining differences in bank profitability (Berger, 1995). Thus greater predictive accuracy could be achieved in assessing the relationship of the HHI with profitability *after* the influence of cost efficiency is "subtracted" or otherwise accounted for. Studies showing that the HHI is generally associated with higher loan rates and lower deposit rates (as surveyed in Dick and Hannan, 2010) are

[12] In banking, the FDIC collects branch level deposit data to compute the HHI. Other measures would also be relatively simple to compute if the requisite cost accounting data were collected at the branch (or bank) level.

similarly affected since they too are not adjusted for differences in efficiency across banks. Cost efficiency differences associated with productivity differences and operating scale can affect observed factor input prices and hence the pricing of deposit services as reflected in the deposit interest rate.

Following Hirtle (2007), a deposit-based HHI is determined for each of the 2,644 commercial banks for 2010 in each of the 956 MSAs. These MSA HHIs are then weighted by each bank's deposit share across all the MSA's the bank operates in to give a bank-level HHI. Unfortunately, only deposit information is collected at the branch level across MSAs, not the value of consumer loans (although the level of consumer loans should be related to the level of deposits).[13] Our bank-level HHIs are weighted averages of branch-level deposit data and, as averages, can understate or overstate individual branch-level effects in different MSAs. However, a bank-level HHI is needed in order to compare the HHI with the other competition measures for which data are only available at the level of an individual bank.

The U.S. Justice Department's 2010 horizontal merger guideline suggests that markets with an HHI below 1,500 can be considered to be unconcentrated. A moderately concentrated market exists when the HHI lies between 1,500 and 2,500 while a highly concentrated market has a HHI above 2,500. While Table 1 shows that the average HHI for our 2,644 banks is 1,165 and thus at the bank-level operate in unconcentrated markets, the quartile of banks with the largest HHI has an average value of 2,127 and as a group would be considered moderately concentrated. Overall, only 4% of banks are in highly concentrated markets with an HHI $\geq$ 2,500. Banks that operate in highly concentrated markets have market power and could use that power to charge prices well above underlying costs or engage in other anticompetitive behavior. This is by no means certain but would bear further investigation of banks so identified. Had we used the 1992 DOJ guidelines, the percent of banks in highly concentrated markets (HHI $\geq$ 1,800) would be 16% but the guidelines were liberalized in 2010.

3.2 Level of the Price-Cost Spread: Lerner Index.

Academics have for solid theoretical reasons favoured the Lerner Index (Lerner, 1934) which seeks to measure realized competition as opposed to the potential for competition as does the HHI. The Lerner Index reflects the percentage spread of the output price or average consumer loan interest rate (P_o) to estimated marginal cost (MC) for individual banks averaged over 2008-2010: $(P_o - MC)/P_o$. Marginal cost is estimated from a logarithmic cost function $\ln C = f(\ln Q_o, \ln P_i)$ where C is total cost, Q_o is output, P_i is composed of funding, labor, and capital input prices, and $MC = \sum_i (\partial \ln C / \partial \ln Q_o)(C/Q_o)$. As scale economies ($SCE$) are the ratio of marginal to average cost (AC), the Lerner Index can be simplified to $P_o - AC \cdot SCE$.[14] This reflects the *level* of the price-cost spread.

It is not possible to estimate a Lerner Index directly for consumer loans using a cost function since the total cost of consumer loans is not reported. Although one can reasonably approximate the average interest expense incurred in making consumer

[13] The Appendix has more information on the calculation process.

[14] As the variation of this unit spread across banks will accord well with its percentage value if divided by P_o or AC, in this illustration we focus on the spread alone.

loans, the allocation of operating costs (labor, physical capital, and other non-interest expense) to consumer loans is not reported. Consequently, a standard Lerner Index was estimated for the whole bank and is used in place of a Lerner Index specific to consumer loans which is not available. Fortunately, this data limitation does not apply to three of the remaining competition measures (but does apply to the adjusted Lerner measure below). Our specification of the Lerner Index is shown in the Appendix and its average value is 39% in Table 1. The quartile of most competitive banks–those with the lowest Lerner Index–have a mean value of 25% while the least competitive quartile has a mean of 51%. To put these values in perspective, if MC was .03 the loan rate P_o would average .049 and range between .040 and .061.

[**Insert Table 1 here**]

3.3 Adjusting for Inefficiency: An Alternative Lerner Index.

A Lerner Index adjusted for cost and profit inefficiency has been proposed and used by Koetter, Kolari, and Spierdijk (2012) to gauge the possible effect of banking deregulation on banking competition. If banks with market power choose the "quiet life" rather than seeking to minimize costs and, given quantities, have the opportunity to set prices to maximize profits, then reported costs will be higher and profits lower than otherwise and in this sense reflect "inefficiencies". A preference for the quiet life if competition is weak can be one reason for inefficiency but others exist as well. Not all bank branches can be located in faster growing and higher income areas even though, if they were, loan revenues and profits would be higher since higher income areas tend to generate more loan demand and branch networks support more low cost deposits per office. Also, not all banks adopt to the same degree cost saving innovations such as replacing branches with ATMs, using peak-load/part-time staffing, applying artificial intelligence in assessing loan applications, monitoring as carefully outstanding loans, or promoting lower cost internet banking. Banks also differ in managerial talent, loan officer skill, loan workout procedures, board oversight, and in their mix of funding sources and loan concentrations, all of which are known in the industry to affect cost and profitability. As most of these influences are not subject to effective measurement, their relative contribution to measured inefficiency is a judgement call. Weak competition is just one possibility.

The cost function used to estimate MC for the adjusted Lerner Index, L, is specified the same way as the function to obtain MC for the unadjusted Lerner Index above but is estimated using a Stochastic Frontier Approach (SFA) rather than OLSQ. Although the resulting MC is not very different, SFA estimation generates an estimate of cost inefficiency from the composed error residuals of the cost function. An alternative profit function, which takes quantities as given and maximizes output price (rather than taking market price as given and maximizing quantity) is also estimated using SFA to obtain an estimate of profit inefficiency. The separation of inefficiency from normally distributed error in these cost and profit models is achieved by assuming inefficiency is distributed as a half normal distribution so that most banks will lie on or close to their cost or profit frontiers.

In simple terms, the adjusted Lerner Index substitutes a cost and profit "efficiency corrected" price (P_o^*) for the observed price (P_o) in a standard Lerner Index giving L

$= (P_o^* - MC)/P_o^*$. The efficiency adjusted price P_o^* is derived from the predicted values of the SFA estimated cost and alternative profit functions since predicted cost and profit will differ from their observed values by the amount of SFA estimated inefficiency, suggesting that costs could be lower and profits higher if inefficiency did not exist. These predicted costs and profits are summed to predict revenues and, divided by the value of banking output produced (all loans plus securities in the model), gives P_o^*.[15]

As seen in Table 1, we find the adjusted Lerner Index to be larger than an identically specified measure–L2–estimated using OLSQ rather than SFA, so it is not adjusted for cost or profit efficiency. This difference should indicate the extent that bank costs are not as low or profits not as high as that for the frontier bank with the lowest cost or highest profit in the sample. Profit inefficiency turns out to be much more important in determining the difference between L and L2 than is cost inefficiency both here and in Koetter, Kolari, and Spierdijk (2012). Even so, the difference in average values between L and L2 in Table 1 is not large since the R^2 between them is .93 in Table 2.

Banks view themselves as attempting to control costs even if they are unable to lower them to the level of the most cost efficient bank on the frontier. Thus a cost-minimizing, price-taking model is a more reasonable economic framework than one of monopsony with strong bank control over input prices. Consistency suggests that banks would also seek to maximize profits even though not all will be as profitable as the bank with the highest profits. If a standard profit function is specified, banks take prices as determined in the market and seek to maximize output. In such a framework profit inefficiency is conceptually the deviation of observed profits from the maximum observed profit obtained by a bank on the frontier, once operating costs, scale, market interest rates, and business cycle influences on profits are controlled for. This is similar to how cost inefficiency is obtained but is different from the alternative profit function used to construct L and L2 since output levels are taken as given and the bank is a output price-setter (not a price-taker). Here profit inefficiency is conceptually the deviation of observed profits from what they could be under monopoly. In reality, banks face markets where price-taking is a more accurate assumption (business loans, securities holding and trading, standard payment and deposit services) than a degree of price-setting behavior (consumer loans, specialized payment services, investment banking and off-balance-sheet activities). Choosing one approach over the other is difficult for the entire bank since different services seem to fit different behavioral models.

3.4 Mark-Up Over Deposit Costs.

While the Lerner Index reflects the mark-up for the entire bank, a more limited measure is possible for consumer loans. This would relate the average price of consumer loans (P_{CL}) to the average cost of deposits that fund these and other loans (P_{DEP}) and is expressed as $(P_{CL} - P_{DEP})/P_{CL}$.[16] The average mark-up of price over deposit costs for

[15] Using our data, predicted revenues are 23% less than observed revenues (TR) while the sum of banking output produced is 27% less than total assets (TA). Output price P_o in the standard Lerner Index is averge revenue per dollar of assets or TR/TA. The lower values used in P_o^* largely offset each other when L is estimated using OLSQ rather than SFA so at the data mean $P_o^* \approx P_o$.

[16] P_{DEP} is the presumed average cost of funding consumer loans. In practice, it is close to the marginal funding cost as almost all bank funding is short term.

consumer loans in Table 1 is 77% and varies from 66% to 86% across quartiles. The mark-up appears high for two reasons: interest rates are at historical lows during our sample period and the numerator of the Mark-Up excludes operating costs. Whether this spread is deemed excessive, suggesting a lack of competition, depends on the spread earned by other banks for their consumer loans and the return on equity in other industries.

3.5 Changes in the Price-Cost Spread: H-Statistic.

Like the Lerner Index, the H-Statistic of Panzar and Rosse (1987) is based on economic theory and seeks to measure realized competition. The H-Statistic relates changes in total consumer loan revenue ($TR = P_o Q_o$) to changes in observed input prices (P_i) holding output level (Q_o) constant and is shown in the Appendix. In contrast to the Lerner Index, the H-Statistic is based on an estimated revenue function $\ln TR = g(\ln P_i, \ln Q_o)$. The H-Statistic itself is the sum of partial derivatives or elasticities: $\sum_i \partial \ln TR / \partial \ln P_i$ and reflects the change in output price to input prices ($\partial P_o / \partial P_i$) since output is being held constant. Banks with a high ratio of changes in output to input prices $\partial P_o / \partial P_i$ will also have a large difference in these prices $\partial P_o - \partial P_i$ so the latter is an alternative expression of the former.

If output and input prices rise and fall together over time or across banks the implication is that non-cost influences on output price are small indicating a competitive market where cost determines price. Competition is strong when the H-Statistic is close to 1.0 and non-existent when it is close to 0.0. The closer the H-Statistic is to zero, the lower the influence of cost on output price, implying that firms are able to set price independently from cost as a result of having and using market power to set prices or collude with others to do so.

The average H-Statistic for bank consumer loans in Table 1 is .87, which is not very distant from 1.0 and is suggestive of a relatively competitive market. The quartile of banks with the lowest H-Statistics have an average value of .79 which is still quite far from zero and, by itself, would not indicate a serious lack of competition although this is a judgement call as no standard exists unless an H-Statistic is close to either 1.0 or 0.0—the two extreme values. At least with the HHI, the Justice Department provides a guideline (although one that has changed over time). While subjective judgement is also used in assessing the Lerner Index, a guideline of sorts exists in the values of this index (or mark-up) in other industries.

Note, however, that a correct identification of the H-Statistic relies on the assumption that markets are in long-run equilibrium. Our H-Statistic estimation seems to have passed a weak test for market equilibrium since the sum of the partial derivatives with respect to input prices found by regressing an approximate ROA for consumer loans on the same set of RHS variables used to estimate the H-Statistic in the Appendix was significantly different from zero. Recently, some studies have appeared that criticized the commonly used procedure to estimate the H-Statistic. Goddard and Wilson (2009) argue that using a static revenue equation leads to a misspecification bias, severely biasing the estimated H-Statistic towards zero (although, as we noted, our estimations do not point in that direction). In practice, adjustment towards long-run equilibrium is not instantaneous and markets are out of equilibrium either frequently or always. Therefore, according to Goddard and Wilson (2009), a partial adjustment equation with a lagged dependent variable is a better specification to capture equilibrium adjustments in response to factor input price shocks (following this procedure our results remain robust, see also footnote 25). Moreover, Bikker et al. (2012) argue there is a further misspecification bias when a price equation or a scaled revenue function is applied instead of an (unscaled) revenue function.

3.6 Comparing the Lerner Index with the H-Statistic.

Assuming that average cost reflects the weighted average of input prices (P_i), the two competition measures favored by academics–for comparison purposes–can be expressed as:

Lerner Index $\quad P_o - AC \cdot SCE \quad$ (Level of the price-cost spread)
H-Statistic $\quad \partial P_o - \partial AC \quad$ (Change in the price-cost spread).

In effect, the Lerner Index looks at the average *level* of the price-cost spread over a sample period while the H-Statistic looks at *changes* in that spread: they measure different aspects of competition. This difference is illustrated in Figures 1 and 2. In both figures, the top line represents the variation in the price of consumer loans (an interest rate) for billion dollar banks in the first quarter of 2008 arrayed by the value of bank assets on the X-axis. The bottom line in the first figure shows the variation in the price of deposits and other funding (also an interest rate) for the same banks in the same quarter. In the second figure, the bottom line reflects the scaled price of labor (annual wages and benefits in thousands of dollars divided by 5,000 for comparison purposes).[17]

[Insert Figure 1 here]

The H-Statistic reflects the sum of the strength of the covariation between the price of consumer loans (the top line in the figures) and of the specified input prices (bottom line). A strong relationship suggests that costs determine prices rather than market power or collusion. Although the Lerner Index is supposed to be a measure of the spread between the price of consumer loans and the sum of the input prices (marginal or average cost) per unit of output, the H-Statistic is only concerned with their covariation.[18] The HHI, in contrast, uses market structure to infer price conduct and/or profit performance but does not directly measure either one.

[Insert Figure 2 here]

In our data set, regressing the Lerner Index (which actually refers to the entire bank, not just to consumer loans) on the H-Statistic gives an $R^2 = .09$ indicating they are only very weakly related to each other. Thus they reflect different aspects of competition: a price-cost markup or spread for the Lerner Index and a measure of possible price collusion for the H-Statistic. Banks identified by the Lerner Index as having high prices will differ from banks so identified by the H-Statistic.

[17] In a double log estimating equation, the scaling would only affect the intercept, not the slope of the relationship between output and input prices. Thus the H-Statistic is unaffected with or without scaling.

[18] Either measure can be estimated with cross-section, time-series, or panel data.

4 Similarity Among Competition Measures.

The fact that the Lerner Index and the H-Statistic appear to measure different aspects of competition was illustrated above. Unfortunately, this seems to be a general result that applies to almost all of the competition indicators used here according to the adjusted R-squares shown in Table 2. Neglecting L2, as it is so similar to L, out of the 15 bivariate correlations among the remaining six measures, only 3 are larger than .10. These three concern the Lerner Index with Mark-Up (.11), Mark-Up with CE (.15) and the Lerner Index with the adjusted Lerner measure L (.50). The four measures here–Lerner Index, L, Mark-up, and CE–are variations on the spread between revenue and cost. Importantly, all correlations with the regulator-favored HHI measure are .01 or less while the relationship between the two often used academic measures–Lerner Index and H-Statistic–is only .09. These results are not as definitive as we would like them to be since, due to data limitations, some competition measures of necessity refer to the whole bank (HHI, Lerner Index, L) while others refer specifically to consumer loan activities (H-Statistic, Mark-Up, and frontier CE). Even so, an earlier analysis comparing competition measures both across and within 14 European countries found a similar lack of correlation among the HHI, H-Statistic, and Lerner Index (Carbo, Humphrey, Maudos, and Molyneux, 2009).

[Insert Table 3 here]

While the relationship between competition measures across all banks is mostly weak to nonexistent, greater correspondence may exist at the tails of these distributions. Table 3 shows the correspondence between the six competition measures for quartiles of the most and least competitive banks in each distribution.[19] For example, comparing the quartile of 661 banks that are most competitive using the HHI (the quartile of banks with the lowest HHI values) with the set of the 661 most competitive banks using the H-Statistic (the quartile of banks with the highest H-Statistics) shows that 228 are contained in both quartiles. This quartile correspondence could have occurred by chance alone since the joint probability of matching two independent series would yield 165 banks (from 2644*1/4*1/4=661/4=165) just by chance. The 95% confidence interval around this chance matching is 144 to 187 banks. Since the match of the most competitive banks using the HHI and the H-statistic is 228, this match is statistically significant, and is starred. There is, however, no significant match when comparing the least competitive HHI banks with the least competitive H-Statistic banks, which is of greater policy interest as identifying the least competitive is more important than identifying the most competitive. A significant match of most competitive with least competitive, or vice versa off the principal diagonal, indicates active dissimilarity and reinforces the lack of a useful relationship between the measures being compared.

Ten out of a possible fifteen tail comparisons are shown in Table 3. The ten shown had at least one significant quartile match of most competitive with most or least competitive with least, or sometimes both were significant on the principal diagonal. The five deleted comparisons either had no significant quartile matches or had only significant matches that were the opposite of what would be useful–a significant match

[19] The least competitive banks have the highest HHI, L, Lerner Index, Mark-up and frontier CE values, while the most competitive quartiles have the lowest. This is reversed for the H-statistic.

of most with least or least with most reinforcing the weak to almost zero R-square values in Table 2. The five tail comparisons in the first column of Table 3 have only one significant match, usually least competitive with least, with the other desired match (e.g., most competitive with most) being insignificant. At times, the opposite match (e.g., most with least or vice versa) is also significant suggesting that the matches in column one are weak overall.

The five matches shown in the second column are all much stronger since the match of most competitive with most and least competitive with least on the principal diagonal are both significant while all off-diagonal matches are insignificant. Neither the HHI or the H-Statistic are represented here. Rather, the strongest relationships are among the four measures–Lerner Index, L, Mark-Up, and frontier CE measures that are, in different ways, based on a price-cost spread. These results are unchanged even if when comparisons are made using the highest and lowest deciles (90% and 10%, not shown).

The fact that there is only a relatively weak correspondence between banks identified as being most or least competitive using the HHI and the other measures, suggests that an effort to benchmark the HHI to more theoretically (and, as we see next, empirically) supported measures appears problematic.

[**Insert Table 4 here**]

5 Characteristics of Most and Least Competitive Banks Across Competition Measures.

A useful measure of bank competition should be able to identify banks that have relatively high prices due to a lack of competition in the output market, rather than being due to higher input costs, a lower scale of operation, lower productivity, etc. If output prices are high due to high costs resulting from a lack of competition (a "quiet life" view), controlling for differences in costs across banks would likely reduce the ability of most of our competition measures to identify banks with relatively high output prices. With the exception of HHI, the other measures attempt to control for observed or estimated cost differences–the H-Statistic by covariation with output price while the spread indicators (Lerner Index, Mark-up, frontier CE) effectively subtract cost from price. The L measure corrects for cost and profit inefficiency before subtracting cost from price. At the limit, not subtracting any cost gives just price which is a perfect predictor of observed price. Our view is that all identifiable costs should be subtracted from price or revenue while the view of Koetter, Kolari, and Spierdijk (2012) who developed L, is that frontier analysis can be used to adjust price (correcting it for both cost and profit inefficiency) while estimating MC using a SFA framework. The result is that L has a larger spread than L2 but a lower one than a standard Lerner Index (due to how the price and marginal costs are defined).

Table 4 illustrates how all of our competition indicators are associated with bank characteristics that are often cited as suggesting a lack of competition. This concerns consumer loan prices, a consumer loan-deposit rate spread (profitability), and the overall return on bank assets (ROA).[20] Each competition measure has been ranked from most to least competitive with the average quartile values shown in the first seven rows of Table 4. As expected, all but the H-Statistic steadily rise in value when moving from quartiles of most to least competitive banks associated with these measures.

Rows 8 to 14 show how the average consumer loan rate of the banks in each of the quartiles of each competition measure in rows 1 to 7 varies from most competitive (where the loan rate should be lowest) to least competitive (where the loan rate should be highest). As summarized in the last column, the relationship is negative for the HHI, the H-Statistic, L and L2. The banks these four measures identify as being least competitive have lower consumer loan rates than the banks they identify as being most competitive. This is the opposite of what we would expect and indicates, at least for consumer loans, that these measures should not be relied upon to identify banks with high prices. The expected positive relationship is seen only for the Lerner Index, Mark-Up, and frontier CE measures. Here the average loan rates of banks they identify as most competitive are lowest while the loan rates of banks identified as least competitive are highest. The same results are obtained when the competition measures are related to bank consumer loan-deposit rate spreads (rows 15 to 21)[21]

In terms of overall bank profitability (net income/asset ratio), banks that the HHI and the H-Statistic identify as being the least competitive are less (not more) profitable than the banks they identify as most competitive. The banks these two measures identify as being the least competitive have the lowest consumer loan rates, the lowest rate spreads, and the lowest profits and all three are the opposite of what a useful competition measure is expected to show. The adjusted Lerner Index L, along with L2, correctly predicts profitability but not consumer loan rates or the loan-deposit rate spread. The three remaining measures (Lerner Index, Mark-up, and frontier CE) consistently give the expected results. It would be nice if these three measures also identified the same banks for each of the competition quartiles, but they don't. The share of our sampled bank assets placed in the most competitive quartile by the Lerner Index is 83% with an asset share of only 5% for banks deemed to be least competitive. This suggests that the vast majority of banks are competitive (last column of Table 4). As the quartile of most competitive banks using the Mark-Up measure accounts for only 10% of bank assets but 48% of assets for the least competitive quartile, this measure suggests that half of the banking industry is not very competitive. Finally, the frontier CE measure would place some large banks in both the most and least competitive categories–a more heterogeneous distribution.[22] At this point, it is not possible to say whether small or large banks are generally least competitive or have the highest consumer loan prices since the three competition measures that seem to perform best in Table 4 give differing results in this regard. This set of three can be narrowed further.

[20]Using Call Report identifiers, the price of consumer loans is PCLOAN = RIADB486/(RCFDB539 + RCFD2011) while the loan price-deposit rate spread is CSPREAD = PCLOAN - [(RIAD4073 - RIAD4185 - RIAD4200)/(RCFN2200 + RCON2200 + RCONB993 + RCFDB995)].

[21]The exception is the HHI since the rate spread does not vary between banks deemed most or least competitive using this measure.

[22]The HHI, and especially the H-Statistic, would place most or almost all large banks in the least competitive quartiles.

[Insert Table 5 here]

6 Association with Loan Prices.

One way to assess the differing results in Table 4 would be to place more confidence in those competition measures that closely accord to what most would accept as indicating a lack of competition. Namely, relatively high prices, a higher spread, and higher profitability. Only the Lerner Index, Mark-up, and frontier CE measures meet all three of these criteria. We now assess the ability of these three and the other measures to actually identify banks with relatively low versus high loan output prices. This is often viewed as a first indicator of the strength versus weakness of market competition so that the greater the match, the greater the possible accuracy of the measure. This type of information may then be helpful for antitrust authorities—as a first screening—to assess the competitive conditions of a specific banking market and the banks that operate in it.

Using the same methodology as Table 3, Table 5 shows the number of matches and their significance for six competition indicators.[23] The left hand side of Table 5 shows that the quartile of banks identified by the HHI, H-Statistic, and L measures as being most (least) competitive do contain some banks that do have the lowest (highest) consumer loan prices. However, the number is less than that needed to be significantly different from a match by chance alone (at the 95% level of confidence). That is, out of 661 possible matches on each of the two principal diagonal elements, the number of matches is less than 187 which is the upper bound to attain significance. None are significant using the HHI and, while there are statistically significant matches for the H-Statistic and L, they are not on the principal diagonal and thus are the opposite of what is desired.[24]

The remaining three competition measures on the right hand side of Table 5—Lerner Index, Mark-Up, and frontier CE—all have significant matches on the principal diagonal (with insignificance off the diagonal), which is what is desired. Of the quartile of banks that are identified by the Lerner Index as being most competitive (those having the lowest index value), 231 banks out of a possible 661 also have the lowest price of consumer loans. As the number of matched banks is larger than 187, this is a significant match. When the Lerner Index is supposed to identify the set of least competitive banks which should have the highest loan price, the match is insignificant. Since both elements on the principal diagonal for the Mark-Up and the frontier CE measures are significant, they both appear to do a better job in distinguishing more competitive from less competitive banks. Even so, the Mark-up has absolutely fewer matched banks on the principal diagonal compared to the frontier CE. The results of Table 5 are not improved when, instead of quartiles, we look at the 10% and 90% decile matches in Table 6. The HHI, H-Statistic, and L measures still perform poorly in having no significant matches on the principal diagonal while the matches for the Lerner Index, Mark-up, and frontier CE are significant as before with the same ranking in terms of the number of bank matches.[25]

[23] The L2 measure is excluded since it is so similar to L.

[24] This reinforces the result seen in Table 4 for these three measures.

[25] The H-Statistic result holds for Tables 5 and 6 even when, as suggested in Goddard and Wilson

One possible reason why the frontier CE measure seems to do better at matching with loan prices is that it controls for a broader selection of cost differences among banks. The Mark-Up controls for average deposit/funding cost while the Lerner Index controls for marginal cost, which should reflect the marginal influence of funding cost, input prices, and scale of operation. In contrast, CE additionally controls for labor and branch productivity as well as risk (loan losses and capital position).

[Insert Table 6 here]

Using the price of consumer loans as our benchmark indicator to assess the apparent predictive accuracy of the various competition measures, the frontier CE measure seems to perform best—at least for consumer loans. However, an important practical consideration would be ease of estimation. Here the Mark-up is much easier to obtain than either the Lerner Index or the frontier CE. Also, due to a lack of data, the Lerner Index was representative of the entire bank while both the Mark-Up and the frontier CE were specific to consumer loans. We do not know if the Lerner Index would have had a more favorable outcome had the requisite data on consumer loans been available. In any case, the Mark-up, defined as the price of consumer loans minus the apparent average cost of funding (deposits and other borrowed funds) all divided by the price of consumer loans is really just a simpler Lerner Index without the need to estimate a cost function. A caution here is that while both the Mark-up and CE measures identify the most banks which do in fact have the highest loan rates, not all the banks so identified are the same banks. That is, some banks identified by the Mark-up as having high consumer loan rates will not also be identified by the CE measure even though all the banks identified by both measures are in the highest quartile or decile of banks with the highest rates. Even so, the overlap here is substantial and ranges from half to three quarters for these two measures in Tables 5 and 6.

Given different theoretical assumptions, all of the six competition measures contrasted here differ in how deviations from (perfect) competition might manifest itself in the available data. Consequently, they all end up inferring the degree of competition differently—from market concentration (HHI), to the change in the price-cost spread (H-Statistic), to the level of the price-cost spread (Lerner Index, Mark-up, frontier CE, and L). Our original expectation was that there would be a strong relationship between the H-Statistic and the Lerner Index and that this could be used to index or benchmark the HHI currently used by regulators to inform their merger/acquisition decisions. This did not occur even though the same economic theory informs the developers of these measures. Rather, the developers of each model have chosen to focus on the different ways that deviations from competition could be reflected in the data and some ways seem to be more predictive of high prices than others.

(2009), it is re-estimated by dropping consumer loan output from the RHS and replacing it with total revenue lagged one period in a panel estimation framework. The Appendix shows the original H-Statistic estimating equation and it is re-specified as noted above. Also, we did not test the original H-Statistics to see if they were significantly different from zero or 1.0. Such testing would not change the correspondence of these values with high or low prices, which is our purpose here.

7 Location of the Most/Least Competitive Banks.

The sets of most and least competitive banks are not distributed randomly across the U.S. Both sets of banks appear to be concentrated in smaller, less densely populated states, which experience a range of per capita income levels. Ranking all 2,644 consumer loan banks by their frontier CE measure–the competition indicator that seemed to do the best in Tables 5 and 6, the decile of the most competitive banks (those with the lowest CE) are located in Vermont, Delaware, New Jersey, Wisconsin, and Alabama. As a group, these banks operate an average of 40% of all branches in these states. The decile of least competitive banks are found in Montana, Wyoming, Louisiana, Oklahoma, and South Dakota and, as a group, operate an average of 17% of the branches there. In these states, the set of most competitive banks are twice as concentrated—in terms of branch ownership—than banks deemed as being least competitive.

One might expect that per capita income in states where the least competitive banks are located may be lower. It is, but only by 3%. Importantly, the income range in the two sets of states noted above is quite similar so income differences are only weakly associated with differences in apparent consumer loan competition. The five states where the most competitive banks are concentrated have an annual per capita income range of \$35,300 to \$56,000 while the range in the other five states where the least competitive banks are concentrated is similar at \$33,900 to \$51,500. If the least competitive banks are indeed behaving in an anticompetitive manner in terms of consumer loan prices, this behavior seems not to be concentrated in states with markedly lower per capita income.[26] These results more or less corroborate the findings by Hannan and Prager (2004) and Rosen (2007). Hannan and Prager (2004) find evidence that the presence of the larger multimarket banks in local banking markets relaxes competition. On the other hand, Rosen (2007) argues that as the number of larger multimarket banks increases, the banks become more similar in size which may then increase competition in local banking markets.

It would be interesting to see which of the bank-specific consumer loan competition measures may be predictive of current regulator consumer loan concerns. For example, the Consumer Financial Protection Bureau (CFPB) is concerned about certain bank short-term consumer deposit advance (loan) products and non-bank payday consumer loan practices (CFPB, 2013a). The Bureau is also concerned with bank deposit overdraft arrangements that generated revenues of \$32 billion in 2012 (CFPB, 2013b; Raice and Zibel, 2013). Additional concerns have included bank mortgage and student loans as well as loan collection procedures. Since the CFPB is a new organization, their sample of banks listed in the consumer complaints is small and would have to be augmented with bank complaint data from other agencies (which is not publicly available). Unfortunately, we are unable to make this comparison.

[26] Publicly available data on consumer loan customer income by bank are not available so it is not possible to determine if differences in customer per capita income are as small as they appear to be using state level per capita averages.

8 Summary and Conclusions.

Consumer loans account for $400 billion at U.S. banks and they have been a focus of congressional legislation, Federal Trade Commission and Consumer Financial Protection Bureau investigations, as well as banking regulator rules and guidance. This is because consumer borrowers are both more numerous than business borrowers and are typically less sophisticated in financial affairs so regulatory oversight can assist in achieving a fair outcome for consumer borrowers in dealing with bank lenders. Identifying potentially unfair or anticompetitive behavior can arise through consumer complaints (for which we have no data) as well as from identifying institutions that have relatively higher prices than their peers (after controlling for cost and productivity differences). This is the goal of the indicators of competition presented here—our frontier CE, HHI, H-Statistic, Lerner Index, inefficiency-adjusted Lerner Index, and Mark-up.

Prior analyses have only compared the HHI with the Lerner Index or, separately, with the H-Statistic. They have not really contrasted the latter two measures with each other and in any case have looked at competition at the level of the entire bank. We compare competition measures with each other at 2,644 banks over 2008-2010 using quarterly data. Ranking banks from most to least competitive for each competition measure, we find that most of them are only weakly related to each other. And there is no economic relationship between these measures and the HHI as measured by R-square. Assessing competition appears to be measure-specific. This holds overall and at the tails of the competition rankings.[27]

The relationship between the various competition rankings of banks–from most to least competitive—and their match with banks having (respectively) the lowest to highest average price of consumer loans is strongest and significant for the Lerner Index, Mark-up (which is a simpler Lerner Index), and the frontier CE measure. This suggests that these measures may be extra informative for antitrust authorities in identifying the price conduct aspect of the Structure, Conduct, and Performance paradigm. This is in line with recent theoretical analysis by Boone (2008) and Shaffer and Spierdijk (2013).

Using the frontier CE measure, which seems to have the best match with bank loan prices, we find that the sets of banks deemed to be most or least competitive are primarily located in smaller U.S. states. As a group, the decile of most competitive banks operate 40% of the branches in these states while the branch concentration is lower at 17% for the set of least competitive banks. Average per capita income differs only by 3% between these two sets of states. Overall, competitiveness is heterogeneous across bank size classes but appears homogeneous across likely depositor income levels.

What are the implications for competition policy? The HHI is simple to compute and apply. It is also well understood by the banking industry and regulators. Thus the HHI enjoys "first mover" advantage and is unlikely to be displaced. Unfortunately, the HHI will likely still be used for merger analysis regardless of results which suggest it performs quite poorly in practice and is inferior to other competition indicators.

[27] A caution is that, due to data limitations, not all competition measures refer to only consumer loans. Indeed, the HHI and Lerner Index reflect the entire bank. Even so, a similar lack of correspondence among competition indicators was found for Europe within and across countries (Carbo, Humphrey, Maudos, and Molyneux, 2009).

Pressure for change would only come if regulatory opinions based on the HHI were challenged (in court or otherwise) using evidence that showed decisions relying on the HHI do not measure what regulators' assert it does. But even here legislation (the Riegle-Neal Act of 1994) effectively enshrined the HHI by fixing at 10% the maximum amount any one bank can hold of nationwide insured deposits through a merger or acquisition.[28]

Even so, for very important mergers or when the DOJ merger guidelines are being reconsidered (as they were in 2010 when the "highly concentrated" guideline was raised by 40% relative to those established in 1992), alternative measures of competition should be among the evidence presented as a backup to the HHI. This would not be difficult or controversial if the Mark-up was used in this capacity, in contrast to the Lerner Index or frontier CE measures. Overall, given the poor performance of the HHI in identifying bank competition, it would be useful to obtain a "second opinion" by computing an additional competition indicator—either a Mark-Up (which is simple to do) or a frontier CE measure (which is more difficult but may be more informative).

[28] At the state level, the maximum concentration was set at 30% of statewide deposits, although 20 state legislatures have opted out of this restriction. The nationwide limit has recently been extended to bank holding companies, savings institutions, and institutions that own insured financial institutions. The restriction now covers non-deposit liabilities and off-balance sheet exposures (Financial Stability Oversight Council, 2011).

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Tables and Figures

Table 1. Mean Values of 2,644 U.S. Bank Consumer Loan Competition Measures (2008-2010)

	HHI	H-Statistic	L	L2	Lerner Index	Mark-Up	frontier CE
Average, All Banks	1,165	.87	32%	29%	39%	77%	9.6
Most Competitive (Q1)	291	.93	5%	7%	25%	66%	5.3
2nd Quartile	935	.89	30%	27%	37%	75%	7.8
3rd Quartile	1,309	.86	40%	35%	43%	80%	10.0
Least Competitive (Q4)	2,127	.79	52%	47%	51%	86%	15.6

Table 2. Adjusted R-Squares Among Six Competition Measures (2008 to 2010)

	HHI	H-Statistic	L	L2	Lerner Index	Mark-Up
H-Statistic	.01					
L	.01	.00				
L2	.01	.00	.93			
Lerner Index	.00	.09	.50	.37		
Mark-Up	.00	.00	.00	.01	.11	
frontier CE	.00	.00	.04	.04	.06	.15

Table 3. Quartile Tail Dependence Between Competition Measures (2008-2010)

Quartile Correspondence Among Most and Least Competitive Banks*
95% Confidence Interval: 144 to 187 (out of possible 661)

HHI, H-Statistic	Most	Least	L, Lerner Index	Most	Least
Most	*228**	95	Most	*437**	17
Least	171	138	Least	27	*364**
HHI, Lerner Index	Most	Least	L, frontier CE	Most	Least
Most	109	*214**	Most	*231**	111
Least	136	*187**	Least	90	*267**
HHI, Mark-Up			Lerner Index, Mark-Up		
Most	163	146	Most	*270**	105
Least	122	*203**	Least	71	*270**
H-Statistic, L			Lerner Index, frontier CE		
Most	126	114	Most	*246**	115
Least	*219**	*201**	Least	93	*255**
H-Statistic Markup	Most	Least	Mark-Up, frontier CE	Most	Least
Most	168	102	Most	*357**	59
Least	*201**	*207**	Least	61	*292**

Note: * Starred values are statistically significant at the 95% level of confidence. Competition measures missing from this table did not have a significant most-with-most or least-with-least correspondence.

Table 4. Characteristics of Most (MC) and Least Competitive (LC) Banks, quartiles

	MC	2nd Quart.	3rd Quart.	LC	Relationship
Competition Measure					
1. HHI	291	935	1,309	2,127	
2. H-Statistic	.93	.89	.86	.79	
3. L	5%	30%	40%	52%	
4. L2	7%	27%	35%	47%	
5. Lerner Index	25%	37%	43%	51%	
6. Mark-up	66%	75%	80%	86%	
7. Competition Efficiency (CE)	5.3	7.8	10.0	15.6	
Average Consumer Loan Rate (%)					
8. HHI	5.5	5.4	5.2	5.3	-
9. H-Statistic	5.6	5.5	5.3	5.1	-
10. L	5.5	5.5	5.3	5.0	-
11. L2	5.5	5.4	5.4	5.1	-
12. Lerner Index	5.2	5.3	5.4	5.5	+
13. Mark-up	4.4	5.1	5.5	6.4	+
14. CE	4.2	5.1	5.5	6.6	+
Consumer Loan-Deposit Rate Spread (% points)					
15. HHI	4.3	4.2	4.1	4.3	flat
16. H-Statistic	4.4	4.3	4.2	4.0	-
17. L	4.4	4.4	4.2	3.9	-
18. L2	4.5	4.3	4.3	3.9	-
19. Lerner Index	4.0	4.2	4.3	4.5	+
20. Mark-up	3.0	3.9	4.5	5.6	+
21. CE	3.1	4.0	4.4	5.5	+
Net Income/Assets (%)					
22. HHI	.56	.39	.37	.52	U-shape
23. H-Statistic	.55	.51	.49	.29	-
24. L	.09	.47	.58	.69	+
25. L2	.18	.46	.55	.65	+
26. Lerner Index	.02	.40	.58	.83	+
27. Mark-Up	.27	.45	.53	.60	+
28. CE	.31	.44	.53	.56	+
Asset Share (%)					Majority of banks are:
29. HHI	4	7	50	39	not competitive
30. H-Statistic	3	5	5	86	not competitive
31. L	36	32	26	5	competitive
32. L2	39	29	26	6	competitive
33. Lerner Index	83	7	5	5	competitive
34. Mark-up	10	30	12	48	mixed
35. CE	38	9	21	31	mixed

Table 5. Quartile Correspondence with Consumer Loan Price

Competition Measures and Consumer Loan Price 95% Confidence Interval: 144 to 187 (out of possible 661)					
HHI	Lowest	Highest	Lerner Index	Lowest	Highest
Most	103	177	Most	*231**	163
Least	150	176	Least	121	180
H-Statistic	Lowest	Highest	Mark-Up	Lowest	Highest
Most	97	*205**	Most	*368**	26
Least	*283**	123	Least	61	*317**
L	Lowest	Highest	frontier CE	Lowest	Highest
Most	166	*193**	Most	*416**	19
Least	*196**	123	Least	52	*363**

Table 6. Decile Correspondence with Consumer Loan Price

Competition Measures and Consumer Loan Price and Spread 95% Confidence Interval: 17 to 36 (out of possible 264)					
HHI	Lowest	Highest	Lerner Index	Lowest	Highest
Most	3	23	Most	*49**	20
Least	20	28	Least	22	33
H-Statistic	Lowest	Highest	Mark-Up	Lowest	Highest
Most	11	30	Most	*133**	1
Least	*94**	32	Least	5	*107**
L	Lowest	Highest	frontier CE	Lowest	Highest
Most	33	34	Most	*146**	1
Least	*46**	15	Least	4	*111**

Appendix

Constructing the HHI.

Using all 7,821 banks in the FDIC's *Summary of Deposits* report for June, 2010, a deposit-based HHI was computed for each of the 956 separate MSA and non-MSA counties in the U.S. Following Hirtle (2007), a deposit share weighted sum of these 956 geographic HHIs was then computed for each bank with over $100 million in assets in the fourth quarter of 2010 that operated and had deposits in these MSA and non-MSA counties. The HHIs were then matched with the 2,644 banks in our final sample yielding the set of deposit-based HHIs used here. The very largest banks have foreign offices but the *Summary of Deposits* only has information on domestic U.S. bank branch deposits and so our calculated HHIs apply only to domestic U.S. market

Computing the Mark-Up.

It is not possible to estimate a Lerner Index directly for consumer loans using a cost function. This is because the allocation of operating costs (labor, physical capital, and other non-interest expense) to consumer loans is not reported. However, it is possible to determine the markup of the average price of consumer loans ($PCLOAN$) over the likely interest rate of total deposit and other funding expenses ($PDEP$). This mark-up measure is determined from $MARK\text{-}UP = (PCLOAN - PDEP)/PCLOAN$. As shown below, this is similar to the dependent variable for the frontier CE estimation: $(PCLOAN - PDEP)/OC$, which is one reason why $MARK\text{-}UP$ is correlated with the frontier measure of competition in the text ($R^2 = .15$). If operating costs were allocated to the consumer loan function, it would have been possible to compute a Lerner Index for just consumer loans. No data exists regarding possible revenues/costs associated with bank-supplied credit insurance for consumer loans, which can at times be required by a bank when giving a consumer loan.

Estimating the Lerner Index.

As noted in deriving the $MARK\text{-}UP$ measure, it is not possible to estimate a Lerner Index for just the consumer loan function. Consequently, a standard Lerner Index was estimated for the whole bank using translog and Fourier functions. As these results were very similar, we use the translog estimation shown below:

$$\begin{aligned}
\ln TC \quad = \quad & \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln X_i + .5 \sum_{i=1}^{3} \sum_{j=1}^{3} \alpha_{ij} \ln X_i \ln X_j \\
& + \sum_{k=1}^{3} \beta_k \ln P_k + .5 \sum_{k=1}^{3} \sum_{m=1}^{3} \beta_{ij} \ln P_k \ln P_m \\
& + \sum_{i=1}^{3} \sum_{k=1}^{3} \delta_{ik} \ln X_i \ln P_k + \upsilon_1 E + \upsilon_2 (E)^2 \\
& + \theta_1 QTR + \theta_2 (QTR)^2
\end{aligned}$$

where:
TC = total cost composed of all funding costs and operating expenses (labor, physical capital, and other noninterest expenses) plus the change in loan loss reserves;[30]
X_i = the value of three banking outputs: consumer loans ($CLOAN$), business loans ($BLOAN$), and securities (SEC);
P_k = three input prices: the prices of all liability funding ($PDEP$), labor (P_L), and physical capital(P_K);[31]

[30]Although the change in loan loss reserves is a cost, it is not typically included in TC but rather as an adjustment to revenue in determining net income. We include it here to be consistent with how Koetter, et al. (2012) define TC in their Lerner Index. The other variables used are also consistent with their specification.

[31]$PDEP$ is defined as the average interest rate on all domestic and foreign deposits and funding except for interest on other borrowed money and subordinated notes and debentures. P_L is the value

E = value of equity capital ($EQUITY$);[32] and

QTR = a quarterly time period dummy variable (the date of the quarter).[33]

The Lerner Index is $(P_o - MC)/P_o$ where P_o is total revenue divided by the value of total assets and marginal cost MC is obtained from the estimated cost function. Mean values of the variables used to estimate all competition indicators except the HHI are shown in Table A1 below. The entire panel was estimated as a single equation using OLSQ.

Estimating L, an Adjusted Lerner Index.

A Lerner Index for the whole bank is adjusted for cost and profit inefficiency in Koetter, Kolari, and Spierdijk (2012). Effectively, the adjustment substitutes an "efficiency corrected" price (P_o^*) for the observed price (P_o) in a standard Lerner Index giving $(P_o^* - MC)/P_o^*$. Observed price would be computed using observed total cost (TC)[34] and profits before taxes (PBT) in the Koetter, et al. (2012), model while we use net income (PFT) as our profit measure.[35] Both TC and PFT are divided by the total value of the sum of specified outputs (TO). As our cost function specification is identical to that above for the Lerner Index, $TO = CLOAN + BLOAN + SEC$.[36] Observed price in the Koetter, et al. (2012) model appears to be $P_o = TC/TO + PFT/TO$ while the efficiency corrected price is $P_o^* = TC^*/TO + PFT^*/TO$. Efficiency corrected prices are based on the predicted values of TC and PFT from the same translog cost specification used above for the Lerner Index and a separately estimated alternative profit function. A Stochastic Frontier Approach (SFA) is used in estimation so the residuals of the cost and profit estimations reflect both normal error and an assumed half-normal distribution of cost or alternative profit inefficiency.[37] The predicted values of TC^* and PFT^* are thus presumed to be reduced by the amount of SFA cost and profit inefficiency. Importantly, an alternative profit function is used which reflects the opposite of perfect competition–namely that banks have (monopoly) pricing

of wages and benefits divided by the number of FTE employees while P_K is the ratio of the value of premises expense divided by the value of premises. The cost of equity capital, can only be reasonably estimated if a bank issues publicly traded equity and many banks in our sample do not do so.

[32] Replacing $EQUITY$ with a loan loss risk measure (LLR, see the H-Statistic) had almost no effect on the value of the Lerner Index.

[33] Replacing QTR with the quarterly 3-month Treasury bill rate or a quarterly measure of the real GDP output gap–a business cycle indicator–had almost no effect on the Lerner Index results.

[34] Koetter, et al. (2012) call this total operating cost but it is actually total cost since it includes the sum of the cost of labor, physical capital, and other non-interest expense (operating cost) plus all interest or funding cost.

[35] Net income is more commonly referred to as profits in the banking industry while profits before taxes abstracts from tax effects. As noted for the Lerner Index, TC includes the change in the provision for loan losses as part of costs.

[36] In their estimation, Koetter, et al. (2012), specify two outputs: TO = total loans (the sum of $CLOAN$ and $BLOAN$) and SEC. Total assets (TA) are, on average, 37% larger larger than total output (TO) in our sample.

[37] If the SFA assumption of a half-normal distribution of inefficiency is deemed problematic, the Distribution Free Approach (DFA) to frontier efficiency measurement can be used instead. With DFA, the predicted values of TC^* and PFT^* can be obtained with multiple quarterly OLSQ cross-section estimation alone as the separation of inefficiency from normal error in the composed error residual occurs later.

power. Just as $TC - TC^*$ reflects the apparent deviation from minimum cost (due to cost inefficiency), $PFT - PFT^*$ reflects the deviation from maximum profits when a bank has pricing power. Our adjusted Lerner Index (L) follows the specification outlined in Koetter, et al. (2012) for their cost function (their equation 4), changing only the dependent variable from TC in the cost function to PFT for the alternative profit function.[38] To estimate L it is necessary to consult the Koetter, et al. (2012) paper as well as Bos and Koetter (2009) for how negative profits are handled, along with a paper that explains the alternative profit function.

Estimation of the H-Statistic.

Sufficient data exists so that a H-Statistic can be estimated directly for consumer loans:

$$\begin{aligned}\ln TR &= \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln Z_i + .5 \sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij} \ln Z_i \ln Z_j \\ &+ \sum_{k=1}^{3} \beta_k \ln P_k + .5 \sum_{k=1}^{3}\sum_{m=1}^{3} \beta_{ij} \ln P_k \ln P_m \\ &+ \sum_{i=1}^{3}\sum_{k=1}^{3} \delta_{ik} \ln Z_i \ln P_k + \upsilon_1 QTR + \upsilon_2 (QTR)^2 \\ &+ \sum_{i=1}^{3} \upsilon_i QTR \ln Z_i + \sum_{k=1}^{3} \theta_k QTR \ln P_k\end{aligned}$$

where:
TR = total revenue for consumer loans (excluding credit card revenues);
Z_i = the value of consumer loans ($CLOAN$), the ratio of total domestic plus foreign deposits to total liabilities ($DEPTL$)–a liability composition measure that also suggests funding/liquidity risk when the ratio is low, and loan risk (LLR) defined as the value of loans minus the change in the reserve for loan losses all divided by the value of loans;[39]
P_k = the same three input prices defined above ($PDEP$, P_L, P_K); and
QTR = the same quarterly time dummy variable used in the Lerner Index.

As this is a translog revenue function, parameter symmetry is imposed in estimation. Linear homogeneity of input prices is not imposed as a doubling of input prices need not double revenues. The H-Statistic equals: $HSTAT = \sum_{k=1}^{3} \partial \ln TR / \partial \ln P_k$.[40] As the value of consumer loans is on the RHS, the partial derivative $\partial \ln TR / \partial \ln P_k$ reflects the output price response to a change in input price.

[38] The average fit of the cost function was $R^2 = .97$ and .89 for the alternative profit function used to compute L2 with OLSQ. No R^2 is available for L since it is estimated using SFA.

[39] $DEPTL$ and LLR both can affect loan pricing and hence revenue. The change in the reserve for loan losses is usually positive–indicating a rise in possible losses as more loans are made–but can be negative if previously written off loans are partially or fully recovered.

[40] The fit of the equation was $R^2 = .73$.

Estimating a Competition Efficiency (CE) Measure.

Our approximation to the ratio of revenues to costs is the ratio of unit consumer loan revenues ($PCLOAN$) minus unit deposit cost ($PDEP$) divided by overall operating cost (OC), comprised of labor, physical capital, and other non-interest expense. Although operating cost is not allocated to the various banking services, we do specify variables to explain the overall level and variation of operating cost among banks which, in turn, influence the effect of operating cost on consumer loans and other banking services. The three major determinants of the dependent variable $(PCLOAN - PDEP)/OC$ in the equation below are the prices of labor and capital inputs, the productivity of these inputs in producing banking services along with other influences on costs, and the existing level of market competition. We specify the first two determinants while the unexplained portion, averaged over six separate quarterly cross-section/panel regressions (of two quarters each), is maintained to reflect the average influence of competition on costs and revenues over 2008-2010.

$$
\begin{aligned}
&\ln((PCLOAN - PDEP)/OC) = \\
&\alpha_0 + \alpha_Q \ln CLOAN + 1/2\alpha_{Q2}(\ln CLOAN)^2 + \sum_{k=1}^{2} \beta_k \ln P_k + 1/2 \sum_{i=1}^{2}\sum_{j=1}^{2} \beta_{ij} \ln P_i \ln P_j \\
&+ \sum_{i=1}^{2} \gamma_i \ln CLOAN \ln P_i + \sum_{k=1}^{3} \delta_k \ln V_k + 1/2 \sum_{k=1}^{3}\sum_{p=1}^{3} \delta_{kp} \ln V_k \ln V_p + \sum_{m=1}^{2} \theta \ln W_m \\
&+ 1/2 \sum_{m=1}^{2}\sum_{q=1}^{2} \theta_{mq} \ln W_m \ln W_q + \varepsilon \ln RATE + \ln e + \ln u
\end{aligned}
$$

where the variables have been defined above and are summarized here:

$(PCLOAN - PDEP)/OC$ = dependent variable, a ratio of unit consumer loan revenues net of unit funding cost divided by overall operating cost;

$CLOAN$ = the value of consumer loans, an output indicator;

$P_i = PL$, the ratio of salaries and benefits to the number of full-time-equivalent employees, and PK, approximated by the ratio of premises expense to the value of premises;

$V_k = DEP/BR$, a deposit/branch "capital productivity" ratio, L/BR, a labor/branch productivity ratio, and $PREDAC$, a prior estimation of average bank operating cost that reflects scale economics by bank size;

$W_m = CAPITAL$, a ratio of risk-based capital to assets, LLR, the value of loans minus the change in the reserve for loan losses all divided by the value of loans.

The composed error term $\ln e + \ln u$ reflects normal error ($\ln e$) and inefficiency ($\ln u$). The model is estimated using quarterly data over 2008-2010, two quarters at a time for 6 separate cross-section/panel regressions consistent with a DFA frontier model. This permits market interest rates, as reflected in the quarterly 3-month Treasury bill rate ($RATE$), to vary across the two quarters in each regression. This variable, which also reflects the business cycle, represents the basic cost environment for banks and is especially important in setting the base cost of loans. The estimation results are shown in Table A2 below.

Appendix Table A1: Mean Values of Variables over 2008-2010

Competition Measure		HHI	H-stat	L	Lerner	Markup	CE
Mean Value:		1,165	.85	.29	.41	.77	9.6
LHS Variables:							
TR	\$6.1M		x				
PFT	\$10M			x			
TC	\$70M			x	x		
$(PCLOAN - PDEP)/OC$	9.8D-6						x
RHS Variables:							
$CLOAN$	\$150M		x	x	x		x
$BLOAN$	\$1,484M			x	x		
SEC	\$517M			x	x		
$PCLOAN$	5.3%					x	
$PDEP$	1.1%		x	x	x	x	
PL	\$37,936		x	x	x		x
PK	.199		x	x	x		x
$EQUITY$	\$300M			x	x		
DEP/BR	\$52M						x
L/BR	13.1						x
$PREDAC$	\$.015						x
$CAPITAL$	0.103						x
$DEPTL$	.93		x				
LLR	0.995		x				x
$RATE$	0.55%						x

Note: Averages for 2,644 banks over 12 quarters (n=31,728). M = Million. PFT and TC are for the entire bank while TR is only for consumer loans. To calculate L both a cost function and an alternative profit function are estimated using SFA.

Appendix Table A2: Parameter Estimates Frontier CE-Model

Variable	2008		2009		2010	
$\ln((PCLOAN - PDEP)/OC)$	Q1-Q2	Q3-Q4	Q1-Q2	Q3-Q4	Q1-Q2	Q3-Q4
Intercept	18.2**	15.4**	15.0**	18.1**	19.0**	8.53**
$\ln CLOAN$	-.443**	-.359**	-.531**	-.455**	-.377**	-.329**
$.5(\ln CLOAN)^2$	-.025**	-.029**	-.019**	-.022**	-.024**	-.023**
$\ln PL$	-.811*	2.03**	-1.20**	1.48**	-.429	.575°
$\ln PK$	.016	-.377*	.353**	.210	.158	.224
$.5(\ln PL)^2$	-.073	-.709**	-.018	-.582**	-.151*	-.328**
$.5(\ln PK)^2$	-.001	-.052**	.048**	.025	.043**	.000
$\ln PL * \ln PK$	.022	.094*	-.056*	-.000	-.034	-.048
$\ln CLOAN * \ln PL$	.001	.000	.022*	.000	-.001	-.025°
$\ln CLOAN * \ln PK$	-.013°	-.001	-.011°	-.020**	-.000	-.001
$\ln LBR$	-1.22*	-1.07°	-.871	-.905	-2.16**	-1.99**
$\ln DEPBR$	1.86**	1.00*	2.07**	1.48**	2.91**	2.48**
$\ln PREDAC$	10.4**	10.3**	11.4**	11.6**	11.7**	10.6**
$.5(\ln L/BR)^2$	.013	-.137	-.012	-.101	-.256*	-.105
$.5(\ln DEP/BR)^2$	.243**	.275*	.109	.016	-.067	.011
$.5(\ln PREDAC)^2$	3.78**	3.58**	3.51**	2.88**	3.31**	3.01**
$\ln L/BR * \ln DEP/BR$	-.050	-.014	.016	.112	.241**	.126
$\ln L/BR * \ln PREDAC$	-.275*	-.250*	-.048	.122	.073	-.096
$\ln DEP/BR * \ln PREDAC$	.920**	.835**	.682**	.372**	.554**	.579**
$\ln CAPITAL$	1.09**	1.46**	2.27**	2.17**	1.19**	1.29**
$\ln LLR$	2.38	-13.7	18.9	5.09	17.0	7.77
$.5(\ln CAPITAL)^2$	.336*	.524**	.816**	.744**	.290*	.325*
$.5(\ln LLR)^2$	758°	231°	602*	167**	439**	282**
$\ln CAPITAL * \ln LLR$	-5.68	-9.10*	.040	-1.30	1.18	-.998
$\ln RATE$	-3.24**	-.175**	-3.16**	-.277**	2.08**	-2.21**
Adj. R^2	0.84	0.84	0.86	0.86	0.88	0.88

Note: p-values .01 (**), .05 (*), and .10 (°).