Bank Competition Efficiency in Europe: A Frontier Approach*

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June 17, 2008

Abstract

There are numerous ways to indicate the degree of banking competition across countries. Antitrust authorities rely on the structure-conduct-performance paradigm while academics prefer price mark-ups (Lerner index) or correlations of input costs with output prices (H-statistic). These measures are not always strongly correlated when contrasted across countries or positively correlated within countries over time. Frontier efficiency analysis is used to devise an alternative indicator of competition and rank European countries by their dispersion from a "competition frontier". The frontier is determined by how well payment and other costs explain variations in loan-deposit rate spread and non-interest activity revenues.
(98 words)

Key Words: Banking competition, frontier analysis, European banks
JEL Classification Code: E41 C53

* Comments by (list individuals here) are gratefully acknowledged.

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1 Introduction.

A recent EC report on retail banking in Europe outlined how bank fees for payment and other banking services often differ markedly across European countries (Economic Commission, 2007). The report noted large cross-country differences in deposit account maintenance fees, payment transaction fees, card interchange fees, deposit interest rates, account switching fees, and other service prices. It also noted important differences in bank profitability as well as banking market concentration. While it was recognized that differences in bank costs and productivity would be one reason for the variation in bank service fees and interest paid on deposits, the tone of the report was that many of the differences were likely "too large" to be due to cost influences alone, suggesting that differences in competition may also account for much of the observed variation. As retail banking accounts for about half of total banking activity in Europe (or around 275 billion euros annually), employs some 3 million people, generates close to 2% of European GDP, and is used by almost the entire population, it is clear that the competitive efficiency of this sector has important implications for the realized efficiency and welfare of individual countries (Economic Commission, 2007).

Bank retail fee and service pricing revenues are essentially determined by three drivers: (1) the level of underlying costs; (2) the productivity of banks in producing their services; and (3) the level of market competition which may permit them to obtain revenues that exceed a normal return on invested capital or equity. While this broad framework–expressed as: retail banking revenues = f (costs, productivity, competition)–is well-accepted, antitrust authorities and academics typically focus on indicators of competition and their apparent association with revenues and prices. The implicit maintained hypothesis is that the share of revenues not associated with a given competition measure is due to underlying cost and productivity influences or possibly variation in total demand.

In practice, antitrust authorities rely on the structure-conduct-performance paradigm to indicate the current level of market competition conditional on information regarding the ease of new firm entry. Evidence of the possible abuse of market power is often provided by a Lerner index. Importantly, this approach also provides an indication of potential future market competition should market structure change via mergers or acquisitions. Academics prefer price mark-up measures (Lerner index) or correlations of changes in input costs with output prices (H-statistic) to infer current and past levels of competition. While there is disagreement about which of these three measures may "best" reflect market competition, the expectation is that since they purport to measure the same thing they are all positively correlated. Unfortunately, this expectation is not always met. These measures are almost unrelated when compared across European countries over time and can be negatively related within the same country over time (Carbo, Maudos, Humphrey, and Molyneux, 2007). Consequently, the choice of which measure to use may affect the outcome.

Our approach in this paper is essentially the reverse of that used in the competition literature. Instead of directly measuring competition with typically one (rarely two) of the three indicators outlined above–as in retail banking revenues = f(competition)–and implicitly maintaining that the unexplained portion of revenues is likely due to cost and productivity influences, we focus on the cost and productivity influences–as in retail banking revenues = f(costs, productivity)–and maintain that the unexplained portion of revenues essentially reflect the influence of competition. In this sense we borrow from cost efficiency frontier analysis and develop a "competition efficiency frontier" and rank European countries by their relative dispersion from this frontier.

In what follows, Section 2 outlines how bank revenues have changed over 20 years (1987-2006) across 11 European countries. Two revenue flows are distinguished: one concerns bank non-interest revenues and the other reflects revenues generated from their loan-deposit rate spread. This distinction is important since unit non-interest revenues have been rising over time while unit spread revenues have been falling. The application of frontier analysis to the measurement of relative banking market competition across countries is outlined in Section 3 as is our econometric framework. The resulting competition frontier and identification of country rankings based on their dispersion from this frontier are presented in Section 4. Elasticities of the effect of payment costs and bank productivity on two classes of banking revenues are presented in Section 5. In Section 6, the competition frontier results are contrasted with "standard" cross-country competition indicators such as an H-statistic (from Bikker, 2007) along with a market concentration ratio and a profitability measure (from Economic Commission, 2007). Our conclusions are presented in Section 7.

2 Changes in Bank Revenues and Costs.

In assessing banking competition, only the interest income from loans and the interest expense of retail deposits is subject to significant variation from monopoly power. Interest income from securities and the expense from other liabilities for borrowed money (e.g., large CDs, interbank funding) are market determined so variation across banks is due almost entirely to different balance sheet compositions. The income sources most subject to monopoly power concern non-interest income (reflecting fee income and some trading gains) and income from the spread between loan and deposit rates times the level of deposits raised. The annual average growth of the sum of these two income sources over 20 years (1987-2006) is shown in Column 1 of Table 1 (Revenue).[1] Sweden, the Netherlands, and Belgium experienced annual revenue growth rates of 7% or more while for Norway, Finland, and Spain this revenue growth was less than 3%. Averaged over all 11 countries, annual revenue growth was 4.9%. Operating costs in Column 2, composed of labor, physical capital, and materials expenses, reflect the input costs incurred to support the revenue expansion of Column 1.[2]

In most cases, banks that experienced higher growth in operating costs also generated greater growth in their non-interest and spread revenues. However, this was not one-to-one. Indeed, most countries experienced higher growth in revenues than in their operating cost. Only for Norway, Germany, and the U.K. was the situation reversed. Overall, revenues grew by 4.9% a year while an approximation of their underlying operating cost grew by 4.2%. Over 20 years, this implies that revenues expanded by 160% while costs rose by 128%, a difference of 32 percentage points. Lacking cost accounting data, it is not possible to determine more precisely the degree to which bank revenues may have exceeded the growth of their underlying costs.[3] Even so, this simple calculation is suggestive of the ability of banks in the majority of our 11 countries to raise revenues more rapidly than their costs. Based on this metric, Germany, the U.K., and Norway would likely be considered as having competitive banking markets (as indeed the first two are using our frontier approach).

While bank revenues are expanding overall, their source is shifting. Revenues obtained from the loan-deposit rate spread are falling as a percent of

[1] These growth rates and all data used in this analysis are based on U.S. dollar purchasing power parity values. This was necessary to maintain cross-country comparability since the euro did not exist prior to 1998.

[2] The revenue and cost variables in Table 1 do not include interest income nor interest expenses, except for the loan-deposit rate spread. Revenues attributed to this spread are included in Column 1 of the table. Banks set their spread depending on the general level of market interest rates and their view of their competitive position in the loan and retail deposit markets.

[3] This problem is not just one of the unavailability of internal bank data. No bank has such cost accounting data and those that do have some approximation to the illustration presented here certainly do not have it for 20 years.

Table 1: Revenue and Cost Growth Rates: 11 Countries, 1987-2006

	Revenue	Operating Cost (OC)	Non-Interest Income/OC	Spread/ OC	PL	Labor/ Deposits	Payment Cost
Sweden	7.0%	4.4%	7.2%	-1.8%	5.8%	-6.0%	-3.3%
Norway	1.5	2.3	1.5	-2.5	5.3	-7.0	-4.4
Netherlands	7.7	6.5	4.2	-1.1	4.6	-7.3	-4.5
Belgium	8.0	3.8	4.7	3.7	4.5	-7.6	-3.6
Finland	2.7	1.6	2.5	-0.2	3.1	-8.9	-4.8
France	6.1	4.3	7.1	-1.6	4.6	-5.3	-2.7
Denmark	4.9	3.7	7.2	-0.9	4.9	-5.4	-5.0
Germany	4.2	5.5	3.0	-2.5	4.4	-5.4	-3.9
Italy	4.5	3.8	3.8	-0.9	2.6	-6.0	-3.2
U.K.	5.0	6.5	-0.4	-1.8	5.4	-7.4	-3.2
Spain	2.4	4.2	6.0	-3.9	3.8	-6.7	-6.5
Average	4.9	4.2	4.3	-1.2	4.4	-6.6	-4.1

operating cost (Column 4) while revenues associated with non-interest income activities are rising (Column 3). This shift in revenue sources is important since academic analyses of banking competition that use the so-called new approach to IO and judge the level and change in competition from price mark-up analysis (Lerner index) or the H-statistic typically focus only on more easily obtainable loan and deposit prices (e.g., Covosier and Gropp, 2002; Northcott, 2004; and many others). As revenue from non-interest income activities across our 11 countries was 20% in 1987 but 44% by 2006, much of the current banking competition literature which requires price information for implementation is increasingly looking only at part of the competition picture. While the one-time collection of otherwise unavailable bank pricing data contained in the EC report on retail banking (Economic Commission, 2007) is a welcome addition, there is no information on the revenue shares associated with these priced activities to form an overall price index to make cross-country comparisons. Comparing separate prices across countries, as the EC report does, gives information on specific services but a high relative price for one service in a country may be offset by a lower price for another. However, if a country has high relative prices for a broad range of priced services this would be suggestive of less competition in that country's banking market.

Just as the rise in overall revenues masks the shift from spread income to non-interest income sources, the rise in operating costs also contains a shift. That is, the labor input/banking output ratio (the labor/deposit ratio of Column 6) is falling on average by 6.6% a year while the average price of labor is rising by 4.4% (Column 5). Put differently, productivity (the labor/deposit ratio) is rising and offsets in whole or in part the rising unit cost of labor. Capital intensity is not easily measured since the size of a branch office differs markedly across countries–from around 6 workers per office in Spain to over 20 per office in the U.K. For this reason, the number of branch offices can not be used in our analysis. What can be said is that the number of branch offices in all but three countries (Germany, Italy, and Spain) have fallen absolutely and been replaced by ATMs.[4] For example, the number of offices fell by 28% in the U.K., by 43% in Norway, and by 49% in the Netherlands. At the same time, the opportunity cost of investing in physical capital–the market interest rate–fell on average by 4.4% annually. Although the number of workers per branch office differs greatly across countries, this ratio is basically constant for individual banks within different countries. Consequently, the best indicators of bank capital intensity within a country are the labor/deposit ratio (which falls by 6.6% a year) and the ATM/deposit ratio (not shown but rose by 1.6% a year). Although only indirect measures are available, it seems clear that branch capital costs are likely falling at a faster rate than ATM capital costs are rising, a substitution which may suggest lower capital expenditures overall for most countries.

A third major cost driver for banks concerns payment processing costs. Detailed cost accounting analyses for Norway, the Netherlands, and Belgium, as well as cross-country estimation using panel data or confidential payment information for a single country, all indicate that substantial operating cost scale economies exist for payments (Bolt and Humphrey, 2007). Average scale economies for non-cash transactions across the same 11 countries used in this study is .27. Thus a 10% rise in payment volume would increase payment costs by only 2.7% so average unit processing cost falls as volume expands. Non-cash payment volume has expanded on average by 6.1% annually and the implied yearly reduction in unit payment cost across all countries is 4.1% (last column in Table 1).

To sum up the analysis of the available raw data on revenues and operating costs, there are good reasons to believe that revenues in many of our 11 countries have risen more rapidly than their underlying operating or production costs. While the price of labor has increased, labor intensity appears to have fallen as has the unit cost of processing payment transactions. Although we do not have detailed data on the unit cost of processing cash

[4] The number of branch offices rose in Italy and Spain as a result of removing branching restrictions. Banks sought to expand their market share by opening new offices in locations previously denied to them and hope that future deposit growth will make them economic.

transactions or back office deposit and loan account management, these costs are also likely to have fallen over time due to increased reliance on computer and automated management systems. We now outline how the variables in Table 1, along with other information, will be used to develop a competition frontier.

3 Estimating A Competition Frontier.

There are at least two reasons to be interested in measuring banking market competition in a different way. First, the mark-up and H-statistic measures focus on banking services where price information is generally available (such as for loans and deposits) but can not cover well other activities where little pricing information exists (such as non-interest income activities which now accounts for 44% of the revenues where a lack of competition is likely to have its greatest impact).

Second, the currently used indicators are basically unrelated when contrasted across countries over time and often give inconsistent answers when applied to a single country over time. For example, looking at 14 European countries covering 1,912 banks over 1995-2001, the R^2 between the Lerner index and the H-statistic was only .06 while the R^2 between the HHI and these two measures was, respectively, .09 and .05 (Carbo, Maudos, Humphrey,and Molyneux, 2007, Tables 2 and 3).[5] Looking at each of the 14 countries separately over time, the relationship between the Lerner index and the H-statistic was positive in only 8 out of 14 countries. The relationship between the HHI and these two measures was positive in only 8 and 5 countries, respectively. Since the choice of an existing competition measure may affect the results obtained, we develop a procedure where choice among the current measures is not necessary.

3.1 Model Specification.

In applying frontier analysis to the measurement of competition, we maintain that the three most important determinants of retail banking service unit revenues are the underlying unit operating costs of producing these services, the productivity of the factor inputs used in producing these services, and the existing level of market competition. A unit revenue function is specified reflecting the ratio of service revenues (*Revenue*) to total bank operating cost

[5] In this analysis, the H-statistic was multiplied by -1.0 so that a larger value of the H-statistic, the Lerner index, and the HHI would all indicate less competition.

(OC), the variables whose growth rates were illustrated in Columns 1 and 2 of Table 1. This variable is conceptually similar to a Lerner index but one where specific price information is not required for its computation.

As noted above, *Revenue* is the sum of two sources of service revenue: (1) non-interest income (NII) associated with priced services (payment transaction fees, ATM fees, deposit account maintenance fees, account switching fees, loan fees, loan commitment fees, etc., as well as trading income) plus (2) revenues from the loan-deposit rate spread times the value of deposits ($SPREAD$). Expressing these two revenue components as a percentage of operating cost (OC) gives our two dependent variables NII/OC and $SPREAD/OC$ whose growth rates are shown in Columns 3 and 4 of Table 1.

The variation of each dependent variable is a function of four indicators of unit costs: the average price of labor (PL in Column 5), the opportunity cost of investing in physical capital (PK, the market interest rate), and an index of the unit cost of processing payment transactions (PC in Column 7 transformed into index). This index is based on estimated country-specific payment scale economies (averaging .27 overall) and changes in observed non-cash payment volume.[6] A similar unit cost index for ATMs ($ATMC$) was developed using ATM scale economies (averaging .30) and changes in ATMs.[7] In addition, the variation in each dependent variable can be influenced by the use and productivity of labor in producing banking services as indicated by the labor/deposit ratio (L/DEP in Column 6), an indicator of the substitution of ATMs for more expensive branch offices to deliver cash to depositors (ATM/DEP the ratio of ATMs to deposits), and an indicator of the variation in demand for banking services associated with the business cycle (GAP a measure of the GDP output gap). In summary, our two equation translog functional form model in logs is:

[6] An index of unit payment costs for all 11 countries was calculated using the procedure outlined in the Appendix. The same procedure was applied to ATMs.

[7] Although the payment and ATM scale economies are quite similar, their unit cost indices (shown in the Appendix) are not strongly related over time ($R^2 = .35$). Payment volumes expanded at a steady rate for all countries over 1987-2006 but ATMs did not. In some countries, ATMs experienced very rapid initial growth only to reach "saturation" by 2000 while other countries already had well-established ATM networks by 1987 and expanded them slowly thereafter.

$$\ln NII/OC = \alpha_0 + \sum_{i=1}^{5} \alpha_i \ln X_i + 1/2 \sum_{i=1}^{5} \sum_{j=1}^{5} \alpha_{ij} \ln X_i \ln X_j + \sum_{i=1}^{5} \sum_{k=1}^{2} \delta_{ik}$$

$$\ln X_i \ln P_k + \sum_{k=1}^{2} \beta_k \ln P_k + 1/2 \sum_{k=1}^{2} \sum_{m=1a}^{2} \beta_{km} \ln P_k \ln P_m \qquad (1)$$

$$\ln SPREAD/OC = \theta_0 + \sum_{i=1}^{5} \theta_i \ln X_i + 1/2 \sum_{i=1}^{5} \sum_{j=1}^{5} \theta_{ij} \ln X_i \ln X_j + \sum_{i=1}^{5} \sum_{k=1}^{2} \psi_{ik}$$

$$\ln X_i \ln P_k + \sum_{k=1}^{2} \phi_k \ln P_k + 1/2 \sum_{k=1}^{2} \sum_{m=1}^{2} \phi_{km} \ln P_k \ln P_m \qquad (2)$$

where:

$X_i = L/DEP, ATM/DEP, GAP, PC, ATMC,$

$P_k = PL, PK.$

and have been defined above and/or illustrated in discussing Table 1.

Equations (1) and (2) are related in that banks may choose to increase revenues over time (in response to higher costs or weaker competition) by raising the fees they charge on various banking services (affecting NII) or they can instead increase revenues by altering their loan-deposit rate spread (raising loan rates and/or lowering deposit rates). Industry observers have suggested that the faster growth in revenues from non-interest income activities and the slower growth in revenues from loan-deposit rate spreads is a response to expanded competition for loans and deposits which banks, in turn, attempt to offset by pricing and pricing higher more non-interest income activities. Some of these activities previously appeared to be "free" as their costs were largely bundled in loan and deposit rates. Since errors in explaining the variation of non-interest revenues in (1) may be correlated with errors in explaining the variation of revenues from the loan-deposit rate spread in (2), these two revenue equations are estimated jointly in a seemingly unrelated regressions (SUR) framework.

3.2 A Competition Efficiency Frontier.

While there are at least four ways to determine a frontier, our preference is to use the composed error Distribution Free Approach or DFA (Berger, 1993). Two other alternatives involve linear programming (Data Envelopment Analysis and Free Disposal Hull). A fourth is the composed error

Stochastic Frontier Approach (SFA). All four approaches have their problems.[8] The Stochastic Frontier Approach, for example, typically assumes a half-normal distribution for inefficiencies (or in our case competition inefficiencies) in order to separate unknown inefficiencies from normally distributed error in a panel regression. The Distribution Free Approach–the model used here–assumes that averaging each observation'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). Although both stochastic approaches involve strong assumptions, they have in past cost analyses generated similar levels and rankings of banking inefficiencies (Bauer, Berger, Ferrier, and Humphrey, 1998). However, this result may or may not hold for competition analysis.

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

$$\ln NII/OC = R(\ln X_i, \ln X_j, \ln P_k) + \ln e + \ln u. \tag{1b}$$

The total residual ($\ln e + \ln u$) reflects the unexplained portion of the revenue dependent variable remaining after cost and productivity 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 DFA concept relies on the assumption that $\ln e$ will average to a value close to zero while the average of $\ln u$ will reflect the average effect of competition ($\ln \bar{u}$). The bank or country with the lowest average residual ($\ln \bar{u}_{\min}$) is also the bank or country where the variation in underlying cost and productivity explains the greatest amount of the variation in revenues. This minimum value defines the competition frontier and the relative competition efficiency (CE_i) of all the other i banks or countries in the sample is determined 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 term u_i is multiplicative to NII/OC_i in the unlogged revenue equation $NII/OC_i = R(X,P)_i\ u_i$. Thus the ratio $\bar{u}_i/\bar{u}_{\min}$ is an estimate of the ratio of NII/OC_i for the i^{th} bank or country, for a given level of underlying cost and service productivity, to the value of $NII/OC_{\min}$ for the bank or

[8] The advantage of linear programming is that there is no need to specify a particular functional form which can affect the placement of the frontier. The disadvantage is that it assumes random error is zero (so hypotheses can not generally be tested) and the more influences (constraints) considered in the analysis, the lower will be the dispersion from the frontier even when–in a regression framework–the added influences (variables) may be insignificant.

country facing the greatest competition and having the same underlying cost and service productivity.[9] If $CE_i = .25$, then $\bar{u}_i$ is 25% larger than $\bar{u}_{\min}$ so the unexplained portion of NII/OC_i is 25% larger than $NII/OC_{\min}$. 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.[10]

A limitation is that equation (3) only indicates the *relative* level of competition: it can not determine the *absolute* level of competition even for the most competitive bank or country. Consequently, it is important to also examine the fit of the estimating equation since, if the R^2 is very high (e.g., .90 or above), the difference in relative competition measured by CE may not be very economically significant since the residuals $\bar{u}_i$ and $\bar{u}_{\min}$ are themselves absolutely small.[11]

4 Assessing Cross-Country Competition.

Aggregate, country-level data were collected from publicly available sources over 20 years for the 11 European countries shown in Table 1. The seven cost and productivity variables specified in equations (1) and (2) were used in a translog function to explain the variation in revenues from bank non-interest income activities (NII/OC) separately from the variation in revenues from setting the loan-deposit rate spread ($SPREAD/OC$). Three separate panel cross-section SUR estimations of (1) and (2) were made, the residuals were pooled, and then averaged for each country separately.[12] The resulting

[9] The ratio $\bar{u}_i/\bar{u}_{\min} = ((NII/OC)_i/R(X,P)_i)/((NII/OC_{\min})/R(X,P)_{\min})$ and when evaluated at the same level of underlying cost and service productivity, the predicted values of revenue $R(X,P)_i$ and $R(X,P)_{\min}$ are equal as both are at the same point on the estimated revenue curve, leaving the ratio $(NII/OC)_i/(NII/OC_{\min})$.

[10] The cost efficiency literature reports efficiency (EFF) and inefficiency (INEFF) values. If efficiency is 80% (EFF = .80), then inefficiency is INEFF = (1 - .80)/.80 = .25 or 25%. In (3), CE reflects the relative weakness of competition in restraining revenues and is equivalent to INEFF which reflects relative weakness of cost efficiency.

[11] This qualification is not well-understood in the frontier literature. Almost all published bank cost efficiency studies merely report relative efficiency and inefficiency values without considering how well their specified model explains the variation in bank cost. Absolute differences in residuals need to be considered along with their relative size, so goodness of fit should be an additional consideration (Carbó, Humphrey, and Lopez del Paso, 2007).

[12] The three cross-section estimations covered 1987-1993 (7 years), 1994-1999 (6 years), and 2000-2006 (7 years) and the estimated parameters are shown at the end of the Appendix. The panel data was not large enough to run a cross-section for each year separately. Greater CE variation would exist if individual bank data were used to obtain the country-

competition efficiency values (CE) are shown in the first two columns of Table 2 (along with their efficiency ranks, 1 being the most competitively efficient). In terms of model performance, the six R^2s ranged from .81 to .95 while Durbin-Watson statistics varied from 1.24 to 2.52. As the time-series dimension of the three panel data sets used in the estimation of (1) and (2) is less than two-thirds of the cross-section dimension, data stationarity is not of great importance but, when tested, unit roots could be rejected in 75% of the cases.[13]

The relatively high R^2 values indicate that operating cost and productivity explain by far most of the variation in revenues across our 11 countries. Another way to illustrate this is to compute the average percent that the residuals are of the two dependent variables for the three cross-section estimations. These values were 4%, 6%, 9% (three times), and 13%. Thus the share of the value of revenues not explained, and maintained here to reflect the effect of competition, is rather small. It is smaller still when one considers that revenues need to exceed costs by some degree in order to earn a positive return on invested capital or equity.

In the frontier literature, cost functions with high R^2s generate relatively low levels of measured inefficiency since the average values of the unexplained residuals are themselves usually low.[14] In terms of determining competition efficiency in (3), this means that $\bar{u}_i$ and $\bar{u}_{\min}$ are both relatively small so the computed CE_i value is also low. Consequently, CE values from country-level averaged residuals in Columns 1 and 2 suggest that differences in the apparent level of competition efficiency across countries is small. Indeed, the difference in averaged residuals for non-interest income activities ($CE_{NII/OC}$) between the U.K.–which defines the frontier–and Sweden–the country with the greatest apparent inefficiency–is only 14%. In contrast, Sweden defines the loan-deposit rate spread ($CE_{SPREAD/OC}$) frontier while the U.K. has the greatest apparent inefficiency at 9%. By the standards of the cost efficiency literature where inefficiency is commonly found to be around 25% (Berger and Humphrey, 1997), competition inefficiency appears to be much smaller.

Averaging the residuals for each country across separate cross-section estimations will clearly reduce the variance of CEs across countries. Av-

level averages. All value data is expressed in U.S. dollar purchasing power parity values for cross-country comparability.

[13] Nine variables were tested in each of three data sets giving 27 tests. Non-stationary variables were the labor/deposit and ATM/deposit productivity ratios in two of the data sets and the unit payment (or ATM) cost index in one of the data sets.

[14] This was a clear result in Carbó, Humphrey, and Lopez del Paso (2007).

Table 2: Competition Efficiency (CE) for 11 Countries, Cross-Section vs. Panel Residual, 1987-2006

	Averaged Residuals:				Panel Residuals:					
	$CE_{NII/OC}$		$CE_{SPREAD/OC}$		$CE_{NII/OC}$			$CE_{SPREAD/OC}$		
Sweden	.140	(11)	.000	(1)	.90	(11)	0	.30	(4)	-3
Norway	.042	(4)	.026	(5)	.53	(2)	+2	.26	(1)	+4
Netherlands	.046	(5)	.034	(8)	.57	(3)	+2	.39	(10)	-2
Belgium	.075	(10)	.017	(4)	.66	(8)	+2	.30	(5)	-1
Finland	.057	(7)	.030	(6)	.64	(7)	0	.34	(6)	0
France	.036	(3)	.008	(2)	.61	(5)	-2	.27	(2)	0
Denmark	.054	(6)	.032	(7)	.60	(4)	+2	.29	(3)	+4
Germany	.065	(8)	.016	(3)	.68	(9)	-1	.36	(8)	-5
Italy	.069	(9)	.036	(10)	.82	(10)	-1	.36	(7)	+3
U.K.	.000	(1)	.091	(11)	.48	(1)	0	.36	(9)	+2
Spain	.028	(2)	.O35	(9)	.62	(6)	-4	.39	(11)	-2

eraging is done so that random error, to the extent it exists, will play a minimal role in the CE calculation. To illustrate this effect, competition efficiency values were computed without averaging the residuals by country before determining the frontier. This assumes that random error is very small to begin with and likely to produce clear outliers whose influence can be deleted from the sample (although there is no way to check this). Here the single lowest u_i value in the panel estimation ($u_{\min}$) defines the frontier rather than the lowest average value ($\bar{u}_{\min}$). These unaveraged CE_i values using panel residuals are shown in Columns 3 and 4 of Table 2. Even after 5% of the highest and lowest individual u_i values in the panel–the clear outliers in the residual frequency distributions–were removed, the CE values are markedly higher when averaged after the frontier is determined. The frequency distributions–before and after the 5% truncation are shown in the Appendix and resemble normal distributions (not half-normal distributions).

As seen in Table 2, averaging or not averaging the residuals by country can influence the efficiency rankings. The change in ranking between the averaged and panel residuals for the same dependent variable is also shown in the table.[15] The change is greatest for spread revenues. Even so, as illustrated in Table 3, some countries appear to be persistently more competitive than others. The U.K. is frequently ranked in the top three countries that appear most competitive in non-interest income activities while France is consistently competitive in loan/deposit activities. In contrast, the U.K. and Spain appear to be among the bottom ranked countries in terms of spread activities while Italy and Sweden are in that position for

[15]For example, Sweden was ranked 11 in Column 1 but also 11 in Column 3 so the change in ranking is 0. It is +2 for Norway since the ranking improves by 2.

non-interest income activities which includes payment services. A similar result occurs when CE values are computed for each country for each of the three estimations separately.[16] The U.K. and France were ranked in the top three most competitively efficient countries in four out of six rankings (not shown) while Sweden was similarly ranked at the other extreme. Although CE values using panel residuals are larger, due to not averaging the residuals before determining the frontier, the difference between the country that defines the panel residuals' frontier to the least competitive country averages 20% for non-interest income activities but only 7% for spread activities. The difference between the frontier and the least competitive country in Table 2 using averaged residuals is similar at 14% and 9% respectively.

Table 3: Most and Least Competitive Countries, Averaged Residual vs. Panel Residual

Averaged Residuals:		Panel Residuals:	
$CE_{NII/OC}$	$CE_{SPREAD/OC}$	$CE_{NII/OC}$	$CE_{SPREAD/OC}$
U.K.	Sweden	U.K.	Norway
Spain	France	Norway	France
France	Germany	Netherlands	Denmark
Italy	Spain	Germany	U.K.
Belgium	Italy	Italy	Netherlands
Sweden	U.K.	Sweden	Spain

These results suggest two conclusions. First, the reduction in the importance of spread revenues over time illustrated in Table 1 would be consistent with the relatively lower CE values measured for this activity in Table 2 (which indicate greater competition). Similarly, the higher CE values evidenced for non-interest income activities (suggesting less competition) could be a reason behind the relative expansion of these priced activities shown in Table 1. Second, the high R^2s for the standard DFA frontier model indicate that most of the variation in banking revenues across our 11 countries is associated with changes in operating cost and productivity influences. This suggests that differences in banking market competition plays a relatively small role in explaining revenue variation. In turn, this implies that the large differences in individual banking service prices noted in the EC report cited in the Introduction (Economic Commission, 2007) may not be as striking when all prices–including prices for various payment services–are

[16] As noted above, the three cross-section estimations covered 1987-1993 (7 years), 1994-1999 (6 years), and 2000-2006 (7 years).

effectively weighted and combined into the two revenue measures that form our dependent variables in (1) and (2). While these conclusions hold in relative terms, we are unable to assess the possibility that the level of banking costs, as well as revenues, in our 11 countries may be too high compared with other countries (e.g., the U.S. or Canada), although this could be addressed by expanding the countries in the sample.

5 How Costs and Productivity Affect Revenues.

The effect of changes in bank productivity, payment transaction and ATM scale economies, and labor and capital factor input costs across 11 countries on non-interest income and loan-deposit rate spread revenues (the two dependent variables) are illustrated in Table 4. The elasticities shown are averages across 11 countries for the entire 20 year period. In terms of productivity effects, the 6.6% average annual reduction in the labor/deposit ratio shown in Table 2 is associated with significant increases in the ratios of both non-interest income and spread revenues to operating cost. However, the benefit of reducing the number of workers per value of deposits "produced" (similar to a lower input/output ratio) is to some degree offset by the negative elasticity for the price of labor, indicating that the 4.4% annual rise in unit labor cost (Table 2) significantly lowers spread revenues. There is no such labor price offset for non-interest income activities so the rise in labor productivity allows these revenues to be higher.

As noted earlier, marked differences in the size of branch offices across countries means that these offices are not comparable and could not be used as a variable in our analysis. Fortunately, an ATM in one country is quite similar to an ATM in other countries and the elasticity of the ATM/deposit ratio for spread revenues indicates that the 1.6% average annual growth in this "capital/output" ratio is associated with a relatively small reduction in spread revenues. Small, perhaps, because the expansion of ATMs is typically associated with a reduction in expensive branch offices and banks view ATM networks as a way to attract low cost deposit funding for loans. Thus the effect of expanding ATMs, reducing branch operations, and generating low cost deposits is apparently a small net reduction in spread revenues.

Strong scale economies exist in processing payment transactions in Europe (Bolt and Humphrey, 2007) and the reduction in unit payment cost is estimated to be 4.1% annually (Table 2). Multiplied by the payment cost elasticity of .82, the reduction in unit payment cost is associated with a 3.4% yearly fall (not rise) in the ratio of non-interest activity revenues as

Table 4: Elasticities of the Cost Effect on Revenues

	Non-Interest Income Activity Revenues	Loan-Deposit Rate Spread Revenues
Productivity:		
Labor/Deposit ratio	-.42*	-.83*
ATM/Deposit ratio	.06	-.17*
Scale Economy:		
Payment Cost Index	.82*	-.02
ATM Cost Index	.06	-.24*
Factor Input Cost:		
Price of Labor	.01	-1.08*
Capital Opportunity Cost	-.53*	.70*

* Elasticity is significantly different from zero at p-value = .01.

a percent of operating cost. This seems odd since scale economies should reduce costs and presumedly raise revenues. The explanation is that scale economies reduce unit costs while total payment operating expenses rise as payment volumes expand (rising by 6.1% annually). Total revenues could rise to offset the increase in total operating cost (the denominator in the non-interest income dependent variable) if payment transactions were directly priced but this is rare in Europe. Although more and more banking services are being priced and some transaction-based fees have been instituted, only Norway has implemented transaction-based pricing for all payment services. Thus a significant source of revenues are not being tapped, likely due to depositor views that payment services have been "free" and antitrust strictures against banks coordinating the implementation of pricing so as not to disrupt deposit market shares if only one or a few banks implemented transaction pricing.[17]

Finally, ATM networks also experience scale economies and unit ATM costs are estimated to fall by 5.5% annually.[18] In contrast to non-cash payment services, banks do price some ATM cash withdrawals (usually those made by customers of other banks) and the expansion of ATM networks are viewed as an important element of strategic non-price competition to attract and hold depositors. Consequently, as ATM networks expand and

[17] Norway coordinated the timing of when payment pricing would be implemented but there was no agreement on the price to be charged (and some banks did not initially price at all). The quid pro quo was the elimination of payment float–a benefit for depositors (Enge and Øwre, 2006). Pricing was efficient: it speeded up the adoption of lower cost electronic payments by 20% (Bolt, Humphrey, and Uittenbogaard, 2008).

[18] This can be determined from the ATM cost indices shown in the Appendix.

unit costs fall, there is a significant rise in spread revenues as a percent of operating costs. This is the reverse of the effect seen for the ATM/deposit productivity ratio.

6 Comparison with "Standard" Indicators of Banking Competition.

The frontier measure of banking market competition is compared with three other indicators of country-level banking competition in Table 5. This concerns an H-statistic (Panzar and Rosse, 1987), a ratio of pre-tax bank profit to revenues for retail activities, and the share of retail banking income of the top three banks in estimated total retail income (CR-3), a special concentration ratio. While there is some consistency across these measures, it is sporadic.[19] For example, Spain and Italy are the most competitive countries according to the revenue concentration ratio (CR-3) but the $CE_{SPREAD/OC}$ measure and the H-statistic both place Italy among the least competitive countries while the profit/revenue ratio suggests that Spain (which has the highest ratio of retail profits to revenues) is ranked as the most uncompetitive. However, in terms of non-interest income activities ($CE_{NII/OC}$), Spain appears to be very competitive. Another example is that Finland is ranked as very uncompetitive in the three standard measures but is only a little above average in lack of competition for both CE measures. Finally, both the U.K. and Sweden trade places as the most competitive by one CE measure only to be ranked as the least competitive for the other CE measure. If these extreme ranks are averaged, we would obtain a "middle" value overall and this is in rough agreement with the average of the other three competition measures for these two countries.

These inconsistencies are perhaps clearer in Table 6 where the three most and least competitive countries are shown for each of the five indicators from Table 5. Overall, the most competitive countries would seem to include the U.K. (observed among the top ranked countries 3 out of 5 times) and Germany (also 3 out of 5).[20] The least competitive countries across all measures in Table 6 seem to be Italy and Finland (each ranked as least

[19] This was not unexpected since, in an earlier analysis comparing only "standard" measures of competition across 14 countries, the relationships were only weakly positive across countries and sometimes negatively related within the same country (Carbo, Maudos, Humphrey,and Molyneux, 2007).

[20] The Netherlands, France, and Spain all were ranked as most competitive for 2 out of 5 times.

Table 5: Competition Efficiency (CE) for 11 Countries, 1987-2006

	Averaged Residuals:				Other Competition Measures:					
	$CE_{NII/OC}$		$CE_{SPREAD/OC}$		H-Statistic[1]		Profit/Revenue[2]		CR-3[2]	
Sweden	.140	(11)	.000	(1)	.58	(6)	.38	(8)	.78	(7)
Norway	.042	(4)	.026	(5)	.54	(8)	na		na	
Netherlands	.046	(5)	.034	(8)	1.01	(1)	.18	(2)	.88	(9)
Belgium	.075	(10)	.017	(4)	.56	(7)	.11	(1)	.79	(8)
Finland	.057	(7)	.030	(6)	.41	(9)	.39	(9)	.93	(10)
France	.036	(3)	.008	(2)	.61	(5)	.27	(5)	.57	(5)
Denmark	.054	(6)	.032	(7)	.22	(10)	.37	(7)	.75	(6)
Germany	.065	(8)	.016	(3)	.70	(3)	.20	(3)	.55	(4)
Italy	.069	(9)	.036	(10)	.09	(11)	.22	(4)	.41	(2)
U.K.	.000	(1)	.091	(11)	.76	(2)	.33	(6)	.51	(3)
Spain	.028	(2)	.035	(9)	.65	(4)	.40	(10)	.40	(1)

[1]Bikker, Spierdijk, and Finnie (2007), Table 2. [2]European Commission (2007), Figures 5 and 1.

competitive 3 out of 5 times).[21] Both the U.K. and Germany remain the most competitive countries even if an asset value HHI (European Central Bank, 2007) replaces the revenue concentration ratio (CR-3) in Table 6 (not shown). The same holds for Italy and Finland as the least competitive countries in Table 6.[22] These results for the U.K., Germany, and Italy are in general accord with conventional wisdom regarding country-level banking competition.

Like sightless men each describing a different part of an elephant and trying to generalize from their limited information, each of the various competition measures in Tables 5 and 6 probably is only part of the answer. Consequently, a reasonable future research or antitrust strategy would be to try to distinguish important subsets of banking activities–more than just the two we develop in this paper–and separately determine the relative competitiveness of each subset rather than attempt–as is common in the literature–to draw a summary conclusion that applies to all banking activities together. Such an approach is basically a middle ground between the EC retail banking study that (usefully) focused on individual price comparisons and that in the competition literature which typically relies on a single indicator for the entire banking firm. Clearly, data availability is a constraint here.

[21]Sweden, Belgium, and Spain all were ranked as least competitive 2 out of 5 times.

[22]An asset value HHI using Bankscope data, which does not include all banks, produces the same results.

Table 6: Most and Least Competitive Countries

	Averaged Residuals:		Other Competition Measures:		
	$CE_{NII/OC}$	$CE_{SPREAD/OC}$	H-Statistic	Profit/Revenue	CR-3
Most	U.K.	Sweden	Netherlands	Belgium	Spain
Competitive	Spain	France	U.K.	Netherlands	Italy
	France	Germany	Germany	Germany	U.K.
Least	Italy	Spain	Finland	Sweden	Belgium
Competitive	Belgium	Italy	Denmark	Finland	Netherlands
	Sweden	U.K.	Italy	Spain	Finland

7 Summary and Conclusions.

Antitrust authorities and the industrial organization literature tend to focus on different measures of banking market competition (e.g., usually the structure-conduct-performance paradigm versus the H-statistic or Lerner index). Unfortunately, these measures are not always strongly correlated when contrasted across countries over time and are sometimes negatively correlated within a country. We borrow from frontier efficiency analysis to devise an alternative indicator of competition and rank European countries by their dispersion from a "competition efficiency frontier". In effect, we maintain that the three main determinants of differences in the ratio of bank revenues from non-interest income activities to operating cost and in the ratio of bank revenues associated with the loan-deposit rate spread to operating cost are both a function of: (a) underlying bank operating costs; (b) indicators of bank internal productivity; and (c) banking market competition. In the frontier approach to assessing bank competition, (a) and (b) are directly specified and accounted for in estimation but the influence of (c) is assumed to be reflected in the average of the unexplained residual from a translog function relating the two classes of revenues to (a) and (b). This approach is applied to a panel of 11 European countries over 1987-2006.

Over this time period, the ratio of bank revenues from non-interest income activities to operating cost has expanded considerably and now accounts for 44% of the total value of revenues used in this study. Correspondingly, the ratio of bank revenues associated with the loan-deposit rate spread to operating cost has been falling over this period. In sum, there has been a large shift from spread revenues to revenues from non-interest income activities in pricing various banking services. The reduction in spread revenues would be consistent with the relatively lower competition inefficiency values we measure for this activity while the reverse–higher competition inefficiency values for non-interest income activities–may be one reason why revenue from these activities has been expanding.

In our application, the frontier approach yielded relatively high R^2 values (ranging from .81 to .95) indicating that by far most of the variation in the two classes of banking revenues across 11 countries is associated with changes in operating cost and productivity influences. This suggests that differences in banking market competition appears to play a relatively small role in explaining cross-country variations in banking revenues. Thus the large differences in individual banking service prices noted in an important EC report on retail banking (Economic Commission, 2007) do not seem to roll over into similarly large differences in revenues associated with non-interest income activities. This is consistent with high prices for some banking services in some countries being offset by low (or no) prices for other services so observed revenue differences among countries would be mitigated. Overall, the maximum dispersion of the least competitive country from the competition efficiency frontier was rather small, ranging from 9% to 14%. This is considerably less than the average cost inefficiency values of around 25% (or efficiency levels of 80%) often found in bank cost efficiency studies.

Elasticities of the effect of changes in bank productivity, payment transaction and ATM scale economies, and labor and capital factor input costs on revenues were obtained and, for the most part, generated the expected signs. Increases in the labor/deposit ratio, an indicator of productivity in "producing" deposits, raised both non-interest activity and spread revenues albeit with some offset attributed to the contemporaneous rise in the price of labor. Increases in capital intensity associated with the rise in the ATM/deposit ratio reduced spread revenues while reductions in ATM unit costs related to ATM network scale economies raised spread revenues (both are expected outcomes). An unexpected result was that reductions in unit payment costs due to scale economies were associated with lower (not higher) non-interest activity revenues. The explanation is that while unit cost is falling, total payment operating expense is rising due to the steady expansion of non-cash payment transactions. As payment transactions are rarely directly priced, revenues do not rise and the ratio of revenues to operating costs falls. Thus an important potential revenue source remains untapped.[23]

In future work, it may be useful to identify revenues from more than just the two subsets of banking activities identified here. Attempts to continue to rely on a single indicator of banking market competition (as is typical in

[23] The experience of Norway in pricing payment transactions could be applied to other countries when tailored to meet antitrust concerns.

the literature) seem to lead to weak and/or inconsistent results among them in identifying the degree of competition. This is likely due to the separate indicators identifying only a portion of a bank's activities and using this portion to generalize to the entire bank. It may be more productive to develop separate indicators of competition specifically for certain activities and focus on addressing these differences alone in the effort to address a lack of competition. Such an effort should not be too narrow, however, if only not to create a theory of the second best applied to antitrust action–tamping down high prices for one product which is already offset by lower prices for other services within the same product or service category. The real challenge will be to develop the information to do this and perhaps the best place to start would be in a country that is known to have very detailed publicly available banking data (e.g., the U.S.).

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9 Appendix

9.1 Calculating an Index of Unit Payment and ATM Cost.

The average bank cost of a payment (AC) is known for only 3 of our 11 countries but we have estimates of each country's payment scale economy (SCE) or cost elasticity and know the volume of payment transactions (VOL). Set $AC_t = OC_t/VOL_t = 1/1$ and for illustration let $SCE =$ (percent change in payment cost)/(percent change in payment volume) $= ((OC_{t+1} - OC_t)/OC_t)/((VOL_{t+1} - VOL_t)/VOL_t) = .27$, which is the mean SCE value across our countries. If we observe that the percent change in payment volume is .10 from t to $t+1$, then the percent change in total payment cost is $(OC_{t+1} - OC_t)/OC_t) = .27 * .10 = .027$. Thus $AC_{t+1} = OC_{t+1}/VOL_{t+1} = (OC_t * 1.027)/(VOL_t * 1.10) = .9336$ since $OC_t/VOL_t = 1/1$. Consequently, the percent change in unit payment cost is $(AC_{t+1} - AC_t)/AC_t = (.9336 - 1)/1 = -.0664$ so unit costs are reduced by 6.64%. Letting 1987 = 100 and adjusting this starting value for subsequent percent changes in unit payment costs for each country over 20 years gives us an index of unit payment costs (PC) used as an explanatory variable in our analysis. This index for 11 countries over 1987-2006 (1987 = 100) is shown below.

The index of unit ATM costs ($ATMC$) for 11 countries, developed in a similar manner, is also shown below and used in the analysis.

9.2 Frequency Distributions of CE_i values.

The figure below shows the frequency distributions of CE_i before and after a 5% truncation of the panel (unaveraged) residuals. This adjustment clearly drops observations that are not close to the mass of the data.

9.3 Parameter Estimates.

Parameter estimates using equations (1) and (2) are for the three separate time periods noted below. The CE results from these estimations are shown in Tables 2 and 4 under the heading "Averaged Residuals".

PC index

	SW	NO	NL	BE	FI	FR	DE	GE	IT	UK	SP
1987	100	100	100	100	100	100	100	100	100	100	100
1988	95	101	97	96	93	99	99	98	102	97	92
1989	94	100	94	92	85	95	97	95	98	93	85
1990	96	98	93	89	83	89	91	85	92	89	80
1991	95	95	90	86	77	88	88	76	93	87	75
1992	95	92	87	84	75	84	81	70	91	86	71
1993	95	93	84	79	73	82	73	68	91	85	65
1994	92	86	80	76	71	80	67	65	91	83	62
1995	91	82	75	73	67	78	61	64	86	76	65
1996	89	77	68	70	67	76	61	62	77	73	64
1997	87	72	63	69	65	75	57	59	74	71	59
1998	87	67	59	68	62	73	54	57	71	69	56
1999	73	63	56	68	53	70	51	65	66	66	47
2000	71	60	53	68	54	68	49	61	63	64	43
2001	69	55	49	62	52	66	47	60	60	62	43
2002	73	53	47	58	49	63	45	61	58	61	37
2003	67	49	45	58	45	62	42	56	57	58	33
2004	62	46	43	54	43	60	40	50	54	55	27
2005	56	43	42	50	41	60	39	47	53	53	27
2006	52	41	39	48	38	58	36	45	52	52	26

ATMC index

	SW	NO	NL	BE	FI	FR	DE	GE	IT	UK	SP
1987	100	100	100	100	100	100	100	100	100	100	100
1988	97	87	58	96	85	98	82	100	81	93	75
1989	91	84	38	91	74	90	71	85	63	87	61
1990	86	83	29	89	71	84	62	73	52	82	52
1991	84	82	25	82	70	78	56	63	45	80	44
1992	84	84	22	80	70	74	51	49	39	79	40
1993	84	85	20	44	69	70	44	40	36	77	37
1994	82	84	18	40	71	66	41	35	31	74	35
1995	81	82	16	36	78	61	36	31	27	72	32
1996	80	81	16	33	81	59	34	29	25	70	29
1997	80	80	15	29	81	55	32	26	24	68	27
1998	78	79	15	26	83	52	31	25	22	65	24
1999	76	77	15	25	83	48	30	25	20	61	23
2000	76	75	14	23	85	46	29	24	20	54	21
2001	77	74	14	22	85	44	29	24	19	51	21
2002	75	73	13	23	85	43	29	23	18	48	20
2003	75	73	13	23	88	41	28	23	18	44	19
2004	74	73	13	22	96	40	28	23	18	40	18
2005	73	73	14	22	98	38	27	22	17	38	18
2006	73	75	13	22	98	37	27	22	16	37	18

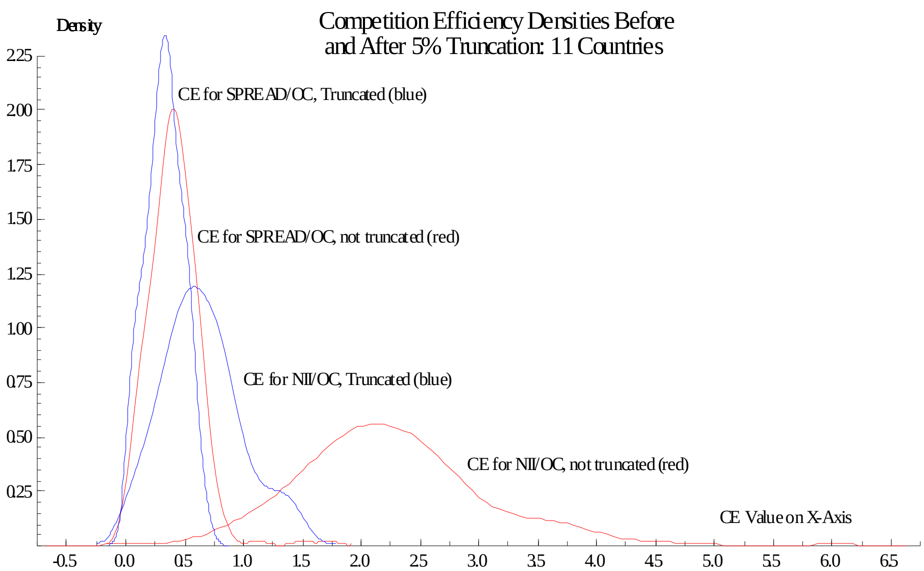
Density
Competition Efficiency Densities Before
and After 5% Truncation: 11 Countries
CE for SPREAD/OC, Truncated (blue)
CE for SPREAD/OC, not truncated (red)
CE for NII/OC, Truncated (blue)
CE for NII/OC, not truncated (red)
CE Value on X-Axis
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5

Figure 1:

Table 7: Estimation results of Equation (1)

Variable	Parameter	1987-93	1994-99	2000-06
$\ln NII/OC$				
Constant	α_0	104.8	-63.1	72.6∘
$\ln L/DEP$	α_1	7.73	-52.2*	23.2*
$\ln ATM/DEP$	α_2	-9.09*	18.9*	-9.39
$\ln GAP$	α_3	-24.5	-232	-36.5
$\ln PC$	α_4	-46.4	7.30	-15.0
$\ln ATMC$	α_5	-10.4	-21.0*	-14.7*
$1/2(\ln L/DEP)^2$	α_{11}	.790	-9.09*	-.061
$1/2(\ln ATM/DEP)^2$	α_{22}	.312	-1.90*	-3.33*
$1/2(\ln GAP)^2$	α_{33}	9.51	-45.7	930
$1/2(\ln PC)^2$	α_{44}	15.2	3.18	4.21
$1/2(\ln ATMC)^2$	α_{55}	.479	1.54*	3.89*
$\ln L/DEP * \ln ATM/DEP$	α_{12}	-.326	3.92*	3.62∘
$\ln L/DEP * \ln GAP$	α_{13}	2.90	-15.6	-12.6
$\ln L/DEP * \ln PC$	α_{14}	1.30	6.92*	-1.35
$\ln L/DEP * \ln ATMC$	α_{15}	-2.04*	-1.42	1.50∘
$\ln ATM/DEP * \ln GAP$	α_{23}	.082	23.6	-13.7
$\ln ATM/DEP * \ln PC$	α_{24}	.728	-3.51	1.45
$\ln ATM/DEP * \ln ATMC$	α_{25}	.254	-.235	-1.65*
$\ln GAP * \ln PC$	α_{34}	6.63	88.8*	-24.5
$\ln GAP * \ln ATMC$	α_{35}	-.201	-7.80	-5.62
$\ln PC * \ln ATMC$	α_{45}	-.517	.948	1.25
$\ln L/DEP * \ln PL$	δ_{11}	3.17∘	-12.7*	1.66
$\ln L/DEP * \ln PK$	δ_{12}	1.68	-1.65	-4.06*
$\ln ATM/DEP * \ln PL$	δ_{21}	-2.31*	2.61*	-.381
$\ln ATM/DEP * \ln PK$	δ_{22}	.705	.760	1.03
$\ln GAP * \ln PL$	δ_{31}	-5.35	2.61	-24.6
$\ln GAP * \ln PK$	δ_{32}	-9.56∘	-14.6	15.2
$\ln PC * \ln PL$	δ_{41}	1.63	7.87*	1.49
$\ln PC * \ln PK$	δ_{42}	-5.11*	-2.78	1.64
$\ln ATMC * \ln PL$	δ_{51}	-3.47*	-2.70*	2.87*
$\ln ATMC * \ln PK$	δ_{52}	-.070	.564	-.581
$\ln PL$	β_1	7.98	-49.0*	7.71*
$\ln PK$	β_2	14.8∘	22.7*	-14.0
$1/2(\ln PL)^2$	β_{11}	1.88	-6.01*	7.14
$1/2(\ln PK)^2$	β_{22}	1.27	-1.32	-.033
$\ln PL * \ln PK$	β_{12}	-1.08	3.47*	-2.76
	R^2	.90	.89	.84
	D-W	1.68	2.39	1.85

* (∘) Parameter is significantly different from zero at p = .05 (.10).

Table 8: Estimation results of Equation (2)

Variable	Parameter	1987-93	1994-99	2000-06
$\ln SPREAD/OC$				
Constant	θ_0	.021	61.3*	50.5*
$\ln L/DEP$	θ_1	-21.2∘	1.15	10.6*
$\ln ATM/DEP$	θ_2	2.70	-11.0*	2.33
$\ln GAP$	θ_3	6.94	-197*	-12.9
$\ln PC$	θ_4	-28.2	-43.9*	-6.31
$\ln ATMC$	θ_5	11.6	4.11	.619
$1/2(\ln L/DEP)^2$	θ_{11}	-3.25∘	.051	3.79*
$1/2(\ln ATM/DEP)^2$	θ_{22}	-.287	.503	.804
$1/2(\ln GAP)^2$	θ_{33}	-15.6	110	371
$1/2(\ln PC)^2$	θ_{44}	12.5	12.1*	-1.52
$1/2(\ln ATMC)^2$	θ_{55}	-.501	-.200	-.257
$\ln L/DEP * \ln ATM/DEP$	θ_{12}	.756∘	-1.05∘	-1.69∘
$\ln L/DEP * \ln GAP$	θ_{13}	.575	-24.1*	-21.8*
$\ln L/DEP * \ln PC$	θ_{14}	3.03	-1.63	-2.21*
$\ln L/DEP * \ln ATMC$	θ_{15}	.808	-.158	.282
$\ln ATM/DEP * \ln GAP$	θ_{23}	7.55*	16.7∘	15.5*
$\ln ATM/DEP * \ln PC$	θ_{24}	.555	2.95*	.178
$\ln ATM/DEP * \ln ATMC$	θ_{25}	-.883∘	-1.37*	-.348∘
$\ln GAP * \ln PC$	θ_{34}	8.25	59.5*	7.52
$\ln GAP * \ln ATMC$	θ_{35}	1.59	-9.05*	.971
$\ln PC * \ln ATMC$	θ_{45}	-2.72	-1.96*	-.327
$\ln L/DEP * \ln PL$	ψ_{11}	-1.98	-.173	2.12*
$\ln L/DEP * \ln PK$	ψ_{12}	-.893	.717	.630
$\ln ATM/DEP * \ln PL$	ψ_{21}	-.464	-1.53*	-.192
$\ln ATM/DEP * \ln PK$	ψ_{22}	-1.77*	-.047	-1.15∘
$\ln GAP * \ln PL$	ψ_{31}	2.33	-18.4∘	-23.3*
$\ln GAP * \ln PK$	ψ_{32}	-6.82	-17.9*	-34.8∘
$\ln PC * \ln PL$	ψ_{41}	.573	-4.83*	-4.73*
$\ln PC * \ln PK$	ψ_{42}	-5.10*	-2.23*	-.714
$\ln ATMC * \ln PL$	ψ_{51}	.382	.494	-.579
$\ln ATMC * \ln PK$	ψ_{52}	.378	.458*	-.662*
$\ln PL$	ϕ_1	-15.5	8.55	20.6*
$\ln PK$	ϕ_2	10.6	14.8*	-3.94
$1/2(\ln PL)^2$	ϕ_{11}	-2.14	.222	-.762
$1/2(\ln PK)^2$	ϕ_{22}	2.26	-.400	3.04∘
$\ln PL * \ln PK$	ϕ_{12}	.300	1.92*	-.501
	R^2	.81	.95	.90
	D-W	1.24	2.52	1.96

* (∘) Parameter is significantly different from zero at p = .05 (.10).