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ABSTRACT

This study uses the distribution free approach to investigate cost efficiency in a panel of Greek banks over 1993-1999, a period characterized by major changes in the banking sector brought about by gradual financial deregulation. These reforms were supposed to provide an opportunity to Greek banks to improve their efficiency and to enhance their competitiveness in view of ongoing financial integration in Europe and the introduction of the euro. The results obtained indicate that important cost X-inefficiencies are in place. Some evidence is provided that bank characteristics such as bank size, type of ownership and risk behaviour do play a role in explaining differences in measured inefficiencies. Scale economies are also examined and the findings indicate that the Greek banking industry experiences economies of scale, though they have declined throughout the observed period. This suggests that competitive viability may be an important factor for further consolidation in the Greek banking industry.

Keywords: X-efficiency, scale economies, panel data
JEL classification: C33, G21, G28

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1. Introduction

During the last two decades, financial sectors have undergone profound changes worldwide. Deregulation of financial systems and liberalisation of external transactions, as well as the application of advanced information and communications technologies have all intensified competition among institutions in local and international financial markets and paved the way for the introduction of new financial instruments and practices. Indeed, the way that banking is conducted was gradually altered and the technology of bank production was significantly modified. As a result, banking systems internationally have entered an era of restructuring and reorientation of their activities. Similar developments were also observed in the Greek banking system, as Greek banks had to adjust to the new conditions that resulted from the gradual liberalisation of the domestic financial market and the completion of the European internal market and, thus, to the increasingly competitive environment in recent years. This trend is expected to continue as the number of non-bank competitors increases and competition from foreign, and in particular from European banks, picks up, mainly in response to the introduction of the common currency and the initiatives taken by the European Commission in the context of the Financial Services Action Plan to remove remaining obstacles to the European financial integration, but also in response to the general globalization of markets.

In this regard, a frequently asked question is about the effect(s) of these changes on Greek banks and, more precisely, how Greek banks will be affected by the intensified competitive pressures. In other words, concerns raised about the long-run competitive viability of various Greek banks in the new environment that has gradually emerged. The answer to this question depends at least in part on how efficiently they are run. Accordingly, the objective of this paper is to investigate the efficiency of Greek banks and how it has developed in recent years. More specifically, our aim is to shed light on the following: (1) whether all banks are cost efficient, that is whether all banks operate on or close to the best practice cost frontier; (2) whether larger banks enjoy a cost advantage over smaller competitors, that is, whether the system is characterized by important economies of scale; and (3) whether factor productivity has changed over time, that is, whether banks have benefited from technical progress.

Previous research in Greek banking provides some contradictory evidence on scale economies. A study by Karafolas and Mantakas (1996), who used a sample of 11 Greek banks over the period 1980-89, did not find any significant total cost scale economies, although operating cost economies of scale were estimated to be statistically significant. Eichengreen and Gibson (2001) investigating the profitability of 25 Greek banks over the period 1993-98 found evidence of a bell-shaped relationship between profitability and bank size, implying that profitability initially increases and then declines as bank size increases. More specifically, their results indicate that when profitability is measured by the rate of return on assets, ROA, scale economies are exhausted at around the average size of banks in their sample, which is indeed very low by European standards. On the other hand, when profitability is measured by the rate of return on equity, ROE, their estimates suggest that banks of all sizes may reap scale economies. More recently, Athanasoglou and Brissimis (2003), comparing operational costs across banks of different size, concluded that for the period 1994-97 economies of scale are present in the case of small and medium size banks, but diseconomies of scale exist for large banks, whereas for the period 2000-02 economies of scale were found for all banks. No study has yet been published on the X-efficiency of Greek banks. It has been widely recognized that for a group of banks of similar size that show greater dispersion of average costs (or profits) than banks of different sizes, X-efficiency is a much more important source of cost reduction (or profit increase) than achieving an optimum size of production to minimize average costs (see Maudos *et al* 2002). Given the lack of such analysis and taking into account the considerable merger activities among Greek banks during recent years, answers to the above questions are clearly of interest.

The paper is structured as follows. Section 2 describes briefly the liberalisation of Greek financial system and how this has affected banking structure and operations. Section 3 provides an overview of the methodology used to investigate cost efficiency. Section 4 presents the theoretical model and discusses data problems. Section 5 discusses the main empirical findings and Section 6 concludes.

2. Deregulation and restructuring of the financial system

Until the mid-1980s, the banking system in Greece was used as a means of implementing economic policy and promoting, mainly, industrial development, by applying a highly complicated system of selective credit controls and regulations along with a wide range of administratively-determined bank interest rates. In practice, however, that system proved to be ineffective and led gradually to allocative inefficiencies and to serious distortions in the functioning of the financial system. The creation of a modern, market-oriented system necessitated the liberalisation of interest rates, the deregulation of the domestic market and the lifting of restrictions on external transactions.

By the early 1990s, bank interest rates had been gradually liberalised and all quantitative credit restrictions and investment requirements concerning the financing of specific economic sectors, notably the public sector, had been phased-out. Moreover, the central bank had authorised the introduction of new financial products, such as leasing, factoring, forfaiting and venture capital, while specialised credit institutions had been given permission to expand their activities to sectors formerly open only to commercial banks and vice versa. At the same time, restrictions on capital movements and current transactions were also gradually lifted. Thus banks were increasingly able to grant loans on their own terms and differentiate their lending rates based on liquidity and risk considerations only, as well as to choose the types of activity on which they wished to focus, to expand their operations in preferred segments of the market and use new techniques for hedging against interest rate and foreign exchange risks.

Important measures were also taken to promote the operation of the capital market and new institutions were introduced such as brokerage firms. Furthermore, the operating framework of undertakings for collective investment in transferable securities (UCITS) was improved and the supervisory role of the Capital Market Committee was enhanced. As a result, the capital market gradually became an important source of capital for the funding of enterprises as an alternative to bank financing. It also became an important source of funds for the banks themselves, especially in the late-1990s.

The environment that emerged gave impetus to the establishment and operation of new banks, either domestic institutions or branches of foreign banks.

Indeed, from the late-1980s to the late-1990s, ten commercial banks were incorporated in Greece[1]. In addition, since 1993 when the Bank of Greece set the operational and supervisory framework concerning cooperative banks, fifteen cooperative banks have been established and operate, although their market share remains very low (less than one per cent of total assets of the banking system). Regarding foreign banks, the picture is mixed. On the one hand, seven foreign banks established branches in Greece from the late-1980s to the late-1990s. On the other hand, some foreign banks, in the context of their broader strategies, have withdrawn from the Greek market over the past few years.

Following financial deregulation and the enactment of new legislation implementing EU directives, banks operating in Greece had to adjust to new conditions and cope with the ensuing intensified competition, both domestically and cross-border. Besides, the completion of the European internal market along with the major advances in information technology and telecommunications, which have led to the globalisation of the financial services market, necessitated the reorientation of banks' activities and resulted in a restructuring of the banking system. Another factor putting pressure on banks was the increasing role of institutional investors, which made it more difficult for the former to attract deposits and, consequently, induced banks to search for alternative sources of funds and for ways of reducing their operating costs.

Moreover, Greek banks pursued restructuring policies in order to become more efficient and obtain a size that would enable them to increase or, at least, maintain their domestic market shares, facilitate their access to international financial markets and exploit any possible economies of scale. To this end, since the mid-1990s several Greek banks have been involved in mergers and acquisitions. Most of them concerned the domestic market, including not only banks but also non-bank financial enterprises. Some large credit institutions opted to merge with their subsidiaries with a view to restructuring their activities and cutting their operating expenses. Others have forged strategic alliances with major European institutions in order to benefit from the latters' know-how, large branch network and presence in international financial centres. Some Greek banks have also expanded their operations in countries to the

[1] Six more banks were incorporated in the early 2000s.

wider area of south-eastern Europe, notably in the Balkans, either via subsidiaries or through the establishment of branches.

At the same time, Greek credit institutions have taken important steps towards improving their efficiency by installing modern information technology systems, cutting their operating costs and improving their organisational structure, while they have extended their scope of business by offering new products and services. They have merged their subsidiaries engaging in the same line of business and integrated several of their activities in an effort to reduce costs and improve control and service quality. Additionally, several banks have tried to expand or further develop their activities in such sectors as bank assurance, where they can profit from synergies and cross-selling by both bank networks and insurance companies.

Another very important aspect on which Greek banks have focused their attention is on the branch network and alternative distribution channels. Branches offer the advantage of (physical) proximity to customers, especially in retail banking. On the other hand, the maintenance of an extensive branch network entails high operating costs, with negative implications for bank efficiency. Technological advances have allowed banks to develop remote banking channels: ATMs, telephone banking, online PC banking and Internet banking, the first two being the most commonly used in the Greek market at present. During the 1990s, the number of bank branches operating in Greece almost doubled, from 1,529 in 1990 to 3,004 in 2000, mainly reflecting the relatively low level of branching in the past.[2] In the same period, the number of ATMs exhibited a remarkable increase, from 326 in 1990 to 3,472 in 2000. In addition, new technologies changed the way in which bank branches are organised, by favouring the operation of smaller branches with fewer but more highly qualified staff, focused on a better promotion of bank products and meeting of customers' needs.

Mergers and acquisitions have resulted in higher concentration in the banking industry: the market share of the top-5 banks as a percentage of total assets rose from 57% in 1995 to 65% in 2000. This, however, has not led to less competition, as evidenced by the reduction in interest rate spreads, especially in the segments of consumer and housing loans, in the past few years, which can only partly be attributed

[2] It is worth noting that in terms of inhabitants per branch the Greek credit system is still underbranched as compared to other EU countries. This is not, however, the case when GDP per branch is taken into account.

to convergence to the rates prevailing in the eurozone. Accordingly, this indicates that, if anything, oligopolistic rents have been reduced in Greek banking.

The privatisation of several banks controlled by the Greek State was another important development in the second half of the past decade, which also contributed to the enhancement of competition in the market. In the period 1995-2000, the market share of the State-controlled banks fell by almost 20 percentage points, from 72.3% in 1995 to 52.9% in 2000.

3. Efficiency measurement

To evaluate the effects of the banking sector reforms, the frontier of the most efficient practices should first be estimated (as a function of the relevant variables), and then one can measure how far from this frontier the efficiency levels of different institutions or groups of institutions are.[3] Efficiency can be measured in terms of profits, costs or revenues. Studies in bank efficiency are usually based on costs. Profits and revenues are more vulnerable than costs to extraordinary factors that can affect disproportionately different institutions or categories of institutions. In addition, financial sector reforms in Greece had a relatively moderate impact on bank profitability, given that the pressures to achieve cost efficiency were to some important extent offset by the lower margins resulting from fiercer competition, as indicated in the next section. That is, the welfare gains from financial reforms to a large extent accrued to users of bank services. For these reasons, the particular approach used here is based on cost efficiency.

A firm is said to be cost efficient if it produces a given volume of output at the least possible cost. Thus, cost efficiency is directly related to the firm's cost minimisation objective. Deviations from this minimum thus determine cost inefficiencies. Hence, realised cost can be defined as a function of the output vector, the price of inputs, the level of cost inefficiency and a set of random factors. In logarithimic terms, realised cost, y, can be expressed as follows:

$$y = f(x, w) + u + v \qquad (1)$$

where x is the output vector, w the input prices vector, u the level of cost inefficiency and v a random error term.

[3] Berger and Humphrey (1997) survey a large number of studies of bank efficiency based on this approach.

The problem of measuring cost inefficiency is to isolate it from the effect of random factors on production costs. At least four cost frontier methods have been used to measure inefficiencies in studies of the banking sector: the stochastic frontier approach, the distribution free approach, the thick frontier approach, and the data envelopment analysis.[4] As the efficient cost frontier is not *a priori* known, the objective of these approaches is to estimate it by using the data. However, each approach is based on different assumptions and thus may lead to quite different results.

The stochastic frontier approach assumes that deviations of realised cost from the cost frontier are due either to cost inefficiency or to random fluctuations or both. The inefficiencies are usually assumed to follow a truncated normal distribution, whereas the random fluctuations are assumed to be normally distributed.

Although the stochastic frontier model gives inconsistent estimators when cross-sectional data are used for the estimation of the cost frontier, many of its assumptions can be relaxed when panel data are used. According to Schmidt and Sickles (1984), a data panel enables standard models of fixed and random effects to be estimated without needing to make any assumption about the distribution of the inefficiency term, provided that efficiency is constant over time. This method is thus known as the 'distribution free' approach and it was first used by Berger (1993) in the banking industry context. In the case of a fixed effects model, a bank specific constant is taken to be the bank's measure of inefficiency, while in the case of a random effects model the average predicted residual for each bank in the panel is the estimate of that bank's average inefficiency.

The thick frontier approach (Berger and Humphrey, 1991; Humphrey, 1993) attempts to reduce the impact of outliers in estimating the cost frontier and identifies a 'thick frontier' consisting of those firms which are on the frontier plus those close to it. The thick frontier method selects a larger subset of firms with only low costs -

[4] Most earlier studies of bank efficiency, and in particular those dealing with the efficiency implications of bank mergers, are based on inter-temporal comparisons of simple financial ratios, such as operating costs divided by total assets, or the return on equity or assets, see for example Rhoades (1986) and Srinivasan (1992). However, there are several problems with these studies. As noted by Berger *et al* (1993, p. 233) “first and foremost, financial ratios may be misleading indicators of efficiency because they do not control for product mix or input prices”, as is the case with frontier methods. By comparing cost-to- asset ratios inter-temporally, it is “implicitly assumed that all assets are equally costly to produce (and all locations have equal costs of doing business). In addition, the use of a simple ratio cannot distinguish between X-efficiency gains and scale and scope efficiency gains”. For a more recent survey of studies on financial institutions’ efficiency, see Berger and Humphrey (1997).

typically the quartile of firms with the lowest average cost - and estimates the 'thick' cost frontier from a standard regression using only these observations. Similarly the high cost frontier is determined from the quartile of firms with the highest average costs. Inefficiency is measured as the range between these two frontiers.

Finally, the data envelopment analysis has also been used extensively in banking studies. As against the three previous methods, this is a non-parametric approach that maximises a function of weighted inputs and outputs subject to given restrictions. It has the advantage that the efficient frontier is estimated solely on the basis of the data, without requiring the specification of a particular form for the cost function or the imposition of any distributional assumptions about the error term and/or the inefficiency term, which may not be met in practice. Being deterministic, this model does not allow for error. All deviations from the frontier are considered as inefficiencies. This often results in their overestimation (Lozano-Vivas, 1998), as the method is very sensitive to extreme observations (outliers), to measurement errors and to the number of constraints specified.

There is no consensus in the literature as to which method should, in general, be preferred. The choice usually depends on the available data. However, parametric models are considered to be relatively more robust and for this reason such a model will be used in this study. In particular, the fixed effects model proposed by Schmidt and Sickles (1984) is used as it requires fewer assumptions and it is thus more appropriate for a relatively small panel. This model was recently applied by Maudos *et al* (2002) to measure the efficiency of European banks.

The general form of the model to be estimated is the following:

$$y_{it} = a + X'_{it}b + v_{it} + u_i \qquad (2)$$

where i=1,…,N indexes the banks and t=1,…,T indexes the time periods. In the case of a translog cost function y_{it} will be the log of cost, X'_{it} a vector of the relevant independent variables (in logs) and v_{it} the random errors. The v_{it} are uncorrelated with the regressors X_{it}. The u_i represent technical inefficiency and thus $u_i = 0$ for all i. In addition, u_i are assumed to be iid with mean μ and variance s_u^2 and independent of the v_{it}. A particular distribution may or may not be assumed for the u_i. If we let $E(u_i) = \mu > 0$ and define $a^* = a + \mu$ and $u_i^* = u_i - \mu$, so that the u_i^* are iid with mean 0, the model can be rewritten in the following way:

$$y_{it} = a^* + X'_{it}b + v_{it} + u_i^* \quad (3)$$

Both the error terms v_{it} and u_i^* now have zero means, and all results of the panel data literature apply directly, with the exception of those that require normality. Letting $a_i = a + u_i = a^* + u_i^*$ the model becomes

$$y_{it} = a_i + X'_{it}b + v_{it} \quad (4)$$

Treating u_i as fixed, a separate intercept for every bank can be estimated, as above. A frontier can be estimated using the fact that $u_i = 0$ for all i. If the N estimated intercepts are $a_1,\ldots a_i\ldots, a_N$, the frontier can be simply defined as $a = \min(a_i)$ and the estimated inefficiency of each bank as $\hat{u}_i = a_i - a$. The estimates a and $\hat{u}_i$ are asymptotically consistent (see Schmidt and Sickles (1984)). Since in the linear form of the cost function the variables are the logs of the initial variables, taking the exponents of the $(-\hat{u}_i)$s gives each bank's (estimated) efficiency, E_i, as a ratio of the minimum cost to produce the output vector, Y^{min} , to each bank's realised cost, Y_i (i.e. $E_i = (Y^{min}/Y_i) = \exp(-\hat{u}_i)$).

4. Model specification and data

4.1 The model

In estimating a cost function it is important to distinguish between a firm's inputs and outputs. In the case of banks, this is not an easy job, given their important role in intermediating between lenders and borrowers (i.e. between financial savings and investments) and in providing financial services to their customers. Thus, in estimating a bank's cost function, two approaches have been proposed: the "production approach", and the "intermediation approach".

According to the "production approach", banks use capital and labour as inputs to produce individual accounts of various sizes and incur operating costs in the process. (Benston (1972), Benston *et al* (1983), Mester (1987), Hunter *et al* (1990)). Operating costs are incurred in the course of processing deposits and loan documentation and debiting and crediting deposit and loan accounts. Therefore, the number of deposits and loan accounts is, according to this approach, a measure of a bank's output, while average account size is used as a proxy for the characteristics of

this output. Consequently, total bank costs in this approach include only operating costs and exclude interest costs.

On the other hand, the "intermediation approach" asserts that banks collect deposits and purchase funds from other financial institutions, and use them as inputs to grant loans and to purchase other financial assets and securities, such as bonds and shares (Benston *et al* (1982)). Accordingly, the amounts of loans and securities are used as a measure of a bank's output and interest costs on deposits and purchased funds are included, along with operating costs, in the measurement of total costs. As the "intermediation approach" is more inclusive of the total costs of banking, it is preferred if the objective is to evaluate the economic viability of banks, given that interest costs and operational costs are functionally the same from bank managers' point of view. But there are drawbacks, too. Using this approach it is not possible to analyse the implications of the fact that a large number of small accounts are much more costly to service than a small number of large accounts as is the case with the "production approach", since outputs in the intermediation approach are computed as outstanding amounts in all these accounts. Accordingly, the "production approach" is preferred when more emphasis is placed on investigating banks' operational efficiency and productivity.

This study uses the "intermediation approach" to estimate the bank's cost function, because it investigates banks' economic or competitive viability. This is a more general concept than operational efficiency and hence is more appropriate when the purpose is to evaluate the implications of the deregulation of the banking system and the liberalisation of financial transactions in an economic environment characterised by the gradual integration of the European financial systems and markets. It is also more useful for analyzing the efficiency of bank mergers.

The translog cost function we use is of the form

$$TC = a_i + \sum_{j=1}^{3} b_j Y_j + \sum_{k,j=1,k\le j}^{3} b_{kj} Y_k Y_j + \sum_{l=1}^{3} g_l P_l + \sum_{r,s=1,r\le s}^{3} g_{rs} P_r P_s + \sum_{n=1,m=1}^{n=3,m=3} d_{nm} Y_n P_m + Jt + e_i \qquad (5)$$

where:

TC = total cost (financial and interest expenses)

Y_1 = loans (outstanding amount)

Y_2 = other income (fees)

Y_3 = securities

P_1 = price of loanable funds calculated as the ratio of interest expenses to the total value of deposits and repos

P_2 = price of labour input, calculated as the ratio of personnel costs to the total number of employees

P_3 = price of physical capital, calculated as the ratio of depreciation to fixed assets.

i indexes the banks. The time subscript is omitted from the variables for simplicity of presentation.

All the above variables are expressed in logs.

t = an indicator variable with values 1,…,7 for each year of the estimation period. This variable is assumed to be closely related to technical progress and thus it is included in the equation to control for the effects of technical progress on bank costs.[5]

In the above model the symmetry restriction ($ß_{ij} = ß_{ji}$ and $?_{ij} = ?_{ji}$) is implied and it is estimated applying the price homogeneity restriction,[6] i.e.

$$\sum_{l=1}^{3} g_l = 1$$

The above specification of the cost function allows investigation of another aspect of the cost structure of banks, that is the potential to realise scale economies. Economies of scale exist if the average cost of producing a given (constant) product mix is declining as bank size expands. In this case, a proportional increase in all input levels would lead to a greater than proportionate increase in output. Evidence of economies of scale would mean large banks have a cost advantage over small banks. Scale economies are empirically measured by the ray scale elasticity:

$$SCALE = \sum_j \partial TC/\partial Y_j$$

SCALE measures the relative cost increase caused by a proportional increase in outputs. Values of SCALE of less than one indicate economies of scale, that is cost increases that are less than proportionate to output increases. A given output vector can then be produced at a lower cost within one big bank compared to several smaller banks with the same composition of outputs. Similarly, values of SCALE equal to or

[5] Because of sample size limitations, the time trend indicator t is not specified to interact with the outputs Y_i and input prices P_j variables. Accordingly, only the impact of the neutral technical change on the cost function is considered in the paper, whereas the relevant impact, if any, of the non-neutral technical change is not identified.

greater than one indicate no economies or diseconomies of scale, respectively. Furthermore, if SCALE is different from one then the firm is not competitively viable (see Berger *et al* (1987)). A firm is competitively viable when its cost does not exceed the scale-adjusted cost of producing the same product mix by any other set of firms. Hence, if a firm is not competitively viable either a larger or a smaller firm, i.e. a lower-cost competitor, could drive it from a competitive market in the long run if it does not make necessary adjustments to its size.

4.2 The data

The above model is used to examine cost efficiency in Greek banking during the period 1993-1999 by analysing annual data from a sample of 20 banks. The sample includes all Greek commercial banks plus two mortgage banks which were merged with a commercial bank during the period of analysis. Not included in the sample are the institutions which did not publish profit and loss statements i.e. branches of foreign banks and certain specialized credit institutions. Co-operative banks have also been excluded because of their very small size. In 1999, banks included in the sample accounted for 67% of total banking assets and 80% of total employment. The final empirical results were based on 18 institutions because two institutions had to be dropped: one institution went through a major restructuring program during the period of investigation and it was eventually re-established as a new bank, whereas the other institution was publishing until 1995 profit and loss statements for the twelve-month period ending in June instead of December like all other banks. A more detailed description of the sample is given in the following paragraphs.

Total cost (operating expenses and interest paid) as a percent of total assets declined significantly over the sample period from 11.8% in 1993 to 8.5% in 1999 (see Figure 1 and Table 1). More specifically, a marked reduction in the cost/asset ratio took place in 1995, because the absolute amount of cost fell in 1995, following a reduction in official rates and, as a result, in the total amount of 'interest paid'. The cost ratio remained more or less stable during the period 1995-1998 but fell again in 1999, this time as a result of the considerable increase in bank assets, to some extent

[6] This restriction is required for the translog cost function to satisfy duality theory. It implies that if all input prices were multiplied by a factor k, then total cost will also be multiplied by this factor k. See for example Nadiri (1982).

attributed to the doubling of share prices on the Athens Stock Exchange. Cost ratios differed significantly among banks at the beginning of the sample period but these differences gradually narrowed. This convergence in bank cost ratios was due to the more pronounced improvement in the cost ratios of the least efficient institutions as well as mergers that took place during the period, which typically involved banks with very different cost ratios. It should be pointed out that because of these mergers the sample contained 20 institutions in 1993 but only 15 in 1999, while their number was further reduced to 10 in the coming years. As a matter of fact it is because of this merger activity that the period of analysis was not extended with the more recent data for the years 2000-2002.

The profitability ratio also improved during the period of analysis as ROA increased from 0.84% in 1993 to 2.84% in 1999 (see Figure 1), but it should be borne in mind that 1999 was a year of exceptional profits for banks because of the doubling of share prices which allowed banks to realise profits on shares held and also increased the level of turnover on the stock market. Since a lot of this business went to banks, huge commissions were made for banks from dealing in shares on behalf of their customers. In general, differences among banks are quite pronounced though the sample contains certain outliers in the sense that some banks have recorded losses or exceptional profits. Excluding these outliers, the data indicate significant and persistent divergences in bank profitability during the period of analysis, with the ROA exhibiting greater dispersion than cost ratios not only through time but also across banks (see Table1).

As far as the output of banks in the sample is concerned, in 1999 about a third of their assets constituted loans granted to domestic residents. The loan to assets ratio increased from 25.9% in 1993 to 36.3% in 1999, while significant differences existed among individual institutions. As with the cost ratio, differences among banks gradually diminished mainly as a result of mergers. Other earning assets of banks include securities and in particular Greek government paper. The relative amount of securities held by the sampling banks declined from 31.9% (with a minimum value of 3.2% and a maximum of 42.4%) of total assets in 1994 to 24.4% in 1999, despite the fact that the large increase of share prices has boosted the value of securities.

Other variables included in the cost function are the unit cost of loanable funds, the unit cost of labour and the unit cost of physical capital. The cost of loanable funds is calculated by dividing total interest paid by total deposits and repos and is

obviously closely linked to developments in interest rates. Indeed, the main characteristic of the period of analysis is the drastic reduction in bank interest rates, with the key savings deposit rate declining from 17.5% in 1993 to 8.0% in 1999, while the rate on deposits with an agreed maturity up to 12 months fell in the same period from 19.4% to 8.7%. As a result of these cuts, the cost of loanable funds for the sampling banks declined from 12.3% in 1993 to 6.9% in 1999. Differences among banks were again more pronounced in 1993 than in 1999 (see Table 1).

The price of labour (personnel expenses over the number of employees) increased from 5.7 million drachmas in 1993 to 11.1 million in 1999, which implies an average annual increase of 5,4% in real terms. If we exclude certain outliers connected with a small bank, differences in the price of labour among banks in the sample look persistent and there is no indication that they diminished with the passage of time. In general, the maximum value of the unit price of labour exceeds the corresponding minimum value by a factor of 1.9.

Finally, the price of physical capital, which is calculated by dividing depreciation expenses by the amount of fixed assets, exhibits the largest variability among banks in the sample. This is hardly surprising since the sample includes on the one hand the big and long established banks and on the other a set of new and fast expanding institutions. In 1993, the price of capital was ranged from 4.3% to 20.3% with an average value of 8.9%, whereas at the end of the sampling period the range was 16.0% to 53.1% with an average value of 23.4%.

5. Results

5.1. Efficiency estimates

Equation (5) is fitted to an unbalanced and a balanced sample of the 18 banks. In the unbalanced sample the observations of a bank stop when it is involved in a merger (for example, the observations for the National Bank of Greece stop at 1997, since in 1998 it merged with the National Mortgage Bank[7]). The balanced sample is obtained by imputing values for the merged banks after the merging. The imputation (for a particular variable) is based on the share of the merged banks to the total value of both banks the year before the merger occurred.

Initially a model with bank specific constants is fitted. In this model the bank with the smallest constant comprises an estimate of the cost frontier of the banks in the sample. The exponent of the difference of a bank specific constant from the frontier is an estimate of that bank's relative efficiency, i.e. $\exp(-\hat{u}_i = a_i - a)$. The estimated relative efficiencies range from 20% to 83% for the unbalanced sample and from 14% to 80% for the balanced sample, with average efficiency 48% and 56%, respectively. The latter indicate that banks could save on average around 50% of their realised costs if X-inefficiencies were eliminated. This is a rather large value, and it may be biased as a result of estimation errors. The estimation may be hampered by the small sample (i.e. the random errors may not have all cancelled out as expected in larger samples, leading to an inflation of the estimated inefficiencies). To combat this problem Maudos *et al* (2002) truncate the extreme values from the estimated inefficiencies. In this study, the truncation of the two extreme banks closest to or at the cost frontier is proposed, since these two banks had a very narrow scope of activities and one of them was also affiliated with a foreign bank for part of the estimation period. The substitution of their estimates with the estimate of the third most efficient bank gives average efficiencies of 69% and 67% for the two samples. Furthermore, substituting the least efficient bank with the second least efficient one left average efficiencies almost unaffected (70% and 68%), indicating that these estimates are relatively robust.[8] The estimated efficiencies (computed after the substitution of the values of the two most efficient banks) are plotted in descending order (for the unbalanced sample) in Figure 2. As the figure suggests the majority of banks lie around the average.

The above estimates of average cost efficiency for Greek banks do not seem to be significantly different from the corresponding estimates for European banks. Vennet (2002) investigates cost efficiency for a sample comprising banks from 17 European countries[9] for the period 1995-96 and found that the overall average cost

[7]Eurobank, which acquired three smaller private banks throughout 1993-99, is included as merged because the mergers were relatively small and they did not result in severe breaks in the variables considered.

[8] This measure of efficiency assumes that the cost frontier and relative efficiencies remain constant over time. Yet both absolute and relative cost efficiencies inevitably change, in part because the financial reforms may have affected the efficiency of the banking sector and thus shifted the cost frontier. Evaluating the cost frontier and the relative X-inefficiencies in various sub-periods could provide some indication on these shifts. However, the lack of sufficient degrees of freedom prevents us from addressing this issue.

[9] The sample investigated by Vennet (2002) includes 2,375 banks from all EU-member countries plus Norway and Switzerland.

efficiency for the entire sample is 70 per cent for the traditional bank intermediation activities, i.e. extending loans and holding securities.[10] Furthermore, Maudos *et al* (2002), using a fixed effects model similar to ours for a sample of banks from 10 EU-member countries,[11] has estimated an average efficiency which is higher than that for Greek banks (Greece: 70%, EU-10: 76.9% or 86.6%[12]), though their difference is not statistically significant.[13] Considering the estimates for individual 10 EU countries at 5% truncation, one can conclude that Greek banks seem to be more efficient than those in Finland and Luxembourg , to be as efficient as banks in the UK, France, Italy and Portugal. By contrast, they are less efficient than the banks in the remaining countries in the sample, in particular German and Austrian banks which emerge as the most efficient in this study. At 10% truncation though, only banks in Finland and Luxembourg have average efficiency levels similar to the Greek banks.

As stated above, the coefficient on *t* may be regarded as an indicator of the impact of technical change on cost efficiency (see Lozano-Vivas (1998)). The estimated coefficient is not statistically significant for either sample. Similarly, fitting a model with a common constant and time does not give a significant time coefficient either.[14] This is a surprising result, given the important investment that Greek banks had made throughout the sample period in modernising their production process and distribution channels, in particular in the area of information technology. It could be argued that it takes some time for such investments to affect productivity. To test the robustness of this result, a model with a common constant and time dummies for the seven years of the sample (6 dummies were used) fitted as an alternative. This model gave statistically significant (at 5% or 10% level) negative coefficients for all years after 1994 in the case of the balanced sample, and for 1995, 1996, and 1997 in the case of the unbalanced sample (see Tables A and B in the Appendix). It is also of interest to note that all coefficients are negative for the 1995-1999. These findings

[10] The estimated average efficiency is higher (80 per cent) if the output includes non-traditional activities, such as stock trading and insurance. This suggests that the traditional model may underestimate efficiency (Vennet, 2002).

[11] Maudos *et al* (2002) have investigated the efficiency of 832 banks of relatively large size (all banks in the sample have more than $1000 in assets) over the period 1993-96. Their sample contains banks from 10 EU- member countries, namely Austria, Belgium, Germany, Finland, France, Italy, Luxembourg, Portugal, Spain, and the UK.

[12] With 5% and 10% truncation of the extreme values respectively.

[13] The standard error of the estimated average EU-10 cost efficiency is reported to be 9.3% (see Maudos et al (2002)), implying that the estimated average cost efficiency for Greek banks is well within the area defined by subtracting from and adding two standard errors to the EU-10 average.

suggest that although technical changes were not found to be associated with a continuous improvement in cost performance throughout the sample period, they seem to be quite important in the period 1995-1999 and indeed to have had marked effects in particular years within this period.

5.2 Explaining inefficiencies

Figure 2, where the particular labels indicate the size (large/small depending whether their assets are above or below three billion euros) and the type of ownership (pubic/private) of individual banks, suggests that these two characteristics are important in explaining bank cost efficiencies: the small private banks seem to be the most efficient ones (average efficiency including the three banks on the frontier 81% or 82% for the balanced and unbalanced samples respectively), while the large public banks are shown to be the least efficient (average 43% and 35%, respectively). Furthermore, the small public banks are on average (average efficiency 75% for both samples) less efficient than the small private ones but more efficient than the private large banks (average efficiency 63% or 52%).

In the literature, factors other than size and type of ownership have been found to affect a bank's efficiency. Such factors are the type/ specialisation of the bank, the number of branches and attitudes to risk. With the exemption of one institution, the sample used here includes only commercial banks which to a considerable extent offer a similar variety of products. Thus, only the number of branches or attitudes to risk might be important here. Attitudes to risk can be proxied by equity and the ratio of loans to assets. Maudos *et al* (2002) argue that large equity implies risk aversion, since a risk-averse bank will tend to have more financial capital than the optimum (the minimiser of costs or the maximiser of profits). On the other hand, a high loan to assets ratio implies a willingness to take on risks.[15]

To investigate whether the above mentioned factors are important in explaining Greek bank inefficiencies, their correlations with the estimated inefficiencies were computed, but, in addition, these variables were included in the cost function to test their significance.

[14] It is noted that Karafolas and Mantakas (1996) also fail to detect any impact of technical change on the cost function.
[15] See also Mester (1996).

The correlations are presented in Table 2. As the results indicate, the inefficiencies show a strong positive correlation with size of assets and also with own funds. It seems therefore that, in the Greek banking sector, the larger a bank is and the higher its own funds are the more inefficient it is. The positive correlation of own funds with inefficiencies can easily be explained if own funds are regarded as a proxy for size. But it is also consistent with the argument that large equity implies risk aversion and consequently higher inefficiency.

In line with the above, the estimated inefficiencies are negatively correlated with the loan to assets ratio, a measure of the willingness to take on risk, implying that risk-taking banks are more efficient. It may be argued though that this finding simply reflects the fact that most of the small banks are also relatively newly established and thus have a higher loan to assets ratio as they were less affected by past credit restrictions.

A strong positive correlation between inefficiencies and the number of branches is also evident. This suggests that the higher overhead costs imposed by a large number of branches dominates any cost savings derived by the broader and cheaper deposit base. This result may also reflect that banks are under strong pressures to open branch offices in order to reduce customers' transaction costs and thus gain a competitive edge , eventhough this strategy may not be efficient in the short run. In any case, this finding indicates that Greek banks can improve their performance if they seek to optimize the size of their branch network, by reducing, for example, branchs in overlapping markets.

The results from fitting the cost function with the above factors as additional explanatory variables are presented in the Appendix in Tables A and B. A group effects model testing for differences among the four groups[16] -private-large, private-small, public-large and public-small -does not give statistically significant differences between the groups (for either the unbalanced or the balanced sample, see model 2 in Tables A and B in the Appendix). Rerunning the model with group effects for the size characteristic (large/small) only does not give statistically significant differences between the two (see models 5 and 6), though a model with a common constant and the size of assets as an additional explanatory variable gives a positive and statistically significant coefficient for assets (see model 7). This indicates that the larger a bank is

[16] That is a model with dummies for the above bank characteristics instead of the bank specific ones.

the more inefficient it is.[17] A model with group effects for private / public banks shows that private banks are on average 9% or 7% more efficient than the public banks (see model 3). Furthermore, a model with these two groups (private/public) and their time interactions shows a negative effect for private banks (see model 4), indicating that the private banks were benefiting from reductions in costs of the order of 3% to 4% per annum as a consequence of technical change.

Finally, the inclusion of the number of branches[18] or of the own funds into the cost function gave positive but statistically insignificant impacts (see Table A and B, models 8 and 9, respectively). Thus, though they seem to have an impact on costs, the inclusion of these variables in the cost function does not alter significantly the estimated inefficiencies. Accordingly, both these results are taken to be supportive of the conclusions drawn on the basis of the simple correlations of these variables with the estimated cost inefficiencies.

5.3 Scale economies

Table 2 reports the estimated values of scale economies using both the unbalanced and the balanced samples. The values in this Table indicate the percentage increase in costs if all outputs were increased by 1%. All reported values are below unity and hence indicate that Greek banks experienced scale economies in the period 1993-99. According to the unbalanced sample estimates, these economies averaged 12%. Scale economies fell during the sample period from 20% in 1993 to only 8% in 1999. As noted above, until the early 1990s the conduct of banking business was governed by strict regulations, which acted as important constraints on the growth of banks' balance sheets. The gradual removal of these regulations strengthened banks' assets and liabilities management and have accordingly led to more efficient bank sizes. As expected, economies of scale are shown to be more important for the 12 smaller banks (14%) than for the 6 larger banks (10%). In both cases, however, the estimated values indicate that further consolidation could lead to more efficient institutions and improve their competitive viability. Balanced sample estimates lead in

[17] A similar finding is reported by Allen and Rai (1996).

[18] A model that included the number of branches and the interaction of this variable with the variable for technological change yielded positive but again statistically insignificant coefficients.

general to same conclusions, though the estimated economies of scale are in this case somewhat larger.[19]

6. Conclusions

This study investigated cost efficiency of Greek banks between 1993-1999, a period characterised by major changes in the banking sector brought about by gradual financial deregulation. The 'distribution free' approach was used, whereby a fixed effects model was fitted to a panel of 18 banks. Despite the fact that the number of banks is not large and the consistency of the estimators may be questioned, the results obtained can be considered indicative of conditions in the Greek banking system. Greek banks were found to exhibit substantial cost inefficiencies, indicating that there is significant room for improving their competitiveness and profitability. However, it should be noted that the estimated X-inefficiencies are not, on average, different from these found in studies for other European banks.

Additionally, the study explored the potential relationships between various bank characteristics and cost inefficiency and found that bank size, type of ownership (private /public) and attitude to risk seem to be related to bank inefficiencies. In particular, large, public and risk averse banks tend to be more inefficient.

During the sample period, banks made significant investments in technology, in particular in information systems. Such technical change seems to have had a beneficial effect on costs, but only after 1995. This is expected since, in general, such investments need time to pay off. Private banks were found to benefit more from technical change, managing to reduce cost inefficiency throughout the sample period. However, a caveat should be added here, the time indicator used may not be an adequate proxy of technical change, capturing simply the effect of other variables not included in the model.

Scale economies were also examined. The Greek banking sector is characterised by important scale economies, although they have declined throughout the estimation period. It seems, therefore, that further consolidation may prove beneficial for Greek banks (taking also into account the European orientation they exhibit).

[19] The inconsistency in the results for the groups of small and large banks perhaps reflects the distortion of the means of the relevant variables because of the imputation.

Using costs in evaluating efficiency may not be sufficient to make inferences about banks' overall performance, as it does not take into account the revenue side. Output quality as well as market power may have a significant effect on revenues and profits and, indeed, profit efficiency will be the subject of further research. It can be argued, however, that efficiency as it is inferred from costs, provides a lower boundary estimate for the competitive viability of various banks, in particular in the more intensely competitive environment in which Greek banks operate.

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Table 1: Summary Statistics of Banks in the Sample

		1993	1994	1995	1996	1997	1998	1999
Cost/asset ratio[1] (%)	Average	11.8	11.9	10.3	10.1	9.6	9.6	8.5
	Maximum	17.1	18.4	17.5	18.5	13.2	12.9	10.7
	Minimum	8.3	6.5	7.1	6.2	6.3	4.6	4.2
Profitability ratio[2] (%)	Average	0.84	1.12	1.14	0.81	0.99	1.18	2.84
	Maximum	4.06	3.66	3.95	4.26	4.10	3.84	6.93
	Minimum	0.38	0.24	0.20	0.03	0.04	0.00	0.61
Loans/assets ratio (%)	Average	25.9	25.4	29.2	29.8	32.7	37.8	36.3
	Maximum	42.3	43.6	53.9	59.7	67.6	63.7	48.6
	Minimum	10.6	11.5	11.7	12.3	13.6	21.2	14.2
Securities/assets ratio (%)	Average	31.9	26.5	22.2	24.8	28.1	23.4	24.4
	Maximum	53.4	39.6	35.4	45.4	42.2	33.8	37.7
	Minimum	2.0	1.8	1.5	2.5	2.6	2.8	7.5
Cost of loanable funds[3] (%)	Average	12.3	13.6	10.9	10.8	9.0	8.0	6.9
	Maximum	18.5	18.1	14.6	14.3	13.4	12.2	9.6
	Minimum	4.6	5.7	6.8	7.3	6.0	3.8	3.9
Price of labour[4] (Drs. million)	Average	5.7	6.5	7.3	8.6	9.4	9.9	11.1
	Maximum	9.7	9.8	9.6	11.3	12.0	11.6	13.5
	Minimum	4.3	5.1	5.9	5.9	6.5	6.1	7.0
Price of capital[5] (%)	Average	8.9	12.2	15.4	15.9	17.9	21.2	23.4
	Maximum	20.3	30.6	51.9	48.5	49.4	50.5	53.1
	Minimum	4.3	5.0	7.0	7.1	9.7	11.3	16.0

[1] Operating expenses and interest paid as a percentage of total assets.
[2] Return on assets, ROA.
[3] Total interest paid as a percentage of deposits plus repos.
[4] Personnel expenses over the number of employees.
[5] Depreciation expenses as a percentage of fixed capital.

Source: Bank of Greece

Table 2: Correlations between inefficiency terms and bank characteristics

	Unbalanced sample	Balanced sample
Assets	0.87	0.93
Own funds	0.76	0.87
Loan/asset ratio	-0.55	-0.45
No of branches	0.78	0.91

Table 3: Estimated scale economies

	Unbalanced sample	Balanced sample
All 18 banks	0.88	0.78
All 18 banks in 1993	0.80	0.75
Al 18 banks in 1999	0.92	0.80
6 large banks	0.90	0.70
12 small banks	0.86	0.82

Figure 1. Total cost and profit (as a percentage of total assets)

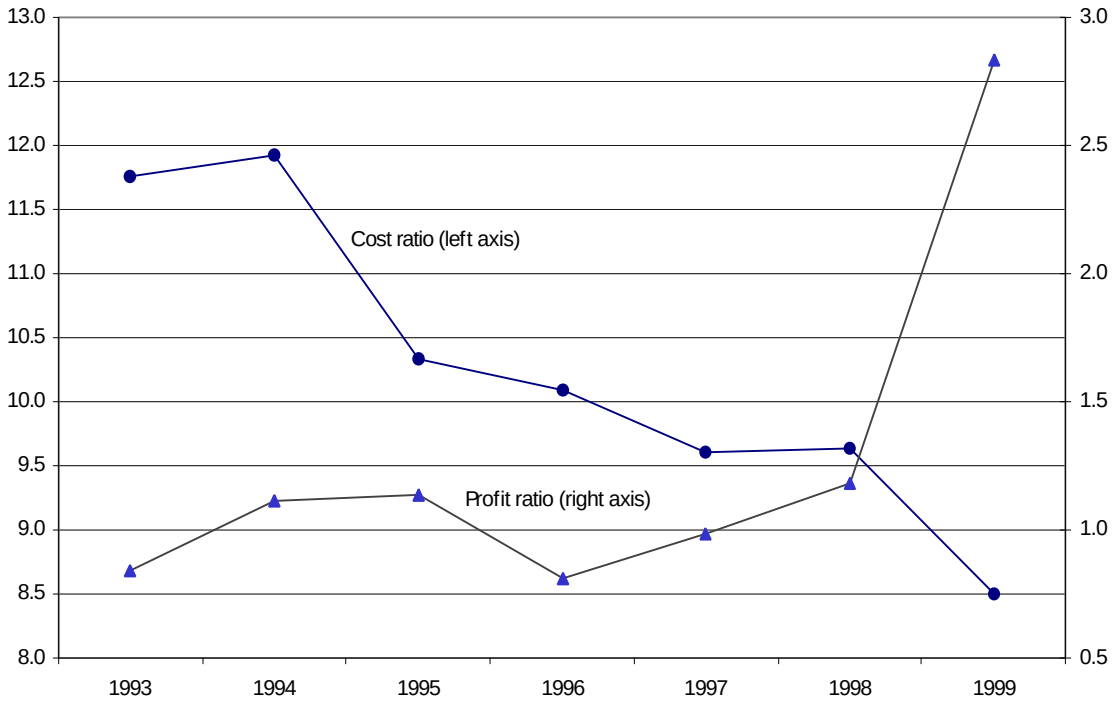

Figure 2. Estimated efficiencies from the unbalanced and balanced samples

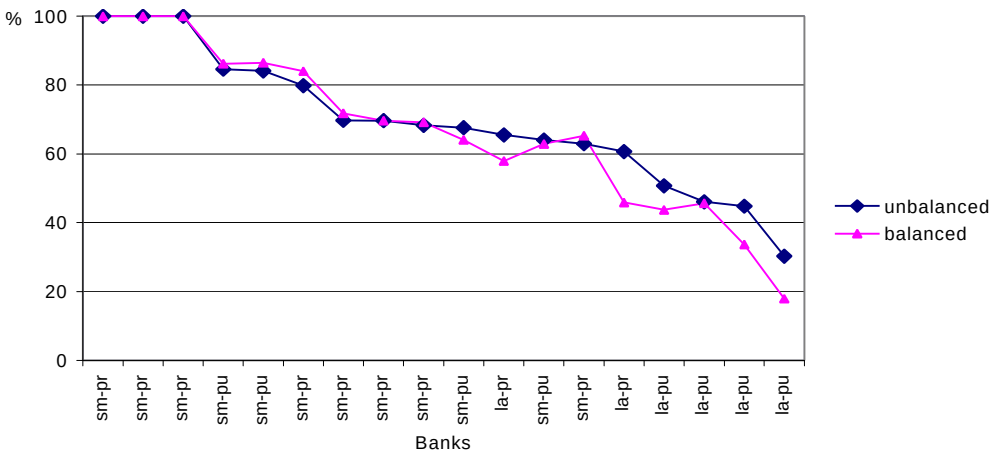

TABLE A: Model coefficients and probability values, unbalanced data

Models	1		2		3		4		5	
	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value
a			2.23	0.41	2.60	0.35	3.22	0.25	2.56	0.37
Y_1	-0.70	0.13	0.36	0.53	0.78	0.15	0.76	0.16	0.91	0.11
Y_2	1.20	0.02	0.46	0.48	0.30	0.65	0.16	0.81	0.31	0.65
Y_3	0.15	0.67	-0.45	0.36	-0.63	0.21	-0.55	0.27	-0.68	0.19
P_1	1.33	0.01	-0.18	0.78	-0.06	0.92	0.04	0.95	0.10	0.87
P_2	0.51	0.52	1.46	0.14	0.89	0.37	0.72	0.47	0.57	0.56
P_3	-0.84	0.09	-0.28	0.62	0.16	0.77	0.24	0.67	0.32	0.57
Y_1^2	-0.06	0.28	0.10	0.10	0.09	0.13	0.07	0.26	0.10	0.08
Y_2^2	0.04	0.05	-0.01	0.64	-0.01	0.83	0.00	0.95	-0.01	0.78
Y_3^2	0.03	0.24	0.00	0.98	0.02	0.61	0.01	0.76	0.03	0.44
P_1^2	0.12	0.18	0.01	0.95	0.03	0.80	0.01	0.94	0.04	0.77
P_2^2	-0.20	0.20	-0.26	0.18	-0.34	0.07	-0.26	0.18	-0.32	0.11
P_3^2	0.07	0.06	0.06	0.23	0.09	0.05	0.12	0.02	0.08	0.11
Y_1*Y_2	0.14	0.09	-0.02	0.80	-0.03	0.73	-0.01	0.93	-0.06	0.53
Y_1*Y_3	0.07	0.24	-0.09	0.17	-0.09	0.17	-0.06	0.40	-0.11	0.11
Y_1*P_1	-0.19	0.04	0.14	0.19	0.19	0.08	0.16	0.13	0.21	0.06
Y_1*P_2	0.11	0.38	-0.05	0.77	-0.04	0.80	-0.09	0.59	-0.04	0.79
Y_1*P_3	0.02	0.80	0.16	0.08	0.20	0.03	0.22	0.01	0.18	0.05
Y_2*Y_3	-0.18	0.02	0.08	0.41	0.06	0.55	0.03	0.78	0.07	0.48
Y_2*P_1	0.21	0.02	0.03	0.81	-0.03	0.76	-0.07	0.50	-0.06	0.57
Y_2*P_2	-0.24	0.18	-0.34	0.12	-0.25	0.24	-0.27	0.21	-0.23	0.29
Y_2*P_3	0.22	0.02	0.01	0.95	-0.03	0.83	-0.02	0.90	-0.08	0.51
Y_3*P_1	0.01	0.82	-0.13	0.10	-0.13	0.11	-0.09	0.28	-0.12	0.17
Y_3*P_2	0.02	0.81	0.22	0.15	0.21	0.17	0.23	0.13	0.22	0.16
Y_3*P_3	-0.12	0.04	-0.10	0.26	-0.12	0.16	-0.15	0.09	-0.07	0.40
P_1*P_2	-0.26	0.16	-0.01	0.97	-0.01	0.97	-0.04	0.87	-0.09	0.72
P_1*P_3	-0.23	0.03	-0.15	0.31	-0.15	0.33	-0.22	0.15	-0.09	0.53
P_2*P_3	-0.14	0.39	-0.32	0.14	-0.44	0.05	-0.55	0.02	-0.36	0.10
TIME	0.01	0.65	-0.01	0.50	-0.02	0.25	0.01	0.76	-0.02	0.29
D94										
D95										
D96										
D97										
D98										
D99										
a_1 (large-public)	5.25	0.06								
a_2 (large-public)	4.86	0.08								
a_3 (large-public)	4.74	0.09								
a_4 (large-public)	4.83	0.09								
a_5 (large-private)	4.56	0.10								
a_6 (large-private)	4.48	0.11								
a_7 (small-private)	4.06	0.15								
a_8 (small-private)	4.52	0.11								
a_9 (small-private)	4.42	0.11								
a_{10} (small-private)	4.29	0.13								
a_{11} (small-private)	4.44	0.11								
a_{12} (small-private)	4.42	0.11								
a_{13} (small-private)	3.81	0.17								
a_{14} (small-private)	3.62	0.18								
a_{15} (small-public)	4.23	0.13								
a_{16} (small-public)	4.45	0.12								
a_{17} (small-public)	4.51	0.11								
a_{18} (small-public)	4.23	0.13								
PUBLIC-SMALL			0.00	0.98						
PRIVATE-LARGE			-0.10	0.30						
PUBLIC-LARGE			0.18	0.10						
PRIVATE					-0.07	0.09	0.07	0.43		
PRIVATE* TIME							-0.04	0.06		
LARGE									-0.02	0.86
LARGE * TIME										
ASSETS										
BRANCHES (BR)										
(BR)*(BR)										
OWN FUNDS										

TABLE A (continued)

Models	6		7		8		9		10	
	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value
a	1.27	0.73	2.34	0.36	2.90	0.34	2.65	0.35	0.91	0.75
Y_1	1.00	0.10	0.68	0.16	0.96	0.09	0.90	0.11	0.76	0.18
Y_2	0.36	0.60	0.78	0.22	0.24	0.73	0.36	0.61	0.03	0.96
Y_3	-0.64	0.22	-0.94	0.04	-0.67	0.18	-0.71	0.16	-0.35	0.49
P_1	-0.09	0.91	0.36	0.53	0.08	0.90	0.14	0.83	-0.97	0.18
P_2	0.71	0.49	0.34	0.70	0.58	0.55	0.54	0.58	1.51	0.14
P_3	0.37	0.52	0.29	0.56	0.34	0.54	0.32	0.57	0.46	0.42
Y_1^2	0.10	0.10	0.08	0.16	0.07	0.23	0.11	0.08	0.11	0.07
Y_2^2	-0.01	0.84	-0.01	0.58	-0.01	0.70	-0.01	0.70	0.00	0.89
Y_3^2	0.03	0.42	0.03	0.43	0.01	0.83	0.03	0.46	0.06	0.15
P_1^2	0.04	0.77	0.02	0.86	0.01	0.92	0.04	0.73	-0.03	0.80
P_2^2	-0.31	0.13	-0.29	0.09	-0.24	0.23	-0.35	0.08	-0.53	0.01
P_3^2	0.08	0.09	0.05	0.26	0.10	0.04	0.07	0.12	0.03	0.59
Y_1*Y_2	-0.06	0.57	-0.07	0.43	-0.03	0.73	-0.07	0.47	-0.05	0.61
Y_1*Y_3	-0.11	0.10	-0.08	0.22	-0.08	0.24	-0.11	0.10	-0.15	0.04
Y_1*P_1	0.21	0.06	0.13	0.17	0.16	0.13	0.19	0.09	0.18	0.09
Y_1*P_2	-0.05	0.78	0.03	0.84	-0.06	0.73	-0.02	0.92	0.04	0.79
Y_1*P_3	0.18	0.05	0.10	0.23	0.20	0.03	0.17	0.06	0.11	0.21
Y_2*Y_3	0.07	0.52	0.07	0.46	0.07	0.47	0.09	0.41	0.05	0.62
Y_2*P_1	-0.04	0.71	-0.01	0.89	-0.04	0.72	-0.05	0.62	-0.09	0.43
Y_2*P_2	-0.23	0.29	-0.24	0.22	-0.26	0.24	-0.23	0.29	-0.19	0.37
Y_2*P_3	-0.07	0.57	-0.04	0.74	-0.01	0.93	-0.09	0.48	-0.16	0.19
Y_3*P_1	-0.12	0.16	-0.10	0.18	-0.11	0.16	-0.11	0.19	-0.05	0.51
Y_3*P_2	0.20	0.20	0.19	0.16	0.22	0.15	0.21	0.18	0.19	0.23
Y_3*P_3	-0.09	0.34	-0.05	0.52	-0.14	0.12	-0.07	0.43	0.00	0.98
P_1*P_2	-0.08	0.73	-0.05	0.82	-0.06	0.80	-0.06	0.81	0.25	0.34
P_1*P_3	-0.10	0.49	0.03	0.83	-0.17	0.27	-0.10	0.52	-0.09	0.53
P_2*P_3	-0.40	0.08	-0.16	0.41	-0.50	0.03	-0.34	0.13	-0.17	0.45
TIME	-0.03	0.24	-0.01	0.43	-0.03	0.20	-0.02	0.30		
D94									-0.01	0.89
D95									-0.15	0.06
D96									-0.23	0.01
D97									-0.22	0.03
D98									-0.16	0.14
D99									-0.10	0.41
a_1 (large-public)										
a_2 (large-public)										
a_3 (large-public)										
a_4 (large-public)										
a_5 (large-private)										
a_6 (large-private)										
a_7 (small-private)										
a_8 (small-private)										
a_9 (small-private)										
a_{10} (small-private)										
a_{11} (small-private)										
a_{12} (small-private)										
a_{13} (small-private)										
a_{14} (small-private)										
a_{15} (small-public)										
a_{16} (small-public)										
a_{17} (small-public)										
a_{18} (small-public)										
PUBLIC-SMALL										
PRIVATE-LARGE										
PUBLIC-LARGE										
PRIVATE										
PRIVATE* TIME										
LARGE	-0.09	0.59								
LARGE * TIME	0.02	0.60								
ASSETS			0.19	0.00						
BRANCHES (BR)					0.03	0.83				
(BR)*(BR)					0.01	0.56				
OWN FUNDS							0.02	0.64		

TABLE B: Model coefficients and probability values, balanced data

Models	1		2		3		4		5	
	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value
a			2.42	0.31	3.27	0.19	3.30	0.18	3.41	0.18
Y_1	0.24	0.60	0.12	0.83	0.57	0.24	0.66	0.18	0.62	0.26
Y_2	1.07	0.02	0.25	0.68	0.07	0.91	-0.02	0.97	0.08	0.90
Y_3	-0.03	0.93	-0.37	0.43	-0.59	0.20	-0.52	0.26	-0.60	0.22
P_1	1.75	0.00	-0.62	0.31	-0.39	0.52	-0.27	0.67	-0.28	0.66
P_2	0.48	0.53	2.39	0.01	1.63	0.07	1.38	0.13	1.39	0.14
P_3	-1.22	0.00	-0.77	0.13	-0.24	0.62	-0.12	0.81	-0.11	0.83
Y_1^2	-0.02	0.70	0.05	0.28	0.05	0.30	0.03	0.50	0.06	0.27
Y_2^2	0.00	0.89	0.00	0.88	0.00	0.98	0.01	0.72	0.00	0.98
Y_3^2	0.00	0.97	0.01	0.84	0.02	0.55	0.02	0.59	0.04	0.36
P_1^2	0.15	0.07	0.02	0.83	0.09	0.41	0.09	0.40	0.08	0.51
P_2^2	-0.20	0.16	-0.36	0.05	-0.45	0.01	-0.41	0.02	-0.42	0.02
P_3^2	0.07	0.03	0.05	0.27	0.08	0.06	0.10	0.02	0.06	0.16
Y_1*Y_2	0.04	0.56	0.07	0.40	0.04	0.64	0.05	0.51	0.03	0.74
Y_1*Y_3	0.01	0.77	-0.08	0.18	-0.08	0.19	-0.05	0.39	-0.09	0.15
Y_1*P_1	-0.07	0.34	0.13	0.18	0.18	0.06	0.18	0.06	0.18	0.07
Y_1*P_2	0.08	0.46	0.03	0.83	0.03	0.80	0.00	0.99	0.03	0.83
Y_1*P_3	0.09	0.15	0.11	0.19	0.15	0.07	0.17	0.04	0.11	0.20
Y_2*Y_3	-0.04	0.50	0.04	0.67	0.03	0.70	0.00	1.00	0.03	0.74
Y_2*P_1	0.04	0.58	0.09	0.32	0.05	0.62	0.01	0.93	0.02	0.82
Y_2*P_2	-0.25	0.14	-0.46	0.02	-0.31	0.12	-0.29	0.14	-0.32	0.12
Y_2*P_3	0.20	0.00	0.09	0.35	0.05	0.64	0.05	0.65	0.00	0.98
Y_3*P_1	0.00	0.93	-0.15	0.05	-0.15	0.04	-0.13	0.09	-0.12	0.12
Y_3*P_2	0.05	0.53	0.22	0.09	0.20	0.14	0.20	0.14	0.22	0.12
Y_3*P_3	-0.13	0.02	-0.09	0.20	-0.11	0.12	-0.13	0.07	-0.05	0.45
P_1*P_2	-0.25	0.14	0.06	0.77	0.09	0.67	0.07	0.73	0.00	0.99
P_1*P_3	-0.23	0.02	-0.17	0.18	-0.12	0.34	-0.18	0.18	-0.10	0.47
P_2*P_3	-0.27	0.05	-0.26	0.16	-0.33	0.08	-0.42	0.03	-0.27	0.16
TIME	0.00	0.95	-0.02	0.35	-0.02	0.18	0.00	0.85	-0.02	0.18
D94										
D95										
D96										
D97										
D98										
D99										
a_1 (large-public)	2.34	0.34								
a_2 (large-public)	1.72	0.50								
a_3 (large-public)	1.45	0.57								
a_4 (large-public)	1.41	0.58								
a_5 (large-private)	1.41	0.58								
a_6 (large-private)	1.17	0.65								
a_7 (small-private)	0.63	0.81								
a_8 (small-private)	1.05	0.69								
a_9 (small-private)	0.99	0.70								
a_{10} (small-private)	0.80	0.76								
a_{11} (small-private)	0.99	0.70								
a_{12} (small-private)	0.96	0.71								
a_{13} (small-private)	0.41	0.87								
a_{14} (small-private)	0.41	0.87								
a_{15} (small-public)	0.77	0.76								
a_{16} (small-public)	1.07	0.68								
a_{17} (small-public)	1.09	0.67								
a_{18} (small-public)	0.77	0.77								
PUBLIC-SMALL			0.01	0.78						
PRIVATE-LARGE			-0.12	0.26						
PUBLIC-LARGE			0.18	0.12						
PRIVATE					-0.09	0.03	0.04	0.67		
PRIVATE* TIME							-0.03	0.09		
LARGE									-0.03	0.77
LARGE * TIME										
ASSETS										
BRANCHES (BR)										
(BR)*(BR)										
OWN FUNDS										

TABLE B (continued)

Models	6		7		8		9		10	
	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value	coeffs	p-value
a	2.45	0.48	2.65	0.27	2.63	0.33	3.44	0.18	1.04	0.69
Y_1	0.70	0.24	0.52	0.27	0.95	0.06	0.65	0.20	0.76	0.13
Y_2	0.09	0.89	0.34	0.56	0.24	0.70	0.09	0.88	-0.34	0.59
Y_3	-0.56	0.26	-0.80	0.07	-0.76	0.10	-0.65	0.17	-0.34	0.47
P_1	-0.42	0.56	-0.15	0.79	-0.06	0.92	-0.25	0.69	-1.35	0.06
P_2	1.48	0.12	1.34	0.12	1.06	0.24	1.35	0.14	2.33	0.02
P_3	-0.07	0.90	-0.19	0.68	0.00	1.00	-0.11	0.83	0.02	0.97
Y_1^2	0.06	0.28	0.04	0.42	0.04	0.40	0.06	0.26	0.04	0.45
Y_2^2	0.00	0.95	-0.01	0.65	-0.01	0.59	0.00	0.91	0.01	0.66
Y_3^2	0.04	0.35	0.02	0.51	0.01	0.74	0.03	0.40	0.05	0.15
P_1^2	0.08	0.49	0.06	0.57	0.11	0.33	0.08	0.46	0.01	0.90
P_2^2	-0.42	0.02	-0.45	0.01	-0.37	0.04	-0.45	0.01	-0.65	0.00
P_3^2	0.07	0.14	0.03	0.49	0.09	0.05	0.06	0.16	0.03	0.43
Y_1*Y_2	0.03	0.74	0.00	0.98	0.02	0.85	0.02	0.82	0.06	0.44
Y_1*Y_3	-0.09	0.14	-0.06	0.32	-0.08	0.17	-0.09	0.15	-0.10	0.11
Y_1*P_1	0.18	0.07	0.11	0.23	0.19	0.05	0.17	0.11	0.16	0.10
Y_1*P_2	0.02	0.87	0.08	0.53	0.05	0.72	0.04	0.80	0.02	0.89
Y_1*P_3	0.12	0.18	0.04	0.61	0.14	0.08	0.11	0.18	0.08	0.35
Y_2*Y_3	0.03	0.75	0.05	0.51	0.07	0.44	0.04	0.64	-0.01	0.86
Y_2*P_1	0.03	0.74	0.07	0.48	0.04	0.67	0.03	0.80	-0.01	0.92
Y_2*P_2	-0.31	0.14	-0.25	0.19	-0.34	0.10	-0.32	0.12	-0.25	0.21
Y_2*P_3	0.00	0.99	0.02	0.84	0.07	0.48	0.00	0.97	-0.04	0.69
Y_3*P_1	-0.12	0.11	-0.11	0.13	-0.16	0.03	-0.12	0.14	-0.06	0.46
Y_3*P_2	0.20	0.17	0.16	0.22	0.21	0.11	0.22	0.11	0.24	0.09
Y_3*P_3	-0.06	0.40	-0.02	0.74	-0.14	0.06	-0.06	0.41	-0.02	0.73
P_1*P_2	0.00	1.00	0.07	0.75	0.05	0.83	0.01	0.96	0.27	0.25
P_1*P_3	-0.11	0.43	-0.01	0.91	-0.08	0.54	-0.10	0.46	-0.13	0.31
P_2*P_3	-0.30	0.15	-0.07	0.70	-0.35	0.06	-0.26	0.18	-0.21	0.28
TIME	-0.03	0.17	-0.03	0.11	-0.02	0.34	-0.02	0.18		
D94									-0.04	0.51
D95									-0.18	0.02
D96									-0.26	0.00
D97									-0.26	0.01
D98									-0.20	0.04
D99									-0.18	0.10
a_1 (large-public)										
a_2 (large-public)										
a_3 (large-public)										
a_4 (large-public)										
a_5 (large-private)										
a_6 (large-private)										
a_7 (small-private)										
a_8 (small-private)										
a_9 (small-private)										
a_{10} (small-private)										
a_{11} (small-private)										
a_{12} (small-private)										
a_{13} (small-private)										
a_{14} (small-private)										
a_{15} (small-public)										
a_{16} (small-public)										
a_{17} (small-public)										
a_{18} (small-public)										
PUBLIC-SMALL										
PRIVATE-LARGE										
PUBLIC-LARGE										
PRIVATE										
PRIVATE* TIME										
LARGE	-0.08	0.61								
LARGE * TIME	0.01	0.68								
ASSETS			0.19	0.00						
BRANCHES (BR)					-0.03	0.80				
(BR)*(BR)					0.02	0.29				
OWN FUNDS							0.01	0.76		

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