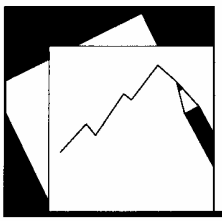
WP/06/143



IMF Working Paper

Are More Competitive Banking Systems More Stable?

Klaus Schaeck, Martin Čihák, and Simon Wolfe

INTERNATIONAL MONETARY FUND

 WP/06/143

IMF Working Paper

Monetary and Financial Systems Department

Are More Competitive Banking Systems More Stable?

Prepared by Klaus Schaeck, Martin Čihák, and Simon Wolfe[1]

Authorized for distribution by Mark Swinburne

June 2006

Abstract

This paper provides the first empirical analysis of the cross-country relationship between a direct measure of competitive conduct of financial institutions and banking system fragility. Using the Panzar and Rosse H-Statistic as a measure for competition in 38 countries during 1980–2003, we present evidence that more competitive banking systems are less prone to systemic crises and that time to crisis is longer in a competitive environment. Our results hold when concentration and the regulatory environment are controlled for and are robust to different methodologies, different sampling periods, and alternative samples.

JEL Classification Numbers: C41, G21, G28, L11

Keywords: systemic risk, banking competition, market structure, regulation, duration analysis

Author(s) E-Mail Address: kschaeck@soton.ac.uk, mcihak@imf.org, ssjw@soton.ac.uk

[1] Klaus Schaeck and Simon Wolfe are with the University of Southampton; Martin Čihák is with the Monetary and Financial Systems Department (MFD). The project was started while Klaus Schaeck was a summer intern in MFD. We thank Mahvash Saeed Qureshi, Sarah Odesanmi, Erlend Nier, Robert Eisenbeis, Johnnie Johnson, Alain Ize, George McKenzie, Gianni de Nicoló, Anastasios Plataniotis, and seminar participants at the MFD, the University of Southampton, and at the workshop "The Architecture of Financial System Stability: From Market Microstructure to Monetary Policy" in Capri, Italy for helpful comments. All remaining errors are our own.

Contents Page

I. INTRODUCTION

The existing literature and regulatory practice is divided on whether intense competition in the banking sector contributes to its stability or leads to the buildup of vulnerabilities. Some theoretical studies argue that competition erodes profits and tends to motivate banks to embark upon risky investments (Smith, 1984). Others take a diametrically opposite view and argue that banks in uncompetitive, monopolistic markets with intermediate monitoring costs are prone to originate risky loans that set the stage for subsequent problems in the system (Caminal and Matutes, 2002).

Due to the absence of sufficiently large datasets on financial institutions' competitive behaviors, hardly any empirical research has so far been dedicated to this subject in a cross-country setting. Consequently, many researchers and policymakers have drawn heavily upon bank concentration as a proxy for competition. However, others argue that concentration is an inappropriate measure to gauge the degree of competition. For example, Claessens and Laeven (2004) find no supportive empirical evidence for the intuitively anticipated inverse relationship between concentration and competition.[2] Moreover, relying on concentration as a measure of bank competition gives rise to misleading inferences and measurement problems since concentration measures such as the Herfindahl-Hirschman Index and the *k* bank concentration ratio tend to exaggerate the level of competition in small countries and are increasingly unreliable when the number of banks is small (Bikker, 2004). While the recent literature differentiates between competition and concentration (Berger and others, 2004), none of these studies specifically tests for the relationship between competitive conduct of financial institutions and its implications for systemic risk.

In this paper, we analyze empirically the effect of competitive conduct of financial institutions on banking system fragility in a cross-country setting. Our aim is to address the important questions of whether competitive bank behavior decreases banking system fragility and how the regulatory environment impacts upon the likelihood and timing of systemic banking problems.

Our research contributes to the literature in four ways. First, using data on 38 countries over the period 1980–2003, we provide the first cross-country investigation of the implications of competitive bank conduct, as measured by the Panzar and Rosse (1987) H-Statistic, on banking fragility. This method is considered superior to previously used proxies for the degree of competition since it describes competitive behavior of financial institutions using comparative static properties of reduced-form revenue equations based on cross-sectional data. Moreover, the H-Statistic also captures competitive behavior of other market participants and is therefore a measure of direct competitive conduct. Second, we introduce a methodological advancement in the literature on financial fragility by estimating parametric duration models with time-varying covariates to examine the timing of systemic banking crises, controlling for the institutional and regulatory setting. While several studies employ discrete choice models based on logit and

[2] Claessens and Laeven (2004) also refer to evidence in the industrial organization literature that underscores that measures of market structure such as the number of institutions and concentration ratios are not necessarily related to the level of competitiveness in an industry.

probit analysis (Eichengreen and Arteta, 2000; Demirgüç-Kunt and Detragiache, 1998, 2005) that compute the probability of observing a crisis at some unspecified point in time, the duration model offers an additional advantage in that it yields estimates for the time until a crisis is observed. Moreover, using time-varying covariates in the duration model accurately accounts for multiple observations per country and can be considered to be more appropriate for the panel structure of our data set than commonly utilized discrete choice models where the estimation is run for a pooled sample. We consider these two modeling techniques to be complementary and believe an evaluation of the hypotheses with two different estimation procedures sheds more light on the relationship between competition and crises than using only one technique on its own. Third, our analysis helps to further disentangle the relationship between competition and concentration by simultaneously incorporating explanatory variables that proxy both competitive bank conduct and concentration. Previous studies provide evidence for a significant bearing of the level of concentration on the probability of observing systemic crises without controlling for competition. Our research reinvestigates the concentration-fragility nexus and explores whether concentration and competition measure different characteristics of banking systems. Fourth, independently of the investigation of the relationship between competition, fragility, and the timing of systemic crises, we analyze the extent to which the regulatory setting impacts the timing of systemic crises. Incorporating regulatory variables not only provides an additional robustness check for the relationship between competition and fragility, but also sheds light on the impact of the regulatory environment on banking system soundness.

Our findings suggest that competitive behavior of financial institutions, as measured by the Panzar and Rosse (1987) H-Statistic, not only significantly decreases the probability of systemic banking problems but also increases the survival time of banking systems. We view our results as initial empirical substantiation of the "competition–stability" view in the theoretical literature. The results for the probability of experiencing a systemic crisis and for time to crisis hold when the level of concentration in the banking system is controlled for, and are robust to a set of tests involving: (i) alternative samples, (ii) different sampling periods, (iii) first differences rather than levels for the macroeconomic control variables; and (iv) and fitting a control variable that captures competition from financial markets more directly. Our core result for the positive effect of competitive conduct in banking systems is also widely robust to controlling for a set of institutional and regulatory variables, which furthermore confirms the evidence indicative for the "competition–stability" view. We find no empirical support for the "competition–fragility" view, i.e. the view that more competitive systems are more fragile.

The virtual absence of empirical work in a cross-country setting on the relationship between competitive conduct of financial institutions and fragility necessitates that we qualify our results. First, the measure of competitiveness, the Panzar and Rosse (1987) H-Statistic gauges competition by examining marginal bank behavior in 1994–2001. Thus, competitive behavior is measured in some instances after a crisis surfaced. We therefore utilize different sampling periods and different sample coverage but the results reiterate our finding that more competition is correlated with more banking system stability. Clearly, future research is necessary to shed more light on this relationship. Second, caution has to be exercised when interpreting the results on the findings obtained in the regressions that control for the regulatory environment. This information has been collected toward the end of the sampling period. However, this only

mildly affects the outcome of the H-Statistic on fragility as we obtain largely identical results when excluding regulatory variables. Third, the dating scheme for banking crises is important. We therefore utilize an updated version of the widely employed root source for the classification of systemic banking problems provided by Demirgüç-Kunt and Detragiache (2005). Fourth, the analysis presented here does not allow making firm conclusions on causality, i.e., whether competition increases stability or vice versa; we therefore abstain from interpreting the results in a causal sense.

The remainder of the paper is organized as follows. We review the relevant literature on the links between competition, concentration, and fragility in Section II. A detailed exposition of the methodology, including the Panzar and Rosse (1987*)* H-Statistic and the parametric duration models with time varying covariates is presented in Section III. Section IV provides an overview on the data set and summary statistics. We report the results and a variety of robustness tests in Section V. Section VI offers concluding remarks.

II. LITERATURE REVIEW

Our review of related studies on the question of competition versus stability draws from several strands in the literature. We first focus on the link between competition and concentration. Second, we review studies on concentration and stability. Third, we discuss theoretical and empirical studies on the relationship between competition and stability. The final section briefly surveys the literature on the implications of the regulatory and institutional environment for financial system soundness.

A. Competition and Concentration

The literature is short on the direct relationship between competitive conduct of financial institutions and its bearing for concentration.[3] This is surprising, given that issues of competition and concentration in the banking industry are heavily debated by policymakers. Bikker (2004) underscores that concentration may have an impact on competition and that increasing the size of financial firms has substantial bearing for financial stability. Following an approach pursued in the industrial organization literature, he proposes that competition can be measured by the Panzar and Rosse (1987) H-Statistic. This statistic is a way to capture competitive behavior of financial institutions to examine empirically if the efficiency of larger

[3] We constrain our review to the key studies that focus on the direct link between measures of competition and concentration. A variety of other studies on the relationship between concentration and competition in a wider sense exists and is reviewed in detail by Berger and others (2004). For example, Berger and Hannan (1989) and Neumark and Sharpe (1992) examine the effect of concentration on the pricing of banking services, whereas Berger (1995) and Frame and Kamerschen (1997) consider concentration to be a function of scale and X-efficiencies. DeYoung, Hunter, and Udell (2004) and Berger and Udell (2002), among others, discuss the role of different types and sizes of institutions for their competitive conduct. The ownership–competition nexus is explored in depth by DeYoung and Nolle (1996), Berger and others (2000), and Berger, Hasan, and Klapper (2004). Petersen and Rajan (1995) review the consequences of competition and concentration for credit availability and economic growth and empirical work on this link is presented by, among others, Jayaratne and Strahan (1996, 1998), Cetorelli (2003), and Berger, Hasan, and Klapper (2004).

banks drives superior performance. To test the effect of concentration on competition, Bikker and Haaf (2002) regress the H-Statistic on a variety of concentration indices and the number of banks in a sample of 23 industrialized countries and find that increasing concentration significantly decreases competition across a number of different model specifications. Contrary to these results, drawing upon a sample of 50 countries, Claessens and Laeven (2004) use four different models to compute the H-Statistic and report that their analysis provides empirical support for a positive association of concentration and competition. Their findings are robust to the incorporation of regulatory variables that capture the contestability of the banking systems in the countries under consideration. Claessens and Laeven (2004) conclude that the degree of concentration may be a poor indicator for the competitive environment in which banks operate.

Thus, the case for using concentration as a proxy for competition can be seriously disputed. This is critical for the inference of policy implications since concentration does not necessarily imply the lack of competition, given that factors other than competition may drive concentration. For instance, regulatory initiatives to increase capital may spark off a wave of mergers that considerably increases the level of concentration in the industry. Moreover, a banking system with high entry barriers, in which a small number of institutions dominate the industry, can nevertheless be characterized by competition.

B. Concentration and Stability

Two distinct strands in the literature reflect contrasting views on the relationship between concentration and stability. In theoretical models, Allen and Gale (2000, 2004) exemplify that financial crises are more likely to occur in less concentrated banking systems. This is due to the absence of powerful providers of financial products that can reap benefits from high profits that serve as a cushion against asset deterioration. A similar view is taken by Boot and Greenbaum (1993) who highlight that increasing bank charter values arising from increased market power create incentives for bank managers to act prudently thereby contributing to higher bank asset quality. These institutions are also considered to be easier to monitor from a regulatory perspective.

These theoretical studies have been substantiated by empirical work. Paroush (1995) argues that increases in market power arising from diversification benefits of bank mergers suggest higher bank stability. Benston, Hunter, and Wall (1995) also investigate bank mergers in the United States and report that pre-merger variance of target bank earnings and the pre-merger covariance between target and acquiring bank earnings show a negative association with bid prices, thereby underlining the hypothesis that increases in market power contribute to financial stability. Similar results for mergers of U.S. banks are obtained by Craig and Santos (1997), who analyze post-merger profitability and post-merger risk. Recent work by Beck, Demirgüc-Kunt, and Levine (2005a, 2005b) using a cross-country data set on 69 jurisdictions provides strong empirical evidence that is consistent with the "concentration–stability" view. They report that increases in national bank concentration do not feed into increased fragility of the banking system and that the results are robust subject to a broad array of robustness tests. In addition, they show that less contestable markets, approximated by a set of regulatory variables such as activity restrictions for banks, are more prone to experience episodes of systemic crises.

However, while this study provides suggestive evidence that regulatory policies that impede competition are undesirable from a financial stability viewpoint, the study falls short in presenting evidence for the effect of financial institutions' competitive behavior on banking system stability. An analysis of the underlying mechanisms substantiates that concentration cannot be considered as a proxy for less competition as their results hold when controlling for institutional and regulatory variables supportive of contestable markets (Beck, Demirgüc-Kunt, and Levine, 2005b).

Contrary to this "concentration-stability" view, Boyd and de Nicolo (forthcoming) illustrate in a theoretical model that powerful institutions' ability to charge higher interest rates encourages risk taking behavior such that increased concentration eventually gives rise to greater vulnerabilities. Mishkin (1999), holding a similar view, suggests that banking systems with a limited number of large institutions are more likely to be subject to regulators' "too important to fail" policies that encourage risk taking behavior of banks.

Research by de Nicoló and Kwast (2002) scrutinizes the correlation between Large and Complex U.S. Banking Organizations (LCBOs) to draw inferences about correlated exposures and hence the presence of systemic risk. The authors detect increasing return correlations during the sampling period 1988–99 and interpret this as a sign for increased systemic risk. This view is subsequently substantiated by de Nicoló and others (2004). Using an alternative measure for systemic risk, an aggregate Z-index that gauges the joint probability of failure of the five largest banking firms in a country for the period 1993–2000 and drawing upon a cross-country data set, the study presents evidence for a positive relationship between concentration and banking system fragility. Boyd and Graham (1991, 1996) also provide weak support for this view by examining failures of large financial institutions in the United States and test whether large banks fail more frequently than smaller institutions. They report that large banks failed more often than smaller banks over the entire sampling period of 1971–94. However, splitting the sample in different sub-samples gives rise to a more mixed picture such that it becomes difficult to establish firm conclusions.

C. Competition and Stability

In a similar vein to the studies on concentration and fragility where the two conflicting views hold that concentration either increases stability or decreases stability, we observe a similar pattern in the literature on competition and stability. Carletti and Hartmann (2003) provide an in-depth survey and assessment of this literature.

Matutes and Vives (1996) argue that instabilities can arise in any kind of market structure as depositors' propensity to run is determined exogenously by their expectations in the sprit of the Diamond and Dybvig (1983) model. In contrast, Smith (1984) puts forward a theoretical exposition of how increasing competition for bank deposits gives rise to vulnerabilities in the system. Besanko and Thakor (1993) illustrate that banks decide on risky portfolio strategies when competition stiffens. Taking the design of deposit insurance schemes into consideration, Cordella and Yeyati (1998) show that risk-based deposit insurance restrains risk-taking behavior of financial institutions even in the presence of increased competition, whereas fierce

competition in an environment with flat fee deposit insurance translates into higher risk in the system. Similarly, Matutes and Vives (2000) also investigate bank risk taking behavior and deposit insurance. They additionally consider social costs associated with bank failures and find that excessive competition gives rise to maximal bank risk in the absence of risk-based deposit insurance. Likewise, Hellman, Mudroch, and Stiglitz (2000) contemplate that accelerating competition makes financial institutions embark upon riskier investments but that capital requirements and deposit rate ceilings can help restore prudent bank behavior.

With exception of the study by Matutes and Vives (1996) all the aforementioned theoretical studies imply a positive association between competition and fragility, and we therefore refer to this strand as "competition–fragility" literature. By contrast, Caminal and Matutes (2002) demonstrate that monopoly banks with intermediate monitoring costs can be more prone to originate risky loans that give rise to higher probability of subsequent failure. Similarly, Nagaraja and Sealey (1995) illustrate that forbearing regulatory policies are likely to decrease the quality of bank assets. Using a dynamic duopolistic model, Perotti and Suarez (2002) investigate potential failure of financial firms due to competition and argue that the failed institution can be either closed or merged with another agent, highlighting the trade-off between stability and competition. If no new competitor enters the market, the surviving bank will benefit from the failure, a consequence referred to as the "last bank standing" effect. This effect strengthens the institution's incentive to act prudently as higher rents can be generated if the competitor fails. Perotti and Suarez (2002) show that an active merger policy by the regulatory agency which encourages takeovers of failed institutions contributes to banking stability. These three latter studies can thus be assigned to the "competition–stability" strand in the literature.

Allen and Gale (2004) however argue that the relationship between competition and financial stability is multifaceted and that a mere consideration of the trade-off between competition and stability is inappropriate. Rather, they identify the efficient levels of both competition and stability by reviewing a number of different theoretical models and conclude that different models yield different answers. Allen and Gale (2004) maintain that perfect competition propels the socially optimal level of stability if financial markets and contracts between customers and intermediaries are complete. In a number of other instances however, where deposit insurance is present or where institutions compete heavily for deposits due to increasing returns to scale, competition tends to weaken bank soundness. Finally, they highlight that fragility also depends on the structure of the interbank market: Contagion effects arising from small liquidity shocks in a perfectly competitive interbank market where all institutions are price takers can force all the banks to liquidate assets. Similar to Allen and Gale (2004), Boyd and others (2004) also put forward that the probability of observing a banking crises does not only dependent on the degree of competition. Rather, monetary policy is a major determinant as well. Monopolistic banking systems are found to be more fragile if the rate of inflation is below a certain threshold, whereas more competitive banking markets are more vulnerable if inflation is above this threshold.

The empirical literature is largely characterized by studies that focus on one or two individual countries. Influential work by Keeley (1990) finds a highly significant relationship between the erosion of bank charter values in the United States and increased competition and hence offers empirical support for the "competition–fragility" hypothesis. Bordo, Redish, and Rockoff

(1995) embark on a comparison of the Canadian and U.S. banking system between 1920 and 1980 and report that Canadian banks failed less often than U.S. institutions, a finding they assign to the oligopolistic structure of the Canadian banking system. Capie (1995) reviews stability and efficiency in the U.K. banking market between 1840 and 1940 and concludes that a less competitive environment contributed to a period during which no major disruptions surfaced. Hoggarth, Milne, and Wood (1998) contrast the German and U.K. banking systems over the past few decades and report that profits in the U.K. were higher, but also more variable than in Germany and infer that the less competitive German system can be perceived to be more stable. Finally, Staikouras and Wood (2000) run similar analyses for Greece and Spain and find that Spanish institutions are both more profitable and more stable than Greek banks.

Assigning the empirical studies to either the "competition–fragility" literature or "competition – stability" literature is more ambiguous than for the theoretical research. The work by Keeley (1990), Capie (1995), Bordo, Redish, and Rockoff (1995) and Hoggarth, Milne, and Wood (1998) can be classified into the "competition – fragility" literature suggesting a possible trade-off between competition and stability, while the paper by Staikouras and Wood (2000) is a prime example of empirical analysis finding no such trade-off.

D. Regulation, Supervision and Stability

Fischer and Chenard (1997) explore the link between liberalization, regulation, and stability. They offer both theoretical and empirical evidence that banking system deregulation increases systemic risk which they attribute to, inter alia, intensified competition in the aftermath of deregulation and the increased contestability of the banking systems under consideration. Similarly, Drees and Pazarbasioglu (1998) state that the Nordic banking crises coincided with a period of liberalization in the respective countries' financial systems that gave rise to unsustainable behavior by both lenders and borrowers. By contrast, Barth, Caprio, and Levine (2004) draw on a large database on financial regulation and supervision to investigate the regulatory environment that sets the stage for systemic banking crises, and document that less contestable banking systems with higher entry barriers and activity restrictions exhibit higher degrees of fragility, a finding corroborated by Beck, Demirgüc-Kunt, and Levine (2005a, 2005b). Barth, Caprio, and Levine (2004) hypothesize that the lower propensity to suffer systemic problems in more contestable markets with fewer restrictions imposed upon institutions is attributable to higher levels of efficiency of financial institutions operating in such an environment. This suggests that contestability of markets and the supervisory framework play an important role in the likelihood of observing systemic problems. However, the variables that aim to capture the contestability of the market in these studies may not adequately control for the legal and institutional environment, in which financial institutions operate. This would explain the contradicting conclusions drawn by Fischer and Chenard (1997) on the one hand and by Barth, Caprio, and Levine (2004) on the other. Thus, little agreement has been reached as to whether contestability and strengthening the regulatory framework of banking systems contributes to banking stability. We therefore consider the findings that more contestable markets and fewer restrictions are supportive of financial stability as tentative in nature. In fact, related research by Podpiera (2004) that investigates the relationship between compliance with Basel Core Principles for Effective Banking Supervision and banking sector performance as

measured by nonperforming loans and net interest margins puts forward that higher compliance with Basel Core Principles significantly improves bank asset quality, even after controlling for the level of development of the country and the macroeconomic setting. However, his study does not account for the contestability of the banking systems under consideration.

In summary, the review of several related studies on the links between concentration and competition, regulation, and stability indicates that neither theoretical work nor empirical research provides clear-cut answers to the question whether competition increases or decreases financial stability. The assertion of trade-offs between competition and financial stability is challenged by recent advancements in the theoretical literature. Likewise, empirical research to date is largely dominated by studies on individual countries and the virtual absence of cross-country studies involving more than two jurisdictions renders the literature and the findings drawn to date far from conclusive.

III. METHODOLOGY

We utilize two different estimation procedures to asses the relationship between competition and stability, and also provide an exposition of the Panzar and Rosse (1987) measure of competition.

A. Duration Analysis

First, we introduce a parametric duration model with time-varying covariates to investigate the timing of systemic banking crises. While duration analysis has been used at the micro level to analyze failures of financial firms (Lane, Looney, and Wansley, 1986; Whalen, 1991) we are not aware of any macro level studies that draw upon this methodological approach. We therefore briefly review some key characteristics of duration analysis.

Our duration model measures the time to transition from a sound banking system to the occurrence of a systemic crisis. The crucial difference from the frequently employed logit models (Demirgüç-Kunt and Detragiache, 1998, 2005) presented in the subsequent section is as follows: Logit models yield the unconditional probability of observing a banking crisis in a certain jurisdiction and all observations are ”stacked” such that the panel data structure is not appropriately accounted for. By contrast, duration models with time-varying covariates, if interpreted in the proportional hazards metric, provide the conditional probability of observing a banking crisis at point t, given that no such crisis has occurred in the country until period t.

The time until a crisis is observed can be formalized as a probability density function of time t. A convenient way of describing survival of a banking system past time t is through its survivor function

$$S(t) = P(T \geq t), \tag{1}$$

which equals one minus the cumulative distribution function of T. Therefore, we can compute the conditional probability of leaving the state of being a sound banking system within the time interval t until $t + h$, given survival until time t, as

$$P\{t \le T \langle t \langle t+h \big| T \ge t\}. \tag{2}$$

This probability can be divided by h, to calculate the instantaneous rate of failure, i.e. the average probability of leaving per unit time period over the interval t until $t + h$ such that the hazard function can be written as

$$\lambda(t) = \lim_{h \downarrow 0} \frac{P\{t \le T \langle t \langle t+h \big| T \ge t\}}{h} = \frac{-d \log S(t)}{dt} = \frac{f(t)}{S(t)}. \tag{3}$$

In the econometric literature, researchers frequently assume a proportional hazards specification, where

$$\lambda(t, X(t), \beta) \lim_{h \downarrow 0} \frac{P\{t \le T \le t+h \big| T \ge t, X(t), \beta\}}{h} = \lambda_o(t) \exp(\beta' X_t), \tag{4}$$

whereby X_t denotes our time-varying explanatory variables, β is the vector of parameters to be estimated, $\lambda_0(t)$ is the baseline hazard function and $\exp(\beta' X_t)$ provides a convenient interpretation of the coefficients due to its non-negativity. The baseline hazard $\lambda_0(t)$ determines the shape of the hazard function with respect to time. We estimate the duration model based on the exponential distribution. This form assumes a constant hazard rate over time. This is justified given that countries, contrary to individuals or firms, do not exhibit a life cycle. Thus, the hazard of experiencing a systemic banking crisis does not depend on the ”age” of a country. Previously employed duration models in the finance literature frequently use constant covariates from the beginning of the measurement period t_0 to the time of the measurement $T = t_i$. This is a serious problem in these earlier models since it would be inappropriate to assume that the macroeconomic setting remains constant during the entire sampling period. In order to overcome this limitation, we therefore expand the methodology by using time-varying covariates (Petersen, 1986). The model is then estimated using the maximum likelihood estimation technique.

We observe 38 countries over the period 1980–2003. A country’s duration is determined by the number of spans it remains in the data set. Thus, the minimum duration is $t = 1$ if the banking crisis was experienced in the first span and the maximum duration is $t = 23$ if the crisis occurred in 2003 or if the country never records a crisis.[4] In addition, in countries that have never experienced a systemic crisis, our duration data are ”right censored,” in the sense that the studied event has not occurred during the sampling period. The initial setup of our data set with up to 23 time spans per country is well suited for duration analysis with time-varying covariates as the hazard function is modeled as a step function with different values for the covariates through the intervals between $t = 0$ and $t = t_i$, the terminal value of the observation, at which either censoring or exit takes place.

[4] Since duration analysis focuses on time spans for each country rather than ”physical” observations, the estimator utilizes data from the end of the first span and consequently disregards the values of the first observation.

Coefficients can be reported in both the accelerated failure time metric and in the proportional hazards metric when estimating exponential duration models since they can be parametrized in the form

$$\ln(t_j) = \beta_0 + x_j\beta_x + \varepsilon_j \tag{5}$$

as accelerated failure time model or in the corresponding hazard metric as

$$h(t|x_j) = h_0(t)\exp(\beta_0 + x_j\beta_x). \tag{6}$$

Since we are interested in time to failure, we report our coefficients in the accelerated failure time (AFT) metric. These models are called AFT models because the effect of the independent variables is to accelerate or decelerate time to crisis. In the AFT models, a distribution is assumed for

$$\tau_j = \exp(-x_j\beta_x)t_j \tag{7}$$

and $\exp(-x_j\beta_x)$ is usually referred to as the acceleration parameter. We can rearrange (7) such that

$$t_j = \exp(x_j\beta_x)\tau_j \tag{8}$$

and therefore write

$$\ln(t_j) = x_j\beta_x + \ln(\tau_j). \tag{9}$$

The exponential accelerated failure time model assumes $\tau_j \sim \text{Exponential}\{\exp(\beta_0)\}$ with mean $\exp(\beta_0)$ such that

$$\ln(t_j) = x_j\beta_x + \ln(\tau_j) \text{ and} \tag{10}$$

$$\ln(t_j) = \beta_0 + x_j\beta_x + u_j, \tag{11}$$

where u_j follows the extreme-value distribution. Transforming the proportional hazards metric to the accelerated failure time metric in an exponential duration model is thus merely one of flipping the signs of regression coefficients (Cleves, Gould, and Gutierrez, 2004).

B. Logistic Probability Analysis

Second, we also estimate a more commonly used logit probability model that takes the form

$$LnL = \sum_{t=1\ldots T}\sum_{i=1\ldots n}\left\{P(i,t)\ln\left[F(\beta' X(i,t))\right] + (1-P(i,t))\ln\left[1-F(\beta' X(i,t))\right]\right\}, \tag{12}$$

where *P (i,t)* is a dummy variable that takes on the value one when a systemic banking crisis is observed or zero otherwise. The parameter β is the vector of coefficients to be estimated and the explanatory variables are denoted by *X (i,t)*. Due to the common use of this model, we refrain here from a more detailed exposition of this estimator and refer the interested reader to the work

by Demirgüç-Kunt and Detragiache (1998, 2005). In terms of comparability between the two modeling techniques, it has to be recognized that the duration model draws on a fewer number of crisis observations due to the fact that it focuses on spans of time and disregards the values of the explanatory values of the first observation per country. While this decreases the variation in the dependent variable in comparison to the logit model, it is not a major impediment to our analysis, as the two methodological approaches are complementary (which is largely corroborated by our findings).

C. Panzar and Rosse (1987) H-Statistic

The H-Statistic, frequently used in the "new empirical industrial organization literature," is designed to discriminate between competitive, monopolistically competitive, and monopolistic markets. Claessens and Laeven (2004) argue that the H-Statistic is a more appropriate measure for the degree of competition than previously used proxies for competitive conduct. Studies by Bikker and Haaf (2002) and Bikker (2004) also use this approach. Shaffer (2004) argues that the analytical strength and superiority of the H-Statistic over previously used measures of competition is based on its formal derivation from profit-maximizing equilibrium conditions. Moreover, the statistic is robust with respect to the market since it only draws upon characteristics of reduced-form revenue equations at the firm level. Its limitation lies in the fact that the inferences based on the statistic are only valid if the market is in (or close to) equilibrium. The measure is based on a general banking market model which determines equilibrium output and the number of institutions by maximizing profits at both the firm and the industry level. Precisely, bank *i* maximizes profit when marginal revenue equals marginal cost

$$R_i'\ (x_i, n, z_i) - C_i'(x_i, w_i, t_i) = 0\,, \tag{13}$$

whereby R_i' denotes revenues and C_i' refers to costs of bank *i*. Output of bank *i* is denoted by x_i and *n* characterizes the number of institutions. The term w_i is the vector of *m* input prices for bank *i* and z_i and t_i are vectors of exogenous variables that shift the banks revenue and cost functions respectively. Adopting similar line of reasoning for the market level yields the following equation such that the zero profit condition constraint is maintained

$$R_i^*\left(x^*, n^*, z\right) - C_i^*\left(x^*, w, t\right) = 0\,, \tag{14}$$

where the asterisks denote equilibrium values. Under perfect competition, increases in input prices cause marginal costs and total revenues to increase by the same amount as the costs increase. By contrast, under monopoly conditions increases in input prices raise marginal cost, reduce equilibrium output, and thereby reduce total revenue. The H-Statistic measures market power by the extent to which a change in factor input prices, $\left(dw_{k_i}\right)$, translates into equilibrium revenues, $\left(dR_i^*\right)$, earned by bank i. In short, the H-Statistic is a measure of the sum of the elasticities of the reduced-form revenues with respect to factor prices and is computed as

$$H = \sum_{k=1}^{m} \frac{\partial R_i^*}{\partial w_{k_i}} \frac{w_{k_i}}{R_i^*}\,. \tag{15}$$

Thus, the H-Statistic is an increasing function of the demand elasticity, suggesting that as *H* increases the less market power is exercised on the part of the banks. Therefore, the magnitude of *H* can be perceived as a measure of competition and interpretation is straightforward:

$H \leq 0$	indicates monopoly equilibrium
$0 < H < 1$	indicates monopolistic competition
$H = 1$	indicates perfect competition

IV. DATA AND SUMMARY STATISTICS

We focus the empirical analysis on a set of 38 countries during the period 1980–2003. The sample is slightly smaller than in previous studies on systemic banking problems since we have to constrain the sample to countries for which the H-Statistic as computed by Claessens and Laeven (2004) is readily available. Descriptive statistics for the entire set of variables are presented in Table 1. Detailed explanation of the variables and their sources is provided in the Appendix.

Table 1. Descriptive Statistics

	Mean	Std.Dev.	Minimum	Maximum
GDP growth (real)	3.20	3.13	-13.13	14.82
Real interest rate	1.59	25.49	-558.91	48.86
Inflation	16.67	83.40	-16.33	2076.79
Terms of Trade	-0.72	33.98	-607.00	622.00
Depreciation	19.14	116.21	-320.37	2421.59
M2/international reserves	10.06	9.37	0.78	59.48
Credit growth (real)	73.76	171.60	-256.35	1421.95
Moral hazard index	1.41	0.72	0.00	2.03
Concentration	0.47	0.13	0.16	0.69
H-Statistic	0.67	0.12	0.41	0.92
British legal origin	0.16	0.36	0	1
French legal origin	0.51	0.50	0	1
German legal origin	0.03	0.17	0	1
Scandinavian legal origin	0.02	0.15	0	1
Activity restrictions	9.36	2.59	5	15
Capital regulatory index	5.94	1.45	3	9
Government ownership	0.47	0.34	0	1
Foreign ownership	0.18	0.24	0	0.95

GDP growth is the rate of real growth of the Gross Domestic Product. Real interest rate is the nominal interest rate minus the rate of inflation. Inflation is the rate of change of the GDP deflator. Terms of trade is the change in net barter terms of trade. Depreciation is a measure of the change of the exchange rate. M2/international reserves measures the ratio of broad money over international reserves. Credit growth (real) is the rate of growth of domestic credit divided by the GDP deflator. Moral hazard index is the first principal component of a variety of deposit insurance design features as detailed in the Appendix. Concentration measures the proportion of assets held by the three largest institutions in a country, averaged over the sampling period 1980–2003. H-Statistic is a measure of competitiveness in the financial services industry. British, French, German and Scandinavian legal origin are dummies that take on the value one if a country's legal system has British, French, German or Scandinavian origin or zero otherwise. Activity restrictions is an index variable that measures barriers to entry into different banking activities (securities, insurance, real estate and ownership of nonfinancial firms). Capital regulatory index is a variable that captures capital stringency in the industry. Government and foreign ownership measure the proportion of ownerships rights held by the government and foreign entities respectively.

Our crisis variable is a dummy that takes on the value one if a systemic banking crisis surfaced in the particular year of observation or zero otherwise. We use the widely employed Demirgüç-Kunt and Detragiache (2005) dating scheme as root source for episodes of systemic banking

problems. Accordingly, one of the following criteria has to be met by a country to be classified as having experienced a systemic crisis: i) emergency measures such as deposit freezes or bank holidays are implemented; ii) large-scale bank nationalizations take place; iii) non-performing assets reach at least 10 percent of total assets; iv) fiscal cost of the rescue operations reach 2 percent of GDP. Following these classifications and depending on the model specification, we record up to 28 systemic crises between 1980 and 2003 that can be utilized for the logit model and present an overview on these countries in Table 1. The number of counts for the duration analysis is slightly lower, depending again on the model specification because the duration model focuses on the span of time between two records rather than actual 'physical' observations. Thus, the estimator captures the information at the end of the span and therefore disregards values of the first observation per country in the initial data set. The differing number of observations between the duration and the logit model is entirely due to the different setup of the data for the duration model to account for multiple crises per country.[5] The dependent variable in the duration models is the log of the time to crisis, whereby the crisis dating follows the exposition provided above.

Information on the H-Statistic as a measure for competitiveness is taken from Claessens and Laeven (2004). They derived the statistic along the lines presented in Section III.C and also test for long-run equilibrium. Using data for the period 1994–2001, Claessens and Laeven (2004) compute this competitiveness measure and include all commercial, savings, co-operative banks and bank holding companies across a sample of 50 countries.[6] We use this sample as a starting point and exclude countries for which we do not have a sufficient number of observations for the explanatory variables and transition economies as including them would distort estimation. We record 38 countries that satisfy our sampling criteria. Table 1 suggests that monopolistic competition is the most appropriate way of describing the level of competition in the countries of study. While our sample tracks back until 1980, the information on the measure of competitiveness is only available for the more recent period and we therefore assume it to be constant over the sampling period. This is justified, given the following four arguments: First, no data set other than the one by Claessens and Laeven (2004) offers information on a sufficiently large cross-country sample that can be utilized for the purpose of our study. Second, the regulatory and supervisory environment, found to be a major determinant for the degree of competition by Claessens and Laeven (2004), has not undergone major changes according to Barth, Caprio, and Levine (2001) in the aftermath of banking problems. By extension, we therefore argue that the level of competition has likewise not seen much change over time. Third, Beck, Demirgüc-Kunt, and Levine (2005b) contemplate that in cases where the regulatory environment has changed, it was modified toward less rather than more regulation. This therefore biases our results against finding a positive relationship between competition and systemic banking fragility. Fourth, recent work by Barth, Caprio, and Levine (2005) indicates

[5] For details on the setup of the data with multiple instances of events per cross-sectional unit and the different notion of "sample size" in duration modeling, see Cleves, Gould, and Gutierrez (2004).

[6] Employing four different estimation techniques and averaging the results provides according to the authors close estimates of the H-Statistic for each jurisdiction. We refer the interested reader to the work by Claessens and Laeven (2004) and the literature cited therein for additional details.

that no considerable alterations in the regulatory environment have taken place since the initial survey by Barth and his co-authors in 1999, which reinforces our assumption that the competitive environment has likewise remained stable over time.

The fact that previous studies relied upon concentration as a proxy for competition and report a significantly negative association between concentration and the likelihood of suffering systemic crises suggests that we enter concentration into our regression equations. While this may give rise to multicollinearity, it is a way to investigate if the contemplated link between concentration and fragility holds when competitive conduct of financial institutions is included in the equations.[7] Earlier empirical results on the concentration–fragility nexus would have to be re-evaluated, if concentration is no longer found to be significant in our analyses. Furthermore, this would lend empirical support to the assertion that concentration and competition are two different concepts. We therefore use a concentration variable obtained from Beck, Demirgüc-Kunt, and Levine (2005a, 2005b) who retrieve information on the market share of the three largest institutions in each country in their sample from Bankscope and average it for the period 1988–97 to smooth out coverage problems. Following this approach, we additionally incorporate concentration ratios using additional data for the years 1998–2003 to widen the scope.

[7] The correlation between concentration and the H-Statistic is 0.1503.

Table 2. Banking Sector Crises 1/

Country	Demirgüç-Kunt and Detragiache (2005)
Argentina	1980-82, 1989-90, 1995, 2001-02*
Australia	
Austria	
Bangladesh	
Belgium	
Canada	
Colombia	1982-85, 1999-00
Costa Rica	1994-97 *
Denmark	
Ecuador	1995-02*
France	
Germany	
Greece	
Honduras	
Hong Kong, China	
India	1991-94**
Indonesia	1992-95**, 1997-02 *
Italy	1990-95
Japan	1992-02*
Kenya	1993-95
Luxembourg	
Malaysia	1997–2001
Mexico	1982, 1994-97
Netherlands	
Nigeria	1991–95
Norway	1987-93
Pakistan	
Panama	1988–89
Paraguay	1995-99
Philippines	1981-87, 1988-02 *
Portugal	1986-89
South Africa	1985
Spain	
Switzerland	
Turkey	1982, 1991, 1994, 2000-02 *
United Kingdom	
United States	1980-92
Venezuela	1993-97

1/ Episodes for the occurrence of systemic banking crises are taken from Demirgüç-Kunt and Detragiache (2005). * indicates that the crisis is still going on as at 2005. A four-year duration of a crisis is indicated by **. Additional details are provided in the Appendix.

We also include the following commonly employed macroeconomic control variables in the model specifications: Real GDP growth, the real interest rate, the rate of inflation, changes in the terms of trade, changes in the foreign exchange rate, the ratio of M2 to gross foreign reserves, and credit growth. To avoid simultaneity problems, we lag all these macroeconomic variables by one period. We also account for the finding by Demirgüç-Kunt and Detragiache (2002) that generously designed deposit insurance schemes tend to weaken bank stability and incorporate an updated version of their moral hazard index. This index is computed as the first principal component of eight deposit insurance design features that are modeled using dummy variables that capture coinsurance, foreign and interbank deposit coverage, type and source of funding, management, membership, and the level of explicit coverage. We use additional information from the updated database on deposit insurance design features (Demirgüç-Kunt, Karacaovali, and Laeven, 2005) to augment the moral hazard index by Demirgüç-Kunt and

Detragiache (2002) using additional dummy variables for the design features regarding risk-adjusted premiums, the deposit insurer's power to revoke bank licenses and its ability to intervene in a bank. In a similar vein to the original version, we find that the first principal component explains well over 80 percent in the variation of the design features.[8] We also consider regressors that capture the legal origin of the country. This is due to the fact that La Porta, Lopez-de-Silanes, and Shleifer (1998) contemplate that legal origin is a major determinant for the legal protection of creditor rights which, in turn, play a key role for the financial system of a country. Furthermore, Beck, Demirgüc-Kunt, and Levine (2003) argue that these proxies ought to be controlled for when analyzing the performance of banking systems since legal origin helps explain cross-country differences in financial development.

To provide additional robustness tests for the relationship between competition and fragility, we also test the effect of including a variety of regulatory variables. If consideration of these variables diminishes the significance of the H-Statistic in our results, we could conclude that the relationship between competition and fragility may be spurious and attributable to the failure to control for the regulatory environment. Moreover, as we are also interested in learning whether or not the timing of banking crises depends on the design features of the regulatory environment, we incorporate variables that capture the regulatory and institutional setting in which banks operate in. As a consequence, we initially investigate the effect of some proxies for the contestability of banking markets such as activity restrictions and a capital regulatory index. Detailed explanations for these regulatory variables are provided in the Appendix and by Barth , Caprio, and Levine (2004). While information on the regulatory environment was collected towards the end of the 1990s, Barth, Caprio, and Levine (2001) put forward that the regulatory environment has not undergone substantial change over time. The assertion by Barth, Caprio, and Levine (2004) is also substantiated by Podpiera (2004) who argues that the application of core principles of supervision and regulation is unlikely to change in the short run and there is a considerable time lag between changes in regulation and supervision until these alterations are observable in banking system performance.

Subsequently, we consider the implications of the regulatory and institutional variables in terms of their impact upon survival time of banking systems. Since the relationship between the probability of suffering a crisis and these regressors is reversed, we do not discuss this here for brevity. An index of activity restrictions that captures banks' potential to engage in securities, insurance, and real estate activities and whether they can own nonfinancial firms is utilized to check if banks can gain market power by offering a vast array of services. Increasing values of this index indicate more activity restrictions and we anticipate an inverse relationship between competition and activity restrictions that is likely to translate into increased survival time of banking systems. However, if fewer activity restrictions enable banks to better diversify risk, a negative relationship between these restrictions and time to crisis is also possible.

[8] We also ran the regressions reported in Section V with the original version of the Moral Hazard Index from Demirgüç-Kunt and Detragiache (2002). The results were virtually unchanged.

We also examine a capital regulatory index as a proxy for the entry requirements imposed by regulators on the capital of institutions. This serves as a further barrier to entry to the market. The higher the index value, the higher the entry barrier. We assume a negative association of the capital regulatory index with the degree of competition and also a positive relationship between the capital regulatory index and time to crisis. On the other hand, since lower capital requirements would increase competition and assuming competition boosts efficiency, a negative association between the capital regulatory index and survival time might be detected.

To capture the effect of ownership structure in the countries' banking systems, we include the proportion of bank assets controlled by foreign entities, obtained from Barth, Caprio, and Levine (2001) and the degree of government ownership, taken from La Porta, Lopez-de-Silanes, and Shleifer (2002). Higher degrees of foreign ownership are interpreted as a sign for a more competitive environment and are therefore anticipated to shorten survival time. By contrast, if foreign ownership improves efficiency of the banks operating in this environment, it could however also increase time to crisis. Large degrees of government ownership, on the other hand, are likely to impede competitive behavior of financial institutions and we would therefore anticipate a positive relationship between government ownership and time to crisis. However, empirical work by Barth, Caprio, and Levine (2004) suggests a weakly positive association between government ownership and bank fragility.

V. Regression Results

We report the main results obtained from the duration and logit models in Section V.A and numerous robustness tests in Section V.B. A detailed examination of the effect of regulatory variables on competition, and, ultimately, banking system soundness and time to crisis is presented in Section V.C.

A. Main Results

We present the main results of our analyses in Table 3. The coefficients obtained from the duration model are reported in Specification (1)–(4) and we re-examine the findings from the duration analysis with the more commonly utilized logit model in Specification (5)–(8). The number of observations in the duration models is greater than in the logit models since the data set has to be set up differently for analyzing duration data with multiple crises. When interpreting results, it is important to consider that the signs for the coefficients are reversed between the two different modeling techniques: A positive sign in the duration model indicates increased time to crisis and can therefore be interpreted as contributing to increased stability whereas a positive sign in the logit model implies a greater probability of experiencing a systemic crisis.

Specification (1) and (5) are our canonical models that include previously used explanatory variables, whereby we additionally incorporate three dummy variables for the origin of the legal system (British, French and Scandinavian legal origin) since it is a major determinant for differences in the development of financial systems. We capture German legal origin in the intercept to avoid perfect collinearity. In Specifications (2) and (6) we include the H-Statistic in

the equations and the averaged three bank concentration ratio additionally enters the equations in Specification (3) and (7). The final Specifications (4) and (8) include an interaction term between the H-Statistic and concentration, to control for possible nonlinear relationships.

In the duration model, the H-Statistic enters Specification (2) and (3) positively and significantly at the 1 and 5 percent level, respectively. The positive sign for the coefficient implies that time to crisis increases as the degree of competitive behavior among financial institutions increases and therefore does not support the view that competitiveness gives rise to banking system vulnerabilities. This core result will persist throughout the remainder of the paper with only minor changes observed. Moreover, our finding for the positive effect of the level of competition for banking system soundness also holds when the level of concentration is controlled for.[9] While concentration also enters with a positive coefficient in Specification (3) suggesting that survival time is lengthened in more concentrated banking systems, its effect on time to crisis is however rendered insignificant. Neither competition nor concentration assumes significance when the interaction term between the two is included in Specification (4).[10] This analysis provides suggestive evidence that competitive behavior contributes to increased survival time of banking systems.[11]

[9] We investigated whether the significance of the H-Statistic is due to spurious correlation between certain dummies for legal origin and the H-Statistic and therefore tested alternate specifications of the equation with dummies for German, French and Scandinavian legal origin, and British, German, and Scandinavian legal origin. However, the impact upon the H-Statistic is virtually unchanged. Additionally, we replaced the three dummy variables for legal origin with the variable GDP (real) per capita as a proxy for the institutional environment in unreported regressions. These results again confirm the significantly positive relationship between the H-Statistic and the timing of banking crises and the significantly negative relationship between competition and the probability of suffering a crisis. These additional results can be obtained from the authors upon request.

[10] In unreported regressions, we drop the two variables H-Statistic and concentration and only include the interaction term between the two. This interaction term enters the equation in the duration model positively and significantly at the 5 percent level. We obtain the corresponding negative and significant sign at the one percent level for the logit model. The results are available upon request from the authors.

[11] We also analyzed if our results are sensitive to using different techniques for the specification of the duration model and estimated a semiparametric Cox proportional hazards model with time-varying covariates that does not assume any parametric form for the baseline hazard function. This analysis produces very similar results with respect to the contribution of the H-Statistic to increased banking system soundness. However, since the Cox model does not permit making inferences about the baseline hazard as it is left unestimated, and, given that we obtain more efficient estimates with the parametric duration model, we do not report these results here. Additionally, we re-estimated the duration models using the Weibull distribution, which assumes $\lambda_0(t)=\lambda\alpha t^{\alpha-1}$ and allows for positive duration dependence if $\alpha>1$ and negative duration dependence if $\alpha<1$. We applied a Wald test to investigate if $\ln(\alpha)=0$, which is equivalent to testing $\alpha=1$. Across the four specifications, we cannot reject this hypothesis and conclude that it is justified assuming a constant hazard rate. The exponential model is nested within the Weibull model as the case $\alpha=1$. The results are available upon request from the authors.

Table 3. Competitiveness, Timing, and Probability of Systemic Banking Crises

	Duration Models				Logit Models			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Constant	4.6274	0.8507	0.0802	6.5739	-5.4307	-1.1953	-0.6020	-2.8211
	(0.6236)***	(1.5846)	(1.9978)	(5.2874)	(0.7062)***	(1.4726)	(1.8109)	(4.3279)
GDP growth (real)	-0.0691	-0.0214	-0.0184	-0.0141	0.1315	0.0787	0.0719	0.0709
	(0.0803)	(0.0904)	(0.0909)	(0.0880)	(0.0817)	(0.0922)	(0.0935)	(0.0920)
Real interest rate	-0.0084	-0.0103	-0.0085	-0.0067	0.0219	0.0253	0.0235	0.0231
	(0.0118)	(0.0139)	(0.0126)	(0.0131)	(0.0100)**	(0.0130)*	(0.0130)*	(0.0130)*
Inflation	-0.0021	-0.0018	-0.0010	0.0002	0.0053	0.0043	0.0036	0.0033
	(0.0018)	(0.0017)	(0.0018)	(0.0022)	(0.0031)*	(0.0037)	(0.0039)	(0.0038)
Terms of trade change	-0.0024	-0.0029	-0.0026	-0.0025	0.0002	0.0001	-0.0000	-0.0001
	(0.0017)	(0.0017)*	(0.0017)	(0.0018)	(0.0027)	(0.0035)	(0.0032)	(0.0033)
Depreciation	-0.0039	-0.0025	-0.0027	-0.0030	0.0002	-0.0010	-0.0008	-0.0007
	(0.0015)***	(0.0017)	(0.0015)*	(0.0014)**	(0.0023)	(0.0020)	(0.0019)	(0.0018)
M2/international reserves	0.0138	0.0187	0.0293	0.0266	0.0057	-0.0020	-0.0110	-0.0080
	(0.0296)	(0.0305)	(0.0324)	(0.0319)	(0.0239)	(0.0262)	(0.0326)	(0.0320)
Credit growth (real)	-0.0014	-0.0019	-0.0020	-0.0022	0.0010	0.0016	0.0017	0.0018
	(0.0004)***	(0.0005)***	(0.0005)***	(0.0006)***	(0.0008)	(0.0008)**	(0.0008)**	(0.0008)**
Moral hazard index	-0.0372	0.2685	0.2602	0.0527	0.3375	0.0299	0.0601	0.1363
	(0.2190)	(0.2772)	(0.2933)	(0.3306)	(0.3417)	(0.3690)	(0.3683)	(0.3984)
British legal origin	-0.5227	-0.3812	-0.1951	-0.6531	1.1127	1.1103	1.0450	1.2049
	(0.6629)	(0.7934)	(0.8777)	(0.9105)	(0.8397)	(0.9437)	(0.9338)	(0.9193)
French legal origin	-1.1209	-1.5525	-1.3319	-1.2832	1.6562	2.2597	2.1015	2.1036
	(0.6180)*	(0.5790)***	(0.5518)**	(0.6086)**	(0.6230)***	(0.6465)***	(0.5998)***	(0.6185)***
Scandinavian legal origin	-1.1441	-1.0797	-1.5069	-1.2270	1.2795	1.2279	1.5485	1.4447
	(0.5604)**	(0.5249)**	(0.7134)**	(0.7192)*	(1.1575)	(1.1414)	(1.2624)	(1.2846)
H-Statistic		5.0854	4.2562	-6.3020		-5.8513	-5.2130	-1.7627
		(1.7922)***	(1.9919)**	(8.2633)		(1.7523)***	(1.8819)***	(6.2430)
Concentration			2.3486	-11.8460			-1.8366	2.9196
			(2.4725)	(11.2600)			(2.4980)	(8.6863)
H-Statistic * Concentration				23.9997				-7.8430
				(18.7818)				(13.1666)
Observations	619	619	619	619	567	567	567	567
Number of crises	22	22	22	22	28	28	28	28
Type I Error (%)	n/a	n/a	n/a	n/a	25.00	28.57	25.00	25.00
Type II Error (%)	n/a	n/a	n/a	n/a	41.37	33.95	33.58	33.21
Akaike Info. Criterion	0.1610	0.1555	0.1571	0.1578	0.400	0.387	0.390	0.393
Pseudo R^2	n/a	n/a	n/a	n/a	0.091	0.132	0.135	0.136

We estimate exponential duration models with time varying covariates for the period 1980–2003 in column (1) - (4) and logit models in column (5) - (8). The dependent variable is the log of time to crisis in the exponential duration models. The observations are right hand censored if no crisis surfaced during the observation period. The number of observations in the duration models is greater than in the logit models since the data set has to be set up differently for analysing duration data with multiple crises. If a crisis runs over multiple years, the years following the onset of a crisis are deleted from the data set. If a country experienced multiple crises, subsequent systemic episodes are included in the sample. The number of crises in the duration model setup is smaller since duration analysis focuses on time spans for each country and exploits information in the data at the end of each span. Therefore, values of the first observation for each country recorded in the initial data set are discarded in this analysis. The dependent variable in the logit models is a dummy variable that equals one if a crisis is observed or zero otherwise. All explanatory variables are lagged in the models by one period to avoid simultaneity problems. If a crisis runs over multiple years, the years following the onset of a crisis are deleted from the data set. If a country experienced multiple crises, subsequent systemic episodes are included in the sample. The Appendix provides detailed information on the explanatory variables. Specifications (1) and (5) are our baseline models that include covariates used in previous studies, whereby we update the Moral Hazard Index by Demirgüç-Kunt and Detragiache (2002). We also incorporate three dummies for origin of the legal system, whereby we capture German legal origin in the intercept. Specifications (2) and (6) include the *H-Statistic* as measure for the competitiveness of the industry and Specification (3) and (7) incorporate the level of concentration as measured by the three bank concentration ratio, averaged over the sampling period. To control for nonlinear relationships between the degree of competitiveness and the level of concentration, we include an interaction term of these two variables in Specification (4) and (8). White's heteroskedasticity consistent standard errors are given in parentheses. Type I and Type II Error are calculated as the total number of crisis observations (28) divided by the number of observations in the sample (567); this yields a cut-off point of 0.0494. Significance levels of 1, 5 and 10 percent are indicated by ***, ** and *.

The control variable for terms of trade change is weakly significant at the 10 percent level in Specification (2) indicating an inverse relationship between changes in terms of trade and time to crisis. While this appears counterintuitive, it may be due to sample composition. The impact of terms of trade on time to crisis is largely determined by the countries' dependency on primary commodity exports. If no such dependency is prevalent in our sample, we are unlikely to discover the anticipated positive sign. Moreover, previous studies also fail to consistently find the expected pattern. While Demirgüç-Kunt and Detragiache (2005) find no significant relationship with changing signs across different regressions, Beck, Demirgüc-Kunt, and Levine (2005a) report a negative association between the probability of observing a systemic crisis and adverse terms of trade shocks which would result in a positive relationship between changes in terms of trade and time to crisis in a duration model. Consistent with theory, the rate of depreciation exhibits a negative sign and enters the equations significantly in Specification (1), (3) and (4) since currency devaluations often pose a threat to bank profitability (Demirgüç-Kunt and Detragiache, 1998). Moreover, our model provides strong evidence for the 'boom and bust' hypothesis across the four specifications in that it highlights that strong credit growth shortens survival time of banking systems. The significant dummy for French legal origin enters throughout negatively and significantly suggesting that time to crisis is shorter in countries with French legal origin. This may be driven by weak law enforcement and comparatively less protection of creditor rights in countries with French legal origin than in countries with British legal origin as illustrated by La Porta, Lopez-de-Silanes, and Shleifer (1998). The dummy for Scandinavian legal origin is likewise significant and negative across the different regressions, which may be again attributable to the fact that less emphasis is placed on the protection of creditor rights in Scandinavian countries than in jurisdictions with British legal origin (Levine, 1998). The lack of significance of some of the macroeconomic control variables may be attributable to multicollinearity as underscored by Detragiache and Spilimbergo (2001). We nevertheless keep them in the equation to test our hypothesis regarding competitive behavior of financial institutions while the macroeconomic setting is controlled for.

To investigate whether our findings are sensitive to different methodological approaches, we re-run Specification (1)–(4) with the more widely used logit model and report the results in Specification (5)–(8). This modeling technique largely corroborates the findings obtained with the duration model. The H-Statistic enters Specifications (6) and (7) negatively and significantly at the 1 percent level.[12] We compute the impact of an increase of a one standard deviation in the H-Statistic (0.12) using the marginal effect (-0.1498) rather than the coefficient from the logit model reported in Specification (7), evaluated at the mean, on the probability of observing a crisis (-0.1498*0.12=-0.0180) to illustrate that a one standard deviation increase in competitiveness decreases the probability of observing a crisis by 1.8 percent.[13] This underscores that more competitive banking systems are more resilient to crises. The effect of

[12] The H-Statistic is also significant when including the years following the onset of a crisis. We do not report these results for brevity.

[13] The results for the computation of marginal effects for the logit model can be obtained from the authors upon request.

competitive conduct is greater than the impact of increased concentration in the industry. Although insignificant in Specification (7), we compare the two results for illustrative purposes and also calculate the effect of a one standard deviation increase in concentration (0.13) upon fragility, using again the marginal effect (-0.0528). This decreases the probability of suffering a systemic crisis by 0.53 percent (-0.0528*0.13). When the interaction between concentration and competitiveness is controlled for in Specification (8), these variables are no longer significant.

Among the control variables, we find evidence that increases in real interest rates give rise to banking vulnerabilities according to Specification (5)–(8). The positive and significant coefficient for inflation in Specification (5) furthermore underscores that inflation is a precursor for banking problems. We again find evidence for the ”boom and bust” story in the literature in Specifications (6)–(8) where credit growth enters with a significant and positive sign. The dummy for French legal origin is now positively signed and significant across the logit models, indicating that countries with French legal origin are more prone to experience a crisis, which confirms the results from the duration model.

The logit models provide additional information in terms of the classification accuracy. Only 25–28 percent of the crises in the sample are misclassified according to the results of the Type I Error. The predictive power is aligned with previous studies and we therefore regard these results as satisfying. The Akaike Information Criterion suggests that Specification (2) and (6), that additionally incorporate the H-Statistic, are the most parsimonious model setups. However, since we want to perform the subsequently presented robustness tests when concentration is controlled for, we use Specifications (3) and (7) for the robustness tests in Sections V.B. and V.C. We find in neither of our two methodological approaches evidence that competitive behavior of banks increases banking system fragility. Moreover, the results indicate that concentration and competitive behavior are of distinct character and that concentration does not significantly impact banking system soundness when competition is controlled for.

B. Robustness Tests

We perform several robustness tests using both the duration approach and the logit model in Table 4 whereby we omit the period 1994 – 2001 during which the H-Statistic was measured by Claessens and Laeven (2004) to account for the fact that the measure of competition assumes long run equilibrium. We furthermore employ different samples in terms of the country coverage and with respect to the sampling period. In addition, we use first differences of the macroeconomic control variables rather than levels to capture the behavior of the macroeconomic environment more dynamically. Since we are not specifically interested in the behavior of our control variables, we constrain the subsequent discussion to the H-Statistic and the three-bank concentration ratio.[14]

[14] We do not report the results for the macroeconomic control variables, the moral hazard index and the dummies for legal origin in Tables 4 and 5 for space constraints. The results can be obtained from the authors upon request.

Table 4. Robustness Tests for Competitiveness and Timing and Probability of Crises

	Duration models				Logit models			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
H-Statistic	6.0382 (2.8014)**	5.7925 (2.3317)**	4.9358 (2.4638)**	5.3638 (2.0009)***	-6.5980 (1.9158)***	-6.1835 (2.2136)***	-5.2564 (2.1689)**	-4.3798 (2.3654)*
Concentration	-0.0476 (2.3974)	4.5866 (3.2740)	0.3286 (2.3985)	4.8894 (3.4130)	-0.1835 (2.0577)	-3.8898 (2.7648)	-1.0092 (1.9934)	-0.8001 (3.0274)
Observations	388	534	594	504	395	481	538	452
Number of crises	13	19	21	20	20	25	25	21
Type I Error (%)	n/a	n/a	n/a	n/a	28.27%	16.00	32.00	23.81
Type II Error (%)	n/a	n/a	n/a	n/a	25.00%	28.73	30.02	32.48
Akaike Info. Criterion	0.2368	0.1453	0.1484	0.2002	0.418	0.395	0.379	0.397
Pseudo R^2	n/a	n/a	n/a	n/a	0.133	0.1761	0.129	0.108

To investigate the robustness of the results presented in Table 3, we perform several robustness tests using Specification (3) and (7) from Table 3 for the duration and the logit model respectively. The control variables are not reported for brevity and the results can be obtained from the authors upon request. We estimate exponential duration models in Specification (1)-(4) and logit models in Specification (5)-(8), whereby Specifications (1) and (5) omit the years 1994 – 2001 during which the H-Statistic was measured by Claessens and Laeven (2004). We exclude in Specification (2) and (6) low-income economies as defined by the World Bank (Bangladesh, India, Kenya, Nigeria and Pakistan) and use first differences rather than levels for the macroeconomic control variables in Specification (3) and (7). The sampling horizon is constrained to the period 1985–2003 in Specification (4) and (8). The dependent variable is the log of time to crisis in the exponential duration models. The observations are right hand censored if no crisis surfaced during the observation period. The number of observations in the duration models is greater than in the logit models since the data set has to be set up differently for analysing duration data with multiple crises. The number of crises in the duration model setup is smaller since duration analysis focuses on time spans for each country and exploits information in the data at the end of each span. Therefore, values of the first observation for each country recorded in the initial data set are discarded in this analysis. The dependent variable in the logit models is a dummy variable that equals one if a crisis is observed or zero otherwise. All explanatory variables are lagged in the models by one period to avoid simultaneity problems. If a crisis runs over multiple years, the years following the onset of a crisis are deleted from the data set. If a country experienced multiple crises, subsequent systemic episodes are included in the sample. The Appendix provides detailed information on the explanatory variables. White's heteroskedasticity consistent standard errors are given in parentheses. Type I and Type II Error are calculated as the total number of crisis observations divided by the number of observations in the sample. Significance levels of 1, 5 and 10 percent are indicated by ***, ** and *.

Specifications (1)–(4) in Table 4 depict the results for four robustness tests obtained with the duration models and Specifications (5)–(8) report the findings from the logit models. In order to capture the effect of concentration, we employ Specifications (3) and (7) from Table 3 for the robustness tests. Regressions (1) and (5) in Table 4 omit the period 1994 – 2001 for which Claessens and Laeven (2004) measure the H-Statistic. This approach helps account for the fact that the H-Statistic assumes long run equilibrium. Given that crises, consolidation and changing environment challenge this restrictive assumption we investigate whether dropping the period during which the H-Statistic was measured affects our inferences. Both the duration and the logit model reiterate the significant relationship between competitive conduct and banking system soundness.[15] Similarly to the results presented in Table 3, concentration is still insignificant in these specifications.

To test for robustness of our results with respect to the level of development of the financial system in question, we perform two robustness tests. First, we exclude the low-income

[15] Claessens and Laeven (2004) point out that the H-Statistic may be biased in countries with many small banks operating in local markets (e. g. US, Italy, France and Germany). To analyse the impact of dropping those countries from our dataset, we re-run the duration and logit models and again confirm the significantly positive relationship between competition and the timing of crises in the duration model and the significantly negative relationship in the logit model. The results can be obtained upon request.

economies as classified by the World Bank (Bangladesh, India, Kenya, Nigeria and Pakistan) from the sample in Specification (2) and (6) to examine sample bias. In both equations, the H-Statistic enters significantly at the 5 and 1 percent level and shows the anticipated sign, suggesting that our results are not driven by sample selection. Concentration remains insignificant in this alternative sample. Second, we exclude major industrial countries. Both in the duration model and in the logit model, the point estimate of the H-statistic retains the anticipated sign. It is significant at 10 percent level in the logit model, and insignificant in the duration model; concentration remains insignificant in both models.[16]

In order to capture whether a more dynamic measure of the behavior of the macroeconomic control variables impacts the link between competitiveness and fragility, we use first differences for the macroeconomic variables rather than levels in Regressions (3) and (7). We again find a positive and significant association between competitive bank behavior and time to crisis and the anticipated inverse relationship between the probability of observing a systemic crisis and competitiveness. The results of the impact of concentration on fragility remain unchanged in these regressions.

In a final robustness check, we examine whether our results also hold for the sampling period 1985–2003.[17] Specification (4) indicates again a significant relationship between a banking system's survival time and the degree of competition, while concentration remains insignificant. The thus far contemplated association between the H-Statistic and banking system vulnerabilities also holds in the logit model in (8), although both the coefficient and the level of significance decrease. We again cannot reject the hypothesis that concentration has no independent effect on fragility when competitive conduct of banks is controlled for.

Thus, both the duration analysis and the logit model confirm that the impact of competitiveness on banking system vulnerabilities is robust subject to alternative samples, the consideration of more dynamic effects of the macroeconomic environment, and different sampling periods.[18] We obtain slightly weaker results with an alternative, more judgmental definition of systemic crises. The effect of competitive conduct on banking system soundness only then becomes significant in the logit models when the years following the onset of a crisis are included in the sample. Importantly, our results presented in various regressions do not support the view that

[16] For brevity, Table 4 reports only the results for the exclusion of the low-income countries. The results for the exclusion of the major industrial countries can be obtained from the authors upon request. In unreported regressions, we also test more specifically for the impact of financial sector development on the timing and probability of suffering systemic crises and include as an additional control variable the ratio of stock market total value traded to GDP. We again confirm the significantly positive association between the H-Statistic and crises in the duration model and the significant and negative relationship between the measure of competitiveness and crises in the logit model. The results are also available upon request.

[17] We also considered shortening the sampling period further, but this substantially decreases the number of crisis observations in the sample. Thus, we constrain the final robustness tests to the period 1985–2003.

[18] We also tested whether our results are affected by clustering the error terms and re-ran Specifications (1) – (8) with this alternative setup. The findings on the impact of the H-Statistic are however virtually unchanged in these regressions and we therefore do not report them.

concentration is conducive to banking system stability once competitive conduct is controlled for, which suggests a reconsideration of the findings reported by Beck, Demirgüc-Kunt, and Levine (2005a, 2005b). They put forward that bank concentration boosts banking stability but do not control for the effect of banks' competitive conduct.

C. Competitiveness, Regulation and Systemic Crises

The regulatory environment has an impact on the degree of competitiveness in the banking industry (e.g., Claessens and Laeven, 2004). As an additional robustness test, we therefore investigate and report in Table 5 the impact of competition on banking system soundness while controlling for a set of regulatory and institutional variables. As mentioned previously, if incorporation of these variables diminishes the significance of the H-Statistic, we could conclude that competition does not have an independent effect on banking system vulnerability. Moreover, an analysis of the design features of the regulatory environment on the timing of systemic problems appears independently beneficial. We again constrain the following discussion to the H-Statistic and the three-bank concentration ratio.

Table 5. Regulatory Environment, Contestability, and the Timing and Probability of Crises

	Duration models				Logit models			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	…	…	…	…	…	…	…	…
H-Statistic	4.3392	4.4300	3.8345	3.6107	-5.7529	-5.4366	-5.3887	-4.3336
	(2.3380)*	(2.1107)**	(3.2015)	(1.9182)*	(2.3421)**	(2.0885)***	(2.9989)*	(2.0670)**
Concentration	2.1585	2.7230	1.0349	2.7449	-0.4683	-2.4233	-0.2124	-2.0229
	(2.3569)	(2.2381)	(2.9230)	(2.3386)	(2.3656)	(2.2404)	(3.2036)	(2.4477)
Activity restrictions	-0.1077				0.3427			
	(0.1042)				(0.1514)**			
Capital regulatory index		-0.1924				0.4580		
		(0.2313)				(0.3995)		
Foreign ownership			-2.6596				0.9981	
			(1.6900)				(1.7759)	
Government ownership				-0.7383				0.3385
				(0.5709)				(0.6596)
Observations	598	598	409	598	547	547	371	545
Number of crises	22	22	18	22	28	28	20	28
Type I Error (%)	n/a	n/a	n/a	n/a	17.86	25.00	25.00	21.43
Type II Error (%)	n/a	n/a	n/a	n/a	31.98	29.29	27.07	31.53
Akaike Info. Crit.	0.1609	0.1611	0.1829	0.1631	0.393	0.401	0.432	0.404
Pseudo R^2	n/a	n/a	n/a	n/a	0.163	0.144	0.151	0.1376

Using specification (3) and (7) from Table 3 and utilizing the sample for 1980–2003, we control for the regulatory and institutional environment. The control variables are not reported for brevity and the results can be obtained from the authors upon request. We estimate exponential duration models in Specification (1) - (4) and logit models in Specification (5) - (8). The dependent variable is the log of time to crisis in Specification (1)–(4) and a dummy variable that takes on the value one if a crisis is observed or zero otherwise. The observations are right hand censored if no crisis surfaced during the observation period. All explanatory variables are lagged in the models by one period to avoid simultaneity problems. The number of observations in the duration models is greater than in the logit models since the data set has to be set up differently for analyzing duration data with multiple crises. The number of crises in the duration model setup is smaller since duration analysis focuses on time spans for each country and exploits information in the data at the end of each span. Therefore, values of the first observation for each country recorded in the initial data set are discarded in this analysis. All explanatory variables are lagged in the models by one period to avoid simultaneity problems. If a crisis runs over multiple years, the years following the onset of a crisis are deleted from the data set. If a country experienced multiple crises, subsequent systemic episodes are included in the sample. The equations additionally include variables that capture activity restrictions (1) and (5) and a capital regulatory index (2) and (6) to examine the effect of barriers to entry to the market. We also incorporate regressors to analyze the impact of foreign ownership (3) and (7) and a variable to examine the effect of government ownership (4) and (8). The Appendix provides detailed information on the explanatory variables. White's heteroskedasticity consistent standard errors are given in parentheses. Type I and Type II Error are calculated as the total number of crisis observations divided by the number of observations in the sample. Significance levels of 1, 5, and 10 percent are indicated by ***, ** and *.

Table 5 presents the results for both the duration and the logit model. To avoid collinearity problems, we enter the additional variables for the regulatory environment one at a time. Even when controlling for barriers to entry such as activity restrictions in Specification (1), a capital regulatory index in Specification (2), and government ownership in Specification (4), our core result that more competitive banking systems exhibit increased survival time prevails at the five and 10 percent significance level. The H-Statistic is only rendered insignificant when foreign ownership is included in Specification (3). None of the regulatory and ownership variables enters the equation at meaningful levels of significance in the duration model. The results however improve in the logit model as illustrated in Specification (5)–(8). The negative coefficient for the H-Statistic underscores again that banking systems with higher degrees of competition are more resilient to systemic crises and that including additional variables that shape the competitive environment of a banking system does not drive out the significance of the H-Statistic which enters with significance levels between 1 and 10 percent.[19] Moreover, the variable that captures activity restrictions becomes positive and significant at the 5 percent level. This indicates that a more restrictive environment is conducive to the buildup of banking system vulnerabilities, a finding consistent with the work by Beck, Demirgüc-Kunt, and Levine (2005a, 2005b) and Barth, Caprio, and Levine (2004). The inference to be drawn is that the regulatory and institutional environment do not play a major role for the likelihood and timing of systemic banking problems. However, we do not find evidence to substantiate the findings by Beck, Demirgüc-Kunt, and Levine (2005a, 2005b) that increased concentration contributes to banking system stability since concentration remains insignificant across all specifications in the duration and in the logit models.

In sum, our results offer evidence that competitive behavior of financial institutions neither gives rise to systemic risk nor shortens time to crisis, even if contestability of banking markets and ownership structure are controlled for. At worst, competition is not found to have an independent effect on the likelihood and timing of systemic problems. Hence, the findings do not support theoretical studies of the ”competition–fragility” literature. Rather, we find support for the “competition–stability” view. Our results furthermore complement the work by Barth, Caprio, and Levine (2004) and Beck, Demirgüc-Kunt, and Levine (2005a, 2005b) on the relationship between regulatory and supervisory policies and banking system soundness.

VI. CONCLUDING REMARKS

This paper provides the first empirical study of the relationship between bank competition as measured by the Panzar and Rosse (1987) H-Statistic and banking system stability. Using a cross-country data set comprising 38 countries with up to 28 systemic banking crises for the period 1980–2003 we find that higher degrees of competition in banking systems decrease the risk of suffering a systemic crisis. Moreover, we present evidence that survival time of banking

[19] We conducted tests for nonlinear relationships and include interaction terms between the H-Statistic and the additionally incorporated regulatory and institutional variables. The H-Statistic enters all these duration models positively and significantly at the 1 and 5 percent level and shows the anticipated negative sign at the 1 and 5 percent level in the logit models, confirming that competitive behavior lengthens time to crisis and increases banking system soundness. The results can be obtained from the authors upon request.

systems tends to increase in a more competitive environment. A broad set of robustness tests using alternative samples, different methodological approaches for the coding of the macroeconomic environment, and alternative sampling periods reiterate our core finding that more competitive banking systems are more resilient to banking problems, even when the level of concentration in the industry is controlled for.

Thus, our results offer empirical support for the "competition–stability" theory and do not conform to the "competition–fragility" literature. This bolsters the view that competition and soundness generally go hand in hand (even though a perfectly competitive system does not "guarantee" absence of failures). While we qualify the conclusions in a number of aspects, the initial findings presented in this paper imply that banking systems with high values of the Panzar and Rosse (1987) H-Statistic are (i) less likely to experience a banking crisis and (ii) exhibit longer time to observing an episode of systemic problems as competition increases. Restricting the sample size by excluding low-income economies, excluding countries in which the measure of competition may be biased downwards, excluding major industrial economies, examining the period 1985–2003, omitting the period during which the H-Statistic is measured, and using first differences for the macroeconomic control variables rather than levels in both the duration analysis and in the logit model does not change the finding of our analysis. Our results for the logit model also hold when controlling for a set of regulatory and institutional variables that capture contestability of banking systems and ownership structure of banks and are only marginally weakened in the duration model. As a side result, the findings offer some evidence that a more restrictive institutional environment is conducive to the buildup of banking vulnerabilities, which is in line with previous research.

An additional contribution of this paper is its examination of the likelihood and timing of suffering a systemic crisis when the degree of concentration is accounted for. In this context, our results reject the view that concentrated banking systems are significantly less prone to suffer a crisis. Therefore, the findings provide initial empirical evidence in a cross-country setting that competition and concentration are distinct from each other and that only competitive behavior of banks impacts upon the probability of suffering a systemic banking crisis whereas concentration does not.

Further research is needed to investigate in more detail the nature of the relationship between competition and fragility. It is important to examine if alternative measures of competitive behavior confirm our initial results and which levels of competition, if any, may be optimal to maintain a stable banking system. Studies on the firm level using cross-country data and controlling for the institutional and regulatory environment would help explore this link further. Likewise, the exact transmission mechanism between competition and stability is an important subject matter. For instance, an analysis of the effects of competition in the short and in the long run may yield different outcomes for stability. Also, as a complement to the 0/1 (crisis/no crisis) measure of financial fragility used in this paper, one could use more continuous measures, such as distance to default, provided that practical problems with these measures (e.g., reliability of stock price data in shallow markets) are addressed.

DEFINITIONS OF VARIABLES AND DATA SOURCES

Variable	Definition	Source
Crisis	Dummy variable that takes on the value one if a systemic crisis is observed or zero otherwise	Demirgüç-Kunt and Detragiache (2005)
H-Statistic	Variable that captures the competitiveness of the banking industry whereby $H \leq 0$ indicates monopoly equilibrium; $0 < H < 1$ indicates monopolistic competition and $H = 1$ indicates perfect competition	Claessens and Laeven (2004)
Concentration	Proportion of total assets held by the 3 largest institutions in a country, averaged over the period 1988–2003	Beck, Demirgüc-Kunt, and Levine (2005a) and Bankscope
Real GDP growth	Rate of growth of the gross domestic product	World Bank Development Indicators
Real interest rate	Nominal interest rate minus the rate of inflation	International Financial Statistics
Inflation	Rate of change of the GDP deflator	World Bank Development Indicators
Terms of trade	Change in the net barter terms of trade	World Bank Development Indicators
Depreciation	Change in the foreign exchange rate	International Financial Statistics
M2/Reserves	Ratio of M2 to gross foreign reserves	World Bank Development Indicators
Credit growth	Rate of growth of domestic credit to the private sector, adjusted for inflation with GDP deflator	International Financial Statistics
Stock market total value traded/GDP	Ratio of the value of total shares traded to average real market capitalization, the denominator is deflated.	Beck, Demirgüc-Kunt, and Levine (2000)
Moral hazard index	Indicator that measures generosity of design features of deposit insurance schemes calculated as the first principal component of the following design features: co-insurance, coverage of foreign currency and interbank deposits, membership, management, type and source of funding, level of explicit coverage and augmented for additional features regarding the presence of risk based premiums, deposit insurer's power to revoke the bank licence and its ability to intervene a bank.	Demirgüç-Kunt and Detragiache (2002) and authors' calculations
British legal origin	Dummy variable that takes on the value one if the country's legal system is of British origin or zero otherwise	La Porta, Lopez-de-Silanes, and Shleifer (1998)
French legal origin	Dummy variable that takes on the value one if the country's legal system is of French origin or zero otherwise	La Porta, Lopez-de-Silanes, and Shleifer (1998)
German legal origin	Dummy variable that takes on the value one if the country's legal system is of German origin or zero otherwise	La Porta, , Lopez-de-Silanes, and Shleifer (1998)
Scandinavian legal origin	Dummy variable that takes on the value one if the country's legal system is of Scandinavian origin or zero otherwise	La Porta, Lopez-de-Silanes, and Shleifer (1998)
Activity restrictions	Activity restrictions index for securities, insurance, real estate and ownership of nonfinancial firms that takes on values between 4 and 16, whereby greater values indicate more restrictions.	Barth, Caprio, and Levine (2004)
Capital regulatory index	Summary index for overall capital stringency calculated as the sum of initial capital stringency and overall capital stringency.	Barth, Caprio, and Levine (2004)
Foreign ownership	Proportion of bank assets owned by foreign entities.	Barth, Caprio, and Levine (2001)
Government ownership	Proportion of bank assets owned by government	La Porta, Lopez-de-Silanes, and Shleifer (2000)

REFERENCES

Allen, Franklin, and Douglas Gale, 2000, "Financial Contagion," *Journal of Political Economy*, Vol. 108, pp. 1–29.

———, 2004, "Competition and Financial Stability," *Journal of Money, Credit and Banking*, Vol. 36, No. 3, pp. 453–80.

Barth, James R., Gerard Caprio, Jr., and Ross Levine, 2001, "The Regulation and Supervision of Banks Around the World - A New Database (Vol.1)" (Washington: World Bank), available at http://web.worldbank.org/servlets/ECR?entityID=000094946_01052204005474&collection=IMAGEBANK&sitePK=469233.

———, 2005, *Rethinking Bank Supervision and Regulation: Until Angels Govern* (Cambridge, Massachusetts: Cambridge University Press).

———, 2004, "Bank Regulation and Supervision: What Works Best?" *Journal of Financial Intermediation*, Vol. 13, pp. 205–48.

Beck, Thorsten, Asli Demirgüç-Kunt and Ross Levine, 2000, "A New Database on Financial Development and Structure," *World Bank Economic Review*, Vol. 14, pp. 597–605

———, 2003, "Law, Endowments and Finance," *Journal of Financial Economics*, Vol. 70, pp. 137–81.

———, 2005a, "Bank Concentration, Competition, and Crises: First Results," *Journal of Banking and Finance*, Vol. 30, No. 5, pp. 1581–603.

———, 2005b, "Bank Concentration and Fragility: Impact and Mechanics," in *Risk of Financial Institutions,* ed. by Mark Carey and Rene Stulz (Cambridge, Massachusetts: National Bureau of Economic Research).

Benston, George W., William C. Hunter, and Larry D. Wall, 1995, "Motivations for Bank Mergers and Aquisitions: Enhancing the Deposit Insurance Put Option versus Earnings Diversification," *Journal of Money, Credit, and Banking*, Vol. 27 (3), pp. 777–788.

Berger, Allen N., 1995, "The Profit-Structure Relationship in Banking–Tests of Market Power and Efficient-Structure Hypotheses," *Journal of Money, Credit and Banking*, Vol. 27, pp. 404–31.

Berger, Allen N., and Timothy H. Hannan, 1989, "The Price-Concentration Relationship in Banking," *Review of Economics and Statistics*, Vol. 71, pp. 291–9.

Berger, Allen N., and Gregory F. Udell, 2002, "Small Business Credit Availability and Relationship Lending: The Importance of Bank Organizational Structure," *Economic Journal*, Vol. 112, pp. F32–F53.

Berger, Allen N., Robert DeYoung, Hesna Genay, and Gregory F. Udell, 2000, "The Globalization of Financial Institutions: Evidence from Cross-Border Banking Performance," *Brookings –Wharton Papers on Financial Services,* Vol. 3, pp. 23–158.

Berger, Allen N., Iftekhar Hasan, and Leora F. Klapper, 2004, "Further Evidence on the Link between Finance and Growth: An International Analysis of Community Banking and Economic Performance," *Journal of Financial Services Research*, Vol. 25, pp. 169–202.

Berger, Allen N., Asli Demirgüç-Kunt, Ross Levine, and Joseph G. Haubrich, 2004, "Bank Concentration and Competition: An Evolution in the Making," *Journal of Money, Credit and Banking*, Vol. 36, No. 3, pp. 434–450.

Besanko, David and Anjan V. Thakor, 1993, "Relationship Banking, Deposit Insurance, and Bank Portfolio," in *Capital Markets and Financial Intermediation,* ed. by Colin Mayer and Xavier Vives (Cambridge, Massachusetts: Cambridge University Press).

Bikker, Jacob A., 2004, *Competition and Efficiency in a Unified European Banking Market* (Cheltenham: Edward Elgar).

Bikker, Jacob A., and Katharina Haaf, 2002, "Competition, Concentration and Their Relationship: An Empirical Analysis of the Banking Industry," *Journal of Banking and Finance*, Vol. 26, pp. 2191–2214, available at http://ideas.repec.org/a/eee/jbfina/v26y2002i11p2191-2214.html

Boot, Arnoud and Stuart Greenbaum, 1993, "Bank Regulation, Reputation and Rents: Theory and Policy Implications," in *Capital Markets and Financial Intermediation,* ed. by Colin Mayer and Xavier Vives (Cambridge, Massachusetts: Cambridge University Press),

Bordo, Michael, Angela Redish, and Hugh Rockoff, 1995, "A Comparison of the United States and Canadian Banking Systems in the Twentieth Century: Stability vs. Efficiency," in *Anglo-American Financial Systems: Institutions and Markets in the Twentieth Century*, ed. by Michael Bordo and Richard Sylla (New York: Irvin).

Boyd, John H. and Gianni de Nicolo, forthcoming, "The Theory of Bank Risk-Taking and Competition Revisited*," Journal of Finance.*

Boyd, John H., Gianni de Nicolo, and Bruce D. Smith, 2004, "Crises in Competitive Versus Monopolistic Banking Systems," *Journal of Money, Credit and Banking*, Vol. 36 (3), pp. 487–506.

Boyd, John H. and Stanley L. Graham, 1991, "Investigating the Banking Consolidation Trend," *Federal Reserve Bank of Minneapolis Quarterly Review*, Spring, pp. 1–15.

———, 1996, "Consolidation in U.S. Banking: Implications for Efficiency and Risk," Federal Reserve Bank of Minneapolis Working Paper, No. 572 (Minneapolis).

Caminal, Ramon, and Carmen Matutes, 2002, "Market Power and Bank Failures," *International Journal of Industrial Organization*, Vol. 20, No. 9, pp. 1341–61.

Capie, Forrest, 1995, "Prudent and Stable (but inefficient?): Commercial Banks in Britain, 1890–1940," in *Anglo-American Financial Systems: Institutions and Markets in the Twentieth Century*, ed. by Michael Bordo and Richard Sylla (New York: Irvin).

Caprio Jr., Gerard and Daniela Klingebiel, 2003, *Episodes of Systemic and Borderline Financial Crises* (Washington: World Bank) available at http://siteresources.worldbank.org/INTRES/Resources/469232-1107449512766/648083-1108140788422/23456_Table_on_systemic_and_non-systemic_banking_crises_January_21_2003.pdf

Carletti, Elena and Philipp Hartmann, 2003, "Competition and Stability: What's Special about Banking?" *Monetary History, Exchanges Rates and Financial Markets: Essays in Honour of Charles Goodhart*, Vol. 2, ed. by Paul Mizen (Cheltenham: Edward Elgar).

Cetorelli, Nicola, 2003, "Life-Cycle Dynamics in Industrial Sectors: The Role of Banking Market Structure," *Federal Reserve Bank of St. Louis Review*, Vol. 85, pp. 135–47.

Claessens, Stijn and Luc Laeven, 2004, "What Drives Bank Competition? Some International Evidence," *Journal of Money, Credit and Banking*, Vol. 36, No. 3, pp. 563–83.

Cleves, Mario A, William W. Gould, and Roberto A. Gutierrez, 2004, *An Introduction to Survival Analysis Using STATA,* (College Station, Texas: Stata Press).

Cordella, Tito and Eduardo L. Yeyati, 2002, "Financial Opening, Deposit Insurance and Risk in a Model of Banking Competition," *European Economic Review*, Vol. 46, No. 3, pp. 471–85

Craig, Ben and João Cabral dos Santos, 1997, "The Risk Effects of Bank Acquisitions," *Federal Reserve Bank of Cleveland Economic Review*, Vol. 33, pp. 25–35

De Nicoló, Gianni, Phillip Bartholomew, Jahanara Zaman and Mary Zephirin, 2004, "Bank Consolidation, Internationalization, and Conglomerization: Trends and Implications for Financial Risk," *Financial Markets, Institutions and Instruments*, Vol. 13, No. 4, pp. 173–217.

De Nicoló, Gianni, and Myron L. Kwast, 2002, "Systemic Risk and Financial Consolidation: Are They Related?" *Journal of Banking and Finance*, Vol. 26, pp. 861–80.

DeYoung, Robert, William C. Hunter, and Gregory F. Udell, 2004, "The Past, Present and Probable Future for Community Banks," *Journal of Financial Services Research*, Vol. 25, pp. 85–133.

DeYoung, Robert, and Daniel E. Nolle, 1996, "Foreign-Owned Banks in the U.S.: Earning Market Share or Buying It?" *Journal of Money, Credit, and Banking*, Vol. 28, pp. 622–36.

Demirgüç-Kunt, Asli and Enrica Detragiache, 1998, "The Determinants of Banking Crises in Developing and Developed Countries," *IMF Staff Papers*, Vol. 45, No. 1, pp. 81–109.

———, 2002, "Does Deposit Insurance Increase Banking System Stability? An Empirical Investigation," *Journal of Monetary Economics*, Vol. 49, pp. 1373–1406.

———, 2005, "Cross-Country Empirical Studies of Systemic Bank Distress: A Survey," IMF Working Paper 05/96 (Washington: International Monetary Fund).

Demirgüç-Kunt, Asli, Baybars Karacaovali, and Luc Laeven, 2005, "Deposit Insurance Around the World: A Comprehensive Database," *Policy Research Working Paper #3628* (Washington: World Bank), available at http://web.worldbank.org/servlets/ECR?entityID=000012009_20050608111717&collection=IMAGEBANK&sitePK=469233

Detragiache, Enrica, and Antonio Spilimbergo, 2001, "Crises and Liquidity–Evidence and Interpretation," IMF Working Paper 01/2 (Washington: International Monetary Fund).

Diamond, Douglas W., and Philip H. Dybvig, 1983, "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy*, Vol. 91, No. 3, pp. 401–419.

Drees, Burkhard and Ceyla Pazarbasioglu (1998) The Nordic Banking Crises: Pitfalls in Financial Liberalization? IMF Occasional Paper 161/1998, Washington, D. C.: International Monetary Fund

Eichengreen, Barry M., and Carlos Arteta, 2000, "Banking Crises in Emerging Markets: Presumptions and Evidence," Center for International and Development Economics Research Paper C00'115 (Berkeley: University of California).

Fischer, Klaus P., and Martin Chenard, 1997, "Financial Liberalisation Causes Banking System Fragility," Working Paper No 97-14, Faculté des sciences de l'administration. Universite Laval.

Frame, Scott W., and David R. Kamerschen, 1997, "The Profit-Structure Relationship in Legally Protected Banking Markets Using Efficiency Measures," *Review of Industrial Organization*, Vol. 12, pp. 9–22.

Hellman, Thomas F., Kevin Murdoch, and Joseph E. Stiglitz, 2000, "Liberalization, Moral Hazard in Banking and Prudential Regulation: Are Capital Requirements Enough?" *American Economic Review*, Vol. 90, No. 1, pp. 147–65.

Hoggarth, Glenn A., Alistair Milne, and Geoffrey E. Wood, 1998, "Alternative Routes to Banking Stability: A Comparison of UK and German Banking Systems," *Financial Stability Review*, Vol. 5, pp. 55–68.

Honohan, Patrick, and Luc Laeven (eds.), 2005, *Systemic Financial Crises: Containment and Resolution* (Cambridge, Massachusetts: Cambridge University Press).

Jayaratne, Jith, and Philip E. Strahan, 1996, "The Finance-Growth Nexus: Evidence from Bank Branch Deregulation," *Quarterly Journal of Economics*, Vol. 111, pp. 639–70.

———, 1998, "Entry Restrictions, Industry Evolution, and Dynamic Efficiency: Evidence from Commercial Banking," *Journal of Law and Economics*, Vol. 41, pp. 239–73.

Keeley, Michael C., 1990, "Deposit Insurance, Risk and Market Power in Banking," *American Economic Review*, Vol. 80, pp. 1183–200.

Lane, William R., Stephen W. Looney, and James W. Wansley, 1986, "An Application of the Cox Proportional Hazards Model to Bank Failure," *Journal of Banking and Finance,* Vol. 10, pp. 511–531.

La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, 1998, "Law and Finance," *Journal of Political Economy*, Vol. 106, pp. 1113–55.

———, 2002, "Government Ownership of Banks," *Journal of Finance*, Vol. 57, No. 1, pp. 265–301.

Matutes, Carmen and Xavier Vives, 1996, "Competition for Deposits, Fragility and Insurance," *Journal of Financial Intermediation*, Vol. 5, No. 2, pp. 184–216.

———, 2000, "Imperfect Competition, Risk Taking and Regulation in Banking," *European Economic Review*, Vol. 44, No. 1, pp. 1–34.

Mishkin, Frederic S., 1999, "Financial Consolidation: Dangers and Opportunities," *Journal of Banking and Finance*, Vol. 23, pp. 675–691.

Nagarajan, S., and C. W. Sealey, 1995, "Forbearance, Deposit Insurance Pricing and Incentive Compatible Bank Regulation," *Journal of Banking and Finance*, Vol. 19, pp. 1109–30

Neumark, David, and Steven A. Sharpe, 1992, "Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits," *Quarterly Journal of Economics*, Vol. 107, pp. 657–80.

Panzar, John C., and Rosse, James N., 1987, "Testing for Monopoly Equilibrium," *Journal of Industrial Economics*, Vol. 35, pp. 443–56.

Paroush, Jacob, 1995, "The Effects of Mergers and Acquisition Activity on the Safety and Soundness of a Banking System," *Review of Industrial Organization*, Vol. 10, pp. 53–67.

Perotti, Enrico C., and Javier Suarez, 2002, "Last Bank Standing: What Do I Gain If You Fail?" *European Economic Review*, Vol. 46, No. 9, pp. 1599–622, available at http://ideas.repec.org/s/eee/eecrev.html

Petersen, Mitchell A., and Raghuram G. Rajan, 1995, "The Effect of Credit Market Competition on Lending Relationships," *Quarterly Journal of Economics*, Vol. 110, pp. 407–443.

Petersen, Torben, 1986, "Fitting Parametric Survival Models with Time-Dependent Covariates," *Applied Statistics*, Vol. 35, No. 3, pp. 281–8.

Podpiera, Richard, 2004, "Does Compliance with Basel Core Principles Bring Any Measurable Benefits?" IMF Working Paper 04/204 (Washington: International Monetary Fund).

Shaffer, Sherrill, 2004, "Comment on 'What Drives Bank Competition? Some International Evidence' by Stijn Claessens and Luc Laeven," *Journal of Money, Credit, and Banking,* Vol. 36, No. 3, pp. 585–92.

Smith, Bruce D., 1984, "Private Information, Deposit Interest Rates, and the 'Stability' of the Banking System," *Journal of Monetary Economics*, Vol. 14, pp. 293–317.

Staikouras, Christos, and Geoffrey E. Wood, 2000, "Competition and Banking Stability in Greece and Spain," *Journal of International Banking Regulation*, Vol. 2, No. 1.

Whalen, Gary, 1991, "A Proportional Hazards Model of Bank Failure: An Examination of its Usefulness as an Early Warning Tool". *Federal Reserve Bank of Cleveland Economic Review*, pp. 21–39.