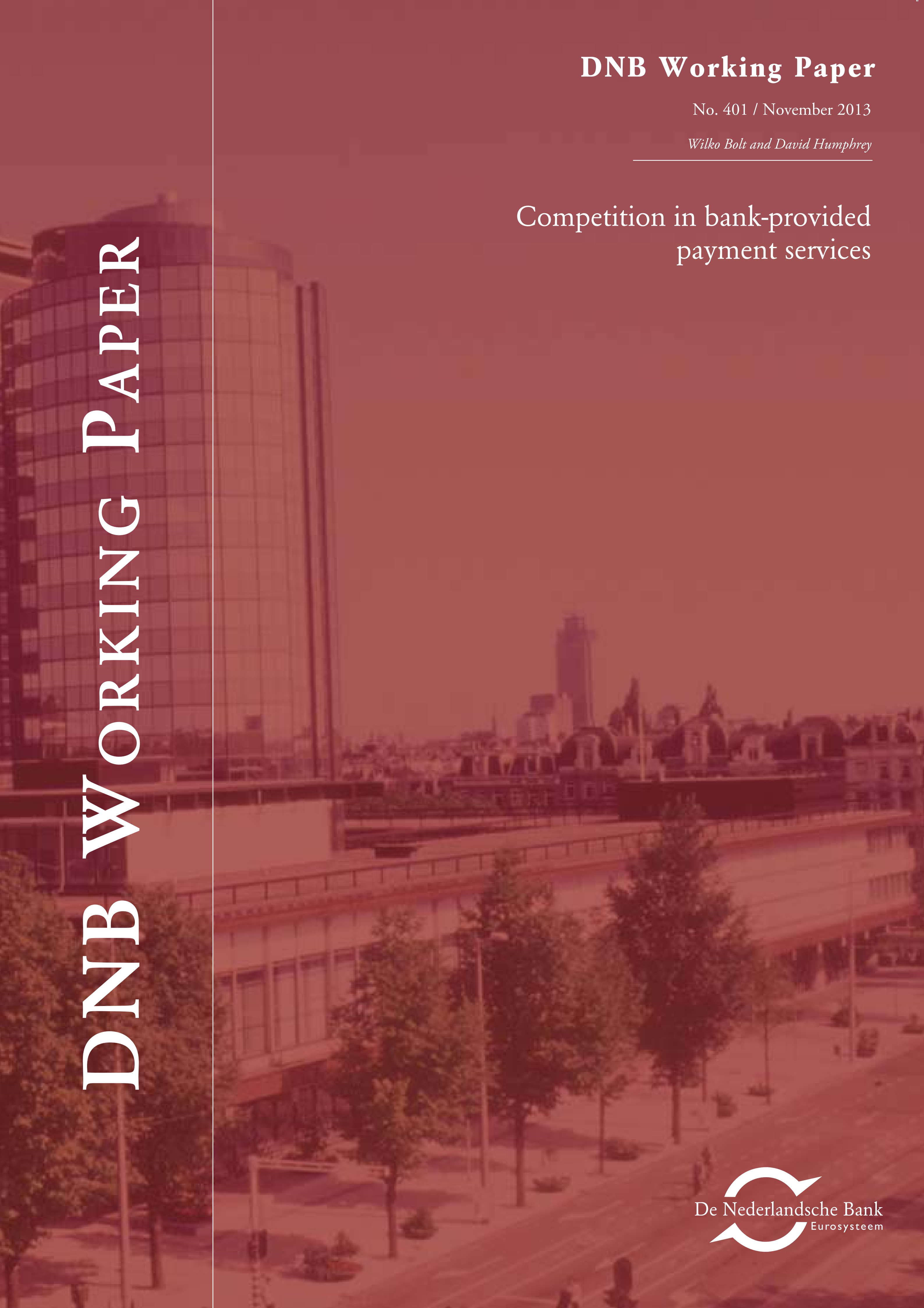

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De Nederlandsche Bank
Eurosysteem

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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# Competition in Bank-Provided Payment Services*

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**Abstract**

Banks supply payment services that underpin the smooth operation of the economy. To ensure an efficient payment system, it is important to maintain competition among payment service providers but data available to gauge the degree of competition are quite limited. We propose and implement a frontier-based method to assess relative competition in bank-provided payment services. Billion dollar banks account for around ninety percent of assets in the US and those with around $4 to $7 billion in assets turn out to be both the most and the least competitive in payment services, not the very largest banks. (97 words)

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# 1 Introduction.

To date, banking competition has been assessed using one of three standard measures. This has required information on deposit and loan market shares for HHI, observed price and estimated marginal cost for the Lerner Index, or the estimated relationship between changes in bank cost and output prices for an H-Statistic. Past studies have assessed competition at the level of the entire bank but recent additions to publicly available bank data have offered the opportunity to gauge competition by at least five separate bank service lines. Due to the importance of having an efficient payment system for the smooth operation of an economy, we focus on assessing relative competition in U.S. bank-provided payment services.

Unfortunately, price and/or profit information by bank service line is quite limited or nonexistent. Instead, we use revenue and cost information in a frontier-based measure of relative competition. We earlier used a similar approach to assess competition across five U.S. bank service lines and found payment services to be less competitive than either business loans or security activities but relatively more competitive than either consumer loans or investment banking activities (Bolt and Humphrey, 2012). In addition, at the level of the entire bank, we found that the three standard competition measures—HHI, Lerner Index, and H-Statistic—were unrelated to each other. Thus determining bank-level competition appears to be measure specific: banks found to be competitive by the Lerner Index, for example, need not be found competitive using the other two measures. As banks competitive in payment services were not also competitive in other activities, our results here should not be generalized to other banking services or to the entire bank.

Uncompetitive behavior can raise bank prices, shift income from consumers to banking firms, generate relatively high profits, and misallocate productive resources. The reason why observed prices and profitability by themselves are not reliable guides here is because both need to be adjusted for differences in cost and efficiency. Higher prices can be due to higher costs or the ability to extract market power and only the latter reflects competition. The same holds for profits: are they relatively high because a bank has fewer close competitors, is conveniently located in a growing and relatively high demand (high income) market, or is it because they are more organized and cost efficient? While there are other indicators of competitive/uncompetitive firm behavior, such as market concentration (HHI), assessing price and profits relative to costs have been the approach of the Lerner Index and the H-Statistic.

Importantly, the overall effect of competition can depend on the time period covered. It has been suggested that an increase in bank competition can Granger cause an improvement in bank efficiency, reduce costs, expand profits, and contribute to bank soundness by permitting institutions to more easily cover loan losses while adding to capital (Schaeck and Cihak, 2008). While competition provides a benefit in normal times, when loan restrictions are substantially relaxed or in times prior to an economic crises, greater competition can lead banks to reduce credit standards and expand their portfolio of risky assets to a point where the cost efficiencies and additions to bank capital obtained earlier are dramatically reduced or wiped out (Altunbas, Manganelli, and Marques-Ibanez, 2011). Depending on the time period, strong competition may have positive or negative effects. This consideration has greater application to a bank's loan channel while we deal here with a bank's payment services.

In what follows, we summarize recent legislative and regulatory concerns with bank-provided payment service pricing and procedures in Section 2 and outline our frontier-based approach to measuring competition in Section 3. Competition results are presented in Section 4 and contrasted with an approximate HHI measure of payment market concentration. Characteristics of the least and most competitive banks in providing payment services, as well as associated aspects of their location, are identified in Section 5. Other aspects of competition—payment market cross-subsidization and market segmentation—are assessed in Section 6 while conclusions are in Section 7.

## 2 Recent Concerns with Bank-Provided Payment Services.

Payment services have been a recent focus of regulatory activity in the U.S., Europe, and Australia as certain card and other payment-related fees and practices have been deemed to be inefficient, uncompetitive, or unfair.[1] Given recent U.S. regulatory and legislative concern with bank deposit overdraft procedures, retroactive interest rates on credit card balances, and a cap on debit card interchange fees it is not surprising that payment activities were estimated to be less competitive than bank business loans or security operations.

Over 2008-2010, bank revenues from account overdraft fees averaged $35.7 billion annually. The average account incurred nine overdrafts per year with a median fee of $26 per occurrence (Moebs Services, 2012). It turns out that most of the overdraft fee income is paid by lower income depositors who have lower average account balances (F.D.I.C., 2008).[2] While the number of overdrafts fell after banking regulators set guidelines requiring banks to have depositors explicitly "opt in" for overdraft coverage rather than have it automatically provided to them, the median fee rose to $29. However, this fee increase was not enough to fully offset the drop in overdrafts so overdraft revenues fell in 2011.[3]

The Credit Card Act of 2009 dealt with a number of credit card practices that were deemed to be unfair or misleading.[4] Among other things, this act (mostly imple-

[1]Competitive concerns for European banks have been outlined in European Commission (2007) while concerns in Australia have focused on credit and debit card interchange fees.

[2]The FDIC study also noted that with a median POS debit, or ATM, or check overdraft, the implied interest rate associated with paying an overdraft fee of $27 was over 1,000 percent (page v), a return that clearly exceeds actual bank expense.

[3]One reason why overdraft revenues have been large was a bank practice of re-sequencing debits (checks, debit cards, ATM and ACH transactions) posted to deposit accounts on a highest-first basis rather than using the actual time sequence during the day. Some even posted deposits last. This increased the probability that multiple low value debits would incur account overdrafts. Recently, one large bank—by its own calculation—generated $500 million in annual aftertax income with this practice (Horwitz, 2012). Today, many large banks now sequence debits (and deposits) according to the time they were made to determine deposit balances.

[4]The full title is: The Credit Card Accountability, Responsibility and Disclosure Act of 2009.

mented in February 2010) protected consumers with outstanding credit card balances from retroactive increases in interest rates, required 45 days notice of an interest rate increase, prohibited double-cycle billing, placed caps on high fee cards, and required card firms to allocate payments to the highest interest cost portion of a card balance first (such as a cash advance). It has been suggested that this legislation may reduce bank payment revenues from credit cards by $5.6 billion annually (Bernard and Protess, 2011).

The Durbin amendment to the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 has had an even greater impact on bank payment revenues. Implemented in October 2011, the Durbin amendment reduced debit card interchange fees by about one-half and reduced payment revenues by $6.6 billion (Bernard and Protess, 2011). In response, some banks have raised their minimum balance requirement and/or their monthly deposit account fee. An effort by large banks to explicitly price debit card use through a monthly fee, however, was not successful due to a consumer backlash. The Durbin amendment essentially cut by half the debit card interchange fee paid by merchants but left card users and banks to sort out who was going to pay for the rest. If merchants pass on the lower interchange fee via price reductions—or, more likely, a slower rate of price increase over time—and banks succeed in recouping their lost interchange revenue by raising other deposit fees or charges, consumers will be no worse or better off. Given that many banks have dropped their debit card reward programs, the cross-subsidy of merchants to users who held reward cards has been substantially reduced. In its place, as was a merchant goal, are pre-existing reward or loyalty programs that tie consumers to particular merchants rather than to a particular debit card.[5]

Finally, the Consumer Financial Protection Bureau was established in 2010. Its

[5] If it goes forward, the 2012 proposed settlement of merchant lawsuits alleging price fixing by credit card networks and bank issuers may have a one-time cost of $7.2 billion (Sidel, 2012). The settlement would allow merchants to surcharge customer use of a credit card which, if laws in 10 states against surcharging are dropped, may force issuers to reduce their swipe fees and reduce further bank payment revenues.

purpose is to deal with consumer payment and consumer loan issues, such as bank overdraft fees, credit card practices, mortgages, student loans, and payday lenders. As well, Regulation Q was eliminated in 2011 so banks are now permitted to pay interest on demand deposits. While banks already indirectly pay interest on large corporate demand deposits via procedures that sweep excess deposits into overnight interest earning instruments, if banks start paying interest directly their costs could rise since these payments would also likely apply to demand deposits that do not benefit from corporate sweep programs. If not offset by a corresponding rise in deposit fees and/or loan spreads, this would further reduce bank revenues going forward. Thus it is clear that banks have experienced regulations and legislation that affects the profitability and revenues from their payment-related deposit services.

# 3 A Frontier Approach to Measuring Payment Competition.

## 3.1 General Framework.

Banking service profits, prices, or revenues are primarily determined by the underlying cost of production (including productivity and scale) combined with the degree of market competition or contestability. The usual approach involves estimating the apparent direct association of competition as in:

$$\pi = f(\text{competition measure, other variables}),$$

where $\pi$ denotes profits, prices, or revenues. The other variables represent cost, productivity, and other "non-competition" influences that may or may not be fully specified in the equation. Our competition frontier approach instead specifies that:

$$\pi = f(\text{costs, productivity, other ``non-competition'' influences}),$$

and maintains that the unexplained portion of this equation reflects the (unspecified) influence of competition. While the HHI is computed directly from data on market shares, the Lerner Index and H-Statistic involve the estimation of a cost or revenue function. Our competition indicator is obtained from estimating a revenue to operating cost frontier. Relative competition among banks is then determined by their dispersion from the resulting frontier (defined by the bank or banks that are on this frontier).

As publicly available information on individual bank payment service prices or profits are limited or do not exist, our approach relies on newly available bank payment revenue data. In simple terms, profits $\pi = f$ (competition, costs). As profits are simply revenues - costs, profit differences across banks can be alternatively measured as the "mark-up" ratio revenue/costs and, if all costs are included, an estimate of relative competition can be obtained from:

$$\text{revenue/costs - } f(\text{costs}) = g(\text{competition}).$$

This represents a mark-up over costs.[6] Our approach is similar to a Lerner Index where $(P - MC)/P$ = competition measure which is also a mark-up. Nothing is lost if the Lerner Index is instead expressed as the ratio $P/MC$. Our approach differs in that we replace $MC$ with average cost ($AC$) and focus on $P/AC$. Since we lack payment service prices, we instead use the ratio of revenues to cost where the numerator and denominator of $P/AC$ are effectively multiplied by their respective output ($Q_O$) and input ($Q_I$) quantities giving: $(P * Q_O/AC * Q_I)$ = revenue/cost.[7]

$AC$ is calculated from observed input prices while $MC$ is estimated from a cost function using these same prices. However, if the productivity of these inputs differ across banks then input prices will not reflect their true cost to the bank. Observed input prices and costs will be higher for banks with greater productivity making them

[6] The revenue/cost ratio is the inverse of the popular Cost Income Ratio used in the banking industry and reflects the ratio of operating cost to operating revenue. More specifically, we use the inverse of the ratio of (labor, capital, other non-interest expense) to (interest revenue - interest expense + fee income) to reflect profitability differences across banks.

[7] The Lerner Index gives the same ranking of bank competition whether it is defined as $(P-MC)/P$ or $(P - AC)/P$ since $MC$ is uniquely tied to $AC$ by the slope of the output supply curve.

appear more competitive than they are as the observed spread $P - MC$ or $P - AC$ will be lower. If these lower real costs are passed on, observed output prices would be lower and a bank would appear to be even more competitive. Thus observed $MC$ or $AC$ need not account for all the costs and would benefit from being adjusted for productivity before a Lerner Index is used to indicate competition. That is, the Lerner Index itself can indicate competition as well as productivity differences across banks.[8] Our frontier competition measure attempts to implement this separation of competition from underlying costs in explaining the variation in profits across banks.

## 3.2 Theoretical Support.

Our empirical approach to measuring competition is supported theoretically by the concept of relative profit differences (RPD) as introduced by Boone (2008a), whose aim was to determine competition based on a firm's (variable) profits. Here competition is determined by subtracting a firm's variable costs from its revenues. This gives a return to fixed inputs plus extra revenues associated with the degree of relative competition.

Within a general model of Cournot competition, Boone analyzes the impact of increased competition on firms' output, profit, and market shares. In his framework, firms differ with respect to their efficiency levels. More specifically, let $\pi(n)$ denote the variable profit level of a firm with efficiency level $n$, where higher $n$ denotes higher efficiency (inducing lower marginal cost). Consider three firms with different efficiency levels, $n_2 > n_1 > n_0$, and calculate the "distance" to the least efficient firm, $\Delta_2 = \pi(n_2) - \pi(n_0) > 0$ and $\Delta_1 = \pi(n_1) - \pi(n_0) > 0$. Then a rise in competition (through increased entry, market conduct, or regulation) reallocates output from less efficient to more efficient firms which raises $\Delta_2$ relative to $\Delta_1$. Hence, these distances themselves depend on the level of competition $d$, i.e. we may write $\Delta_1(d)$ and $\Delta_2(d)$. Boone defines his measure RPD($d$)=$\Delta_2(d)/\Delta_1(d)$ and proves that RPD'($d$) $> 0$. This result

[8] The H-Statistic faces much that same problem as it relates changes in total revenues to changes in observed input prices, holding output constant. Thus the H-Statistic can be expressed as $\partial P - \partial AC$ and measures the change in the output-input price spread.

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. As the industry becomes more competitive, the most efficient firm gains more relative to less efficient firms, so that 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 from a theoretical point of view—more robust than the price-cost margin of a Lerner Index.

Our focus is on an empirical specification of a Boone-type theoretical model. In our approach we derive the "distance" to the most efficient firm in terms of competition once we have controlled for cost, efficiency, productivity, scale, risk, and potential influences of the business cycle. And, as the size of banks in our sample vary from \$100 million in total assets to over \$200 billion (more than 12 doublings in size), we specify a normalized revenue framework that reflects the ratio of revenues to operating cost (rather than total revenues alone).

## 3.3 Model Specification.

The bank production function for payment activities is basically identical across banks for different types of payment instruments: checks, debit and credit cards, ACH, wire transfer, and cash services. While individual bank back office payment costs differ due to scale economies and local labor expenses—both of which we control for—the external prices faced by banks for help in processing these various payment instruments at the Federal Reserve or large correspondent banks are similar. Recent national surveys indicate that the mix of payments is slowly shifting to less expensive electronic processing (by, say, about 1% per quarter in our two-quarter panel regressions) but the mix of payment transactions by individual banks is not reported. Except for wire transfers, which are concentrated at large foreign exchange and trading banks, existing information indicates that individual banks do not differ much in their payment mix:

they all supply cash, process check and debit card payments in what appears to be similar proportions due to the fact that consumer and business users have similar payment needs. While banks also offer credit cards they do not do the processing themselves but instead pay standard fees to a small set of very large banks who have the scale economies to this cheaply. Our payment activities do not include credit card debt which is a loan not a payment function. In terms of growth, the total number of non-cash payment transactions at the national level is slowly falling as a ratio to the value of domestic deposits (about 1% a year) which we control for. While we do not have all influences on payment costs, we do have all cost influences reported and available by individual banks.

Our estimating equation is shown in (1) and relates a measure of payment service revenues ($REV_{pay}$) to overall bank operating cost ($OC$) to an indicator of payment activity or "output level" (the value of domestic deposits, as payment transaction data are not available ) and other variables that reflect banking variable costs. Specifically, our explanatory variables are:

(1) *Technical*: standard cost function influences composed of the value of domestic deposits ($DEPONLY$, which indicates the level of payment service output for most banks), the sum of three classes of reported payment expenses ($PAYEXP$, covering ATM and debit, credit, and prepaid card costs, telecommunication expenses, and data processing costs),[9] the average price of labor ($PL$), and an approximation to the cost of physical capital ($PK$);[10]

(2) *Productivity and Scale*: the productivity of labor and capital in producing or supporting deposits and their related payment activity is the labor/branch ratio ($L/BR$) for labor and the deposit/branch ratio ($DEP/BR$) for capital. A prediction of the effect of scale economies on average operating cost is also used based on a prior

[9]Card and ATM costs are direct payment expenses while telecommunication and data processing costs are mostly associated with payment activities (debiting/crediting deposit accounts, processing payments and funding transactions, and internal accounting).

[10]The capital price is the ratio of premises expense to the value of premises (not perfect but standard in the banking literature).

estimation of how U.S. banking unit operating cost changes with the value of bank output produced ($PREDAC$);[11] and

(3) *Non-Cash Transactions*: the ratio of the quarterly number of all U.S. non-cash transactions (checks, ACH, all cards) nationwide to the value of all U.S. domestic deposits ($PAYTODEP$). This reflects the growth in payment transactions as a ratio to the banking system's deposit base but is a constant for all banks in a quarter.[12]

The unexplained portion of $REV_{pay}/OC$ in (1), averaged over six separate two quarter cross-section/panel regressions, is maintained to reflect the average influence of competition and is determined from the following composed error translog equation in logs:

$$\begin{aligned}\ln(REV_{pay}/OC) \;=\;& \alpha_0 + \sum_{i=1}^{5}\alpha_i \ln X_i + 1/2\sum_{i=1}^{5}\sum_{j=1}^{5}\alpha_{ij}\ln X_i \ln X_j + \sum_{i=1}^{5}\sum_{k=1}^{2}\delta_{ik}\ln X_i \ln P_k + \\ & \sum_{k=1}^{2}\beta_k \ln P_k + 1/2\sum_{k=1}^{2}\sum_{m=1}^{2}\beta_{km}\ln P_k \ln P_m + \theta \ln R + \ln e + \ln u \qquad (1)\end{aligned}$$

where:

$X_i = DEPONLY, PAYEXP, L/BR, DEP/BR, PREDAC$

$P_k = PL, PK$

$R = PAYTODEP$

[11] Predicted bank average unit operating cost uses parameters from a translog cost function estimated with annual data over 1996-2008 but evaluated using bank values for each quarter over 2008-2010. The resulting average operating cost curve was relatively flat when arrayed against the log of total assets with mean scale economies of only .98. Even so, average operating cost ($AOC$) across our sampled banks could fall by 10%. Expressing $AOC$ as the ratio of operating cost to total assets ($TA$), each doubling in size reduces $AOC$ by 1%, from $(OC/TA)(1.98/2.00)$. Our smallest bank size-class is \$100 million and 10 doublings in size gives \$102.4 billion, which is near our largest bank size-class.

[12] Payment values or transaction data for individual banks do not exist. Demand deposits alone should not be used to indicate the level or volume of bank payment transactions since a varying portion of these deposits are either swept into overnight interest earning assets (for corporations) or kept in an interest earning checkable savings deposit account (e.g., MMDA) to reduce reserve requirements (a retail sweep account estimated to total some \$800B monthly). The number of quarterly non-cash transactions is a linear interpolation of payment survey data for the years 2006 and 2009, which is all that exists except for 2003, and the result is expressed as a ratio to all deposits.

and have been defined above.[13] The composed error term $\ln e + \ln u$ reflects normal error ($\ln e$) and competition inefficiency ($\ln u$). Equation (1) is estimated using quarterly data over 2008-2010, two separate quarters at a time for six separate cross-section/panel regressions. This permits the trend in non-cash transactions ($PAYTODEP$) to vary across the two quarters in each regression. The own, squared, and interaction parameters were estimated for the $X_i$ and $P_k$ variables with $R$ serving as an intercept shift.[14] Estimation results are shown in the Appendix.

Our specification includes two banking productivity variables which, along with standard cost function influences (output level and input prices) have been important in reducing cost inefficiency to low levels in both stochastic and linear programming frontier models (Carbo, Humphrey, and Lopez del Paso, 2007).[15] The labor and capital productivity measures indicate inefficiency or overuse when $L/BR$ is "too high" or $DEP/BR$ is "too low" relative to other banks.[16]

Over-staffing of branch offices will raise the $L/BR$ ratio and raise costs even when full-time-equivalent worker wages ($PL$) are the same. Some banks are more successful in meeting their daily peak load in teller window transactions through part-time (rather than full-time) workers or sharing a branch manager between branch offices that are close to one another. A lower $L/BR$ ratio is also associated with in-store or supermarket branches where the staffing level is about half that of a stand-alone office (Radecki, Wenninger, and Orlow, 1996). Also, the capital cost of an in-store branch is only about one-fifth of a conventional branch and is reflected indirectly in the approximation to the average price of capital ($PK$). Importantly, in-store branches and stand-alone branches located in higher per capita income areas (suburban versus city or

[13]Unless otherwise indicated, all data are from quarterly Call Reports available on the Federal Reserve Bank of Chicago website.

[14]Coefficient symmetry was imposed in estimation. Although $OC$ may double with a doubling of input prices, there is no certainty as to what the response will be for $REV_{pay}$. Consequently, homogeneity of degree 1 in input prices was not imposed in (1).

[15]Productivity influences have been shown by Berger and Mester (1997) and Frei, Harker, and Hunter (2000) to be a primary determinant of previously unexplained bank cost inefficiency. Other influences (e.g., balance sheet variables) turn out to have almost no impact.

[16]Other possible influences are Hicksian 'quiet life', agency, or governance differences. These reflect cost inefficiency which we believe is already captured in the productivity variables.

rural) generate more deposits per office, raising the $DEP/BR$ ratio and also generate a greater demand for other banking services. Deposits are typically the cheapest and most stable source of bank funding so a higher $DEP/BR$ ratio allows a larger loan-deposit rate spread. As branch locations in high income areas are limited and in-store branch contracts with supermarket chains are exclusive within states or metropolitan areas, these productivity/cost differences can be relatively persistent. These two productivity variables were always highly significant in (1) and banks with higher $L/BR$ ratios experienced lower revenue/cost ratios while those with lower $DEP/BR$ ratios did the same (as expected).[17]

### 3.4 Estimation.

In estimating the competition frontier, we use the composed error Distribution Free Approach (DFA) in Berger (1993). In earlier work, we applied a more limited DFA model to aggregate European country banking data (Bolt and Humphrey, 2010). A concern in using the DFA approach is that it assumes averaging each bank's residuals across separate cross-section regressions reduces normally distributed error to minimal levels leaving only average inefficiency (or the average effect of competition on revenues).[18] DeYoung (1997), however, 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. We do the same.

In a composed error framework, equation (1) can for illustration be expressed as

$$\ln(REV_{pay}/OC) = R(\ln X_i, \ln X_j, \ln P_k) + \ln e + \ln u. \quad (2)$$

[17] In some cases other costs may offset the productivity advantage of having a higher $DEP/BR$ ratio. According to a recent analysis (Kapner, 2013), the average Citibank branch had \$83 million in deposits (compared to only \$56 and \$44 million for Wells Fargo and J.P. Morgan Chase) but its retail bank incurred costs of 66 cents per dollar of revenue (compared to only 56 cents per dollar at the other two banks).

[18] A problem with the Stochastic Frontier Approach (SFA) is that it assumes—without empirical support—that bank efficiency has a half-normal distribution where most banks lie on or very close to the frontier. A limitation of Data Envelopment Analysis (DEA)—a linear programming frontier—is that each constraint specified improves efficiency even if, in a regression framework, the added variable (constraint) would be insignificant.

The total residual ($\ln e + \ln u$) reflects the unexplained portion of the dependent variable remaining after cost, productivity, and other influences have been accounted for. 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 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 spread 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 (3) by their dispersion from this frontier:

$$CE_i = \exp(\ln \bar{u}_i - \ln \bar{u}_{\min}) - 1 = (\bar{u}_i / \bar{u}_{\min}) - 1 \tag{3}$$

The larger is $CE_i$, the weaker is the ability of market competition to restrain revenues relative to costs. An apparent limitation of (3) is that it only indicates the *relative* level of competition: it can not determine the *absolute* level of competition. This is useful, however, since the unexplained residual includes an unknown but valid mark-up over costs (return on equity/investment) and the relative nature of $CE_i$ reflects differences in this mark-up across banks assumed to reflect the strength of competition.

As frontier analysis relies on a regression residual to reflect cost inefficiency or, in our case competition inefficiency, it is possible that some important omitted variable or influence may affect the results. One way to address this issue would be to estimate a fixed effects model to capture time-series and cross-section heterogeneity using dummy variables. Fortunately, time-series heterogeneity should be limited for us due to the fact that each of the six panel regressions we estimate consists of only 2 quarters at a time (not a panel of 12 quarters over 2008-2010). However, cross-sectional heterogeneity likely exists since our cross-section sample is quite large and banks differ markedly in size. Even so, we have no way of separating out the heterogeneity a cross-section dummy could pick up that is associated with cost (and not competition) versus the influence associated with competition (but not cost). We only wish to correct for the first type of cross-section heterogeneity, not the second type since we want the residual to reflect any cross-section heterogeneity associated with competition. As shown in Section 5.3 below, competition appears to be affected by bank location (per capita income and population density) and while location can also affect labor costs, this is controlled for in (1).

# 4 Competition in Payment Services.

There are over 6,500 commercial banks in the U.S. but banks with less than $100 million in assets are quite small (averaging $57 million in assets) and are even smaller than a branch office of a large bank (at $125 million in assets). Consequently, our competition analysis is restricted to banks with assets of $100 million or more in 2010. This accounts for over 98% of all commercial bank assets and employs close to 1.9 million workers. We eliminate shell banks, special purpose banks, banks with no loans, or no deposits, or no full time employees, etc., or that have variables (e.g., ROA, operating cost to total assets) beyond five standard deviations from the mean that are clearly unrepresentative of the U.S. banking industry. Our final sample contained 382 institutions with more than $1 billion in assets and 2,273 institutions with assets between $100 million and $1 billion. As the 382 billion dollar banks account for 90% of total assets, they are the main focus of our analysis since they have the greatest impact on the competitive efficiency of the U.S. payment system.

For the billion dollar banks we focus on, payment revenues ($REV_{pay}$) accounted for 11% of the average $2.7 billion in total revenue received annually. This exceeds the share of consumer loan revenue (8%) and is close to securities activities (13%). Business loans account for the largest revenue share (44%) while investment banking (including securitization and related activities) is second (24%).

Reported payment revenues are from deposit service charges, card interchange fees, ATM fees, and sale of checks. Income from minimum balance requirements are not reported in bank Call Reports even though these revenues are tied to deposit accounts and help recoup bank payment expenses. Figure 1 shows how the four payment revenue shares vary by bank size (X-axis, log of total assets). By far the largest revenues are raised from deposit service charges, composed of account maintenance fees, overdraft charges, transaction fees, etc. The share of deposit fees in payment revenues averaged 76 percent for banks with more than $1 billion in assets over 2008-2010. Next highest were card revenues at 16 percent while the revenue share from ATM fees and the sale of checks were 7 and 1 percent, respectively. The falling share of deposit fees for larger banks is due to the rising share for cards at large banks.[19]

(Insert Figure 1 here)

## 4.1 Payment Competition Across Banks.

Whether one uses a HHI, Lerner Index, or H-Statistic, large U.S. banks are found to be less competitive and more profitable compared to smaller banks.[20] This suggests that large banks may enjoy more market power and be less competitive than smaller banks. With respect to payment services, the situation seems to be somewhat reversed. Table 1 shows our measure of competition efficiency (CE) by bank size-class for 382 billion dollar banks. The three largest size-classes are composed of 19 banks, all with assets greater than $50 billion. These banks account for 79 percent of the assets of billion dollar banks and have marginally lower CE values than all but one smaller bank size-class. While banks with more than $50 billion in assets seem to be more competitive than the other 363 billion dollar banks, this difference is not large. Overall, the $R^2$s of equation (1) for these banks ranged between .66 to .70 so on average 68% of the

[19]Figure 1 does not reflect the October 2011 implementation of the Durbin amendment but does reflect some of the effects of the Card Act that reduced credit card revenues in 2010 as well as regulatory guidance on deposit overdrafts.

[20]See DeYoung (2010) table 31.2 for the profitability of large versus smaller banks. Bolt and Humphrey (2012) Table 1 support the statement that large banks are generally found to be less competitive than smaller banks. For a theoretic analysis of payment competition between banks, the reader is referred to Bolt and Schmiedel (2013).

variation in the payment service revenue/cost ratio was explained by the specified cost, productivity, scale, and output level variables. This suggests that around one-third of the variation is associated with differences in competition across banks. This compares with an estimated total cost inefficiency of 27% for financial institutions in general.[21] But this cost inefficiency applies to total cost while our one-third inference applies to payment revenue relative to costs—effectively a spread measure—and far smaller than either total payment revenues or total costs.

(Insert Table 1 here)

Table 2 shows CE values for the 2,273 smaller banks with assets of $100 million to $1 billion. The frontier here was computed separately from the billion dollar banks in Table 1. While numerous, the banks in Table 2 only account for 10% of the assets of our sampled banks. The CE values are markedly higher because the dispersion of these smaller banks is so much greater. As seen, average competitive efficiency is relatively stable across the four size-classes. The same stability in average CE values is evident if a single frontier was used for both sets of banks (not shown).

(Insert Table 2 here)

The overall impression is that payment competition across bank size-classes is about the same since the average bank in each size-class seems to be about the same distance away from their respective competition frontiers. While this holds for the *average* CE value by size-class in both tables, a different picture emerges when the *dispersion* of CE values is considered. In what follows, we focus only on the billion dollar banks that comprise 90% of our sample's commercial bank assets and a likely corresponding percent of payment activity in the U.S.

[21] See the survey of over 130 cost frontier studies across different countries and time periods (Berger and Humphrey, 1997). As mean cost efficiency was 79%, cost inefficiency is (1-0.79)/0.79 = .27. In a more recent analysis by Hasan, Schmiedel, and Song, using data for 27 EU countries during 2000-07, they calculate a mean cost efficiency of 74%.

## 4.2 Dispersion of Payment Competition.

When no prior distribution of competition efficiency is imposed in the frontier estimation, the resulting distribution of CE values resembles the gamma distribution seen in Figure 2.[22] While Figure 2 shows the CE distribution for billion dollar banks, a similar CE distribution (but with greater dispersion) is obtained for banks with $100 million to $1 billion in assets.[23] This is not unusual: the frequency distribution of HHI values for the same billion dollar banks reflects a similar gamma distribution (not shown).

(Insert Figure 2 here)

The effect of the dispersion in Figure 2 is illustrated in Figure 3. The top half contains a scatter diagram of bank size, as reflected in average total assets (Y-axis, in logs and dollar value), arrayed against average quarterly payment revenues over 2008-2010 (X-axis in logs and, below it, dollar value). As payment revenues rise from $55 thousand per quarter up to around $8 million, bank asset size stays roughly constant at around $3.3 billion for billion dollar banks. Here the cubic spline fitted curve in the top half of the figure is rather flat (showing little variation in total assets) even as payment revenues rise almost 150 fold. When payment revenues rise above $8 million per quarter, total assets rise along with payment revenues. Thus the expectation that the larger the bank, the larger are payment revenues, only strongly holds for banks with more than $3.3 billion in assets. Banks smaller than this cutoff experience large differences in their payment revenues (and by implication their payment activities) but, on average, not much change in asset value.

(Insert Figure 3 here)

[22]Similar gamma distributions are seen when the goal has been to estimate cost inefficiency in a cost function framework (Bauer, 1990; Berger, 1993). This of course differs from the Stochastic Frontier Approach which imposes a half normal distribution on estimated inefficiencies where the mass of inefficiency values are on and very close to the frontier by assumption.

[23]Truncating the 1% or 5% highest and lowest CE values would reduce the computed average CE values shown in either Tables 1 or 2 but would not alter the ranking (except for the truncated values) and so was not done here.

The bottom half of Figure 3 shows a scatter diagram of our competition efficiency measure (CE) for billion dollar banks (Y-axis, unlogged value) arrayed against each bank's average quarterly payment revenue. As seen, there is considerable dispersion in the competition measures across banks that is "hidden" in the average CE values of Table 1. The fitted cubic spline suggests that, on average, competition falls (since the fitted line rises) as quarterly payment revenues rise from \$55 thousand to \$22 million which—as illustrated in the top half of the figure—occurs for banks with average assets around \$3.3 billion. And for banks larger than this, the fitted line levels off and falls somewhat, indicating either no change in competition or improved competition for banks larger than \$3.3 billion.

Three basic results are illustrated in Figure 3. First, payment revenues only rise with bank size for banks larger than around \$3.3 billion. Second, competition is reduced as payment revenues grow but only for banks with less than around \$3.3 billion in assets. For banks larger than this, competition stays roughly constant and then actually improves as CE values fall somewhat for the very largest banks. Third, looking at the CE dispersion in the lower half of the figure, it appears that both the most competitive banks (those with CE $\approx$ 2.0 on the Y-axis) and the least competitive banks (those with CE $\approx$ 7.7) are roughly of a similar asset size. Thus one can not simply say that larger banks provide less competitive payment services.

How does this variation in payment service competition by bank size-class correspond with an approximate payment service HHI measure? Unfortunately, payment revenue data only exist for the bank as a whole, not by branch office geographic area which would be needed to compute an HHI for payment services alone. The best that can be done is to compare a standard branch deposit-based HHI with our CE measure. If payment revenues by bank branch are roughly proportional to branch deposits for most banks, then the deposit-based HHI is an approximate indicator of a payment revenue HHI.[24]

[24]The computation of the branch deposit-based HHI is described in the Appendix to Bolt and Humphrey (2012).

Correlating the payment service CEs for billion dollar banks with their respective branch deposit-based HHI yields a slight negative relationship as the r = -.04. Overall, the statistical relationship is zero (since the slope parameter is insignificant) as is the economic significance (since $R^2$ = .002). Thus the two indicators of payment service competition—CE as proposed here and a HHI as used by the U.S. Department of Justice for deposits—apparently measure different aspects of competition.

# 5 Characteristics of Most and Least Competitive Banks.

## 5.1 Banks Ranked by Competition Efficiency (CE).

Characteristics of banks with low CE values (most competitive) and high CE values (least competitive) are more easily seen in Table 3. Billion dollar banks were divided into quartiles on the basis of their competition efficiency (CE) measure and averaged. As shown in row 1 the quartile of most competitive banks had an average CE value of 2.0 while for the least competitive it was 7.7. Row 2 shows the average return on assets (ROA) or profitability for these banks which steadily rises with the rise in the CE values. Thus higher CE values across quartiles of billion dollar banks—suggesting less competition—is associated with higher profitability. Indeed, the difference in profitability is quite large: an average ROA of .16% for the most competitive but a return over three times larger at .53% for the least competitive. The relationship of CE with profitability may be expected in a measure that purports to indicate competition, especially one that tries to account for and remove cost influences on profitability associated with the so-called efficient structure hypothesis (discussed in Berger, 1995) that could contribute to measured profitability.[25]

As illustrated in Figure 3, low and high values of competition efficiency seem to

[25] Hasan, Schmiedel and Song (2012) find that increased competition between payment instruments, as measured by an HHI index, leads to lower ROAs for banks.

occur for banks with a similar asset size and value of payment revenues. This is seen more clearly in row 3 of Table 3 where the quartile of most competitive banks have average assets of $7 billion while the least competitive have assets of $4 billion. Thus it seems that both the most and least competitive banks are relatively small in size. The very largest banks, contrary to some media accounts and conventional wisdom, are not the least competitive when it comes to payment services. Nor are they the most competitive, contrary to many public comments submitted by bank management to regulatory agencies considering limits to their payment practices. They are in the middle, not in either extreme.[26]

As smaller banks are well represented in the quartiles of most and least competitive banks, their influence on overall banking competition—in both directions—is also relatively small. The asset share of the quartile of most competitive banks in row 4 of Table 3 is just 10% while that for the least competitive is 7%. The two middle quartiles—where the largest banks are located—account for 83% of all banking assets of our sample of billion dollar banks.[27] Their influence dominates the overall level of banking competition but they are neither the most nor the least competitive players. Although small in size, the least competitive banks not only are the most profitable, they also raise the most payment revenue relative to operating cost ($REV_{pay}/OC$) as this ratio is highest for these banks (row 5).

While the labor/branch and deposit/branch productivity ratios were both important in explaining the revenue/cost ratio of the estimating equation (1), only the deposit/branch ratio differs importantly across quartiles (row 7). Quantile regressions relating CE to these two productivity ratios indicated that the deposit branch ratio was

[26] We do not believe that the financial crisis has had much effect on payment revenues and thus on the relative ranking of payment CE values. The biggest impact from the financial crisis was most likely through loan losses (at .50% of asset value) and reductions in investment banking and related activities. This reduced overall revenues but should not have had much of an impact on payment revenues.

[27] The distribution of branches is similar. The most (least) competitive billion dollar banks account for 14% (8%) of the sample's 55,671 branches while the two middle quartiles account for 78%. This is highly skewed since the mean bank has 146 branches while the median is only 27.

significantly associated with only the most competitive quartile of banks.[28] At $209 million per office, this quartile experienced the highest level of deposits ("output") per unit of branch (physical capital) input.

(Insert Table 3 here)

The last row in Table 3 shows the deposit-based HHI that corresponds to the most and least competitive banks as ranked by the competition efficiency measure. The U.S. Justice Department's 2010 horizontal merger guideline suggest that markets with an HHI < 1,500 are unconcentrated, markets with 2,500 > HHI > 1,500 are moderately concentrated, while an HHI > 2,500 is highly concentrated.[29] As seen, there is not much difference in the HHI across the four quartiles of Table 3. Indeed, the average HHI values shown all indicate, on average, an unconcentrated banking market. This changes when the most and least competitive banks are instead ranked by bank deposit HHI values.

## 5.2 Banks Ranked by HHI.

In Table 4 the HHI rises smoothly when the quartile ranking of the most and least competitive banks is by HHI rather than CE. Indeed, the least competitive banks would now (on average) be considered moderately concentrated using the Justice Department guideline. However, there is not much correspondence between profitability and HHI across quartiles. While the least competitive banks have an ROA of .45%, which is higher than .38% for the most competitive banks, this is much less that the over three-fold difference in ROA seen when banks were ranked by their CE measure (which attempts to control for the effect of cost efficiency on profitability).

(Insert Table 4 here)

[28] Ranking the data by lowest (most competitive) CE values first, the deposit/branch ratio was statistically significant for percentiles .05 and .10.

[29] U.S. Department of Justice and the Federal Trade Commission (2010).

Other differences also occur. The HHI identifies small banks as being the most competitive (with $3 billion in average assets) while some larger banks are in the least competitive quartile (with average assets of $23 billion). However, other large banks with the same level of average assets are in the second quartile so the progression of bank size with HHI is not smooth. The set of most competitive banks only account for 5% of banking assets while the least competitive have a greater impact on overall competition as their share of assets is 35%. Finally, there is little difference in CE values between most and least competitive banks when ranking banks using HHI. This is the same result, but in reverse, when banks were ranked by the competitive efficiency measure and the differences in HHI were small in Table 3.

## 5.3 Can Branch Location Affect Competition?

Since 1997 all states permitted U.S. banks to branch nationwide. Previously, statewide branching was allowed in some states while in others the number of branches was essentially restricted to a single office. Due to these earlier restrictions, few banks are truly nationwide today: the median billion dollar bank has offices in only 1 state out of 50 while at the 99th percentile the average bank is in only 26 states. Thus competition in the U.S. banking industry is basically a local, or at most, a regional affair.[30]

(Insert Table 5 here)

The top five states containing the largest share of branches of the most and least competitive banks, as determined by their CE value, are shown in Table 5. In Vermont, 49% of that state's billion dollar bank offices are operated by the set of most competitive banks. This is followed by Maine where the most competitive banks have a branch share of 44%. The three remaining states account for about one-third of all branches in their states. The state branch shares for the least competitive banks are about at the same level but the states are different Oklahoma is at the top with a 43% share

[30]A similar situation exists in Europe if all the countries using the euro were considered to be "separate regions" that comprise the euro area.

of that state's branches. The branch shares of banks in the second and third quartiles are about double the shares of the most and least competitive banks.

Notice that states with the largest populations—California, Texas, New York, Illinois, and Pennsylvania—are missing from Table 5. This is because the shares of branch offices of billion dollar banks for our quartiles of banks are markedly smaller than those shown in the table. An HHI using branch shares, similar to deposit shares, would do the same. The difference is that all of the states shown in Table 5 have large branch shares implying a high HHI but our CE measure distinguishes competition not by branch shares but by revenues after (statistically) accounting for costs.

Four out of the five states where the least competitive banks have the highest share of branches were one-office or unit banking states prior to 1997. All the other states for the other three quartiles were statewide branching states. Looking only at the states in Table 5, the most competitive banks are located in states where per capita personal income is 16% higher and six times more densely populated. A more accurate comparison is obtained by using a branch weighted average and extending the analysis to all U.S. states. Here the most competitive banks serve depositors with 7% higher per capita income in locations with 100% greater population density.[31] Banks located in more densely populated higher income areas typically find that they generate more deposits per office (Table 3, row 7) and face a greater demand for banking services (raising revenues without as much need to raise prices to earn a given return). In addition, the greater the population density, the more that branches of different banks will be closer together and reduce local market power. These considerations are not at variance with using a competition efficiency measure to assess competition.

[31] The branch weighted average across states for a given ith quartile shown in Table 5 was determined from: $\sum_j (BRQ_iS_j * Y_j)/BRS_j$ where $BRQ_iS_j$ = number of branches of banks in quartile i in state j; $Y_j$ = per capita personal income or population density per square mile in state j; and $BRS_j$ = total number of branches in state j.

# 6 Assessing Payment Service Cross-Subsidization and Market Segmentation.

## 6.1 Cross-Subsidization.

Payment services are typically viewed as a cost center within a bank and have at times been characterized as a "loss leader" for earning a low return. Even so, transaction and savings deposits—the basis for providing payment services—are typically a bank's lowest cost source of funding for loans and tend to tie a depositor to a bank which then can cross-sell more profitable services. If the return on payment services is too low, where might the compensating benefit come from? Are relatively lower average interest rates on deposits used to cross-subsidize relatively low payment service fee income? Even though location is the most important consideration in choosing a bank, consumers do have access to comparative deposit rate and payment fee information so perhaps a higher loan-deposit rate spread is associated with relatively lower payment service revenues. The loan-deposit spread is more opaque than deposit rate and fee information due to the fact that loan fees and compensating balances are often tailored to the individual borrower and thus more difficult to compare across banks.

Deposit fee income accounted for 76 percent of payment service revenue during 2008-2010 and it is used to represent payment service income. Consequently, the log of the ratio of deposit fee income to the value of domestic deposits can be regressed on the log of the average interest rate paid on domestic deposits to see if banks with relatively low payment revenues seem to also pay somewhat lower deposit interest rates to compensate.[32] This relationship, however, is negative and significant, suggesting that banks that have lower deposit fees pay higher, not lower, deposit interest rates. While this suggests there is no apparent compensation, the economic significance of

[32] The ratio of deposit fee income to the value of domestic deposits is a better revenue "rate" measure than would be the dependent variable in (1) and so is used in place of $REV_n/OC$ to represent payment revenues.

this relationship is de minimus as the $R^2$ is only 0.06.[33]

While we obtain greater economic significance when the log of the ratio of deposit fee income to domestic deposits is regressed on the logs of the consumer loan-deposit rate spread and the business loan-deposit rate spread, the relationships here are both significantly positive. That is, a bank with lower deposit fee income also has lower spreads for consumer and business loans ($R^2 = .20$) so there is no apparent cross-subsidy here as well. Finally we assess the possible contribution of competition to this result. Interacting CE with the two spreads and adding these two new variables to the RHS, the positive relationship between deposit fee income and consumer and business loan rate spreads still exists, although the relevant parameters are slightly lower.[34] Thus we find no real support for banks either lowering the deposit rates they pay or raising their loan rate spreads to cross-subsidize or offset lower deposit fee income. This suggests that the CE measure itself is apparently not biased by cross-subsidization.

## 6.2 Market Segmentation.

To what extent is one bank's competition efficiency measure ($\text{CE}_i$) influenced by the competition efficiency measures of other banks ($\sum_{j \neq i} \text{CE}_j$) in the same geographic area? That is, if other banks are on average relatively competitive in the same Metropolitan Statistical Area (MSA), does this influence the competitive efficiency of bank $i$? If not, then the local markets that bank $i$ is in would appear to be segmented in some manner. This is akin to using an HHI to identify local markets of greater or lessor competition. Similar to the computation of an HHI, the sum of the value of the other banks' $\text{CE}_j$ values are deposit share weighted averages of the $j$ banks ($j \neq i$) in each of the MSAs bank $i$ is operating in. This measure for each MSA is then summed using

[33] The billion dollar bank data used here are quarterly averages over 2008-2010 so the sample size is 382. This is because we wish to include our CE measure next in this analysis and there is only one CE value for each bank (rather than quarterly data).

[34] This final regression was: ln (deposit fee income/value of deposits) = f (ln consumer loan rate spread, ln business loan rate spread, ln consumer loan rate spread * CE, and ln business loan rate spread * CE).

bank $i$'s deposit shares as weights across the MSAs giving $\mathrm{CE}_i^*$ as the end result.[35]

Correlating $\mathrm{CE}_i$ with $\mathrm{CE}_i^*$ to determine the extent to which other banks in the same geographic area may influence a given bank's CE value, we find little relationship for billion dollar banks or all banks together. Although the slope parameter is positive and significant, the R-square is effectively zero ($\mathrm{R}^2$ = .01).[36] This suggests that local payment markets are to a degree segmented. The implication is if some large banks decided to become more price/service/fee competitive in order to expand local market share, that most of the other banks would not strongly respond. This would be consistent with the fact that once a customer chooses a bank—and location is the main determinant, not price—they do not often switch to another bank unless they move or are mad about something. It also fits with the practice of banks acquiring market share almost entirely through mergers and acquisitions rather than de novo entry (Rhoades, 1985). De Novo entry requires a bank to offer significantly lower loan rates and/or higher deposit rates to attract/expand local market share and is not common for established banks (while mergers and acquisitions are). Indeed, credit unions have for years commonly offered lower loan rates, lower service fees and/or higher deposit rates than commercial banks and this difference still exists.[37]

# 7 Summary and Conclusions.

Banks supply payment services that underpin the smooth operation of the economy. Payment system efficiency is maintained when these services are supplied in a competitive market. However, it has been difficult to determine payment market competition

[35] First, for all $K_n$ banks in MSA $n$, $n = 1, ..., N$, calculate $\mathrm{CE}_{ni} = \alpha(\sum_{j=1}^{K_n} \beta_{nj}\mathrm{CE}_j - \beta_{ni}\mathrm{CE}_i)$, where $\alpha$ denotes a scale factor, $\mathrm{CE}_j$ denotes the competitive efficiency of bank $j$, and deposit weights $\beta_{nj} = D_{nj}/\sum_{l=1}^{K_n} D_{nl}$, $j = 1, ..., K_n$. Total deposits of bank $i$ are $D_i = \sum_{n=1}^{N} D_{ni}$ and weights are $\alpha_{ni} = D_{ni}/D_i$. Second, calculate $\mathrm{CE}_i^* = \sum_{n=1}^{N} \alpha_{ni}\mathrm{CE}_{ni}$ for billion dollar banks, and compare $\mathrm{CE}_i^*$ with $\mathrm{CE}_i$ to gauge market segmentation. Unscaled weights (i.e. $\alpha = 1$) do not sum up to 1, scaled weights (i.e. $\alpha = 1/(1 - \beta_{ni})$) do sum up to 1.

[36] Applying scaled weights improves the correlation slightly ($\mathrm{R}^2$ = .02).

[37] As a cooperative, credit union profits are not taxed but, typically, returned to their members in the form of more competitive loan/deposit rates.

as publicly available cost accounting data on bank-provided payment services do not exist. Some price data are available but there are so many different prices and fees that an overall picture by bank is difficult to obtain, especially since a high price for one payment service can be offset by a lower price on a different one or by a cross-subsidy obtained from other banking services. But even if good price data were available, the underlying output quantities associated with payment services are not reported and payment transaction data only exists at the national level based on survey information. It is within this restricted data environment that we propose and implement a frontier-based method to assess relative competition in bank-provided payment services using recently available Call Report payment service revenue data over 2008-2010.

As billion dollar banks account for around ninety percent of commercial bank assets in the U.S., these banks are the focus of the analysis (although results are also reported for banks with assets of $100 million to $1 billion). Our frontier approach to measuring relative competition builds on the extant cost efficiency literature and applies a Distribution Free Approach (Berger, 1993) rather than using the Stochastic Frontier Approach (which imposes a half-normal distribution for inefficiency) or Data Envelopment Analysis (linear programming).

We find that average payment competition efficiency does not differ much across bank size-classes but dispersion does. Indeed, the frequency distribution of our competition efficiency measure for individual banks resembles a gamma distribution (not half normal). As expected, the quartile of the most competitive banks had the lowest average return on assets (ROA) while the least competitive had the highest return. This is generally consistent with results using the HHI, Lerner Index, or H-Statistic applied to the entire bank. (Due to a lack of data, these standard measures were not computed for payment services.) Thus, uncompetitive banks had the highest profits which, with our measure, is after we control for the effect of cost efficiency on profitability. Importantly, we find billion dollar banks that are the most competitive in providing payment services are small (average assets of $7 billion). But so are the least competitive banks (assets of $4 billion). The very largest banks are solidly in the middle—not at either extreme.

While banks could branch nationwide after 1997, the median billion dollar bank has offices in only 1 state out of 50 while at the 99th percentile the average bank is in only 26 states out of 50. Thus competition is local or regional, not national. And where banks are located seems to matter: the quartile of most competitive banks are located in states with 7% higher per capita income and 100% greater population density than the quartile of least competitive banks. Branches in higher income areas typically generate more deposits per office—raising branch productivity—while higher population density puts different banks closer together and can reduce locational market power.

Finally, while some banks say they view their payment services as a loss leader so they can cross-sell other profitable banking services, we did not find that this view goes as far as generating a cross-subsidy. Lower payment service revenues (as a percent of deposits) were not related to lower interest rates paid on deposits nor to higher consumer or business loan rate spreads. In fact, we found the opposite which does not support cross-subsidization. The possibility of payment market segmentation was also investigated. Results indicated that the measured competition efficiency of one bank in a local market (MSA) is not significantly associated with the competition efficiency of all the other banks in the same market, summed over all markets a bank is in. This suggests a degree of market segmentation that would be consistent with bank reliance on expansion via mergers and acquisitions rather than (more competitive and time consuming) de novo entry.

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# Tables and Figures

Table 1: Competition Efficiency Values (CE) by Bank Size Class, Billion Dollar Banks 2008-2010

| Bank Asset Size ($ Billions) | CE Value | Asset Share | Number of Banks | Bank Asset Size ($ Billions) | CE Value | Asset Share | Number of Banks |
|---|---|---|---|---|---|---|---|
| 1-2 | 4.6 | .04 | 216 | 15-25 | 5.4 | .02 | 6 |
| 2-3 | 4.5 | .02 | 55 | 25-50 | 4.7 | .05 | 9 |
| 3-4 | 4.2 | .01 | 20 | 50-100 | 4.1 | .10 | 9 |
| 4-5 | 4.7 | .01 | 14 | 100-200 | 4.2 | .13 | 6 |
| 5-10 | 4.3 | .04 | 32 | $> 200$ | 4.0 | .56 | 4 |
| 10-15 | 4.7 | .02 | 11 | | | | |
| | | | | All Banks | 4.5 | 1.00 | 382 |

Table 2: Competition Efficiency Values (CE) for Banks with Assets of 100 Million to 1 Billion, 2008-2010

| Bank Asset Size ($ Millions) | CE Value | Asset Share | Number of Banks |
|---|---|---|---|
| 100-250 | 18.4 | .34 | 1,335 |
| 250-500 | 19.2 | .36 | 648 |
| 500-750 | 17.9 | .20 | 215 |
| 750-1 B | 19.1 | .10 | 75 |
| All Banks | 18.6 | 1.00 | 2,273 |

Table 3: Characteristics of Most and Least Competitive Billion Dollar Banks, Ranked by CE

| | Most Competitive | 2nd Quartile | 3rd Quartile | Least Competitive |
|---|---|---|---|---|
| 1. Competition Efficiency ($CE$) | 2.0 | 3.6 | 4.9 | 7.7 |
| 2. Net Income/Assets | .16% | .37% | .41% | .53% |
| 3. Total Assets ($) | 7 B | 27 B | 26 B | 4 B |
| 4. Asset Share | 10% | 42% | 41% | 7% |
| 5. $REV_{pay}/OC$ | .09 | .15 | .19 | .21 |
| 6. Labor/Branch ratio | 27 | 25 | 17 | 25 |
| 7. Deposit/Branch ratio | $209 M | $111 M | $73 M | $136 M |
| 8. HHI | 1,297 | 1,460 | 1,391 | 1,306 |

Table 4: Characteristics of Most and Least Competitive Billion Dollar Banks, Ranked by HHI

| | Most Competitive | 2nd Quartile | 3rd Quartile | Least Competitive |
|---|---|---|---|---|
| 1. HHI | 789 | 1,157 | 1,403 | 2,109 |
| 2. Net Income/Assets | .38% | .29% | .34% | .45% |
| 3. Total Assets ($) | 3 B | 23 B | 15 B | 23 B |
| 4. Asset Share | 5% | 36% | 24% | 35% |
| 5. $REV_{pay}/OC$ | .17 | .13 | .18 | .19 |
| 6. Labor/Branch ratio | 23 | 19 | 19 | 33 |
| 7. Deposit/Branch ratio | $111 M | $185 M | $106 M | $127 M |
| 8. Competition Efficiency ($CE$) | 5.0 | 3.9 | 4.6 | 4.5 |

Table 5: Most and Least Competitive Banks by State

| | Most Competitive | 2nd Quartile | 3rd Quartile | Least Competitive |
|---|---|---|---|---|
| 1 | Vermont 49% | North Carolina 67% | Rhode Island 84% | Oklahoma 43% |
| 2 | Maine 44% | Georgia 61% | Delaware 72% | Kansas 36% |
| 3 | New Hampshire 34% | Virginia 60% | New Hampshire 65% | Arkansas 31% |
| 4 | New Jersey 33% | New Mexico 59% | Michigan 64% | Missouri 29% |
| 5 | Wisconsin 32% | Arizona 57% | Ohio 61% | Montana 29% |

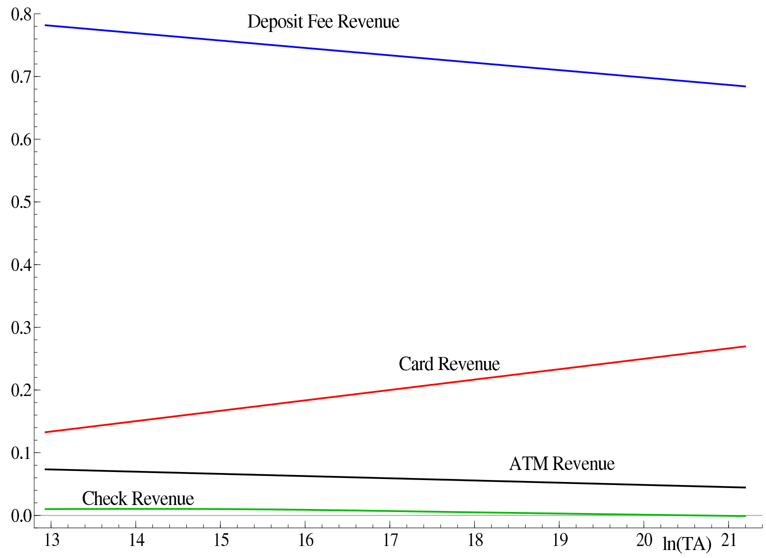


Figure 1: Payment Revenue Shares by Bank Asset Size (2008-2010, Billion Dollar Banks)

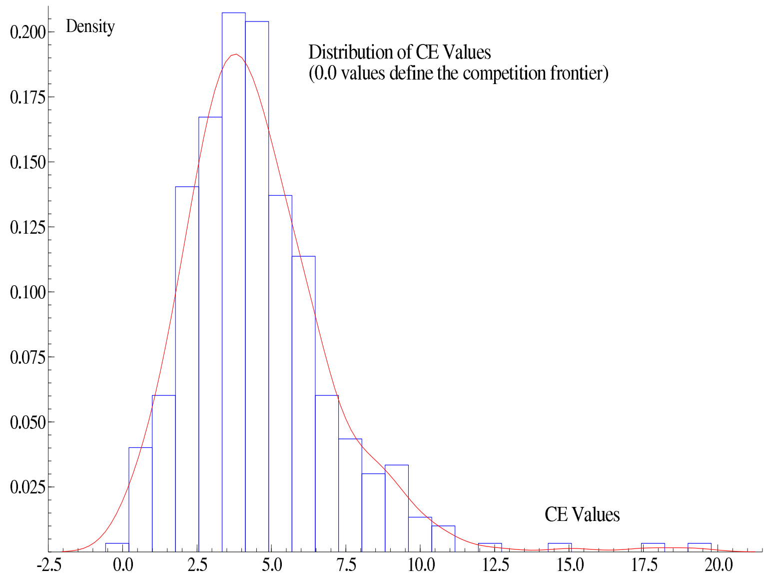


Figure 2: Frequency Distribution of CE for Billion Dollar Banks

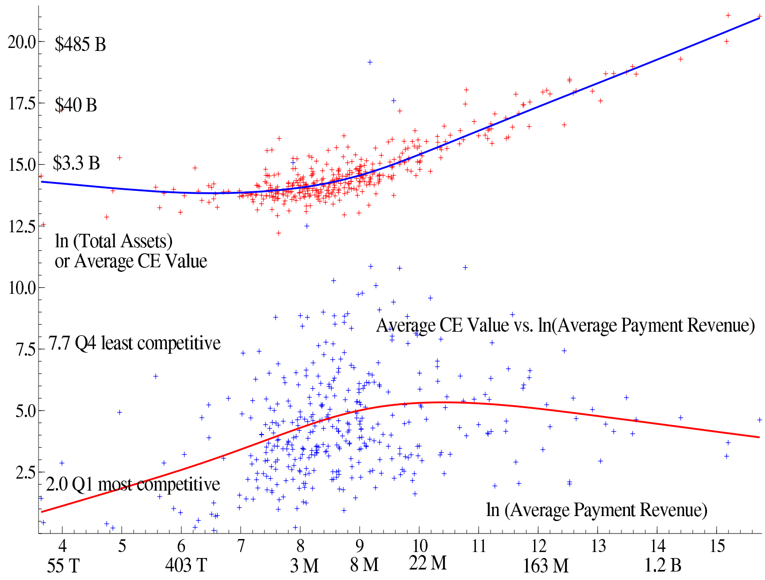


Figure 3: Average Cost Against Time (CE Values, Payment Revenues, and Total Assets (1998-2010)

# Appendix

Table 6: Parameter Estimates

| Variable | 2008 | | 2009 | | 2010 | |
|---|---|---|---|---|---|---|
| $REV_{pay}$/OC | Q1-Q2 | Q3-Q4 | Q1-Q2 | Q3-Q4 | Q1-Q2 | Q3-Q4 |
| Intercept | 52.2** | -71.6** | 294.** | -55.8** | 126** | -105** |
| DEPONLY | 0.976° | 1.05* | 0.27 | 0.074 | -0.293 | -0.542 |
| PL | 2.55° | -1.04 | 1.48 | -2.79 | -3.17* | -7.78** |
| LPK | -5.05** | -6.43** | -3.16** | -2.36* | -0.652 | 0.339 |
| LBR | -5.90** | -5.71** | -7.77** | -6.41** | -8.12** | -6.30** |
| DEPBR | 5.51** | 5.88** | 4.21** | 4.03* | 3.89* | 2.91° |
| PAYEXP | 0.496° | 0.313 | 0.790** | 0.515 | 0.787* | 0.301 |
| UNITCOST | -5.70* | -6.81** | -0.448 | -0.992 | -4.49° | -5.85* |
| $.5(\text{DEPONLY})^2$ | -0.067** | -0.062** | -0.049** | -0.033° | -0.062** | -0.062** |
| $.5(\text{PL})^2$ | -1.30** | -1.77** | -0.972** | -1.95** | -0.636** | -1.23** |
| $.5(\text{PK})^2$ | -0.402** | -0.302** | -0.252** | -0.302** | -0.252** | -0.245** |
| $.5(\text{LBR})^2$ | -0.491° | 0.151 | -0.496° | -0.403 | -1.61** | -1.32** |
| $.5(\text{DEPBR})^2$ | -0.655** | -0.468* | -0.504** | -0.763** | -1.06** | -1.02** |
| $.5(\text{PAYEXP})^2$ | 0.050** | 0.044** | 0.043** | 0.035** | 0.034** | 0.026** |
| $.5(\text{UNITCOST})^2$ | -0.062 | -0.671 | -0.208 | -0.504 | -1.05° | -1.02° |
| DEPONLY*PL | -0.123* | -0.173* | -0.147** | -0.102 | -0.054 | 0.079 |
| DEPONLY*PK | 0.134** | 0.174** | 0.134** | 0.087* | 0.065° | 0.015 |
| DEPONLY*LBR | -0.012 | -0.069 | 0.001 | 0.026 | 0.001 | -0.021 |
| DEPONLY*DEPBR | 0.086 | 0.126* | 0.057 | 0.034 | 0.112° | 0.115° |
| DEPONLY*PAYEXP | 0.034** | 0.018* | 0.003 | 0.001 | 0.003 | 0.009 |
| DEPONLY*UNITCOST | -0.039 | 0.024 | -0.200* | -0.169° | -0.128 | -0.045 |
| PL*PK | 0.405** | 0.249 | 0.332** | 0.275* | 0.175° | 0.074 |
| PL*LBR | -0.149 | 0.087 | 0.037 | -0.261 | -0.528** | -0.898** |
| PL*DEPBR | 0.303° | 0.383° | 0.287* | 0.892** | 0.692** | 1.10** |
| PL*PAYEXP | -0.047 | -0.063 | -0.063* | 0.004 | 0.022 | 0.016 |
| PL*UNITCOST | -0.094 | -1.37** | -0.107 | -0.678* | 0.103 | -0.313 |
| PK*LBR | -0.014 | -0.332** | -0.165 | -0.065 | 0.254* | 0.203° |
| PK*DEPBR | -0.06 | 0.220° | -0.001 | -0.067 | -0.297** | -0.247* |
| PK*PAYEXP | 0.067** | 0.083** | 0.106** | 0.048* | 0.003 | -0.009 |
| PK*UNITCOST | -0.452** | -0.305° | -0.107 | -0.164 | -0.293* | -0.236° |
| LBR*DEPBR | 0.575** | 0.181 | 0.533** | 0.616** | 1.32** | 1.17** |
| LBR*PAYEXP | -0.038 | -0.059 | -0.021 | 0.063° | 0.069* | 0.048 |
| LBR*UNITCOST | -0.401 | -0.858* | -0.729* | -0.442 | -0.196 | -0.409 |
| DEPBR*PAYEXP | 0.009 | 0.091* | 0.092** | -0.009 | -0.009 | -0.001 |
| DEPBR*UNITCOST | 0.641* | 1.09** | 0.509* | 0.500* | 0.2 | 0.436° |
| PAYEXP*UNITCOST | 0.084 | 0.171** | 0.244** | 0.061 | 0.178** | 0.105* |
| PAYTODEP | 24.9** | -6.01** | 75.9** | -11.1** | 33.5** | -25.9** |
| Adj. $R^2$ | 0.68 | 0.70 | 0.68 | 0.69 | 0.67 | 0.66 |

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

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