Number of ATMs, IT investments, Bank profitability and efficiency in Greece

ABSTRACT

This paper investigates the effect of Automated Teller Machines (ATMs), Information Technology (IT) investments and other determinants on the efficiency and profitability of Greek commercial banks. Following the two- step procedure, (i) efficiency is derived via the non-parametric Data Envelopment Analysis (DEA) technique under the Variable Returns to Scale (VRS) assumption, and (ii) efficiency scores are linked to a series of determinants of bank efficiency using a Tobit regression model. We find that profitability (ROAA and ROAE), ATMs and capitalisation show a negative impact on the efficiency of Greek banks. We also report that banks' size, capitalisation, IT investments and ATMs do not have any effect on the ROAA or the ROAE but they have a positive effect on the fees and commissions. However, we find that ATMs have a negative effect on the net interest income.

Keywords: Banking, ATM, IT investments, Efficiency, Profitability, Greece

1. Introduction

The Greek Banking system has undergone major reforms since the 1990s; it experienced the establishment of the single EU marker, the internationalisation of competition, as well as the deregulation and the liberisation of the interest rates. In addition, Greece had to adopt macroeconomic and structural policies after joining the Economic Monetary Union (EMU), which led to reductions in inflation and interest rates (Tsionas et al. 2003). Furthermore, several Greek banks were involved in mergers and acquisitions, which allowed them to have easier access to international money and capital markets (Pasiouras and Zopounidis 2008). Moreover, Greek banks have invested heavily in electronic distribution channels, such as ATMs, mobile and Internet banking, and this has lead to major improvements in the services they are offering to their customers as well as to their profitability. Customers are now able to perform various banking transactions quicker and easier after closing time, through the ATMs, the mobile, telephone and Internet banking. Banks are therefore able to reduce any excessive personnel and branching costs, by offering services at lower cost, and increase their profits through the Information Technology (IT) systems. A secure and profitable banking sector is better able to survive negative shocks and contribute to the stability of the financial system (Athanasoglou et al. 2008). Hence, the determinants of bank efficiency and profitability have attracted the interest of academic research, in addition to bank management, financial markets and bank supervisors.

The purpose of this paper is to extend earlier works by Holden and El-Bannany (2004), Pasiouras (2008), Kosmidou (2008) and Kondo (2008) on the determinants of bank efficiency and profitability. In particular, we examine to what extend the efficiency and profits of Greek commercial banks over the period 2004-2009 are influenced from factors such as the number of ATMs and IT investments. The Greek banking system has undergone major reforms since the 1990s (i.e. market liberalisation, mergers- acquisitions, the introduction of the Euro currency, deregulation of interest rates etc)[1].

We study the above period as it includes (i) the post-EMU period of Greece and (ii) the 2004 Athens Olympic Games period (where significant growth in the economy was observed as a result of heavy investments in constructions and communication technologies)[2]. Following the two step approach, where TE (TE) scores are obtained from the VRS input-oriented non-parametric DEA method, scores are linked to a series of bank efficiency determinants; this can be modelled with a Tobit regression model. Furthermore, we investigate whether the number of ATMs and IT expenses contribute to increasing the profitability of Greek banks in terms of the Return on Average Assets (ROAA), Return on Average Equity (ROAE), Net Fees and commissions, and Net Interest Income.

This paper is organised as follows: Section 2 reviews the literature of the DEA method and the determinants of bank efficiency and profitability and Section 3 describes the methodology and the data employed. In Section 4 the empirical findings are presented and interpreted, while the final section (Section 5) provides a summary of our study and conclusions.

2. Literature Review

2.1 Determinants of bank efficiency

Noulas (1997) studies the productivity growth for state and private Greek banks for years 1991 and 1992. The Malmquist productivity index is employed with three inputs which are physical capital, labour and deposits and three outputs, which are liquid assets, loans and advances and investments. This study uses the intermediation approach as banks are considered to be financial intermediaries, and it assumes Constant Returns to Scale (CRS), as this would allow a comparison between small and larger banks. Overall, the results show that state banks experienced technological progress, while there was no change for private banks. As far as TE is concerned, private banks' efficiency increased while the opposite happens for state banks.

Isik and Hassan (2002) investigate the efficiency of the Turkish banking sector over the years 1988-1996. This study employs the DEA intermediation method, by considering three inputs as labour, capital and loanable funds, and four outputs, short-term and long-term loans, off balance sheet items and other earning assets. The findings show a positive and significant correlation between ROA, ROE and efficiency in Turkey.

Berger (2003) examines the economic effects on technological progress of the U.S. banking industry. He argues that advances in IT appear to have increased productivity and economies of scale in processing electronic payments and thus costs were reduced significantly; in some cases more than 50% during the 1990s. The findings also report that bank cost productivity declined while profit productivity increased; this is attributed to the fact that technological progress resulted in improved quality and variety of banking services that increased the costs for banks. However, banks were able to cover the higher costs for new technologies and still make profits, since customers were willing to pay for these services as they offered convenience.

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[1] For recent studies on the structure of Banking sector in Europe, see Yiannaki (2007, 2011, 2013).

[2] During the period 2004-2009 there was a significant post-Olympic dynamic growth in Greece (see Floros 2010), while after 2009 the Greek Banking system was influenced by the international economic crisis (see National Bank of Greece 2009).We don't consider data after 2009 as the structure of the Greek Banking has been changed a lot due to several M&As.

Casu and Molyneux (2003) investigate whether there was improvement in the productive efficiency of European banks since the creation of the Single Internal Market. Following the intermediation approach and the DEA model, the outputs specified are total loans and other earning assets, while the two inputs specified are total costs and total deposits. Moreover, the determinants of European bank efficiency were assessed by employing the Tobit regression and the efficiency scores derived from the DEA model. The results show that ROAE and Equity over Total Assets have a positive and significant relationship with efficiency. However, country specific factors are also considered to be important determinants in explaining differences in bank efficiency levels across Europe.

Moreover, Casu and Girardone (2004) estimate TE and scale efficiency (SE) scores for Italian banking groups, by implementing a DEA input-oriented cost minimising model that assumes VRS. This study employs the intermediation approach with inputs being labour, deposits and capital and the two outputs, total loans and other earning assets. The efficiency score are then regressed on a number of determinants, where it is reported that ROAA has a negative relationship with the efficiency, while the equity to total assets ratio is positively related to efficiency, confirming that the higher the equity capital the more efficient Italian banking groups will be. However, it is reported that overall the Italian banking groups have not experienced a clear improvement in cost efficiency and productivity.

Also, the efficiency differences between large German and Austrian for the period 1995-1999 are explored by Hauner (2005). By employing the DEA method and the intermediation approach, the two inputs considered are, funds and labour, and the three outputs, are interbank loans, customer loans and fixed-income securities. In order to examine the cost-efficiency differences among the banks in the sample, the cost-efficiency scores are pooled for the five year period and are regressed on a number of explanatory variables. Results show that the size of banks (measured by total assets) have a positive impact on the cost-efficiency, and therefore it can be concluded that Increasing Returns to Scale exist in this model, that might stem from fixed costs. Moreover, the risk variable (measured by the standard deviation of ROA) has a negative relationship with cost-efficiency, implying that banks that are bad at managing their risks are also bad at managing their costs.

Havrylchyk (2005) investigates the efficiency of the Polish banking sector between 1997 and 2001. As previously, this study applies the intermediation DEA method, as banks are considered to be financial intermediaries. The inputs employed are capital, labour and deposits and the outputs are loans, government bonds and off-balance sheet items. The findings show that ROA has a positive effect on the efficiency and riskier banks are more efficient and profitable in Poland.

Pastor and Serrano (2006) examine the cost efficiency for 10 EU countries over the period 1992-1998. By employing the DEA input-oriented approach with two outputs, loans and other earning assets and three inputs, customer and short-term funding, fixed assets and personnel expenses, they find that Greece and Spain exhibit high cost inefficiencies. The specialisation of the Greek and Spanish banking system towards retail banking reveals that bank branches and ATMs are of great importance. It is reported that Greece, Spain, Belgium and Italy have a high number of ATMs per inhabitant and per square kilometre as well as a high number of bank branches. It might be that high cost inefficiencies are attributed to the heavy investments in ATMs.

Beccalli (2007) investigates the effect of IT investments on the performance of European banks in terms of ROA, ROE, profit efficiency and cost efficiency, for the period 1995-2000. Profit and cost efficiency scores are estimated by employing the standard stochastic frontier approach (SFA) for panel data with firm effects which are assumed to be distributed as truncated normal random variables. The intermediation approach is followed, in which inputs are used to produce earning assets; this study employs three inputs which are labour, loanable funds and physical capital, while the three outputs considered are total loans, securities and off-balance sheet items. The paper finds little relationship between IT investments and bank efficiency or improved bank profitability, indicating the existence of a profitability paradox[3]. However, it reports that investments in IT services from

[3] The IT profitability paradox is suggested by Hitt and Brynjolfsson (1996), who find that there is a positive impact of technology on productivity and consumer surplus for the US banks; this is in contrast with Beccalli (2007) who

external providers have a positive relationship with ROA, ROE and the profit efficiency, while the acquisition of software and hardware have a negative impact on banks' profit performance.

Likewise, Pasiouras (2008) applies the input-oriented DEA method assuming VRS, to examine the efficiency of Greek commercial banks over the period 2000-2004. He employs a mix of inputs and outputs, where inputs are fixed assets, customer deposits and short-term funding and the number of employees. The outputs are loans, other earning assets and off-balance sheets. The Tobit regression is then applied in order to investigate the determinants of bank efficiency. Results show that well-capitalised banks are more efficient both in terms of TE and SE. It is also reported that ROAA has a positive relationship with the efficiency measures, explaining that profitable banks are more efficient. However, it is found that ATMs do not have a statistically significant relationship with the efficiency measures. Pasiouras (2008) explains that this might be due to the fact that Greek banks have invested heavily on branches as a distribution network, and ATMs are considered supplementary to branches.

Fu and Heffernan (2009) examine the effect of the TE and SE on the profitability of Chinese banks over the period 1985-2002. In order to measure the efficiency of Chinese banks the parametric Stochastic Frontier Approach was adopted. The results indicate that SE has a positive and significant relationship with the profitability of Chinese banks in terms of the ROA.

Delis and Papanikolaou (2009) analyse the efficiency estimates derived from DEA on a number of bank-specific, industry-specific and macroeconomic determinants for 10 newly acceded EU countries. This study follows the intermediation approach with two outputs, total loans and total securities and two inputs, operating expenses and total deposits and short-term funding. The results show that when a bootstrapping procedure is applied for regressing efficiency on determinants instead of a Tobit regression, banks' size has a positive and significant relationship with efficiency.

Recently, Paradi and Zhu (2013) provide a survey of 80 DEA applications on Bank branch efficiency and performance. They argue that DEA is a significant tool in banking sector analysis. Finally, Arora and Arora (2013) examine the effect of IT investments of bank performance in India using a 2-stage GLS and GMM techniques. They find that investments in IT show positive impacts on both the operating profits per employee. They also argue that heavy investments in IT led to high profits.

2.2 Determinants of bank profitability

Various academic studies have identified the determinants of banks profitability as the Structure Conduct Performance (SCP) hypothesis and the relative efficiency hypothesis (Rhodes and Rutz 1982, Clarke et al. 1984, Smirlock 1985, Evanoff and Fortier 1988, Holden and El-Bannany 2004, Kondo 2008, Kosmidou 2008, etc.).

According to Evanoff and Fortier (1988), the SCP hypothesis states that the higher the market concentration in EU banks, the higher is the probability of larger profits, while the relative efficiency hypothesis states that larger banks in the UK are more efficient than smaller banks and hence they are more profitable (Clarke et al. 1984).

Smirlock (1985) examines the relationship between concentration and profitability for U.S. banks over the period 1973- 1978. The findings suggest that total assets have a negative relationship with banks' profitability, while the market structure and the market concentration affect positively the profitability of U.S. banks.

Similarly, Goldberg and Rai (1996) assess the relationship between concentration, efficiency and profitability for a sample of banks across 11 European countries, over the period 1988-1991. They apply the Stochastic Frontier Approach to derive measures of X-inefficiency under the assumption that the errors are distributed half-normal. Their study uses two outputs, loans and other earning assets and three inputs, defined as the price of labour, capital and borrowed funds. They test the effect of cost and SE on performance, the market structure and concentration

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reports that there is no significant positive correlation between IT spending and profitability for the EU banking industry.

in the market, while they also test the effect of concentration and market structure on cost and SE scores separately. Their findings suggest that x-efficiency and SE do not play a role in explaining changes in the profitability of European banks in terms of ROE. However, they find that the Relative Market Power hypothesis[4] exists, since the market structure variable has a positive and significant effect on ROE.

Ali et al. (2011) reveal that the profitability, measured by ROA, of commercial banks of Pakistan, is positively affected by the size of banks, while when ROE is considered, it is negatively affected by the size of banks. Similarly, Kosmidou (2008) finds that there is a positive and significant relationship between the size of Greek banks and their performance over the period 1990-2002. However, Pasiouras and Kosmidou (2007) report that there is a negative relationship between EU foreign and domestic commercial banks' size and their profitability. This indicates that larger banks earn lower profits, while smaller banks earn higher profits.

In addition to the above determinants, papers have identified the following factors that affect bank profitability: Evanoff and Fortier (1988) identify that in the US, as far as the market size is concerned, it is easier for larger banks to dominate in a small market and to achieve higher profits. Regarding the growth in market size they explain that larger banks are benefited from growth in the market and they are more profitable. Molyneux and Teppett (1993) also identify that the cost of funds can be one of the determinants of bank profitability for European, due to the fact that profitability is affected by the type of deposits, as deposit accounts pay higher interest rates to customers than current accounts.

Moreover, Molyneux (1993) states that the capital risk might also be one of the profitability determinants for European banks, as a low level of financial capital risk results in a high level of profits. Pasiouras and Kosmidou (2007), report that the equity to assets ratio for EU domestic and foreign commercial banks has a highly significant and positive relationship with the profitability in terms of ROAA. This supports the argument that well-capitalised banks reduce their costs of funding, as they face lower costs of going bankrupt, or they have lower needs for external funding, which results in higher profitability. Similarly, Abreu and Mendes (2001), report that the equity to assets ratio for Portugal, Spain, France and Germany has a positive impact on the profitability. Furthermore, Naceur and Goaeid (2001) for Tunisia and Rhoades and Rutz (1982) for the US, report that highly capitalised banks, banks with higher levels of productivity and banks that issue more loans(and hence generate profits through the interest rates received) are more profitable.

Allen and Rai (1996) add that one other important determinant of bank profitability is the portfolio composition, because higher total deposits to total assets ratios means that banks have more funds to invest or lend to customers, and they can increase their profitability in terms of ROA.

There are a few studies that examine the effect of ATMs and IT investment in bank profitability and efficiency. Holden and El-Bannany (2004) report that investments in IT, and more specifically ATMs have a positive effect on the profitability of UK banks over the period 1976-1996. However, more recently, Kondo (2008) reports that the number of ATMs has no effect on the profitability of Japanese banks for the period 2000-2003.

3. Methodology and Data

3.1 Methodology

DEA

There are several approaches that can be followed to examine the efficiency of banks, such as Stochastic Frontier Analysis (SFA), Thick Frontier Approach (TFA), Distribution Free Approach (DFA), Free Disposal Hull (FDH) and DEA. The theoretical foundations for the frontier estimations were laid by Debreu (1951), Koopmans (1951)

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[4] The Relative Market Power hypothesis states that firms with larger market shares are able to exercise market power and therefore can earn higher profits (Goldberg and Rai 1996).

and Farrell (1957). Farrell (1957) proposed that the efficiency of a firm consists of two components: TE and allocative efficiency. TE reflects the ability of a firm to achieve maximum output from a given set of inputs, and allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, considering their respective prices. Coelli (1996) explains that when these two measures are combined they provide a measure for total economic efficiency. For this present study we use the DEA non-parametric method in order to estimate the efficiency of Greek commercial banks. DEA, which was firstly introduced by Charnes et al. (1978), uses principals of linear programming to examine how decision making units (DMU) operate relative to other DMUs in the sample. Cooper et al. (2000) explain that DEA was given this name because of the way it 'envelops' observations, in order to identify the frontier that is used to assess observations representing the performances of all DMUs. Efficiency can be defined as the ratio of an output to an input. The DMUs that are on the frontier are assigned a score of one, while the ones that are inside of the frontier curve are assigned efficiency scores between zero and one (Ketlar and Ketlar 2008). However, the efficiency estimation becomes complex, when we have to consider multiple inputs and outputs. The main advantage of the DEA method is that it can overcome this problem by constructing an efficiency frontier from weighted outputs and weighted inputs. Furthermore, Halkos and Salamouris (2004) add that there is no need to determine the functional form or the statistical distribution of the scores, as we need to do with parametric methods (such as the SFA). In addition, the DEA method can allow for zero output values as well as zero input values as well as is less data demanding and can handle small sample sizes (Damar 2005, Sufian 2006). Nevertheless, the deficiency of the DEA method is that it very sensitive to outliers and assumes that data are free of measurement errors (Pasiouras, 2008). DEA can be applied by assuming either CRS or VRS. Charnes et al. (1978) introduced the DEA method that had input orientation and assumed CRS. In this case, it is assumed that there is data on K inputs and M outputs on each of N DMUs. For the ith DMU these are represented by the vectors x_i and y_i, respectively. The data of all N DMUs are represented by a K x N input matrix, X, and a M x N output matrix, Y. We calculate the input oriented measure of a particular DMU, under the assumption of CRS as:

$$\begin{aligned} & \text{Min}_{\theta,\lambda}\ \theta, \\ \text{s.t.}\quad & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & \lambda \geq 0 \qquad (1) \end{aligned}$$

where θ is a scalar efficiency score and λ is a Nx1 vector of constants. It will satisfy the $\theta \leq 1$, with the value 1 indicating a point on the frontier and consequently a technically efficient DMU (Farrell, 1957), while $\theta < 1$ indicates that the DMU is inefficient and therefore needs a 1- θ reduction in the inputs employed to reach the frontier. The above linear programming model can be solved N times, once for every DMU and obtain a value of θ for each DMU.

Coelli (1996) explains that the CRS assumption is appropriate only where all DMUs operate at an optimal scale. The reasons that a DMU is not operating at an optimal scale might be attributed to imperfect competition, constraints on finance, etc. The use of the CRS model, in the case that not all DMUs operate at an optimal scale, will result in TE scores that are confounded by SE scores. Banker et al. (1984) introduced the extension of the CRS model to account for VRS, which permits the calculation of TE scores, which are free of any SE effects. Under the VRS assumption, the overall TE (OTE) is decomposed into a product of two components. The first component is TE under the VRS assumption or pure TE, and it relates to the ability of managers to utilise firms' given resources. The second component is SE and refers to the exploitation of scale economies by operating at a point where the production frontier exhibits CRS (Pasiouras 2008). The CRS model is then modified to account for VRS by adding the convexity constraint N1'λ=1 to equation (1) to provide:

$$\text{Min}_{\theta,\lambda}\ \theta,$$

s.t. $- y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$N1'\lambda=1$

$\lambda \geq 0$ (2)

where N1 is a N x 1 vector of ones. Pasiouras (2008) adds that the TE scores obtained under the VRS method are higher than or equal to the scores obtained under the CRS model, and SE scores can be obtained by dividing the overall TE by the pure TE (for a recent description of DEA, see Paradi and Zhu; 2013).

3.2 Determinants of Bank efficiency

In order to investigate further the determinants of bank efficiency for the Greek commercial banks we follow the so called Two-step approach, as suggested by Coelli et al. (1998). The first step is to calculate the efficiency scores from the DEA input-oriented and assuming VRS method and the second step is to estimate a Tobit regression model. The Tobit model (or censored normal regression model) is a model that describes the relationship between a non-negative dependent variable that it is observed in a selected sample and is not representative of the sample, and an independent variable. In this case we don't apply Ordinary Least Squares (OLS) regressions because the Xs are correlated with the disturbance term and therefore, they will provide inconsistent estimates ofβ. The general Tobit model is as follows:

$$y_i^* = X_i\beta + \varepsilon_i \qquad (3)$$

where ε_i~ N(0, σ^2). y^* is a latent variable that is observed for values greater than τ and censored otherwise. The observed y is defined by the following measurement equation

$$y_i = \begin{cases} y^* \_if\_ y^* > \tau \\ \tau_y \_if\_ y^* \leq \tau \end{cases} \qquad (4)$$

In the typical Tobit model, it is assumed that τ=0. That means that data are censored at 0. Therefore, we have:

$$y_i = \begin{cases} y^* \_if\_ y^* > 0 \\ 0\_if\_ y^* \leq 0 \end{cases} \qquad (5)$$

We follow Pasiouras (2008) and Kosmidou (2008) to formulate the proposed Tobit regression model that examines the determinants of bank efficiency, as follows:

$$\theta_{it} = \beta_1 \log BSize_{it} + \beta_2 Risk_{it} + \beta_3 \log ATMs_{it} + \beta_4 \log ITExp_{it} + \beta_5 \Pi_{it} + \varepsilon_{it} \qquad (6)$$

where i refers to bank i and t is the year. θ_i is the dependent variable and is the TE of bank i. The independent variables are LBSize, Risk, LATMs, LITExp and profitability measures, such as ROA or ROE. BSize is the total assets of bank i and it should be positive and significant, as large banks are considered to be more efficient. Risk is the equity capital of bank i divided by its total assets; This variable is a expected to have a positive relationship with efficiency, as a lower equity to total assets ratio leads to lower efficiency levels, because lower equity ratios imply a higher risk-taking propensity, which might result in higher borrowing costs (Casu and Molyneux, 2003. ATMs is the number of ATMs that bank i holds. In the case that ATMs is an important determinant of bank profitability, this will be positive and significant. Floros and Giordani (2008) report that Greek banks with large number of ATMs are more efficient than smaller banks[5]. ITExp is the expenses in IT that bank i has invested over the period 2004-2009. This is also expected to have a positive impact on the efficiency of Greek banks. Π_{it} is the profitability of bank i at year t, measured by ROA, ROE, net fees and commissions and net interest income. ROA is the profits of bank i in year t measured as after tax returns on assets. ROE measures a firms' efficiency in generating profits from investments in share holders' equity. Net fees and commissions are profits generated from fees collected for the various services that banks offers to their customers and Net interest income is the amount of money the bank receives from interest on assets (loans, mortgages, etc.), minus the amount of money that the banks has to pay for interest in their liabilities (deposits) Therefore we estimate four regressions considering the different profitability measures.

3.3 Determinants of Bank profitability

We follow Holden and El-Bannany (2004), Beccalli (2007) and Kondo (2008) to formulate our model that assesses the effect of various determinants on the profitability of Greek banks. We estimate the parameters of the following model by using a balanced panel data regression with fixed effects[6], as our dataset is not considered as being drawn from a random sample.

$$\Pi_{it} = \beta_0 + \beta_1 \log BSize_{it} + \beta_2 Risk_{it} + \beta_3 \log ATMs_{it} + \beta_4 \log ITExp_{it} + u_{it} \qquad (7)$$

where i refers to bank i. Π is the dependent variable and is the profitability of bank i expressed in terms of ROA, ROE, Net Interest Income and Net Fees and Commissions. We consider net fees and commissions which represent the direct sources of profits from ATMs including fees collected by ATMs (Kondo, 2008). We also consider the net interest income as banks are able to invest the fees from ATMs and succeed in making high profits (Kondo, 2008). The independent variables are LBSize, Risk, LATMs and LITExp. BSize should be positive and significant for larger banks as they might explore economies of scale that reduces the costs of collecting and processing information (Boyd and Runkle 1993). Risk is a measure of capital strength. Risk and bank performance have often a negative relationship when there is high risk of loss or liquidation. However, banks with higher equity to total assets ratio will have lower need of external funding and therefore will have a positive relationship with banks' performance (Pasiouras and Kosmidou 2007). In the case that ATMs is an important determinant of bank profitability, this will be positive and significant. We expect ITExp to have a positive impact on Greek banks' profitability. Therefore, we estimate Equation 4 using four different dependent variables; ROA, ROE, net fees and commissions and net interest income.

3.4 Data

Our sample consists of 11 Greek commercial banks[7] with financial statements that are available from the Bankscope database, for the period 2004-2009. Additional information on the number of employees, number of

[5] The number of ATMs has been considered as an input or output from several studies, such as Athanassopoulos (1997) for Greece, Camanho and Dyson (1999) for Portugal, Coughlan et al. (2010) for UK, Drake and Howcroft (1994, 2002) for UK, Sherman and Rupert (2006), Sherman and Zhu (2006) for US, and Yavas and Fisher (2005) for US.

[6] We have performed a Hausman test, in order to compare the fixed effects estimates to the random effects estimates, and we find that the estimates are equal in both methods, so it is safe to apply the fixed effects model.

[7] These banks were selected in terms of their total assets. The banks in our sample are the following: Agricultural Bank of Greece, Alpha Bank, Attica Bank, Eurobank, Emporiki Bank, Geniki Bank, Marfin Bank, Millenium Bank, National Bank of Greece, Piraeus Bank and Post Bank.

ATMs and number of branches was collected from the Hellenic Bank Association. In total, our panel dataset consists of 66 observations.

Berger and Humphrey (1997) identify two approaches for the proper selection of inputs and outputs; the production approach and the intermediation approach. In the production approach it is assumed that banks produce loans and deposit accounts, by using labour and capital as inputs, and outputs are measured by the type of accounts. In the intermediation approach, banks are viewed as financial intermediaries, who collect funds and use labour and capital to transform these funds into loans and other assets. They also point out that the production approach might be more appropriate for evaluating the efficiency of branches of financial institutions and the intermediation approach for evaluating the entire financial institution. Casu and Molyneux (2003) add that 'the intermediation approach might be superior for evaluating the importance of frontier efficiency to the profitability of financial institutions, since the minimisation of total costs, not just production costs, is need to maximise profits'. Therefore, following various studies (Paradi and Zhu 2013, Mester 1996, Berger and Humphrey 1997, Casu and Molyneux 2003, Beccalli 2007, Pasiouras 2008) we adopt the intermediation approach and we employ three inputs and two outputs. Our inputs are the number of employees, the number of branches and the total deposits, while our outputs are total loans and total securities[8].

<<Table 1 - about here>>

4. Empirical Results

Table 1 represents the descriptive statistics for the variables employed in our Tobit and Pooled Fixed Effects estimations. The mean DEA scores for TE with VRS are reported in Table 2. It is clear that the mean TE of Greek commercial banks was quite high in 2004 and then it gradually fell, until 2007. After 2007, an increase in the efficiency scores is indicated until 2009, where TE reached the highest observed value of 0.977. This indicates that Greek banks could have improved their TE by reducing their inputs by 0.023.

<<Table 2 - about here>>

The empirical results for the Tobit regression are reported in Table 3. We examine the effect of various bank related variables on banks' TE. We estimate four regressions that allow us to consider different profitability measures such as ROAA, ROAE, LFees and Lninc. ROAA is statistically significant and negatively related to efficiency in Model 1. This result is consistent with Casu and Girardone (2004) for Italy and Attaulah and Le (2006) for India; nevertheless, Christopoulos et al. (2002) for Greece, Casu and Molyneux (2003) for EU and Isik and Hasan (2002) for Turkey, report a significant and positive relationship between ROA and efficiency. This result indicates that banks with higher profits in Greece are less efficient than banks with lower profits. Similarly, we report a negative and significant relationship between ROAE and efficiency in Model 2, while Isik and Hasan (2002) and Casu and Molyneux (2003) report a positive relationship between ROE and efficiency, indicating that more profitable banks are more efficient. LATMs is found to be statistically significant and negatively related to efficiency in Models 1, 2 and 4. This might be attributed to the fact that there are significant investments in ATMs in Greece, while at the same time there is expansion of the branch network. This is in line with Pastor and Serrano

[8] The choice of inputs and outputs for DEA depends on the purpose of the empirical analysis (see Eskelinen et al., 2014).

(2006), who report high cost inefficiencies in Greece and Spain, due to the high investments in ATMs. On the other hand, Pasiouras (2008) reports that there is no significant relationship between ATMs and efficiency, as high investments in the branch network lead ATMs to be considered as supplements to branches. RISK has a negative and statistically significant impact on efficiency, which is consistent with Hauner (2005) for EU banks; hence, well-capitalised banks are less efficient than other Greek commercial banks with a lower equity to total assets ratio. This is not in line with Kwan and Eisenbis (1997) for US, Isik and Hasan (2003) for Turkey, Casu and Girardone (2004) for Italy, Rao (2005) for United Arab Emirates, Havrylchyk (2005) for Poland and Pasiouras (2008) for Greece, who report a positive and significant impact of the equity over total assets ratio on efficiency. Although Hauner (2005) and Delis and Papanikolaou (2009) for EU banks report a positive and statistically significant relationship between Banks' size and efficiency, we find no evidence of a significant relationship for Greek commercial banks. We further report that LITexp has no significant impact on Greek banks' TE; this is consistent with Beccalli (2007), who finds little relationship between IT investments and efficiency.

<<Table 3 - about here>>

Tables 4-7 report the regression results for the Fixed Effects Model for our panel dataset. We estimate four models for Equation 7, considering the determinants of various forms of profitability measures (ROAA, ROAE, Lfees and Lninc).

We report that LBsize has a positive and highly significant (at 1% level of significance) relationship with Greek commercial banks' profitability, in terms of Net interest income, which is in line with Kondo (2008) for Chinese banks. This confirms the fact that banks with higher assets are more profitable, compared to banks with lower assets. However, Holden and El-Bannany (2004) report a negative impact of BSize on ROA for UK banks. While we find no significant relationship between LBSize and ROAA, ROAE, and Lfees, Pasiouras and Kosmidou (2007), Kosmidou (2008) and Kondo (2008) report a positive and significant, at 5% level of significance, relationship with ROA and a highly significant and positive relationship between BSize and Fees and commissions. In addition, Ali et al. (2011) find a positive impact of banks' size to the profitability of commercial banks in Pakistan, measured by ROA, while they report a negative relationship between banks' size and ROE.

RISK has a significant and positive relationship with Greek banks' profitability, in terms of ROAA and Lninc at 5% level of significance and with ROAE, at 1% level of significance. These findings are consistent with previous studies by Rhoades and Rutz (1982) for US, Naceur and Goeaid (2001) for Tunisia, Abreu and Mendes (2001) for EU banks, Holden and El-Bannany (2004) for UK, and Pasiouras and Kosmidou (2007). However, Kondo (2008) reports a negative relationship between banks' size and ROA and Net Interest income and a positive relationship between banks' size and Net Fees and commissions. This confirms that well-capitalised banks are more profitable than other banks with lower levels of equity over total assets ratios.

We report a positive and significant relationship between LATMS and Lfees at 1% level of significance, but a negative and highly significant (at 1%) relationship with Lninc. This is in line with Kondo (2008), for Lfees, but is not in line when the Lninc is considered. Likewise, Holden and El-Bannany (2004) report a positive and significant relationship at 5% level of significance, of ATMs on ROA. Therefore, banks with a higher number of ATMs are more profitable in terms of the Net fees and commissions, but less profitable when the Net interest income is considered.

LITexp has a positive and highly significant relationship with Lfees and Lninc. Higher investments in IT have a positive impact on Greek commercial banks' profitability. This result in not in line with Beccalli (2007), who finds little relationship between IT expenses and bank profitability or improved bank profitability, and indicates the existence of a profitability paradox.

<<Table 4 - about here>>

5. Conclusions

This paper investigates the determinants of efficiency and profitability for 11 Greek commercial banks over the period 2004-2009. More specifically, we extend models by Beccalli (2007), Pasiouras (2008) and Kondo (2008), to examine the effect of ATMs and IT investments on the Greek banking industry. We employ the non-parametric DEA method, assuming VRS and follow the intermediation approach for the selection of our inputs and outputs, in order to calculate the TE scores. We follow the two step approach and regress the TE scores on a number of bank specific variables, so as to examine the determinants of banks' efficiency. In addition, we run Panel Regressions with Fixed Effects, in order to identify the determinants of banks' profitability.

Overall, we find that Greek commercial banks' TE scores vary between 0.916 for 2007 and 0.977 for 2009, implying that banks could have improved their TE by decreasing their inputs by 0.084 and 0.023 respectively. Tobit regressions on banking variables reveal that profitability (ROAA and ROAE), LAtms and RISK, have a negative effect on Greek banks' efficiency, while we report that LBSize and LITexp have no impact on TE of Greek banks.

Panel regressions with fixed effects identify that LBSize, RISK, and LITexp have a positive and significant impact on Greek bank profitability. Furthermore, LAtms have a positive relationship with Lfees, but a negative relationship with Lninc. This might be explained by the fact that Greek banks have invested heavily in the expansion of the ATM network as well as their branch network, but ATMs are considered as being supplements for branches; therefore, they do not play a significant role into generating profits.

Future research should consider parametric methods (i.e. SFA) for the estimation of recent TE scores for EU countries, with a different combination of inputs/outputs. In addition, we should examine the effect of recent mergers and acquisitions on Bank profitability and efficiency in Greece. Our results provide important insights to policy makers, bank managers and practitioners, on the determinants of bank efficiency and profitability, which would help them in taking important decisions and improve the efficiency and profitability of Greek Banks.

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Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max

ROA	66	0.371	1.054	-2.340	1.970
ROE	66	3.447	20.590	-66.670	33.110
LBsize	66	4.229	0.500	3.282	5.055
RISK	66	0.552	2.788	-0.019	17.023
LAtms	66	2.576	0.415	1.716	3.182
Lfees	66	1.959	0.586	0.255	2.888
Lninc	66	2.646	0.505	1.774	3.596
LITexp	66	2.207	0.430	1.521	2.989
Eff	66	0.941	0.115	0.557	1.000

Table 2. DEA Results with Intermediation approach

	Mean TE VRS
2004	0.963
2005	0.930
2006	0.925
2007	0.916
2008	0.957
2009	0.977
(Overall 2004-2009; N=66)	

Table 3. Tobit censored regression results (Dependent Variable Eff, N=66)

Model 1	Coefficient	Z-Statistic	P Value	Model 2	Coefficient	Z-Statistic	P Value
Intercept	1.027***	5.920	0.000	**Intercept**	1.074***	6.370	0.000
ROAA	-0.027**	-2.310	0.021	**ROAE**	-0.002***	-3.280	0.001
LBSize	0.072	1.030	0.303	**LBSize**	0.055	-2.010	0.411
LAtms	-0.178*	-1.850	0.064	**LAtms**	-0.188**	-2.010	0.044
LITexp	0.036	0.360	0.720	**LITexp**	0.058	0.610	0.541
RISK	-0.006*	-1.950	0.051	**RISK**	-0.005*	-1.680	0.093
Model 3	**Coefficient**	**Z-Statistic**	**P Value**	**Model 4**	**Coefficient**	**Z-Statistic**	**P Value**
Intercept	1.020***	5.460	0.000	**Intercept**	0.968***	5.200	0.000
Lfees	-0.061	-0.980	0.329	**Lninc**	-0.188	-1.410	0.158
LBSize	0.034	0.470	0.636	**LBSize**	0.149	1.360	0.175
LAtms	-0.145	-1.380	0.167	**LAtms**	-0.179*	-1.920	0.055
LITexp	0.124	1.130	0.258	**LITexp**	0.137	1.260	0.207
RISK	-0.008**	-2.420	0.015	**RISK**	-0.008**	-2.240	0.025

NOTES:*** ,,** and * Significant at the 1, 5 and 10% levels, respectively

Table 4. Regression Results for Model 7

A. DEPENDENT VARIABLE ROAA

Variable	Coefficient	T-statistic	P value
Intercept	1.115	0.249	0.804
LBSize	0.720	0.499	0.620
RISK	0.055*	1.838	0.072
Latms	-0.559	-0.970	0.336
LITexp	-1.078	-1.259	0.214
Adjusted R^2 0.570 *Prob (F statistic) 0.000****			

NOTES:*** and * Significant at 1 and 10 % levels, respectively

B. Regression Results for Model 7 (DEPENDENT VARIABLE ROAE)

Variable	Coefficient	T-statistic	P value
Intercept	49.079	0.970	0.337
LBSize	-0.103	-0.005	0.996
RISK	1.380*	1.680	0.099
Latms	-17.837	-0.903	0.371
LITexp	-0.002	-0.000096	1.000
Adjusted R^2 0.497 *Prob (F statistic) 0.000****			

NOTES:*** and * Significant at 1% and 10 % levels, respectively.

C. Regression Results for Model 7 (DEPENDENT VARIABLE LFees)

Variable	Coefficient	T-statistic	P value
Intercept	-1.234**	-2.350	0.023
LBSize	-0.069	-0.390	0.698
RISK	0.005	1.384	0.172
Latms	0.806***	2.825	0.007
LITexp	0.637***	2.757	0.008
Adjusted R^2 0.968 *Prob (F statistic) 0.000****			

NOTES:*** and ** Significant at the 1% and 5 % level, respectively.

D. Regression Results for Model 7 (DEPENDENT VARIABLE Lninc)

Variable	Coefficient	T-statistic	P value
Intercept	0.284	1.513	0.137
LBSize	0.602***	11.956	0.000
RISK	0.002**	2.083	0.042
Latms	-0.354***	-3.977	0.000
LITexp	0.330***	3.947	0.000
Adjusted R^2 0.992 *Prob (F statistic) 0.000****			

NOTES:*** and ** Significant at the 1% and 5 % level, respectively.