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Antonis Michis

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Address
80 Kennedy Avenue
CY-1076 Nicosia, Cyprus

Postal Address
P. O. Box 25529
CY-1395 Nicosia, Cyprus

E-mail
publications@centralbank.gov.cy

Website
http://www.centralbank.gov.cy

Fax
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Measuring Market Power in the Banking Industry in the Presence of Opportunity Cost

Antonis Michis[1]

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Abstract

A conjectural variations model is developed to measure market power in the banking industry. Unlike previous studies, which use complete cost function specifications in the modelling framework, this study defines marginal cost based on an opportunity cost, which is represented by the interest rate on minimum reserves offered by the monetary authorities in a country. Deposits with the monetary authorities are considered to be an alternative use of available funds that are usually allocated to loans. The estimates of market power in the banking industry in Cyprus, using the proposed model, reject the monopoly hypothesis.

Keywords: market power, conjectural variations, interest rates, opportunity cost

JEL classification: G21, L11

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[1] Central Bank of Cyprus. The opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Central Bank of Cyprus or the Eurosystem.

Correspondence: Antonis A. Michis, Statistics Department, Central Bank of Cyprus, 80 Kennedy Avenue, P.O.Box 25529, CY-1395, Nicosia, Cyprus. Email: AntonisMichis@centralbank.gov.cy

1. INTRODUCTION

Research on the industrial organisation of the banking sector has grown considerably during the past two decades as a result of parallel developments in the industrial organisation literature. The measurement of market power and the development of competitive models for the banking industry using advances in the New Empirical Industrial Organisation literature (NEIO) have particularly generated important insights and improved understanding of several complicated issues that are of great importance to policy makers and regulators.

Initial efforts to model competition in the banking industry have relied mainly on the structure-conduct-performance (S-C-P) model and the relationship between interest rates and market concentration. The limitations associated with this approach led to the development of more sophisticated methods of modelling competition, most notably the Panzar-Rosse and conjectural variations approaches. Research using these approaches is still active and also addresses several econometric issues associated with the empirical measurement of market power. More recent research has adopted alternative approaches that can provide useful insights for competitive banking markets, such as discrete choice models and structural models of entry, which are reviewed along with other methods in Section 2 of this article.

In this study, a conjectural variations model for loans is developed, incorporating opportunity cost in the form of the interest rate on minimum reserves offered by the monetary authorities of a country. The model is derived from a profit maximisation programme, and the equilibrium price condition is incorporated into the perceived marginal revenues function proposed by Bresnahan (1982). This function depends on the opportunity cost, as in Merel (2009), and not on a complete cost function specification. This finding is desirable for the banking sector because most available banking micro-data (e.g., from financial statements) provide only aggregated cost information that encompasses all the operations and products offered by banks. The aggregated nature of most available cost data introduces several measurement problems in empirical applications and therefore complicates the validity of the results.

The proposed conjectural variations model is used to estimate the degree of market power in the banking industry in Cyprus, and the results are compared to two alternative methods proposed in the literature. The first of these is based on the conjectural variations model proposed by Coccorese (2005), and the second is based on the Panzar-Rosse revenue test proposed by Delis et al. (2008). All estimates reject the monopoly hypothesis for the banking industry in Cyprus. The model of Coccorese suggests a competitive equilibrium, the revenue test suggests a market structure close to monopolistic competition and the proposed conjectural variations model suggests a market structure that is almost perfectly competitive. The remainder of this article is organised as follows. Section 2 provides a detailed literature review of banking market power models, and Section 3 develops a conjectural variations model based on opportunity cost. Section 4 addresses the empirical applications of the study, presents the data and estimates the models using data from the banking industry in Cyprus. Finally, Section 5 summarises the main conclusions of the study.

2. EMPIRICAL MEASUREMENT OF MARKET POWER IN THE BANKING INDUSTRY

This section reviews several methods of measuring market power and competition in the banking industry that have been proposed in the literature. Cabral (2000, p. 6) defines market power as the ability to set the price of a product or service above the marginal cost, suggesting that the lower the level of competition faced by a bank in a country, the higher its market power. This section begins with the S-C-P and efficient markets (EM) models, which represent the first attempts at measuring competition in the banking literature. It then proceeds to describe some of the more recent NEIO methods that have been used for the banking sector, such as the Panzar-Rosse and conjectural variations approaches to measuring market power. Some alternative methods, which use more recent developments in the industrial organisation literature, are also reviewed.

The systematic study of market power and its determinants in the banking industry began in parallel with the development of the S-C-P model in the industrial organisation literature. In a banking context, this model suggests that changes in the market structure of a geographical area (e.g., country or state) affect the way banks structure their economic policies and consequently their performance. Market structure is usually represented by a concentration measure, and the leading hypothesis is that higher concentration (structure) is associated with more market power for banks (Cabral, 2000, p. 157). As a result, banks are able to set higher interest rates for loans and lower interest rates for deposits (conduct), thereby increasing their profits (performance). The existence of market power ensures that firms can be inefficient without being forced out of the market, as would be the case in a competitive setting. An underlying assumption of the S-C-P model is that there are barriers to entry in the market (which generally characterise the banking industry), and few banks are able to raise lending interest rates as in a Cournot oligopoly setting (see, Heffernan, 2005, p. 495).

An alternative model for measuring the influence of market power on interest rates is the efficient markets (EM) model, and its associated efficiency hypothesis, proposed by Demsetz (1973). This model assumes that some banks are more efficient than others (e.g., due to superior management or technology) and, as a result, are able to offer lower lending interest rates and higher deposit rates than competitors. These banks are able to progressively increase their market shares (thereby increasing concentration) and profits. In contrast to the S-C-P model, this model predicts that lending interest rates will decrease with increasing market concentration (Heffernan, 2005, 495).

Empirical tests of the two models and their associated hypotheses are usually conducted by considering econometric models in which the dependent variables are either profits or interest rates and the independent variables include a measure of market concentration such as the Herfindahl-Hirschman index along with other control variables. The following is a simple regression representation of these tests:

$$r_{it} = \beta_0 + \beta_1 \, CONC_{it} + \sum_{k=2}^{K} \beta_k \chi_{itk} + \varepsilon_{it} \, . \qquad (1)$$

The dependent variable (r_{it}) is the interest rate on loans or the interest rate offered on deposits, the first independent variable represents a measure of market concentration ($CONC_{it}$) and the model includes additional control variables (χ_{itk}) that can vary across different banks (i) and periods (t).

Table 1.1: Expected concentration coefficients: S-C-P and EM models

Model	Concentration - Lending interest rates	Concentration - Deposit interest rates
S-C-P	Positive	Negative
EM	Negative	Positive

If the dependent variable represents loan interest rates, then, according to the S-C-P model, the coefficient of the concentration variable (β_1) will be positive, implying that increasing market concentration is associated with higher interest rates. If the dependent variable represents deposit interest rates, then the coefficient will be negative. Positive and negative coefficients should be expected if the EM model holds. There will be a negative coefficient between concentration and loan interest rates and a positive coefficient between concentration and deposit interest rates. These cases are summarised in Table 1.1.

Several empirical studies have tested these two models in the banking context, primarily using data from the United States (US). Berger and Hannan (1989) used the quarterly deposit data of 470 banks belonging to different metropolitan areas from 1983 to 1985 to estimate the relationship between deposit interest rates and market concentration in the US. The Herfindahl-Hirschman index and the three firm concentration ratios were used as measures of market concentration in each metropolitan area. The authors were able to find a negative and statistically significant relationship between market concentration and deposit interest rates in the majority of the cases; this relationship is consistent with the S-C-P hypothesis.

The study by Berger and Hannan was criticised by Jackson (1992), who divided the same sample into three groups based on concentration level: low, medium and high. By estimating different coefficients for each group, the author found a negative and statistically significant coefficient (at the 1% level) only in the first group. In the second group, the coefficient had the same sign but was statistically insignificant, whereas the coefficient was positive and significant in the third group. These results are more consistent with the EM hypothesis because the higher levels of market concentration realised by the increasing share of efficient firms are associated with higher deposit interest rates. Berger and Hannan (1992) published a response to Jackson that included new results, using the same market segmentation approach adopted by Jackson. They found a negative relationship between concentration and deposit interest rates at lower levels of concentration, but they were not able to find a statistically significant positive or negative relationship for high levels of concentration.

Molyneux and Forbes (1995) estimated a different model in which the dependent variable referred to profits instead of interest rates. Their dataset covered the years from 1986 to 1989 and many European countries. The results of their analysis were consistent with the S-C-P hypothesis, which predicts a positive relationship between market concentration and profits. Berger (1995) used both financial performance (return on equity and return on assets) and interest rate data as dependent variables to test for the validity of the S-C-P and EM hypotheses but additionally included measures of X-efficiency and relative scale efficiency in his analysis to identify the driving factors behind the EM hypothesis if it were to hold. He used an extensive dataset of 4800 US banks from the 1980s. Econometric estimation did not find any support for the S-C-P hypothesis and found only weak evidence for the X-efficiency hypothesis. The scale efficiency hypothesis was rejected.

Goldberg and Rai (1996) used the market segmentation approach of Jackson (1992) and an econometric methodology similar to Berger (1995) to examine the EM hypothesis in eleven European countries using data for the period from 1988 to 1991. Unlike previous studies, their results provided evidence for the existence of scale efficiencies in markets characterised by low levels of concentration, which supports the EM hypothesis. A similar study that also controlled for differences in efficiency among firms was conducted by Berger and Hannan (1997), who found a negative relationship between market concentration and lending interest rates. Berger’s modelling framework was also used by Goddard, Molyneux and Wilson (2001) in a study that included data for 15 European countries for the period from 1980 to 1996 and whose results supported the S-C-P hypothesis.

Unlike previous empirical studies, Covoisier and Gropp (2002) developed a theoretical Cournot model to explain interest rate margins (the difference between lending and money market rates) and proceeded to empirically test the relationship between margins and market concentration with an econometric model. One distinct characteristic of their study is that different Herfindahl-Hirschman indexes were calculated for the different products offered by banks (short-term loans, mortgages, time deposits, etc.). Their empirical results for a sample of European countries were consistent with the S-C-P hypothesis in the case of loans and demand deposits (higher concentration was found to be associated with higher margins) but not for savings and time deposits.

Another choice for a dependent variable in testing the S-C-P and EM hypotheses is the Lerner Index, which is the price mark-up over marginal cost divided by the price $(p - MC)/p$. An advantage of using the Lerner index is that it provides a more direct measure of market power that is also free of the accounting measurement problems (e.g., depreciation and capital valuation) that can distort the relationship between market concentration and price. A disadvantage of using the Lerner index is the inherent difficulty in accurately measuring marginal cost in industries that produce multiple products, as is the case in banking. This approach was followed by Angelini and Cetorelli (2003) in a study of 900 Italian banks that covered 14 years of data beginning in 1984. A regression analysis of the Lerner index on the number of banks and the Herfindahl-Hirschman Index did not find evidence in favour of the S-C-P hypothesis because increases in market concentration were found to be associated with lower values for the Lerner Index and, therefore, with lower price mark-ups. This type of relationship is consistent with the EM hypothesis.

A common limitation among the studies examining price-concentration relationships is the possible endogeneity problem associated with measures of market concentration (see, Evans et al., 1993), which can bias econometric results. Endogeneity bias can result either from the possible inverse effects of prices on concentration or from errors in the measurement of both price and concentration, which are difficult to measure in the banking industry. These problems led to the development of new methods of measuring banking market power that are distinctly characterised by the formulation of profit maximisation models for banks and the endogenous estimation of market power along with the other parameters of the associated systems of econometric models. These methods are generally referred to as New Empirical Industrial Organisation methods (see, Bresnahan, 1989 for a review), and two basic approaches have been extensively used in the banking literature: the Panzar-Rosse and conjectural variations methods.

The Panzar-Rosse (1987) method measures market power by examining how changes in input prices affect the equilibrium revenues of firms in an industry. The sensitivity of revenues to changes in input prices depends on the level of competition in the market and is calculated as the elasticity of revenues (R) with respect to a vector of input prices (see, Dick and Hannan, 2010, p. 410):

$$H_R = \sum_{i=1}^{k} \frac{\partial R}{\partial W_i} \frac{W_i}{R}.$$

The revenue function is defined as $R = f(W_1,...,W_k, Z, Y)$ and includes an exogenous vector Z of cost determinants, an exogenous vector Y of demand determinants and k input prices W. In the context of a monopoly, a change in input prices (and therefore in marginal costs) will reduce the revenues of the monopolist; it should therefore be expected that $H_R < 0$. In contrast, in a perfectly competitive market, revenues will increase proportionally with marginal cost and it should be expected that the Panzar-Rosse statistic will equal unity: $H_R = 1$.

Shaffer (1982) estimated the Panzar-Rosse statistic in a study of New York banks and obtained a value of 0.318, which suggests that this specific market is neither a monopoly nor a perfectly competitive market but something between these two extremes. Nathan and Neave (1989) examined a cross section of Canadian banks and estimated the Panzar-Rosse statistics for 1983 and 1984. They obtained positive values of the statistic that were different from unity, which led them to reject the monopoly power hypothesis.

Similar values were also obtained for European markets. Molyneux et al. (1994) analysed banking data from Germany, the UK, Italy and Spain for the period from 1985 to 1989 and concluded that the market structure in these countries is compatible with monopolistic competition. An exception to the previous findings is the study by

Molyneux et al. (1996) on the Japanese banking market, where the monopoly hypothesis was not rejected. More recently, Claessens and Laeven (2004) estimated the Panzar-Rosse statistic for fifty countries and then proceeded to examine the regulatory and country-specific characteristics that influence competitiveness. Their results suggest that countries with fewer restrictions on entry and a greater presence of foreign banks tend to be associated with more intense competition.

The Panzar-Rosse approach, although useful, is also characterised by some important limitations. First, values that are close to unity ($H_R = 1$) should be expected to hold only in the long-run (see, Dick and Hannan, 2010, p. 410). In contrast, most studies assume that there is no lag in the adjustment of interest rates (they are assumed to change in parallel with changes in revenues) and that entry and exit by other firms in the market occurs within the same period. Second, negative values of the statistic can also arise in cases that are not monopolistic. Heffernan (2005, p. 508) describes one such case in the context of a perfectly contestable market. Finally, additional limitations are related to possible endogeneity issues in the estimation procedure and the identification of appropriate instrumental variables as well as correctly accounting for all the input factors in the estimation of the revenues elasticities.

The conjectural variations approach is based on the empirical conjectural variations model, proposed by Bresnahan (1982) and Lau (1982), that allows for strategic interactions among firms (see, Varian, 1992, p. 302-303). This model considers the assumptions (conjectures) that a firm might have concerning the reaction of other firms to its price or quantity decisions. For example, in the case of a quantity (q_A) change decision by bank A, attention is paid to the partial derivative $\partial q_B / \partial q_A$, which quantifies the reaction of any competitive bank B.

The first order condition for profit maximisation is more complex in this framework relative to when there are no strategic interactions among firms ($\partial q_B / \partial q_A = 0$), and takes the following form (Dick and Hannan, 2010, p. 411):

$$P = MC(Q, Z) - D_1(Q, Y)\, Q\, \lambda .$$

In this equation, the price (P) of the product is equal to the marginal cost (MC) minus the derivative of the inverse demand (D_1) multiplied by the quantity (Q) and the conduct parameter (λ). The conduct parameter (or conjectural derivative) can be endogenously estimated by a system of equations that includes the demand and cost functions associated with a financial product in addition to the first order condition mentioned above. The conduct parameter will have a value of zero ($\lambda = 0$) in a perfectly competitive market (because the marginal cost will be equal to the price of the product) and a value of one ($\lambda = 1$) in a monopoly. Varying degrees of imperfect competition will produce values between one and zero ($0 < \lambda < 1$).

This approach was used by Shaffer (1989, 1993) to study market power in the US and Canadian banking industries, rejecting the possibility of collusion in any of the markets. Although this is a promising approach for measuring market power in banking, it also presents some limitations. First, it is sensitive to the correct specification of the demand function. Second, it is sensitive to the geographic definition of a market, which can often be imprecise in the banking industry (see, Dick and Hannan, 2010, p. 412).

Other more recent approaches to measuring banking competition have relied on developments in the industrial organisation literature. One family of models that has been used with promising results is that of the discrete choice models with random coefficients as proposed by Berry et al. (1995). These models have the advantages of allowing for the structural estimation of demand with aggregated data while addressing endogeneity problems by imposing moment conditions (and not using difficult to find instrumental variables). The foundation of these models is the consumer utility function, which incorporates interactions between consumer and product characteristics to allow for varying marginal utilities depending on the characteristics of the product.

The discrete choice framework was used by Dick (2008) in an effort to estimate a structural model for deposits and to identify how the deregulation of branching networks in the US during the nineties affected consumer welfare. The empirical results did not find any evidence of a reduction in consumer welfare as a result of the deregulation. Another application of these models was provided by Adams et al. (2007), who compared the deposit demand of banks and thrift institutions and found that they cannot be considered to be close substitutes.

Another area of industrial organisation applications in banking involves structural entry models, such as those used in Bresnahan and Reiss (1987). In these models, the emphasis is on the relationship between price, the number of firms in the market and the size of the market necessary to accommodate the entry of new firms. The level of competition in the market is indirectly identified by estimating entry thresholds, which refer to the size of the market per bank when an additional bank enters the market (Dick and Hannan, 2010, p. 416). The idea is that when a new bank enters the market, price competition will increase and banks will be expected to realise lower variable profits as a result. Consequently, the size of the market per bank (entry thresholds) must increase to provide the opportunity for variable profits to cover fixed costs (which are assumed to remain constant) and allow the new bank to survive in the market. If estimates indicate that entry thresholds have increased, then it can be inferred that price competition also has increased.

Structural entry models have been used in a banking context by Cetorelli (2002) and Cohen and Mazzeo (2007). The former study examined a large sample of US local banking markets and concluded that the degree of competition had increased in these markets since the increase of entry thresholds to accommodate the entry of new banks. The latter study focused on competition between different types (groups) of institutions, such a multiple-market banks, single-market banks and thrift institutions. The results suggest that within-group competition has increased more than between-group competition.

In a promising article, Boone (2008) introduced a new way of measuring competition that combines elements of the structural entry and efficiency hypothesis models. Based on this measure, competition can be intensified in two ways: (1) through a fall in the barriers to entry that characterise an industry and (2) through more aggressive market interactions between the participating firms. In the first case, lower entry barriers in an industry are associated with higher firm participation and therefore with more intense competition. In the second case, more aggressive interactions between firms force inefficient firms to exit the market and market concentration increases as a result. By capturing both effects, this competitive measure is shown to be more robust than the price-cost margin, which is often employed in competition studies.

To illustrate this competitive measure, consider three firms with efficiency levels $n^{**} > n^{*} > n$, an entry cost function of $\bar{\gamma}_i = \gamma_i - \varepsilon\zeta_i$ and a variable profit function of $\pi(n, N, I, \theta)$. This function depends on the efficiency level of each firm (n), the aggregated efficiency index (N), the number of firms that enter the market (I), and a parameter that represents the aggressiveness of firm interaction in the market (θ). Based on this profit function, Boone (2008) defined the following relative profit differences metric:

$$\Phi = \frac{\pi(n^{**}, N, I, \theta) - \pi(n, N, I, \theta)}{\pi(n^{*}, N, I, \theta) - \pi(n, N, I, \theta)} > 0 .$$

Increases in competition increase this metric as follows: $d\Phi / d\theta > 0$ (increases in firm interaction increase competition) and $d\Phi / d\varepsilon > 0$ (decreases in entry costs increase competition). In empirical applications, the profit elasticity provides a way of capturing both effects and can be estimated from log-linear models as follows (see, Degryse et al. 2009, p. 36):

$$\log \pi_i = a + \beta \log c_i .$$

In this model, the price elasticity (β) is estimated as the coefficient of the marginal cost variable (c_i). More efficient firms with lower marginal cost will be expected to realize higher profits (π_i) and therefore $\beta < 0$. Consequently, higher absolute values of this negative coefficient will be associated with stronger bank competition. Van Leuvensteijn et al. (2007) used the Boone indicator to measure banking competition in several countries and the results suggested considerable variability among countries. As suggested by Degryse et al. (2009), more research is needed to evaluate the usefulness of the Boone indicator.

3. A CONJECTURAL VARIATIONS MODEL WITH OPPORTUNITY COST

In this section, a conjectural variations model that incorporates opportunity cost in the form of interest income forgone by the provision of loans is developed. This is a reasonable assumption in banking markets because the total deposits received by banks in a period are usually allocated into two channels. The first is the provision of loans to economic agents in the market and the second is the placement of deposits with the monetary authorities of the country. At a minimum, these deposits should be equal to the minimum (or required) reserves requested by the monetary authorities. As emphasised by Mishkin and Eakins (1998, p.325), banks also hold additional amounts of reserves with the monetary authorities because these deposits (called excess reserves) are considered to be the most liquid assets in a bank’s balance sheet. In this way, these deposits are readily available to meet unexpected obligations that may arise, especially in case of large withdrawals.

The idea of incorporating opportunity cost in models that examine competition in banking was also proposed by Heffernan (2002), who used the Libor rate in generalised pricing econometric models. In these models, the Libor rate is used as a proxy for the deposit rate forgone by a bank when it provides an additional monetary unit of loans instead of withholding it as part of its deposits in another institution. In this study an alternative opportunity cost concept is used: the interest rate that is offered by monetary authorities on minimum reserve deposits (see, Heffernan, 2005, p.290). In Europe, banks in countries that are members of the Eurosystem (as is the case for Cyprus) are required to keep a minimum reserves ratio as defined by the European Central Bank. This ratio is calculated based on their short-term liabilities and banks earn interest on these reserves that is equal to the average rate of the weekly tenders over the maintenance period (Matthews and Thompson, 2008, p. 54).

The interest rate on minimum reserves is used in a conjectural variations model that incorporates competitive responses. Mérel (2009) used a similar modelling framework for a commodities market by incorporating the opportunity cost of the revenue forgone by not producing a substitute product in the context of a profit maximisation programme. However, his study did not consider competitive responses, as is common in conjectural variations models, by estimating the relevant cross-price elasticities. This section develops one such model for banking that also incorporates an opportunity cost measure in the form of the interest rate on minimum reserves.

An advantage of the proposed model is that it does not require a complete cost function specification to estimate the market power parameter in a system of equations. This is a frequently encountered problem in empirical studies because financial statements and other banking industry data sources do not separate expenses by product or service category (e.g., operating cost attributed to loans and deposits). As a result, it is difficult to accurately measure bank output (see, for example, Heffernan, 2005, p. 476), which introduces several problems for econometric estimation.

Consider the following profit maximisation programme for bank i:

$$\max_{p,q} \Pi_i = p_i\, q_i \; + k_i\,(D_i - q_i) - C_i\,(q_i, \omega_{1i}, \omega_{2i}, \omega_{3i}, z_i, D_i - q_i)\,.$$

The total loan revenues are equal to the quantity demanded $q_i = f(p_i, p_j, \chi_i)$ multiplied by the price charged for the financial product p_i. The quantity demanded is also a function of a price index for competition p_j (e.g., competitors' weighted average interest rate) and a vector of exogenous factors χ_i. The total loans provided by the bank are derived from the deposits it receives ($D_i = s_i + q_i$) after subtracting the amount placed by the bank as an interest-bearing deposit (equal to or in excess of the minimum reserves) with the monetary authorities (s_i). Similarly, the cost function $C_i(q_i, w_i, z_i, D_i - q_i)$ depends on several factors: the loan output q_i; input factors such as interest paid on deposits (ω_{1i}), labour wages (ω_{2i}) and the cost of physical capital (ω_{3i}); and the deposits held by other institutions ($D_i - q_i$), which also involve a managing cost. The deposits at other institutions are associated with an interest rate (k_i) that also contributes to profitability. This will constitute the opportunity cost concept of the analysis and will be measured by the interest rate on minimum reserves. This profit maximisation programme is similar to that used in Coccorese (2005), which also estimated a conjectural variations model. However, this model includes the opportunity cost variable, which further complicates the first-order profit maximisation conditions.

The partial derivative of the profit function with respect to price is as follows:

$$\frac{\partial \Pi}{\partial p_i} = q_i + \; p_i \frac{\partial q_i}{\partial p_i} + \; p_i \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i} - k_i \frac{\partial q_i}{\partial p_i} - k_i \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i} - \frac{\partial C_i}{\partial q_i}\frac{\partial q_i}{\partial p_j} - \frac{\partial C_i}{\partial q_i}\frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}.$$

Setting this expression equal to zero and letting $\frac{\partial C_i}{\partial q_i} = MC$ provides the first order condition

$$q_i + [p_i - k_i - MC]\left[\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}\right] = 0.$$

This can be written in a price-cost margin format as

$$p_i - k_i - MC = -\frac{q_i}{\frac{\partial q_i}{p_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}}.$$

To obtain an equilibrium condition in terms of own and cross-price elasticities, as is common in conjectural variations models, both sides of the above equation are multiplied by q_i / p_i. In addition, the second term in the denominator of the right side is multiplied by $p_j / p_j = 1$. The equation then becomes

$$\frac{p_i - k_i - MC}{q_i}\frac{q_i}{p_i} = -\frac{1}{\frac{\partial q_i}{p_i}\frac{p_i}{q_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}\frac{p_i}{q_i}\frac{p_j}{p_j}}.$$

When written in terms of elasticities, the equation is equal to

$$p_i - k_i - MC = -\frac{p_i}{\varepsilon_{ii} + \varepsilon_{ij}\, n_{ji}}. \tag{1}$$

The own-price elasticity is $\varepsilon_{ii} = \frac{\partial q_i}{p_i}\frac{p_i}{q_i}$, the cross-price elasticity is $\varepsilon_{ij} = \frac{\partial q_i}{p_j}\frac{p_j}{q_i}$ and the competitive price-reaction elasticity is $\eta_{ji} = \frac{\partial p_j}{\partial p_i}\frac{p_i}{p_j}$. This elasticity shows how price changes by bank i generate a competitive price reaction by competitor j (which also influences the market price, as is common in conjectural variations models).

In Coccorese (2005), the equilibrium condition (1) does not include the interest rate on minimum reserves on the left side and only two elasticities are included on the right side. Instead of the elasticity η_{ji}, a conjectural variation parameter $\lambda = \partial p_j / \partial p_i$ is defined and is multiplied by p_i / p_j. However, estimation of this parameter in the context of equation (1) requires a system of equations with a cost function specification, an approach not adopted by this study due to the problems associated with cost measurement in banking. Leaving only marginal cost on the left side and rearranging provides the following equilibrium condition:

$$MC = p_i\left(1 + \frac{1}{\varepsilon_{ii} + \varepsilon_{ij}\,\eta_{ji}}\right) - k_i. \tag{2}$$

To introduce a market power parameter in the modelling framework, a perceived marginal revenue function is defined, as proposed by Bresnahan (1982) and used by Shaffer (1989) and Mérel (2009) in the banking and commodities markets, respectively. The perceived marginal revenue function is

$$PMR = (1-h)\, p_i + h\, MR. \tag{3}$$

Equation (3) includes the market power parameter h (also referred to as the conduct parameter in the literature). Values of this parameter that are close to zero ($h = 0$) indicate a competitive industry while values that are close to one indicate monopoly power ($h = 1$). Accordingly, intermediate values represent equilibria between these two extremes. Because profit maximisation in equilibrium (see, Pepall et al., 2008, p. 247) implies equality between marginal revenue and marginal cost ($MR = MC$), expression (2) can be substituted into (3):

$$PMR = p_i - h\,p_i + h\,p_i\left(1 + \frac{1}{\varepsilon_{ii} + \varepsilon_{ij}\,\eta_{ji}}\right) - h\,k_i\,.$$

By cancelling out equal terms, the equation becomes

$$PMR = p_i\left(1 + \frac{h}{\varepsilon_{ii} + \varepsilon_{ij}\,\eta_{ji}}\right) - h\,k_i\,. \tag{4}$$

Another expression for marginal revenues can be obtained by taking the partial derivative of the profit function with respect to the quantity demanded:

$$\frac{\partial \Pi}{\partial q_i} = p_i + \frac{\partial p_i}{\partial q_i} q_i - k_i - \frac{\partial C_i(q_i,.)}{\partial q_i} + \frac{\partial C_i(.,D_i - q_i)}{\partial q_i}\,.$$

The first partial derivative of the cost function $\frac{\partial C_i(q_i,.)}{\partial q_i}$ refers to the first quantity expression q_i in the cost function $C_i(q_i, \omega_{1i}, \omega_{2i}, \omega_{3i}, z_i, D_i - q_i)$ and, as is the case of the second partial derivative, which refers to the deposits with the monetary authorities $D_i - q_i$ that are also included in the cost function. The first two terms in the above first order condition are equal to the marginal revenue $MR = p_i + \frac{\partial p_i}{\partial q_i} q_i$ (see, for example Cabral, 2000, p. 25). Equating the first order condition to zero and substituting for the marginal revenues expression gives

$$MR = k_i + \mu \,. \tag{5}$$

The term $\mu = \frac{\partial C_i(q_i,.)}{\partial q_i} - \frac{\partial C_i(.,D_i - q_i)}{\partial q_i}$ in equation (5) is the difference between the two partial derivatives of the cost function, and according to Mérel (2009), represents the difference in marginal cost associated with the two alternative uses of inputs. In the context of this study, the deposits collected by bank i are directed to two alternative uses: (1) for the production of loans and (2) as deposits held with the monetary authorities. Consequently, according to equation (5), in equilibrium, the marginal revenue from producing an additional unit of loans is equal to the marginal revenue forgone if the unit was deposited with the monetary authorities (the opportunity cost k_i) plus the difference in marginal cost (μ_i) between producing an additional unit of loans instead of managing an additional unit of deposits. By equating the *PMR* in (4) with the *MR* in (5), the following price equation is obtained, which is to be used in a nonlinear system of equations to estimate the market power parameter:

$$p_i\left(1 + \frac{h}{\varepsilon_{ii} + \varepsilon_{ij}\eta_{ji}}\right) = h\,k_i + k_i + \mu \,. \tag{6}$$

In addition to equation (6), the nonlinear system of equations will also include a demand function for bank i based on the previously defined specification for the quantity demanded $q_i = f(p_i, p_j, \chi_i)$. Following Coccorese (2005), a log linear model will be used as follows:

$$\log q_i = a_0 + a_1 \log p_i + a_2 \log p_j + a_3 \log Y + a_4 \log p_i \log p_j + \varepsilon_q \,. \tag{7}$$

However, in addition to the interaction term ($\ln p_i \ln p_j$), which is to be used as an elasticity shifter in the estimation procedure, equation (7) also includes the exogenous variable Y that represents the level of income in the economy. Bresnahan (1982) emphasises that elasticity shifters are necessary to change (rotate and shift) the demand slope in such a way that distinguishes between the hypotheses of competition and monopoly. Rotation is achieved through the new exogenous variable p_j (competitors' price index) in the demand equation, which enters interactively with the price variable p_i, whereas shifts in the demand function are achieved through the income variable Y. Joint movements in the two exogenous variables enable the estimation of the degree of market power. In a perfectly competitive market, the rotations will not change the equilibrium price, but the opposite is true if market power exists, as in the case in a monopoly.

Equations (6) and (7) can be estimated as a nonlinear system of equations. However, unlike the studies by Coccorese (2005) and Mérel (2009), the equilibrium price condition (6) additionally includes the competitive price elasticity $\eta_{ji} = \frac{\partial p_j}{\partial p_i}\frac{p_i}{p_j}$ that captures the price reaction of competition when bank i changes the price of its product. To estimate this elasticity, an additional equation will be included in the system of equations, in log-linear format, using the competitors' price index as the depended variable:

$$\log p_j = \gamma_0 + \gamma_1 \log p_i + \gamma_2 \log EURIB_{it} . \qquad (8)$$

The competitive price elasticity will be estimated using parameter γ_1. Equation (8) also includes the Euribor rate ($EURIB_{it}$) as an independent variable, following the analysis of Heffernan (2002), which included the Libor rate in econometric models for lending interest rates in the UK. It is to be used as a proxy for the term $k_i + \mu_i$ in equation (6), which is the interest rate on minimum reserves plus the difference between the marginal cost of producing an additional unit of loans and the marginal cost of managing an additional unit of deposits placed with the monetary authorities.

4. ECONOMETRIC ANALYSIS

4.1. Data and preliminary analysis according to the S-C-P model

The empirical testing of the modelling framework proposed in the previous section was conducted using data from the banking industry in Cyprus. The data were collected from the financial statements of twenty financial institutions that offer banking services in the country. Commercial banks can be separated in two groups: (1) those with an ultimate controlling affiliate in Cyprus and (2) those with an ultimate controlling affiliate abroad. In addition to traditional banks, which primarily offer retail, corporate and investment banking services, the sample includes cooperative societies (COOPs), which have developed similar products during the last decade and can be considered direct competitors of traditional banks in Cyprus. For simplicity, in the remainder of the analysis, all financial institutions in the sample will be referred to as banks.

Table 1.2 provides information on the lending market shares of the top six banks in Cyprus, which account for 80% of the market. Two major commercial banks in the market have market shares ranging from 16% to 24%. The total market share of COOPs ranges from 19% to 20%. Most COOPs are local in character, and, according to their constitutions, are allowed to provide services only within the boundaries of the municipality in which they are established. However, they have a central authority (the Cooperative Central Bank), which takes over their economic and financial policies towards competition and administers a common network of automatic teller machines (ATMs). For example, the ATM network of a particular COOP can be used by the subscribers of any other COOP irrespective of geographical location.

Table 1.2: Lending shares of major financial institutions in Cyprus

Financial Institution	Dec 2008	Dec 2009	Dec 2010	Dec 2011
Bank of Cyprus Ltd	24%	24%	24%	24%
Cooperative Societies	19%	19%	20%	20%
Marfin Popular Bank Public Co Ltd	16%	16%	17%	16%
Hellenic Bank Ltd	7%	7%	7%	7%
Alpha Bank Cyprus Ltd	8%	8%	8%	7%
Eurobank EFG Cyprus Ltd	2%	5%	4%	3%
Total	76%	79%	80%	77%

Source: Central Bank of Cyprus

To estimate market power in the banking industry of Cyprus based on the modelling method outlined in Section 3, several variables were collected or constructed from the financial statements of the banks used in the sample: the total value of loans for each bank i in year t (Q_{it}); the interest rate on loans for each bank i in year t (P_{it}), obtained by dividing total interest income from loans by total loans, as suggested by Coccorese (2005); the (loan value based) weighted average lending interest rate of the competitors of bank i in year t (CP_{it}); and the total loans included in the assets of the competitors of bank i in year t (CQ_{it}).

Table 1.3: Summary statistics

Variable	Sample	Mean	St dev	Min	Max
Loans (million EUR)	216	1843	4991	31	27725
Interest rate on loans (%)	216	7.138	1.722	2.026	11.739
Competitors inter. rate on loans (%)	216	6.531	1.393	1.748	9.357
Interest rate on deposits (%)	216	3.952	1.103	1.624	7.010
Cost of physical capital (EUR)	216	1.246	1.323	0.017	9.136
Euribor (%)	216	2.893	1.263	0.931	4.571
Interest rate on minimum reserves (%)	216	2.395	1.064	0.546	3.689
Gross domestic product (million EUR)	216	13769	2931	9008	17761
Total cost (million EUR)	161	114.419	298.628	1.254	1864
Average cost (EUR)	161	0.062	0.023	0,03	0,214
Labour cost (EUR)	161	25573	18313	6965	72300
Total Revenues (million EUR)	161	865	2995	1046	19744
Deposits to total assets ratio (%)	161	81.053	17.074	6.726	98.937
Assets (million EUR)	161	3867	7559	79.783	42638
Herfindahl-Hirschman Index (%)	206	10.231	0.707	9.380	11.700

Banks with ultimate controlling affiliate in Cyprus: 4
Banks with ultimate controlling affiliate abroad: 5
Cooperative societies: 11
Unbalanced panel for the period: 1999-2011

For comparison purposes, measures of market power in the banking industry of Cyprus were also obtained by using two additional models. The first is the conjectural variations model proposed by Coccorese (2005). Because this method requires the full specification of a cost function, additional cost information was collected from financial statements: the total cost of each bank i in year t (C_{it}); the average cost of each bank i in year t (AC_{it}), calculated by dividing total cost by the total value of loans; a proxy variable for the per unit cost of physical capital of bank i in year t (ω_{1it}), calculated by dividing operating cost (excluding interest expenses and labour costs) by funds under management, as in Coccorese (2005); the average labour cost of each bank i in year t (ω_{2it}), calculated by dividing total labour expenses (salaries, social security and pension fund contributions plus any other staff expenses) by the total number of employees; and the interest rate paid on deposits (ω_{3it}), calculated by dividing total interest expenses on deposits by the total amount of deposits reported by each bank i in the financial statements of year t. The second model considered in Section 4 is based on a revenue model proposed by Delis et al. (2008) to estimate the Panzar-Rosse statistic, which additionally includes the following variables: total assets ($Assets_{it}$); the ratio of total deposits to total assets for each bank i and year t ($Deposits_{it} / Assets_{it}$) and total revenues ($TR_{it}$);

Additional variables obtained from other sources included the interest rate on minimum reserves in year t (R_t), calculated from data in the annual reports of the Central Bank of Cyprus by dividing the interest expenses of the Central Bank by the total deposits placed with the Central Bank by banks; the gross domestic product of the country in year t at current market prices (Y_t), published by the Cyprus Statistical Service; the Herfindahl-Hirschman index of market concentration (HHI_{it}) for the banking industry of Cyprus, published by the European Central Bank (ECB), based on the assets of the banks operating in the country from 1999 to 2010; and the Euribor rate (euro interbank offered rate) in year t ($EURIB_t$), published by the European Banking Federation and upon which banks in the European Union (EU) exchange funds. The financial statements used in the dataset covered the period from 1999 to 2011; however, the data were not available for all the periods in the analysis for several banks. In several cases, this was because some banks began operating in Cyprus after 2005. The available annual observations for each bank are included in Table 1.3 along with summary statistics for the variables used in the analysis.

To investigate the relationship between lending interest rates and market concentration according to the S-C-P model, a log-linear fixed effects model was estimated as follows:

$$\log P_{it} = \beta_0 + \sum_{i=1}^{19} \delta_i d_i + \beta_1 \log CP_{it} + \beta_2 \log EURIB_{it} + \beta_3 \log HHI_{it} + \beta_4 \log Y_{it} \\ + \beta_5 \log T + \varepsilon \tag{9}$$

The lending interest rate of bank i in year t is a function of competitive interest rates, the Euribor rate, which is used as a proxy for the average competitive interest rate in the EU, the Herfindahl-Hirschman index of market concentration, the gross domestic product, and a time trend variable (T). In addition, the model includes indicator variables for each bank in the sample to be used as fixed effects.

Table 1.4: Log-linear interest rate model

Coefficient	Estimate	St error	t test
Intercept	10.273	2.977	3.450*
log HHI	0.565	0.293	1.930*
log Y	-0.769	0.239	-3.210*
log EURIB	0.047	0.027	1.740**
log CP	0.160	0.078	2.050*
log T	0.055	0.063	0.870
R squared:	0.667		

Sample size: *206*
*Significance level: *5%; **10%*

The coefficient estimates from the OLS method are included in Table 1.4. All the coefficients are statistically significant at the 5% or 10% levels and have the expected sign except for the coefficient of the trend variable. The coefficient for the Herfindahl-Hirschman index of market concentration is positive and suggests that an increase in market concentration of an average of 1% is associated with a 0.565% increase in lending interest rates. This finding is consistent with the S-C-P model, according to which increasing market concentration is associated with increasing market power, resulting in higher prices (lending interest rates) and higher profits. Conversely, increasing competition in the market (decreasing market concentration) is associated with declining interest rates.

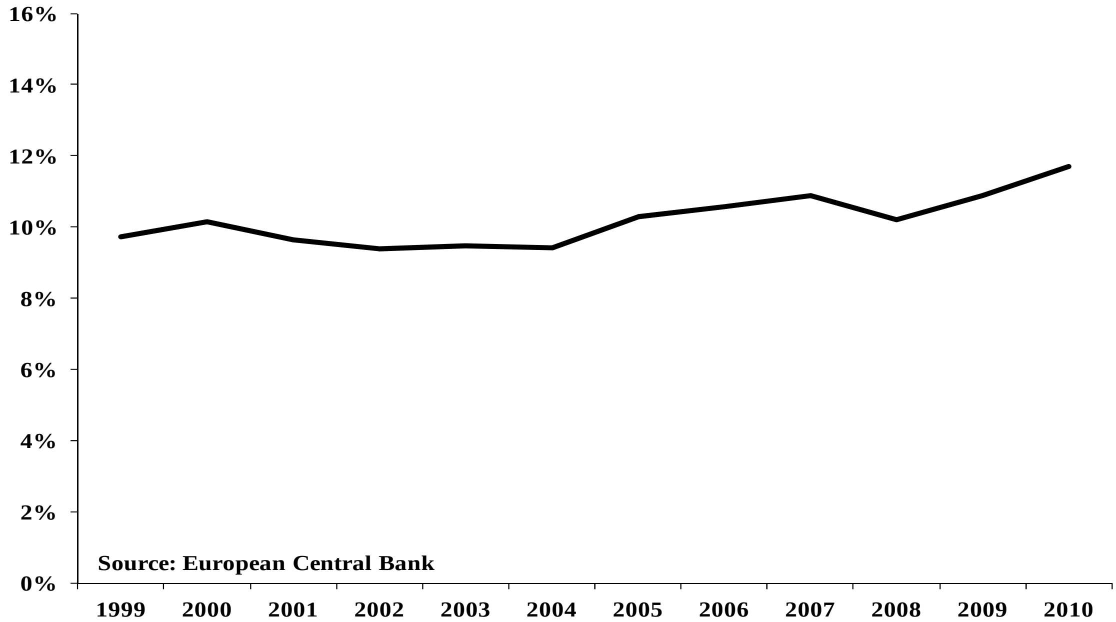

Figure 1.1: Herfindahl-Hirschman index for the banking sector in Cyprus (assets)

Figure 1.1 exhibits the trend of the Herfindahl-Hirschman index during the period from 1999 to 2000. The overall market concentration level is low and has not changed significantly during the decade covered by the available data, remaining mostly around the 10% level. Small increases are observed after 2005, particularly in 2007 and 2010. This analysis, similarly to most empirical S-C-P tests, cannot offer clear conclusions with regards to the level of competition in the industry. It is therefore necessary to estimate a market power parameter as explained in Section 3.

4.2. Estimation of the conjectural variations model

To measure market power in the banking industry of Cyprus, this section proceeds with the estimation of the nonlinear system consisting of equations (6)-(8). Using the variable notation introduced in Subsection 4.1, the system (model 1) to be estimated can be represented as follows:

$$\log Q_{it} = a_0 + a_1 \log P_{it} + a_2 \log CP_{it} + a_3 \log Y_t + a_4 \log P_{it} \log CP_{jt} + a_5 Coop_{it}$$
$$+ a_6 Foreign_{it} + a_7 \log T + \varepsilon_Q$$

$$P_{it} = \beta_0 + hR_{it} - h\left(\frac{P_{it}}{\varepsilon_{ii} + \varepsilon_{ij}\eta_{ji}}\right) + \beta_1 EURIB_{it} + \beta_2 \log T + \varepsilon_P \quad (10)$$

$$\log CP_{it} = \gamma_0 + \gamma_1 \log P_{it} + \gamma_2 \log EURIB_{it} + \gamma_3 \log CQ_{it} + \gamma_4 \log T + \varepsilon_{CP}$$

The system is subject to the following parameter restrictions: $a_1 = \varepsilon_{ii}$, $a_2 = \varepsilon_{ij}$, $n_{ji} = \gamma_1$ and $0 < h < 1$, and all interest rate variables have been deflated as suggested by Coccorese (2005). The first equation is similar to equation (7) except that it includes a time trend variable (T) and two indicator variables in the list of explanatory variables. The first indicator variable takes the value of 1 when the observations in the sample refer to a cooperative society ($Coop_i$). Similarly, the second indicator variable takes the value of 1 when the observations in the sample refer to a bank with a foreign ultimate controlling affiliate ($Foreign_{it}$).

Based on these specifications, the control group, which refers to banks with an ultimate controlling affiliate in Cyprus, is captured by the intercept. Because we are using a panel dataset in the estimation procedure, it is possible to use separate indicator variables (fixed effects) for each bank in the sample. However, due to the limited number of observations and the unbalanced nature of the panel dataset, it was not possible to obtain individual coefficient estimates for all the banks in the sample because the generalised method of moments (GMM) estimator did not converge. The classification based on the control status of the banks is sensible because the banks within each group have historically been similar in terms of size and strategic orientation.

In the second equation, the Euribor rate has been included as a proxy for the term $k_i + \mu_i$ in equation (6), which is equal to marginal revenues. It consists of the interest rates on minimum reserves (k) and the difference in marginal cost (μ) associated with the two alternative uses of deposits (provision of loans or deposits at the Central Bank). In a competitive market, the marginal revenues of a bank should reflect movements in the Euribor rate, as suggested by Heffernan (2002) for the relationship between lending rates and the Libor rate in the UK economy.

The third equation has been included in the system in log-linear form to estimate the competitive price elasticity $\eta_{ji} = (\partial p_j / \partial p_i)(p_i / p_j)$ that enters the equilibrium price condition in the second equation. The weighted average index of the competitive interest rates is considered to be a function of four independent variables: the lending rate offered by bank i, which is not included in the calculation of the index (for each cross section of observations in the panel dataset); the Euribor rate, which is again used as a proxy for the competitive interest rate in the EU; and the total loans offered by all banks included in the calculation of the index except for bank i. The equation also includes a trend variable. The terms $\varepsilon_Q, \varepsilon_P$ and ε_{CP} represent the errors in the system of equations.

It is possible that the CQ_{it} variable is correlated with the error term of the model in the third equation because a general decline in the total loans in the market might generate a reduction in the lending interest rates charged by banks to recover. However, because the total amount of loans comprises data collected from nineteen different banks, it is unlikely that it will exhibit variation that represents a common policy reaction by all banks. To test for the possibility of endogeneity bias in the results, a Haussman endogeneity test (see Cameron and Trivedi, 2005, p.271) was constructed and a second version of the model (model 2) was estimated without the use of this variable. In addition to the exogenous variables included in each equation, the per unit cost of physical capital was used as an instrumental variable for CQ_{it} in the estimation of model 1 and was also used as an additional instrumental variable in the estimation of model 2. This variable is expected to be correlated with the total value of loans in the market because it is one of the input factors used by banks in the production process.

Table 1.5: GMM estimation of nonlinear conjectural variations models

	Model 1			Model 2		
Coefficients	**Estimate**	**St error**	**t test**	**Estimate**	**St error**	**t test**
Equation 1: Demand for loans						
Intercept	-56.429	22.155	-2.550*	-42.881	21.409	-2.000*
log P	-2.087	0.976	-2.140*	-1.819	0.853	-2.130*
log CP	2.172	1.025	2.120*	1.953	0.923	2.120*
log Y	4.824	1.396	3.450*	3.962	1.349	2.940*
Coop	-2.880	0.295	-9.760*	-2.933	0.281	-10.430*
Foreign bank	-1.801	0.357	-5.050*	-1.826	0.351	-5.200*
log P × log CP	-0.003	0.030	-0.110	0.002	0.032	0.080
log T	-0.578	0.443	-1.300	-0.282	0.424	-0.670
R square	0.573			0.578		
Equation 2: Interest rate						
Intercept	-0.005	0.003	-1.690**	-0.009	0.002	-4.380*
log Euribor	-0.002	0.001	-3.060*	-0.002	0.001	-3.970*
log T	0.003	0.001	2.160*	0.003	0.001	4.210*
R square	0.990			0.990		
Equation 3: Competitors' interest rate index						
Intecept	2.781	0.982	2.830*	0.287	0.085	3.400*
log P	0.956	0.025	37.580*	0.925	0.021	44.730*
log CQ	-0.116	0.045	-2.570*	-	-	-
log Euribor	-0.154	0.048	-3.240*	-0.142	0.045	-3.160*
log T	-0.042	0.052	0.810	-0.086	0.022	-3.970*
h (market power)	0.010	0.003	2.980*	0.013	0.003	4.400*
R square	0.894			0.898		
Chi-square test	10.650			17.580		

Sample size:216

*Significance level: *5%, **10%*

The coefficient estimates for the two versions of the model using the GMM method are included in the Table 1.5. All coefficients have the expected sign and are statistically significant at the 5% or 10% levels, except the coefficients for the CQ_{it} and $EURIB_{it}$ variables in the third equation. However, because the variables in this model concern average movements in 19 different banks, the signs of the coefficients cannot be known with certainty. The demand for loans is elastic, and the elasticities that enter the price equation have the following values: $\varepsilon_{ii} = -2.087$, $\varepsilon_{ij} = 2.172$ and $\eta_{ji} = 0.956$. The market power parameter (h) is statistically significant at the 5% level in both models and is close to zero. Based on these values, the banking industry of Cyprus can be considered to have a nearly perfectly competitive market structure, and the monopoly hypothesis is rejected.

Based on the value of the Chi-square test for over-identifying restrictions, the validity of the additional instrument (the per unit cost of physical capital) used in the GMM estimation procedure cannot be rejected at the 5% significance level in either of the two models (the associated p-values of the tests in models 1 and 2 were 0.385 and 0.227, respectively). Finally, a Hausman endogeneity test for the CQ_{it} variable in model 1 was constructed based on the equivalence of the OLS and 2SLS estimators under the null hypothesis that the two estimators are asymptotically equivalent and that there is no endogeneity bias. The estimates provided a value of 6.75 with a corresponding p-value of 0.748, according to which the equality of the two estimators is accepted at both the 5% and 10% significance levels.

4.3. Results with alternative models

As already noted in Section 2, most empirical studies of market power in banking have concentrated on the conjectural variations and Panzar-Rosse approaches. To compare the results of the previous subsection with alternative models that have been proposed in the banking literature, two further models were estimated and compared with model (10) using similar variable definitions as in the previous section.

The first is the conjectural variations model proposed by Coccorese (2005), who estimated a nonlinear system of three equations using a translog cost function as shown below (model 3). The first equation in this system represents loan demand and is similar to the first equation in system (10) in which the interest rate variables in the system have been deflated. The translog-cost equation includes three input factors: the interest rate paid on deposits $\omega_{1it} = DR_{it}$, the average price of labour $\omega_{2it} = LB_{it}$ and the per unit cost of physical capital $\omega_{3it} = PC_{it}$. To identify parameter J (the conjectural derivative), five restrictions that are consistent with linear homogeneity in input prices were incorporated into the estimation procedure as follows: $d_1 + d_2 + d_3 = 1$, $\beta_2 + \beta_3 + \beta_4 = 0$, $d_6 = d_4 + d_5 - 2d_7$, $d_8 = -d_4 - d_7$ and $d_9 = -d_5 - d_7$.

$$\log Q_{it} = a_0 + a_1 \log P_{it} + a_2 CP_{it} + a_3 \log Y_{it} + a_4 Coop_i + a_5 Foreign_i + a_6 \log T + \varepsilon_Q$$

$$\begin{aligned}\log C_{it} &= d_0 + \beta_0 \log Q_{it} + \frac{\beta_1}{2}(\log Q_{it})^2 + \sum_{k=1}^{3} d_k \log \omega_{kit} + \sum_{k=1}^{3} \beta_{k+1}(\log Q_{it} \times \log \omega_{kit}) \\ &+ \sum_{k=1}^{3} d_{k+3}(\log \omega_{kit})^2 + d_7(\log \omega_{1it} \times \log \omega_{2it}) + d_8(\log \omega_{1it} \times \log \omega_{3it}) \\ &+ d_9(\log \omega_{2it} \times \log \omega_{3it}) + d_{10} Coop + d_{11} Foreign + d_{12} \log T + \varepsilon_C\end{aligned} \tag{11}$$

$$P_{it} = AC_{it}\left(\beta_0 + \beta_1 \log Q_{it} + \sum_{k=1}^{3} \beta_{k+1} \log \omega_{it}\right) - \frac{1}{(a_1 / P_{it}) + J(a_2 / CP_{jt})} + \beta_5 T + \varepsilon_p$$

The third equation represents the price-cost margin equilibrium condition derived from profit maximisation and includes the conjectural derivative $J = \partial p_j / \partial p_i$. This derivative measures the degree of competition in the market and can take the following values:

(a) $0 < J < 1$: Competitors are expected to match price changes in the market (cooperative profit maximisation).

(b) $J = 1$: Collusion.

(c) $J = 0$: Non-cooperative Nash price equilibrium (each firm acts alone in setting its own optimal price in the market).

(d) $J < 0$: Competition among firms (competitive price reductions expected from rivals).

(e) $J = -\infty$: Perfect competition

Table 1.6: GMM estimation of conjectural variations model 3

Coefficients	Estmate	St error	t test
Equation 1: Demand for loans			
Intercept	-1.036	0.009	-118.880*
log P	-1.459	0.355	-4.100*
log CP	1.498	0.377	3.970*
log Y	1.334	0.019	69.210*
Coop	-2.619	0.239	-10.970*
Foreign bank	-1.461	0.235	-6.230*
log T	0.364	0.136	2.680*
R square	0.450		
Equation 2: Total cost			
Intercept	-17.575	6.436	-2.730*
log Q	2.322	0.529	4.390*
log Q × log Q	-0.114	0.031	-3.660*
log DR	-0.321	0.703	-0.460
log LB	- 0.053	0.893	-0.060
log PC	1.374	0.743	1.850**
log Q × log DR	0.055	0.039	1.430
log Q × log LB	0.109	0.033	3.330*
log Q × log PC	-0.164	0.033	-4.930*
log DR × log DR	0.066	0.036	1.840**
log LB × log LB	-0.093	0.021	-4.420*
log PC × log PC	0.143	0.066	2.180*
log DR × log LB	-0.084	0.030	-2.810*
log DR × log PC	0.018	0.034	0.540
log LB × log PC	0.177	0.048	3.670*
Coop	-0.229	0.096	-2.400*
Foreign bank	-0.287	0.095	-3.010*
log T	-0.265	0.055	-4.860*
R square	0.975		
Equation 3: Interest rate			
J (conjectural derivative)	-0.023	0.007	-3.020*
T	-0.006	0.001	-10.910*
R square	0.990		
Chi-square test	53.904		

Sample size:161

*Significance level: *5%, **10%*

The system was estimated with the GMM method, using the competitors' weighted average interest rate on deposits as an instrumental variable for the average competitive interest rate on loans (CP_{it}) in the equilibrium interest rate equation, which could be endogenous. A reduction in the average competitive interest rate on loans can motivate an interest rate reduction response by firm i. However, an inverse relationship is also possible and can introduce endogeneity bias to the system. If firm i is associated with a sufficiently large market share and reduces its lending interest rate, competitors might follow by adopting similar interest rate reductions. It is therefore necessary to use instrumental variables to consistently estimate the parameters of the third equation. The results are presented in Table 1.6.

The interest rate elasticities in the first equation ($\varepsilon_{ii} = -1.459$, $\varepsilon_{ij} = 1.498$) are lower than the results obtained in model (10) and included in Table 1.5. In the cost equation, the coefficient of the loan variable (Q) indicates that the banking industry of Cyprus is characterised by diseconomies of scale. This finding is most likely due to the inclusion in the sample of COOPs, which generally exhibit lower efficiency and productivity levels than commercial banks. The market power parameter in the third equation has a statistically significant negative value that is close to zero. This result suggests the existence of a competitive market structure (compatible with a Nash non-cooperative equilibrium) and a rejection of the monopoly hypothesis.

The second model considered in this section is a log-linear econometric model for total revenues. As shown in the study by Delis et al. (2008), this model can be used to measure market power based on the Panzar-Rosse statistic (H) and has the following form:

$$\log TR_{it} = \beta_0 + \sum_{i=1}^{19} b_i D_i + \beta_1 \log LB_{it} + \beta_2 \log DR_{it} + \beta_3 \log PC_{it} + \beta_4 \log\left(\frac{Depos._{it}}{Assets_{it}}\right) + \beta_5 \log Assets_{it} + \beta_6 \log T + u_{it} \quad (12)$$

The dependent variable represents the total revenues of bank i in period t (TR_{it}). The independent variables in the model include the average labour wage (LB_{it}); the interest paid on deposits (DR_{it}); the cost of physical capital (PC_{it}); bank-specific dummy variables (D_i); the ratio of total deposits to total assets for each bank and period in the sample ($Deposits_{it} / Assets_{it}$); the size of assets of each bank ($Assets_{it}$); a time trend variable (T) and an idiosyncratic disturbance term (u_{it}). Instead of using the debt-to-assets ratio and total assets independent variables, Delis et al. (2008) used the equity-to-assets ratio. However, because the dataset used in this study includes unlisted COOPs that do not report equity capital in their financial statements, the deposits-to-assets ratio and total assets variables were preferred in this study. Furthermore, for the cost of physical capital, the authors used the ratio of administrative expenses to total fixed assets and the same variable was used for the estimation of model (12).

According to the intermediation approach in finance, banks are considered primarily as financial intermediaries whose output is measured by the total value of generated loans, investments and other income (see, Matthews and Thompson, 2008, p. 148). Deposits can be considered as a necessary input in the production process (see, Berger and Mester, 1997) and accordingly input costs consist of deposit interest rate payments and payments to other factors of production e.g. labour. Use of the deposits-to-assets ratio in model (12) is further justified by the fact that, during the last ten years, there has been a considerable inflow of foreign deposits in the Cyprus banking system. This has enabled the banking industry in Cyprus to expand the size of its assets considerably (primarily through loan provisions and investments in securities abroad), thus reaching 896% of the country's GDP in 2010.

The Panzar-Rosse statistic for measuring market power is equal to $H = \beta_1 + \beta_2 + \beta_3$ (the sum of the three input factor elasticities). According to this definition, market power is measured by the sensitivity of total revenues to changes in the three factor prices and can take the following values: (1) $H < 0$, the market structure is characterised by a monopoly or by collusion in an oligopoly; (2) $H = 1$, the market structure is characterised by perfect competition and (3) $0 < H < 1$, the market structure is characterised by monopolistic competition. Following Delis et al. (2008), two versions of the model were estimated. The first was based on the specification in equation (12), whereas in the second, time dummy variables were used in place of the time trend variable.

Table 1.7: Estimation of the revenue test (Panzar-Rosse) model

	with time dummies			with time trend		
Coefficients	**Estimate**	**St error**	**t test**	**Estmate**	**St error**	**t test**
Intercept	-7.151	2.908	-2.460*	-9.321	2.330	-4.000*
log LB	0.298	0.108	2.750*	0.368	0.069	5.360*
log DR	-0.025	0.124	-0.200	0.011	0.114	0.100
log PC	0.087	0.127	0.690	0.129	0.125	1.040
log (Deposits/Assets)	0.246	0.102	2.410*	0.290	0.103	2.810*
log (Assets)	0.901	0.113	7.950*	0.943	0.111	8.480*
log T	-	-	-	-0.062	0.077	-0.800
H	0.360			0.508		
R square	0.990			0.990		
Wald test (H=0)	2.750			6.160		
Wald test (H=1)	8.710			5.740		

Sample size:161
*Significance level: *5%*

The estimation was performed with the OLS method and the results are included in Table 1.7. In the model with the time dummies, all the coefficients have the expected sign except the coefficient of the deposit interest rate. The coefficients of the deposit interest rate and cost of physical capital variables are not statistically significant in either of the two models; however, the F-test for the joint significance of all the coefficients in the models indicated a valid specification at the 1% significance level. The positive coefficient of the total deposits-to-total assets ratio suggests that higher deposits rates provide a bank with the opportunity for additional loan provisions and investments (e.g., in government bonds), which can further increase interest rate revenues. Similarly, the positive coefficient of the total assets variable suggests that increases in bank size are associated with higher revenues.

The estimated values of the Panzar-Rosse statistic (0.360 and 0.508) suggest a market structure that is compatible with monopolistic competition and are similar to those calculated for Latvia, Greece and Spain by Delis et al. (2008). Wald tests were also conducted to test the hypotheses of perfect competition ($\beta_1 + \beta_2 + \beta_3 = 1$) and monopoly ($\beta_1 + \beta_2 + \beta_3 = 0$) and were rejected at the 5% significance level in both models.

5. CONCLUSIONS

This study developed a conjectural variations model for banks using opportunity cost. In contrast, most of the existing research in the competitive banking literature has relied on complete functional form specifications for the total cost. The adoption of the opportunity cost is sensible because the available banking micro-data used in most empirical studies do not provide detailed cost information on the different financial products offered by banks.

The interest rate offered by the monetary authorities on minimum reserves was used as the opportunity cost variable. It was incorporated in the equilibrium price condition through the inclusion of interest income from minimum reserves in the profit maximisation problem facing a representative bank. Estimates of the market power parameter with the proposed model as well as with alternative conjectural variations and Panzar-Rosse models rejected the monopoly hypothesis for the banking industry in Cyprus.

REFERENCES

Adams, R., Brevoort, K. and Kiser, E. (2007), "Who competes with whom? The case of depository institutions", *Journal of Industrial Economics*, 55, 141-167.

Angelini, P. and Cetorelli, N. (2003), "The Effects of Regulatory Reform on Competition in the Banking Industry", *Journal of Money, Credit and Banking*, 35, 664–684.

Berry, S., Levinsohn, J. and Pakes, A. (1995), "Automobile prices in equilibrium", *Econometrica*, 63, 895-947.

Berger, A.N. (1995), "The profit structure relationship in banking – tests of market power and efficient structure hypothesis", *Journal of Money, Credit and Banking*, 27, 404–431.

Berger, A. N. and Hannan, T. H. (1989), "The price–concentration relationship in banking", *Review of Economics and Statistics*, 71, 291–299.

Berger, A. N. and Hannan, T. H. (1992), "Reply to a comment by W.E. Jackson", *Review of Economics and Statistics*, 74, 373–376.

Berger, A. N. and Hannan, T. H. (1997), "Using efficiency measures to distinguish among alternative explanations of the structure-conduct-performance relationship in banking", *Managerial Finance*, 23, 6–31.

Bresnahan, T. F. (1982), "The oligopoly solution concept is identified", *Economics Letters*, 10, 87-92.

Bresnahan, T. F. (1989), "Empirical studies of industries with market power", in R. Schmalensee and R. Willig (eds.), The Handbook of Industrial Organizations, vol. 2, pp. 1011-1157, Amsterdam: Elsevier.

Bresnahan, T. F. and Reiss, P. C. (1990), "Entry in monopoly markets", *Review of Economic Studies*, 57, 531-53.

Boone, J. (2008), "A new way to measure competition", *Economic Journal*, 118, 1245-1261.

Cabral, L. M. B. (2000), Introduction to industrial organization, Cambridge, Massachusetts: MIT press.

Cameron, C. A. and Trivedi, P. K. (2005), Microeconometrics, New York: Cambridge University Press.

Cetorelli, N. (2002), "Entry and competition in highly concentrated banking markets", *Economic Perspectives*, Federal Reserve Bank of Chicago, 18-27.

Claessens, S. and Laeven, L. (2004), "What drives bank competition? Some international evidence", *Journal of Money, Credit and Banking*, 36, 563-92.

Coccorese, P. (2005), “Competition in markets with dominant firms: A note on the evidence from the Italian banking industry”, *Journal of Banking and Finance*, 29, 1083-1093.

Cohen, A. M. and Mazzeo, M. J. (2007), “Market structure and competition among retail depository institutions”, *Review of Economics and Statistics*, 89, 60-74.

Corvoisier, S. and Gropp, R. (2002), “Bank concentration and retail interest rates”, *Journal of Banking and Finance,* 26, 2155–2189.

Degryse, H., Kim, M. and Ongena, S. (2009), Microeconometrics of banking: methods, applications and results, New York: Oxford University Press.

Delis, M. D., Staikouras, C. K. and Varlagas, P. T. (2008), “On the measurement of market power in the banking industry”, *Journal of Business Finance & Accounting*, 35, 1023-1047.

Demsetz, H. (1973), “Industry structure, market rivalry and public policy”, *Journal of Law and Economics*, 16, 1-10.

Dick, A. (2008), “Demand estimation and consumer welfare in the banking industry”, *Journal of Banking and Finance,* 32, 1661-76.

Dick, A. and Hannan, T. H. (2010), “Competition and antitrust policy in banking”, in Berger, A., Molyneux, P. and Wilson, J. O. S. (eds.), The Oxford Handbook of Banking, PP. 405-429, Oxford, UK: Oxford University Press.

Evans, W. N., Froeb, L. M. and Werden, G. J. (1993), “Endogeneity in the concentration-price relationship: causes, consequences and cures”, *Journal of Industrial Economics*, 41, 431-8.

Goddard, J.A., Molyneux, P. and Wilson, J.O.S. (2001), European Banking: Efficiency, Technology and Growth, Chichester, UK: John Wiley & Sons.

Goldberg, L. G. and Rai, A. (1996), "The structure–performance relationship for European banking", *Journal of Banking and Finance*, 20, 745–771.

Heffernan, S.A. (2002), ''How do UK Financial Institutions Really Price their Banking Products?'', *Journal of Banking and Finance*, 26, 1997–2006.

Heffernan, S. (2005), Modern Banking, Chichester, UK: John Wiley and Sons Ltd.

Jackson, W. E. (1992), "The price–concentration relationship in banking: a comment", *Review of Economics and Statistics*, 74, 291–299.

Lau, L. (1982), "On identifying the degree of competitiveness from industry price and output data", *Economic Letters*, 10, 93-99.

Matthews, K. and Thompson, J. (2008), The economics of banking, Chichester, UK: John Wiley and Sons Ltd.

Mérel, P. R. (2009), "Measuring market power in the French Comte cheese market", *European Review of Agricultural Economics*, 36, 31-51.

Mishkin, F. S. and S. G. Eakins (1998), Financial Markets and Institutions, 2nd ed. Reading, Massachusetts: Addison-Wesley.

Molyneux, P. and Forbes, W. (1995), "Market, structure, and performance in European banking", *Applied Economics*, 27, 155–159.

Molyneux, P., Lloyd-Williams, D. M. and Thornton, J. (1994), “Competitive conditions in European banking”, *Journal of Banking and Finance*, 18, 445-59.

Molyneux, P., Thornton, J. and Lloyd-Williams, D. M. (1996), “Competition and market contestability in Japanese commercial banking”, *Journal of Economics and Business*, 48, 33-45.

Nathan, A. and Neave, E. H. (1989), “Competition and contestability in Canada’s financial system: empirical results”, *Canadian Journal of Economics*, 22, 576-94.

Panzar, J. C. and Rosse, J. N. (1987), “Testing for monopoly equilibrium”, *Journal of Industrial Economics*, 35, 443-456.

Pepall, L., Richards, D. and Norman, G. (2008), Industrial organization: contemporary theory and empirical applications, 4 ed., Oxford, UK: Blackwell Publishing.

Shaffer, S. (1982), “A non-structural test for competition in financial markets”, Federal Reserve Bank of Chicago, Proceeding of a Conference on Bank Structure and Competition, 225-43.

Shaffer, S. (1989), “Competition in the U.S. banking industry”, *Economics Letters*, 29, 321-23.

Shaffer, S. (1993), “A test of competition in Canadian banking”, *Journal of Money, Credit and Banking*, 25, 49-61.

Van Leuvensteijn, M., Bikker, J. A. and van Rixtel, A. A. R. J. M., Sorensen, C. K. (2007), “ A new approach to measuring competition in the loan markets of the euro area”, mimeo, De Nederlandsche Bank.

Varian, H. (1992), Microeconomic Analysis, 3rd ed., NY:W.W. Norton & Company, Inc.