Competition, Efficiency and Interest Rate Margins in Latin American Banking

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Abstract

High interest rate spreads and low credit availability to the private sector have been persistent problems in Latin American banking in spite of the recent financial sector reforms. This paper considers the determinants of interest rate margins focusing on their relationship with (structural and non-structural) measures of competition and non-parametric estimates of efficiency. The empirical analysis provides an extension of the traditional Structure-Conduct-Performance framework and we estimate panel regressions using a Generalized Method of Moments (GMM) framework, for a sample of over 2,300 bank observations covering the period 1999-2006. The results show that the concentration index and the market share have little or no influence on interest rate margins. In contrast, we produce evidence suggesting that greater X-efficiency and competitive markets result in lower spreads. Moreover, while well capitalized banks seem to be associated with high spreads, economic growth appears to reduce them.

Keywords: *Net Interest Margins; Banking Competition; Efficiency; Data Envelopment Analysis; Latin America.*

JEL classification: *G21; D24; L11.*

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1. Introduction

Financial intermediation in Latin America is relatively low by international standards. Most countries' financial systems are predominantly bank-based and despite the reforms aimed at liberalizing and deregulating the financial sector, the region still experiences relatively low ratios of credit to the private sector.[1] These low levels of financial intermediation appear to be tied in with high borrowing prices and interest-rate spreads. Over 1999-2006 the average interest rate spread in Latin America reached 16.19% (with peaks of 42% in Brazil and 26% in Uruguay) compared to 5.02% in India, 6.21% in South East Asia, 3.26% in the Euro area and 2.9% in the US.[2] The high persistence of these spreads is considered as one of the greater failures of financial sector reforms carried out in Latin America over the last two decades. Moreover, the credit crunch and liquidity shortage generated by the global financial crisis exacerbates this situation by further decreasing the liquidity supply to the private sector.

While high interest rate spreads can contribute to the strengthening of a country's banking system if for instance, the profits earned are transferred by banks to their capital bases (Barajas et al. 1998; Saunders and Schumacher, 2000a) they are also associated with a number of drawbacks. High spreads are generally thought to reflect the inefficiencies of a financial system or, as Bernanke (1983) puts it, the costs of financial intermediation. When the spread is too high, it not only discourages potential savers with low returns but also impedes credit expansion because of the higher loan rates. Developing countries may be especially at risk because their financial systems and capital markets are less extended and sophisticated and their economies are primarily bank-based (Martinez Peria and Mody, 2004). Brock and Rojas-Suarez (2000) emphasize that high interest rate spreads are associated with bank-

[1] The average levels (over GDP) over 1999-2006 was 28.7% in Latin America, compared to 66.6% in South East Asia, 111.5% in the Euro Area and 145.7% in the UK. The only country with a similar ratio as South East Asia is Chile, having a ratio of 66% followed by Uruguay with 43.8% (data obtained from the IFS/IMF (International Financial Statistics provided by the International Monetary Fund).

[2] Spreads are measured as lending rate minus deposit rate as in Brock and Rojas-Suarez (2000). "Spreads" and "interest rate margins" will be used indistinctively throughout this paper.

specific inefficiencies which impact negatively on credit expansion and investment. Hanson and Rezende Rocha (1986) and Barajas et al. (1998) on the other hand observe that high spreads are frequently attributed to high operational costs, inflation rates, financial taxation and lack of competition. The economic reasoning is straightforward: if a handful of banks dominate the market, they can earn monopoly rents by behaving as price setters. This in turn lowers competition, increases inefficiencies at the bank level and results in an overall welfare loss. Yet, if bank mergers and acquisitions are driven by economies of scale, higher market concentration may actually result in efficiency improvements. Moreover, while one of the aims of financial liberalization carried out in Latin America was to increase actual and potential competition in the industry, banks have reacted to the new operating environment by strategically increasing their relative size through mergers and acquisitions. Consequently relying solely on concentration measures to gauge competitive conditions may be deceptive, as it would appear that the deregulation process in Latin America has actually decreased competition, because concentration has risen.

Typically, competition policies are intended to monitor banking markets and if necessary to prevent financial institutions from gaining excess market power. Although recent events demonstrate that trade-offs between the degree of competition and financial stability exist,[3] in 'normal' times antitrust authorities usually intervene to prevent large banks' mergers and/or acquisitions activities if they believe that the costs in terms of reduction in competition maybe too high.

This paper considers the possible determinants of interest rate margins in the Latin American banking markets during the period 1999-2006. We specify an empirical model which constitutes an extension of the traditional market power (Structure-Conduct Performance—SCP and Relative Market Power—RMP) and efficient-structure (X- and scale efficiency) hypotheses.[4] Specifically, we explore

[3] For example, consider the recent case of the merger between Lloyds TSB and HBOS in the UK.
[4] See e.g. Claeys and Vander Vennet (2008).

how (measures of) a set of variables used in the SCP and RMP frameworks (e.g., market concentration and market share) and efficiency measures explain interest rate margins. To capture cost efficiency, instead of relying on traditional financial ratios such as the cost-to-income ratio, we use X- and scale efficiency (as in Berger, 1995) estimated using Data Envelopment Analysis (DEA). Then, assuming that highly concentrated banking markets are not necessarily uncompetitive, we test the relationship between bank margins and a non-structural measure of bank competition (the H-statistic) introduced by Panzar and Rosse (1987). Finally, we include a set of relevant macroeconomic and bank-specific control variables. The correlation between margins and market structure, rather than being direct, may run via a higher level of efficiency. We run panel regression models, using a Generalized Method of Moments (GMM) framework, simultaneously to account for this possibility. As far as we are aware there are no similar studies for Latin America and this is the first to test alternative measures of competition simultaneously in a model of determinants of bank margins. Our results indicate that the concentration index and the market share have little or no influence on interest rate margins. In contrast, greater X-efficiency and non-structural measures of competition are important determinants in lowering spreads. High levels of bank capitalization are associated with high margins suggesting that banks set higher interest margins in response to profitability losses caused by greater (regulatory and endogenous) capital ratios. Economic growth appears to reduce interest rate spreads.

The paper is organized as follows: Section 2 provides a brief background of the banking sector in Latin America and reviews the relevant literature; Section 3 describes the data sources and main methodological issues; Section 4 discusses the results of the analysis and finally Section 5 concludes.

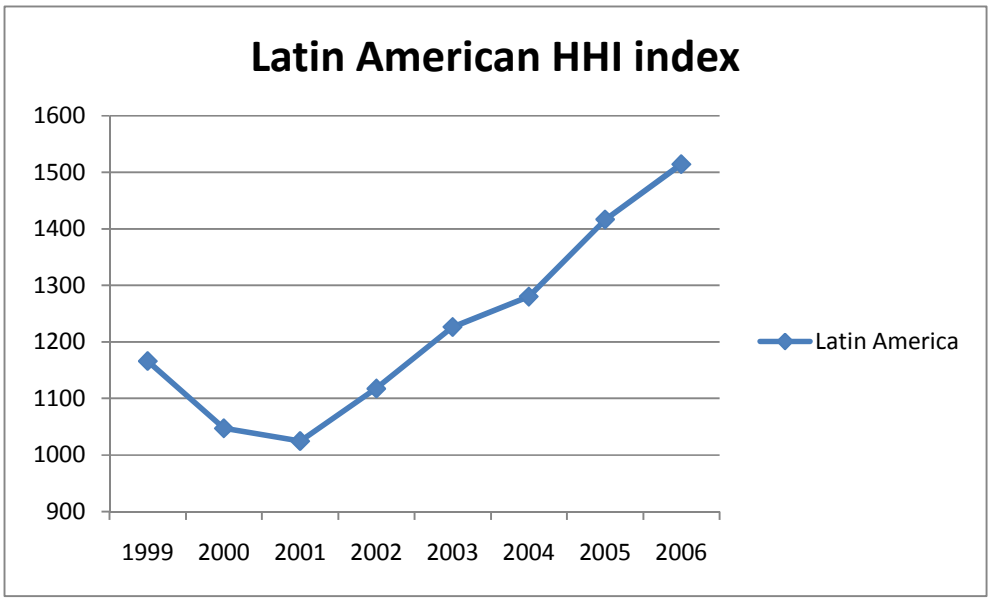
2. Background and Literature Review

2.1 Financial Intermediation in Latin America: A Bird's Eye View

The attempts of financial liberalization experienced by Latin American countries during the 1990s affected their banking sectors in many ways. A notable consequence was a higher degree of consolidation, reflected in increasing degrees of market concentration as shown in Figure 1. Williams et al. (2009) point out that the consolidation of the banking sectors in Latin America was necessary in order to restructure the financial systems after several financial crises.

Figure 1

Herfindahl-Hirschmann Index (1999-2006)



Source: Elaborated with data from *Bankscope*.
Notes: The Latin American HHI index is the average of the HHI index of the banking sectors for Argentina, Brazil, Chile, Colombia, Costa Rica, Paraguay, Peru, Uruguay and Venezuela for the period under study.

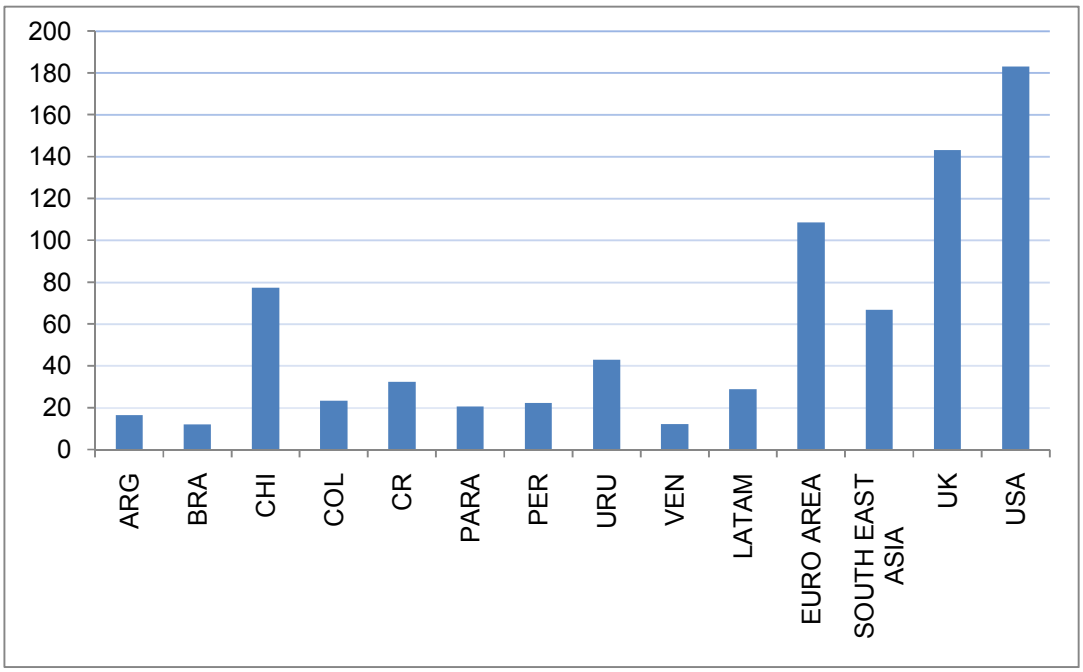
At the same time the financial sector still remains highly bank-based and financial intermediation is low compared to other developed and developing nations. The level of credit increased during the 1990s, to contract again soon after the economic crises experienced in the region (Singh et al., 2005) and currently

remains relatively low (see Figure 2).[5] The persistently high lending rates are among the factors explaining the relative low ratios of credit to the private sector.

Figure 2

Bank Credit to the Private Sector in terms of GDP, Average Percentage

(1999-2006: Latin America and other selected countries)



Source: Data obtained from the IFS.
[a]The Latin American average is calculated using the following countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Paraguay, Peru, Uruguay and Venezuela. For Venezuela the average is calculated from 1999-2004 due to data availability.
[b]The South East Asia average is calculated using the following countries: Brunei, Cambodia, Malaysia, Laos, Myanmar, Singapore, Thailand, Hong Kong, South Korea, Philippines and Vietnam. The average for Brunei and Vietnam was computed for the years 1999-2005 and for Myanmar from 1999-2004 due to data availability.
[c]The data for the euro area was elaborated including all the countries in the European Union.

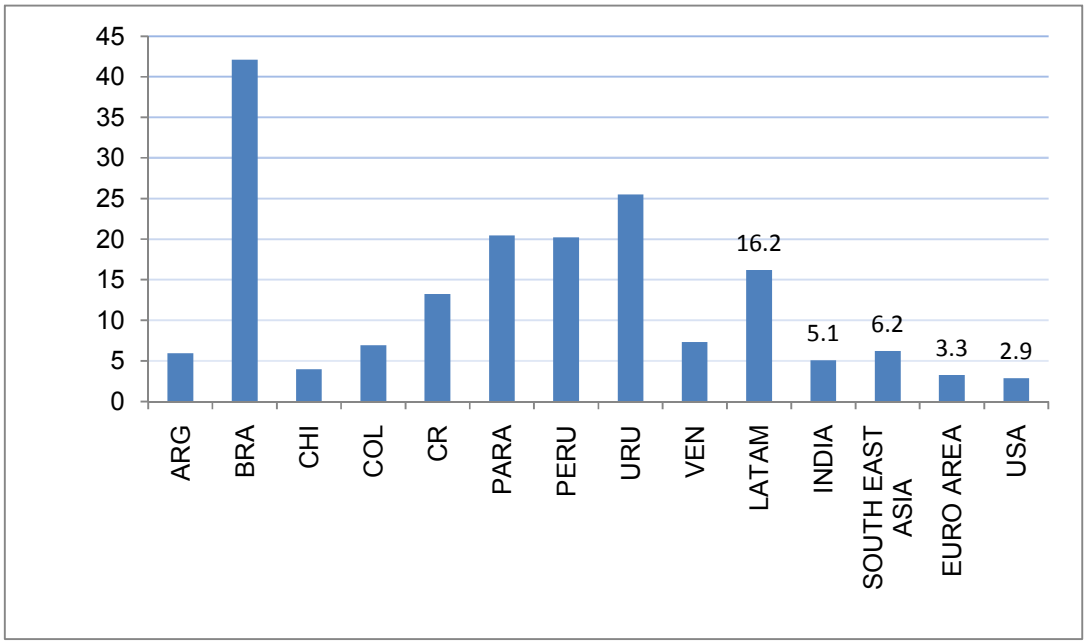
The initial attempts of financial liberalization nourished the anticipation that interest rate spreads would converge to (the lower) international levels. Foreign bank entry, the rationale goes, could

[5] The average of Latin America is 28.7% compared to 66% in South East Asia, 111.5% in the Euro Area and 145.7% in the UK. The only country with a similar ratio as South East Asia is Chile, having a ratio of 66% followed by Uruguay with 43.8%. Nevertheless, the rest of the region experiences excessively low ratios of credit to the private sector.

contribute to lower interest rate spreads by raising competition, generating efficiency gains and enhancing banking sector capitalization through, for example, greater deposit rates (Williams et al., 2009). Nevertheless, the spreads remained relatively high compared to other industrial and developing nations (Gelos, 2006). While, in general, foreign banks have operated with lower spreads as compared to domestic banks in Latin America, the main impact of financial liberalization has been the inducement of all banks to reduce costs rather than a marked decline in spreads (Martinez Peria and Mody, 2004). Brock and Rojas-Suarez (2000) suggest that high spreads are typically associated with bank inefficiencies, which impact negatively on credit expansion and investments. The interest rate spreads in Latin America, however, persist at high levels compared to international standards (see Gelos, 2006) validating earlier analyses (e.g., Brock and Rojas-Suarez, 2000). Figure 3 presents the interest rate spreads in Latin America compared to other developed and emerging economies.

Figure 3

Interest Rate Spreads (1999-2006, yearly averages)



Source: Data obtained from the IFS.
See notes to Figure 2.

To capture the interest rate spreads in this paper we use the Net Interest Rate Margin (NIM), defined as the net income minus the next expenses over total earning assets of the commercial banks. This measure has been used extensively in the literature (see e.g. Ho and Saunders, 1981; Demirguc-Kunt and Huizinga, 1999; among others).

Table 1 reports the net interest rate margin for commercial banks by country and by year over the period 1999-2006.

Table 1

Commercial Banks' Average Net Interest Margin

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*1999-2006 (%)*
Argentina	6.73	7.15	7.35	11.95	3.77	3.26	3.11	3.06	**-55**
Brazil	15.65	12.27	10.73	13.14	12.55	12.33	13.44	13.38	**-15**
Chile	5.33	5.6	5.3	6.65	4.75	4.91	5.46	5.79	**8**
Colombia	3.86	3.78	4.46	6.26	6.39	5.91	6.08	5.28	**37**
Costa Rica	3.96	7.04	7.31	7.51	8.97	7.47	7.61	7.57	**91**
Paraguay	12.03	10.09	12.78	12.66	9.17	8.94	9.05	9.39	**-22**
Peru	9.03	9.06	9.66	10.39	9.93	9.36	10.87	11.42	**26**
Uruguay	5.65	5.39	4.63	3.78	6.04	2.42	2.49	5.02	**-11**
Venezuela	21.84	17.02	17.02	19.38	17.68	13.21	9.9	8.3	**-62**

Source: Bankscope.

While NIMs have decreased in some countries and increased in others over the period under study,[6] they remain excessively high by international standards. In the aftermath of Argentina's economic crisis the majority of the countries considered displayed NIM ratios averaging at 8.57%.[7]

2.2 Literature Review

Studies attempting to capture the costs of financial intermediation typically focus on the difference between lending and deposits rates, and assume that higher spreads are associated with higher financial inefficiencies. Recent empirical studies on the determinants of bank spreads are cross-country investigations covering large samples of countries. Demirguc-Kunt and Huizinga (1999) examine the determinants of interest rate spreads using bank-level data for 80 countries for the period 1988-1995. They identify bank-specific, institutional, regulatory and macroeconomic variables that affect bank spreads and profits. Typically domestic banking institutions in developing countries appear to have lower margins and profits than foreign banks, while the opposite holds true in developed economies. Using a sample of 1,400 banking institutions over 72 countries in 1995-99, Demirguc-Kunt et al. (2003) investigate the impact on bank margins of market concentration, regulatory and macroeconomic variables while controlling for bank-specific variables. They also test the impact of indexes of the overall institutional structure of the economy, such as property rights and economic freedom indexes. Their results suggest that higher interest margins are associated with increased regulation aimed at restricting bank operations and freedom to entry. Although competition is not measured directly, this study seems to imply that overall banks operating in less competitive markets are able to achieve higher

[6] In particular NIMs have decreased in Argentina (-55%), Brazil (-15%), Paraguay (-22%) and Venezuela (-62%) and increased in Chile (+8%), Colombia (+37%), Costa Rica (+91%) and Peru (+26%).
[7] The Latin American average is elaborated using data from the database Bankscope for Argentina, Brazil, Chile, Colombia, Costa Rica, Paraguay, Peru, Uruguay and Venezuela (see for more details Section 3).

margins. National approaches to property rights also appear to be significant factors in explaining higher than normal margins.

Carbo-Valverde and Rodriguez-Fernandez (2007) study the determinants of interest rate margins in seven European Union (EU) countries for the period 1994-2001. They use three different measures of interest rate margins, namely, a wide accounting margin measure, the loans to deposits ratio, and the Lerner index of monopoly power. Their findings reject the hypothesis that a relationship between the degree of concentration and interest rate margins exists. They find, however, a strong positive relationship between interest rate margins and variables such as credit risk, liquidity risk, interest rate risk and the degree of capitalization. The degree of capitalization is interpreted as a minimum premium on bank margins due to regulatory pressures relating to solvency issues. Moreover, their evidence suggests a positive relationship between operational inefficiency (cost-to-income ratio) and greater margins. Hence, banks with higher costs tend to operate with higher margins (see also, Altunbas et. al., 2001). Finally, they find a negative relationship between GDP growth and margins, suggesting that economic growth fosters lower margins.

Recently Claeys and Vander Vennet (2008) analyze the determinants of interest rate margins in Central and Eastern European countries as compared to Western European countries over 1994-2001 focusing on bank market structure, efficiency, and changes in the regulatory framework. They test these relationships for a large cross-country sample in the context of the industrial organization market power (SCP and RMP) and efficiency hypotheses. Specifically, scale and X-efficiency measures are derived from the estimation of a stochastic frontier approach (see e.g. Goddard et al., 2001). However the authors do not measure bank competition and simply infer it from market structure. A main finding is that changes in regulation result in riskier bank activities and increase their margins before competition effects push them down.

Several studies analyze the possible determinants of high lending rates and spreads in the Latin American banking sector using almost invariantly panel data methodologies. Table A1 (Appendix 1) reports selected country-specific and cross-country studies carried out since the early 1990s. Furthermore, high operating costs, macroeconomic variables and concentration ratios are usually found to be significantly associated with banks' margin and spreads. Brock and Rojas-Suarez (2000) apply a two-step procedure first developed by Ho and Saunders (1981) for five Latin American countries (Argentina, Colombia, Bolivia, Chile and Peru) during 1991-96. The method essentially consists in running two separate regression models for the microeconomic and macroeconomic variables on the interest rate spreads. Bank spreads in Bolivia are explained by microeconomic variables, whereas in Chile and Colombia they are explained by both micro and macroeconomic factors. Both the above factors, however, leave unexplained a large portion of the spread in Argentina and Peru.

Martinez Peria and Mody (2004) analyze how foreign participation and market concentration impact bank spreads in Latin America. They focus on Argentina, Chile, Peru, Colombia and Mexico over 1995-2001 and define the spread as the difference between the implicit average interest charged on loans and the implicit average interest paid on deposits. They consider bank-specific (such as non-performing loans and equity) and macroeconomic variables, as well as a structural measure of market share, concentration and merger and acquisition effects. Their evidence suggests that foreign entry lowers interest rate margins and fosters competition. The degree of market concentration is a strong determinant of spreads, particularly for domestic banks. Finally, the long-term benefits of foreign entry are materialized through lower administrative costs, fostering further cost reduction throughout the banking system (generating greater competition).

Gelos (2006) examines banks' spreads in a wider set of fourteen Latin American countries using the net interest rate margin as the dependent variable. The bank-specific variables include bank size,

equity, overhead costs and foreign ownership. To measure competition the author uses the H-statistic.[8] It emerges that Latin American interest rate margins are determined by low efficiency levels, high reserve requirements and relatively high market interest rate spreads. Moreover, a less developed legal environment seems to contribute to higher spreads.

On balance most studies suggest that to explain the high interest spreads one should look at a multitude of factors rather than a single one. The determinants of spreads include inefficiencies, market structure and macroeconomic variables. Williams et al. (2009), for example, find that the most common factors influencing spreads include high operating costs, poor loan quality, high capitalization, reserve requirements and the macroeconomic environment (including interest rate volatility and GDP growth and volatility). No analysis exists, however, on the potential role of market power and efficient structure in Latin America. As far as we are aware, only one study (Gelos, 2006) has empirically tested the relationship between margins and bank competition as measured by the H-statistic. In this paper we provide an extensive analysis of the interest rate spreads determinants in Latin America focusing explicitly on the role of competition and efficiency.

3. Data and Methodology

3.1 Econometric specification

To examine the determinants of net interest rate margins in Latin America we employ a dynamic panel data approach. There are many advantages of using these models. The first advantage resides in the ability to acknowledge both the time and cross-sectional variation in the model. The second benefit is that it allows avoiding any bias between cross-country regressions. The third is the possibility to use instrumental variables producing more precise and accurate estimators. In addition, these methods are useful for panels that are characterised by a relatively low number of years and a large number of cross-

[8] The Panzar and Rosse (1987) H-Statistic is discussed below and Appendix 2 provides further methodological details.

sections per year. We use a GMM dynamic panel data approach as proposed by Arellano and Bond (1991) and further developed by Arellano and Bover (1995) and Blundell and Bond (1998).

The empirical model is an extension of the original market power and efficient structure hypotheses (for the conventional models see Berger, 1995 and Goldberg and Rai, 1996) as follows:

$$NIM_{it} = \alpha_i + \beta_1 NIM_{1,t-1} + \beta_2 HHI_t + \beta_3 MS_{it} + \beta_4 ESX_{it} + \beta_5 ESS_{it} + \sum_{j=1}^{3} \eta_j X_{it} + \sum_{k=1}^{4} \delta_k Z_t + \varepsilon_{it} \qquad (1)$$

where NIM is the net interest margin and is calculated as the interest rate income minus the interest rate expenses divided by total earning assets. HHI is the Herfindahl-Hirschman Index measured as the squared sum of the market share in terms of total assets of the banks in the industry at time t, $HHI_t = \sum_{m=1}^{n} (MS_{it}^{assets})^2$. A positive coefficient for the HHI implies a direct effect from the market structure on the interest rate margins, indicative of collusion, and thus supportive of the traditional SCP hypothesis. Greater concentration can offset the apparent benefits of foreign bank penetration through greater spreads (Martinez Peria and Mody, 2004). MS is the market share in terms of each bank's assets. A positive coefficient indicates that banks with high market share are able to set prices autonomously, supporting the RMP hypothesis. ESX is a measure of managerial (technical efficiency) and ESS is a measure of scale efficiency. The efficient structure hypothesis suggests a negative relationship between NIM and both efficiency variables. That is, efficiency gains should be reflected in lower interest rate margins.

The vector of control variables, X includes a number of firm- and market- specific characteristics, Z is a vector of country-specific macroeconomic variables, and finally ε_{it} is the error term. More specifically the controls of X_{it}, can be written as follows:

$$\sum_{j=1}^{3} \eta_j X_{it} = \eta_1 CAP_{it} + \eta_2 LOAA_{it} + \eta_3 LLR_{it} \quad (2)$$

where CAP is the degree of capitalization measured as equity over assets, LOAA is a measure of liquidity risk proxied by loans over assets, and LLR is the loan loss reserves which constitutes a proxy for banks' asset quality. Saunders and Schumacher (2000a,b) rationalize the anticipated positive relationship between CAP and NIM on the grounds that banks respond to the loss in profitability due to greater capital ratios by demanding higher interest margins.

Other reasons of this costly relationship between capital and debt reflected in greater spreads include the excessive taxes on capital and high governance costs (see Brock and Rojas-Suarez, 2000). LOAA is a liquidity risk measure estimated as the total amount of loans over total assets. As higher LOAA ratios imply greater loans, a potential positive relationship with NIM emerges. This is because more loans can be risky and costly to service and monitor. These extra costs are therefore transferred as lower deposit rates or higher lending rates (see Claeys and Vander Vennet, 2008).

Finally, the level of loan loss reserves (LLR) is a proxy for the quality of the bank loan portfolio. The anticipated sign on this variable is determined by counterbalancing forces. On one hand, the higher the loan loss reserves the lower the resources allocated to alternative investment opportunities and the LLR should be negatively related to interest rate margins. On the other hand, the relationship could also be positive because a high LLR may reflect a poorer loans' quality inducing banks to charge customers an extra premium for these loans and thus increasing the spread.

We specify the vector *Z* of the macroeconomic variables in equation (1) as follows:

$$\sum_{n=1}^{4} \delta_n Z_t = \delta_1 XRATE_t + \delta_2 CPI_t + \delta_3 GDP_t + \delta_4 INT_t \quad (3)$$

where XRATE is the domestic exchange rate (home currency in terms of USD); CPI is the inflation rate; GDP is the real growth rate of the economy and INT is the average annual market interest rate. The exchange rate affects bank margins, although its impact varies depending on the structure of the bank's assets and liabilities in foreign currency (Fuentes and Basch, 1998). The inflation rate is measured as the average percentage change of the consumer price index and, in general, a positive relationship is expected with NIMs. Greater inflation increases the risk of default and thus banks will charge a higher lending price that increases the interest rate spreads. On the other hand, banks can often be constrained by regulatory, institutional, and market factors so that are unable to keep up raising rates when inflation rates are high and variable. Moreover, inflation affects asymmetrically lenders and borrowers and thus its net affect on NIMs depends on the structure of the asset side of banks' balance sheet. Economic growth has a wealth effect, raising the net worth of depositors and reducing lending rates (see Gelos, 2006). Finally, since greater market interest rate fluctuations increase interest rate margins (Saunders and Schumacher, 2000a) the expected relationship between INT and NIM is positive.

To observe the bank-specific effects in relation to the degree of competition, we consider a second model specification which allows us to measure the influence of the Panzar and Rosse H-statistic on bank interest margins.[9] Failing to account for (a measure of) competition may be misleading because in Latin America banks have responded to the process of liberalizion by increasing significantly their asset size. In other words, the deregulation process that was intended to increase competition resulted in a much more concentrated industry.

Technically, a high degree of competition in the banking sector should yield lower spreads and it has also been documented that administrative expenses are positively related to greater interest rate

[9] See Appendix 2 for details on estimating the H-statistic. A recent study by Schaeck et al. (2009) also provides an extensive discussion.

margins. The inefficiencies in a country's banking sector are likely to reflect the absence of a competitive environment (Gelos, 2006). Thus, we write the modified model as:

$$NIM_{it} = \alpha_i + \beta_1 NIM_{i,t-1} + \beta_2 HHI_t + \beta_3 MS_{it} + \beta_4 H - stat_t + \sum_{j=1}^{3} \eta_j X_{it} + \sum_{k=1}^{4} \delta_k Z_t + \varepsilon_{it} \quad (4)$$

We call equation (4) *Model I* and we estimate it for the whole Latin American region because the H-statistics is time-invariant and we can only obtain one measure per country for the period under study. To check the robustness of our findings, however, we introduce a variation of the above model which includes the interaction variables H*ESX and H*ESS in order to capture whether the changes in the degree of competition depend on the managerial and scale efficiencies, respectively. We write the resulting *Model II* as:

$$NIM_{it} = \alpha_i + \beta_1 NIM_{i,t-1} + \beta_2 HHI_t + \beta_3 MS_{it} + \beta_4 H*ESX_{it} + \beta_5 H*ESS_{it} + \sum_{j=1}^{3} \eta_j X_{it} + \sum_{k=1}^{4} \delta_k Z_t + \varepsilon_{it} \quad (5)$$

As noted above, greater banking competition should generate lower interest rate margins as conditions for consumers improve implying a negative relationship between the H-statistic index and NIM. More competition lowers bank interest rate spreads on policy market rates and increases the speed of adjustment of the latter rates (Van Leuvensteijn, 2008). Carbo-Valverde (2008) explains that allocative efficiency refers to the maximization of social welfare that is achieved under perfect competition (*P=MC*), and thus both operational and allocative efficiency could affect social welfare and market power in various ways. He describes two channels through which efficiency could deviate from

perfect competition: it may enable banks to depart from marginal cost pricing (allocative inefficiency) and/or it may affect the efforts of bank managers to control costs (operational inefficiency).[10]

We estimate the models described in equations (1) and (5) using an unbalanced panel of data. This choice is dictated by two main reasons: first, to account for the consolidation process that has taken place in Latin America over the period under study; and second, to observe heterogeneity between observations and time effects.

To estimate the X- and scale efficiency variables we use the non-parametric Data Envelopment Analysis (DEA) technique (Charnes et al. 1978) which is based on mathematical linear programming. The DEA frontier is formed by the "best-practice observations" yielding a convex production possibility set. Since our focus is on the cost side of banking operations, we employ an input-oriented, variable-returns-to-scale (VRS) model. Specifically, we compute two variables: the X-Efficiency (ESX) and the scale efficiency (ESS). This latter is defined as the ratio of Constant Returns to Scale (CRS) to VRS, i.e. ESS = CRS/VRS and the value for scale efficiency is bounded between 0 and 1. The VRS linear programming model we use is defined as follows:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &st \\ &y_t + Y\lambda \geq 0 \\ &\theta q_i - Q\lambda \geq 0 \\ &N1\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{6}$$

where θ is a scalar, λ is a N times 1 vector of constants, y_0 is the output vector for the DMU_0 (Decision Making Unit), Y is the matrix of outputs of the other DMUs and the number of DMUs ranges from i=1…n, q_0 is a vector of inputs of DMU_0 and q_i is the matrix of input of the other DMUs. The value of θ represents the efficiency score for the 0-th DMU where $0 \leq \theta \leq 1$. If θ is equal to 1, then the DMU

[10] This is the so-called "quiet life" hypothesis which describes how market power may detriment operational efficiency.

lies on the efficient frontier and the particular DMU (bank) is fully (i.e. 100%) efficient. Removing the convexity constraint $N1\lambda = 1$ from (6) one obtains the CRS based efficiency scores.

In our analysis the inputs are: interest rate expenses, personnel expenses and other operative expenses. The output variables capture the traditional lending activities of banks (total loans) and the growing non-lending activities (other earning assets).[11]

3.2 Data

Our sample includes 2,305 bank observations from nine Latin American countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Paraguay, Peru, Uruguay and Venezuela over the period 1999-2006. Balance sheet and income statements data are drawn from the Fitch/IBCA/Bureau Van Dijk Bankscope database. We use an unbalanced panel of data to account for merger and acquisition effects in the model. We obtain the macroeconomic data from the International Financial Statistics (IFS) of the International Monetary Fund.

Table 2 presents the descriptive statistics of the sample. The net interest margin, the proxy variable for interest rate spreads, is on average 9.8%. The region's average inflation rate over the period considered is 8.6%, and GDP growth averages only 2.17%.

[11] Following e.g. Beccalli et al. (2006) we use the flow of costs as one single input.

Table 2

Descriptive Statistics

Observations 2,305	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
NIM	9.845	10.248	-51.16	104.21
HHI	1,026.125	382.992	676.19	2,358.36
MS	2.946	5.194	0.01	39.26
LOAA	46.06	23.221	-20.75	99.72
CAP	18.309	18.574	-172.88	100
LLR	8.254	33.095	-664.94	750
ESX	0.598	0.31	0.01	1
ESS	0.703	0.284	0.01	1
XRATE	665.516	1,285.256	1	6,424.34
CPI	8.649	6.708	-1.17	31.12
GDP	2.157	5.239	-11.03	17.33
INT	16.092	12.544	1.25	86.1
H-stat	0.78	0.123	0.64	1

Notes: NIM is the net interest rate margin defined as the interest rate income minus interest rate expenses over total earning assets; HHI is the Herfindahl-Hirschman Index measured as the sum of squared market shares in terms of total assets; MS is the market share in terms of total assets; LOAA is a measure of liquidity risk calculated as loans over total assets; CAP represents the degree of capitalization and is measured as equity over total assets; LLR is a measure of default risk calculated as loan loss reserves over gross loans; ESX is a measure of managerial efficiency estimated using DEA; ESS is a measure of scale efficiency estimated using DEA; XRATE is the average annual exchange rate (domestic currency against US dollars); CPI is a measure of annual inflation; GDP is the average GDP real growth.

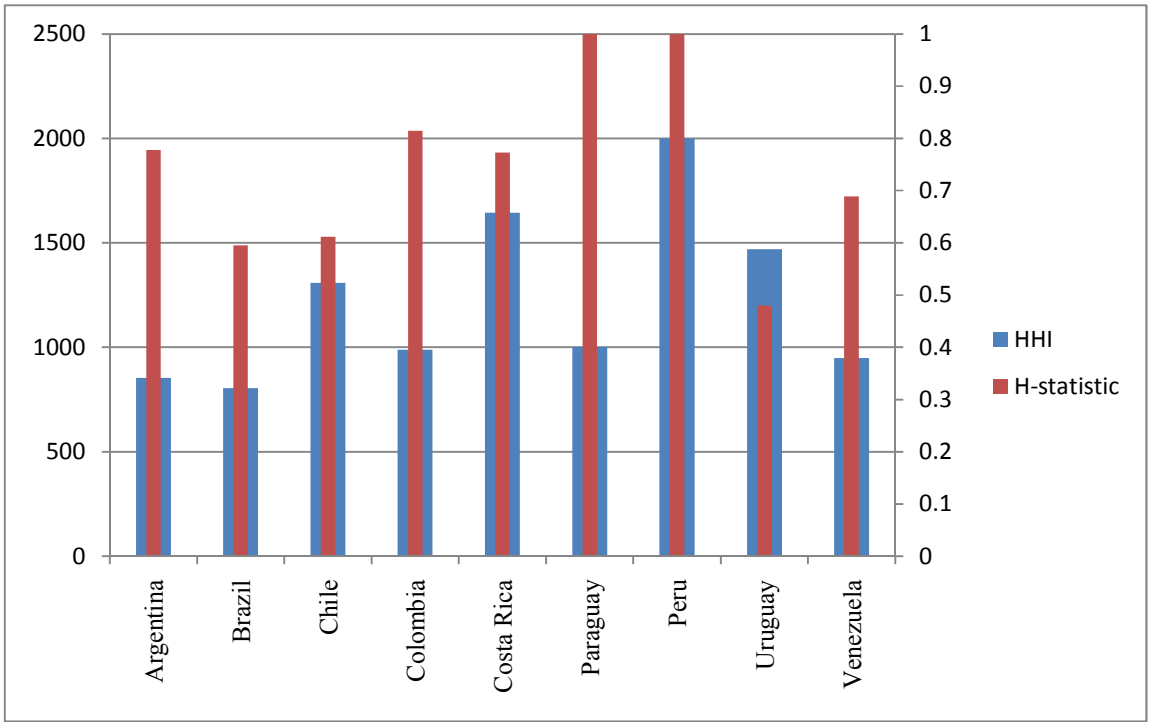
[a] The variable loan loss provisions over net interest revenue is included instead of the loan loss reserves over gross loans for Uruguay due to data availability.

4. Empirical results

Figure 4 reports the average Herfindahl-Hirschman index (HHI) and the Panzar and Rosse H-statistics by country, capturing the degree of concentration and competition respectively for the period 1999-2006.

Figure 4

Bank Concentration and Competition in Latin America (1999-2006)[a]



[a] HHI is the Herfindahl-Hirschmann Index and is the average of the period (1999-2006).

[b] The H-statistic is comprised between 0 (monopoly) and 1 (perfect competition); $0 \leq H \leq 1$ implies monopolistic competition. Test Ho=1 accepted for Paraguay and Peru. For methodological details see Appendix 2.

Our results indicate that there are wide differences across countries in Latin America. Three countries (Peru, Costa Rica and Uruguay) show relatively high HHIs. Nevertheless, the non-structural measures of competition imply that no country is experiencing a monopoly and the average H-statistic for the region is 0.70. Similarly, Levy Yeyati and Micco (2005) find that the banking systems in eight

Latin American countries (during 1996-2002) are characterized by monopolistic competition.[12] Our evidence also indicates that the relationship between concentration and competition for the banking industry in Latin America is not straightforward. Figure 4 reveals that in some countries high concentration does not necessarily imply lack of competition as for example, in the case of Peru. Equally, countries that have similar concentration indexes, such as Argentina and Brazil, appear to have considerably different H-statistics. These findings broadly suggest that high concentration does not necessarily imply low competition in Latin American banks, thus giving support to our choice of including both variables in the models of the determinants of interest rate margins.[13] Specifically, this study first examines whether and to what extent market power and efficiency hypotheses explain banks' interest rate spreads for each Latin American country while controlling for the effect of other bank- and market specific variables (Table 3). Then, since the non-structural measures of bank competition calculated using the Panzar and Rosse (1987)'s methodology are constant for each country over the period, we pool the data for the whole Latin American region and test the impact of the H-statistics (and the interaction variable between the H statistics and X- and scale efficiencies) on the dependent variable NIM (results are reported in Table 4). Table 3 presents the findings of the panel regression analysis (equation 1) carried out by country. The first market structure variable, HHI, is positive and significant, thus validating the SCP argument in Argentina and Peru. No significantly positive relationship exists between HHI and NIM in the remaining countries. The evidence is weaker concerning the Relative Market Power hypothesis: the MS variable is positive and significant only for Colombia.

[12] The countries under study are: Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Mexico and Peru.
[13] This is in line with a recent study by Schaeck et al. (2009) that find that competition and concentration capture different characteristics of banking systems, meaning that concentration is an inappropriate proxy for competition. See also Casu and Girardone (2006).

Table 3

GMM regression by country (NIM as dependent variable)

Variables	*Argentina*	*Brazil*	*Chile*	*Colombia*	*Costa Rica*	*Paraguay*	*Peru*	*Uruguay*	*Venezuela*
NIM lagged	.305***	.23*	.473*	.474***	.233	.706**	-.18	.179	.572***
HHI	.048**	.069	-.003*	-.009	-.007	-.017	.081*	-.0001	-.025
MS	.113	-.513	.12	.083*	.022	-.351	.07	-.154	.217
LOAA	.202***	.182***	.023	.101**	-.022	.015	-.304	.013	.135***
CAP	.127***	.046	.017	.122*	.171**	-.002	-.134	-.037	.097**
LLR	.052	.004	-.005	.025	-.127	-.031	-.515	.034***	-.026
ESX	-.049*	-.066**	-.061***	-.049***	-.031**	.013	-.304**	.001	-.039*
ESS	.023	-.083*	-.061	-.028	-.033	.043	-.244	.021	.025
XRATE	.015	-2.323	-.032***	-0.000	.038	.002***	.716**	-.027	-.003**
CPI	-.017	-1.317	-1.42	-.542	.191	-.679	1.578	.139	.418*
GDP	-.844***	-1.043	-1.204**	-.402	-.381	-.376	-4.385	-.033	.064
INT	-.156	.946**	-.292	-.151	.044	.385	8.898*	-.018	.214**
Constant	-41.737***	-40.31	38.258	15.508	4.93	7.035	-357.818*	2.092	14.346
F- test	11.50	2.27	8.94	34.98	43.28	97.40	104.84	3.97	47.29
(p-value)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.001)	(0.00)
AR(1)	-2.91	-2.12	-1.87	-1.87	-1.27	-1.72	-1.84	-1.80	-2.10
(p-value)	(0.00)	(0.034)	(0.062)	(0.061)	(0.205)	(0.085)	(0.066)	(0.072)	(0.036)
AR(2)	1.35	1.44	1.41	-0.72	0.64	-0.15	0.64	-1.80	-1.58
(p-value)	(0.176)	(0.151)	(0.160)	(0.473)	(0.523)	(0.877)	(0.521)	(0.071)	(0.115)
Hansen-J test	64.20	52.58	15.67	15.70	14.81	4.59	2.34	6.10	28.48
(p-value)	(0.732)	(0.267)	(1.00)	(1.000)	(1.000)	(1.000)	(0.311)	(1.000)	(1.00)
Time Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	254	568	137	142	116	109	73	128	199

*, **, ***, denote significance from zero at 10%, 5%, 1% level respectively

Notes: NIM is the net interest rate margin, HHI is the Herfindahl-Hirschman Index, MS is the market share in terms of assets, LOAA is a measure of liquidity risk, CAP is a measure of the degree of capitalization, LLR is a measure of default risk, ESX is a measure of managerial efficiency, ESS is a measure of scale efficiency, XRATE is the average annual exchange rate, CPI is a measure of annual inflation, GDP is the average GDP real growth.

Arellano-Bond order 1 (2) are tests for first (second) order correlation, asymptotically N(0,1). These test the first-differenced residuals in the system GMM estimation.

The Hansen test is a test of overidentification restrictions. Under the null hypothesis, the test statistic is distributed as a chi-squared in the number of overidentifying restrictions.

System GMM are two-step estimates. The two-step errors are computed in accordance to the Windmeijer (2005) finite-sample correction.

Turning to the efficiency variables[14], when significant, ESX displays invariantly a negative coefficient. This is the case for the majority of countries considered, including the largest ones (i.e. Argentina, Brazil and Chile). Estrada et al. (2006) and Gelos (2006) find similar results, implying that more efficient banks tend to have lower interest rate spreads. In contrast, the scale efficiency variable, ESS, appears to be less important in explaining NIM.[15] Our evidence suggests that ESS is negative and statistically significant only for Brazil.

The bank-specific variables show mixed results, reflecting the significant differences across countries in Latin America in terms of banks strategies and risk profiles. The variable LOAA, which proxies for the degree of liquidity risk, when significant, is positively related to NIM. This result is in tune with the literature since banks tend to pass their liquidity risks to consumers via increasing interest rate margins. The variable CAP is statistically significant and positively related to NIM for four out of nine countries in the sample. Saunders and Schumacher (2000a) clarify that high capital ratios can be interpreted as a form of taxation on bank profitability that forces banks to impose an additional premium to the banks' NIM. Another possible reason is that well-capitalized banks have lower expected bankruptcy costs and lower funding costs; hence, if loan rates do not change much with equity, higher levels of capital tend to imply larger NIMs (e.g., Demirguc-Kunt et al. 2003). Finally, the results for the asset quality variable (LLR) show a statistically significant and positive sign only in Uruguay. Indeed, higher levels of loan loss reserves may signal both lower resources allocated to alternative investment opportunities (thus decreasing the spread) and poorer loan quality thereby inducing banks to charge customers a premium that increases the spread.

The results for the macroeconomic variables (XRATE, CPI, INT and GDP) are mixed. The coefficients of the exchange rates (XRATE) are statistically significant in four cases only and their

[14] See Table A2 in Appendix 1 for the detailed breakdown of the X- and scale efficiency scores by country over the period.
[15] Finding a significant effect for the X-efficiency but not for the scale-efficiency is consistent with the empirical evidence that X-efficiencies explain much more cost differences than scale (Berger, Hunter and Timme, 1993; Jeon and Miller, 2005).

magnitude is generally low. The exchange rate effect on NIMs is positive for Paraguay and Peru but negative for Chile and Venezuela. We find that the inflation rate (CPI) is statistically significant and positive in Venezuela. According to Fuentes and Basch (1998), increases in the inflation rate increment both the loan and deposit rates although in different proportions, therefore resulting to higher or lower interest rate margins. The average annual interest rate (INT) is statistically significant only for Brazil, Peru and Venezuela, displaying positive coefficients. Again the interpretation of this finding is not straightforward since the structure of the banks' assets and liabilities differ across countries and thus banks are influenced differently by the market interest rate (Fuentes and Basch, 1998). Brock and Rojas-Suarez (2000) find that interest rate volatility affects spreads positively in Bolivia and Chile but not for the remaining Latin American countries in study. The effect of the inflation rate and the interest rate on NIMs may be subject to significant nonlinearities (especially for high and variable inflation and interest rates) and differences in the regulatory and market environment. Finally, GDP growth, when significant, is negative as is in Argentina and Chile. This implies that for these countries a better macroeconomic environment decreases NIMs, possibly by reducing the lending rate as a result of the lower credit risk of corporate and private borrowers.

The second step of our analysis consists in using a dynamic panel data methodology for the whole Latin America in order to complement the analysis by individual country and account for an explicit measure of competition. Specifically, this approach allows the inclusion of the Panzar and Rosse (1987) non-structural measures of competition in the models. *Model I* incorporates the country specific H-statistic variables and *Model II* can be considered a robustness check that accounts for two interaction terms with the efficiency variables (H*ESX and H*ESS). We follow a two-step GMM panel data

procedure and the estimates are Windmeijer (2005) corrected.[16] Moreover, the models are correctly identified as they satisfy the second order no-autocorrelation criterion AR(2) and the Hansen J-tests.

The results are reported in Table 4 and they broadly corroborate the findings obtained by estimating the models on a country by country basis (as illustrated in Table 3). The market structure variables do not appear significant in explaining interest rate margins. Thus, both the SCP and RMP hypotheses are rejected.

Table 4

GMM regression for Latin America (NIM as dependent variable)

Variables	*Model I*	*Model II*
NIM lagged	.389***	.685***
HHI	.002	-.001
MS	-.083	.045
LOAA	.121***	.048***
CAP	-.037	.05*
LLR	.029*	.019**
ESX	-.024**	.139
ESS	-.0003	.069
XRATE	.001***	-.0001
CPI	.075	.079*
GDP	-.215***	-.274***
INT	-.06*	-.0722*
H-stat	-18.629***	
H*ESX		-18.73*
H*ESS		-5.278
Constant	15.19***	-3.323
F-test	14.94	32.45
p-value	(0.00)	(0.00)
AR(1)	-3.77	-4.04
p-value	(0.00)	(0.00)
AR(2)	1.04	0.99
p-value	(0.30)	(0.324)
Hansen J-test	119.70	65.05
p-value	(0.125)	(0.475)

[16] We use the correction suggested by Windmeijer's (2005) for the possibility that the estimated asymptotic standard errors of the efficient two-step GMM estimator are downward biased. See also notes to the table.

Time dummies	Yes	Yes
Country dummies	Yes	Yes
No. Observations	1,724	1,724

*, **, ***, denote significance from zero at 10%, 5%, 1% level respectively.
Notes: NIM is the net interest rate margin, HHI is the Herfindahl-Hirschman Index, MS is the market share in terms of assets, LOAA is a measure of liquidity risk, CAP is a measure of the degree of capitalization, LLR is a measure of default risk, ESX is a measure of managerial efficiency, ESS is a measure of scale efficiency, XRATE is the average annual exchange rate, CPI is a measure of annual inflation, GDP is the average GDP real growth, INT is the average annual market interest rate and H-stat is a measure of competition.
[a] Arellano-Bond order 1 (2) are tests for first (second) order correlation, asymptotically N(0,1). These test the first-differenced residuals in the system GMM estimation.The Hansen test is a test of overidentification restrictions. Under the null hypothesis, the test statistic is distributed as a chi-squared in the number of overidentifying restrictions. System GMM are two-step estimates. The two-step errors are computed in accordance to the Windmeijer (2005) finite-sample correction.

The bank-specific variables LLR and LOAA are positive and significant as expected. There is also evidence of a positive relationship between CAP and NIM for the region. The role of macroeconomic variables appears less ambiguous and more informative with the coefficient of the exchange rate rate being positive and statistically significant with NIMs. The degree of inflation is positively related to greater margins. Moreover, the annual market interest rate and GDP growth display negative relationships with NIMs.

Turning to the competition and (X- and scale) efficiency variables, in Model I the degree of competition exhibits a strong negative relationship with NIM. The magnitude of the coefficient is quite high and the results of Model II corroborate this finding as H*ESX shows a strong negative relationship with interest rate margins. Nevertheless, ESS does not appear to be statistically significant. The relatively low importance of the scale efficiency effects as compared to X-efficiencies is often encountered in the literature (see e.g. Berger et al., 1993; Jeon and Miller, 2005) and is typically attributed to the fact that banks appear more effective in reducing costs by emulating best practice rather than growing.

The negative relationship between H-stat and ESX with NIM is consistent with the hypothesis that increasing banking X-efficiency in a competitive market environment can reduce interest rate

margins. Gelos (2006) also suggests that less efficient banks are related to greater interest margins. He alludes to the possibility that this link between inefficiency and greater margins can reflect weak competition. Thus, increased efficiency in the banking sector could be a direct effect of increased banking competition. It follows that fostering competition in the banking sector alongside with increasing cost efficiency can be strongly linked to declining interest rate margins. Establishing a robust negative relationship between banking competition and margins is a key finding that could be taken into consideration in the design of policies aiming to tackle the long-lasting problem of exceptionally high bank spreads in many Latin American countries.

5. Conclusions

The financial liberalization process in Latin America brought about changes in the structure of the banking sector and triggered the elimination of various restrictions including foreign capital entry barriers, interest rate ceilings and floors, and credit rationing. Despite this wave of changes the interest rate spreads (or NIMs), remain excessively and persistently high. As a consequence credit availability to the private sector remains limited. Moreover, the recent global financial crisis and the subsequent liquidity shortage may further exacerbate this situation.

A number of studies have examined the determinants of interest rate margins and this paper further contributes to the literature by focusing on the role of competition and non-parametric X- and scale efficiency in explaining interest rate margins in Latin America. We develop an extension of the traditional Structure-Conduct-Performance framework and we produce panel regression model estimates using a GMM framework and focusing on a sample of over 2,300 banks over 1999-2006. In order to obtain the efficiency and the (non-structural) competition measures we use Data Envelopment Analysis (DEA) and the Panzar and Rosse (1987) H-statistics respectively. We also control for the bank-specific and macroeconomic variables typically used in the NIMs literature.

Our results show that the concentration index and the market share have little or no influence on interest rate margins. On the contrary, we uncover evidence suggesting that greater X-efficiency and competitive market structures are important determinants in lowering spreads. Moreover, we find that the degree of capitalization increases spreads, while economic growth contributes to their reduction. The main implications of our results are that policies aiming to contain banks' interest rate margins should encouraging greater competition and incentivize banks to enhance their operational efficiency. Growth enhancing macroeconomic policies can further complement the effects of such policies.

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Appendix 1

Table A1

Selected studies on the determinants of interest rate spreads in Latin America

Authors	*Data*	*Methodology*	*Main Findings*	*Countries*
Ahumada et al. (1998)	1993-1996	Panel Data	High lending rates are explained mainly by high costs.	Argentina
Steiner et al. (1998)	1992-1996	Panel Data	Non-performing loans, non-financial expenses, and market power explain the spreads.	Colombia
Rojas (1998)	1991-1996	Panel Data and Time Series	Country risk, credit risk, exchange rate risk, bank concentration and non-interest expenses increase spreads.	Peru
Brock and Rojas-Suarez (2000)	1991-1996	Panel Data	High operational costs, non-performing loans, reserve requirements, and macroeconomic volatility increase spreads.	Argentina, Bolivia, Colombia, Chile, Mexico and Peru.
Afanassieff et al. (2001)	1997-2000	Two Stage Panel Data	Banks spreads are determined by macroeconomic variables.	Brazil
Brock and Franken (2003)	1994-2001	Panel Data	Macroeconomic volatility, bank size and concentration increase spreads; management efficiency and capital ratios decrease spreads.	Chile
Martinez Peria and Mody (2004)	1995-2001	Panel Data	Concentration and high costs increase spreads; foreign entry and banking competition reduce spreads.	Argentina, Chile, Peru, Colombia and Mexico.
Gelos (2006)	1999-2002	Panel Data	Less efficient banks, less competition, high market interest rates and high reserve requirements increase spreads.	14 Latin American countries

Table A2

DEA X- and scale efficiency scores for Latin American banks (1999 - 2006)

	Countries	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
	Argentina	34.03	51.97	48.26	48.65	58.36	65.23	75.96	85.20
	Brazil	50.07	50.36	41.58	26.74	35.09	48.35	58.39	56.89
ESX	Chile	87.00	87.91	86.50	85.25	79.58	70.83	85.21	77.60
(%)	Colombia	76.40	67.77	80.73	84.04	65.13	66.83	63.67	88.21
	Costa Rica	79.00	87.17	81.65	77.90	72.22	77.81	79.71	83.62
	Paraguay	72.86	61.05	72.16	62.29	67.23	71.62	76.08	76.92
	Peru	82.56	86.25	91.38	90.50	90.36	90.27	90.78	83.83
	Uruguay	61.23	67.00	44.70	35.38	58.74	40.93	63.24	73.11
	Venezuela	48.56	46.60	66.44	50.48	59.69	67.94	84.20	84.44
	Argentina	70.82	83.02	80.91	64.58	60.40	87.77	83.61	79.20
	Brazil	34.79	44.05	51.11	39.42	71.66	72.95	81.76	76.85
ESS	Chile	88.55	64.00	84.92	87.71	93.17	49.17	92.29	81.30
(%)	Colombia	67.50	90.14	89.23	92.57	84.83	80.48	79.94	95.79
	Costa Rica	85.53	87.33	72.70	77.20	83.17	90.44	86.76	86.08
	Paraguay	90.48	87.90	93.95	78.71	79.15	90.46	87.85	87.46
	Peru	84.44	95.00	89.62	89.67	93.82	65.55	91.00	94.08
	Uruguay	81.00	61.58	54.76	55.12	35.44	45.19	53.29	88.06
	Venezuela	67.22	60.28	67.11	61.39	85.00	68.36	69.80	62.64

Note: ESX = estimated DEA managerial efficiency scores; ESS = estimated DEA scale efficiency scores.

Appendix 2

The Panzar and Rosse H-statistic

The Panzar and Rosse (1987) H-statistic is derived from the equilibrium output and equilibrium number of banks when they maximize their profits as follows:

$$R_i^{'}(x_i, n, z_i) - C_i^{'}(x_i, w_i, t_i) = 0 \tag{A1}$$

where $R_i^{'}$ refers to marginal revenue, $C_i^{'}$ is the marginal cost of each firm, x_i is the output of each firm, n is the number of banks, w_i contains several input price factors for each firm, z_i is a set of exogenous variables which influence the bank's revenue function. Accordingly, in equilibrium, the marginal profit and the marginal costs equal zero:

$$R_i^{*}(x^{*}, n, z) - C_i^{*}(x^{*}, w, t) = 0 \tag{A2}$$

where the * represents values in equilibrium. The measure of competition (H-statistic) results from summing the elasticities of the reduced-form revenue equation with respect to the change in input prices:

$$H = \sum_{k=1}^{m} \frac{\delta R_i^{*}}{\delta w_{ki}} \frac{w_{ki}}{R_i^{*}} \tag{A3}$$

Under a monopoly, an increase in input prices increases marginal costs reducing equilibrium output and the bank revenues; in this case the H-statistic has a zero or negative value. Two cases emerge when the H-statistic is positive. First, Panzar and Rosse show that, under several assumptions, $0 \leq H \leq 1$ when there is monopolistic competition. Firms´ revenues will increase less proportionally to changes in factor prices as the demand for

banking products in inelastic. The case where $H = 1$, corresponds to perfect competition, where there is an increase in input prices and marginal costs without affecting the total output of the firms.

To compute the Panzar and Rosse H-statistic in this paper we run the following model (see e.g. Bikker and Haaf, 2002 and Schaeck et al. 2009):

$$\ln(r_{i,t}) = \delta_{o,i} + \sum_{j=1}^{J} \delta_j \ln(w_{j,i,t}) + \theta' x_{i,t} + \eta_{i,t} \tag{A4}$$

Where $r_{i,t}$ = total revenue of bank i in year t; $w_{j,i,t}$ = price of factor input j; $x_{i,t}$ is a vector of exogenous control variables; and $\eta_{i,t}$ is a random disturbance term. The H-statistic is defined as $H = \sum_{j=1}^{J} \delta_j$, where $H < 0$ indicates monopoly since an increase in the costs of banks leads to an increase in the equilibrium price and thus a reduction in revenue.[17] Under monopolistic competition $0 \leq H \leq 1$ and an increase in input prices (costs) produces smaller increases in revenue. The value of H also measures the intensity of competition in the market. When $H = 1$, banks operate under perfect competition, with output maintained constant and increases in costs producing proportional price increases. The dependent variable in (A4) is the logarithm of the total revenue and the input prices are: a) the logarithm of the interest rate expense over the total deposits, b) the personnel expenses over the total assets and c) other operating expenses over the total assets. The control variables are: a) the logarithm of the total assets, b) the logarithm of equity over assets, and c) the logarithm of loans over assets. Thus, the extended model is:

$$\begin{aligned} \ln(r_{i,t}) = \delta_{o,j} &+ \ln(IE/TD)_{i,t} + \ln(PE/TA)_{i,t} + \ln(OE/TA)_{i,t} \\ &+ \ln(TA)_{i,t} + \ln(E/TA)_{i,t} + \ln(L/TA)_{i,t} + \eta_{i,t} \end{aligned} \tag{A5}$$

[17] Considering that the profit-maximizing bank operates on the price elastic segment of the market demand function. (see Goddard and Wilson, 2007)

where r is the total revenue, IE/TD is the interest rate expenses over total deposits, PE/TA is the personnel expenses over total assets, OE/TA are other operating expenses over fixed assets, TA are total assets, E/TA is total equity over total assets and L/TA are the total loans over total assets. The term $\eta_{i,t}$ is the stochastic disturbance term.