Centre for Global Finance
Working Paper Series (ISSN 2041-1596)
Paper Number: 06/11

Title:
Determinants of bank efficiency in Mexico: a two-stage analysis

Author(s):
J.G. Garza-Garcia

Centre for Global Finance
Bristol Business School
University of the West of England
Coldharbour Lane
Bristol BS16 1QY

Telephone: 0117 32 83906
Email: cgf@uwe.ac.uk
Website: http://www.uwe.ac.uk/bbs/research/cgf/

Determinants of bank efficiency in Mexico: a two-stage analysis

Jesus G. Garza-Garcia[b]
Ministry of Finance (Mexico)
jesus_garza@hacienda.gob.mx

Abstract

Mexico experienced a process of financial liberalization during the 1990s that was expected to generate a more competitive and efficient banking sector. However, high interest rate margins and increased market concentration may suggest greater inefficiencies in the banking industry. This paper analyses the developments and main determinants of bank efficiency in the Mexican banking industry during 2001-2009. The Data Envelopment Analysis (DEA) methodology is applied to obtain efficiency estimates and then a Tobit model is run to find its main determinants. The first result indicates that the Mexican banking sector experienced average inefficiencies for the period of study of 15%, 29% and 14% for Technical Efficiency (TE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE) respectively. In particular, an increase in bank efficiency is observed from 2001 to 2006, however, a decline in the efficiency levels is found from 2006 to 2008, although a recovery in efficiency is observed from 2008 onwards. Furthermore, the main determinants of increased bank efficiency are loan intensity, GDP growth and foreign ownership; on the other hand, non-interest expenses, non-performing loans and the inflation rate reduce bank efficiency.

Keywords: Data Envelopment Analysis, Tobit regression, Mexican banking sector, Bank efficiency
JEL Codes: G21, G28.

[b] *Director of Financial Planning and Head of the Office of Investor Relations, Economic Planning Unit, Ministry of Finance, Plaza Inn, Insurgentes Sur # 1971, Torre III, Piso 10, Col. Guadalupe Inn, Del. Alvaro Obregon, CP. 01020, Mexico City. Phone: + 52 (55) 36882618, Email: jesus_garza@hacienda.gob.mx*
Centre for Global Finance at Bristol Business School (UWE). Email: Jesus.Garzagarcia@uwe.ac.uk.

I. Introduction

The Mexican banking sector experienced a process of financial liberalization during the 1990s aimed at generating a more efficient and competitive banking sector (Hernandez-Murillo, 2007). The aftermath of the process of financial liberalization in Mexico immediately resulted in a deep crisis as a result of rapid credit growth and increased levels of non-performing loans alongside lacking the adequate financial regulatory and supervisory framework. As a result, and in order to recapitalize the banking sector, foreign banks were allowed in the banking sector alongside stringent regulatory policies.[1] Many studies have suggested that the banking system has recently become more efficient and more competitive, due in part to the entrance of foreign banks (Pineda Ortega, 2009).[2]

Avalos and Hernandez-Trillo (2006) find that net interest rate margins decreased soon after financial liberalization, although they are still high compared to international standards. However, they conclude that the Mexican banking sector has not benefited fully from a more efficient financial intermediation. Murillo (2002) finds that after the privatization of the banking sector in Mexico, the degree of competition increased and that the banking sector experienced a reduction in administrative costs.[3] Guerrero and Negrin (2006) have found that the inefficiency levels in the Mexican banking sector increased for the period 1997-2001, but have decreased afterwards fostered by a new institutional and regulatory framework and a greater participation of foreign institutions. It is

[1] From controlling 17% of bank assets in 1997, foreign banks increased their market share to more than 80% by the year 2006 (Haber and Musacchio, 2004; Hernandez-Murillo, 2007).
[2] Pineda Ortega (2009) argues that from 2001-2006 the number of financial products offered from commercial banks increased in 46% (from 132 to 192).
[3] Soon after the 1995 financial crisis, there was an observable reduction in the number of employees per branch in a need to cut costs and also in an aim to expand building more branches.

important therefore to analyse the developments of bank efficiency in Mexico and its main determinants.

This paper has twofold aims; first, it investigates the evolution of cost efficiency in the Mexican banking sector by estimating three efficiency estimators, namely Technical Efficiency (*TE*), Pure Technical Efficiency (*PTE*) and Scale Efficiency (*SE*), and then attempts to find its main determinants. In order to do so, the Data Envelopment Analysis (DEA) non-parametric methodology is used to generate cost-efficiency scores and then a Tobit regression is applied to find the determinants of the cost-efficiency scores. The paper is divided into six sections. Section 2 describes the background of the Mexican banking sector, Section 3 presents the literature review on banking efficiency, Section 4 shows the data and methodology used, Section 5 presents the main results of the study and finally Section 6 is the conclusion.

II. Background

The Mexican banking sector experienced a process of financial liberalization during the 1990s which was focused on generating a more competitive and efficient banking sector. Moreover, one of its main aims was to increase the level of credit to the private sector in the economy which was low by international standards.[4] After a short period of increased credit (1990-1994), it is now at very low levels if compared with other emerging economies.

[4] Credit to the private sector grew rapidly from 1990 to 1995, however the financial system lacked of sound regulatory and supervisory institutions, which created large amounts of non-performing loans, an important factor leading to the *tequila crisis* (Hernandez-Murillo, 2007).

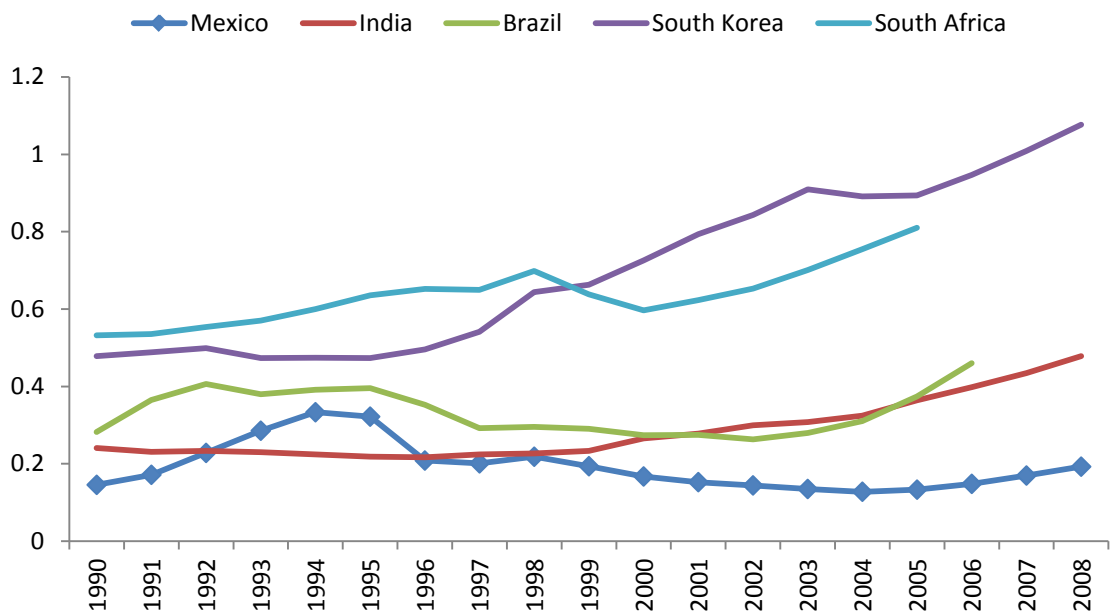

Fig. 1. Credit to the Private Sector (% of Gross Domestic Product, GDP)
Source: Beck and Demirguc-Kunt (2009)

However, there have been gradual improvements in the degree of banking competition and efficiency in the banking sector. Murillo (2002) argues that the privatization of the banking sector has increased the degree of competition in the sector. He points out that the market share of all banks has decreased over time (from financial liberalization until 2002) and those banks have reduced their costs substantially. Most studies suggest that increased foreign entry in the banking sector has a positive effect on the efficiency of banking systems increasing the degree of contestability in the industry. At the same time many studies conclude that foreign entry reduces administrative costs and lowers net interest rate margins (Hernandez-Murillo, 2007). However, the net interest rate margin (NIM) has increased for the period of study in the Mexican banking sector, see Fig. 2. Claeys and Vander Vennet (2008) argue that high levels of NIM are normally associated with high inefficiencies.

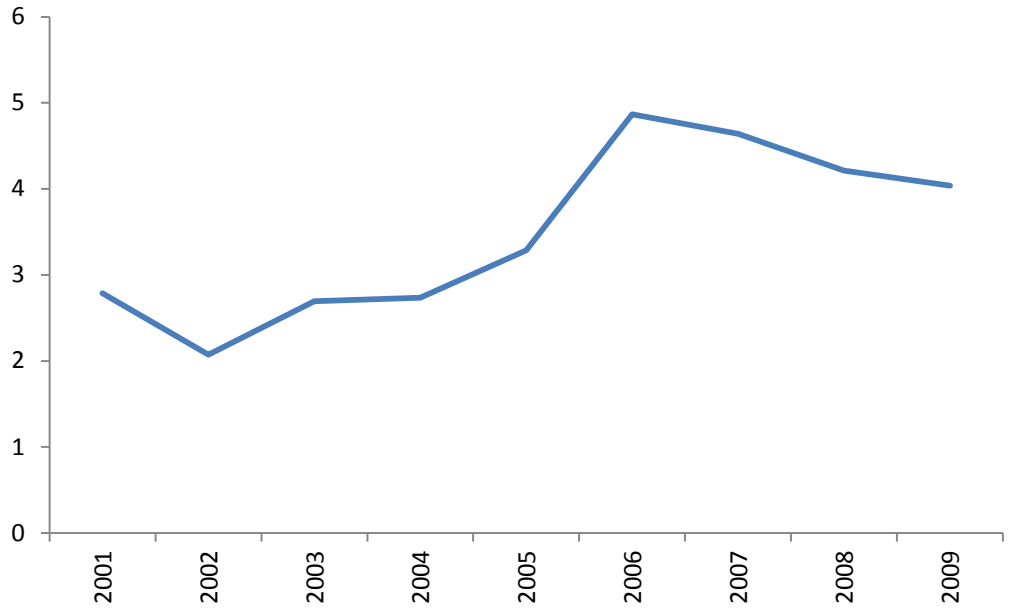

Fig. 2. Net Interest Margin, 2001-2009, (%)
Source: CNBV (banking supervisor in Mexico).
Notes: The net interest rate margin is defined as interest rate income minus interest rate expenses divided by total earning assets.

On the other hand, Fig. 3 shows the trend of the degree of concentration, measured as the Herfindahl-Hirschman index (HHI), of the banking sector in Mexico. There is significant increase in the HHI suggesting that the banking sector has become more consolidated; in particular a significant rise is observed from 2001 to 2003, although a reduction in HHI is observed from 2007 to 2009.[5] However, the degree of concentration is still higher than at the beginning of the decade. According to Berger and Hannan (1998) high concentration is normally associated with lower deposit rates and higher loan rates, which could be a reflection of greater inefficiencies. Moreover, financial institutions with more market power may experience greater cost inefficiencies as managers pursue other goals rather than efficiency maximization, "quiet life hypothesis" (Berger and Humphrey, 1997).

[5] Recently, new small banks have entered the market, particularly from 2006 to 2009, however the level of market concentration is still high.

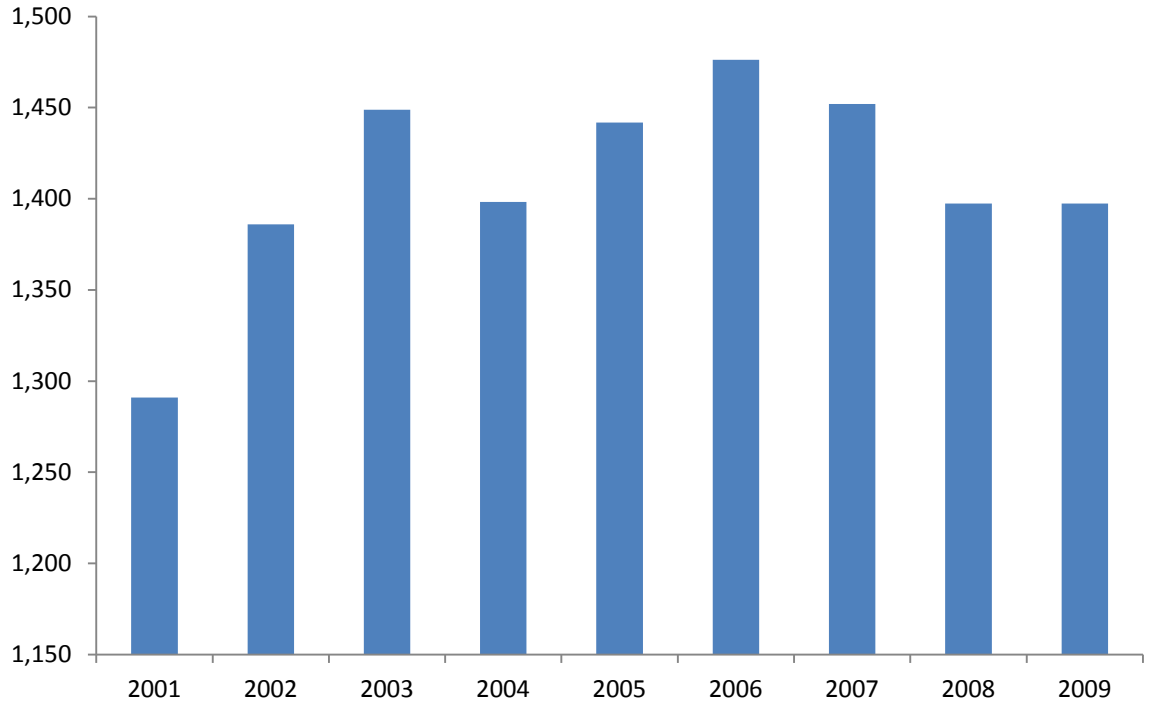

Fig. 3. Herfindahl Hirschman Index (HHI), 2001-2009
Source: Elaborated by author with data from CNBV (banking supervisor in Mexico).
Notes: The Herfindahl Hirschman index is the sum of the squared market share in terms of assets of each bank.

Fig. 4 shows the trend in non-performing loans with regards to total loans in the Mexican banking sector for the period of study. The trend shows a reduction in this ratio from 2001 to 2006 and then a gradual increase afterwards. Some authors argue that increased levels of non-performing loans reflect the quality of the portfolio of a bank and thus a deterioration of such portfolio represents reduced bank efficiency (Kwan and Eisenbeis, 1995; Resti, 1997; Barr et al., 2002; Hassan and Sanchez, 2007). An initial drop in this ratio, from 2001 to 2006, would suggest increased bank efficiency; however, the recent rise is indicative of asset quality deterioration.

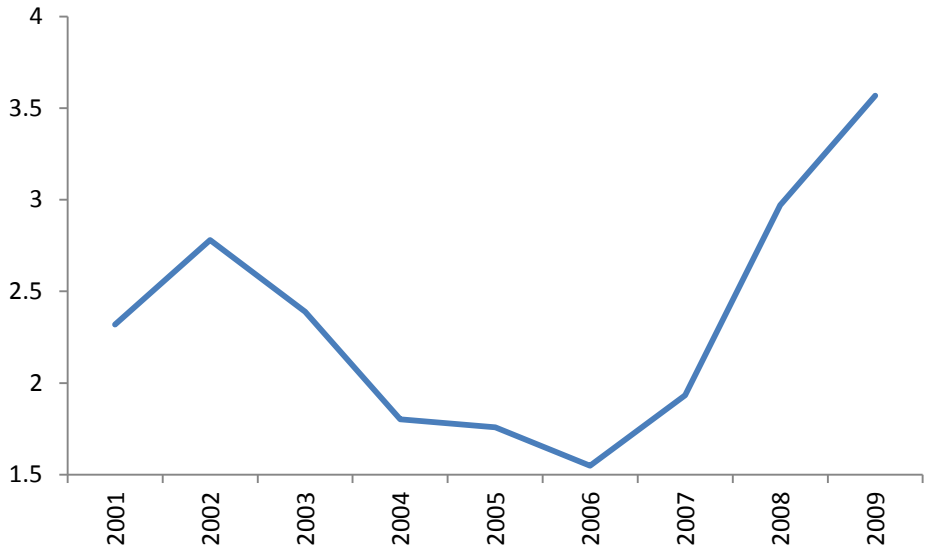

Fig. 4. Non-performing loans to total loans, 2001-2009
Source: CNBV (banking supervisor in Mexico).

Finally, as mentioned by Haber and Musacchio (2004) and Hernandez-Murillo (2007), there has been a dramatic increase in foreign bank participation in the Mexican banking industry. Foreign banks have increased their market share from 17% in terms of assets in 1997 to more than 80% by 2006. This trend has been fueled an increased activity in M&As.[6] Delis and Papanikolaou (2009) argue that foreign ownership has a positive impact on bank efficiency due to increases in the capital brought by the new banks, the expertise brought in risk management and better corporate governance, and increases in the level of competition.

[6] The most important M&As during the last decade have been: Citigroup acquiring CONFIA and Banamex, BBVA acquiring Bancomer, Santander acquiring Grupo Financiero SERFIN, Scotiabank acquiring INVERLAT, and HSBC acquiring BITAL.

III. Literature Review

There are several studies which have analysed efficiency in banking, particularly using parametric or non-parametric methods to do so. However, only a few studies have analysed the determinants of bank efficiency.

Grigorian and Manole (2002) study the determinants of bank performance in transition economies. They estimate the efficiency scores by applying the Data Envelopment Analysis (DEA) methodology and then run a Tobit censored regression in order to obtain the determinants of bank efficiency. Their main results suggest that foreign ownership and consolidation enhance commercial bank efficiency. They also find that well capitalized banks, greater market share, and GDP per capita are positive determinants of bank efficiency. Finally, they find evidence suggesting that the securities market and nonbank financial institutions hinder bank efficiency. Casu and Molyneux (2003) apply the DEA approach in order to investigate whether the productive efficiency of European banking systems has improved and converged to a common frontier for the period 1993-1997. They also employ a Tobit regression to indentify the main determinants of European bank efficiency. Their main results indicate that profitability ratios are positively related to bank efficiency as well as public listed banks; at the same time they do not find any relationship between the degree of capitalization and bank efficiency. Pasiouras *et al*. (2007) analyse the cost efficiency of Greek banks and its determinants. They apply a DEA approach to estimate technical, allocative and cost efficiency. Moreover, they use a Tobit regression to find the internal and external factors influencing the level of bank efficiency. The main results indicate that Greek banks operate at an average

efficiency of 82%. Furthermore, they find that the size of the bank is positively associated with greater bank efficiency; however, they find that GDP per capita and unemployment influences bank efficiency negatively. Finally, they argue that the degree of capitalization, the number of branches and quantity of ATMs influence bank efficiency differently depending on the measure of efficiency used. Hassan and Sanchez (2007) study the determinants of efficiency and its dynamics on the banking industry in Latin America. Their results indicate that the degree of capitalization, profitability ratios, the interest rate spread and GDP growth are positively related to greater bank efficiency. On the other hand, loan loss reserves, the value of stock traded, and the inflation rate have an inverse relationship with bank efficiency. Delis and Papanikolaou (2009) study the determinants of bank efficiency in ten newly acceded European countries. They apply a semi-parametric two-stage model to examine the effects of bank-specific, industry specific and macroeconomic variables on bank efficiency. The main results indicate that foreign ownership, market interest rates and GDP growth are positively related to bank efficiency. On the other hand, credit risk and the concentration of the industry presents a negative relationship with bank efficiency. Naceur *et al*. (2009) evaluate the level of bank efficiency in MENA countries using a Meta frontier calculated by DEA. Afterwards, they apply a Tobit regression to investigate the impact of institutional, financial and bank-specific determinants of bank efficiency. They find that on average, MENA countries show an efficiency score of 67%. On the other hand they find that highly capitalized banks, greater liquidity, and stock market developments increase bank efficiency; whilst greater credit to the private sector and higher market concentration lowers bank efficiency. Daley and Mathews (2009) use the DEA

methodology to estimate technical efficiency scores among a group of Jamaican banks for the period 1998-2007. They estimate conditional convergence using panel data estimation techniques and find that cost over income and the size of the bank are inversely related to bank efficiency; whereas GDP growth is positive with regards to bank efficiency. Kalluru and Bhat (2009) examine the determinants of cost efficiency of commercial banks in India for the period 1992-2006. In order to calculate the efficiency scores, they apply the parametric Stochastic Frontier Approach (SFA) and then obtain the determinants of the efficiency scores by applying a Tobit regression. The first set of results indicates that cost efficiency in commercial banks in India has decreased for the period of study. They also find that the earning capacity of banks is the main positive determinant of bank efficiency followed by diversification and other non-interest activities.

Tecles and Tabak (2010) study the determinants of bank efficiency in Brazil for the period 2000-2007. They apply a Bayesian Stochastic Frontier in order to obtain the determinants of bank efficiency. The main results suggest that large banks are the most cost and profit efficient alongside foreign owned banks. Furthermore, they find a positive relationship between the degree of capitalization and bank efficiency. Wezel (2010) investigates the efficiency of domestic and foreign banks in Central America for the period 2002-2007. He applies the DEA and SFA methodologies in order to obtain the efficiency estimates. His main findings suggest that foreign banks are not necessarily more efficient than domestic banks and that large banks are consistently more efficient than smaller banks.

With regards to specific studies related to the efficiency of the banking sector in Mexico there are only a handful of studies. Rodriguez-Montemayor (2003) tests two hypotheses, Structure-Conduct-Performance and the Efficient-Structure-Hypotheses, in order to find the determinants of profitability of the Mexican banking sector. He finds that both hypotheses cannot be disregarded, so regulatory entities should only limit mergers and acquisitions when efficiency gains are low and market entry does not ensure more competition. As a measure of efficiency, Rodriguez-Montemayor (2003) uses the inverse of the cost over income variable. Guerrero and Negrin (2006) analyse the efficiency of the Mexican banking sector for the period 1997-2004. They apply a translogarithmic cost and profit functions to generate an efficient frontier. Both static and dynamic models were estimated and the overall results indicate that the average inefficiency of the banking system is around 15% to 19%. In terms of efficiency evolution, the efficiency indicators have decreased from 1997 to 2001 but have increased afterwards. Solis and Maudos (2008) study the social costs of market power and the "quiet life" hypothesis in the Mexican banking sector for the period 1993-2005.[7] They find that the social cost attributable to market power in around 0.15% of GDP; whilst the cost inefficiency of bank management is around 0.075% of GDP. The authors use the DEA methodology to estimate the X-efficiency scores. Guerrero and Villalpando (2009) test the Market Power and Efficient-Structure hypotheses and their validity in the Mexican banking sector for the period 1997-2005. In order to estimate the efficiency scores they apply the Distribution Free Approach (DFA) and obtain measures of X-efficiency and two measures of scale efficiency. They conclude that profitability in the Mexican banking sector is dependent on the

[7] The "quiet life" hypothesis indicates a negative relationship between market power and technical efficiency (Solis and Maudos, 2008)

degree of market share and not on the efficiency levels. As seen above, there are scant studies related to the efficiency of the banking sector in Mexico, and to the best of my knowledge there are no studies researching the determinants of bank efficiency in the Mexican banking sector.

IV. Data and Methodology

Data

The data in this study was obtained from the *Comision Nacional Bancaria y de Valores* (CNBV) - the supervisor of Mexican banks and financial intermediaries. An unbalanced panel of more 2 332 observations is used. The data comprises monthly information for the period of December 2001 to December 2009. The macroeconomic data was obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Table 1 presents the description of the variables used in this study.

Table 1. Description of variables

Variable	**Description**
EQTA	Degree of capitalization: total capital over total assets.
NIM	Net interest rate margin: interest rate income minus interest rate expenses over total earning assets.
ROA	Profitability ratio: net income over total assets.
NIE	Non-interest expenses over total assets.
NII	Non-interest income over total assets.
NPL	Credit risk: non-performing loans over total loans.
MS	Market share in terms of assets.
SIZE	Measure of bank size: logarithm of total assets.
LOATA	Measure of loan intensity: Loans over total assets.
GDP	Measure of economic growth: GDP annual growth.
MCAP	Measure of market capitalization: Annual market capitalization over GDP.
CONC	Market concentration: Herfindahl Hirschman index (the sum of the squared market share in terms of assets of each bank).
OWN	Dummy variable: 1 refers to foreign owned and 0 refers to domestic owned.

CPI	Inflation rate: yearly change of the consumer price index.
INT	Market interest rate volatility: the annual standard deviation of the monthly money market interest rates.

Table 2 shows the descriptive statistics of the variables used. The descriptive statistics show interesting insights on the trends that the economy has followed throughout the period of study. For example, the levels of GDP growth vary from -6.5% to 5%, showing how volatile the macroeconomic situation has been. Moreover, the *MCAP* variable shows the low levels of market capitalization in 2001 (3.3%) compared to the levels shown in 2009 (11%). It is also interesting to observe the high values of the *CPI* in 2001 (8.5%) compared to the ones observed in 2009 (4.2%), an indicative of sound macroeconomic policies.

Table 2. Descriptive Statistics

	Mean	**Std. Dev.**	**Min**	**Max**
EQTA	12.839	14.154	.325	98.518
NIM	3.606	6.059	-10.841	63.673
ROA	.101	6.873	-101.136	33.698
NIE	3.596	6.357	.0289	95.555
NII	1.514	2.547	-3.44	26.555
NPL	2.379	3.117	-.013	35.473
MS	3.638	6.25	.005	25.7
SIZE	14.948	.285	14.425	15.414
LOATA	37.082	21.146	0	95.095
GDP	1.353	3.408	-6.538	4.933
MCAP	7.426	2.645	3.354	11.273
CONC	1 387.384	72.03	985.308	1 489.999
OWN	.452	.498	0	1
CPI	6.137	1.489	4.276	8.546
INT	.751	.632	.144	4.136

Notes: Where *EQTA* is the degree of capitalization, *NIM* is the net interest rate margin, *ROA* is a measure of profitability, *NIE* are non-interest expenses to total assets, *NII* are non-interest income to total assets, *NPL* is a measure of credit risk, *MS* is a measure of market share, *SIZE* is the logarithm of assets, *LOATA* is a measure of lending intensity, *GDP* is a measure of GDP growth, *MCAP* is the degree of market capitalization in terms of GDP, *CONC* is the Herfindahl Hirschman index, *OWN* is the ownership variable, *CPI* is the inflation rate and *INT* is the volatility of market interest rates.

Methodology

The methodology in this paper follows a two-stage analysis following previous studies (Casu and Molyneux, 2003; Delis and Papanikolaou, 2009). The first stage includes the estimation of three measures of efficiency (Technical Efficiency, Pure Technical Efficiency and Scale Efficiency) by applying the non-parametric Data Envelopment Analysis (DEA) methodology.[8] Consequently, a Tobit regression in run using the efficiency estimates obtained as the dependent variables and including other control variables as explanatory variables of bank efficiency.[9]

Data Envelopment Analysis (DEA). The DEA methodology is a mathematical programming approach used to develop efficient frontiers, which are then used to generate relative efficiency measurements. In other words, DEA generates a specific efficiency score for a Decision Making Unit (DMU) relative to other DMUs and not as an absolute standard. Non-parametric approaches have the characteristic that they do not require a model specification in order to compute the best-practice frontier. The DEA methodology in this study follows an input-oriented (intermediation) approach since commercial banks are considered as acting as financial intermediaries following previous studies (e.g. Hasan and Morton, 2003; Ray, 2007; Berger *et al*., 2009), and the inefficiency levels are identified as a as a proportional reduction of inputs (Casu and Molyneux, 2003).

The DEA input oriented model was first proposed by Charnes *et al*. (1978) and assumed that the model followed constant returns to scale (CRS). However, CRS is appropriate only when all DMUs are operating at an optimal scale, and factors

[8] The statistical software R was used to estimate the DEA efficiency scores.
[9] The Tobit regression was run using STATA.

such as imperfect competition and constraints on finance may impede a DMU from operating at an optimum level (Casu and Molyneux, 2003). Banker *et al*. (1984) suggested the alternative variable returns to scale (VRS) model, which absorbs other factors explained above. The VRS linear program can be defined as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &st - y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &N1' = 1 \\ &\lambda \geq 0 \end{aligned} \qquad (1)$$

Where θ is a scalar which represents the efficiency score for the ith bank and will range from 0 to 1, λ is a vector of $N \times 1$ constants, *y* is the output vector for the *i-th* DMU, Y is the matrix of outputs of the other DMUs and the number of DMUs ranges from *i*=1…*n* ; *x* is a vector of input of the *i-th* DMU and X is the matrix of input of the other DMUs. When the convexity constraint λ =1 is omitted from (1) we obtain the CRS based efficiency scores. A firm which is efficient under CRS is considered to be Pure Technically Efficient (PTE), whereas a firm which is efficient under VRS is Technically Efficient (TE). On the other hand, a firm is Scale Efficient (SE) under SE = CRS / VRS, and when SE = 1 then the bank is efficient under both CRS and VRS, when SE < 1 the bank is not scale efficient. This paper computes the efficiency scores considering VRS, CRS and SE.

The selection of inputs and outputs was considered by analyzing previous studies (Sealey and Lindley, 1977; Beccalli *et al*., 2006; Chortareas *et al*., 2011). The study considers two inputs: the total costs (the sum of personnel expenses, administrative expenses and interest rate expenses) and total deposits, and two

outputs: total loans and other earning assets. Table 3 presents the descriptive statistics of the inputs and outputs selected.

Table 3. Input/output descriptive statistics

	Mean	Std. Dev.	Min	Max
Inputs				
Total Costs	5 223.691	10 277.26	3.397	76 237.48
Deposits	57 448.27	102 862.5	.0189	556 147.3
Outputs				
Loans	49 140.21	87 740.23	0	526 530.4
Other Earning Assets	52 093.58	96 881.81	0.022	572 355.9

Source: CNBV (banking supervisor in Mexico).
Notes: Data is in millions of pesos

Tobit regression. The Tobit regression is useful when the dependent variables are limited by a specific threshold, which is the case in this study. DEA efficiency measures obtained in the first step are then run as dependent variables with the restricted (0, 1) range. Estimation with OLS would lead to bias results for the efficiency parameter since it assumes normality and a homoskedastic distribution of the error term (Jackson and Fethi, 2000). The Tobit model used in this study follows the work of other studies (Stavarek, 2004):

$$y_0^* = \beta' x_0 + \varepsilon_0$$

$$y_0 = y_0^* \quad \text{if} \quad y_0^* \succ 0 \ \text{otherwise,} \qquad (2)$$

$$y_0 = 0 \ , \ \varepsilon_0 \approx N(0, \sigma^2)$$

Where x_0 and β are the vectors of explanatory variables and its coefficients respectively, and y_0 and y_0^* are the vectors of the observed DEA efficiency score and the vector of the latent variable. Afterwards, a likelihood function is

maximized in order to find the values for the coefficients and variance of the explanatory variables based on the observed values of the explanatory variables and the DEA scores:

$$L = \prod_{y_0=0} (1 - P_o) \prod_{y_0^* > 0} \frac{1}{(2\prod\sigma^2)^{\frac{1}{2}}} \times e^{-\left[1/(2\sigma^2)\right](y_o - \beta x_0)^2} \quad (3)$$

Where

$$P_0 = \int_{-\infty}^{\beta x_0 / \sigma} \frac{1}{(2\prod)^{\frac{1}{2}}} \times e^{-t^2/2} dt \quad (4)$$

The extended equation, Equation 5, used in this study including the DEA scores as the dependent variables is:

$$EFF_{it} = \alpha + \beta_1 EQTA_{it} + \beta_2 NIM_{it} + \beta_3 ROA_{it} + \beta_4 NIE_{it} + \beta_5 NII_{it} + \beta_6 NPL_{it} + \beta_7 MS_{it} + \beta_8 CONC_t + \beta_9 SIZE_{it} + \beta_{10} LOATA_{it} + \beta_{11} GDP_t + \beta_{12} MCAP_t + \beta_{13} OWN_i + \beta_{14} CPI_t + \beta_{15} INT_i + \varepsilon_{it} \quad (5)$$

$i = 1...18;\ t = 1...n$

Where EFF_{it} is the efficiency score (either TE, PTE or SE), $EQTA_{it}$ is the degree of capitalization, NIM_{it} is the net interest rate margin, ROA_{it} is the return on assets, NIE_{it} are non-interest expenses over total assets, NII_{it} are the non-interest income over total assets, NPL_{it} is a measure of credit risk, MS_{it} is the market share in terms of assets, $CONC_t$ is the degree of concentration in terms of assets, $SIZE_{it}$ is the logarithm of total assets, $LOATA_{it}$ are total loans over total assets, GDP_t is the annual economic growth, $MCAP_t$ is the annual stock market capitalization in terms of GDP, OWN_i is a dummy variable reflecting 1 if the bank is foreign owned and 0 if it is not, CPI_t is the annual change in the consumer

price index, and INT_t is the annual standard deviation of the money market interest rate.

Naceur *et al*. (2009) state that *EQTA* reflects the capital strength of banks and high levels of equity may mitigate the risk of insolvency and the cost of borrowed funds, thus suggesting a positive relationship with bank efficiency. According to Isik and Hassan (2003) well capitalized banks are more technically efficient, thus the expected sign of *EQTA* with bank efficiency is positive. With regards to *NIM*, Demirguc-Kunt and Huizinga (1999) suggest that wider margins imply lower banking competition which reflects a degree of lower bank efficiency. The expected sign between *NIM* and bank efficiency is negative. The expected sign between *ROA* and *EFF* is positive since more efficient banks generate higher returns (Mester, 1996; Pastor *et al*., 1997; Carbo *et al*., 1999; Casu and Molyneux, 2003). The variable *NIE* proxies operating expenses across the banking sectors; the literature has found that reduced operating expenses increase the efficiency of the financial institutions (Bourke, 1989), thus a negative sign is expected. On the other hand the *NII* variable captures the effect of diversification of the bank´s activities and there is no a priori expected sign. The variable *NPL* captures the level of credit risk and the expected relationship with *EFF* is negative since more efficient banks have a better quality portfolio (Kwan and Eisenbeis, 1995; Resti, 1997; Bar *et al*., 2002). However, the empirical literature finds mixed evidence, Altunbas *et al*. (2000) suggests that efficiency is not very sensitive to credit risk whilst Hughes and Mester (1993) and Delis and Papanikolaou (2009) find an inverse relationship between credit risk and bank efficiency. With regard to market share, the Efficient-Structure paradigm suggests that relative efficient banks compete more aggressively for greater market share which leads to a more

concentrated market (Demsetz, 1973). Moreover, banks with greater market share tend to be more efficient due to economies of scale (Grigorian and Manole, 2002), thus the expect sign between *MS* and *EFF* is positive. With regards to the degree of market concentration, some authors believe there is a negative relationship between *CONC* and *EFF* since in highly concentrated markets risk aversion may prevail (Sathye, 2001). Moreover, Naceur *et al*. (2009) suggest that greater market concentration might reduce competition and thus efficiency. However, if economies of scale drive bank M&As, then increased concentration may lead to efficiency improvements (Demirguc-Kunt and Levine, 2000; Casu and Girardone, 2009). Therefore there is no expected sign between *CONC* and *EFF*. With regards to *SIZE*, Hauner (2005) explains that larger banks could pay less for their inputs than their counterparts and that there could be increasing returns to scale through the allocation of fixed costs. Thus, the expected size between *SIZE* and *EFF* is positive. The *LOATA* variable reflects the lending intensity of the banking sector and a positive relationship with *EFF* is expected since loans are the main source of bank profits; however, the quality of the loans may deteriorate under some circumstances, for example during an economic recession, in which case a higher degree of loan intensity may be detrimental to bank efficiency.

Turning to the macroeconomic variables the expected sign between *GDP* and *EFF* is positive since the demand for financial services tends to grow as economies expand, boosting demand for financial services and improving the quality of loans. The variable *MCAP* has mixed interpretations depending on the resulting sign of the coefficient. A positive impact of *MCAP* on bank efficiency is expected if the banking sector and capital markets complement each other and a negative impact in the case these markets are competing (Naceur *et al*., 2009). With

regards to *CPI*, Boyd *et al*. (2001) find that high inflation reduces the amount of financing to the private sector. On the other hand, Khan *et al*. (2001) find that low inflation is harmful to the banking sector. Thus, a negative relationship with *EFF* is expected. The variable *INT* is expected to have a negative sign since greater volatility limits total credit (Hassan and Sanchez, 2007). Finally, a positive sign is expected between *OWN* and *EFF*. According to Tang *et al*. (2000), foreign ownership in banking brings capital which decreases the fiscal costs of a bank. Moreover, foreign banks bring expertise in risk management and a better culture of governance (Bonin *et al*., 2005). Foreign banks also increase competition which stimulates further cuts in costs in the banking sector improving the efficiency level (Claessens *et al*., 2001).

V. Results

The first set of results is the elaboration of the efficiency estimators obtained by applying the DEA methodology. Table 4 shows the three efficiency estimators obtained: Technical Efficiency (*TE*), Pure Technical Efficiency (*PTE*) and Scale Efficiency (*SE*).

Table 4. Efficiency estimators: TE, PTE and SCALE

	Technical Efficiency (*TE*)	Pure Technical Efficiency (*PTE*)	Scale Efficiency (*SE*)
2001*****	0.808	0.647	0.804
2002	0.845	0.70	0.83
2003	0.883	0.741	0.845
2004	0.865	0.707	0.82
2005	0.896	0.778	0.872
2006	0.852	0.783	0.924
2007	0.821	0.72	0.884
2008	0.768	0.659	0.893
2009	0.835	0.732	0.86
Mean	**0.841**	**0.719**	**0.859**

Notes: The efficiency estimators are the average efficiency scores for all banks for a given year.

*The average efficiency in 2001 only includes the month of December.

Overall the efficiency scores present and average of 84%, 72% and 86% for *TE*, *PTE* and *SE* respectively. These results are similar to the ones reported by Guerrero and Negrin (2006) who report inefficiencies in the system of around 15% to 19% for *TE* and *SE* respectively. The efficiency trend can be observed in Fig. 5.

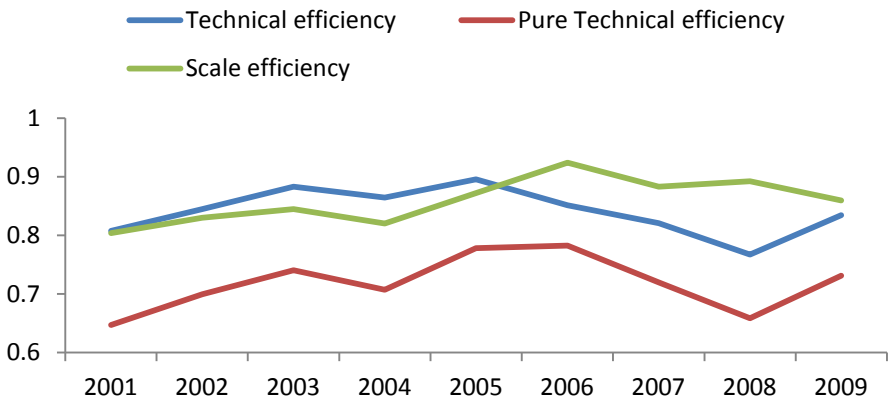

Fig. 5. Technical Efficiency, Pure Technical Efficiency and Scale Efficiency
Source: Elaborated with data from CNBV.
Notes: The efficiencies reported are the yearly averages of all bank monthly efficiency scores.

From Fig. 5 there is clear evidence of an increased period of bank efficiency from 2001 to 2005. Guerrero and Negrin (2006) report a decrease in bank efficiency from 1997 to 2001 but show an increase in efficiency afterwards. In particular they observed a constant increase in the efficiency estimators from 2001 to 2004, a period where the banking sector experienced increasing M&As. Fig. 5 shows that after 2006 there is a clear downward trend in the level of bank efficiency although there is a recent recovery in the efficiency trend from 2008 onwards.

The second stage of the study is to run a Tobit regression with bootstrap[10] standard errors in order to obtain the main determinants of bank efficiency. The

[10] The number of bootstrap iterations were 1,000.

three efficiency variables *TE*, *PTE* and *SE* are the dependent variables. Table 5 presents the main results of the Tobit regression.

Table 5. Tobit regression

	Technical Efficiency (*TE*)	Pure Technical Efficiency (*PTE*)	Scale Efficiency (*SE*)
EQTA	**.011*** **	.0002	**-.004*** **
NIM	-.006*	-.005	-.0003
ROA	-.001	.003	**.005*** **
NIE	**-.013*** **	**-.01***	-.004
NII	-.003	-.004	-.005
NPL	**-.016*** **	**-.009*** **	.003
MS	**.021*** **	**-.006*** **	**-.013*** **
CONC	.0001	**.0001***	.0001
SIZE	.026	.03	.022
LOATA	**.005*** **	**.006*** **	**.003*** **
GDP	**.004***	.0002	.0005
MCAP	**-.027*** **	-.007	**.008****
OWN	**.068*** **	**.067*** **	**.014***
CPI	**-.025*** **	**-.016*** **	-.001
INT	.013	-.003	-.012
CONST	.441	.115	.44
Pseudo R2	0.562	0.631	10.511
Wald test *p*-value	1 503.19 (0.00)	858.41 (0.00)	1 523.12 (0.00)
Log likelihood	-491.978	-233.372	467.405
Observations	2 310	2 310	2 310

Notes: *,**,*** represent significance at 10, 5, and 1% confidence intervals.

Where *EQTA* is the degree of capitalization, *NIM* is the net interest rate margin, *ROA* is a measure of profitability, *NIE* are non-interest expenses to total assets, *NII* are non-interest income to total assets, *NPL* is a measure of credit risk, *MS* is a measure of market share, *SIZE* is the logarithm of assets, *LOATA* is a measure of lending intensity, *GDP* is a measure of GDP growth, *MCAP* is the degree of market capitalization in terms of GDP, *CONC* is the Herfindahl Hirschman Index, *OWN* is the ownership variable, *CPI* is the inflation rate and *INT* is the volatility of market interest rates.

From Table 5, *EQTA* is positive and significant with regards to *TE* but negative and significant with regards to *SE*. Similarly other studies have found a positive relationship between the degree of capitalization and technical efficiency (Pasiouras *et al.*, 2007; Hassan and Sanchez, 2007; Naceur *et al.*, 2009). Moreover, Pasiouras *et al*. (2007) also finds no significance between the level of

capitalization and other measures of efficiency besides technical efficiency such as allocative and scale efficiency. Naceur *et al.* (2009) suggests that banks with sound capital face lower bankruptcy risks which reduce their funding costs. There is a positive relationship between *ROA* with *SE* suggesting that profitability plays an important part in determining greater scale efficiency. More profitable banks attract more deposits as well as more creditworthy customers. *NIE* is negative and significant with regards to *TE* and *PTE*; expenses other than interest rate expenses are the most controllable and an increase in them reduces overall efficiency levels. The same result can be found with *NPL*, which represents credit risk, suggesting that greater credit risk reduces the degree of bank efficiency. This result is consistent with other studies (Demir *et al*., 2005; Kalluru and Bhat, 2009; Delis and Papanikolaou, 2009) arguing that reduced efficiency in banks can be a result of large amounts of non-performing loans. With regards to *MS* there are mixed results: on the one hand *MS* is positive and significant with regards to *TE* but negative and significant with regards to *PTE* and *SE*. Grigorian and Manole (2002) find a positive relationship between technical efficiency and market share, finding that banks with greater market share are more efficient due to advantages of economies of scale. The variable *CONC* presents a positive and significant coefficient with regards to *PTE*; however the coefficient is very low. Casu and Girardone (2009) explain that higher concentration may lead to greater bank efficiency when economies of scale drive M&As. *LOATA* is positive and significant in every case, thus an increase in loans increases the efficiency of banks. Isik and Hassan (2003) argue that more efficient banks may have lower costs and consequently more and better quality loans. Finally, the results report no significance between *SIZE* and *EFF*.

Turning to the macroeconomic variables, there is a positive and significant relationship between *GDP* and *TE*, suggesting that an increase in the economic activity increases the demand for financial services, improving bank efficiency (Daley and Mathews, 2009; Delis and Papanikolaou, 2009). In terms of market capitalization, *MCAP*, there is mixed evidence, having a positive and significant relationship with *SE* and negative and significant relationship with *TE*. Naceur *et al.* (2009) finds a positive relationship between market capitalization and technical efficiency arguing that stock market developments are complementary to bank financing since stock markets ease access of banks to more financial resources. The variable *CPI* presents a negative and significant relationship with *TE* and *PTE*. Similarly, Hassan and Sanchez (2007) find a negative relationship between inflation and efficiency in a group of Latin American countries. Boyd *et al*. (2001) argue that high inflation reduces the financing resources to the private sector, affecting bank efficiency negatively. Finally, there is no relationship between *INT* and bank efficiency but there is a positive relationship between *OWN* and *TE* and *PTE*. Thus, foreign banks seem to have contributed to greater bank efficiency. It seems that foreign ownerships contributes the overall bank efficiency by increasing competition, by better governance and risk management, and by introducing greater amounts of capital in the sector (Delis and Papanikolaou, 2009).

VI. Conclusion

The Mexican banking sector experienced a process of financial liberalization during the 1990s aimed at generating a more efficient and competitive banking sector. On the other hand, these measures were thought would increase overall credit in the economy, which was (and still is) low compared to other emerging economies. Moreover, a more competitive and efficient banking sector was expected, reflected as lower net interest rate margins and the increase in financial products and services. After a sudden and rapid credit growth, the economy and financial sector collapsed, due to a lack of financial regulation and supervisory framework and excessive credit lending. Soon after, the presence of foreign market participants was permitted, which consolidated the banking sector. Many authors have argued that foreign bank presence alongside financial liberalization have contributed to creating a more efficient and a more competitive banking sector in Mexico. However, at the same time, the net interest margin has increased recently alongside high levels of non-performing loans and a more concentrated banking sector, which could reflect the inefficiencies of the banking sector in Mexico. Therefore the research question of determining and analyzing the efficiency developments in Mexico becomes relevant.

This paper analysed the developments of bank efficiency and its determinants for Mexican banks for the period 2001-2009. By employing the DEA methodology, three measures of efficiency were estimated, namely: Technical Efficiency (*TE*), Pure Technical Efficiency (*PTE*) and Scale Efficiency (*SE*). Afterwards, the determinants of these measures of efficiency were obtained by running a Tobit regression with bootstrapped standard errors. The main results indicate that the average bank inefficiencies for the period of study are 15%, 29% and 14% for *TE*,

PTE and *SE* respectively. Moreover, the developments of bank efficiency shows that the efficiency levels have increased for the period 2001-2006, then decreased sharply from 2006-2008, mainly due to the international financial crisis, and show a recovery from 2008 onwards. Finally, the main determinants of bank efficiency were obtained. The main variables increasing bank efficiency are loan intensity, GDP growth and foreign ownership. On the other hand non-interest expenses, non-performing loans and the inflation rate reduce the levels of bank efficiency.

References

Altunbas, Y., Liu, M., Molyneux, P. and Seth, R. (2000) Efficiency and risk in Japanese banking, *Journal of Banking and* Finance, **24**, 1605-28.

Avalos, M. and Hernandez-Trillo, F. (2006) Competencia bancaria en México, CEPAL Working Paper No. LC/MEX/L.722/Rev.1.

Banker, R. D., Charnes, A. and Cooper, W.W. (1984) Some models for estimating technical and scale inefficiencies in data envelopment analysis, *Management Science,* **30**, 1078-1092.

Barr, R.S., Killgo, K.A., Siems, T.F. and Zimmel, S.A. (2002) Evaluating the productive efficiency and performance of U.S. commercial banks, *Managerial Finance*, **28**, 3–25.

Beccalli, E., Casu, B. and Girardone, C. (2006) Efficiency and stock performance in European banking, *Journal of Business Finance and Accounting*, **33**, 245- 262.

Beck, T and Demirgüç-Kunt, A. (2009) Financial institutions and markets across countries and over time: data and analysis, World Bank Policy Research Working Paper No. 4943.

Berger, A. and Hannan, T. (1998) The efficiency cost of market power in the banking industry: a test of the "quiet life" and related hypotheses, *The Review of Economics and Statistics*, **80**, 454-465.

Berger, A. and Humphrey, D. (1997) Efficiency of financial institutions: international survey and directions for future research, *European Journal of Operational Research*, **98**, 175-202.

Berger, A., Hasan, I. and Zhou, M. (2009) Bank ownership and efficiency in China: what will happen in the world's largest nation?, *Journal of Banking and Finance*, **33**, 113-130.

Bonin, J.P., Hasan, I. and Wachtel, P. (2005) Bank performance, efficiency and ownership in transition countries, *Journal of Banking and Finance*, **29**, 31-53.

Bourke, P. (1989) Concentration and other determinants of bank profitability in Europe, North America and Australia, *Journal of Banking and Finance*, **13**, 65-79.

Boyd, J, Levine, R. and Smith, B. (2001) The impact of inflation on financial sector performance, *Journal of Monetary Economics*,**47**, 221-248.

Carbo, S., Gardener, E.P.M. and Williams, J. (1999) Efficiency and technical change in the European savings bank sector, paper presented at the Annual Seminar of the European Association of University Teachers of Banking and Finance (Lisbon, 2-3 September1999).

Casu, B. and Girardone, C. (2009) Testing the relationship between competition and efficiency in banking: a panel data analysis, *Economics Letters*, **105**, 134-137.

Casu, B. and Molyneux, P. (2003) A comparative study of efficiency in European banking, *Applied Economics*, **35**, 1865-1876.

Charnes, A., Cooper, W.W. and Rhodes, E. (1978) Measuring the efficiency of decision making units, *European Journal of Operational Research*, **2**, 429-444.

Chortareas, G., Garza-Garcia, J.G. and Girardone, C. (2011) Banking sector performance in Latin America: market power versus efficiency, *Review of Development Economics*, **15**, 307-325.

Claessens, S., Demirguc-Kunt, A. and Huizinga, H. (2001) How does foreign entry affect domestic banking markets?, *Journal of Banking and Finance*, **25**, 891-911.

Claeys, S. and Vander Vennet, R. (2008) Determinants of bank interest margins in Central and Eastern Europe: a comparison with the west, *Economic Systems*, **32**, 197-216.

Daley, J. and Matthews, K. (2009) Efficiency and convergence in the Jamaican banking sector: 1997-2007, Cardiff Economics Working Papers, E2009/30.

Delis, M. and Papanikolaou, N. (2009) Determinants of bank efficiency: evidence from a semi-parametric methodology, MPRA Working Paper No. 13893.

Demir, N., Mahmud, S.F. and Babuscu, S. (2005) The technical efficiency effects of Turkish banks after financial liberalization, *The Developing Economics*, **43**, 396-411.

Demirgüç-Kunt, A. and Huizinga, H. (1999) Determinants of commercial bank interest margins and profitability: some international evidence, *World Bank Economic Review*, **1**3, 379-408.

Demirguc-Kunt, A., and Levine, R. (2000) Bank concentration: cross-country evidence, World Bank Working Paper No. 272828.

Demsetz, H. (1973) Industry structure, market rivalry, and public policy, *Journal of Law and Economics*, **16**. 1-9.

Grigorian, D. and Manole, D. (2002) Determinants of commercial bank performance in transition: an application of data envelopment analysis, IMF Working Paper No. 02/146.

Guerrero, R. and Negrin, J. (2006) Eficiencia del sistema bancario mexicano 1997-2004: una estimación dinámica, *Monetaria*, **29**, 235-259.

Guerrero, R. and Villalpando, M. (2009) Rentabilidad, concentración, y eficiencia en el sistema bancario mexicano, *El Trimestre Económico*, **76**, 237-263.

Haber, S. and Musacchio, A. (2004) Foreign banks and the Mexican economy, 1997-2004, Stanford Centre for International Development, Working paper No. 228.

Hasan, I. and Marton, K. (2003) Development and efficiency of the banking sector in a transitional economy: Hungarian experience, *Journal of Banking and Finance*, **27**, 2249-2271.

Hassan, K. and Sanchez, B. (2007) Efficiency determinants and dynamic efficiency changes in Latin American banking industries, Networks Financial Institute, Working Paper No. 32, Indiana University.

Hauner D. (2005) Explaining efficiency differences among large German and Austrian banks, *Applied Economics*, **37**, 969-980.

Hernandez-Murillo, R. (2007) Experiments in financial liberalization: the Mexican banking sector, *Federal Reserve Bank of St. Louis Review*, **89**, 415-32.

Hughes, J.P. and Mester, L.J. (1993) A quality and risk adjusted cost-function for banks: evidence on the 'too-big-to-fail' doctrine, *Journal of Productivity Analysis*, **4**, 293-315.

Isik, I. and Hassan, M.K. (2003) Efficiency, ownership and market structure, corporate control and governance in the Turkish banking industry, *Journal of Business Finance and Accounting*, **30**, 1363–421.

Jackson, P.M. and Fethi, M.D. (200) Evaluating the Technical Efficiency of Turkish Commercial Banks: An Application of DEA and Tobit Analysis, In *Proceedings of the Annual Meeting of the European Public Choice Society*, European Public Choice Society, Siena, Italy.

Kalluru, S.R. and Bhat, S. (2009) Determinants of cost efficiency of commercial banks in India, *The IUP Journal of Bank Management*, **3**, 32-50.

Khan, M. Senhadji, A. and Smith, B. (2001) Inflation and financial depth, IMF Working Paper No. 44.

Kwan, S.H., and Eisenbeis, R. (1995) An analysis of inefficiencies in banking, *Journal of Banking and Finance*, **19**, 733–4.

Mester, L.J. (1996) A study of bank efficiency taking into account risk-preferences, *Journal of Banking and Finance*, **20**, 389 - 405.

Murillo, J.A. (2002) La banca en México: privatización, crisis, y reordenamiento, Unpublished Paper, Banco de Mexico.

Naceur, S., Ben-Khedhiri, H. and Casu, B. (2009) What drives efficiency of Selected MENA banks? a meta-frontier analysis, Working Paper Series No. 03, Cass Business School.

Pasiouras, F., Sifodaskalakis, E. and Zopounidis, C. (2007) Estimating and analysing the cost efficiency of Greek cooperative banks: an application of two-stage data envelopment analysis, University of Bath Working Paper No. 12.

Pastor J.T., Lozano, A. and Pastor, J.M. (1997) Efficiency of European banking systems: a correction by environmental variables, Economics Department Working Paper No. 97-12, Instituto Valenciano de Investigaciones Economicas, Valencia, Spain.

Pineda Ortega, P.A. (2009) La competencia bancaria en México: propuestas analíticas para su comprensión, *Revista de Administración, Finanzas y Economía*, **3**, 63-83.

Ray, S. (2007) Are some Indian banks too large? an examination of size efficiency in Indian banking, *Journal of Productivity Analysis*, **27**, 41-56.

Resti, A. (1997) Evaluating the cost efficiency of the Italian banking system: what can be learned from the joint application of parametric and non-parametric techniques, *Journal of Banking and Finance*, **21**, 221–50.

Rodriguez-Montemayor, E. (2003) Concentración industrial y rentabilidad de la banca en México. Evaluación posterior a la crisis de 1995, *El Trimestre Económico*, **70**, 371-404.

Sathye, M. (2001) X-efficiency in Australian banking: an empirical investigation, *Journal of Banking and Finance*, **25**, 613–30.

Sealey, C.W. and Lindley, J.T. (1977) Inputs, outputs, and theory of production cost at depository financial institutions, *Journal of Finance*, **32**, 1251-1266.

Solis, L. and Maudos, J. (2008) The social costs of bank market power: evidence from Mexico, *Journal of Comparative Economics*, **36**, 467-488.

Stavarek, D. (2004) Banking efficiency in Visegrad countries before joining the European Union, *European Review of Economics and Finance*, **3**, 129–167.

Tang, H., Zoli, E. and Klytchnikova, I. (2000) Banking crises in transition economies, fiscal costs and related issues, World Bank Policy Research Working Paper, No. 2484.

Tecles, P. and Tabak, B. (2010) Determinants of bank efficiency: the case of Brazil, Banco Central do Brasil Working Paper No. 210.

Wezel, T. (1995) Bank efficiency amid foreign entry: evidence from the Central American region, IMF Working Paper No. 10.