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Meryem Duygun, Vania Sena, Mohamed Shaban

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TRADEMARKING STATUS AND ECONOMIC EFFICIENCY AMONG
COMMERCIAL BANKS:
SOME EVIDENCE FOR THE UK

Meryem Duygun
School of Management
University of Leicester

Vania Sena*
Essex Business School
University of Essex

Mohamed Shaban
School of Management
University of Leicester

Abstract

We compare the cost and profit efficiency of trademarking and non-trademarking banks in the UK, over the period 2001-2012. We address self-selection into trademarking by using propensity score matching and explicitly test the hypothesis that trademarking and non-trademarking banks share the same cost and profit frontiers. We reject the hypothesis of a common profit frontier but we cannot reject the hypothesis of a common cost frontier. We also find that trademarking banks tend to be more profit efficient than non-trademarking banks while there is no significant difference between the cost efficiency scores of trademarking and non-trademarking banks.

Key words: propensity score matching, cost frontier, profit frontier, trademarks.

*Corresponding author. vsena@essex.ac.uk

1. Introduction

Since the nineties, the European banking sector has been substantially deregulated and liberalized so to better integrate the national banking markets and improve their competitiveness (Cetorelli, 2004). Researchers agree that the deregulation process did increase competition across the industry along several dimensions (Cetorelli, 2004). For instance, the deregulation of interest rates and the abolition of credit ceilings intensified price competition while the lifting of the restrictions on cross-border activities allowed national and foreign banks to compete directly.

As a result of the more competitive environment they had to face, commercial banks across Europe started to compete not only by altering the price of their products but also by offering a wider range of products and services, so to be able to attract new customers (Goddard et al. 2001). At the same time, they also started to make a more extensive use of trademarks¹ in an attempt to differentiate their products and services from those offered by their competitors while at the same time signaling their quality and distinctiveness. This increasing trademarking activity among banks is well documented for the UK. For instance, Greenhalgh and Rogers (2006) reported a surge of the trademarking activity in the financial services sector at the same time as the sector started to grow and competition intensified.

Despite the extensive use of trademarks among banks, very little is known about the actual impact of the trademarking activity on their performance. A couple of studies have focused on the association between the trademarking activity of commercial banks and their market value and have discovered that there exists a positive association between the value of the Tobin's q among commercial banks and their trademarking activity (Gonzalez-Pedraz and Majordomo, 2011; Greenhalgh and Rogers, 2006). However, trademarking may affect other dimensions of a bank's performance. For instance, by signaling the quality of the products offered by a bank, trademarks may help boost their demand with a positive impact on the bank's profits and possibly its profit efficiency. Equally, trademarks associated to products that allow a bank to reduce its costs may contribute to improve its cost efficiency.

¹ A trademark is defined as any sign (a word, a logo, a phrase, etc.) which makes the goods or the services offered by a firm distinctive.

However, in spite of its potential importance and interest, so far there has been no research on the role that trademarking can play in improving the economic efficiency of a commercial bank.

Against this background, the purpose of this paper is to fill this gap in the banking literature and compare the economic efficiency of trademarking and non-trademarking banks so to quantify the gain in efficiency a bank may experience as a result of its trademarking activity. Our analysis is conducted on an unbalanced panel of UK commercial banks, observed over the period 2001-2013 and we use the so-called “frontier” approach to the measurement of economic efficiency (Kumbhakar and Lovell, 2000).

Traditionally, the banking literature has focused on the concept of cost efficiency (Berger and Mester, 1997); however, as the main objective of a bank is to maximise its profits, fulfilling this goal requires that not only costs are minimised but that revenues are maximised as well. As pointed out by Maudos et al. (2002), computing profit efficiency, therefore, may be more interesting than just estimating cost efficiency. For instance, higher levels of profit inefficiency than of cost inefficiency may suggest some inefficiency either due to the wrong choice of output or to the mispricing of output (Berger and Mester, 1997; Rogers, 1998; Maudos et al., 2002). For these reasons, in our analysis we will focus on both cost and profit efficiency.

Comparing the efficiency (either cost or profit efficiency) of trademarking and non-trademarking commercial banks poses interesting challenges. The use of frontier analysis requires that the units under observation share the same frontier so that (in our case) differences among the efficiency scores of the two groups can be simply attributed to their trademarking status. However, it can be argued that trademarking banks may have access to a better technology which allows them to produce more innovative products and/or services which may boost their profits (or reduce their costs) and make them more profit (cost) efficient. If so, imposing a common (cost or profit) frontier to both trademarking and non-trademarking banks without controlling for their trademarking status may not be acceptable. At the same time, to be able to attribute changes of the banks’ performance to their trademarking status only, we need to ensure that the trademarking and non-trademarking banks we analyze share

the same characteristics (apart from for the trademarking status) in such a way that variations in efficiency among the two groups of banks can only be attributed to whether they trademark or not.

To address these issues, we use the following procedure. First of all, we use a class of matching models called Propensity Score Matching (PSM) - first proposed by Rosenbaum and Rubin (1983) - to identify among the non-trademarking banks a subset of banks whose main characteristics are similar to those of the trademarking banks. This procedure involves the estimation of a bank's trademarking propensity (propensity score) over a set of bank's characteristics. A non-trademarking bank is then selected as a match to the trademarking bank, using the radius matching method proposed by Dehejia and Wahba (2002).

Second, we run a formal test of the common frontier assumption; to this purpose, we estimate the stochastic frontier model proposed by Greene (2005) which allows inefficiency to vary over time while at the same time allowing to disentangle inefficiency from the bank's fixed effects. When estimating the frontier models, we will formally test whether trademarking and non-trademarking banks share a common cost (profit) frontier by introducing a dummy variable controlling for the trademarking status in the frontier models and then testing whether it is significant or not.

Our results show that: a) the assumption of a common cost and alternative profit frontiers for trademarking and non-trademarking banks cannot be rejected (although there exists some circumstantial evidence that the assumption of a common alternative profit frontier may be rejected for the period before 2008); b) trademarking banks tend to be more profit efficient: the mean score for the trademarking banks is 0.90 while the average score for non-trademarking banks is 0.83. The mean cost efficiency of trademarking banks (which is 0.99) is not significantly different from that of the non-trademarking banks (0.97).

The structure of the paper is the following. Section 2 reviews the small empirical literature on trademarking and firms' performance. Section 3 focuses on the empirical methodology as well as the data-sets and the measurement of the variables. The

empirical results are presented in Section 4. Finally, Section 5 offers some conclusions.

2. Trademarking activity and performance

As mentioned above, a trademark is defined as any sign (a word, a logo, a phrase, etc.) which makes distinctive the goods or the services offered by a firm and, therefore, it allows consumers to differentiate among several goods. The key requirement for a new trademark to be registered is the novelty of the sign itself, which must not be similar to any other registered trademark. Once a Trademark is successfully registered, the owner has the exclusive rights to use the trademark for the goods (or services) the sign refers to. To obtain a trademark, a UK-based firm faces two options: a) it can file a trademark registration with the UK Intellectual Property Office (UKIPO) which offers protection only in the UK or b) it has to apply for a more expensive Community Trademark which has the advantage of covering all the EU countries. In both cases, applications for trademarks are examined and published allowing a period of time for objections before the trademarks are fully registered. Trademark rights must be maintained through the actual use of the trademark. If they are not used, they may be removed from the register after a certain period of time.

In spite of the fact that they are widely used by firms to complement patents when protecting their intellectual property, economists have suggested that there may be other reasons which explain the widespread use of trademarks among firms. For instance, Landes and Posner (1987) suggest that firms which engage in constant product differentiation use trademarks to guarantee the commercial origin of a good (or service) and to increase their customers' loyalty. More specifically, trademarks can facilitate consumer choice in the case of *experience goods* (frequently bought goods) and may signal the quality of goods which are not bought frequently (*search goods*). In this respect, trademarks are especially important for firms from the service sectors, as customers cannot test the products before buying them and therefore, they may need additional information about the quality of the product (Elliott and Percy, 2006)².

² Trademarks are more represented in the consumer goods sector than in the intermediate goods sector (Mainwaring *et al.* 2004). A number of studies have also noted that the amount of trademarks related

In spite of the fact that they are widely used, the empirical literature on trademarks is very small. Empirically, only a handful of studies have investigated whether there is a link between the trademarking activity of a firm and its performance which is typically proxied by either its stock market value or its productivity³. In the former case, researchers have extended the approach used by Hall (2000) to estimate the contribution of a firm's intellectual property to its market value and have directly tested whether the stock of trademarks (jointly with other types of intangible and tangible assets) owned by a firm can contribute to its stock market value (Bosworth and Rogers, 2001; Griffiths and Webster, 2006; Greenhalgh and Rogers, 2006). Overall, these studies suggest that stock markets tend to value trademarking firms more than the non-trademarking ones⁴.

This effect is particularly strong in the case of services as investors often lack the information provided by the investment in R&D and patent activity to assess the value of a firm. For instance, using data for a small sample of large Australian firms observed in 1994-6, Bosworth and Rogers (2001) found out that the stock of trademarks contributed positively to the market value of firms from the service sectors while other types of intangible assets which are traditionally included among the determinants of the stock market value, were not. Equally, using a dataset of 1600 large and medium sized UK firms, Greenhalgh and Rogers (2012) found that, while the impact of a firm's trademarking status on its market value was positive in the full sample, the coefficients were much larger in services than in manufacturing.

to services (service marks) have been growing rapidly during the last decade (Schmoch, 2003; Jensen and Webster, 2004; Loundes and Rogers, 2003).

³ A couple of studies have focused on the impact of trademarking on firms' profitability. Krasnikov *et al.* (2009) have found that the stock of trademarks owned by a firm is positively correlated with their cash flow, Tobin's q , return on assets and stock returns while it negatively correlated to their cash-flow variability. Equally, Griffiths, Jensen and Webster (2011) have analysed the determinants of financial profitability for a sample of nearly 2,700 Australian firms observed from 1990-2006 and they find that both patent and trade mark stocks are key contributors to profits.

⁴ Subsequent research has showed not all the trademarks contribute equally to a firm's market value. For instance, Sandner and Block (2011) used a multi-country database of around 1200 large firms observed for the period 1996-2002 to quantify the impact of their stock of Community trademarks on their market value. They took into account the characteristics of the trademarks like their breadth (i.e. the number of classes applied for) and the seniority of the mark claimed at the time of registration among the others. Their results show that holding senior trade marks contributes to the stock market value of a firm while the breadth of the trade mark does not.

Additional studies have investigated whether trademarking firms tend to be more productive than their non-trademarking counterparts (Greenhalgh and Longland, 2005; Greenhalgh and Rogers, 2012). Overall, it seems this is the case empirically and this seems to be driven by the increasing demand for the new products which may induce a firm to produce more for a given amount of inputs (Schautschick and Greenhalgh, 2013). For instance, Greenhalgh and Longland (2005) found that increasing trademarking intensity had a significant positive impact on the subsequent levels of output in the UK manufacturing. Also, Greenhalgh and Rogers (2012) show that trademarking creates a large value-added premium ranging between 10 per cent and 30 per cent. More importantly, the value-added for firms from the service sector is around 47 per cent higher than for firms from the non-service sectors.

There is very scant evidence on the extent to which trademarking may affect the performance of commercial banks or other types of financial institutions. In a study on the impact of trademarking on the market value of UK firms in the manufacturing, financial services and utilities over the period 1996-2000, Greenhalgh and Rogers (2006) found that, while overall firms with a higher trademarking intensity tend to have a higher market value as well, this effect is particularly evident for the financial services sector. Similarly, Gonzalez-Pedraz and Majordomo (2011) have analyzed the effects of trademarking on the market value (proxied by the Tobin's q) of the US commercial banks between 1996 and 2006 and found that commercial banks with large portfolio of recently registered trademarks tend to have a higher value of the Tobin's q .

3. The Empirical Strategy: Data and Methodology

3.1 Data

All the bank-specific data were obtained from the global database Bankscope⁵. We selected unconsolidated data and used reports prepared under international accounting standards. Our starting sample consists of all the banks which are recorded as commercial banks by Bankscope and that have been in operation between 2001 and 2013. There are 206 commercial banks which are recorded as such by Bankscope.

⁵ The data used in this version of the paper were downloaded in November 2013.

However, not all of them have been in operation continuously since 2001 and therefore the accounts of these banks are not available every year. Once this is taken into account, the initial dataset is made of 328 observations. This dataset was cleaned so that missing and zero values for either inputs or outputs or costs or profits before tax were excluded. Therefore it further reduced to an unbalanced dataset of 213 observations running from 2001 to 2013. The size of our sample is not different from the one used by Drake (2001) in his paper on the measurement of technical efficiency in the UK banking sector. Equally, Gonzalez-Pedraz and Mayordomo (2011) analyse the impact of trademarking on the commercial banks' Tobin's q using a dataset of 16 commercial banks.

The data were expressed in British pounds (in 2001 prices) and were deflated using the GDP deflators. We focus on commercial banks to be able to examine a more homogenous sample of banks in terms of outputs and inputs. Also according to the literature, this is the segment of the banking industry where the competitive pressure following the deregulation of the European banking sector was felt more (Gonzalez-Pedraz and Mayordomo, 2011). Data on whether a commercial bank has filed an application for either a UK-based trademark or a Community trademark have been sourced from: a) the Intellectual Property Office (IPO) trademark database and b) the Office for the Harmonization in the Internal Market (OHIM) trademark database. Both databases are available through the web-sites of the Intellectual Property Office and of the Office for the Harmonization in the Internal Market (OHIM), respectively.

3.2 The Empirical Methodology

As indicated in the Introduction, our empirical analysis starts with the Propensity Score Matching (PSM) techniques to identify a group of non-trademarking banks which are similar to the trademarking banks on the basis of some observable characteristics. Propensity score matching is a two-stage procedure. In the first stage, the probability (or "propensity score") that a bank files an application for a trademark is estimated by using a logit model. In the second stage, each trademarking bank is then matched to a non-trademarking bank with a similar propensity score. For this analysis we consider the caliper matching, where each trademarking bank is paired

with the non-trademarking counterparts that have the closest propensity scores within a given threshold (or *caliper*).

The empirical specification of the logit model used to compute the propensity scores for our sample of commercial banks is inspired by the literature on the determinants of trademarking (see for instance Greenhalgh *et al.*, 2011)⁶. Papers which use data for the whole of the British economy find that: a) larger and older firms do trademark more than their smaller and younger counterparts; b) firms which engage with the intellectual property system (either by having a patent or having a trademark) tend to trademark more and c) firms operating in very competitive markets tend to trademark more. If we adapt these findings to the banking sector, we can argue that a bank's propensity to trademark is typically associated to: a) its age and size (measured by the total assets owned by the bank) as older and larger banks do tend to trademark more; b) to whether or not they have filed an application for a trademark before the start of the sample period (as this would indicate whether the bank has engaged with the IP system beforehand) and c) the degree of competition they face; this last variable will be proxied by the lagged number of trademarks' applications filed by the competitors (normalised by the total assets owned by the banks across the sector each year – with the exception of the bank under observation) as banks may be more willing to use trademarks if facing large competitive pressure. Finally, we introduce a set of time dummies.

Once the propensity scores have been computed, the propensity scores of the trademarking banks need to be matched to those of the non-trademarking banks. There are two main methods which match untreated units to those treated: the nearest neighbour matching (where a treated unit is matched to an untreated unit with the closest propensity score) and the caliper matching (where again treated units are matched to untreated units with the closest propensity score but within a pre-specified caliper).

⁶ Heckman et al. (1997) show that omitting important variables can increase the bias in the resulting estimates of the parameters of the propensity scores model. At the same time, Bryson et al. (2002) show that it is important not to over-parameterise the model as the inclusion of non-significant variables in the model may create additional problems (for instance, it increases the variance of the scores).

We use a variant of the caliper matching, called radius matching (Deheja and Wahba, 2002). The basic idea behind this approach is to use not only the nearest neighbour within each caliper but all the comparison members within a certain caliper. The advantage of this approach is that it uses only as many comparison units as are available within the caliper and therefore allows for usage of extra units when good matches are not available. We also allow for replacement to ensure that there is a sufficient number of matches. The chosen caliper is equal to 0.2 of the standard deviation of the propensity scores generated by the logit model⁷. Once the treated and the control units have been matched, balancing tests can be used to test whether the estimated propensity score balances the characteristics between the treatment and the control group units. The balancing tests allow to check whether observations with the same propensity scores have the same distribution of the observable characteristics. To carry out the balancing tests, observations are divided into strata (or blocks) based on the estimated propensity score such that no statistically significant difference between the mean of the estimated propensity score in both the treatment and the control groups remain. Afterwards, t-tests are carried out within each block to test whether the distribution of each independent variable is the same between both groups.

After having identified the matched sample, we employ stochastic frontier analysis to estimate the two frontier models of interest (namely, the cost frontier and the alternative profit frontier) on our matched sample of commercial banks and test whether these banks share a common cost (profit) frontier. The empirical specification of the cost frontier is the following:

$$\begin{aligned} \ln C_{kt} &= \alpha_k + C(q, w; \beta) + \delta dtm_{kt} + \varepsilon_{kt} \\ k &= 1, \dots, K \\ t &= 1, \dots, T \end{aligned} \quad (1)$$

where C_{kt} denotes the total costs of bank k at time t , q is a vector of outputs, w is a set of input prices and dtm_{kt} identifies the banks' trademarking status. β is the vector of unknown parameters which will be estimated and α_k are the fixed effects. In any

⁷ We have followed Austin (2011) who finds that this is the optimal caliper's width that minimises the mean squared error of the estimated treatment effect in several scenarios.

given year, each bank in the sample can deviate from its optimal costs due to a random noise v_{kt} or due to inefficiency u_{kt} . In the case of cost inefficiency, the total error is $\varepsilon_{kt} = v_{kt} + u_{kt}$ while in the case of profit inefficiency the total error is equal to $\varepsilon_{kt} = v_{kt} - u_{kt}$. The random error term v_{kt} is assumed to be i.i.d with $v_{kt} \sim N(0, \sigma_v^2)$ and independent of the explanatory variables. The inefficiency term u_{kt} is assumed to be i.i.d with $u_{kt} \sim N(0, \sigma_u^2)$ and independent of the random error terms. The banks' fixed effects are allowed to be correlated with the outputs of the banks, their inputs' prices and the quasi-fixed inputs⁸ (Greene, 2005).

To estimate the profit efficiency among our sample of commercial banks, we estimate an alternative profit frontier (Berger and Mester, 1997). As explained by Berger and Mester (1997), the alternative profit frontier assumes that banks take the output quantities and the input prices as given and maximize profits by adjusting output prices and input quantities. In other words, the alternative profit frontier does not assume perfect competition and does not assume that banks in the sample take the output prices as given; it is preferable to standard profit frontiers when the quality of the outputs varies among banks and output markets are not competitive because of existing regulation. In terms of its empirical specification, alternative profit frontier shares the same specification as the cost frontier (1) with the main difference being that the profits before tax (*PBT*) replace the total costs as the dependent variable. Also, unlike the cost frontier, the alternative profit frontier does not need to be homogenous of degree one⁹ and therefore we do not need to divide the new dependent variable (as well as the other input prices) by one of the inputs' price. One issue with the use of the profits before tax as the dependent variable is that a number of banks in the sample exhibits negative profits with the result that they cannot be used for the estimation of the alternative profit frontier. The literature has offered a set of solutions to this problem: typically, the dependent variable is transformed to $\ln(PBT + |(PBT)^{\min}| + 1)$ where $|(PBT)^{\min}|$ is the minimum absolute value of *PBT* over all banks in the sample. The advantage of this transformation is that the new

⁸ A quasi-fixed input is any input which does not vary with the quantity of output produced but it is needed by the firm as long as it is producing a positive amount of output. In the banking literature, equity is usually treated as a quasi-fixed input.

⁹ In other words, a doubling of output quantities and input prices can lead to more than double profits since output prices may also be a function of the scale of output.

variable does not exhibit negative values. However, other researchers have used different approaches. For instance, Bos and Koetter (2009) suggest to transform the dependent variable in such a way that the negative profits take the value of 1 while adding to the independent variables an indicator for negative profits equal to the value of 1 for positive profits and to the absolute value of profits when they are negative. We do try to implement this different way of estimating the alternative profit frontier to check whether the results differ.

To define the input and outputs variables of our cost and profit frontiers, we follow the existing literature on the estimation of cost and profit frontiers for commercial banks (Bikker and Bos, 2008). Total costs (our dependent variable) are measured as the total operating cost i.e. the sum of interest expenses, salaries and employee benefits and other operating costs. Net loans, securities investments and the off balance sheet total business volume are the three outputs where the net loans variable is calculated as the difference between the gross loans and the reserves allocated for non-performing loans. As for the input prices, we use: a) the cost of loanable funds calculated as the ratio of interest expenses to total assets, b) the cost of physical capital calculated by dividing overhead expenses (other than personnel expenses) by the book value of the banks' fixed assets and c) the cost of labour calculated as the ratio between the personnel expenses and the total assets. Economic theory requires cost function to be linearly homogeneous of degree one and this is ensured by normalising the dependent variable and all the input prices by the cost of labour. Finally, researchers suggest to control for the differences in risk preferences among commercial banks (Berger and Mester (1997) and Lozano-Vivas *et al.* (2010)) and this is usually done by introducing the level of equity as a quasi-fixed input¹⁰. We allow for the possibility of both neutral and non-neutral technical change and we do so by introducing a continuous time trend and its square as well as its interaction with the outputs and the prices of the inputs. We control for the trademarking status of the banks in our sample with a dummy variable having the value of one for banks which have filed at least one application for a trademark of any type (i.e. either a UK or a Community trademark) in the year under observation and zero otherwise.

¹⁰ Using the level of equity rather than the equity to assets ratio is standard in this literature (see Lozano-Vivas *et al.*, 2010).

To estimate our cost and profit frontiers, we use the True Fixed Effects frontier model suggested by Greene (2005) which is based on Maximum Likelihood. This has two advantages over the traditional estimators for stochastic frontier in a panel set-up. First, it allows inefficiency to vary over time without imposing restrictions unlike some frontier estimators for panel data which either treat inefficiency as being time-invariant or impose some structure on the evolution of inefficiency over time (Pitt and Lee, 1981; Battese and Coelli, 1988). Indeed, the inefficiency term is not parameterized as a function of time and may exhibit any pattern for a given bank. Second, the True Fixed Effect model allows systematic differences other than inefficiency to enter the bank-specific effect with the result that the fixed effects are identified separately from the inefficiency component. In this respect, it differs from those estimators of stochastic frontiers for panel data which although can estimate time-varying efficiency scores cannot estimate the firm's fixed effects separately from the efficiency scores (Cornwell *et al.*, 1990; Kumbhakar, 1990; Battese and Coelli, 1995). Also Greene (2005) has shown that the performance of this estimator is superior to that of the previous panel estimators. Bank-specific efficiency scores are then computed using the Jondrow *et al.* (1982) formula. In both cases (profit and cost efficiency scores), the efficiency score varies between zero and one: the closer the score of a bank is to zero, the more inefficient it is.

4. The Empirical Results

4.1 The Propensity Score Matching Analysis

Table 1 presents the descriptive statistics for the initial sample of 213 observations. The estimated parameters of the trademarking propensity equation are presented in Table 2¹¹. The results show that older banks are more likely to file an application for trademarks. This is true for larger banks as well. The number of trademarks filed by other commercial banks in the sample (normalised over their total assets) is significantly associated to a bank's propensity to trademark. Finally banks which have previously filed a trademark application are less likely to apply for a new one.

¹¹ The logit model has been estimated on a sample of 190 observations as the age is not known for all the banks in the sample. Age is not available in Bankscope and needs to be retrieved from external sources.

We use the logit estimates to generate a propensity score—i.e., the predicted probability of trademarking—for each bank. An important assumption underlying the matching technique is the Conditional Independence Assumption (or CIA) requiring that all the variables which influence the propensity of a bank to apply for a trademark are observed by the researcher. It cannot be tested *per se*; however, we have run some tests on the chosen empirical specification of the logit model. Our empirical specification passes both the Hosmer-Lemeshow test for the goodness of fit¹² and the test for the empirical specification of the logit model¹³. We then create a sub-sample of non-trademarking banks that we match to the trademarking banks by selecting for each trademarking bank all the non-trademarking banks with propensity scores closer to that of the trademarking bank within a given caliper. For our analysis, this is equal to 0.050. The results of the balancing tests are presented in Table 3; the observations have been divided across five blocks¹⁴ (or strata) and the tests cannot reject the hypothesis that the mean of each characteristic is equal across the control and the treatment groups in each block.

The resulting matched sample consists of 136 observations (53% of the observations are in the untreated group and 48% are in the treated group) representing with an average of 13.5 banks a year. Large banks dominate the sample. Indeed the mean total assets are equal to £360 million pounds while in the original sample on average the total assets are equal to £130 million pounds. The descriptive statistics on the matched sample are presented in Table 4 as well as the results of the t-tests on the difference of the means of each variable between trademarking and non-trademarking banks. The descriptive statistics show that the banks included in the matched sample tend to have larger total costs than the banks in the cleaned sample. They also produce more outputs while they face lower inputs' prices. As for the t-tests, they cannot reject the null hypothesis, and there is no difference between the means of the variables. In addition, in Table 5 we also show the descriptive statistics for our sample before and

¹² The Hosmer-Lemeshow's goodness of fit test is based on the idea that predicted frequencies and observed frequencies should match closely and that the fit of the model improves as the match get closer.

¹³ The test on the empirical specification of the logit model is based on the idea that no additional regressors should be significant in a well specified model. To do this, the test adds to the existing model the predicted value of the dependent variable and its square and tests their (individual) significance. In a well specified model, the predicted value of the dependent variable should always be significant while its square should not.

¹⁴ This is the default number of strata that Stata stratifies the scores into.

after the financial crisis in 2008, as a portion of our sample covers the years after 2008. The descriptive statistics show that on average, the profits are negative after 2008; at the same time, following the financial crisis, the total costs for the banks in our sample increase. However, the prices of the inputs do not change dramatically unlike the outputs which increase after 2008. In terms of the distribution of treated and untreated observations over time, the proportion of trademarking banks fluctuates over time while decisively decreasing after 2009.

4.2 Stochastic Frontier Specification: The Main Results

Once we have identified our matched sample, we proceed to the estimation of the cost and of the alternative profit frontier. We have mean-corrected our sample data before the estimation so that we can interpret the 1st order coefficients as the partial cost (profit) elasticities evaluated at the sample mean. We have tried to estimate the alternative profit frontier by using the method suggested by Bos and Koetter (2009) but the standard error for the dummy variable for the negative profits was not estimated precisely; so we decided to use the specification of the alternative profit frontier with the scaled profits.

We estimate the two frontiers on the whole sample while controlling for the fall in profits (and the increase in costs) after 2008 with a dummy variable taking the value of 1 for the years after 2008 and 0 otherwise. Table 6, Columns 1 and 2 report the estimated cost (and profit) elasticities with respect to the outputs and the price of inputs calculated at the sample mean for the whole sample. In all cases, the estimates are generally statistically different from zero at the 5% level. On average, the elasticity of the total costs to loans is larger than their elasticity to both securities and off-balance-sheets activities; as for the alternative profit frontier, the elasticities of the profits to the loans and securities are quite large compared to the elasticity of the profits to the off-balance sheets activities. As for the elasticity of profits to the inputs' prices, the elasticities of profits to the price of capital and of labour are much larger than the one to price of funds. There is evidence of significant cost-saving technical progress in the sector as both time trend variable and its square are significant; on the contrary, they are not significant in the alternative profit frontier. The dummy variable for the trademarking status is never significant in the case of the cost frontier. It

becomes significant (at 10%) but with a negative sign in the case of the profit frontier estimated over the whole sample. In other words, we cannot reject the hypothesis that trademarking and non-trademarking commercial banks in the UK share the same cost frontier but we can reject the hypothesis that they share the same alternative profit frontier although the sign of the coefficient indicates that the profits of the trademarking banks tend to be lower than those of the non-trademarking banks. One possible explanation for the fact that over the whole sample period trademarking banks do not have lower total costs than their non-trademarking counterparts is that banks prefer to use trademarks to launch the new products which have the potential to maximise their revenues rather than to reduce their total costs. This result is consistent with the economic theory of the trademarks which suggests that trademarks are mostly associated to new products for consumers and are used mostly used to assure consumers about the quality of the new products. However, our results suggest over the whole sample period our trademarking banks do not experience larger profits than non-trademarking banks. This result may be due to the fact that our sample covers the period after 2008 where large UK commercial banks experienced large falls of their profits¹⁵. We have tested the Cobb-Douglas functional form against the alternative translog functional form for each frontier and the results are presented in Table 7. The test rejects the null hypothesis that the second-order terms of the translog functional form are equal to zero.

Next, we estimate both the cost and the profit efficiency scores for our banks based on the estimated frontiers, and compare the two sets of efficiency scores between trademarking and non-trademarking banks. Table 8 shows the mean values of the cost and profit efficiency scores (computed from the specification of the two frontiers with the interaction terms). Overall, profit efficiency scores tend to be lower than the cost efficiency scores; this result is consistent with other studies (Berger and Mester (1997), Rogers (1998) for the US banking system). Overall, it seems that UK commercial banks are much better at controlling costs than at expanding profits although the levels of cost and profit efficiency tend to be high. If we focus on the trademarking banks and we compare them with the non-trademarking ones, we find

¹⁵ To understand whether this is the case we have tested whether the sign of the dummy variable associated to the trademarking status is different before 2008 by re-estimating the two frontiers before 2008. The results show that the variable for the trademarking status is still not significant in the case of the cost frontier but it is now positive and significant in the case of the alternative profit frontier.

that with a truncation point of 5%, the mean cost efficiency score of the trademarking banks is 0.99 while it is 0.97 for non-trademarking banks. In other words, the costs of the trademarking banks in our sample are on average around 3% higher than at the best practice banks. As for profit efficiency, the corresponding mean score (with a truncation point of 5%) of the trademarking banks is 0.90 implying that their profits are 10% lower than at the best-practice banks. The average profit efficiency score for the non-trademarking banks is 0.83. This figure seems to be consistent with the findings of Maudos et al. (2002) who also report that on average profit efficiency tends to be low for ten EU countries.

Table 8 presents the results of a t-test on the difference of the mean cost (profit) efficiency scores between the trademarking and non-trademarking banks; the results show that the difference between the mean cost efficiency scores of the two groups is not statistically significant while it is significant at 5% in the case of the profit efficiency scores. In other words, trademarking banks are not more cost-efficient than the non-trademarking banks implicitly confirming that the trademarks are mostly used to launch products with the potential to maximise bank's revenues rather than to reduce costs. Equally the results of the test suggests that trademarking banks are more profit-efficient than non-trademarking banks suggesting that banks can benefit from their trademarking activities as they can help banks to improve their revenues and close the gap with the more profit-efficient banks.

The implication is that in the UK commercial banking sector, there is a group of banks which is good at introducing new products that can have a real impact on the their profits although in the context of the current analysis we cannot identify in clear terms why this is the case. Equally, the results show that there is a segment of commercial banks which prefers not to use trademarks while at the same time could benefit from trademarking in terms of increased profits. Again, the analysis does not suggest why this is the case; it may be that this is an indication of the fact that their propensity to introduce new products is low and that they operate in niche markets where they are sheltered by competition but further analysis is needed to understand whether this is really the case.

5. Conclusions

This paper has contributed to the literature on the economic benefits of trademarking in the banking sector by quantifying the gain in profit and cost efficiency that a commercial bank can experience as a result of its trademarking activities. To this purpose we have estimated a cost and an alternative profit frontier on an unbalanced panel of UK commercial banks (drawn from the database Bankscope), observed over the period 2001-2013 and compared the cost and profit efficiency scores of the trademarking banks with those of the banks which do non-trademark. We have addressed the potential self-selection into trademarking by using the Propensity Score matching technique which has allowed us to create a matched sample of trademarking and non-trademarking commercial banks. In turn we have used the matched sample to estimate our cost and alternative frontiers. Finally, we have tested whether trademarking and non-trademarking banks share a common cost (profit) frontier.

Our results show that: a) the assumption of a common cost and alternative profit frontier for trademarking and non-trademarking banks cannot be rejected although some evidence suggests that it has to be rejected in the case of the alternative profit frontier for the period before 2008; b) trademarking banks tend to be more profit efficient: the mean score for the trademarking banks is 0.90 while the average score for non-trademarking banks is 0.83. The mean cost efficiency of trademarking banks is not significantly different from that of non-trademarking banks. The mean cost efficiency score for trademarking banks is 0.99 while it is 0.97 for non-trademarking banks.

The results suggest that trademarking can make a difference to the profit efficiency of the UK commercial banks; however they also suggest there is a group of commercial banks which might benefit (in terms of profit efficiency) from trademarking but at the same time, prefers not to. Our analysis does not allow us to clarify why this is the case; however, assuming that trademarks are associated systematically to new products or services offered by banks, one implication of these results is that some commercial banks do not innovate as much as it could be beneficial to them and therefore more research is needed to better understand why this is the case.

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Table 1. *Descriptive Statistics*

	UNMATCHED SAMPLE	TRADEMARKING BANKS	NON- TRADEMARKING BANKS
	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)
Equity	2.67 (8.88)	3.95 (9.29)	2.47 (8.82)
Total Costs	1.42 (3.94)	2.456 (4.56)	1.28 (3.82)
Net Loans	27.6 (77.2)	50.1 (93.7)	24.1 (74)
Security	30.8 (11.3)	58.1 (13.9)	26.5 (10.8)
Offshore business	96.8 (302)	149 (347)	88.6 (29.5)
Price of Funds	0.018 (0.013)	0.019 (0.014)	0.018 (0.013)
Price of Labour	0.009 (0.012)	0.0068 (0.0056)	0.010 (0.012)
Price of Capital	4.96 (10.56)	2.92 (2.30)	5.28 (11.30)
Net Profit (before taxes)	0.142 (2.1)	1.178 (2.21)	-0.029 (2.12)

Source: Monetary figures are expressed in millions British pounds.
Bankscope (2013).

Table 2. *Propensity to Trademark – Logit model*

	Coefficients	t-ratios
<i>Has a bank has filed a trademark application before the start of the sample period (Yes=1, No=0)</i>	-0.69	(-1.74)
<i>Total Assets</i>	0.069	(2.74)
<i>Age</i>	2.32	(3.32)
<i>Total trademark applications in a given year over total assets in the sector</i>	1.21	(2.59)
<i>N</i>	190	
<i>Hosmer-Lemeshaw test (p-value)</i>	0.3423	
<i>Chi-squared (p-value)</i>	0.00	
<i>Test on the Link function (p-value on the predicted value of the dependent variable)</i>	0.00	
<i>Test on the Link function (p-value on the square of the predicted dependent variable)</i>	0.326	
<i>Standard Deviation of the Propensity Score</i>	0.25	

Note: The dependent variable is a dummy variable taking the value of 1 for banks which file a trademark application in a given year and 0 otherwise. When computing the ratio between the total trademark applications in the sector in a given year and the total assets in the sector and year, care has been taken to exclude the bank under observation. t-ratios are computed by using standard errors clustered around each bank. Time effects are included for but the estimates are not reported. The Hosmer-Lemeshaw test goodness-of fit statistic is computed as the Pearson chi-square from the contingency table of observed and expected frequencies. The test on the Link function is a specification test based on the idea that if we add the predicted value of the dependent variable and its square to a well specified model, the former should be significant while the latter should not. The p-value reported in the table refers to p-value associated to the value of the predicted dependent variable and its square. The size of the sample reduces to 190 observations because we have not been able to compute the age of all the commercial banks in our initial sample.

Table 3. *Balancing tests*

	Block 1	Block 2	Block 3	Block 4	Block 5
<i>Has a bank has filed a trademark application before the start of the sample period (Yes=1, No=0)</i>	0.20	0.62	0.58	0.83	0.33
<i>Total Assets</i>	0.70	0.47	0.44	0.77	0.81
<i>Age</i>	0.26	0.37	0.49	0.16	0.26
<i>Total trademark applications in a given year over total assets in the sector</i>	0.96	0.81	0.12	0.80	0.77

Note: The Balancing tests are t-tests which have been carried out on all the independent variables included in the logit regression. In the table, we report the p-values. All the variables used as independent variables in the logit model pass the balancing tests but we only show the values of the t-tests for the variables which were shown in Table 2.

Table 4. *Descriptive statistics – Matched sample*

	TRADEMARKING BANKS	NON- TRADEMARKING BANKS	T-TEST ON THE MEAN OF EACH VARIABLE FROM THE MATCHED SAMPLE
	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	P-VALUE
Equity	14.2 (16.6)	13.5 (17)	0.82
Total Costs	6.31 (6.6)	5.9 (7.1)	0.77
Net Loans	174 (179)	142 (158)	0.27
Security	135 (220)	127 (234)	0.83
Offshore business	75 (94.5)	68.3 (89.5)	0.67
Price of Funds	0.008 (0.010)	0.008 (0.009)	0.75
Price of Labour	0.007 (0.006)	0.0064 (0.0071)	0.43
Price of Capital	1.86 (2.69)	3.06 (4.86)	0.083
Net Profit (before taxes)	0.78 (3.98)	0.93 (2.26)	0.78

Note: A p-value larger than 0.05 indicates that the difference between the mean of a variable in the treatment group and the mean of the same variable in the control group is not significantly different from zero.

Table 5. Descriptive statistics before and after 2008– Matched sample

	BEFORE 2008			AFTER 2008		
	WHOLE SAMPLE	TRADEMARKING BANKS	NON- TRADEMARKING BANKS	WHOLE SAMPLE	TRADEMARKING BANKS	NON- TRADEMARKING BANKS
	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)	MEAN in million (STANDARD DEVIATION in million)
Equity	8.9 (10.3)	10.7 (11.5)	6.33 (7.65)	17.2 (19.9)	18.9 (20.8)	16.3 (19.6)
Total Costs	4.20 (4.5)	4.7 (4.7)	3.41 (4.42)	7.25 (7.88)	8.32 (8.30)	6.68 (7.67)
Net Loans	110 (11.5)	130 (128)	79.2 (85.8)	185 (189)	224 (211)	165 (175)
Security	68 (96)	70.5 (93.8)	64 (104)	171 (279)	220 (303)	145 (265)
Offshore business	57.3 (79.6)	61 (83.1)	51.4 (75.6)	79.3 (98.7)	92.1 (107)	72.4 (94.3)
Price of Funds	0.010 (0.013)	0.008 (0.012)	0.012 (0.015)	0.006 (0.004)	0.0059 (0.0046)	0.0062 (0.0050)
Price of Labour	0.007 (0.0037)	0.0077 (0.0037)	0.0072 (0.0037)	0.006 (0.008)	0.0075 (0.0094)	0.0063 (0.0082)
Price of Capital	2.64 (5.63)	1.42 (0.77)	4.58 (8.82)	2.61 (3.21)	2.34 (4.10)	2.75 (2.66)
Net Profit (before	2.04	2.40	1.466	-0.11	-1.51	0.63

taxes)		(2.32)	(2.55)	(1.81)	(3.35)	(4.48)	(2.30)
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Table 6. *Estimates of the Cost and Alternative Profit Frontier – True Fixed Effect Model*

	<i>Elasticity of total costs at sample mean with respect to the corresponding variable.</i>	<i>Elasticity of Profits before Tax (PBT) at the sample mean with respect to the corresponding variable.</i>
	<i>Coefficient (p-value) (Full Sample)</i>	<i>Coefficient (p-value) (Full Sample)</i>
<i>Loans</i>	0.82 (0.00)	6.34 (0.00)
<i>Securities</i>	0.045 (0.00)	7.75 (0.00)
<i>Off-balance sheet activities</i>	0.11 (0.00)	0.0001 (0.00)
<i>Price of funds</i>	0.08 (0.00)	-0.67 (0.00)
<i>Price of capital</i>	0.37 (0.00)	-9.15 (0.00)
<i>Price of Labour</i>	- (0.00)	-5.17 (0.00)
<i>Year</i>	0.049 (0.00)	0.10 (0.649)
<i>Year²</i>	-0.0023 (0.00)	-0.0037 (0.219)

	0.22	0.49
<i>Equity</i>	(0.00)	(0.473)
	0.004	
<i>TRADEMARKING STATUS</i>	(0.367)	-0.161
		(0.086)
Additional parameters		
λ	1.18	1.3
<i>Observations</i>	136	136

Note: Maximum Likelihood estimates of the parameters. The dependent variable of the cost frontier model is the log of the total costs normalised over the price of labour while the dependent variable of the alternative profit frontier is the log of the net profits before taxes. We control for the heteroskedasticity of the stochastic term in our estimation where the control is the size of the bank. λ is the ratio between the variance of the inefficiency term and the variance of the stochastic term.

Table 7. Hypothesis tests on the parameters of the two frontier models.

NULL HYPOTHESIS	LIKELIHOOD RATIO TEST
COST FRONTIER	
<i>Null Hypothesis: Cobb-Douglas functional form (Full Sample)</i>	-260.47**
ALTERNATIVE PROFIT FRONTIER	
<i>Null Hypothesis: Cobb-Douglas functional form (Full Sample)</i>	-207.8**

Notes: The test statistic has a mixed chi-square distribution and so critical values at 5% significance level are sourced from Kodde and Palme (1986).

Table 8. *Efficiency Scores.*

	Trademarking Banks	Non- trademarking Banks	t-test (p-value)
<i>Cost Efficiency</i>	0.99	0.97	0.234
<i>Profit Efficiency</i>	0.90	0.83	0.000