Competition and banking stability in Europe: Empirical evidence

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Abstract

Although the increasing concern about financial stability in the aftermath of the Global Financial Crisis has been a fundamental focus of academic research, the academic literature has not yet reached a conclusion on whether competition is truly beneficial for banking stability. Under the traditional "competition-fragility" view, concentrated banking systems are more stable since the possession of a valuable "charter" discourages banks in engaging in imprudent behaviors. In contrast, the alternative "competition-stability" view argues that concentrated systems are more fragile as higher loan rates attract riskier borrowers. Extending the empirical study by Uhde and Heimeshoff (2009), the present Dissertation empirically investigates the relationship between banking competition and stability in 27 European countries during the 1997-2017 period, using annual data extracted from the World Bank and the ECB databases. The Herfindahl-Hirschman Index is used as a proxy for competition, while the Z-score is employed to capture banking sector stability.

Using a GLS random effect model (coupled with 2SLS instrumental variable technique), the present Dissertation's main findings unveil a positive relationship between competition and banking stability in Europe while controlling for macroeconomic, banking, regulatory, and institutional variables. In addition, the present critical analysis indicates that the higher volatility of returns renders concentrated systems more prone to financial instability. All in all, the present Dissertation's results raise concerns about the banking consolidation trend in the recent years in Europe. Policymakers must encourage competition as market discipline is a necessary requisite for a safe banking system.

Keywords: Banking competition, banking stability, Herfindahl-Hirschman Index, Z-score, Europe, volatility of returns.

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Abstrato

Na sequência da Crise Financeira Global, tem existido uma preocupação crescente com a estabilidade financeira (um foco fundamental de investigação). Todavia, a literatura não determinou se a concorrência é benéfica para a estabilidade bancária. A perspectiva '*competition-fragility*' propõe que os sistemas bancários concentrados são mais estáveis pois a existência de um '*charter*' valioso desencoraja os bancos a serem imprudentes. Por contraste, a perspectiva '*competition-stability*' argumenta que sistemas concentrados são mais frágeis pois as taxas de juros sobre empréstimos mais elevadas atraem mutuários de risco mais elevado. A partir de Uhde e Heimeshoff (2009), a presente Dissertação investiga empiricamente a relação entre a concorrência bancária e a estabilidade em 27 países Europeus para 1997-2017, usando dados anuais extraídos de *World Bank* e *ECB*. O índice *Herfindahl-Hirschman* é usado como uma *proxy* para a concorrência, e o Z-score é usado para captar a estabilidade do sector bancário.

A presente Dissertação utiliza o modelo *GLS random effect* (2SLS de variáveis instrumentais), e os resultados principais permitem descortinar uma relação positiva entre a concorrência e a estabilidade bancária na Europa, incluindo variáveis de controlo macroeconómicas, bancárias, regulatórias, e institucionais. Complementarmente, a presente análise crítica indica que a elevada volatilidade dos retornos propicia que os sistemas concentrados sejam mais propensos à instabilidade financeira. Os resultados da Dissertação suscitam algumas dúvidas sobre a tendência de consolidação bancária em curso nos últimos anos no continente Europeu. Os *policy makers* deverão encorajar a disciplina de mercado como um requisito necessário para a implementação de um sistema bancário seguro.

Palavras-chave: Concorrência Bancária, Estabilidade Bancária, Índice Herfindahl-Hirschman, Z-score, Europa, Volatilidade de Retornos.

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Our deepest fear is not that we are inadequate.

Our deepest fear is that we are powerful beyond measure.

It is our light, not our darkness, that most frightens us.

Nelson Mandela

1. Introduction

It is well-known that banks play a fundamental role in promoting economic growth within any given economy by allocating funds from savers to borrowers. However, while performing their function as financial intermediaries, banks typically accumulate different types of complex risks in their balance-sheet. The experience of the Global Financial Crisis of 2008 made clear the importance of monitoring and controlling such risks. Through financial interconnectedness, the insolvency of a bank can lead to a systemic banking crisis which has a deep impact on the economic activity. Indeed, it is documented that financial crisis are associated with huge fiscal costs and output losses (Leaven and Valencia, 2018). Furthermore, these events severely undermine public trust in the global banking sector. For this reason, and especially after the US subprime crisis, the major concern of regulators and public institutions is to safeguard the stability of the global financial system. In this regard, enhancing competition is generally viewed as necessary for a fully functioning banking system, just as it is in other non-financial sectors (Beck, 2008). Nevertheless, the academic literature has not reached a proper consensus on whether competition is beneficial for banking stability.

The traditional "competition-fragility" (or “concentration-stability”) literature suggests that the possession of a valuable "charter" induces banks to mitigate risks in concentrated systems. A prominent exponent of this view is represented by Keeley (1990) who shows how banking liberalization has reduced banking stability during the 1980's in the U.S.A. In support of this hypothesis, relevant literature has provided evidence that financial consolidation improves stability through higher capital buffers and a greater degree of diversification (Boyd et at., 2004; Diamond, 1984; Ramakrishnan and Thakor, 1984; Boyd and Prescott, 1986; Williamson, 1986). In addition, the surplus that credit institutions earn from their relationship with borrowers, and the strategic synergy between banks in case of liquidity shocks strengthens stability in less competitive frameworks (Chan et al., 1986; Saez and Shi, 2004). In contrast to this strand of literature, Boyd and De Nicolo (2005) conjecture a positive relationship between competition and stability. According to their model, a higher level on interest rates charged in concentrated systems induces borrowers to shift their investments to riskier projects, thus increasing the probability of loans default. Moreover, relevant studies supporting the “competition-stability” view have noticed that the presence of large banks in concentrated systems exacerbates the too-big-to-fail problem and reduces the supervision efficiency due to their higher organizational complexity (Mishkin, 1999;

Beck, 2008). Finally, as argued by Martinez-Miera and Repullo (2010), a non-linear relationship between competition and banking soundness may arise, with moderate competitive systems displaying a greater level of bank stability.

Against this background, the present Dissertation empirically assesses the impact of competition on banking stability for 27 European countries (henceforth EU-27) over the period from 1997-2017. Following Uhde and Heimeshoff (2009), the present document employs a GLS random effect model, and it adopts a 2SLS instrumental variable technique in order to address a potential endogeneity issue between competition and banking stability. Overall, the present Dissertation's main findings suggest that banking competition is stability enhancing across European countries. Further, the present paper shows that although concentrated banking systems display on average a higher level of capital, they are less stable than competitive systems due to their larger exposure to risk. These findings provide support to the "competition-stability" view proposed by Boyd and De Nicolo (2005) and complement and extend the empirical study by Uhde and Heimeshoff (2009) on the same research topic in several aspects. First, a longer time interval including the Global Financial Crisis of 2008 and the post-crisis period is considered. Second, while Uhde and Heimeshoff (2009) uses only the Z-score as a measure of banking soundness, the present critical analysis also includes non-performing loans (NPL's) as further proxy for stability. Third, previous studies, including Uhde and Heimeshoff (2009), have focused on using bank-level data for their analysis. Instead, the present Dissertation examines the competition-stability link from a broader perspective by employing country-level data provided by the World Bank and the European Central Bank (ECB) databases. All in all, using this approach allows for the critical stability analysis of the whole banking system in a given country and not of individual banks, thus providing a more macro perspective.

The Dissertation is structured as follows: section 2 presents the theoretical and the empirical literature review on the relationship between banking competition and financial stability; section 3 describes the data and reports the descriptive statistics; section 4 introduces the empirical methodology; section 5 contains the baseline empirical findings and the corresponding robustness tests; and, lastly, section 6 presents the main conclusions and corresponding policy implications.

2. Literature Review

The present section of the Dissertation critically reviews the theoretical and the empirical literature addressing the relationship between concentration and stability in the global banking industry. Although regulators/policymakers have been increasingly concerned about systemic stability after the Global Financial Crisis of 2008, no consensus has emerged in relation to the effect of greater or lesser consolidation on the soundness of the financial system, as the academic debate is still on-going.

According to the traditional concentration-stability hypothesis, less competitive banking systems are more stable since the earning of a monopoly rent reduces the incentives to take excessive risks. Keeley (1990), a prominent exponent of the well-known "charter-value" paradigm, presents a theoretical framework to explain why banking liberalization has led the number of US banks failures to hit a record high during the 1980's. The author shows that a fixed-rate deposit insurance system incentivizes banks to reduce the capital-to-asset ratio and to undertake excessive risk since potential losses are completely borne by the insuring agency. However, in a concentrated banking system where "charters" are limited in supply, and banks are protected by entry restrictions as well as interbank competition, banks are discouraged to increase the underlying default risk (Keeley, 1990). As the author asserts, the possession of a valuable charter creates "a regulatory bankruptcy cost which counterbalances the incentive for excessive risk taking due to fixed-rate deposit insurance" (Keeley, 1990: p. 1198). In other words, banks opt for mitigating risks since the opportunity cost of failure, namely the loss of a valuable charter, is very high. As the author observes, this is what happened in the U.S.A. during the 1950's and the early 1960's when U.S. banks were protected by anticompetitive regulation and banks' failure rate was at a minimum level. However, starting from the mid-1960's onwards, the banking sector became completely deregulated, and banks also began to face significant competition from nonbank financial institutions. The increase in competition eroded banks' market power, and the decline in "charter" value reduced the incentive for bank owners to invest prudently. In fact, as predicted by the theoretical model, as the charter value diminishes, the loss associated with insolvency decreases, and the risk-taking incentive created by the deposit-insurance system prevails. As a result of this imbalance between these two contrasting forces, capital-to-asset ratios have decreased, and a huge number of banks declared bankruptcy during the 1980's.

Boyd and De Nicolò (2005) revisit the theory of competition and bank risk taking by presenting a moral hazard model which predicts a positive relationship between banking concentration and fragility. According to the authors, the literature related to the "charter-value" paradigm focuses purely on the risk-taking mechanism operating in the deposit market, neglecting the existence of the loan market. This literature concludes that a way to reduce banks' risk incentives prevalent on the deposit side is to accommodate bank owners earning monopoly rent, so that a higher risk of failure is costly to them (Boyd and De Nicolò, 2005). To put it differently, by restricting banking competition, bank profit increases (as deposit interest rates decrease) and bank owners become less prone to take risks. As the authors observes, the key assumption of these studies is that banks optimally choose their level of risk by solving a portfolio selection problem where return distributions are given. However, the authors argue that less competition in the deposit market implies less competition in the loan market, and consequently higher loan rates charged to borrowers. As the level of loan interest rates increases (decreases), borrowers shift their investments to riskier (safer) project, thus increasing (lowering) the probability of loan default. This effect is known in the literature as 'risk-shifting effect'. So, in contrast to the "charter-value" literature, the riskiness of assets is not chosen by the bank owner, but it is the borrowers who endogenously choose the riskiness of their projects undertaken with bank loans (Beck, 2008). Therefore, once the bank-borrower relationship is taken into account, the "charter-value" paradigm is radically reverted: a concentrated banking system is characterized by lower stability due to a given borrower's excessive risk-taking.

As observed by Martinez-Miera and Repullo (2010), Boyd and De Nicolo (2005) derive a direct relationship between loan interest rates and banks' probability of failure under the assumption of perfectly correlated loan returns. In other words, to demonstrate that the competition-stability hypothesis actually holds, they implicitly assume the probability of loans default to totally coincide with the banks' probability of failure. Martinez-Miera and Repullo (2010) show that, in a more realistic case of an imperfect correlation of loan defaults, the effect of a greater bank competition on the system stability is ambiguous. As they observe, once imperfect default correlation is introduced in Boyd and De Nicolo's model, in addition to the "risk-shifting effect", there is a "margin effect" that goes in the opposite direction: as the degree of competition increases, the lower level of loan rates charged to borrowers reduces revenues from performing loans. Since revenues provide a capital buffer against losses, their reduction diminishes banks' stability. Hence, depending on the magnitude of these two contrasting effects, tightening, or loosening competition may be beneficial or not for banking stability. Thus, Martinez-Miera and Repullo (2010) prove, from a theoretical standpoint, that in very competitive banking system the "risk-shifting effect" is always dominated by the "margin effect", so that a further increase in competition worsens stability. On the other hand, when the number of banks is very low, any additional entry in the loans market improves the soundness of banks. In other words, in a concentrated banking system the "margin effect" is dominated by the "risk-shifting effect". In general, they provide evidence of a U-shaped relationship between competition and the risk of a bank failure, with moderate level of competition displaying the lowest probability of banks default (greater stability).

According to Mishkin (1999), both dangers and opportunities are associated with consolidation in the financial system. As the author asserts, a consequence of greater banking concentration is the shrinkage in the number of banks and the increase in size of many credit institutions. Since in a context of adverse market condition, the failure of a large bank exposes the financial system to systemic risk and contagion, policymakers tend to follow a "too-big-to-fail" policy exacerbating the moral hazard problem. In other words, large banks are more prone to take excessive risks since they know that they are backed by the government in case of potential failure (Stern and Feldman, 2004). The major consequence of these implicit guarantees is related to the increasing fragility of the financial system. Additionally, the government safety net protection dramatically reduces the depositors and creditors' incentives to monitor large banks, which in turn causes credit institutions to take on too much risk (Mishkin, 1999). In this regard, Boyd and Gertler (1993) show that, during the 1970's and the 1980's, U.S. large institutions hold riskier assets and liability positions than smaller banks and this contributed to a higher amount of loan losses for the large banks. Also, Boyd and Gertler (1993) observe that large banks tend to be less capitalized than small banks, thus fostering banking industry fragility. This stands in contrast to that strand of the academic literature assessing that large banks in concentrated systems enjoy higher "capital buffers" that protect them in case of adverse macroeconomic events or a liquidity shock (see Boyd et al., 2004). Mishkin (1999) points out that financial consolidation may also benefit banking stability if it leads to more cross-border activities that make banking institutions less prone to failure. Indeed, relevant literature related to financial intermediation has provided theoretical evidence that large banks are able to diversify loan-portfolio risks more efficiently due to higher economies of scale and scope (see Diamond, 1984; Ramakrishnan and Thakor, 1984; Boyd and Prescott, 1986; Williamson, 1986).

In support of the traditional concentration-stability hypothesis, Chan et al. (1986), Boot & Greenbaum (1993), and Besanko and Thakor (1993) provide theoretical evidence that as the level of competition increases, the surplus that banks can earn from their relationship with borrowers decreases. Consequently, banks have less incentive to properly screen and monitor borrowers which in turn causes a higher probability of loans losses. However, Carminal and Matutes (2002) argue that a higher degree of market power is often associated with credit rationing and larger loans. All else equal, the size of a loan is correlated with its riskiness, therefore concentrated markets are more likely to suffer from an insolvency crisis than competitive banking systems.

Allen and Gale (2004) presents a general review of theoretical models which have been developed to analyze the “competition-stability” nexus in the financial sector. First, analogously to the Arrow-Debreu model of general equilibrium, in the presence of complete financial markets and complete contracts, competition is stability enhancing (Allen and Gale, 2003a). However, considering a more realistic context with market imperfection, the authors show, similarly to Keeley (1990), that greater competition weakens stability by worsening the agency problem between depositors and managers. In fact, as profits converge to zero, banks have extreme incentives for risk taking in an attempt to remain profitable (Allen and Gale, 2004). Additionally, competition may impact stability through the interbank channel. Allen and Gale (2000) show that if markets are perfectly competitive, banks are price takers, and they have no incentive to provide liquidity to insolvent banks. The same conclusion is reached by Saez and Shi (2004), who suggest that concentrated markets are more stable since banks may act strategically and cooperate in case of a liquidity shock.

Another debatable argument concerns the supervision of banks in competitive *versus* concentrated system. Proponents of the competition-stability hypothesis argue that concentrated banking systems are less stable since they tend to have few large banks which are characterized by a higher degree of complexity than smaller banks in competitive systems. Indeed, due to the use of structured financial products and to their exposure across different geographical markets, large banks are hard to monitor and therefore more prone to evade regulatory frameworks and to take excessive risks (see Beck, 2008; Cetorelli et al., 2007). Also, Cetorelli et al. (2007) suggest that the increasing complexity of the organizations may reduce managerial efficiency and lead to bank governance failures. On the other hand, exponents of the concentration-stability hypothesis support the idea that fewer banks are easier to supervise than a massive number of small banks (Allen and Gale, 2000).

Uhde and Heimeshoff (2009) constitutes the first research that empirically investigates the impact of banking concentration on financial stability in EU-25 during the 1997-2005 period. Using a country-specific random-effects panel model to control for unobserved heterogeneity, the authors find evidence of a negative relationship between various measures of banking market concentration and banks' financial soundness as measured by the Z-score. The negative effect of concentration on the Z-score is statistically significant at 1% level and it is non sensitive to macroeconomic, banking, and regulatory control variables. As robustness check, the 2SLS instrumental variable technique is employed to address reverse causality bias concerning concentration and banking stability. Again, their findings remain consistent to the "competition-stability" view (Boyd and De Nicolo, 2005). The authors also find a positive impact of concentration on the Z-score components (ROA, capital ratios, and the volatility of ROA). Consequently, they conclude that the overall negative impact of concentration on banking stability is driven by a higher volatility of returns of larger banks in concentrated markets.

Fu, Lin and Molyneux (2013) inspect the competition-stability nexus in 14 Asia Pacific countries for the period from 2003 to 2010. Mindful of the theory of contestability[1], the authors extend previous empirical literature by including both structural and non-structural measures of competition (e.g., Lerner Index) in their analysis. Furthermore, as a proxy for banking stability they use both an accounting-based risk measure (Z-Score) and a market-based risk measure (Probability of Bankruptcy). Using data on commercial banks, extracted from BankScope database by Bureau van Dijk, and country concentration ratios from the World Bank database, the authors employ an instrumental variable technique with a GMM estimator to address endogeneity issues between bank competition and risk. Their main findings suggest that both excessive concentration and lower market pricing power can compromise banking stability. As the authors assert, these results are

[1] According to this theory, the structure of a market does not necessarily reflect the conduct of the firms in that market (i.e., even a duopoly may be a perfect competitive market if firms' behavior and the threat of new entrants leads them to earn zero profits) (Baumol et al., 1982).

consistent with the "finance for growth" policies adopted in the Asia Pacific region which have deterred banks from adopting a healthy credit culture in "too-concentrated" systems.

In the light of the Martinez-Miera and Repullo (2010) model, which has identified a U-shaped relationship between banking competition and risk-taking, Jiménez, Lopez and Saurina (2013) empirically assess the existence of a similar non-linear pattern using data for Spanish banks from 1988 to 2003. In order to perform their analysis, the authors employ standard concentration measures, which have been used in the literature to measure the degree of banking competition, such as the 5-bank asset concentration, the Herfindahl-Hirschman Index, and the number of banks. Also, the authors construct a direct measure of market power, the Lerner Index, by accessing the Banco de España's database, which provides granular data on marginal interest rates charged by Spanish banks for various banking products. The non-performing loan (NPL) ratio is used as proxy for bank riskiness since, as the authors observe, credit risk constitutes the major source of risk that Spanish banks accumulate in their balance-sheets. After controlling for macroeconomic variables and bank characteristics, Jiménez, Lopez and Saurina (2013) provide significant evidence of a convex relationship between competition and risk-taking when standard concentration measures are used as independent variables. More specifically, for extreme levels of concentration (too high or too low) banks experience a high incidence of non-performing loans in their portfolios which makes them more exposed to financial distress. On the contrary, lower levels of non-performing loans (high stability) are associated with a moderate level of concentration. Nevertheless, when the Lerner index is considered as a measure of competition, their empirical results find support for the traditional "charter-value" paradigm which predicts greater stability in highly concentrated system.

All in all, there is no clear consensus in the theoretical literature on the competition-stability nexus. Also, as showed by Beck (2008) which provide a comprehensive review on this fundamental research topic, empirical studies provide mixed results depending on the country and the period analyzed. Following Uhde and Heimeshoff (2009), the present Dissertation extends and complements the existing academic literature by analysing the relationship between banking competition and stability in Europe during the 1997-2017 period. To the best of knowledge, this is the longest timespan ever considered for such a critical analysis in Europe.

3. Data

The present Dissertation uses banking data across EU-27 countries for the period from 1997-2017, the longest period for which data is available. The original dataset contained banking data related to all the 28 European Member States from 1997 to 2017[2]. The adoption of this time interval, which encompasses both the Great Recession and the European Debt Crisis, is justified by the intention of significantly extending the empirical findings advanced by Uhde and Heimeshoff (2009), which only covers the 1997-2005 period. After excluding Croatia due to missing data for the main competition variable, we obtain a balanced panel data set with 566 annual observations. The primary source of our data is the Global Financial Development database provided by the World Bank. The Global Financial Development Database is a comprehensive dataset of financial system characteristics which includes aggregated annual data for 214 countries starting from 1960 until 2017. The dataset contains indicators that measure the depth, the access, the efficiency, and the stability of the banking system.

Table 1 presents the description of variables and data sources. Table 2 reports descriptive statistics for the entire dataset.

[2] The original dataset includes the Central, Eastern, and Baltic European member states (EU-11) that joined in 2004, 2007 and 2013: in 2004 the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic, and Slovenia; in 2007 Bulgaria, Romania; and in 2013 Croatia (Vértesy, 2018). 2017 is the end year because data about our main variables are not available after this date. This is a limitation of our dataset which does not include the whole business cycle up to 2020.

Table 1 – **Description of variables and data sources**

Variable	Definition	Data Sources
Z-score	Ratio of the sum of equity capital to total assets and ROAA to standard deviation of ROAA	Global Financial Development, World Bank
NPL	Bank non-performing loans to total gross loans (%)	Global Financial Development, World Bank
HHI	The Herfindahl-Hirschman Index is computed by summing the squares of the market shares of all the credit institutions in the banking sector	ECB Statistical Data Warehouse
5-bank asset concentration	Percentage of bank assets held by top 5 banks	Global Financial Development, World Bank
Num. of Credit Institution	Total number of credit institutions in a country	ECB Statistical Data Warehouse
GDP per capita	Gross domestic product per capita at constant prices, 2017 international dollar	World Economic Outlook database
Industrial Prod. Growth	Rate of industrial production growth (annual % growth)	World Development Indicators, World Bank (data for Malta are retrieved from Eurostat)
Inflation	Inflation as measured by the consumer price index (annual % change)	World Development Indicators, World Bank
Crisis dummy	Dummy variable that takes a value equal to 1 if the country experiences a systemic banking crisis and 0 otherwise.	Global Financial Development, World Bank
Net interest margin	Bank net interest margin (%)	Global Financial Development, World Bank
Non-Interest Income	Bank non-interest income to total income (%)	Global Financial Development, World Bank
Cost to Income	Bank cost to income ratio (%)	Global Financial Development, World Bank
Regulatory Capital	Minimum required risk-based regulatory capital ratio per country (%)	World Bank Survey of Bank Regulation and Supervision (BRSS)
Openness	Composite index of three indicator ranking policies in the areas of trade, capital flows and banking independence from government control	Heritage Foundation, authors calculation
EU-integration	Indicator that measures political parties' opposition to European policies and to the net-contribution to the EU budget	Manifesto Project, version 2020b

Several academic studies employ actual episodes of individual or systemic bank crisis in order to measure the soundness of the banking system (see Beck, 2008). However, as observed by Uhde and Heimeshoff (2009), using the number of bank failures as an indicator of banking stability may not be appropriate for several reasons. First, it is difficult to define the exact timing of a bank default i.e., the beginning and the end year of the crisis. Second, supervising authorities are less likely to announce a bank failure when this occurs due to poor bank governance and monitoring, since it would ultimately undermine confidence in the financial system. Third, as soon as a bank crisis occurs, regulators tend to put in place various containment policies in order to rescue defaulted banks and to avoid the onset of international financial contagion[3]. Considering all these aspects, the present Dissertation employs the Z-score as the main proxy for banking soundness[4]. The Z-score is an accounting-based risk measure which combines information on banks profitability, its volatility, and the leverage ratio. Developed by Boyd and Graham (1986) and Hannan and Hanweck (1988), the Z-score is defined as follows:

$$Z_{it} = \frac{ROA_{it}+E_{it}/TA_{it}}{\sigma_{it}^{ROA}} \quad (1)$$

where ROA is return on assets, E/TA is equity on total assets, and σ^{ROA} is the standard deviation of return on assets.

The Z-score is generally considered an inverse indicator of bank insolvency since it estimates the number of standard deviations banks' returns must fall in order to erode all equity (Schaeck and Cihák, 2014). To put it differently, the higher the Z-score, the lower the likelihood of bankruptcy. Indeed, a bank with a high level of profit and a high capital buffer is more capable of absorbing losses in case of an extreme financial event[5]. On the contrary, a bank with a volatile stream of profits is less stable and it could be severely affected by adverse market condition. As reported in Table 2, the Z-score has a median value of 10.025 with a wide variation between 0.017 and 47.573.

[3] See Leaven and Valencia (2018) for a general review of the policy responses to banking crisis.
[4] Zigraiova and Havranek (2016) show that 45% of the studies investigating the competition-stability nexus use the Z-score to measure banking stability (cited in Leroy and Lucotte, 2017).
[5] According to Berger and Bouwman (2013), a greater capital ratio enhances banks' survival probability during financial crises.

Table 2 – **Descriptive statistics**

Variable	N	Mean	SD	Min	Median	Max
Z-score	566	12.004	7.305	0.017	10.025	47.573
NPL	487	6.125	7.375	0.100	3.660	48.676
HHI	548	0.111	0.077	0.011	0.099	0.407
5-bank asset concentration	556	81.609	13.948	37.010	84.399	100.000
Num. of Credit Institutions	506	325.478	456.315	7.000	160.500	3238.000
GDP per capita	567	37833.369	17871.631	9891.390	36302.860	116338.070
Industrial Prod. Growth	563	2.312	6.663	-24.857	2.566	75.056
Inflation	567	5.124	45.012	-4.478	2.158	1058.374
Crisis dummy	567	0.145	0.352	0.000	0.000	1.000
Net interest margin	567	2.374	1.702	0.126	2.015	20.473
Non-Interest Income	566	40.680	11.530	14.638	39.530	81.250
Cost to Income	566	59.882	13.093	19.895	59.102	150.000
Regulatory Capital	547	8.374	0.982	8.000	8.000	12.000
Openness	567	74.632	8.722	45.900	74.100	89.300
EU-Integration	514	1.128	1.280	0.045	0.413	5.263

In addition to the Z-score, the present research also considers the non-performing loans ratio to total gross loans[6] (NPL) as a further measure of banking system soundness.

The NPL is conventionally used to assess the financial stability of banks since a high volume of NPL's may cause a given bank to default. Indeed, if borrowers fail in the repayment of loans, then the bank may not have enough liquid assets to meet its obligations towards depositors. In the extreme case of massive loan losses, the bank is forced to declare bankruptcy. Also, as pointed out by Jiménez, Lopez and Saurina (2013), using the NPL as a proxy for stability is judicious for two reasons: first, credit risk constitutes the main financial risk that commercial banks accumulate in their balance-sheets; second, both Boyd and De Nicolò (2005) and Martinez-Miera and Repullo (2010) focus on borrower behavior to model the relationship between banking competition and stability.

A fervent debate exists in the academic literature on how to accurately measure the degree of banking competition. Proponents of the traditional structure-conduct-performance hypothesis

[6] Note that the non-performing loans ratio is expressed in percentage. In addition, data about NPL are only available for the 1998-2017 period and contain missing values thus reducing the number of observations to 487.

argue that the structure of a market determines the level of competition. According to this strand of literature, concentration and competition are inversely related, so that extremely concentrated markets exhibit low levels of competition and vice versa (Fu, Lin and Molyneux, 2013). On the other hand, exponents of the New Industrial Organization (NIO) literature contend that it is improper to infer the actual degree of competition from conventional concentration measures. In essence, they argue that concentration indexes are crude measures of competition which do not consider that banks may not compete directly with each other in the same line of business (Beck, 2008). Also, concentration measures may overestimate the level of competition in small countries and tend to be biased when the number of banks is small (Bikker and Spierdijk, 2008). However, alternative measures of competition, such as the Panzar and Rosse (1987) H-Statistic, require certain assumptions on the long-run market equilibrium and impose restrictive conditions on the banks' cost function (see Beck, 2008; Schaeck and Cihák, 2014). Moreover, the Lerner Index poses some operational issues, as it requires the estimation of banks' marginal cost, and it is not able to fully capture product substitutability (Vives, 2008). All in all, despite the recent advances in the industrial organization literature, no clear consensus has been reached on how to properly measure the level of competition in a market (Beck, 2008). For this reason, the present Dissertation employs the traditional Herfindahl-Hirschman Index (HHI) to capture the level of banking competition in European countries. Data about the Herfindahl–Hirschman Index are retrieved from the European Central Bank Statistical Data Warehouse which contains an extensive dataset of annual structural financial indicators for the banking industry in every country of the European Union. The HHI is calculated by adding the squares of the market shares of all credit institutions in the banking sector. Also, the 5-bank asset concentration and the number of credit institutions are used as further proxy for competition.

Following relevant academic literature that have inspected the concentration-stability nexus (Uhde and Heimeshoff, 2009; Jiménez, Lopez and Saurina, 2013; Fu, Lin and Molyneux, 2013), macroeconomic, banking, regulatory, and institutional variables are included in the present econometric analysis in order to mitigate omitted variable biases. Macroeconomic variables are retrieved from the World Economic Outlook and the World Development Indicators whose data are provided by the World Bank and the International Monetary Fund (IMF). We include the following variables: GDP at constant prices in US dollar (2017), the Industrial Production growth rates, and the annual inflation rates. Banking system stability is likely to be related to the general level of economic development (Beck et al., 2007). Specifically, we expect a positive sign of the GDP per capita coefficient if a more efficient financial market corresponds to a higher level of economic progress. Instead, the inclusion of the Industrial Production growth rates serves to control for business cycle fluctuations. It is well known that banks enjoy better investment opportunities during the upward stage of the business cycle. This allows them to foster their profitability and to increase their capital buffers. Furthermore, as economic performance improves, borrowers' solvency may improve, raising the asset quality of banks (Uhde and Heimeshoff, 2009). The effect of inflation is somewhat ambiguous. Generally, when inflation increases, central banks set higher interest rates which may positively stimulate banks profitability. However, under these circumstances, banks may also face greater funding cost thus reducing their profits (Uhde and Heimeshoff, 2009). Moreover, 'Crisis' is a yearly dummy variable proposed by Leaven and Valencia (2012) that assumes a value equal to 1 if the country experiences a systemic banking crisis and 0 otherwise. A banking crisis is considered systemic if a country's banking system experiences significant financial distress and significant policy interventions are put in place in order to restore banks' solvency[7].

In order to assess the relationship between banking stability and competition, it is imperative to control for banking variables. We employ the net-interest margin as a proxy for banks' lending profitability, the non-interest income ratio to control for the business model diversification (see Leroy and Lucotte, 2017), and the cost to income as an indicator of banks' efficiency (Uhde and Heimeshoff, 2009). All banking control variables are taken from the Global Financial Development and are calculated using bank-by-bank data from Bankscope.

Regulatory capital proposed by Barth et al. (2001) is retrieved from the World Bank Survey of Bank Regulation and Supervision (BRSS). This variable indicates the minimum required risk-based regulatory capital ratio (i.e., as percent of risk-weighted assets) per country. If holding more capital reduce banks' insolvency risk and it induces managers to act more prudently, then we expect a positive effect of the regulatory capital coefficient on banks' stability[8].

[7] For more details on the criteria used to define and date systemic banking crisis see Leaven and Valencia (2012).
[8] Notably, capital requirements constitute the main instrument set within the Basel II and Basel III Agreements in order to safeguard financial stability.

Additionally, we include the variable Openness to control for the institutional environment and the general openness of the economy. It is obtained as an average of three indicators provided by the Heritage Foundation: Trade Freedom, Investment Freedom, and Financial Freedom[9]. Specifically, Openness contains information about trade barriers, existing constraints on the flow of capital, and governments' interference in the financial sector. Openness ranges from 0 to 100, with a higher value indicating less restrictions to competition and banking activity. If banks use a greater freedom to improve efficiency and diversify risk, we expect a positive effect of Openness on banking stability. On the other hand, higher levels of freedom may induce fragility in the financial system if credit institutions take on too much risk (Beck et al., 2007).

4. Methodology

To examine the effect of banking competition on financial stability, we estimate the following panel data regression:

$$Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k \, C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it} \qquad (2)$$

where Y_{it} represents alternatively one of the measures of banking stability used in the present Dissertation (Z-score or NPL), X_{it} is the Herfindahl-Hirschman Index (HHI), $C_{it,k}$ is the set of control variables described in the previous section, and ε_{it} is the error term. Also, year dummies $Year_t$ are included in the model to control for year-specific shocks[10]. The *i* subscript refers to the country and the *t* subscript to the year. Eq. (2) is estimated using the GLS random effect. The rationale behind the use of random effect is that it allows the inclusion in the model of time-invariant variables such as *Regulatory Capital*. Our choice is also validated by the Hausman test[11] which does not reject the null hypothesis according to which the random effects model is preferred (see Figure A.1 in the Appendix).

Additionally, the present Dissertation employs a two-stage least squares (2SLS) estimator to deal with the potential endogeneity of the competition variable considered. Following previous

[9] For more details about these three indicators see https://www.heritage.org/index/open-markets.
[10] The inclusion of year dummies is validated by the Wald test (rejected the null hypothesis according to which all coefficients are equal to 0). The dummy for the year 1997 is excluded to avoid perfect collinearity.
[11] See Hausman (1978). Specification tests in econometrics. Econometrica 46: 1251–1271.

academic literature, the instrumental variables used are the EU-Integration and the first lag of the HHI.

5. Empirical results

The present section of the Dissertation presents a detailed overview and a general discussion of the main findings.

Table 3 (see below) displays the pairwise correlation among the main variables used in this paper. Although moderate, there is a negative correlation (-0.259) between our main measure of competition (the HHI) and our proxy for stability (the Z-score). Hence, a simple correlation analysis may suggest a detrimental effect of a low level of competition on banking stability. Nevertheless, when NPL is considered as a measure of banking soundness, there is no evidence in supporting of either the “competition-stability” view (Boyd and De Nicolò, 2005) or the “concentration-stability” hypothesis (Keeley, 1990). Indeed, the correlation between the NPL and the HHI is 0.015. Ultimately, it is important to notice the strong positive correlation (0.556) between the Z-score and the GDP per capita. As expected, banking systems in higher developed countries may enjoy a greater degree of stability due to a more efficient performance of their financial markets. This is in line with Berger et al., (2009) which find evidence of a negative relationship between economic development and banks’ fragility.

<u>Table 3</u> – Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Z-score	1.000												
(2) NPL	-0.222***	1.000											
(3) HHI	-0.259***	0.015	1.000										
(4) GDP per capita	0.556***	-0.288***	-0.260***	1.000									
(5) Industrial Prod. Growth	-0.022	-0.087*	0.054	-0.072*	1.000								
(6) Inflation	-0.011	-0.117***	0.046	-0.104**	0.036	1.000							
(7) Crisis	-0.089**	0.185***	-0.106**	0.081*	-0.354***	0.097**	1.000						
(8) Net Interest Margin	-0.283***	0.237***	0.113***	-0.595***	0.106**	0.118***	-0.100**	1.000					
(9) Non-Interest Income	0.120***	-0.018	-0.217***	0.251***	0.105**	0.120***	-0.040	-0.241***	1.000				
(10) Cost to Income	-0.021	0.075*	-0.115***	-0.123***	0.024	-0.069*	-0.036	-0.004	0.141***	1.000			
(11) Regulatory Capital	-0.118***	0.004	0.129***	-0.303***	0.071*	0.189***	0.060	0.456***	-0.105**	-0.018	1.000		
(12) Openness	0.167***	-0.322***	0.120***	0.518***	-0.064	-0.122***	0.086**	-0.466***	0.168***	-0.189***	-0.316***	1.000	
(13) EU-Integration	-0.050	0.064	0.156***	-0.141***	-0.013	-0.083*	-0.140***	-0.003	-0.111**	-0.027	0.080*	0.052	1.000

**** p<0.01, ** p<0.05, * p<0.1 (Bonferroni-adjusted significance level)*

5.1 Main findings

Table 4 – Banking competition and stability

Variables	(1) Z-score	(2) Z-score	(3) Z-score	(4) Z-score
HHI	-23.90***	-14.58***	-14.45***	-13.92**
	(5.618)	(5.513)	(5.219)	(5.474)
GDP per capita		0.000214***	0.000249***	0.000260***
		(3.90e-05)	(3.36e-05)	(3.76e-05)
Industrial Prod. Growth		0.0793***	0.0672**	0.0612**
		(0.0289)	(0.0297)	(0.0306)
Inflation		0.128	0.0346	0.0378
		(0.0819)	(0.0867)	(0.0867)
Crisis		-0.460	-0.561	-0.582
		(0.555)	(0.566)	(0.589)
Net interest margin			0.816***	0.646***
			(0.219)	(0.237)
Non-Interest Income			0.0197	0.0185
			(0.0178)	(0.0178)
Cost to Income ratio			-0.0111	-0.00888
			(0.0153)	(0.0155)
Regulatory Capital				0.297
				(0.239)
Openness				-0.0762*
				(0.0442)
Observations	547	545	544	524
R-squared	0.105	0.357	0.343	0.349
Number of countries	27	27	27	27
Year fixed effects	YES	YES	YES	YES
Wald chi2	106.9***	154.2***	180.5***	172.6***
Prob > chi2	0.0000	0.0000	0.0000	0.0000

The panel model estimated is $Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it}$ where the dependent variable is the Z-score, X_{it} is the Herfindahl-Hirschman Index (HHI), $C_{it,k}$ is the set of control variables described in the data section, and ε_{it} is the error term. Year dummies $Year_t$ are included in the model. Constant term included but not reported. All control variables are omitted in specification (1). Banking control variables, regulatory and institutional variables are omitted in specification (2). Regulatory and institutional variables are omitted in specification (3).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 and Table 5 present the results of our baseline model (Eq.2) which examines the competition-stability nexus across the EU-27 countries. In Table 4, we estimate random effect GLS regressions controlling for macroeconomic, banking, regulatory, and institutional variables. The research goal is to study the impact of banking competition (herein measured by the HHI) on the banking system stability (herein evaluated by the Z-score). The R-squared and the Wald statistic are reported as general measures of the goodness of fit.

As described in Table 4, HHI's coefficient is negative in all regression specifications (1)-(4), thus indicating that increases in banking concentration (low bank competition) are associated with more fragile banking systems in the EU-27 countries. More specifically, the coefficient of HHI is negative and statistically significant at 1% level for specifications (1)-(3), whereas it is statistically significant at 5% level for specification (4) when all the remaining control variables are considered.

In regression specification (1) we start by including only the HHI as the main explanatory variable. The coefficient estimate indicates that a one standard deviation increase in the concentration ratio (i.e. a 0.077 increase in HHI) is associated with a 1.84 (=0.077 x -23.9) unit reduction in the Z-score. Further, this implies that a country increasing 0.077 in its HHI, would move up to one decile in the Z-score ranking (see Table A.1 in the Appendix). This result is consistent with Uhde and Heimeshoff (2009) who find a negative effect of concentration on European banks' financial soundness. Also, since banking variables are not included in specification (1), results are not attributable to banking variables endogeneity (Uhde and Heimeshoff, 2009). Specification (2) presents the coefficient estimates when macroeconomic variables are included in the regression model. The coefficient of HHI reduces its magnitude since part of the variation in the dependent variable is actually captured by the GDP per capita and the Industrial Production Growth. As expected, GDP per capita enters the regression positive and statistically significant at 1% level. As discussed above, this result may suggest that a thriving economic environment enhances banks' strength through the greater development of the credit markets, higher liquidity of financial markets, and a compelling prudential supervision[12]. In this regard, it is important to observe that although one of the major goals of the European Union is the economic convergence among its Member States, regional differences do still exist between Western and Eastern countries, a fact

[12] Accordingly, Leaven and Valencia (2018) show that during the 1970-2017 period, most of the systemic banking crisis episodes have taken place in low and middle-income countries.

which may affect financial stability. Nonetheless, Industrial Production Growth is positively and significantly related to the Z-score, which implies that banks are less vulnerable during economic booms.

Moreover, banking control variables are considered in column (3), and regulatory and institutional variables are addressed in column (4). As Table 4 displays, our results remain consistent to the "competition-stability" view (Boyd and De Nicolò, 2005). In addition, net interest margin enters both specifications (3) and (4) significantly positive at the 1% level thus confirming that revenues from traditional intermediation activities are fundamental to preserve banking stability. Indeed, De Jonghe (2010) finds that banks focusing on lending activities are safer than banks shifting to non-traditional banking activities in order to diversify risks[13]. Surprisingly, Regulatory Capital does not seem to possess a significant effect on banking system stability, although the coefficient estimate is positive as expected. Finally, as shown in column (4), Openness enters the regression significantly negative at 10% level. Given that Openness is a composite index of trade, investment, and financial freedom, this result may indicate that excessive liberalization may lead to banks' imprudent behavior (Beck, 2008; Demirguc-Kunt and Detragiache, 1999).

When examining the competition-stability nexus, it is imperative to control for omitted variables bias (see Anginer et al., 2014). Also, a potential endogeneity issue may arise between the competition variable and the measure of banking system soundness. As observed by Berger et al., (2009) and Uhde and Heimeshoff (2009), if a financially steady bank starts to pursue a growth strategy by merging with an insolvent and less-capitalized bank, then the causality between stability and competitiveness is completely inverted: banking stability would have a causal effect on concentration. To further address these points, and following previous literature (see Uhde and Heimeshoff, 2009; Anginer et al., 2014; Leroy and Lucotte, 2017), the present Dissertation adopts an instrumental variables technique using the two-stage least square (2SLS) panel estimator. EU-Integration and the first lag of HHI are used as instruments for HHI. EU-Integration is retrieved from the Comparative Manifesto Project by the Manifesto Research Group, which codes the policy positions of all relevant parties (i.e., those that won at least one seat in Parliament or two seats in Central and Eastern European (CEE) countries) for 50 countries from 1945 onwards. EU-

[13] See also Mercieca et al. (2007) for a further discussion about business diversification in the European banking markets.

Integration measures political parties' opposition to European policies and to the net-contribution to the EU budget. As stated by Uhde and Heimeshoff (2009), to the extent that a country opposition to the European Integration Project can be seen as a general aversion towards competitiveness, EU-Integration should have a positive effect on market concentration. Table 5 presents the results of the 2SLS estimation approach. EU-Integration is employed as an instrument in specification (5), while the first lag of HHI is used in specification (6)[14]. The coefficient estimates remain quite consistent with the random-effect panel model (Table 4) previously presented, thus excluding the line of argumentation that our main findings are distorted by endogeneity.

[14] Table 6 reports the first stage regressions of the 2SLS estimator which confirm the validity of the instruments used.

<u>Table 5</u> – Instrumental variables regressions

	(5)	(6)
Variables	Z-score	Z-score
HHI	-46.49*	-15.06**
	(27.96)	(6.489)
GDP per capita	0.000192***	0.000254***
	(6.43e-05)	(4.12e-05)
Industrial Prod. Growth	0.0546	0.0565*
	(0.0348)	(0.0311)
Inflation	0.0297	0.0281
	(0.115)	(0.0970)
Crisis	-0.759	-0.631
	(0.654)	(0.597)
Net interest margin	0.604**	0.613**
	(0.301)	(0.250)
Non-Interest Income	0.0145	0.0211
	(0.0202)	(0.0188)
Cost to Income ratio	-0.00395	-0.00936
	(0.0175)	(0.0163)
Regulatory Capital	0.374	0.327
	(0.275)	(0.244)
Openness	-0.0553	-0.0961**
	(0.0630)	(0.0462)
Observations	482	498
R-squared	0.239	0.346
Number of countries	27	27
Year fixed effects	YES	YES
Wald chi2	134.2***	153.2***
Prob > chi2	0.0000	0.0000

The panel model estimated is $Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it}$ where the dependent variable is the Z-score, X_{it} is the Herfindahl-Hirschman Index (HHI), $C_{it,k}$ is the set of control variables described in the data section, and ε_{it} is the error term. Year dummies $Year_t$ are included in the model. Constant term included but not reported. A 2SLS estimation approach is used to estimate specifications (5) and (6). HHI is instrumented using EU-integration in specification (5) and the first lag of HHI in specification (6).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 – **First stage regressions (instruments)**

Variables	(1) HHI	(2) HHI
GDP per capita	-1.54e-06***	-1.60e-07
	(3.13e-07)	(1.50e-07)
Industrial Prod. Growth	5.76e-06	-0.00010
	(0.0003)	(0.0001)
Inflation	0.00014	-0.00068*
	(0.0008)	(0.0004)
Crisis	-1.98e-06	-0.00196
	(0.0049)	(0.0022)
Net interest margin	0.00301	0.00145
	(0.0022)	(0.0008)
Non-Interest Income	-0.00015	-0.00005
	(0.0001)	(0.0001)
Cost to Income ratio	0.00014	-0.00002
	(0.0001)	(0.0001)
Regulatory Capital	-0.00028	0.00005
	(0.0021)	(0.0009)
Openness	0.00110***	0.00011
	(0.0004)	(0.0002)
EU-Integration	0.00675***	
	(0.0014)	
L1.HHI		0.90926***
		(0.0482)
Observations	482	498
Number of countries	27	27
Year fixed effects	YES	YES
Wald chi2	90***	2045***
Prob > chi2	0.0000	0.0000

HHI is instrumented using EU-integration in specification (5) and the first lag of HHI (L1.HHI) in specification (6).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Further, to shed light on the channels through which competition enhances banking stability, the present document investigates the relationship between concentration and the components of Z-score (ROA, Capital Ratio, standard deviation of ROA)[15]. Such analysis allows us to understand whether the positive impact of competition on stability is driven by greater profitability, a larger amount of capital owned by banks, or a lower volatility of returns (see Schaeck and Cihák, 2014). Table 7 exhibits the correlation matrix of the Z-score components and the HHI. Table 8 reports the result of random-effect regressions analysis.

Table 7 – Z-score components and HHI pairwise correlations

Variables	(1)	(2)	(3)	(4)
(1) HHI	1.000			
(2) ROA	0.048	1.000		
(3) cap_to_assets	0.283***	0.050	1.000	
(4) stdevROA	0.176***	-0.480***	0.074*	1.000

*** *p<0.01, *** *p<0.05, ** *p<0.1 (Bonferroni-adjusted significance level)*

[15] Data about ROA and Capital Ratio are taken from Global Financial Development Database. Standard deviation of ROA is computed for a given country by using three years rolling window. Given space constraints, data pertaining to these three variables were not analyzed in the summary statistics table.

<u>Table 8</u> – The effect of HHI on the Z-score components

Variables	(1) ROA	(2) Capital Ratio	(3) Sd ROA
HHI	-2.295	6.354***	25.92***
	(9.837)	(2.211)	(8.069)
GDP per capita	0.000104*	1.44e-05	-9.02e-05**
	(5.47e-05)	(1.40e-05)	(4.47e-05)
Industrial Prod. Growth	0.384***	0.0499***	-0.170**
	(0.108)	(0.0124)	(0.0808)
Inflation	0.672**	-0.0640	-0.360
	(0.309)	(0.0413)	(0.244)
Crisis	-9.475***	0.0637	5.615***
	(2.075)	(0.244)	(1.556)
Net interest margin	0.663	0.330***	0.538
	(0.729)	(0.105)	(0.568)
Non-Interest Income	-0.0826	0.00934	0.145***
	(0.0584)	(0.00771)	(0.0456)
Cost to Income ratio	-0.184***	0.00110	0.0312
	(0.0493)	(0.00642)	(0.0376)
Regulatory Capital	1.250	-0.165	-0.567
	(0.805)	(0.109)	(0.606)
Openness	0.0357	-0.0941***	-0.0418
	(0.106)	(0.0196)	(0.0854)
Observations	525	457	503
R-squared	0.296	0.313	0.169
Number of countries	27	27	27
Year fixed effects	YES	YES	YES
Wald chi2	216.3***	221***	97.43***
Prob > chi2	0.0000	0.0000	2.51e-09

The panel model estimated is $Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it}$. ROA, Capital Ratio and St. Dev of ROA are respectively the dependent variable in specification (1)-(3). X_{it} is the Herfindahl-Hirschman Index (HHI), $C_{it,k}$ is the set of control variables described in the data section, and ε_{it} is the error term. Year dummies $Year_t$ are included in the model. Constant term included but not reported.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

ROA is included as a dependent variable in specification (1). Conversely to the traditional theory of industrial organization (Tirole, 1988), there is no evidence that higher profitability is associated with concentrated markets. A similar result is found in Schaeck and Cihák (2014) who suggest that the increase in profits in less competitive banking systems is vanished by cost inefficiencies. Also, in support of this hypothesis, Berger and Hannan (1998) show that banks in concentrated systems have poorer cost efficiency due to the lack of market discipline. In addition, specification (1) shows, as expected, that banks' profitability is enhanced during the upward stage of the economic/business cycle, whereas it sharply declines throughout a systemic banking crisis. Further, regression specification (2) investigates the relationship between competition and the fraction of capital owned by banks. As Table 8 shows, HHI enters the regression (2) positive and statistically significant at the 1% level thus implying that the average capital ratio of banks in concentrated systems is higher than the average of banks operating in competitive markets. This finding is in line with the "charter value" literature (Marcus, 1984; Keeley, 1990) according to which banks in less competitive systems tend to hold more capital as protection against the risk of failure. Also, Uhde and Heimeshoff (2009) find the same type of relationship in their empirical study. Nevertheless, this stands in contrast with Allen et al. (2011), which supports the idea that greater competition induces banks to hold a larger stake of capital.

Finally, we include the standard deviation of ROA as the dependent variable in specification (3). The coefficient estimate of HHI is positive and statistically significant at the 1% level. As the volatility of returns is generally associated with greater exposure to risk, specification (3) may imply that concentrated banking systems incentivize banks to imprudent behaviors which in turn weaken their stability. Such evidence is consistent with Boyd and De Nicolò (2005) claiming that loan losses are bigger in oligopolistic environments and with the moral hazard problem related to higher market power (Stern and Feldman, 2004).

All things considered, the negative relationship between HHI and Z-score for the EU-27 countries is most likely due to the positive impact of HHI on the volatility of ROA. Notwithstanding greater capital ratios, concentrated banking systems bear on average more risks than competitive systems. This finding may suggest that market discipline deriving from competition is crucial for financial stability (see Schaeck and Cihák, 2014).

5.2 Robustness Tests

Table 9 – Robustness analysis

Variables	(1) Z-score	(2) Z-score	(3) NPL
5-banks asset concentration (%)	-0.0651***		
	(0.0220)		
Number of Credit Institutions		0.00321**	
		(0.00130)	
HHI			8.737**
			(4.043)
GDP per capita	0.000271***	0.000258***	-3.74e-05
	(3.72e-05)	(4.37e-05)	(2.32e-05)
Industrial Prod. Growth	0.0465	0.0722**	-0.0339
	(0.0298)	(0.0326)	(0.0509)
Inflation	0.00807**	0.141**	-0.467***
	(0.00352)	(0.0700)	(0.161)
Crisis	-0.417	-0.357	6.582***
	(0.573)	(0.659)	(0.967)
Net interest margin	0.705***	0.459	1.126***
	(0.157)	(0.292)	(0.338)
Non-Interest Income	0.00799	0.0246	0.0559**
	(0.0180)	(0.0192)	(0.0277)
Cost to Income ratio	-0.0256	-0.0125	-0.00855
	(0.0185)	(0.0172)	(0.0226)
Regulatory Capital	0.401*	0.230	-0.914**
	(0.213)	(0.247)	(0.408)
Openness	-0.0932**	-0.102**	-0.332***
	(0.0410)	(0.0520)	(0.0464)
Observations	530	484	460
R-squared	0.322	0.355	0.398
Number of countries	27	27	27
Year fixed effects	YES	YES	YES
Wald chi2	414***	146.8***	284.7***
Prob > chi2	0.0000	0.0000	0.0000

The panel model estimated is $Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it}$. The Z-score is the dependent variable in specification (1) and (2). NPL is the dependent variable in specification (3). X_{it} is the 5-bank asset concentration in (1), the Number of Credit Institutions in (2), the HHI in (3). $C_{it,k}$ is the set of control variables described in the data section, and ε_{it} is the error term. Year dummies $Year_t$ are included in the model. Constant term included but not reported.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The present Dissertation runs a variety of robustness checks on the main baseline model. Table 9 shows the result of the sensitivity analysis performed in this work. Following previous empirical literature (Uhde and Heimeshoff, 2009; Jiménez, Lopez and Saurina, 2013), 5-banks asset concentration and the number of credit institutions are also employed as proxies for banking concentration[16]. As Table 9 reports, the result of our baseline model is not sensitive to the measure of concentration used. The 5-bank asset concentration enters specification (1) negative and statistically significant at the 1% level, thus confirming that high banking concentration is associated with a greater fragility of the system. Instead, regression specification (2) includes the number of credit institutions as the main explanatory variable. The related coefficient estimate is positive and statistically significant at 5% level. Considering that the number of banks is a direct proxy of competition (i.e., the higher the number of banks, the greater the competition), findings related to specification (2) support the competition-stability view. This result is consistent with Stiglitz and Weiss (1981) showing that banking risk declines as the number of banks increases. Also, in line with Table 4, we find a positive effect of economic development and banks profitability on stability. In addition, Regulatory Capital enters specification (1) positive and statistically significant at the 10% level, thus implying that measures like capital requirements provided by the Basel Agreements may be effective in strengthening banking soundness. Indeed, capital buffers protect any given bank during the downward stage of the business cycle, and they also encourage managers to act prudently (Keeley, 1990). Finally, the Z-score is replaced by the NPL as a measure for stability in specification (3). Berger et al., (2009), Schaeck and Cihák (2014), Jiménez, Lopez and Saurina (2013) also use the NPL metric in their research. As specification (3) shows the effect of HHI on NPL is positive and statistically significant at the 5% level. This indicates that credit risk rises as banking concentration get higher. Again, the latter finding fully endorses that the competition-stability view holds for the EU-27 countries.

Following Uhde and Heimeshoff (2009), the present document also runs the baseline model (Eq.2) by splitting the dataset in Western and Eastern European countries. Such analysis is required since the European banking system appears somewhat fragmented with significant regional differences which may bias our results. Indeed, some European countries display greater banking concentration

[16] 5-bank asset concentration is retrieved from the Global Financial Development database by the World Bank. The number of credit institutions is extracted from the ECB Statistical Data Warehouse.

since they are smaller than other countries (e.g., Estonia). Also, privatization of large state-owned banks arising from financial deregulation has led to highly consolidated banking systems in Eastern European countries (Uhde and Heimeshoff, 2009). Table 10 displays the result of the regression analysis. The regression specification (1) reports the coefficient estimates for Western countries. Eastern countries are then considered in specification (2). Consistently with previous baseline findings (Table 4) the coefficient of HHI is negative and statistically significant at 1% level for both specification (1) and (2), and the impact (measured in absolute value) is greater in Western countries, given the value of the coefficients related to HHI in both specifications. Overall, this confirms that banking competition is stability enhancing and that our main findings are not biased from heterogeneity between countries.

<u>Table 10</u> – Western *vs.* Eastern countries

Variables	Western (1) Z-score	Eastern (2) Z-score
HHI	-17.28***	-13.09***
	(6.182)	(4.854)
GDP per capita	0.000258***	-0.000123*
	(3.17e-05)	(7.10e-05)
Industrial Prod. Growth	-0.0408	0.173***
	(0.0587)	(0.0621)
Inflation	-0.202	-0.0823
	(0.361)	(0.122)
Crisis	-2.730**	1.481
	(1.306)	(0.997)
Net interest margin	0.0361	0.375
	(0.558)	(0.368)
Non-Interest Income	-0.0225	-0.161***
	(0.0320)	(0.0360)
Cost to Income ratio	-0.00436	-0.0345
	(0.0258)	(0.0331)
Regulatory Capital	0.602	-0.515
	(0.634)	(0.344)
Openness	-0.227***	0.176***
	(0.0692)	(0.0484)
Observations	339	185
R-squared	0.337	0.280
Number of countries	17	10
Year fixed effects	YES	YES
Wald chi2	133.7***	60.04***
Prob > chi2	0.0000	0.000912

The panel model estimated is $Y_{it} = \alpha_{it} + \beta_1 X_{it} + \sum \gamma_k C_{it,k} + \sum_{n=1}^{20} \delta_n Year_t + \varepsilon_{it}$ where the dependent variable is the Z-score, X_{it} is the Herfindahl-Hirschman Index (HHI), $C_{it,k}$ is the set of control variables described in the data section, and ε_{it} is the error term. Year dummies $Year_t$ are included in the model. Constant term included but not reported. Western countries are considered in specification (1). Eastern countries are considered in specification (2). See Table A.2 in the appendix for the list of countries included in both the groups.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Lastly, in order to test the hypothesis suggested by Martinez-Miera and Repullo (2010) of a non-linear relationship between banking competition and stability, the squared HHI term is included in the baseline model (Eq.2). The results are reported in Table A.3 (see Appendix). Overall, there is no evidence that greater stability is associated with moderate levels of competition. Instead, in contrast to Martinez-Miera and Repullo (2010) model, Table 10 seems to indicate that banking stability is enhanced in very competitive or extremely concentrated systems. However, considered the previous findings of this document, some degree of caution is nevertheless warranted in assessing that concentrated systems fully promote banking stability in European countries, in light of the significant complexity associated with this fundamental research question.

6. Conclusion

Using cross country annual data, the present Dissertation investigates the relationship between banking competition and stability for the EU-27 countries during the 1997-2017 period. Following the previous related literature, the Z-score is employed as the main measure of banking system stability, while the traditional Herfindahl-Hirschman Index (HHI) is used to estimate the level of banking competition in European countries. Data about our main variables are retrieved from the Global Financial Development Database by the World Bank and the ECB Statistical Data Warehouse. By applying a GLS random effect model, the present document unveils a significant negative association between the HHI and the Z-score, thus suggesting that, across European countries, banking competition is stability enhancing. Our findings hold while controlling for macroeconomic, banking, regulatory and institutional variables. Additionally, in order to address a potential endogeneity issue, an instrumental variables technique using the two-stage least square (2SLS) panel estimator is adopted. Also, a wide variety of robustness testing is performed by using alternative measure of concentration and stability, and also by splitting the dataset in Western and Eastern countries. Overall, the results remain consistent with the "competition-stability" view proposed by Boyd and De Nicolò (2005) and extend empirical findings by Uhde and Heimeshoff (2009). The present Dissertation also inspects the relationship between the HHI and the Z-score components. We find no evidence that concentrated banking systems enjoy greater profitability. Instead, higher capital ratios and higher volatility of returns are associated with less competitive systems. All in all, this may indicate that the negative effect of concentration on stability is driven by greater risk undertaken in consolidated system. Regarding this point, it is worth to notice that although some hypotheses can be advanced, the identification of channels through which concentration intensify banks risk-taking is beyond the scope of this paper, due to space constraints. Therefore, further research is needed in this area. Our empirical findings have important implications for policymakers and regulators. In the last decade, the EU-28 countries have experienced a sharp decline in the number of banks as a consequence of mergers and acquisitions involving European credit institutions [17]. The ECB is encouraging consolidation as a strategy to strengthen capital position, rationalize costs, and to improve European banks' profitability[18]. In particular, the latter determinant represents the main challenge facing European banks due to the low level of interest rates and the emerging competition of non-bank companies providing financial services (Saravia and Saletta, 2020). The present Dissertation nevertheless suggests that if banking concentration boosts capital ratios, it does not necessarily increase profitability. More importantly, concentrated banking systems are less stable due to higher exposure to risk. It may happen that banks in concentrated systems use their market power to increase the lending-deposit spread and boost earnings. However, in a context of adverse selection, the increase of interest rates attracts riskier borrowers which in turn causes a greater amount of non-performing loans. Also, managers in concentrated systems may engage in speculative activities by exploiting regulatory arbitrage and the presence of implicit guarantees. Therefore, regulators should not undervalue the detrimental effect of concentration on stability when examining a potential merger. Further, they should encourage the promotion of transparent and competitive markets.

[17] The European Banking Federation reports a 30% decline in the number of banks since 2009 (see Banking in Europe: EBF Facts & Figures 2020)
[18] KPMG (2021)

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Appendix

Figure A.1 – **Hausman Test**

```
                 b = consistent under Ho and Ha; obtained from xtreg
  B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(29) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =       41.37
             Prob>chi2 =      0.0640
             (V_b-V_B is not positive definite)
```

Table A.1 - **Z-score Percentile**

10	4.517537
20	6.049034
30	7.47642
40	8.520854
50	10.02462
60	12.09858
70	14.9209
80	17.56446
90	21.52281

<u>Table A.2</u>

List of countries

Western	**Eastern**
Austria	Bulgaria
Belgium	Cech Republic
Cyprus	Croatia
Denmark	Estonia
Finland	Hungary
France	Latvia
Germany	Lithuania
Greece	Poland
Ireland	Romania
Italy	Slovak Republic
Luxembourg	Slovenia
Malta	
Netherlands	
Portugal	
Spain	
Sweden	
United Kingdom	

Croatia is then excluded from the original dataset due to missing values.

Table A.3– Non-linear relationship between competition and stability

Variables	(1) Z-score
HHI	-45.14***
	(14.91)
HHI Squared	74.34**
	(32.88)
GDP per capita	0.000248***
	(3.68e-05)
Industrial Prod. Growth	0.0609**
	(0.0306)
Inflation	0.0442
	(0.0870)
Crisis	-0.505
	(0.592)
Net interest margin	0.632***
	(0.237)
Non-Interest Income	0.0148
	(0.0179)
Cost to Income ratio	-0.0106
	(0.0155)
Regulatory Capital	0.214
	(0.243)
Openness	-0.0965**
	(0.0449)
Observations	524
R-squared	0.347
Number of countries	27
Year fixed effects	YES
Wald chi2	180.6***
Prob > chi2	0.0000

<u>Table A.4</u> - Average Z-score and HHI by country

CountryName	Z-score	HHI	GDP per capita
Austria	20.17	0.05	49816.52
Belgium	11.00	0.15	46110.60
Bulgaria	9.05	0.08	15211.28
Croatia	4.49	0.14	22160.35
Cyprus	7.50	0.12	35530.83
Czech Republic	11.49	0.11	30738.22
Denmark	17.35	0.12	50731.09
Estonia	6.48	0.33	24892.67
Finland	12.04	0.29	43281.22
France	17.95	0.06	42869.30
Germany	18.43	0.02	46565.20
Greece	5.80	0.14	30970.45
Hungary	5.56	0.08	23573.88
Ireland	5.33	0.06	54381.76
Italy	13.19	0.03	42473.88
Latvia	5.95	0.11	19719.61
Lithuania	6.18	0.20	22032.30
Luxembourg	28.51	0.03	103123.27
Malta	24.45	0.15	32150.67
Netherlands	12.42	0.19	50068.90
Poland	8.03	0.06	21101.91
Portugal	9.86	0.10	30635.49
Romania	7.08	0.10	18228.47
Slovak Republic	15.38	0.12	22475.67
Slovenia	2.99	0.12	30781.00
Spain	18.54	0.06	36262.76
Sweden	10.74	0.08	45487.94
United Kingdom	9.87	0.04	41379.99