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## Measuring competition in banking : A critical review of methods

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**Abstract**

Many studies have attempted to investigate the determinants and implications of competition in the banking industry. The literature on the measurement of competition can be divided between the structural and non-structural approaches. The structural approach infers the degree of competition from the structure of the market. The non-structural approach, based on the New Empirical Industrial Organization, assesses the degree of competition directly by observing behavior of firms in the market. This paper reviews the most frequently-used structural and non structural measures of competition in banking. It highlights their strengths and weaknesses, especially for studies based on a limited number of observations.

**Mots clés / Key words :** Competition, Bank, HHI, Lerner index, conjectural variation model, Panzar-Rosse model, Boone indicator

**Code JEL / JEL classification :** D4, G21, L11, L13, O55

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## 1 Introduction

The issue of competition in the banking sector has attracted much interest in recent years, not least because of the recent financial crisis. Alongside the usual concerns about competition, the issue has additional significance in banking because of its crucial role on non-financial activity. Many theoretical papers have attempted to explain the ambiguous consequences of competition on access to credit, cost and quality of financial services, innovation, the stability of financial systems, and thus economic development. To empirically address these important questions, one first needs to come up with reliable measures of the intensity of bank competition. The more accurate the measure, the more precise empirical results are likely to be.

The fact that competition is a complex notion, and therefore not directly observable, has resulted in the development of many methods for its assessment. The assessment of competition in the banking industry has a long tradition. The literature on the measurement of competition is generally categorized into two major streams. Based on traditional Industrial Organization, early research focused on market structure-performance linkages (the *Structure-Conduct-Performance* paradigm) which stated that the likelihood of collusion increases with market concentration. Some authors, however, raised doubt about the reliability of the *Structure-Conduct-Performance* paradigm and associated structural measures of competition. In response to deficiencies found in the structural approach, non-structural measures of competition have been developed. The aim of the New Empirical Industrial Organization (NEIO) measures is to directly assess the competitive conduct of firms. The first generation of non-structural measures is based on oligopoly theory and a static model of competition. The Lerner index, the conjectural variation model and the Panzar-Rosse model can all be attached to this conception of competition. Subsequently, other non-structural measures, especially the Boone indicator, have been developed with the objective of capturing the dynamic of the market rather than focusing on static analysis.

While some researchers may prefer one measure over another, there is no consensus regarding the best measure by which to gauge competition. The different indicators of banking market competition do not provide the same inferences about competition ([Carbó-](#)

Valverde et al., 2009; Liu et al., 2013). Therefore, the choice of a particular indicator influences conclusions regarding the implications of competition. The choice of techniques involves tradeoffs. The usefulness of the different approaches hinges on data availability, the conceptions of competition assumed, and the questions being addressed. This paper's objective is to present the most widely-applied methods in banking, highlighting their strengths and weaknesses. It complements existing reviews written by Degryse et al. (2009) and Liu et al. (2013).

The rest of the paper is structured as follows. Section 2 briefly presents the different conceptions of competition in the history of economic thought. The following sections review the different methodological approaches that have been employed to investigate competition in banking. This empirical research can be subdivided into the structural (Section 3) and non-structural (Section 4) approaches. These sections highlight assumptions, advantages and shortcomings of the different measures as well as differences and similarities between them. The final section provides a synthesis for studies on banking systems in developing countries.

## 2 Two conceptions of competition

Although the concept of competition has always been central to economic thinking, it is one that has taken on a number of interpretations and meanings. Conceptions of competition originate in *The Wealth of Nations* (Smith, 1776).<sup>1</sup> In the Smithian analysis, free competition is an ordering force toward equilibrium. In the long run, free competition leads to prices being equal to the costs of production. Nonetheless, for Smith, competition is not a state or situation but a race between competitors to gain market share. It is rivalry that forces price towards the equilibrium of supply and demand. An essential condition for free competition is not the number of rivals (while it may help) but rather individual freedom.

Subsequent works on the conception of competition were inspired by Smith but have

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1. Competition was a familiar concept in economic writing when Smith published *The Wealth of Nations*. McNulty (1967) points out that the merit of Smith was his description of the competitive process as a central element of economy.

developed two major views of competition (McNulty, 1967; Vickers, 1995; Blaug, 2001). Standard theory refers to the results of competition as a static equilibrium outcome. According to this theory, competition is a static state in which firms cannot charge over-price and then earn abnormal profit. On the other hand, other economists, particularly the Austrian School, have criticized this static view and have retained the central role played by rivalry to define competition.

## 2.1 Competition as a static state

Cournot (1838) was the first to relate free competition to the result of competition.<sup>2</sup> Cournot defined the ideal of competition, not as the process that in the long run tends toward a certain equilibrium position, but rather as the equilibrium condition itself. Competition is a situation where prices equal the costs of production (natural prices). To obtain a competitive situation, there must be several assumptions (a considerable number of rivals, possessing common knowledge about market opportunities, free entry and exit), which was never explicitly mentioned by Smith with the exception of the number of rivals (Blaug, 2001). This latter assumption plays a central role in Cournot's analysis. According to him, the excess of the price of cost approaches zero as the number of producers increases. The analytical refinement was extended by some economists, particularly Edgeworth, Jevons, Walras, Marshall, Clark, and received its fullest expression in Knight's book *Risk, Uncertainty and Profit*.<sup>3</sup> Perfect competition is the antithesis of monopoly. In monopoly, there is no one to compete and a monopolist could extract abnormal profits, although limited by the elasticity of demand.

By 1883, Bertrand criticized Cournot's oligopoly theory arguing that relevant strategies for firms are prices and not quantities. As a result, the linkages between structure and conduct are less clear than postulates of the Cournot model. A half century later, Chamberlin (1933) and Robinson (1933) wrote other important contributions to the oligopoly theory. They proposed reconciling perfect competition and reality by developing a theory of workable competition. Much of the business world is a mixture of competition and

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2. Stigler (1957) acknowledges that Cairnes, while attached to Classics, expressed a similar idea.

3. Stigler (1957) documents how each of them add and specify the neoclassical definition of competition.

monopoly. Monopolistic competition is a type of imperfect competition such that many producers sell products that are differentiated from one another as goods but are not perfect substitutes.<sup>4</sup> In monopolistic competition, a firm takes the prices charged by its rivals as a given and ignores the impact of its own prices on the prices of other firms. Different critiques have been introduced in the static oligopoly theory that recognize different possible forms of market structure (Vives, 2001). The oligopoly theory allows scholars to derive testable hypotheses and therefore measure degree of competition. As a consequence, the *neoclassical conception of competition* based on the oligopoly theory is at the root of both structural and the majority of non-structural measures of competition (the Lerner index, the conjectural variation model and the Panzar-Rosse model). The oligopoly theory distinguishes between the different forms of market structure (perfect competition, imperfect competition and monopoly). This conception of competition is, however, challenged by another view that focuses on dynamic aspects of competitive rivalry.

## **2.2 Competition as a process of rivalry**

The Austrian School, led by von Mises, Schumpeter and Hayek, argue that economists in the neoclassical tradition misuse the term competition by applying it to a state rather than to a process.<sup>5</sup> Competition is viewed not as a static state but as a complex process of rivalry between firms. The core of competition is the behavior of firms (and entrepreneurs) in the market. Firms are engaged in a continuing dynamic competitive process, constantly creating and adopting new products and processes in order to cope with competition. The competition process acts as a selection mechanism through the destructive-creation principle : Less efficient incumbents are removed and replaced by more efficient entrants. Stigler (1957) defines competition as "*a rivalry between individuals (or groups or nations), and it arises whenever two or more parties strive for something that all cannot obtain*".

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4. In 1929 Hotelling developed the model of horizontal differentiation. He emphasized the softening effect of differentiation on price competition. According to Vives (2001), Edgeworth considered product differentiation and imperfect substitution.

5. Other economists have developed some related arguments such as the theorists of evolutionary economics (Nelson and Winter, 1982, 2002) or heterodox economists (e.g. Perroux).

Vickers (1995) points out that this rivalry "encompasses all sorts of forms of rivalry (market trading, auctions, races, wars of attrition, etc.), instruments of rivalry (prices, advertising, R&D, takeover bids, effort levels, etc.), objects of rivalry (profits, market share, corporate control, promotion, prices, survival, etc.), as well as types of rival".

Box 1 : An attempt of synthesis : The theory of contestability

The Austrian School's arguments were revived by the Chicago School. Economists in the Chicago tradition tend to the view that many if not most markets tend to approximate perfect competition in the long-run. Thus positive profits are considered a transitory phenomenon since their presence stimulates entry and hence leads to their demise (Posner, 1979).

Baumol et al. (1982) give a neoclassical formalization of this idea through the theory of contestability.<sup>a</sup> They argue that regulation is unnecessary when markets are contestable. In contestable markets, the threat of entry would not only restrain incumbents' market power, but also generally satisfy the requirements for static welfare maximization. A market is contestable if (i) the entry is free and without limit ; (ii) the entry is absolute ; and, (iii) the entry is perfectly reversible. Market forces ensure that monopoly power will usually be short lived. The intensity of competition is then unrelated to market structure but linked to market contestability. Audretsch et al. (2001) shed light on the divergence between the two conceptions of contestability. In the theory of market contestability, the analysis remains static, divergence from long-run equilibrium is temporary and focuses on prices. By contrast, the Austrian School argues that disequilibrium and monopoly power are the normal functioning of competitive markets. The theory of contestability cannot explain why entrepreneurs innovate or adopt risky strategies in markets, and thus it cannot explain the evolution of economics.

Subsequent developments in industrial organization have rediscovered the major contributions of the Austrian School (dynamics analysis, non-price strategy, etc.). The literature has provided significant advances moving beyond the traditional static models and price competition (Audretsch et al., 2001). Audretsch et al. (2001) point out that the evolution of industrial economics from static to dynamic analysis does not capture the central attribute of Austrian dynamic competition, namely technical change.

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<sup>a</sup>. While Baumol's thought about competition and entrepreneurship was highly influenced by Schumpeter's view, Baumol cannot be considered as a member of the Chicago School.

In the Austrian School's perspective, a market is competitive when rivals are sufficiently aggressive to give an incumbent incentive to improve (better quality, lower price, new services, more innovation, improved management, etc.) in order to maintain its advantage. Inefficient firms are directly sanctioned by consumers while more efficient and innovative companies are rewarded.

The role of monopoly and market power is revisited in the Austrian School perspective. While firms are unable to raise prices over marginal cost in a perfect competition framework, for the Austrians the existence of rents is a normal aspect of the competitive process. In a free competitive market, each firm innovates and develops risky strategies in order to gain a competitive advantage over its rivals. Firms that do obtain such an edge temporarily derive static monopoly power during the interval before imitating competitors replicate their innovation, or supersede it with one that is superior. Successful firms earn temporary monopoly profits as their reward for risky strategies. As a result, a free competitive market is compatible with market power and "abnormal" profit rates.

The fact that the *neoclassical conception of competition* poses some clear testable hypotheses explains that a majority of competition measures are rooted in this model. The structural approach refers to the structure-performance relationship that exists in Cournot's analysis. The first generation of NEIO measures (the Lerner index, the conjectural variation model and the Panzar-Rosse model) was built on this model. More recently, new non-structural measures which are in many ways sympathetic to the *Austrian conception of competition* have been proposed, most notably the Boone indicator.

## 3 Structural approach

### 3.1 From SCP paradigm to concentration measures

The *Structure-Conduct-Performance* (SCP) paradigm, initially developed by [Mason \(1939\)](#) and [Bain \(1956\)](#), seeks to explain aspects of the conduct and performance of firms in terms of the structural characteristics of the markets in which they operate. The structural characteristics of a market cover the number of firms and their absolute and relative size as well as the entry and exit conditions and the extent of product differentiation. Market structure is expected to influence the conduct of firms. Conduct variables include pricing strategies, collusion and other forms of strategic decisions (such as product quality and advertising expenditures). Conduct, influenced by structure determines performance. The SCP paradigm's most important insight is that the more concentrated an industry is, the

easier it is for firms to operate in an uncompetitive manner. For instance, tacit collusion becomes more likely when the number of firms operating in an industry decreases (Tirole, 1988). Remaining firms can exploit their market power in order to charge prices above marginal costs and thus become more profitable at the expense of social welfare.

The SCP paradigm argues that competitive features of industry are inferred from structural characteristics. Empirical works focus on the number of firms and their relative size in order to gauge market concentration. General agreement prevails on the elements that constitute concentration measures. Concentration indices take both the distribution in firm size (inequality) and the number of firms into account in a given market. Hall and Tideman (1967) argue that a good concentration index should satisfy a number of key criteria :

1. Concentration should be a one dimensional measure ;
2. Concentration in an industry should be independent of the size of that industry ;
3. Concentration should increase if the market share of any firm is increased at the expense of a smaller firm ;
4. If each firm in a given industry is divided into two firms of equal size then the concentration index should be reduced by one-half ;
5. When an industry is divided into  $N$  equal sized firms, a measure of competition should be a decreasing function of  $N$  ;
6. A concentration measure should have a range of zero to one (while this property is not strictly necessary, it makes the measure easier to interpret).

Attention is focused on the three widely-used measures of concentration namely the number of firms, the concentration ratios and the Herfindahl-Hirschman index (HHI).<sup>6</sup> Measures of concentration differ according to their weighting schemes and structure. Existing measures of concentration do not respect all the criteria listed above.

The number of firms is the simplest index to compute insofar as the data requirement is very limited. However, this index does not take into account the distribution of firms.

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6. Bikker and Haaf (2002) present other concentration measures such as the Hall-Tideman index, the Rosenbluth index, the CCI, the Hannah-Kay index, the U-index, the Hause indices, and the Entropy measure. Insofar as industrial organization literature focuses on concentration ratios and the HHI, this paper ignores the other concentration measures.

The level of concentration between two industries may differ greatly if one industry is dominated by one firm, while another industry assembles firms with same size. As a result, few papers employ the number of firms as an index of concentration.

Simplicity and limited data requirements make the concentration ratio one of the most frequently used measures of concentration in the empirical literature. The concentration ratio requires more information than the number of firms, insofar as researchers need to obtain the market share of leading firms. The  $k$ -firm concentration ratio measures the market share of the top  $k$  firms in the industry :

$$CR_k = \sum_{i=1}^K s_i, \quad \text{with } s_1 \geq \dots \geq s_K \geq s_N, \quad \forall N \geq K$$

where  $s_i$  is the market share of the  $i$ 'th firm, when firms are ranked in descending order of market share and  $N$  is the total number of firms. The index approaches zero for an infinite number of equally sized firms and equals 1 if the firms included in the calculation make up the entire industry. While there is no rule for the determination of the value of  $K$ , commonly used values include 3, 5 or 10. By focusing only on the market share of the top  $k$  firms, the concentration ratio takes no account for the size distribution of remaining firms. For example, a merger between small firms may not be reflected in the concentration ratio, although the market becomes more concentrated. Some of the criteria listed above fail to be fulfilled by the concentration ratio (e.g., the third criteria).

The Herfindahl-Hirschman Index (HHI) is the concentration measure most frequently used by researchers and antitrust agencies ([Hirschman, 1964](#)). The HHI is more data intensive than the number of firms or the  $CR_k$ , insofar as it requires information on the entire firm size distribution (market share of each firm). It is computed by summing the squares of the market share of all firms :

$$HHI = \sum_{i=1}^N s_i^2, \quad \forall i = 1, \dots, N$$

where  $N$  is the total number of firms in the market. The HHI index ranges between  $1/N$  (for equal-sized firms) and 1 for monopolies. According to current screening guidelines in the USA, the banking industry is regarded to be a competitive market if the HHI is less than 0.10, a somewhat concentrated market if the HHI lies between 0.10 and 0.18,

and a very concentrated market if the HHI is more than 0.18 (Cetorelli, 1999). The HHI stresses the importance of larger firms by assigning them a greater weight than smaller ones, thus reflecting their relative importance. Contrary to the concentration ratio, the HHI avoids the arbitrary cut-off by incorporating each firm individually.

### 3.2 Advantages and shortcomings

The major advantage of concentration measures is the low data requirement. Even for developing countries, concentration measures can be computed at least at the national level. The majority of contributions focusing on industrial organization in low- and middle-income countries use concentration measures to proxy competition.

Unfortunately, the *SCP* paradigm and associated concentration measures suffer from major conceptual and practical limitations. A number of studies have questioned the theoretical underpinnings of these concentration measures. Under the SCP hypothesis, a rise in concentration is regarded as increasing collusive opportunities between firms, and hence would lead to higher prices and profitability. Alternative theories undermine the linkage between structure and conduct. Even in a duopoly, price competition can be fully efficient as the Bertrand equilibrium is a possible outcome. The theory of contestability (Baumol et al., 1982) suggests that a concentrated markets industry can behave competitively if hurdles for entry and exit are low. The threat of entry can exert pressure on incumbents and keep the sector competitive. Other theories show that collusive actions can be sustained even in the presence of many firms. For instance, multimarket contacts raise the incentive for collusion by changing the relative costs and benefits of cooperating (Bernheim and Whinston, 1990).

Not only is the linkage between structure and conduct uncertain, but the direction of causality is also problematic. The efficiency structure (ES) hypothesis (Demsetz, 1973; Peltzman, 1977) entails the notion that the structure of the market may reflect differences in efficiency rather than a competitive situation. Under the ES hypothesis, firms that have higher productive efficiency tend to gain market share, which can lead to higher market concentration. Therefore, concentration indices are not exogenous and may reflect

differences in terms of efficiency.<sup>7</sup> The core of the problem is the difficulty of knowing what different levels of concentration exactly reflect. Market structure and concentration may proxy for a whole range of conduct-determining bank and market characteristics, including average bank size, bank complexity in terms of product variety and activities, the ease of information flow within the market and the overall size of the market itself, for instance ([Ergungor, 2004](#)).

Another part of the argument against concentration measures concerns empirical implementation. The major practical problem concerns the appropriate definition of the market. Defining the relevant geographical market (local, regional, or national) as well as the product market can be difficult ([Shaffer, 2004b](#)). The relevant geographical market may differ according to banking activities. For example, banks compete locally to provide credit to SMEs due to informational requirements. Credit to transparent firms, however, is based on hard information that is easily transferable in impersonal ways. Therefore, a bank outside the local market may compete to provide funds for well-established firms. At the extreme, the geography of the relevant market for granting loans to multinational firms is international. Furthermore, all products that are substitutes need to be included in the product market definition. In the financial sector, a number of substitutable products are supplied by non-banking firms. As a consequence, defining the relevant market may be a complex issue. In practice, the choice is often constrained by data availability. Studies on industrialized countries often produce market share and concentration indices at the local level (such as the *Metropolitan Statistical Areas* in the U.S.). In studies on developing economies, concentration indices can only be calculated at the national level due to the lack of disaggregated data. This might raise concerns about the relevance of concentration measures used in applied works. For example, studies on credit conditions for SMEs should employ concentration measures at the local level insofar as SMEs borrow locally. When disaggregated data are available, researchers should use proxy concentration at the local level. An illustration of this approach can be found in [Chong et al. \(2013\)](#).

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7. Without referring to the ES hypothesis, one should raise concerns about the exogeneity of market structure. In a two-stage game, such as the Salop model, entry decision (market structure) and price setting (conduct) are both endogenous and are determined by the equilibrium of the game. A firm will enter only if it expects to earn profit in the future.

They consider each Chinese city as a separate banking market and measure concentration using the number of branches for each bank in the city. Unfortunately, for many economies such intensive information is rarely provided. Researchers employ national measures of concentration to infer conclusions about the degree of concentration in local banking markets. They implicitly assume that national concentration indices are a good proxy for local ones.

Despite the fact that concentration measures continue to be widely used in the banking literature, they suffer from some theoretical and empirical limitations. Unfortunately, especially in studies on developing countries, researchers do not benefit from rich information on banks. They do, however, keep in mind that concentration and competition are two different concepts that are not always related.

### **3.3 New structural measures : Regulation in banking**

Concentration indicators are still used as the main structural indicators mainly because they are easier to measure than other dimensions of structure (entry and exit conditions and product differentiation). Nevertheless, several studies have begun to investigate other elements of market structure, especially entry and exit conditions. The theory of contestability argues that firms behave competitively in the absence of entry and exit barriers (see : Box 1).

Barriers consist of both formal and informal obstacles to entering and exiting a market. Financial regulation is one of the major constraints to free entry in banking. The financial sector is among the most regulated sectors in many countries. Several contributions (Claessens, 2009; Demirgüç-Kunt and Peria, 2010) propose considering regulatory framework to gauge the degree of contestability in banking. Following the initial work of Barth, Caprio and Levine (Barth et al., 2005, 2013), a rich international database on bank regulations (and supervision) has been developed and may be used. It takes into account entry requirements for domestic and foreign banks, capital requirements and the regulations affecting bank activities. Not only are *de jure* (in book) regulations included but the database also considers regulator activities and *de facto* limits.

A major limitation with this approach is the omission of non-regulatory barriers and sunk costs that play a significant role in the banking industry (Dietsch, 1992). The degree of contestability in banking is influenced by non-legal barriers, such as technical and informational barriers. The existence of scale and scope economies may create barriers to entry, while empirical contributions on developed economies fail to provide evidence for the existence of scale and scope economies in banking (Degryse et al., 2009). Another important element affecting the nature of competition in retail banking is the presence of networks. Incumbents can choose to share or extend their network to exclude rivals from the market and limit competition (Matutes and Padilla, 1994).<sup>8</sup> The most important economic barrier is certainly the presence of informational rents of incumbent banks. The informational gap between incumbents and outside banks acts as a barrier in the market. Private information may limit effective competition from uninformed outside banks (Sharpe, 1990; Fisher, 1990; Rajan, 1992) due to the adverse selection problem. The adverse selection problem for potential entrant banks stems from their inability to distinguish new (good) borrowers from old (bad) borrowers who have been rejected by their previous bank. The adverse selection problem and incumbent banks' information act as a barrier to entry in the banking industry (Dell'Ariccia et al., 1999; Dell'Ariccia, 2001; Marquez, 2002). Unfortunately, no paper gives a simple method to assess the information gap between incumbents and outside banks.<sup>9</sup> One might expect that this gap is larger in more opaque markets. The presence of an informational wedge may explain why regulatory frameworks are weakly related to competition in banking for developing economies (Delis, 2012).

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8. The Stackelberg-Spence-Dixit model (Tirole, 1988) shows that incumbent(s) may endogenously deter entry or at least try to limit the expansion of entrants through overinvestment in production capacity. The bank branches network of incumbent banks is often heavy. An incumbent must establish several branches and bear the high fixed costs to compete with incumbents.

9. Non-structural models have been developed to assess the sunk-cost (Sutton, 1991; Dick, 2007) or the decision to enter for outside banks (Bresnahan and Reiss, 1991). These models require strong assumptions and/or strong data requirements. As a result, they are rarely implemented in the banking industry. For a presentation of these models and their implementation in the banking industry : see Degryse et al. (2009).

To summarize, although the structural approach is open to criticism, these proxies have often been employed in recent contributions on developing countries. Information on the structure of markets or regulatory framework is often the sole data that researchers focusing on less mature banking systems can obtain. However, it is important to be aware of the strong limitations of these different indicators. With the development of micro-data on banking institutions, new measures of competition based on bank behavior have been developed and are beginning to be used in developing countries.

## 4 New Empirical Industrial Organization

Shortcomings in the structural approach have led to a number of attempts to collect empirical evidence on the nature of competition by observing conduct directly. The New Empirical Industrial Organization (NEIO) make conclusions about competitive pressure by directly observing the conduct of firms in the market. The NEIO employs a variety of alternative methodologies requiring different data and assumptions. [Carbó-Valverde et al. \(2009\)](#) point out that the first generation of non-structural measures is based on the oligopoly theory (*neoclassical conception of competition*). These models include the Lerner index, the conjectural variation models ([Iwata, 1974](#); [Bresnahan, 1982](#); [Lau, 1982](#)) and the [Panzar and Rosse \(1987\)](#) model. While sharing a common standard theoretical framework, results are often divergent ([Carbó-Valverde et al., 2009](#); [Liu et al., 2013](#)).

A second generation of NEIO measures focus on the dynamics of markets and are thus in line with the *Austrian (dynamic) conception of competition*. These include the Persistence of Profits developed by [Mueller \(1977, 1986\)](#) and the Boone indicator recently proposed by [Boone \(2008\)](#).

This subsection reviews the widely-used non-structural measures in banking, namely the Lerner index, the conjectural variation model, the Panzar-Rosse model and the Boone indicator.<sup>10</sup>

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10. Insofar as applications of Persistence of Profits in banking are scant, this method is not presented in this paper. Furthermore its implementation may be complex in highly unstable countries, such as developing economies. The interested reader may refer to [Goddard et al. \(2011\)](#) for more on this methodology. Other methods have been developed in the literature such as the Hall-Roeger model ([Rezitis, 2010](#)) and the structural demand models ([Dick, 2008](#)). These models require strong assumptions and/or have strong

## 4.1 Lerner index

### 4.1.1 From theory to application

The Lerner index (or price-cost margin) is a popular measure of market power in empirical research. The market power of a firm is identified by the divergence between the firm's price and its marginal cost. The price and marginal cost should be equal in perfect competition, but will diverge in less competitive environments. A bigger wedge between price and marginal cost signals greater monopoly power.

The theoretical foundation of the Lerner index is rooted in static oligopoly theory. Let us suppose a quantity-setting oligopoly model (Cournot model). In an industry producing a single good, let  $P$  be the market price of product  $Q$  and let  $q_i$  be the quantity produced by firm  $i$ . The profit maximization problem for firm  $i$  is written as :

$$\max_{q_i} [P(Q)q_i - C(q_i, \omega_i)] \quad (1)$$

where  $q_i$  is the quantity produced by firm  $i$ ,  $Q$  is the total quantity ( $Q = \sum_{j=1}^J q_j$ ), and  $P(Q)$  the price in the market.  $C(q_i, \omega_i)$  is the total cost of firm  $i$ , where  $\omega_i$  is the vector of the prices of the factors of production employed by firm  $i$ . [Lerner \(1934\)](#) proposes the following measure of market power, known as the Lerner index :

$$L_i = \frac{P(Q) - C'_{q_i}(q_i, \omega_i)}{P(Q)} \quad (2)$$

where  $C'_{q_i}(q_i, \omega_i)$  is the marginal cost of firm  $i$ . The Lerner index ranges from 0 in situation of perfect competition to the inverse of the price elasticity of demand in situation of monopoly or collusion.

Although the Lerner has been known by economists since the mid-1930s, its application to banking is relatively recent due to the difficulty of assessing marginal costs. Marginal costs have only been econometrically estimated during the last two decades and are extracted from the estimation of the cost function. Cost function is often assessed using the intermediation approach (see the Box 2) from a translog equation including a single data requirements. As a result, they are rarely implemented in the banking industry. Implementation of the persistence of the profit model remain scarce in banking. For a presentation of these models and their implementation in the banking industry, the interested reader may refer to [Degryse et al. \(2009\)](#) and [Liu et al. \(2013\)](#).

output (total assets) and three inputs (labor, deposit, and physical capital). The translog function is generally as follows :

$$\begin{aligned} \ln(C_i) = & \beta_0 + \beta_1 \ln(q_i) + \frac{1}{2} \beta_2 [\ln(q_i)]^2 + \sum_{l=1}^3 b_l [\ln(\omega_{l,i})] + \frac{1}{2} \sum_{l=1}^3 b_{3+l} [\ln(\omega_{l,i})]^2 \\ & + \sum_{l=1}^3 \beta_{2+l} [\ln(q_i)] [\ln(\omega_{l,i})] + \sum_{l \neq l'} b_{6+l} [\ln(\omega_{l,i})] [\ln(\omega_{l',i})] + \sum_{k=1}^K \kappa_k Z_{k,i} + \varepsilon_i \end{aligned} \quad (3)$$

where  $C_i (= C(q_i, \omega_l))$  represents total bank costs of bank  $i$ ,  $q$  represents a proxy of bank output (total assets),  $\omega_l$  the price of  $l^{th}$  input, and  $Z$  a set of control variables. From Eq. 3, the marginal cost is merely obtained by taking the first derivative and multiplying by the average cost :

$$C'_{q_i} = \frac{\partial C_i}{\partial q_i} = \left( \beta_1 + \beta_2 \ln(y_i) + \sum_{l=1}^3 \beta_{2+l} [\ln(\omega_{l,i})] \right) \frac{C_i}{q_i} \quad (4)$$

The price of output ( $P$ ) is computed as the average revenue.

This indicator is a good measure of individual market power. It allows researchers to simply quantify the pricing market power of individual bank. The Lerner index has the main advantage to be bank-specific and to vary over time, allowing comparison of market power among banks and/or over the period.

Many papers have tried to assess banking competition by averaging the individual Lerner indices (Fernández de Guevara et al., 2005, 2007; Maudos and Solís, 2011; Weill, 2013, among others). The Lerner index for the market  $j$  is obtained as follows :

$$L_j = \sum_{i \in j} \phi_{ij} L_{ij}$$

where  $L_{ij}$  is the Lerner index of firm  $i$  in market or country  $j$  and  $\phi_{ij}$  the weighting of firm  $i$  (often the market share of firm  $i$  in market  $j$ ). An unweighted Lerner index implies that  $\phi_i = 1/N$ , where  $N$  is the number of firms in market  $j$ .

## Box 2 : Models of banking firms and measures of prices and quantity

Non-structural measures of competition often require a model of a banking firm to specify the output(s) and input(s). In the literature, two main approaches may be identified.

Under the *production approach*, financial institutions are thought of as primarily producing services for account holders. Banks offer various financial services such as savings or credit by mobilizing labor and physical capital. This view argues that deposit products provide a valuable service for depositors (safe storage of valuable, record keeping, and means of payment).

Many empirical studies use an alternative approach ; the *intermediation approach* (Klein, 1971; Monti, 1972; Sealey and Lindley, 1977). A bank is considered as an intermediary between depositors and borrowers. A bank employs labor and physical capital to attract deposits, which are used to fund loans. In addition to labor and physical capital, deposits are considered as an input. Bank output is often defined as total assets, or total loans.

Insofar as intermediation function remains the core of bank activity in developing economies, this thesis keeps the traditional intermediation approach. Under the intermediation approach, outputs are computed as total assets. Contrary to total loans, total assets take into account other earning assets. <sup>a</sup> Three inputs are considered, namely labor, physical capital and deposits. Insofar as prices are not directly observable, researchers use balance sheets and income statements to infer prices. Using banks' financial figures to proxy prices may be problematic. Prices reflect average prices for each bank and mix the price of each product (or factors) and the mixing of product (or factors). Changes in prices may reflect changes in absolute prices or changes in the composition of outputs or inputs. By contrast, changes in absolute (outputs or inputs) prices are not automatically captured by average price if the bank modifies the composition of its portfolio or of its production factors. One might keep in mind these limitations and be cautious when interpreting results employing "endogenous" prices.

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*a.* Various factors have fostered the growth of non-traditional banking activities, especially in mature markets. Non-traditional activities include securitization, standby letters of credit, and derivative securities, which have rarely been considered as outputs. Recent contributions, in particular on developed countries, should more explicitly consider these new products insofar as their share in bank revenues increases.

#### 4.1.2 Advantages and shortcomings

The main reasons for the popularity of the Lerner index are its simplicity, its straightforward interpretation, and the fact that it does not pose stringent data requirements. Insofar as the Lerner index provides a firm-year specific measure of market power, it offers the possibility of studying the evolution of bank pricing behavior over time. This indicator has other interesting advantages. The Lerner index is a flexible indicator and does not require defining the relevant market. It allows market power to be measured separately

for the different banking markets (geographic and by products). Furthermore, researchers may easily disentangle monopoly and monoposony power by excluding financial costs to total costs and deposit prices (Turk Ariss, 2010). Finally, the Lerner index can be calculated with a limited number of observations. The latter advantage is far from anecdotal insofar as competitive concerns occur mainly when the number of firms is limited (in such cases, the marginal costs may be proxied by average costs).

The Lerner index, however, suffers from major theoretical and practical limitations. In fact, it is a measure of pricing market power and not a proxy of competition. In other words, an increase of average market power over time can be consistent with an increase in the intensity of competition. Contributions show that there are theoretically possible scenarios in which price-cost margins increase with more intense competition (Stiglitz, 1987, 1989; Bulow and Klemperer, 2002; Amir, 2010, among others).<sup>11</sup> Recent works show that even if individual Lerner indices decreases with competition, the average degree of market power may increase, decrease or remain stable due to the reallocation effect from inefficient to efficient firms (Boone, 2008; Boone et al., 2013). Efficient firms have higher price-cost margin than their counterparts. Thus, the weighted average Lerner index can increase if the increase in the market share of more efficient firms overcompensates the decrease of the respective individual Lerner indices.<sup>12</sup>

Other practical concerns have been raised about the Lerner index. Vives (2008) maintains that the Lerner index is not able to appropriately capture the degree of product

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11. The Austrian School reaches similar conclusions in a completely different framework. In the Austrian perspective, competition gives firms incentives to innovate in order to cope with competition. Incumbent's banks will develop new products or expand their network of branches to maintain an advantage over their rivals. These banks can continue to extract some margins on customers even after the increase of competition. An increase of Lerner indices over time does not necessarily signal a worsening of competitive conditions. On the contrary, this might suggest a strengthening of competitive conditions. Extraction of market power may be a normal feature of competitive behavior. Therefore, the Lerner index is, at least theoretically, potentially misleading.

12. The reallocation effect can be partly eliminated by using the unweighted Lerner index as measure of competition. This reduces the problem caused by the reallocation effect to a certain extent but does not remove it completely : an increase in competition can induce the destruction of inefficient firms (with low margins) which raises the average Lerner index in the market.

substitutability. [Oliver et al. \(2006\)](#) emphasize that, when a bank's risk taking is not accounted for, the Lerner index could overestimate market power, because banks that in relative terms spend more of their resources granting credits enjoy higher margins. This issue is particularly problematic for studies employing the Lerner index to investigate the competition-stability nexus ([Berger et al., 2009](#); [Turk Ariss, 2010](#); [Beck et al., 2013](#)). [Koetter et al. \(2012\)](#) point out that the conventional approach of computing the Lerner index assumes perfect technical and allocative efficiency. Unfortunately, banks rarely operate under perfect efficiency. Operating costs and efficiency vary depending on the economic environment in which banks operate ([Chaffai et al., 2001](#)). As a consequence, differences across countries (or changes over time) in Lerner indices can be justified by differences (or changes) in non-competitive factors.

## 4.2 Conjectural-variation model

### 4.2.1 From theory to application

The Lerner index cannot distinguish between markets that have high margins due to inelastic demand and markets that have high margins because they are less competitive or perhaps collusive. To overcome this problem, the conjectural-variation method has been introduced by [Iwata \(1974\)](#), [Bresnahan \(1982\)](#), and [Lau \(1982\)](#). The aim is to control the changes of the Lerner index due to demand changes, and therefore isolate firms' competitive behavior.

The conjectural variation refers to the beliefs that one firm has about the way its competitor(s) may react if it varies its output or price ([Bowley, 1924](#)).<sup>13</sup> Recalling the profit maximization problem for firm  $i$  (Eq. 1), the first order condition for a firm  $i$  is given as :

$$P'_Q Q'_{q_i} q_i + P = C'_{q_i} \quad (5)$$

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13. The validity of the conjectural variation model is criticized by theorists as a dynamic principle in a static framework ([Tirole, 1988](#); [Vives, 2001](#)). There is no opportunity for rivals to react to firm  $i$ 's change in the context of one-shot simultaneous moves games. Nevertheless, the conjectural variation approach has proved useful in applied works because it parameterizes the degree of competition in a market ([Tirole, 1988](#); [Martin, 2002](#)).

For the firm  $i$ , the conjectural variation parameter (in quantity) is measured as :

$$\lambda_i = \frac{\partial \sum_{j \neq i} q_j}{\partial q_i} = Q'_{q_i} - 1 \quad (6)$$

$\lambda_i$  is the expectation of firm  $i$  of the extent to which its own output initiatives will trigger changes in the outputs of its rivals.

Eq. (5) becomes :

$$P'_Q(1 + \lambda_i)q_i + P = C'_{q_i} \quad (7)$$

By multiplying Eq. (7) by  $Q/P$  and rearranging the equation, the Lerner index can be rewritten as :

$$L_i = \frac{P - C'_{q_i}}{P} = -\frac{(1 + \lambda_i)s_i}{\varepsilon_d} \quad (8)$$

where  $\varepsilon_d$  is the elasticity of demand and  $s_i$  the market share of firm  $i$ .

Firm  $i$ 's expectations about the reactions of its rivals (conjectural variation parameter) ranges from  $-1$  to  $N - 1$  ( $N$  is the number of firms in the market). In a collusive situation if firm  $i$  increases its production by 1, all firms will do the same thing and raise their production by one. Hence, the full exploitation of market power exercised by firm  $i$  coincides with  $\lambda_i = N - 1$  and the total output increases by  $N$  unities.<sup>14</sup> Perfect competition (or Bertrand competition) implies that  $\lambda = -1$  what changes expression (8) in the well-known  $P = C'_{q_i}$  condition. Firm  $i$  expects a change in output of firms  $j$  which exactly compensates its own, so as to leave the price unchanged. If  $\lambda = 0$ , then firm  $i$  expects no reaction to its change in output and therefore it is a Cournot situation.

In practise, the conjectural elasticities is employed instead of the conjectural variation (Degryse et al., 2009). The conjectural elasticities is defined as :  $\theta_i = Q'_{q_i} \frac{q_i}{Q}$ . After some manipulations, the Eq. 7 can be rewritten as (Angelini and Cetorelli, 2003) :

$$P = C'_{q_i} - \lambda_i = C'_{q_i} - \frac{\theta_i}{\tilde{\varepsilon}_i} \quad (9)$$

where  $\theta_i$  is the conjectural elasticities and  $\tilde{\varepsilon}_i$  the semi-elasticity of demand ( $\tilde{\varepsilon}_i = Q'_P/Q$ ).

The conjectural elasticity ranges from 0 (perfect competition) to 1 (collusive situation).

The Cournot equilibrium or zero-conjectural variation model occurs when  $\theta = 1/n$ .<sup>15</sup> Eq.

14. It is easy to show that the Lerner index equals the inverse of the elasticity of demand in this case.

15. Other contributions have extended the classical conjectural variation model. Coccoresse (2005) develops a model of conjectural variation in a price-setting framework and Suominen (1994) develops a two-product Cournot model.

9 can be rearranged to give an expression of the Lerner index :  $L_i = \lambda_i/P$  (Angelini and Cetorelli, 2003).

A critical step in applied works is to convert the theory to data. This has historically been done in two ways. The first approach is to estimate a parameter that represents the behavior of firms. The Iwata (1974) model provides a framework for estimating conjectural variation values for individual firms that supply homogenous products. Bresnahan (1982) and Lau (1982) propose an alternative approach based on industry data. The advantage of this method is the ability to use industry aggregate data (more available than firm-level data). More recently, different variants based on panel data have been proposed (Angelini and Cetorelli, 2003; Coccoresse, 2005, 2009; Uchida and Tsutsui, 2005). All methods confront demand and supply equations in a system in order to disentangle changes in elasticity demand and modifications of banks' behavior. The demand equation estimation gives the value of demand elasticity ( $\varepsilon$ ) and the supply equation (based on Eq 9) provides the  $\lambda$  parameter. By confronting both parameters, the behavioral parameter  $\theta$  and the Lerner index can be easily derived.

#### **4.2.2 Advantages and shortcomings**

The conjectural parameter methods have been widely applied in banking following (Shaffer, 1989, 1993). The structural model in this approach consists of a market demand function and an associated supply function for either an individual firm or an average firm. The advantage of this method is the direct analysis of firms' conduct based on static industrial organization theory. The parameter estimated can be treated as a continuous variable under unrestricted conditions and test statistic maps into all oligopoly solution concepts : perfect competition, Cournot competition, Bertrand competition, and collusion (Shaffer, 2004b,a). The conjectural variation model builds a bridge between different conceptions of oligopoly (Cournot and Bertrand). Furthermore, Shaffer (2004b) points out that even if firms follow a strategy other than profit maximization or if regulations constrain banks' behavior, the test remains a valid technique. However, Xu et al. (2013) shed light on the impossibility for this model to consider interest rate regulations. Finally, this test can cope with monopsony power in a deposit market without revising the model

([Shaffer, 1999](#)).

The conjectural variation model is open to criticism. Insofar as the conjectural variation approach is merely an elasticity-adjusted Lerner index, all concerns about Lerner apply (see above). The conjectural variation methods have additional practical drawbacks, especially for studies on less mature banking markets. The structural model in this approach requires specifying functional forms for demand and supply equations. One might raise concerns about the functional forms adopted. Flexible functional forms often imply the need to assess a large number of parameters. This induces two econometric problems. Firstly, the risk of multicollinearity increases when researchers add interactions ([Perloff and Shen, 2012](#)); secondly, studies based on a limited number of observations face major small-sample issues (identification issue and instability). The latter issue is particularly problematic insofar as concerns about competition occur in markets with few suppliers. As a consequence, results may be highly sensitive to the specification employed, rising doubts about the conclusions. It is therefore important to verify that the estimated parameters are consistent with theoretical requirements (e.g. negative price elasticity or convex marginal costs). Furthermore, [Shaffer \(2001\)](#) points out that the estimated parameter can exhibit a bias if the sample fails to span the complete market.<sup>16</sup> The latter shortcoming may cause serious problems in cross-country samples based on a limited sample of banks.

## 4.3 Panzar and Rosse model

### 4.3.1 From theory to application

The Panzar-Rosse model ([Rosse and Panzar, 1977](#); [Panzar and Rosse, 1982, 1987](#)) is the most widely applied assessment of competition in the banking literature. This indicator catches the transmission of input prices on firms' revenues. Weak transmission is interpreted to indicate the exercise of market power in pricing and higher values indicate more competition.

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16. In the financial industry, this issue is far from anecdotal due to the development of non-traditional banking activities by banks and non-bank financial firms. As a result, defining market borders becomes more difficult.

The intuition is straightforward in two opposite cases : collusion and perfect competition. For a monopolist, marginal cost equals marginal revenue at the equilibrium. After input prices increase, marginal cost increases. To maintain the equilibrium between marginal cost and marginal revenue, the monopolist should increase the marginal revenue by reducing the total quantity (insofar as marginal revenue is a decreasing function of quantity). [Rosse and Panzar \(1977\)](#) show that total revenue is reduced if the price elasticity of demand exceeds one. Intuitively, an increase in marginal cost reduces quantity but increases output price. If the demand elasticity exceeds one, the gain due to price increase does not compensate for the loss due to reduction of quantity. By contrast, in a competitive setting an increase in input prices induces an increase in total revenue. Because cost functions must be homogenous of a degree of one in the input prices, any increase in input prices generates an equal percentage increase in costs. A firm's revenue changes by the same percentage as its total cost, and so by the same percentage as its inputs prices to ensure the zero profit condition (total cost equals total revenue). The required adjustments in the total quantity are achieved by a reduction in the number of firms (long-run equilibrium). As a consequence, an increase of 1 percent in input prices induces an increase of 1 percent of total revenue in competitive markets.

From this theoretical framework, the identification of competitive conditions is obtained by calculating the sum of the elasticities of the revenue with respect to all input prices. The sum of elasticity, often called the H-statistic, ranges from  $-\infty$  to  $+1$ . The greater the transmission of cost changes into revenue changes, the more competitive the market is. Under perfect competition, input prices and total revenue increase by the same percentage and the H-statistic equals one. [Shaffer \(1982\)](#) proves that the H-statistic value equals one for a monopoly in a contestable market (free entry). The H-statistic is null or negative for a monopoly. An increase in input prices induces a reduction of total revenue under certain assumptions (e.g. demand elasticity higher than one). [Vesala \(1995\)](#) documents that the H-statistic is non-positive in the monopolistic competition equilibrium without threat of entry or for a collusive oligopolist. This measure is between 0 and 1 for a monopolistic competitor ([Rosse and Panzar, 1977](#); [Panzar and Rosse, 1987](#); [Vesala, 1995](#)).

Applied economists estimate a reduced-form revenue equation. The test is obtained by regressing revenue (in logarithm) on input prices (in logarithm) and other control va-

riables :<sup>17</sup>

$$\ln(Rev_i) = \alpha + \sum_{l=1}^L \beta_l \ln(\omega_{l,i}) + \sum_{k=1}^K \gamma_k Z_{k,i} + \varepsilon_i \quad (10)$$

where  $Rev$  is the total revenue (or interest revenue),  $\omega_l$  the price of  $l^{th}$  input, and  $Z_k$  a set of control variables. In line with the intermediation approach, input prices consider prices of labor, physical capital and deposits (see Box 2). The H-statistic is defined as :

$$H = \sum_{l=1}^L \beta_l \quad (11)$$

Hence, the H-statistic is the sum of the elasticities of the total interest revenue of the banks with respect to their factor prices. It is worth stressing that the interpretation of the H-statistic requires that the sector be in a long-run equilibrium insofar as a monopolistic situation requires an endogenous number of firms.

### 4.3.2 Advantages and shortcomings

The success of the PR model can be explained by its simplicity and the fact that it does not pose stringent data requirements. The test can be derived by running only one equation requiring a few numbers of variables and banks. As a result, the PR model can be obtained from a relatively small number of observations, which is crucial for studies on less mature banking industry. Furthermore, [Shaffer \(2004a\)](#) points out that the PR model is robust to the extent of the market as no specific market definition appears in the revenue equation. Only the data from firms included in the sample are required to estimate revenue equation. This is a huge advantage in cross-country studies ([Claessens and Laeven, 2004](#)).

Nonetheless, these benefits come at the cost of other shortcomings. The major pitfall concerns the econometric identification and the interpretation of the H-statistic. A sample of firm-level observations in a long-run competitive equilibrium would exhibit  $H = 1$ , while a sample of observations from a profit-maximizing monopoly yields  $H \leq 0$ . However,

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17. This specification assumes that the production function is a Cobb-Douglas. This assumption is open to criticism and a more flexible production function should be used. However, [De Brandt and Davis \(2000\)](#) show that loglinear specification reduces simultaneity bias and gives similar results to more flexible equations (such as translog equations).

theoretical studies report that the H-statistic can be negative in a competitive market and positive for a monopoly. A negative H-statistic can occur even in highly competitive conditions in the short-run with a fixed number of firms (Shaffer, 1983) or in the case of constant average cost (Bikker et al., 2012). Shaffer and Spierdijk (2013) point out that the H-statistic can be positive in highly noncompetitive settings. Furthermore, for firms facing constant elasticity of demand, theoretical studies report the H-statistic as alternatively an increasing (Shaffer, 1983) or decreasing (Panzar and Rosse, 1987) function of the Lerner index. Put differently, higher values of the H-statistic do not necessarily imply lower market power.

Another issue is related to the continuous nature of the H-statistic. This outlook has been adopted in many empirical works (Bikker et al., 2012, Table 1). According to Panzar and Rosse (1987), the H-statistic can be interpreted as a continuous monotonic index of conduct; not only the sign of the H-statistic matters, but also its magnitude. Shaffer (2004b), however, casts doubt on the use of the H-statistic as a continuous measure of competition although Vesala (1995) proves that the H-statistic is a continuum under certain conditions. In empirical studies, the H-value is often considered as a continuum value although the question remains unsolved (Bikker et al., 2012).

As a consequence, the interpretation of the value of the H-statistic is more complex than the canonical PR model predicts. In fact, the interpretation of the H-statistic depends on the hypotheses assumed regarding the market equilibrium, demand elasticity and cost function (Shaffer, 1983; Panzar and Rosse, 1987; Vesala, 1995; Bikker et al., 2012). Unfortunately, with the exception of the market equilibrium, applied economists cannot test these required assumptions. As shown above, the long-run equilibrium (endogenous number of firms) is necessary to derive testable hypotheses. An equilibrium test has been developed to validate the market equilibrium hypothesis (Shaffer, 1982). The profits are uncorrelated with the input prices in the long-run equilibrium. Hence, the test consists in switching the total revenue by profit rates in Eq 10 :

$$\ln(\pi_i) = \alpha' + \sum_{l=1}^L \beta'_l \ln(w_{l,i}) + \sum_{k=1}^K \gamma'_k Z_{k,i} + \varepsilon'_i \quad (12)$$

where  $\pi$  is the return on assets. The E-statistic is  $E = \sum_{l=1}^L \beta'_l$ . The market equilibrium condition is  $E = 0$ . Bikker et al. (2012) show that the equilibrium test is essentially a

joint test for competitive conduct and long-run equilibrium, which substantially narrows its applicability. In a market operating under imperfect competition or a monopoly, the E-statistic may differ from 0.

Alongside these difficulties, applications suffer from additional limitations. First, the PR model is sensitive to monopsony power. Inputs should be homogenous and their prices exogenously fixed. The price of deposits is not always exogenous. A bank may behave as a monopsony when alternative savings products are not available. Monopsony power would tend to yield higher values of the H-statistic and thereby mask any market power present on the output side (Shaffer, 2004a). The other non-structural measures of competition are less subject to the monopsony issue.<sup>18</sup> The monopsony issue is rarely discussed in the literature.

Finally, Bikker et al. (2012) acknowledge that some applications employ a scaled revenue equation (introducing size as control) or estimate a price function by using the ratio of revenue to total assets as dependent variable. However, the properties of the price and revenue equations are identical in the case of long-run competitive equilibrium but critically different in the case of monopoly or oligopoly. This disqualifies a large number of studies. The proper revenue equation must exclude the scale variable and use the total revenue as dependent variable.

To summarize, the first generation of non-structural measures of bank competition is based on standard oligopoly theory. The Lerner index assesses the average pricing market power. The conjectural-variation model observes how rivals react to changes in a bank's behavior. The Panzar-Rosse model investigates how changes in input prices are transmitted in revenue. A major advantage of these approaches is that they allow discrimination between the different possible situation : collusion, perfect competition and imperfect competition (oligopoly). Nonetheless, these measures neglect dynamics in the market and non-pricing strategies. The second generation of NEIO measures of competition takes into account these factors. In the following section, I present the Boone indicator, which has begun to be used in the banking literature.

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18. Other methods employ a cost function. As expressed above, the econometrician may run a cost function excluding financial costs and deposits to test the sensitivity of results to monopsony power.

## 4.4 The Boone indicator

### 4.4.1 From theory to application

Recently, [Boone \(2008\)](#) has extended the existing set of competition measures by suggesting a new measure based on the idea that efficient firms are more highly rewarded in more competitive markets. The indicator starts from the notion that in a more competitive market firms are punished more harshly in terms of profits for being inefficient.<sup>19</sup> Under the efficiency hypothesis ([Demsetz, 1973](#)), more efficient firms achieve superior performance in terms of higher profits at the expense of their less efficient rivals and also attract greater market share. The Boone indicator exploits this reallocation effect from inefficient to efficient firms. In the most extreme case, the reallocation effect is combined with a selection effect insofar as the least efficient firms leave the market. [Boone \(2008\)](#) shows that the reallocation effect increases monotonically with the degree of competition.<sup>20</sup> While an intensification of competition can decrease the output of firms, this decrease will be smaller for more efficient firms. As a result, the market share and profits for more efficient firms increase while those the less efficient firms shrink. Phrased differently, the relative profit difference is sensitive to the degree of competition ([Boone, 2008](#), Theorem 1).

[Boone \(2008\)](#) demonstrates how relative profit difference can measure the level of competition in practice. Although the procedure is theoretically applicable, it is computationally intensive. It requires the ranking of firms by efficiency levels. In practice, researchers often gauge the strength of the relationship between efficiency and performance. The intensity of competition is estimated from the following simple profitability equation ([Boone et al.,](#)

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19. It should be noted that [Hay and Liu \(1997\)](#) develop a similar concept of competition by investigating the relationship between market share and firm costs to assess the level of competition.

20. [Boone \(2008\)](#) considers two different forces as causing an increase in competition. The first is a fall in entry barriers. The lower the entry barriers, the more firms should enter and the more competitive the industry should be. This intuition underlines the use of the structural approach. Boone, however, considers another source of competition : the aggressiveness of rivals' conduct in the market.

2007) :<sup>21</sup>

$$\ln\pi_i = \alpha + \beta \ln c_i + \varepsilon_i \quad (13)$$

where  $\pi_i$  stands for profit and  $c_i$  a measure of costs (proxied efficiency). The coefficient  $\beta$  gives the profit elasticity (PE), that is, the percentage drop in profits of bank  $i$  as a result of a percentage increase in bank  $i$ 's costs. This indicator is in theory negative, reflecting the fact that higher marginal costs are associated with lower profits. In addition, its value should be lower the more competitive market conditions are. [Boone et al. \(2007\)](#) conducted simulations for the PE indicator and found that changes in competition are correctly identified with this measure.

Recent contributions introduce two modifications of Eq. 13. First, [Van Leuvensteijn et al. \(2011\)](#) directly estimate the marginal cost  $c_i$ . When data allow for computing marginal costs, studies employ this measure of efficiency ([Delis, 2012; Tabak et al., 2012](#)). Otherwise researchers use imperfect proxies such as average costs ([Schaeck and Cihák, 2013](#)). Second, efficient banks may choose to translate lower costs either into higher profits or into lower output prices in order to gain market share. As a consequence, the bank's market share rather than its profits is often used as the dependent variable to take into account the second possibility ([Van Leuvensteijn et al., 2011, 2013; Tabak et al., 2012](#)) :

$$\ln s_i = \alpha + \beta' \ln c_i + \varepsilon'_i \quad (14)$$

where  $s_i$  is the market share of bank  $i$ .

Equations 13 and 14 are often run by introducing fixed-effects in order to take into account unobserved heterogeneity. Recent works also control for endogeneity by running an instrumental approach. Indeed, changes in performance and costs may be induced by a third factor unrelated to competition.

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21. Instead of in a log/log specification, the costs and profits can be expressed in levels. Employing levels allows for introducing non positive profit values. In doing so, the estimation may introduce a bias in the sample towards profitable banks. [Boone et al. \(2013\)](#) shows that results are weakly sensitive to this exclusion. The main advantage of a log/log specification is to facilitate the interpretation of the  $\beta$  coefficient as an elasticity.

#### **4.4.2 Advantages and shortcomings**

The fact that the relationship between costs and profits is both continuous and monotonic is the main advantage of the Boone approach. In almost all cases, higher competition implies that the value of  $\beta$  is larger in absolute terms (more negative), and therefore,  $\beta$  serves as a continuous indicator of competition. As expressed by Boone in different works ([Griffith et al., 2005](#); [Boone et al., 2007](#); [Boone, 2008](#); [Boone et al., 2013](#)), his indicator avoids some major theoretical drawbacks of price-cost margin measures (see Section 3.4.1.2). Moreover, while the identification of a situation from the PR model is a challenge, the Boone indicators are monotonically related to competition. Furthermore [Xu et al. \(2013\)](#) show that the existence of binding interest rate regulations renders the Boone measure more robust than other NEIO measures.

In practice, the Boone approach has additional advantages for studies on developing countries. This method requires only information on profits (or market shares) and costs. In particular, if costs are assessed by average costs, the computation of the Boone indicator does not require information on prices. Furthermore, the Boone estimation is obtained by a simple linear econometric specification (only one equation with one exogenous variable).

Like other models, the Boone indicator is a simplification of reality and suffers from some limitations. The Boone indicator approach focuses on one important relationship affected by competition, thereby disregarding other aspects. Efficient gains may not be translated into lower prices or higher profits in the short-term. For instance, a bank may invest these gains (developing new products, building brick-and-mortar branches, etc.) in order to cope with competition in the future. [Van Leuvensteijn et al. \(2011\)](#) acknowledge that these distortions are more likely when the Boone indicator is assessed year by year rather than estimations covering the full sample period. Indeed, banking industry may be defined as producing homogenous goods in the long term. Differences in terms of quality, design and innovation are more or less equivalent among firms over the long term.

[Schiersch and Schmidt-Ehmcke \(2010\)](#) show that the Boone indicator makes critical assumptions relative to the definition of the extent of the market. The more precisely we can capture a market, the less other factors or markets influence the outcome and the better

the subsequent competition estimates should be. This rule is common to all non-structural measures of competition.<sup>22</sup>

Finally, the  $\beta$  parameter is expected to be negative but can be positive in empirical implementation. The Boone indicator model assumes that efficiency should be one dimensional and observable. Using costs is the simplest way to capture difference in efficiency. However, in a market where suppliers offer heterogenous goods, changes in costs may merely reflect changes in strategies. In response to competitive pressure, banks may adopt strategies to cope with competition (offering well-designed products, targeting new customers, etc.) instead of reducing prices. In such cases, banks offering the most highly demanded products may not only yield more profit but also spend more. The relationship between marginal costs and performance thus turns to positive. Put differently, the  $\beta$  coefficients may be positive when firms compete in quality (Tabak et al., 2012). In such cases, identification becomes impossible. One should note that this is not only a limit of the Boone approach but also a limit of all non-structural measures. All non-structural measures assume that banks offer homogenous goods and services.

The main advantage of the Boone indicator is that it can both capture market dynamics and be easily implemented for a limited number of observations (by employing average costs as measure of efficiency). Nonetheless, one should note that the Boone indicator is a young tool and therefore has not yet been thoroughly scrutinized by the literature.

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22. A second problem underlined by Schiersch and Schmidt-Ehmcke (2010) is related to firm size. Under the model assumption, the most efficient firm must become the biggest firm in terms of market share and must make the greatest profit. They note that in reality big firms are not necessarily the most efficient ones and thus, it is possible to find a nonnegative  $\beta$  parameter. However, when panel data are used, this issue can be avoided by including fixed-effects. As such, the  $\beta$  parameter will capture change in terms of profit (or market share) and not the level differences among firms. Another possibility is to normalize profits by size (Schiersch and Schmidt-Ehmcke, 2010). For example, Schaeck and Cihák (2013) use the return on assets instead of profits as the dependent variable.

## 5 Synthesis for studies on less mature banking systems

The important role of banking in the economy renders competition among banks a crucial and timely policy issue. Many studies have attempted to investigate the determinants and implications of competition in the banking industry. A critical step is to determine the degree and/or evolution of competition. The literature on the measurement of competition can be divided between the structural and non-structural approaches. The structural approach infers the degree of competition from the structure of the market. The likelihood of collusion is higher in markets with fewer firms and high barriers to entry and exit. The non-structural approach, based on the New Empirical Industrial Organization, assesses the degree of competition directly by observing behavior of firms in the market. The non-structural measures of competition can be sub-divided into two strands. The first generation of NEIO measures originates in the neoclassical model of oligopoly (Vives, 2001). This includes the Lerner index, the conjectural variation model, and the Panzar-Rosse model. Another strand of empirical research considers a dynamic approach of competition more in line with the Austrian School's notion of competition. In banking, the Boone indicator can be attached to this second generation of works.<sup>23</sup> Indeed, each non-structural indicator of competition is based on different assumptions, and thus measures different things. The Lerner index assesses the average degree of pricing power in the market. The conjectural variation model investigates rivals' reactions if a bank in the market increases its output by one percent. The Panzar-Rosse model analyzes the transmission of changes in input prices to bank revenue and the Boone indicator is based on the idea that efficient firms are more highly rewarded in more competitive markets. As a consequence, measures of competition cannot be considered as perfect substitutes. Each indicator has its practical and theoretical advantages as well as its limitations. Table 1 provides a synthesis of advantages and disadvantages of each measure of competition.

This discussion has provided four main results. First, despite their large use in the empiri-

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23. The Persistence of Profit is also attached to this generation but remain rarely applied in banking. Moreover, its implementation may be complex in highly unstable countries, such as developing economies. For more information, see : [Goddard et al. \(2011\)](#).

cal papers, the structural measures suffer from major theoretical and practical limitations. Second, while the Lerner index (and the associated conjectural elasticity) is a good measure of individual market power, it is not always the best measure of competition. The average degree of market power may increase, decrease or remain stable, even if individual Lerner indices decreases due to reallocation effect from inefficient to efficient firms. Third, the Panzar-Rosse H-statistic is a good measure of competition in a static perspective. However, it requires strong assumptions (long-term equilibrium, demand elasticity must exceed one, etc.) that cannot always be tested and checked. In addition, many empirical applications suffer from limitations by estimating scaled revenue equation or price equation. Finally, the Boone indicator catches dynamic aspects of competition but may sometimes fail to identify the degree of competition in the short-run.

In studies focusing on less mature banking systems, the choice of measures of competition is often constrained by data. Despite its strong limitations, the structural approach cannot be avoided when firm-level data are not available. This approach has the major advantage of being easily computed for many markets. Non-structural measures require access to substantial firm-level information. When firm-level information is available, the Lerner index can be computed even with few numbers of firms. However, one should remember that the Lerner index is not a measure of competition but rather a measure of firm pricing power. The Lerner index is thus more useful when the objective is to analyze the consequences of market power on behavior (e.g., risk-taking) or performance (e.g., efficiency) of banks. The associated conjectural variation model is rarely used in developing countries due to strong data requirements. By contrast, even with a limited number of observations (less than one hundred), the Boone indicator can be estimated. If price information is available, the Panzar-Rosse model can also be estimated.

In a perfect world, different measures of competition should be employed insofar as each of them catches an aspect of competition. Researchers should be aware of the limitations of their analysis if multiple measures cannot be considered.

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TABLE 1 – Synthesis of the major advantages and shortcomings of measures of competition

Method	Advantages	Shortcomings
<i>Structural approach</i>		
Concentration measures ( $CR_k$ , HHI)	Low data requirement (available for almost all countries) Does not require firm-level variables	Weaknesses in theoretical foundations Require to define relevant market (geographical, products)
Banking sector contestability (regulatory and supervision framework)	Data available for a large number of countries (BCL database) Does not require firm-level variables	Entry and exit in banking industry can be influenced by non-legal barriers (technological and informational barriers), especially in developing countries
<i>New Empirical Industrial Organization approach</i>		
Lerner index	Bank-year specific measure of market power Requires a few number of observations Simplicity and straightforward interpretation Flexible indicator	Weaknesses in theoretical foundations (Market power $\neq$ Competition) Requires firm-level variables and information on prices Can be fooled by spending in other activities and inefficiency
Conjectural variation (Iwata model and Bresnahan-Lau model)	Test gives direct estimate of firm's conduct that is continuous and maps into all oligopoly solution concepts Technique remains valid if firms do not maximize profit	Requires a large number of observations on firms including prices (system estimation) Sensitive to market definition Limits to Lerner index apply
Panzar-Rosse model	Can be estimated by simple, single-equation, linear model Robust to the extent of market Requires a limited number of observations	Identification can be an issue and some important assumptions have to be verified Requires information on prices and monopsony power can mask monopoly power
Boone indicator	Strong theoretical foundations Can be estimated by simple, single-equation, linear model Requires only a few number of observations Continuous measure of competition Considers (partially) non-price strategies	Efficiency should be one dimensional and observed Different forms of competitive situation cannot be distinguished Requires firm-level variables and information on prices Identification could be an issue in some cases (e.g. if firms compete in quality)