SPOUDAI Journal of Economics and Business, Vol.67 (2017), Issue 2, pp. 3-25

University of Piraeus

SPOUDAI
Journal of Economics and Business
Σπουδαί
http://spoudai.unipi.gr

Competition and Efficiency in EU Banking

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Abstract

On the road to the new landscape in EU banking brought on by the financial crisis we assess the relationship between the level of competitiveness and efficiency. We estimate X-inefficiency for a sample of banks operating in the European Union using the stochastic frontier approach. We relate efficiency levels to market competitiveness employing Panzar & Rosse's ***H*** statistic for three clusters of banks constructed according to their efficiency scores. In addition, we examine the impact of efficiency, as well as concentration, on banking competition measured by the Net Interest Margin (NIM), controlling for bank specific factors. Overall we find that larger banks tend to be more efficient. In contrast, it seems that there exists a group of smaller banks in our sample that are 'relationship', 'niche' or 'regionally' protected from the hazards of competition and are X-inefficient. Moreover, the efficient group of banks entertains increases in NIM as they get more efficient, indicating that efficiency gains are not passed on to customers.

JEL Classification: G20, G21, L10
Keywords: Banking, Competition, Efficiency, Concentration

1. Introduction

Our purpose is to elicit a better understanding of the connection between competition, concentration and efficiency in the EU banking sector. This nexus has not been exhausted despite recent advances in researching the subject, (Goddard, Molyneux, Wilson and Tavakoli, 2007; Wilson, Casu, Girardone and Molyneux, 2010; Schaeck and Cihák, 2014; Bolt and Humphrey, 2015; Clerides, Delis and Kokas, 2015). Two prominent issues calling for a reiteration of this area of research are, the still lingering banking crisis in Europe, as wells as the ensuing drive for a regulatory and possibly banking sector consolidation in the euro zone area.

The drums of reregulation in banking can be heard in a distance. Governments and Central Banks ponder on the issue of designing and implementing institutional changes, which will alter the incentives mechanism of bank management and enhance stability in the sector. A necessary ingredient for a fruitful assessment of these issues would be a depiction of the interconnection between the level of bank X-inefficiency, competition and concentration in EU banking. New regulation for instance, may demand increases in bank capital and a revisiting of bank portfolio risk. Recapitalization funds could be found either in bank retained earnings, or new equity issues and hybrids. An alternative source of new equity capital, albeit for banks that are failing or likely to fail, could be funds from national resolution authorities (that aim to build-up over a ten-year period a European Union single resolution fund (SFR), following however bail-in provisions that would come into force in January 2016, and will enable national authorities to convert into equity the claims of the shareholders and creditors of these banks. What kind of bank industry structure could best address these changes and demands? What we hope to achieve is to set the basis of the discussion which can help extricate the true nature of the industry. For a broader EU and world perspective see also more recent studies (Phan, Daly and Akhter, 2016; Hosseinzadeh and Mahmoodi, 2016; Fu, Lin and Molyneux, 2014; Fiordelisi and Mare, 2014; Clerides, Delis and Kokas, 2015). These studies provide us with mixed results making our contribution even more worthwhile and interesting.

In this paper we estimate X-inefficiency scores for a representative sample of EU banks. We divide the sample into three clubs according to their efficiency, i.e. low efficiency to high efficiency. Then we specify several hypotheses for the competitive conduct of these clubs and put them to test. In doing so we hope to shed some light on the long standing debate between the advocates of banking sector contestability and the efficiency it implies on one hand and those who believe that certain markets such as banking are prone to noncompetitive behaviors and inefficiencies.

This study contributes to the literature by investigating the competitive behavior of different efficiency clubs of EU banks. This is done in two different ways. Firstly we employ Panzar and Rose's ***H*** statistic and we determine that indeed different efficiency clubs tend to exhibit diverse conduct.

In addition, we examine whether there is a difference among these clubs in how sensitive their NIM is to efficiency within the club. We find evidence that the most efficient or least X-inefficient banks can increase their net interest margin upon increasing their efficiency level.

Based on the theoretical and empirical literature there are several narratives that lead to the relationship of efficiency and competition. We shall pin our main hypotheses on these different scenarios. The major obstacles to contestability are sunk costs. Indeed, if the funds needed to obtain a bank charter and start an intermediation process under current technology, cannot be considered sunken, banking is inherently contestable. If however, the intermediation process is based on accumulated proprietary information and trust, then an established bank has sunk these costs in the market it serves and contestants face a clear disadvantage. It is a well-known fact that there is limited penetration from new banks or foreign bank subsidiaries in well-established bank markets, (Berger, 2007; Goddard, Molyneux, Wilson and Tavakoli, 2007). If contestability is questionable, what then is the conduct of existing banks in a market? Summary observation of European banking markets shows the coexistence of regional banks practically not known outside their habitat and much larger institutions with international presence and name recognition. If banking products are homogenous, banks behave as competitors and there exist widespread economies of scale and scope in the production process, then there shouldn't be any small regional banks around, unless the market is effectively or institutionally segmented. However, observed market structures reveal the coexistence of a variety of banking scales and scopes implying a less homogenous product. It seems that relationship and distance or location banking are very important aspects of the banking production process (Degryse and Ongena, 2005; Gennaioli, Shleiffer and Vishny, 2013).

Table 1

Panzar-Rosse models in other studies

Authors	Period	Countries Considered	Results
De Bandt and Davis (2000)	1992-1996	Germany, France & Italy	Monopolistic competition in all countries for large banks Small banks non competitive in Italy Small banks monopoly in Germany & France
Bikker and Haaf (2002)	1988-1988	23 Countries	Greece Perfect Competition for large banks Monopolistic competition for small & medium-sized banks
Claessens and Leaven (2004)	1994-2001	50 Countries	Monopolistic in all countries (including Greece, where H=0.76)
Mamatzakis et al (2005)	1998-2002	South Eastern Europe (Albania, Bosnia, Bulgaria, Croatia, FYROM, Romania, Servia)	Monopolistic Competition
Staikouras and Koutsomanoli-Fillipaki (2006)	1998-2002	EU-15 versus EU-10 (Czech Rep., Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Rep, Slovenia)	Monopolistic Competition in EU-15 (H=0.54) Monopolistic Competition in EU-10 (H=0.78)
Bikker, Shaffer and Spierdijk (2012)	1986-2004	67 Countries	Monopolistic Competition in 40 countries Small banks noncompetitive in Italy Small banks monopoly in Germany & France

Table 2

Properties of the H-Statistic under alternative cost conditions

Market Condition	AC function	Unscaled Equation Bikker, Shaffer and Spierdijk	Price Equation P-R empirical models
Long-run Competition	U-Shaped	H=1	H=1
Long-run Competition	Flat	H<0 or 0<H<1 possible	H=1
Short-run Competition	U-Shaped	H<0 possible	by continuity: H>0
		0<H<1 possible	
Monopoly	U-Shaped	H<0	H>0
Monopoly	Flat	H<0	H>0
Oligopoly	U-Shaped	H<0	H>0
Oligopoly	Flat	0<H<1	H>0
Monopolistic Competition	U-Shaped	0<H<1	by continuity: H>0
		H<0 possible	0<H<1

The first such story presupposes homogeneous and contestable markets in banking. In such markets competitive pressures will inevitably create efficient banks, first minimizing costs and subsequently given the market share and competitive advantage realized, they will maximize rents. Here we have the success stories that will create, in due process, dominant players in their respective markets or even globally. These banks grow at the expense of their less efficient counterparts and there may be a tendency for such markets to become concentrated. The contestability characteristic however ensures that these banks will pass efficiency gains to customers through better screening and monitoring and therefore lower loan rates as well as competitive deposit rates. In its purest form this scenario calls for all banks in the industry to be efficient and behave competitively. A clear causality from competition to efficiency (Schaek and Cihak, 2008, 2014).

There are certain issues however with the previous construction, which could lead to alternative hypotheses. These issues have to do with the nature of the intermediation process and the EU economic architecture. According to (Degryse and Ongena, 2005), and (Hughes and Mester, 2012) relationship banking, switching costs, location and regulation are major factors that determine rents in banking. In such an environment, contestability may play a limited role in shaping the conduct of firms in the EU banking industry. The usual alternative of the 'efficiency' hypothesis in the relevant literature is the 'quiet life' hypothesis (Leon, 2014). Under this hypothesis banking firms use their monopolistic power to engage in inefficient production so they will neither minimize costs nor maximize profits. There are several empirical papers which focus on these two alternatives with similar methodologies, for US, EU or international samples of banks, (Casu and Girardone, 2006, 2009; Delis and Tsionas, 2009; Turk-Ariss 2010; Altubas, Gardener, Molyneux and Moore, 2001; Bolt and Humprey 2010; Chaeck and Cilak, 2008, 2014; Gonzalez, 2009). The outcome is not entirely

clear. It seems that most researchers agree that there is a causal relationship between efficiency and competition. A possible causality exists relating more efficiency to more market power (Maudos and DeGuevara, 2007). Thus intrigued, several studies attempted to estimate marginal costs and compute individual bank Lerner Indices, (Maudos and DeGuevara 2007), (Koetter, Kolari and Spierdijk, 2012; Williams, 2012). These studies shifted the attention towards balance sheet efficiency and competition in the loan and deposit submarkets. Finally Hughes and Mester (2012) claim that more justified strand of this literature includes articles that incorporate risk in the intermediation production process when one attempts assessments of banking sector performance.
In this paper we propose still another alternative based on the idea of tacit collusion proposed by Chamberlin (1929, 1933) and the fact that banking services are based on trust and pertain to the management of an ever accumulating wealth stock. Such a structure causes smaller banks to be viable in non-competitive environments and larger banks to be more efficient preserving market power.

According to this hypothesis, banks of different efficiency levels can coexist. The market structure that existed at the beginning of our sample encompasses local, regional, inter-country or even global submarkets. The nature of banking and the EU architecture allow individual banks to employ value strategies depending on the environment in which they operate. A bank for example, which operates locally or for a given clientele may have significant monopoly power and consequently live a quiet life. Concurrently banks in a different environment may behave more competitively (under a non-collusive oligopoly or monopolistic competition scheme) and hence be more efficient. This could be their response to existing and potential competition and/or to anti-monopoly regulation. When banks attempt to change their niche, there could be a transitory change in the level of competition and efficiency in the affected submarkets until a short of new equilibrium is achieved.

Transitory drives to reduce X-inefficiency by certain banks due to new management, a threat of a hostile acquisition, or due to technological or institutional shocks cannot entirely eliminate lower efficiency enclaves.

Finally, an alternative proposition is that competitiveness in banking is a recipe for X-inefficient performance, (Schaeck and Cihak, 2008). Banks vie for market share and so they cater to their customers more than the optimal screening and monitoring would suggest. Under this hypothesis banks are X-inefficient because they are wasting resources to stay in the game, i.e. retain old customers and gain new ones. As under these circumstances the probability of losing one's customers to competition is rather large, bank management does not invest in information processing technologies but rather on marketing schemes. In such a conduct, efficiency will not discriminate good banks from less successful banks and the market is inhabited by diverse technology institutions.

Competition and efficiency in banking have obvious repercussions to European integration and growth. Banks provide the major portion of liquidity needed for a well-functioning economy. Any possible distortion regarding efficiency and competitive conduct present in banking will be surely felt throughout the rest of the economy. Its central position in disseminating capital and information as well as managing wealth necessitates a well-functioning and stable banking system. The questions we hope to answer then are: How efficient is the banking sector in Europe? How competitive is it? Does efficiency and competitive conduct go hand in hand or the opposite? Does market concentration have anything to do with that?

The rest of the paper is organized as follows. Section 2 reviews the literature and attempts to establish firstly some theoretical and empirical underpinnings for our hypotheses and secondly benchmarks for comparing our results with. Section 3 describes the sample characteristics and methodology. In section 4 we analyze our results and we conclude in section 5.

2. Literature Review

There are considerable research accomplishments on the relationship of efficiency and market power in banking. This line of research is important on the grounds of its implications to social welfare, system stability and regulatory reforms. Most authors motivate their work along these three themes and then focus primarily on the validity of the quiet life hypothesis (QL) attributed to Hicks (1935) versus the alternative of efficient structure (ES) attributed to Demsetz (1973). This issue is at the heart of any subsequent useful discussion of policy aspects related to the banking sector. The quiet life hypothesis (QL) states that when competitive pressures abate so does efficiency, a positive relationship between efficiency and competition (negative relationship between efficiency and market power) with causality running from the competitive level of the market to the level of efficiency of its member banks. It is the well-known argument that monopoly power lowers the drive towards efficiency whereas competition fosters efficiency. The 'rival' efficient structure hypothesis states that as efficiency increases so does market power or that competitiveness recedes, a negative relationship between efficiency and competition (positive with market power) with causality running from the level of efficiency to the level of competition. Implicitly, it is surmised that efficient banks will survive and gain increased market share and power. Banking markets based on strong customer relationships and providing sophisticated intermediation services may not be so easily contestable however, as it has been evident by the limited penetration of foreign banks to established domestic markets despite the efforts towards a more unified and consolidated European market.

The recent literature addresses several issues that need to be analyzed before we can proceed to valid conclusions about the competition efficiency relationship. First, in the process of measuring efficiency and market power several issues have to be settled. A rationalization has to be provided as to whether we should estimate X-inefficiency using a cost function or a profit function. Efficiency estimates could be adjusted to risk or to different banking production lines or account for heterogeneity in production costs among banks.

The estimation methodology can follow the stochastic frontier approach (SFA) or the nonparametric data envelopment analysis (DEA) approaches. If SFA is preferred, we can assume given distributions for the error terms or use the distribution free approach.

In estimating market power, researchers have been using economy wide concentration ratios or the nonstructural $\boldsymbol{H}$ parameter proposed by Panzar and Rose (1987). Both of these are market attributes measuring the degree of competition and cannot be estimated for individual banks. More recently, attention shifted to firm specific measures of market power using the Learner Index under its original specification or adjusted according to the sides of the balance sheet (loans, deposits), or according to the bank efficiency level requiring the correct estimation of marginal costs. In addition to these developments, it is possible to jointly estimate X-inefficiency and market power or run Granger causality tests to settle the issue of endogeneity.

Among the first to analyze the relationship between X-inefficiency and the level of competition were Berger and Hannan (1998). They introduce an empirical testing of Hick's 'quiet life' hypothesis (QL) in the US banking and they find that the cost of X-inefficiency is larger than the deadweight loss caused from noncompetitive pricing behavior. Where banks have the opportunity to exercise market power, in more concentrated markets, they tend to be lax with operational efficiency (exhibit X-inefficiency). According to their results the quite life hypothesis cannot be rejected. In a similar vein, Casu and Girardone (2006) used data for the period 1997-2003 to obtain results on EU banks. They included DEA generated efficiency scores in their ***H***-statistic estimation and concluded that larger banks tend to be more efficient and exercise more market power but also that the banks with the higher inefficiency were the ones with larger market power. Their results could be interpreted as a failure to reject the QL hypothesis. However, Maudos and deGuevara (2007) using same period EU data but utilizing separate market power measures for loans and deposits at the bank level concluded that market power and efficiency are positively related at least in the loan markets. They also measure the social welfare gains from reducing monopoly power and find it greater than the loss from the decrease in cost efficiency. The results of these last two articles are perhaps not directly comparable primarily because of the way they measure the level of competition - the ***H*** statistic at the market level in the former versus Lerner Indices at the bank level for the latter. Meanwhile the seeming contradiction necessitates perhaps the alternative methodology we propose in this paper in order to conveniently disentangle the implied relationship between efficiency and competition. The simultaneity that is naturally embedded in the relationship between competition and efficiency allows for endogeneity problems in the estimation procedure and for the causality issue between the economic forces under consideration unresolved. Several authors recognized and directly addressed these problems. Schaek and Cihak (2008) provide direct results for Granger causality tests between competition and efficiency. They included both US and EU banks in their sample for the 1995-2005 periods. They used stochastic frontier techniques for calculating efficiency and the Lerner Index for estimating the level of competition. Their findings rejected the QL hypothesis in favor of the ES hypothesis, in finding that competition causes profit and cost efficiency in the US and causes cost efficiency in the EU. A similar empirical analysis was performed by Casu and Girardone (2009) for the period 2000-05 and for 2700 banks from the five largest EU economies. Their econometric results indicated that there is causality between market power and efficiency, a clear rejection of QL but also a contradicting result with respect to the previous paper.

Granger causality regressions would not necessarily solve the simultaneity aspect of this relationship. A possible improvement in this line is to jointly estimate market power and efficiency a methodology developed by Delis and Tsionas (2009). They also choose to compute market power for each bank rather than each market for the period 1996-2006. They arrive at a reduced form solution for a bank profit maximization problem and they employ a local maximum likelihood estimation procedure to obtain results indicating that individual banks do deviate from competitive standards and that those that are less efficient exert the highest market power, clearly a manifestation of quiet life. Institutional and political economy variables however, may influence the relationship. This was recognized by Gonzalez (2009) who uses a large dataset of international banks to conclude that the effect of efficiency on the level of competition depends on the characteristics of each market such as conducting and monitoring quality, entry barriers and deposit insurance. His findings corroborate the efficient structure hypothesis (ES) for those markets with more advanced institutions and less regulation.

An alternative way to account for simultaneity and reverse causality, when employing the Lerner Index (LI) to measure market power, is to adjust the original index. This computation necessitates the use of an efficient marginal cost configuration. The two pegged adjustment procedure allows both for deviations from an efficient cost structure and deviations from maximum rent seeking. Turk Ariss (2010) and Williams (2012) report their findings for banking sectors from developing economies concerning the quiet life versus efficient structure hypotheses. Turk Ariss adjusted the original LI for differences in cost efficiency and funding costs, and then measured the effect of market power on cost and profit efficiencies. She found that for a sample of banks operating in an environment that is in a prolonged restructuring because of deregulation and globalization, market power is positively related to cost inefficiency and profit efficiency. Since sample banks operate X-inefficiently when they can control prices, their profit efficiency should only increase the deadweight loss to society, notwithstanding the fact that quiet life is absent. If this societal loss is the price paid for stability then a more general assessment is necessary. In results obtained for Latin American countries by Williams (2012), the efficient structure hypothesis cannot be rejected. Efficient banks were able to contest away market shares and power from less efficient banks. Williams uses 2stage LS with instrumental variables to ensure that causality goes from market power to efficiency and so he can clearly reject the QL hypothesis. Finally in a recent study for US banks, Koetter, Kolari and Spierdijk (2012), 'revisited' the Berger and Hannan (1998) effort to test the QL hypothesis. They adjusted the LI for cost or X-inefficiency and alternatively for profit inefficiency, addressing the possible bank costs heterogeneity in estimating individual bank market power. They also use instrumental variables to account for the possible endogeneity in the relationship between market power and efficiency. If QL suggests that, as banks' market power increases management would both waste money in producing any given output and at the same time, forsake monopoly rents due to lack of effort in maximizing profits from the revenue side, then Koetter, Kolari and Spierdijk (2012) were able to reject QL only on the profit aspect. The found that US banks with market power get lean on operations but will not pursue all rents available to them. This could be the best of all worlds in that deregulation and the sector consolidation that ensued not only did not waste resources but also the deadweight loss to society due to monopoly power was ameliorated.

Last but not least, Bolt and Humphrey (2010) construct a competition efficiency frontier for EU banks so as to avoid comparability problems in cross country comparisons of market power indices. They also account for the potential differences of the level of competition on NIM and non NIM revenue. They measure lower NIM as competition intensifies and higher non NIM revenue as competition recedes, or that banks are competition inefficient with respect to non NIM market. Fare, Grosskopf, Maudos and Tortosa-Aisina (2015) use flexible techniques to uncover the relationship between market power and efficiency in Spanish banking and have concluded that the QL hypothesis holds only for certain types of financial institutions depending on their ownership structure and business model.

3. Methodology and Data

The main hypothesis under investigation is whether efficiency affects competitiveness. Instead of performing the usual causality tests we estimate X-inefficiency for a sample of banks and then divide them ad hoc in three clubs. Within each club we investigate market conduct with the $\boldsymbol{H}$ statistic in line with Claessens and Leaven (2004). If we reject the hypothesis that the least X-inefficient (more efficient) banks behave in a competitive way then an alternative industry structure that of segmentation or tacit collusion could be a better description of bank market structure than either of the quiet life or market efficiency hypotheses.

Additionally, if we cannot reject the hypothesis that the most X-inefficient banks are having monopoly power it will be considered supportive evidence for the quiet life hypothesis. The two tests combined however, generally would support a theory of no contestability of EU banking markets. It is possible that more and less X-efficient banks are involved in a leader - follower type of oligopoly, or otherwise the less efficient ones are niche or regionally protected to survive.

In order to accomplish this test empirically, we first compute efficiency scores for all banks in our sample using standard stochastic frontier methodology. These are cost efficiency scores with respect to best practice bank in the sample. The score measures the overall cost inefficiency termed as X-inefficiency. In addition, we could surmise the main characteristic differences, if any, between efficient and less efficient banks. Subsequently, we will divide our sample into three categories according to their X-inefficiency scores: the efficient club the median efficiency club and the least efficient one. For each club then we compute the H statistic. The results should indicate whether there is a significant difference in competitive conduct between at least the most diverse clubs. The measurement methodology is such that we can only have a broad distinction in the level of competitive behavior or vice versa the degree of monopoly power. The null hypothesis is that all three efficiency clubs will exhibit the same degree of competiveness. There exists a market for intermediation services which is homogeneously competitive. If our results indicate that the market is organized perfectly competitive then we could conclude that as the time dimension of the sample permits to rule out short run disequilibrium, that there are segregated banking markets. If on the other hand the market is not competitive then we are in an oligopolistic equilibrium

For robustness we employ a separate set of regressions where we explore the relationship of NIM and that of the X-inefficiency level controlling for variables such as the market concentration in which bank i operates in, and certain banks specific variables known to affect NIM, such as deposits and short term funding to total assets, equity to total assets and other operating income to total assets, in line with Demirgüc-Kunt, Laeven and Levine (2004). The net interest margin (NIM) measures the cost of financial intermediation, so it is an alternative measure of bank efficiency.

It is expected that as the level of X- inefficiency increases NIM should also increase if higher costs are passed on to borrowers and depositors - loan rates would be higher, deposit rates would be lower. That would necessitate the exercise of monopolistic power. This could be the result of quiet life. If this is the case we expect to observe a positive and significant effect of X-inefficiency on NIM not only within clubs but also a stronger relationship for the least efficient club.

The hypothesis concerning the existence of efficient markets in banking would be supported if the effect of lower X-inefficiency would be passed on to the supply and demand of funds market participants – lower loan rates and higher deposit rates. This however means that the positive sign within and across clubs would not differentiate between the two leading alternatives.

A negative sign both within clubs and across clubs, would suggest that we cannot reject the hypothesis that the least X-inefficient banks exert market power and the most X-inefficient banks find a range of rates in which they can survive.

4. Empirical Models

1. To estimate cost and alternative profit inefficiency, we opt again for the stochastic frontier approach (SFA), which incorporates both noise and inefficiency into the model specification. In particular, in the case of the cost frontier, we assume the following specification:

$$TC_{it} = f(P_{it}, Y_{it}, N_{it}, Z_{it}) + v_{it} + u_{it} \quad (1)$$

where TC_{it} denotes observed total cost for bank i at year t, P is a vector of input prices Y is a vector of outputs of the firm, N is a vector of fixed netputs and Z is a vector of control variables. v_i corresponds to random fluctuations and is assumed to follow a symmetric normal distribution around the frontier and u_i, accounts for the firm's inefficiency that may raise costs above the best-practice level and is assumed to follow a half-normal distribution. To empirically implement the cost frontier, we opt for the following translog specification:[1]

$$\ln TC_i = \alpha_0 + \sum_i a_i \ln P_i + \sum_i \beta_i \ln Y_i + ½ \sum_i \sum_j a_{ij} \ln P_i \ln Pj + ½ \sum_i \sum_j \beta_{ij} \ln Y_i \ln Y_j +$$
$$\sum_i \sum_j \delta_{ij} \ln P_i \ln Y_j + \sum_i \varphi_i \ln N_i + ½ \sum_i \sum_j \phi_{ij} \ln N_i \ln N_j + \sum_i \sum_j \xi_{ij} \ln P_i \ln N_j$$
$$+ \sum_i \sum_j \zeta_{ij} \ln Y_i \ln N_j + \theta_1 t + ½ \theta_2 t^2 \sum_i \mu_i t \ln P_i + \sum_i \kappa_i t \ln Y_i + + \sum_i \nu_i t \ln N_i + kD_i +$$
$$\sum_i \xi_i Z_i + u_i + v_i \quad (2)$$

Standard linear homogeneity and symmetry restrictions in all quadratic terms are imposed in accordance with economic theory, while we also include country dummies to capture any differences across countries and time effects to account for technological progress. The stochastic frontier model (2) is estimated via a maximum likelihood procedure parameterized in terms of the variance parameters $\sigma_\varepsilon^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda = \sigma_u / \sigma_\varepsilon$.

For the definition of bank inputs and outputs, we employ the intermediation approach proposed by Sealey and Lindley (1977), which assumes that banks collect funds, using labour and physical capital, to transform them into loans and other earning assets. [2] In particular, in order to measure productive efficiency, we specify three inputs, labour, physical capital and financial capital, and two outputs loans, and other earning assets.[3] Due to lack of data on the

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[1] The translog function has been widely applied in the literature due to its flexibility. Some papers (Mitchell and Onruval, 1996; Berger et al., 1997; DeYoung and Hasan, 1998) have found that the Fourier-flexible form, that combines a standard translog functional form with Fourier trigonometric terms, provide a better fit. However, Berger and Mester (1997) found that both specifications yielded essentially the same average level and dispersion of measured efficiency, and both ranked the individual banks in almost the same order. For simplification, we omit the subscripts for time ($_t$).

[2] A variety of approaches have been proposed in the literature for the definition of bank inputs and outputs. These include the intermediation (or the asset) approach, the production, the value-added and the user-cost approach (see Berger and Humphrey, 1992; Maggi and Rossi, 2003). Berger and Humphrey (1997) and Yildirim (2002) argue that the intermediation approach may be more appropriate when studying the economic viability of banks as it incorporates the overall costs of banking. Since our main interest lies in the assessment of overall efficiency and economic viability of banks and its relationship with default risk, the *intermediation approach* seems to fit better the purposes of our analysis.

[3] Note that recent studies in the literature (Clark and Siems, 2002; Isik and Hassan, 2002; Casu and Girardone, 2005), as a Referee pointed out, introduce off-balance-sheet activities as an additional output, since some of these activities could affect the efficiency measures. However, the IBCA database does not provide detailed information about off-balance sheet activity. In addition, Becalli et al., (2006) argue that the great variability in accounting practices across countries, especially with respect to the treatment of off-balance-sheet activities, may introduce a remarkable sample bias if off-balance-sheet data are used in cross country studies.

number of employees, labour is measured by personnel expenses, while physical capital is defined as the bank's fixed assets. Loans are expressed as total loans net of provisions, while other earning assets include government securities, bonds, equity investments, CDs, T-bills, equity investment etc.

In addition, for the estimation of cost efficiency, input prices are required. The price of financial capital is computed by dividing total interest expenses by total interest bearing borrowed funds, while the price of labour is defined as the ratio of personnel expenses to total assets. In the case of cost function, physical capital is specified as a fixed netput. Total cost is defined as the sum of overheads (personnel and administrative expenses), interest, fee, and commission expenses, while profit is defined as profit before tax.

In estimating the cost function, we include equity capital as a quasi-fixed input.[4] If financial capital is ignored, the efficiency of banks that may be more risk averse than others and may hold a higher level of financial capital would be mismeasured, even though they are behaving optimally given their risk preferences.[5] Apart from this, a bank's capital directly affects costs by providing an alternative to deposits as a funding source for loans (Berger and Mester, 1997).

2. In addition, we proceed with the Panzar Rosse (PR) revenue test that is based on a reduced-form equation relating revenues to a vector of input prices and other control variables,

$$\log Q=\alpha+\beta_1\log w_{Fit}+\beta_2\log w_{Lit}+\beta_3\log w_{Cit}+\sum_{i=1}^{n}\gamma_i\log BSV_{it}+error \quad (3)$$

with i indexes bank i and t indexes year t, Q takes four forms according to the version of the PR model that we use and, namely, is the Interest Income (P-R Model I-Tables 6-8) or Total Income (P-R Model II Tables 6-8) of bank i of the unscaled version of the model, while Q represents the ratio of Interest Income to Total Assets (P-R Model III Tables 6-8) or the ratio of Total Income to Total Assets (P-R Model IV Tables 6-8) of bank i when controlling for scale. The set of explanatory variables embraces three factor input prices, namely W_F is the ratio of interest expenses to total funds, or the average funding rate (price of loanable funds), W_L is the ratio of personnel expenses to total assets (price of labor) και W_C is the ratio of non-interest expenses to the stock of fixed assets (price of capital expenditures). In addition, the set of bank-specific variables (BSV) which are proposed to catch differences attributed to the characteristics of the banks in our sample incorporates the ratio of total loans to total assets (LNS/TA), the ratio of other income to total assets (ONA/TA), the ratio of deposits to total funding (DPS/F) and finally, the ratio of equity to total assets (EQ/TA). The *H* statistic is given by the following expression

$$H= W_F + W_L + W_C \quad (4)$$

3. As we earlier mentioned, we also employ a separate test where we investigate the relationship of NIM and that of the X-inefficiency controlling for banking system

[4] In the case of the directional distance function, equity capital enters the function with a directional vector value set to zero.
[5] Hughes and Moon (1995) and Hughes et al. (1996) tested and rejected the assumption of risk neutrality for banks.

characteristic structures such as the market concentration of European Union country in which bank i operates in, as well as certain banks specific variables known to affect NIM for robustness. We estimate regressions of the following form:

$$\text{Net Interest Margin}_{i,t} = \alpha + \beta_1 CR_{ik} + \beta_2 INEF_{i,t} + \beta_3 \sum_{i=1}^{n} BSV_{i,t} + error \quad (5)$$

with i indexes bank i and t indexes year t. The set of explanatory variables embraces the concentration ratio (CR_{ik}) of bank i that has its headquarters in country k, with the concentration ratio measured as the share of the five largest credit institutions in total assets of country k (CR5), INEF is the estimated inefficiency, and a set of bank-specific variables (BSV) that includes deposits and short-term funding to total assets (LIQ), equity to total assets (EQTA) and other operating income to total assets (FEE).

Our sample is comprised from 134 European Union banks from 20 EU member states constituting circa 85% of total assets of the European banking sector. Consolidated bank-level data for participating banks in our sample were obtained from the Fitch-IBCA BankScope database over the period 2000-2010, while the exact number for each participating bank according to its foundation, is presented in the following table:

Table 3

EU member states and number of banks

Country	No. of Banks	Country	No. of banks
GERMANY	21	PORTUGAL	4
SPAIN	17	NETHERLANDS	4
ITALY	12	DENMARK	3
GREECE	12	CYPRUS	3
FRANCE	12	LUXEMBOURG	2
BELGIUM	10	HUNGARY	2
AUSTRIA	10	SLOVENIA	1
UNITED KINGDOM	8	POLAND	1
IRELAND	6	MALTA	1
SWEDEN	4	FINLAND	1

5. Results

5.1 The X-inefficiency scores:

Our results indicate that there is a wide variation in X-efficiency among the banks in our sample. Ireland has the most cost efficient banks while Hungary the least efficient ones. The within country spread in efficiency is worthwhile mentioning. For inefficient banks to operate and survive along with efficient ones in the same economy there must be significant economies in relationship banking as well as a tendency for smaller banks to develop niches or operate regionally where familiarity and distance to headquarters may play a role. The results indicate that larger banks tend to be more efficient. These are probably banks for which growth ate up their fat. They tend to be, better capitalized, to depend less on deposits and operate in countries whose banking system has a strong international presence at least for its larger members. Capital structure and portfolio risk choices are not explicitly accounted for in our estimation procedures. According to the analysis due to Hughes et al (2000, 2003), Mester (2008) and Hughes and Mester (2012) the Irish banks which outperform other sample banks need not have made efficient choices as far firm value is concerned. The aftermath of the recent crisis has indicated that their conjecture is right. It is simpler however to avoid the use of management utility function maximization methodology in view of the restrictions it presupposes.

Table 4

Bank Cost Inefficiency Score by Country

Country	Mean	St. Dev.	Min	Max
IRELANS	0.209	0.1552	0.0361	0.5118
UNITED KINGDOM	0.279	0.1521	0.0361	0.4894
BELGIUM	0.300	0.1651	0.0607	0.5343
GERMANY	0.315	0.1313	0.0726	0.5427
LUXEMBOURG	0.322	0.1889	0.1374	0.5065
FRANCE	0.330	0.1052	0.0361	0.4876
NETHERLANDS	0.345	0.0872	0.2396	0.4765
PORTUGAL	0.380	0.0661	0.2801	0.4630
GREECE	0.412	0.0815	0.2842	0.5305
CYPRUS	0.449	0.0838	0.3587	0.5581
AUSTRIA	0.467	0.1814	0.1694	0.8736
SPAIN	0.487	0.1256	0.2705	0.7346
ITALY	0.504	0.1007	0.2845	0.6309
DENMARK	0.506	0.0848	0.4106	0.6140
SWEDEN	0.507	0.0845	0.3716	0.5823
HUNGARY	0.526	0.3357	0.1983	0.8543
SLOVENIA	0.52	-	0.5191	0.5191
POLAND	0.27	-	0.2722	0.2722
MALTA	0.51	-	0.5097	0.5097
FINLAND	0.33	-	0.3290	0.3290

Table 5

Descriptive statistics for X-inefficiency quartiles

	Inefficient scores range	Number of banks	Total Assets[1]	Deposits/ Total Assets	Equity/ Total Assets
Efficient Quartile	0.0179-0.0781	34	207.7 bn euro	68.2%	6.5%
Median	0.0805-0.2505	66	127.7 bn euro	70.9%	5.8%
Inefficient Quartile	0.2544-0.7668	34	161.9 bn euro	68.9%	4.8%

1. 2000-2010 averages for Total Assets, Deposits to Total Assets and Equity to Total Assets

5.2 The *H* scores and the *H* per efficiency quintiles

Next we turn our attention to the ***H*** statistic. The Panzar-Rose ***H*** metric distinguishes banking systems along the competitive divide. According to Shaffer Bikker and Spierdijk (2009) the unscaled regressions provide a correct measurement of ***H***, which is in effect a one sided test of competitive conduct with certain restrictions. We find a statistically significant and rather large negative ***H*** for the inefficient group and statistically zero values for ***H*** for our median and higher efficiency subsamples. Our estimated values of ***H*** for all three groups of X-efficiency though, deserve a cautious interpretation. The strong negative ***H*** estimation for the less efficient group is a probable indication that the member banks have a markedly more noncompetitive conduct compared to the other two groups. Indeed, a negative value signifies pure monopoly or conjectural variation oligopoly under the restriction that the market is in long run equilibrium, Shaffer et al (2009). When ***H***=0 however, the industry is most likely monopolistically competitive, but we cannot rule out a market with leader-follower conduct. The ***H*** regressions then do corroborate our tentative conclusions regarding efficiency. It seems that there exists a group of banks in our sample that are 'relationship' or 'niche' or 'regionally' protected from the hazards of competition and are X-inefficient. The efficient club comprised by larger banks could be exhibiting a typically monopolistic competitive behavior. It remains to be seen in our last attempt to disentangle the connection between competition efficiency and concentration.

Table 6

Efficient Quartile of European banks

	P-R Model I (Unscaled)			P-R Model II (Unscaled)			P-R Model III			P-R Model IV		
Dependent Variable	Interest Income			Total Income			(Interest Income/ Total Assets)			(Total income/ Total Assets)		
Explanatory variables	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values
Funding Rate (Wf)	0.67	0.05	13.51	0.54	0.05	10.65	0.640	0.014	44.98	0.504	0.016	31.77
Wage Rate (WL)	-0.70	0.10	-6.92	-0.63	0.10	-6.13	0.186	0.029	6.47	0.248	0.032	7.71
Capital price (Wc)	-0.09	0.05	-1.79	-0.01	0.05	-0.24	0.000	0.015	-0.03	0.081	0.017	4.86
Loans ratio (LNS/TA)	0.62	0.07	8.93	0.54	0.07	7.60	0.126	0.020	6.35	0.040	0.022	1.80
Non-earnings assets ratio (ONA/TA)	-0.03	0.05	-0.58	0.13	0.05	2.40	-0.089	0.015	-5.99	0.070	0.017	4.22
Deposits to total funding (DPS/F)	-1.25	0.16	-7.80	-1.31	0.16	-8.07	-0.047	0.046	-1.04	-0.101	0.051	-1.99
Equity ratio (EQ/TA)	-0.12	0.08	-1.40	-0.02	0.09	-0.24	0.017	0.024	0.69	0.113	0.027	4.23
Intercept	13.61	0.42	32.39	14.64	0.43	34.24	-0.215	0.120	-1.79	0.777	0.134	5.81
R^2 within	0.61			0.51			0.90			0.84		
R^2 between	0.24			0.20			0.67			0.79		
No. of observations	301			301			301			301		
H-statistic	-0.12	0.203	-0.58	-0.10	0.207	-0.49	0.83	0.058	14.24	0.83	0.065	12.88

Table 6 reports the results arising from the estimation of different versions of the Panzar-Rosse Model: Wf is the ratio of interest expenses to total funds, WI is the ratio of personnel expenses to total assets, Wc is the ratio of other expenses to fixed assets, LNS/TA is the ratio of customer loans to total assets, ONA/TA is the ratio of other non-earnings assets to total assets, DPS/F is the ratio of customer deposits to customer deposits and short-term funding and EQ/TA is the ratio of equity to total assets. The model is estimated by running least square regressions. The standard errors were calculated using White's (1980) correction for heteroscedasticity. The H-statistic is equal to the sum of the elasticities of the dependent variable with respect to three input prices: H=b1(of Wf) + b2(of WI) + b3(of Wc).

Table 7

Inefficient Quartile of European banks

	P-R Model I (Unscaled)			P-R Model II (Unscaled)			P-R Model III			P-R Model IV		
Dependent Variable	Interest Income			Total Income			(Interest Income/Total Assets)			(Total income/ Total Assets)		
Explanatory variables	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values
Funding Rate (Wf)	0.772	0.138	5.61	0.676	0.138	4.89	0.546	0.017	32.64	0.450	0.018	24.78
Wage Rate (WL)	-2.406	0.228	-10.56	-2.514	0.229	-10.96	0.318	0.028	11.46	0.216	0.030	7.16
Capital price (Wc)	-0.111	0.094	-1.19	-0.098	0.094	-1.04	0.031	0.011	2.74	0.043	0.012	3.44
Loans ratio (LNS/TA)	1.833	0.357	5.13	1.711	0.359	4.76	0.148	0.043	3.41	0.024	0.047	0.51
Non-earnings assets ratio (ONA/TA)	0.212	0.142	1.49	0.432	0.143	3.02	-0.052	0.017	-3.00	0.165	0.019	8.78
Deposits to total funding (DPS/F)	1.210	0.205	5.91	1.171	0.206	5.69	0.060	0.025	2.41	0.026	0.027	0.96
Equity ratio (EQ/TA)	0.154	0.253	0.61	0.189	0.254	0.74	-0.078	0.031	-2.53	-0.046	0.033	-1.38
Intercept	8.205	1.163	7.06	8.647	1.170	7.39	-0.066	0.141	-0.47	0.375	0.154	2.44
R^2 within	0.52			0.501			0.88			0.84		
R^2 between	0.12			0.147			0.52			0.55		
No. of observations	243			243			243			243		
H-statistic	-1.75	0.459	-3.80	-1.94	0.462	-4.19	0.90	0.056	16.03	0.71	0.061	11.68

Table 7 reports the results arising from the estimation of different versions of the Panzar-Rosse Model: Wf is the ratio of interest expenses to total funds, WI is the ratio of personnel expenses to total assets, Wc is the ratio of other expenses to fixed assets, LNS/TA is the ratio of customer loans to total assets, ONA/TA is the ratio of other non-earnings assets to total assets, DPS/F is the ratio of customer deposits to customer deposits and short-term funding and EQ/TA is the ratio of equity to total assets. The model is estimated by running least square regressions. The standard errors were calculated using White's (1980) correction for heteroscedasticity. The H-statistic is equal to the sum of the elasticities of the dependent variable with respect to three input prices: H=b1(of Wf) + b2(of WI) + b3(of Wc).

Table 8

Median Quartile of European banks

Dependent Variable	P-R Model I (Unscaled) Interest Income			P-R Model II (Unscaled) Total Income			P-R Model III (Interest Income/Total Assets)			P-R Model IV (Total income/ Total Assets)		
Explanatory variables	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values
Funding Rate (Wf)	0.46	0.04	12.17	0.34	0.04	9.59	0.575	0.010	60.24	0.455	0.008	58.53
Wage Rate (WL)	-0.55	0.07	-7.77	-0.53	0.07	-7.95	0.313	0.018	17.61	0.335	0.014	23.10
Capital price (Wc)	0.03	0.04	0.62	0.05	0.04	1.11	0.007	0.011	0.66	0.024	0.009	2.68
Loans ratio (LNS/TA)	0.61	0.10	6.35	0.49	0.09	5.44	0.247	0.024	10.20	0.133	0.020	6.75
Non-earnings assets ratio (ONA/TA)	-0.10	0.05	-2.17	0.07	0.04	1.50	-0.070	0.012	-6.00	0.095	0.009	9.98
Deposits to total funding (DPS/F)	-1.04	0.11	-9.75	-1.09	0.10	-10.85	0.090	0.027	3.37	0.037	0.022	1.70
Equity ratio (EQ/TA)	-0.24	0.06	-4.01	-0.19	0.06	-3.36	-0.033	0.015	-2.16	0.020	0.012	1.60
Intercept	12.55	0.31	41.01	13.29	0.29	46.00	0.115	0.077	1.49	0.859	0.063	13.70
R^2 within	0.43			0.37			0.91			0.93		
R^2 between	0.28			0.31			0.77			0.76		
No. of observations	636			636			636			636		
H-statistic	-0.06	0.152	-0.40	-0.14	0.143	-0.99	0.90	0.038	23.46	0.81	0.031	26.17

Table 8 reports the results arising from the estimation of different versions of the Panzar-Rosse Model: Wf is the ratio of interest expenses to total funds, WI is the ratio of personnel expenses to total assets, Wc is the ratio of other expenses to fixed assets, LNS/TA is the ratio of customer loans to total assets, ONA/TA is the ratio of other non-earnings assets to total assets, DPS/F is the ratio of customer deposits to customer deposits and short-term funding and EQ/TA is the ratio of equity to total assets. The model is estimated by running least square regressions. The standard errors were calculated using White's (1980) correction for heteroscedasticity. The H-statistic is equal to the sum of the elasticities of the dependent variable with respect to three input prices: H=b1(of Wf) + b2(of WI) + b3(of Wc).

5.3 Efficiency concentration and market power

To investigate still further the relationship between the levels of competition and efficiency we turn to the NIM regressions. Following Demirgüc-Kunt, Leaven and Levine (2004) we interpret NIM as proxy of market power and economic or allocative efficiency. Higher NIM indicates market power and lower NIM indicates a competitive environment and economic (allocative) efficiency. In the least X- inefficient group of banks (more efficient banks) we observe a negative and significant estimated coefficient, implying that "leader" banks do not pass their X-efficiency gains to their customers competing away market share from less efficient "follower" banks. According to this finding efficiency does not procure competition. In effect, the X-efficient group of banks exhibits market power conducts. The banks of this group entertain increases in NIM as they get more efficient.

We do not observe similar patterns with the same intensity in the low efficiency group, merely because these banks according to our previous results on ***H*** obviously operate in a protected environment where NIM is less likely to be sensitive to X-inefficiency. Alternatively, these banks are industry followers leading a ‘quiet life’ which precludes initiatives in pricing their products. This type of conduct resembles an entrenchment strategy which precludes hostile attention.

Indeed our results regarding the X-inefficiency and the ***H*** metric do not contradict our results in this section. Our results indicate that X-efficiency (X-inefficiency) has a significant impact only in the efficient club. For these banks higher efficiency (lower inefficiency) results in higher NIM. The banks in this club do exert market power and translate efficiency gains into higher profits. These types of banks would have the capacity to infuse more capital when needed and enhance the stability of the system.

Our empirical findings suggest that for the efficient group, lowering X-inefficiency is a recipe for higher profitability and for the median and low efficiency groups efficiency gains are not related to their competitive conduct. Can firms in monopolistic competition avoid passing efficiency gains to their customers? In monopolistic competition if the lowest possible marginal cost bank prices at marginal revenue, which is the same for all banks in the same market, then all other banks are priced out of the market. Our results and the present structure of the banking industry in EU do not fit such an environment.

Table 9

Net Interest Margin and Efficiency

	Efficient Quartile of banks			Median quartile of banks			Inefficient Quartile of banks		
	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values	Coefficient	Std. Error	t-values
Deposits/ Total Assets	-0.173	0.18	-0.98	0.761	1.12	0.68	-0.188	0.09	-2.16
Equity/ Total Assets	0.191	0.09	2.23	0.132	0.18	0.75	-0.409	0.09	-4.46
Other Operating Income / Total Assets	0.046	0.03	1.41	0.811	1.00	0.81	-0.024	0.15	-0.16
Concentration Ratio: CRS	-0.082	0.08	-0.99	0.254	0.35	0.74	-0.345	0.91	-0.38
Inefficiency	-0.446	0.15	-2.93	0.119	0.43	0.28	-0.085	0.18	-0.47
Intercept	-3.172	0.49	-6.47	-0.511	5.16	-0.10	-4.286	3.46	-1.24
Adjusted R^2	8.9%			30.7%			78.8%		

Dependent variables is net interest margin. All variables are reffering to the period 2000-2010. Explanatory variables are: concentration ratio of the 5 largest MFIs (CR5), the ratio of deposits and short-term funding to total assets (LIQ), the ratio of other non-interest income to total assets (FEE), growth (GDP) and inefficiency.

6. Conclusions

We estimate X-inefficiency for banks operating in the European Union using a stochastic frontier approach. We relate efficiency levels to market competitiveness employing Panzar & Rosse's ***H*** statistic, for three clusters of banks according to their efficiency scores. Additionally, we examine the impact of efficiency, as well as concentration, on banking competition measured by the net interest margin, controlling for bank specific factors. Overall we find that larger banks tend to be more efficient. In contrast, it seems that there exists a group of smaller banks in our sample that are 'relationship', 'niche' or 'regionally' protected from the hazards of competition and are X-inefficient. In addition we do find that the X-efficient group of banks exhibits market power conduct. The banks of this group entertain increases in NIM as they get more efficient, indicating that efficiency gains are not passed on to customers.

Our results indicate that there is wide variation in X-efficiency among the banks in our sample. Ireland has the most cost efficient banks while Hungary the least efficient ones. The within country spread in efficiency is worthwhile mentioning however. For inefficient banks to operate and survive along with efficient ones in the same economy there must be significant economies in relationship banking as well as a tendency for smaller banks to develop niches or operate regionally where familiarity and distance to headquarters may play a role

Indeed, our results regarding the relationship between efficiency (X-inefficiency) and competition measured by ***H*** corroborate the statistical evidence presented by the relationship between efficiency and NIM. Our results indicate that X-efficiency has a significant impact only in the efficient club. For these banks higher efficiency (lower inefficiency) results in higher NIM. The banks in this club do exert market power and translate efficiency gains into higher profits. These types of banks would have the capacity to infuse more capital when needed and enhance the stability of the system.

Acknowledgements

I thank Angelos Antzoulatos and Manthos Delis for their insights and helpful comments. Emmanuel Mamatzakis for his help with econometric tests. Ilias Tsirigotakis for his help with the data. SPOUDAI editor Evangelos Sambracos for his guidance and patience. Eirini Perantonaki for her help in editing the latest version. The organizing committee and the participants of the 4th International Conference of the Financial Engineering and Banking Society at the University of Surrey for the opportunity to present my work and the helpful comments I received.

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