Estimating risk efficiency in MiddleEast banks before and after the crisis.A Metafrontier framework.

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9 February 2018

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Abstract

The aim of this study is two-fold. Firstly, it attempts to analyse the effect of risk on Middle East bank's efficiency levels before and after the recent financial crisis. Secondly, it seeks to determine the influence of bank size taking into consideration the possible inefficiency originated to risk abatement cost. To examine the aforementioned issues we introduce a risk efficiency index based on an output orientated directional distance function with weak and strong disposability assumptions. The methodology has been applied on a panel data of Middle East banks spanning the period 1998-2014.The empirical findings suggest that on average small banks are more efficient and their size have less negative impact on their technical efficiency and risk management. On the other hand, large banks' risk management is found to be more flexible during financial crisis. Finally, banks with higher fixed assets are associated with more costly dispose of non performing loans justifying the rejection of a positive relation between bank size and technical efficiency.

Keywords: Risk efficiency, Middle East banks, Directional distance function, Metatechnology,

1 Introduction

The last three decades several agreements were singed to create a free trade zone between European and Mediterranean countries. The Barcelona Process (1995) created a "short peace and prosperity zone" while the Agadir declaration in 2004 aimed to establish a Arab free trade zone. These agreements were a step forwards the establishment of a common Arab market creating a more integrated banking system. As a results deregulation, trade intensification and technological change contributed to a financial integration process while lead to an increasing competition in the banking sector leading to a greater risk taking (Casu and Girardone,2009).

The 2008 financial crisis, illustrated the leader position of banks in normal economic development and stability of countries. However, financial sector confront some serious challenges to manage the risk taken with recapitalizations, asset purchases and bad loans specific treatment. The principal aim of bank management and supervisors is the risk oversight, as it is strongly motivated by significant incentives. Financial firms want to enhance their risk and return trade-offs while regulators want to avoid systemic risk, the risk that the entire system collapses, as nearly it did in 2008(Fiordelisi et al.2011). The recent financial crisis is divided in three phases (Degl'Innocenti et al. 2017). During the sub prime financial crisis (2007-2008) large losses in mortgage market mobilize authorities to adopt a wide-ranging interventions which seemed to work effectively. The second phase, global financial crisis (2008-2010), is generated by the collapse of large US financial institutions and expose the profound European sovereign debt crisis. Some countries plugged into a deep recession accompanied by increasing estimates of prospective banking sector looses on bad loans.Even countries with the best competitive advantage and growth prospects experience an significant increase in spreads due to stress in their financial sector in the stage of sovereign financial crisis (2010-2012), which unrevealed the fragile nature of banking system.

Non performing loans, (hereafter NPLs), is an important factor in determining normal operational activity of a bank and its profitability. There are internationally accepted laws which determine the magnitude of risk that a bank is allowed to take on, and the amount of money that must be reserved in order to secure the depositors from bank's bankruptcy. Basel 1,2,3 states that as higher the risk, which is estimated by a bank, the amount of money to be reserved increase. Similarly, capital's opportunity cost is higher for banks with high risk, employing suppress in earnings which result in less efficient production. To maintain a position in the increasingly competitive and regulated financial market banks are forced to operate close to the efficient production. In this environment a number of studies have focused on the estimation of bank efficiency accounting for non performing loans (Fukuyama and Weber, 2008;2015,Barros et al 2015; Mester, 2007 among others) and find important discrepancy in results when ignoring the undesirable output. Other researches emphasize on inefficiency differences attributed to specific bank characteristics as type (Kontolaimou and Tsekouras, 2010; Elyasiani and Mehdian, 1995), organizational form (Mester, 2007) and ownership (Chiu et al. 2016). However, studies have not be found to apply those methods on Middle East banks performance assessments and none of them try to address the issue of opportunity cost of risk.

The objective of this paper is two-fold. Firstly, it attempts to examine the influence of risk on banks' performance in Middle East. Explicitly, a common bank production technology is adopted with both strong and weak disposability of non performing loans. Those hypothesis enable to estimate the significance of risk inclusion and the extent of its influence on banks' efficiency. Furthermore, the relation of bank size and efficiency is explored. Secondly, it purports to explore how size specific technologies affect Middle East banks' efficiency levels. Specifically, a common bank technology is presumed, which nests two size specific technologies, small and large banks technologies, with free and costly disposability of non performing loans. This enables comparison of inefficiencies arising from bank size and its cost to dispose risk.

Panel data which contains annual balance sheet items on 66 Middle East banks during 1998 to 2014 is used under intermediation approach, in an output orientated directional distance function model with non performing loans as bad output. The results suggest that the inclusion of non performing loans is significant for bank efficiency estimations. Moreover, the size-efficiency link is found to be negative for the Middle East financial sector. Also, according to data large banks technology is inferior due to lower efficiency from risk management. On the other hand, small banks are more efficient but, their credit quality management is sensitive to external economic shocks. This paper addresses these issues and provide empirical evidence on the unexplored avenues of research. It specifically contributes to the existing literature on bank performance three ways.Firstly, the influence of risk inclusion on efficiency estimates is examined including a proxy for credit quality using directional distance function approach (DDF) under a DEA framework. While previous papers mainly focus on bank performance estimated through parametric methods, they divert their attention from credit quality and size impact on Middle East financial sector performance. Unlike the previous analysis of Middle East banks efficiency, it attempts to calculate a measure for opportunity cost of risk reduction which may give information of banks' behaviour, specifically interesting to regulators.

The paper unfolds as follows.Section 2 provides an overview of the related studies in the literature, followed by Section 3 that outlines the method used. Section 4 presents the choice of input and output variables for the efficiency model while Section 5 reports our empirical findings. Finally, Section 6 concludes the paper offering some policy implications.

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2 Review of the Literature

A number of empirical studies have investigated the competitive conditions in various banking systems. The majority of these studies conclude that banks operate in a monopolistic competitive environment (Shaffer, 2002; Claessens and Laeven, 2004; Beck, et al., 2006; Mamatzakis et al, 2006; Gutierrez, 2007; Polemis, 2015;Apergis and Polemis, 2016; Apergis et al. 2016). Bank efficiency has been analyzed extensively by many surveys.Regarding the MENA region, Naceur et al. (2011) examine the effect of financial-sector reforms on banks performance in selected MENA countries over the period 1994-2008. They use a meta-frontier approach to calculate efficiency scores in a cross-country setting. Their analysis shows that despite similarities in the process of financial reforms undertaken in the MENA countries, the observed efficiency levels of banks vary substantially across markets, with Morocco consistently outperforming the rest countries in the region.

In addition, the evaluation of the relationship between competition and bank efficiency is rarely found in the MENA region and is mainly focused on the European Union (EU) countries (Casu and Girardone, 2009; Delis and Tsionas, 2009; Andries and Capraru, 2013; Castellanos and Garca, 2013; Polemis, 2014). More specifically, Casu and Girardone, (2009) investigate the relationship between competition and efficiency in the banking sectors of five EU countries (i.e., France, Germany, Italy, Spain and the U.K.) over the period 2000-2005 using Granger causality tests. Their findings indicate that an increase in banks' monopolistic power does not translate into a decrease in cost efficiency. Moreover, they highlight a positive causality between market power and efficiency levels, running from efficiency to competition in a weak pattern, implying that increases in efficiency do not foster market power.

Delis and Tsionas (2009), by applying the local maximum likelihood methodological approach, investigate the relationship between the level of market power as measured by the Lerner index and cost efficiency in a sample of European Monetary Union (EMU) countries over the period

1999-2006.Market power estimates indicate a fairly competitive conduct; however, heterogeneity in market power estimates is substantial across banks. They also claim that efficiency and market power are negatively related, which is in line with the so-called Quiet Life Hypothesis. According to this hypothesis, monopolistic power allows managers to enjoy a share of the monopoly rents in the form of discretionary expenses or a reduction of their efforts, leading to the presence of inefficiencies (Hicks, 1935). In other words, this hypothesis posits that banks enjoy the advantages of market power in terms of foregone revenues or cost savings (Delis and Tsionas, 2009). Andries and Capraru (2013) explore the competition in banking systems in the EU as a whole for the period 2004-2010, providing mixed results towards the QLH in terms of cost and profit efficiency. Furthermore, they find significant evidence towards the validity of the Competition-Inefficiency Hypothesis, denoting that competition does not lead to a decline in bank efficiency. According to this hypothesis, higher competition is likely to be associated with less stable, shorter relationships between customers and banks, amplifying information asymmetries and requiring additional resources for screening and monitoring borrowers, resulting in cost inefficiencies.

Castellanos and Garca (2013) study the relationship between the degree of banking competition and the efficiency of the Mexican banking sector over the period 2002-2012, by employing Tobit regressions. They use the DEA and the Boone indicator to assess the degree of competition among other possible determinants of bank efficiency. Their main results indicate a positive direct relationship between banking competition and efficiency. Finally, Eisazadeh and Shaeri, (2012) use both Stochastic Frontier Analysis (SFA) and second-stage Tobit regressions to investigate the impact of institutional and financial factors on banking efficiency in the case of the MENA countries. They argue that the main drivers of banking efficiency are related with the macroeconomic stability, the financial development and the degree of market openness. Polemis, (2015) assess the level of banking competition in selected MENA countries. The analysis employs the estimation of a non structural indicator (H-statistic) and draws upon a panel dataset of eight MENA countries (Algeria, Egypt, Israel, Jordan, Morocco, Oman, Saudi Arabia and United Arab Emirates) over the period 1997-2012. The empirical findings are consistent with other similar studies, providing sufficient evidence in favor of a banking monopolistic competition regime. This study argues that, despite similarities in the process of financial regulatory reforms undertaken in the eight MENA countries, the observed competition levels of banks vary substantially, with Algeria and Morocco consistently outperforming the rest of the region.

In a recent paper, Apergis and Polemis, (2016) investigate the relationship between competition and efficiency in the banking sector of MENA countries spanning the period 1997-2011. To measure the level of competition, the paper estimates the non-structural indicator known as the H-statistic, while the level of bank efficiency is estimated through the non-parametric methodology of the DEA and the Bootstrapped DEA. They argue that there is a one-way (negative) Granger causality, running from efficiency to competition.The empirical findings lead to the rejection of the Efficient Structure Hypothesis, implying that increases in competition do not precede increases in cost efficiency.

Finally, Bahrini, (2017) analyses the technical efficiency of Islamic banks in the MENA during the period 2007-2012 by employing a bootstrap DEA approach. The empirical findings indicate that pure technical inefficiency was the main source of overall technical inefficiency instead of scale inefficiency. This finding was confirmed for all MENA Islamic banks. Furthermore, he claims that MENA Islamic bank managers must focus more on improving their management practices rather than increasing their sizes. Moreover, financial authorities in MENA countries must implement several regulatory and financial measures in order to ensure the development of MENA Islamic banking.

3 Methodological Underpinnings

Our methodological framework is developed in two stages.In the first stage, we present the theoretical and methodological underpinnings regarding the estimation of the directional distance function and risk efficiency measure.In the second stage, we discuss expansion in a metafrontier framework presenting the theoretical basis for its inclusion.

3.1 Directional Technology Distance Function and risk efficiency measurement

To present our methodology we follow closely the works of Chambers et al.(1996), Chung et al. (1997) and Fare and Grosskopf (2000).Suppose that a bank employs a vector of inputs $x \in \Re_{+}^{K}$ to produce a vector of good outputs $y \in \Re_{+}^{M}$, and undesirable outputs $b \in \Re_{+}^{N}$.It is assumed that $P(x)$ is the feasible output set for a given input vector x, and $L(y, b)$ is the input requirement set for a given output vector (x, b).
The banking technology set can be defined as:

$$T = \{(x, y, b) : \quad x \quad can \quad produce \quad (y, b)\} \tag{1}$$

The technology is modeled in alternative ways. The output is strongly and freely disposable if $(y,b) \in P(x)$ and $(y^{'},b^{'}) \leq (y,b) \Rightarrow (y^{'},b^{'}) \in P(x)$, which implies that if an observed output vector is feasible, then any output vector smaller than that is also feasible. This assumption excludes production processes that generate undesirable outputs that are costly to dispose. For example, regulators concern about risk since it influence the economical stability of bank 's operating environment. On the other hand, managers are worried about the risk taken as it influence profitability, competitiveness and reputation of a bank.Those internal and external concerns imply that risk should not be treated as freely disposable.

In such cases, bad outputs are considered as being weakly disposable: $(y,b) \in P(x)$ and $0 \leq \theta \leq 1 \Rightarrow (\vartheta y, \vartheta b) \in P(x)$. This implies that risk is costly to dispose of and abatement activities would typically divert resources away from the production of desirable outputs (such as loans and earnings) and thus lead to lower good outputs with given inputs. For a bank it means that in order to minimize the risk undertaken, managers have suppress the quantity of given loans, and consequently their profitability (see Fig.1)[1]

The directional distance function (hereafter DDF) acts as a representation of an multi-input, multi-output distance function.Following Chambers et al. (1998) and Picazo-Tadeo et al. (2005) we define directional distance function as:

$$\overrightarrow{D_T^F}(x,y,b;g_x,g_y) = \left\{ max\beta * : (x, y + \beta * g_x, b - \beta * g_y) \in T(x,y,b) \right\} \tag{2}$$

Indeed, the DDF projects the input-output vector (x,y) onto the technology frontier in the $(g_y, -g_b)$ direction (see fig.1) and allows for desirable outputs to be proportionally increased, and bad output to be proportionally decreased. More precisely, it seeks the maximum attainable expansion of desirable outputs in direction g_y and the largest feasible contraction of the undesirable outputs in direction g_b.

For the estimation of the production technology, parametric and non-

[1]Figure 1 illustrates how the technology that satisfies the assumption of strong and weak disposability assumption is constructed.The output set which is bounded by $0cdef$ is the technology under strong disposability of bad outputs. The reasons for the above stated is the absence of reduction in good outputs as the undesirable outputs are diminished in segment cd and the opposite for the segment ef, while de is the section of technology where activate best practitioners. As a result, for cd is assumed strong disposability of bad outputs and in the section ef the same hypothesis states only for the good outputs. Follows that any try to reduce bad outputs below the point d recognize the need to either reduce good outputs or to use more inputs under the non free disposable hypothesis and the output set is described by $0adef$.

parametric methodologies are available. Of the latter, Data envelopment analysis (DEA) was used to perform our measures instead of Stochastic frontier analysis (SFA). DEA is considered an appropriate approach for measuring performance of decision making units (hereafter DMUs) since establishing production standards and measuring absolute efficiency in this setting is hard due to the limited time available (Halkos and Polemis, 2018). The specific estimation of the DDF allows us to estimate the productive efficiency of each region located at its own country-frontier suggesting a common frontier or benchmark for their productive performance scores. The following linear programming problem, after defining a particular directional vector, is used to calculate DDF:

$$\overrightarrow{D_T}(x_n^{l^*}, y_n^{l^*}, b_n^{l^*}; g_x, g_y, -g_b) = Max_{\beta \geqslant 0}\beta \tag{3}$$

$$s.t \qquad (x_n^{l^*} - \beta \cdot g_{xn}^{l^*}) \geq \sum_{l=1}^{L} z^l x_n^l \tag{4}$$

$$(y_n^{l^*} + \beta \cdot g_{yn}^{l^*}) \leq \sum_{l=1}^{L} z^l y_n^l \tag{5}$$

$$(b_n^{l^*} + \beta \cdot g_{bn}^{l^*}) = \sum_{l=1}^{L} z^l b_n^l \tag{6}$$

$$\sum_{l=1}^{L} z^l = 1, \beta \geq 0 \tag{7}$$

where given $l = 1, 2, ..., L$ the banks examined for each specific technological set, using a vector of $m = 1, 2, ..., M$ inputs to produce a vector of $m = 1, 2, ..., M$ desirables and $h = 1, 2, ..., H$ undesirable outputs.

The construction of technology with both strong and weak disposability assumptions of bad output and the assumption of separability of good and bad outputs in financial production process (Kumar and Khanna, 2009) permits for directional distance function to take the form $\overrightarrow{D}_{0,F}^t(y^t, b^t, x^t) = B(b^t)D_{0,F}^t(y^t, x^t)$ where $D_{0,F}^t(y^t, x^t)$ is effect of the 'pure' technical inefficiency and $B(b^t)$ is the effect of undesirable output on technical inefficiency. So following this logic the static measure of banks' risk efficiency (BRE) (Kumar and Khanna, 2009) is defined as:

$$BRE_F = \frac{(1 + D_{0,F}^t(y^t, b^t, x^t))}{(1 + D_{0,F}^t(y^t, x^t)} \tag{8}$$

By construction, BRE_F will takes values less than or equal to one. It represents the extent to which a bank would be constrained in increasing outputs by its potential to transform its production process from free disposability to costly disposal of risk. Banks that are less constrained have a lower opportunity cost of transformation in the production process and are considered to be more risk management efficient [2].

3.2 Directional Technology Distance Function under a metatechnology framework

In Middle East countries with L banks each having their specific state of technology S that belongs to a specific bank system and their own environmental factors, a metafrontier is defined as the boundary of the unrestricted technology set. In this case, if technology is freely interchangeable and the l-banks have potential access to the same overall technology we can apply the same DDF to the metafrontier [3]. Indeed, it is not possible to compare banks belonging to different systems taking into account the case where multiple technologies are possible and available. Moreover, the reality is that this is not the case and banks experience some heterogeneity. Relaxing this hypothesis, the notion of the metafrontier comes into play providing a benchmark for all the participating regions irrespective of the frontier to which each belongs.

Hence, given S technologies $T^1, T^2, ...T^S$ the metatechnology set, denoted as T^M, can be defined as the convex hull of the jointure of all technology sets represented as can produce in at least one of (Rao et al., 2003) [4] denoting as $T^M(x)=\{(y,b)$ x can produce $(y,b)\}$ in at least one of $T^1, T^2, ...T^S$. The output set P^M associated with the metate-

[2] This measure takes a value one only for those countries which are on the segments de and ef or those banks whose expansions fall on these segments (fig.1). Moreover, de and ef are common to both technologies with different assumptions on the disposability of bad outputs. For banks that lie on those segments, the cost of transforming the production process from strong disposability of bad outputs to weak disposability of these outputs would be zero. For banks located along the line segment $0ad$, or in the interior part of the weakly disposable output set, the RE index will assume values less than one, indicating that there is an opportunity cost of transforming the production process from strong disposability to weak disposability of bad outputs

[3] Hayami (1969) and Hayami and Ruttan (1971) were the first to propose the concept of meta-production distance function as the envelope of commonly conceived neoclassical production functions(pp.134-135). The basic thinking behind meta-production is to emphasize the heterogeneity of production technology with different decision-making units (DMUs) to reflect region, type, scale and other inherent attributes. All DMUs are then divided into groups according to the different sources of technological heterogeneity.Each group can form a production frontier, i.e. a group frontier

[4] A global frontier that envelopes each of the individual country frontiers or in other words a basket of available technologies for all industries irrespective of the country to which each belongs

chnology is defined in the same way as for a single technology, while the corresponding efficiency of each region with respect to the homogeneous boundary for all heterogeneous regions can be measured by the output-oriented metatechnical directional distance function defined as (Eq.3):

$$\overrightarrow{D_M^F}(x, y, b; g_x, g_y) = \left\{max\beta* : (x, y + \beta * g_x, b - \beta * g_y) \in T(x, y, b)\right\} \tag{9}$$

The corresponding efficiency score is easily obtained by solving an analogous LP problem as in Eq.(2). The boundary of the metafrontier is used in order that each regional efficiency performance ma be estimated under the hypothesis that technology is freely exchangeable and all regions have potential access to the same level of the European metatechnology (Casu et al. 2016).

The introduction of metafrontier analysis as an approach that allows the investigation of the interrelationships between different technologies (Battese et al. 2004) can be used in order to explain differences in production opportunities that can be attributed to available resource endowments, economic infrastructure, and other characteristics of the physical, social and economic environment in which production takes place (ODonnell et al. 2008; Kontolaimou et al. 2012). Moreover, it accounts for structure of national markets, national regulations and policies, cultural profiles and legal and institutional frameworks (Halkos and Tzeremes, 2011), different ownership types (Casu et al. 2013) and different rate of access and acceptance of General Purpose Technologies-GPT (Kounetas et al. 2009). O'Donnell et al. (2008) extended the Battese et al. (2004) framework using conventional Shepard distance functions to estimate technical efficiency with respect to the same metatechnology and several individual technology sets.

Each productive efficiency score obtained from the estimation with respect to the common technology can be used to define the so-called metatechnology ratio which is considered a measure of proximity of the k-th group individual frontier to its metafrontier or in other words how close a bank system frontier is to the overall (Middle East in our case) metatechnology (metafrontier). Thus, we can define the following ratio (O'Donnell et al.2008):

$$MTR(x, y, b) = \frac{MTE(x, y, b)}{TE(x, y, b)} \tag{10}$$

and identify the technology differential among the Middle East bank systems.Hence,the technology gap of the $i-th$ bank in the $s-th$ group frontier is defined as the distance of the group frontier to the metafrontier, weighted with the minimum inputs which are attainable by employing the group-specific technology,that is:$TG(x, y, b) = 1 - MTR(x, y, b)$

For a bank exhibiting a value equal to zero (or MTR equal to one), it is evident that the group frontier is tangential to the metafrontier and hence no efficiency losses are due to inferiority of the group technology compared to the metatechnology. However productive inefficiency with respect to the group frontier is still a possible situation. Comparing with other approaches that considers technology gap as a partially factor of growth measured as the technological distance from the frontier (Castellaci, 2011) in our case technology gap is calculated as the distance of the specific region to the Middle East metatechnology taking explicitly into account the distance of the corresponding regions frontier from the Middle East technology.

Following the analogous formula in Eq.(4) we can define in a analogous way the risk efficiency corresponding to the metatechnology using the following formula:

$$BRE_{MF} = \frac{1 + D^t_{0,MF}(x^t, y^t, b^t)/(1 + D^t_{0,MF}(x^t, y^t)}{1 + D^t_{0,F}(x^t, y^t, b^t)/(1 + D^t_{0,F}(x^t y b^t)} \tag{11}$$

4 Data and variables

Our data comprises of listed banks in nine Middle East countries over the period 1998 to 2014.Balance-sheet and income statement data were obtained from Bankscope database. All the variables are expressed in millions of US dollar. The total number of banks on which the dataset provide information about are 93 from which 66 are present in every year during the period in question resulting in a balanced dataset[5]. Moreover, we limit our analysis to publicly traded commercial banks since the services they offer are reasonably homogeneous and comparable across countries, while, they do follow international accounting standards as well (Naceur et al, 2011, Apergis and Polemis, 2016). After reviewing the data for reporting errors and other inconsistencies, we obtain a balanced dataset of 1122 observations, which includes a total of 66 different banks.Furthermore, we proceed in an additional categorization of Middle East banks according to their size creating two different clusters. Hence, a bank is classified as large if its total assets are greater than the yearly median of total assets, and small otherwise (Ariff and Luc,2008; Berger et al.2005). Such manner of size determination permits movement of bank between size groups in every year as can be seen from table 1[6]

[5]The percentage of country participation in the sample along with proportion of banks which are not present in the whole research period reaches to a maximum 6 %

[6]No movement between groups of size is observed for 2001, 2010, and 2013 while in 2004 the higher rhythm of movement is observed, then 9% of small banks become

Based on the intermediation approach (Berger and Mester, 1997) inputs and outputs of the financial production process are defined. According to it, banks are considered to act as intermediaries between savers and investors, transforming deposits and purchased funds into loans and financial investments. More importantly, costs include both interest expenses and production costs. However, in the banking literature several other approaches are used for defining and measuring inputs and outputs. A theoretical issue which rises a significant argumentation in the efficiency of banks is the definition of outputs and respectively inputs of bank production. This misunderstanding seems to fade out since three approaches to recognize the outputs in financial sector was defined (Berger and Mester, 1997;Casu and Molyneux,2003). The intermediation approach focuses on the bank's production of intermediation services and the total cost of production. It define the outputs to be banks' assets of various categories (like loans), while inputs are typically specified as labor, physical capital, deposits. Asset approach states that banks are intermediaries in the financial activities, so the assets and loans are defined as outputs while deposits and liabilities are inputs User approach define the accounting items as input or output based on their participation to bank revenue. On the other hand, in value added approach all the balance sheet items are recognize as outputs, but not exclusively. So it is assumed that banks use their fixed assets[7], effort from personnel, deposits and sort term funds to produce loans and earnings.Following this idea, fixed assets, personnel expenses, deposits and short term funds, other operating expenses and deposits are recognized as inputs.Furthermore, outputs are represented to be net loans[8], total earning assets[9] and reserves for impaired loans (NPLs)as the bad ones.

The descriptive statistics of both inputs and outputs are presented in Table 1 and ensure that as expected, on average, large banks tend to have higher expenses, profits and risk compared to small. Moreover, figure 2 illustrate the growth rate of non performing loans for small and large banks during the period in question. Overall the risk taken by large banks is more stable compared to small banks. Although in the periods before and after crisis the risk preferences of small and large banks do not chances differently, the same is not observed for years 2007 through

large. Although the range of movement is limited and shrunken it gives a more realistic and time variable approach to the determination of size.

[7]Fixed assets represents the total value of the tangible assets which can not be easily liquified.

[8]Net Loans represents total loans to customers, reduced by possible default losses and unearned interest income.

[9]Earning assets include stocks, bonds, income from rental property, certificates of deposit (CDs) and other interest or dividend earning accounts or instruments

2010. During the global financial crisis the risk accumulation of banks is excessive. The quality of small bank assets worsen by almost 60% while large banks' risk increase by 20%.

5 Results and discussion

The presentation and discussion of the empirical results follows the structure of the analysis. The size specific efficiency scores with respect to the two different groups of Middle East banks are first presented and discussed. The metatechnology efficiency scores and the associated technology gaps which arises in the context of the metafrontier are then used to examine technological spillovers

5.1 Efficiency estimates for small vs big banks

It is assumed that the role of a manager is to maximize the wealth of a bank, through increment of market share (loans) or profitability (earning assets) in the simple model. On the other hand, the more realistic specification describe the role of a manager to be more complicated. He has to take production decisions that increase loans and earnings but with the constrain of keeping the risk bank exposure to the lowest possible.

In that environment, it will be interesting to find out which bank are more efficient in risk constrained management choses. It is possible through comparing simple and risk adjusted efficiencies of small and large banks with respect to the common frontier[10].Table 2 illustrate the mean distance (inefficiency) of small and big banks with respect to common technology frontier under CRS and VRS, with recognizing the impact of risk on efficiency estimations while the risk efficiency estimate the impact of NPLs inclusion denoted by risk efficiency. In this section it is assumed that in Middle East exists only one technology of financial production and all banks have access to. On average small banks are closer to the underlying available Middle East technology and this is revealed with the lower value of distance in all four specifications. For example, in risk adjusted model, under optimal scale assumption, from 1998 to 2014, the average small bank in order to be efficient needs to increase its loans and earnings by 20% and decrease its NPLs (credit risk) by 20%. However, large banks must expand their market share and profitability by 22% to be fully efficient.So, higher fixed assets seems to be related with more inefficiency, revealing a negative link between bank

[10]Alternatively, heterogeneous frontiers could be assumed but then the comparison ex post between small and big banks would not be possible (Watanabe and Tanaka, 2007)

size and efficiency.

Literature presents contradictory evidence about the correlation sign of bank size and efficiency. Middle East banking industry show sign of a negative relation between the amount of fixed assets and performance during the research period as it was found out. This research output is in line with other studies(Koutsomanoli-Fillipaki et al.2012; Ataullah et al. 2004), and seems to agree that complexity and politically determined bureaucratic organizational structure impede large banks to introduce new technology and products, while small banks are more flexible to adapt changes and remain efficient. On the other hand, disagreement is raising when comparing the results with studies which mention that large bank 's market power make them more efficient (Rangan et al. 1988; Yildirim, 2002; Berger, 2007).

Figure 3 offer an illustration of risk efficiency distribution for small and large banks. In every year the distribution of large banks is at lower RE values which imply a negative effect of risk management on bank inefficiency. However, small bank's asset quality administration tend to increase their efficiency more in 2006-2008 and 2012-2014. Based on figure 3 during the financial crisis both small and large banks experienced a dramatical increase in non performing loans, which means their risk aversion increase also, but the inefficiency did not decrease. According to bad luck hypothesis, the increase in risk do not originate to managerial inefficiency but to external shocks (Berger, 2007). On the other hand, the characteristic positive risk impact on efficiency of banks before crisis and the following vanishing influence suggest the inability to reject the cost skimming hypothesis for all banks (Fiordelisi et al.2011; Koutsomanolli-Fillipaki et al. 2012; Avkiran, 1999)

. Additionally, it was disclosed that more efficiency is attached to large banks when comparing the ability to both increase loans and earning while simultaneously decrease the risk. Having in mind the negative size efficiency link, it can be stated that big banks have an better ability to diversify their credit risk, because of their market power(Rangan,1998; Yildirim, 2002; Berger, 2007; Ataullah et al. 2004). This conclusion demonstrate that the assumptions about risk and efficiency relationship are not exclusive.

5.2 Metafrontier estimates and technology gaps

In this section, the traditional (considering only desirable) and the risk adjusted (considering both desirable and undesirable) performance estimates are compared. Using output orientated directional distance function the scaling vector in case of NPLs inclusion is $g = (g_y, g_b) =$

$(1, 1, -1)$ while for the simple model is $(1, 1, 0)$. Both CRS and VRS scale are considered.Table 3 compares the estimated efficiency levels of banks in every year assuming strong and weak disposability of bad output.The performance scores was calculated with respect to a common Middle East frontier. On average, and for every year the simple model reports higher inefficiencies and lower number of fully efficient banks. As expected, exclusion of NPLs from the objective function results in underestimated efficiency levels and place banks further from the common frontier.

Under VRS and CRS assumptions, the two estimates' distributions of performance are illustrated to be different (Fig.4). Hence, there is a possibility that the underlining real technology of financial production does not permit for analogous expansion of good outputs as the bad output, because the distances from CRS and VRS differ significantly (Watanabe and Tanaka, 2007). Ignoring the other assumptions, the specifications of constant return to scale estimate larger inefficiency compared to variable returns to scale.This conclusion remain valid when reserves for non performing loans are included or otherwise. It is a confirmation of directional distance function definition to report lower values of distance for VRS compared to CRS.

Determining if the omission of NPLs results in biased inefficiency estimations, (Mester 1997; Drake and Hale, 2003; Kounetas, 2015), a non parametric, Mann-Whitney U test was conducted. The null hypothesis of identical population of relative frequency distribution of models including bad outputs and ignoring them is rejected. For both scale assumptions there seems to be a difference between the resulting distances from technology frontier when omitting and including risk, with difference being statistically significant as can be seen from table 4.

In addition, Table 4 shows the estimated values for risk efficiency for every year and different scale assumption. On average, in none of the years banks were fully risk efficient implying the existence of risk minimization opportunity cost. Optimal scale specification of the output orientated directional distance function report a loan and earning sacrifice of 10% for a proportional reduction of risk, for both small and large banks, while VRS model imply that a 1% reduction in banking activity is enough to reduce the cost.Turning the attention to yearly averages, there is observed that in some years small banks have higher constrains to reduce the risk and in others large banks' inefficiency is not reduced by the produced mix of outputs. If the risk efficiency measure is interpreted as an opportunity cost of risk diminished then it can be stated that large banks have higher constrains to increase their asset quality. For example, in 2004 an average bank in order to adopt a more secure strategy was necessary to renounce almost 25% of their market share and profits which is quite useful for supervisors.

It was expected that precluding undesirable outputs from DDF results in biased estimates of the technical efficiency due to the model incapability to describe the true production process. The research conclusions about the influence of bad outputs on efficiency estimates are in the same line with the theory (Stigler, 1976) and consistent to the existing literature (Kounetas, 2015; Watanabe and Tanaka, 2007; Kumar 2009), which also point that the preclusion of bad loans conduct to overestimated inefficiencies and is explained by the lack of rewarding DMUs for succeeding controlling NPLs level.

In this section, also, it is attempted to explore what amount of inefficiency is generated by the size alternative technology. Furthermore, the risk management inefficiency which emerges form the size specific production technology is investigated. To proceed towards, the efficiencies with respect to size specific frontier and to the common frontier are estimated. It is presumed that large and small banks have different technologies, and concomitantly have access to a common Middle East bank technology production. Afterwards the metatechnology ratio calculated. Motivated by the bias produced when NPLs are excluded, previous approximated risk adjusted efficiencies are employed for MTR evaluation.Then BRE of size specific frontiers and common frontier are used to define the metatechnology risk efficiency ratio. The results of average MTR and REMTR of small and large banks are presented in table 5.

MTR express how close is the size specific frontier to the common underlying technology. It has the ability to identify technology differentials among size banking system.To remind, as higher the value of MTR as less inefficient is the adopted technology (small or large).Small banks have higher MTR in all model specifications, indicating more advanced technology selection compared to large banks.Explicitly, if large banks would adopt the available Middle East technology, they could be efficient with a 6% lower change in the outputs (reducing risk and increasing loans and earnings) while keeping their input mix stabile. In the same manner, small banks efforts for efficient output strategy would be minimized by 2.5% (CRS model).In other words, less inefficiency is arising from the management and operational processes, which determine the technology, adopted by small banks.Information about the time trend and distribution of MTR of small and big banks are illustrated in figure 5 for optimal and variable scale assumption. Small bank 's technology is closer to the available Middle East production frontier before financial crisis.Starting with 2007, large banks follow closely the common technology, while it seems to be a difficult task for their smaller counterparts.Although CRS expose the flexibility of large banks to adapt more efficiently to riskier environment, VRS model present small banks' technology to be more efficient in every year.Based on metatechnology ratios described in table 5, the same distribution of small and large banks by year is tested using the non parametric Mann Whitney test on MTRs estimations. The results of the test are presented in table 6 and point out that technology configurations are statistically important factors in efficiency determination.

Several conclusions about bank size and efficiency can be drown from the results presented in this section. Firstly, on average small bank technology of Middle East is more efficient, but is accompanied with more sensibility to external shocks. Macroeconomic events, like financial crisis which started in 2007 seems to increase the inefficiency of small bank production, meaning that the chosen output combination of risk, loans and earnings are further than the possible ones if optimal return to scale characterize the technology. On the other hand, inferiority of large banks technology before crisis period became superior to small bank 's technology during crisis. Affirmation of earlier literature engage the obtained results that find efficiency decrease as the main source of bank 's productivity and competitiveness losses Berger, 2007;Ataullah et al. 2004; rangan,1998). Furthermore, as claimed by "bad luck" hypothesis, the higher inefficiency of small banks does not mean that the managers are not efficient. It is logical to say that, if small banks has a more diversified risk and a higher influence in market, then it could be more efficient during the macroeconomic shocks.On the other hand, the before crisis larger inefficiency of big financial institutions may be explain by either the cost skimming or the moral hazard hypothesis.

Finally,the results of risk efficiency metatechnology ratio are provided in table 5 which gives some valuable information on opportunity cost of risk which is due to size specific technology.On average small banks technology is superior, since only 2% reduction in sacrificed market share and profitability will be necessary if small banks' frontier were absolutely the same as available Middle East technology. Nevertheless, large banks frontier appears to be further from the efficient cost disposal of risk.On average, large banks renounce from more desirable outputs to increase the asset quality. If those banks adopt the common technology they will earn a 4% on loans and profitability spare.To determine the time trend and explore in more depth the behavior of risk efficiency ratio with respect to metafrontier a distribution graph is provided in figure 6. In every year and under variable to scale assumption small banks have the same risk opportunity cost with respect to both frontier and metafrontier.Every small bank in 2004, 2005, and 2007 does not have additional charge originated by its supressed size. This is true also for CRS assumption in 2004 while in the rest years slightily higher contraction of banks activity is required to avoid risk under homogeneity assumption, but it does not exceed the five percent. So large banks are by 4% more inefficient due to their adopted technology of risk management.

Figure 6 highlights the inefficient risk management, due to the inflexibility of big banks to adopt their activities to risk management development. It could be explained by the impersonal interaction between lenders and borrowers in significantly large finacial institutions koutsomanoli2012profit. Additionally, the benefits from diversification of risk could be exploited even more, and higher levels of efficiency could be approached. On the other hand, the risky enviroment of crisis has obligated large banks to adopt more effective credit monitoring systems. Contrary, small banks have more beneficial reaction on their technical efficiency due to they technology process to manage risk. This could be explained by their minor market share which permits them to monitor credit better and to exploit benefits from soft information processes (Elyasiani and Mehdian, 1995).

6 Conclusions

Bank efficiency seems to be one of the most important assets for banks and is given priority in recent decades, because banks operate in an extremely competitive environment where survival has become uncertain. This paper had stressed the impact of risk preferences and size on Middle East bank performance.For this purpose, it was assumed that the financial production is characterized by both free and costly risk abatement, which enable the identification of inefficiency due to risk management.Furthermore, a meta-production model is adopted to identify inefficiency attributed to bank size. An output orientated directional distance function was employed under intermediation approach. Using accounting data on 66 Middle East banks for 1998 to 2014 period, banks' efficiencies were estimated with DEA method.

The evidence from this study points towards the idea of biased efficiency estimations resulting from models which omit bank 's risk preferences. In the same line with relative literature, ignorance of bad loans gives overestimated inefficiency, and lower number of decision making units being fully efficient. Furthermore, the difference of risk adjusted and simple inefficiency was found to be statistically significant. Besides the technical inefficiency of Middle East banks, it was demonstrated that non performing loans have a positive effect on bank efficiency.

The findings suggest that small banks are closer to the underlying common Middle East technology when non performing loans are included in the model. The persistence of such observation during the examined period conduct to the conclusion of a negative relation between size and efficiency of banks. Although large banks' risk preferences have elevated effect on efficiency, they are more inefficient compared to smaller counterparts. Furthermore, the investigation of inefficiency attributed to bank size unrevealed the technological inferiority of large banks which is associate with bad management. On the other hand, small banks technology is closer to the common available Middle East frontier during the research period, excepting 2008 to 2010. This accentuate the idea of bad luck hypothesis and highlight the sensibility of small banks to external economic shocks.

Finally, the results on risk efficiency metatechnology ratio indicate that on average, production inferiority of large banks are ascribed to their low-quality management of non performing loans.Interestingly, during financial crisis the risk abatement cost of large banks is closer to the efficient, which can be explained by the benefits of risk diversification. Contrary, having a lower market share and less diversified risk, small banks face difficulties to adapt their cost of risk reduction to the efficient. However, sacrifice of market share and earnings are not very high, implying more personal relation with borrowers and effective process of soft information for small bank 's management.

Possible policy implications of our study for bank management and regulation are as follows. Since the average large bank 's technical inefficiency is attributed to poor risk management, it is beneficial for large banks to develop a better process of monitoring possible costumers. Also, the results indicate that bank size measured by total assets has a negative effect on technical efficiency. This suggests that consolidation of large banks in the region must be controlled in order to lower technical inefficiency in banking. Moreover, since bank efficiency measures the performance of a bank relative to the performance of a best-practice bank, ranking the banks this way is feasible and useful for the government policy by showing inter alia the effects of deregulation or mergers. Furthermore, in terms of research purposes measuring properly bank efficiency is crucial in order to identify the best and worst practices in order to improve managerial performance

The above findings are valuable for market players (banks, regulators, investors and policy makers) in their attempt to understand what are the main driving forces of bank efficiency in the MENA region. From a policy perspective, the results of this study support the notion of governments toward a deeper revision of regulatory and competition policies in the MENA banking sector. For this reason, policy makers and regulators should opt for reforms that restrict anti-competitive practices (i.e abuse of dominance, cartel agreements, vertical restraints, etc) while in parallel enhance ex-ante the level of effective competition by assessing the disruptive effects of mergers and acquisitions. Owing to its limitations, the research could be extend in a variety of ways.The scope of this study could be further extended to investigate the country and ownership inefficiencies. Second, it is suggested that further analysis to be undertaken in the investigation of bias which the accounting strategy of banks impose.Third, future research into the efficiency of the banking sector could also consider the to decompose the internal and external risk inefficiency. Finally, result comparison with an investigation based on a larger data and determining the size of bank based on market share and profitability, would be interesting.

Despite these limitations, the findings of this study are expected to contribute significantly to the existing knowledge of the operating performance of banking industry in the Middle East countries. Nevertheless, the study has also provided further insight into the banks size efficiency relation, as well as the policy makers with regard to attaining stability in systemic risk. Additionally, directions for technical efficiency improvements through more personal credit monitoring facilitate sustainable competitiveness banking operations in the future.

References

[1] Almarzoqi, R., Ben Naceur, S., Scopelliti, A (2015). How Does Bank Competition Affect Solvency, Liquidity and Credit Risk? Evidence from the MENA Countries, IMF Working Paper 15/210.

[2] Anzoategui, D., Martinez Peria, M., Rocha R. (2010). Bank Competition in the Middle East and Northern Africa Region. Review of Middle East Economics and Finance 6: 26-48.

[3] Apergis N., and Polemis, M (2016) Competition and efficiency in the MENA banking region: a non-structural DEA approach, Applied Economics, 48(54): 5276-5291.

[4] Apergis, N., Fafaliou, I. Polemis, M, (2016). New evidence on assessing the level of competition in the European Union banking sector: A panel data approach, International Business Review, 25(1): 395-407.

[5] Ariff, M., Luc, C. (2008). Cost and profit efficiency of Chinese banks: A non-parametric analysis. China Economic Review, 19(2), 260-273.

[6] Ataullah, A., Cockerill, T., Le, H. (2004). Financial liberalization and bank efficiency: a comparative analysis of India and Pakistan. Applied Economics, 36(17), 1915-1924.

[7] Avkiran, N. K. (1999). The evidence on efficiency gains: The role of mergers and the benefits to the public. Journal of banking and finance, 23(7), 991-1013.

[8] Barros, C. P., Managi, S., Matousek, R. (2012). The technical efficiency of the Japanese banks: non-radial directional performance measurement with undesirable output. Omega, 40(1), 1-8.

[9] G.E. Battese, D.S.P. Rao, C.J. O'Donnell (2004).A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. Journal of Productivity Analysis, 21 (2004), pp. 91-103

[10] Berger, A. N. (2007). International comparisons of banking efficiency. Financial Markets, Institutions and Instruments, 16(3), 119-144.

[11] Berger, A. N.,Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions?. Journal of banking and finance, 21(7), 895-947.

[12] Berger, A.N., Miller, N. H., Petersen, M. A., Rajan, R. G., and Stein, J. C. (2005).Does function follow organizational form? evidence from the lending practices of large and small banks. Journal of Financial economics, 76(2):237269.

[13] Casu, B., Girardone, C. (2006). Bank Competition, Concentration and Efficiency in the Single European Market, The Manchester

School 744: 441-468.

[14] Casu, B., and Girardone, C. (2009). Testing the relationship between competition and efficiency in banking: A panel data analysis. Economics Letters, 105(1), 134-137.

[15] Chambers, R. G., Chung, Y., and Fre, R. (1996). Benefit and distance functions. Journal of economic theory, 70(2), 407-419.

[16] Castellacci, F. (2011). Closing the technology gap?. Review of Development Economics, 15(1), 180-197.

[17] Casu, B., Ferrari, A., Girardone, C., and Wilson, J. O. (2016). Integration, productivity and technological spillovers: Evidence for eurozone banking industries. European Journal of Operational Research, 255(3), 971-983.

[18] Casu, B., Ferrari, A., and Zhao, T. (2013). Regulatory reform and productivity change in Indian banking. Review of Economics and Statistics, 95(3), 1066-1077.

[19] Casu, B., Molyneux, P. (2003). A comparative study of efficiency in European banking. Applied Economics, 35(17), 1865-1876.

[20] Chiu, C. R., Chiu, Y. H., Chen, Y. C., Fang, C. L. (2016). Exploring the source of metafrontier inefficiency for various bank types in the two-stage network system with undesirable output. Pacific-Basin Finance Journal, 36, 1-13.

[21] Chung, Y. H., Fre, R., and Grosskopf, S. (1997). Productivity and undesirable outputs: a directional distance function approach. journal of Environmental Management, 51(3), 229-240.

[22] Delis, M, Tsionas, E. (2009) The Joint Estimation of Bank-Level Market Power and Efficiency. Journal of Banking and Finance, 33: 18421850.

[23] Degl'Innocenti, M., Kourtzidis, S. A., Sevic, Z., Tzeremes, N. G. (2017). Bank productivity growth and convergence in the European Union during the financial crisis. Journal of Banking and Finance, 75, 184-199.

[24] Drake, L., Hall, M. J. (2003). Efficiency in Japanese banking: An empirical analysis. Journal of Banking and Finance, 27(5), 891-917.

[25] Elyasiani, E., Mehdian, S. (1995). The comparative efficiency performance of small and large US commercial banks in the pre-and post-deregulation eras. Applied Economics, 27(11), 1069-1079.

[26] Fre, R., and Grosskopf, S. (2000). Theory and application of directional distance functions. Journal of productivity analysis, 13(2), 93-103.

[27] Fre, R., and Grosskopf, S. (2013). DEA, directional distance functions and positive, affine data transformation. Omega, 41(1), 28-30.

[28] Fiordelisi, F., Marques-Ibanez, D., Molyneux, P. (2011). Efficiency

and risk in European banking. Journal of Banking and Finance, 35(5), 1315-1326.

[29] Fukuyama, H., Weber, W. L. (2015). Measuring Japanese bank performance: a dynamic network DEA approach. Journal of Productivity Analysis, 44(3), 249-264.

[30] Fukuyama, H., Weber, W. L. (2008). Japanese banking inefficiency and shadow pricing. Mathematical and Computer Modelling, 48(11), 1854-1867.

[31] Halkos, G. E., and Tzeremes, N. G. (2011). Modelling the effect of national culture on multinational banks' performance: A conditional robust nonparametric frontier analysis. Economic Modelling, 28(1), 515-525.

[32] Halkos, G., Polemis, M. (2018). The impact of economic growth on environmental efficiency of the electricity sector: A hybrid window DEA methodology for the USA, Journal of Environmental Management, 211: 334-346.

[33] Hayami, Y. (1969) "Resource endowments and technological change in agriculture: U.S. and Japanese experiences in international perspective", American Journal of Agricultural Economics 51, Proceedings Issue (Dec), 1293-1303.

[34] Hayami, N and V. W. Ruttan (1971) "Agricultural development: an international perspective", The John Hopkins University Press, Baltimore.

[35] Kontolaimou, A., Kounetas, K., Mourtos, I., and Tsekouras, K. (2012). Technology gaps in European banking: Put the blame on inputs or outputs?. Economic Modelling, 29(5), 1798-1808.

[36] Kontolaimou, A., and Tsekouras, K. (2010). Are cooperatives the weakest link in European banking? A non-parametric metafrontier approach. Journal of Banking and Finance, 34(8), 1946-1957.

[37] K. Kounetas, I. Mourtos, K. Tsekouras (2009). Efficiency decompositions for heterogeneous technologies.European Journal of Operational Research, 199 (2009), 209-218

[38] Koutsomanoli-Filippaki, A., Margaritis, D., Staikouras, C. (2012). Profit efficiency in the European Union banking industry: a directional technology distance function approach. Journal of Productivity Analysis, 37(3), 277-293.

[39] Kumar, S., Khanna, M. (2009). Measurement of environmental efficiency and productivity: a cross-country analysis. Environment and Development Economics, 14(4), 473-495.

[40] Mester, L. J. (1997). Measuring efficiency at US banks: Accounting for heterogeneity is important. European Journal of Operational Research, 98(2), 230-242.

[41] ODonnell, C. J., Rao, D. P., and Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. Empirical Economics, 34(2), 231-255.

[42] Picazo-Tadeo, A. J., Reig-Martinez, E., and Hernandez-Sancho, F. (2005). Directional distance functions and environmental regulation. Resource and Energy Economics, 27(2), 131-142.

[43] Polemis, M (2015). Does Monopolistic Competition Exist In The MENA Region? Evidence From The Banking Sector, Bulletin of Economic Research, 7(S1), 74-96.

[44] Polemis, M (2014). Did financial crisis alter the level of competition in the EMU banks?, Applied Economics Letters, 21(15): 1065-1069.

[45] Rangan, N., Grabowski, R., Aly, H. Y., Pasurka, C. (1988). The technical efficiency of US banks. Economics letters, 28(2), 169-175.

[46] Stigler, G. J. (1976). The existence of x-efficiency. The American Economic Review, 66(1):213216.

[47] Tsekouras, K., Chatzistamoulou, N., and Kounetas, K., (2017). Productive Performance, Technology Heterogeneity and Hierarchies: Who to compare with whom. International Journal of Production Economics 193 pp.465-478.

[48] Yildirim, C. (2002). Evolution of banking efficiency within an unstable macroeconomic environment: the case of Turkish commercial banks. Applied Economics, 34(18), 2289-2301.

[49] Watanabe, M., Tanaka, K. (2007). Efficiency analysis of Chinese industry: a directional distance function approach. Energy policy, 35(12), 6323-6331.

Table 1: Summary statistics by size of inputs and outputs during 1998-2014

	Total				
	Average	Min	Max	Large	Small
Input					
Fixed Assests	144766.7	705	1071569	255721.9	33811.5
	(197220)			(229069)	(26871)
Personal Expenses	134256.3	846	1569865	236197	32315.67
	(217500)			(270170)	(29745)
Operating Expences	98634.91	1128	1070198	174044.4	23225.45
	(156779)			(193178)	(22100)
Deposits	1180×10^4	72355	10900×10^5	2020×10^4	3299077
	(1580×10^4)			(1850×10^4)	(3834010)
Output	Total	Min	Max	Large	Small
Earning Assets	1229×10^5	118336	1220×10^5	2210×10^4	3650806
	(1750^4)			(2050×10^4)	(4419165)
Net Loans	8156390	59661	9290×10^5	1420×10^4	2126903
	(1240^4)			(1520×10^4)	(2731436)
Impaired Loans	322594.9	722	3265427	528509.7	116680.2
	(465709)			(563498)	(177973)

Note: The column "Average" , "Min" and "Max" present statistical measures of overall sample. The last two columns report the mean inputs and outputs for Large and small banks, respectively.

APPENDIX A

Table 2: Efficiency and risk efficiency by banks size and year

	Efficiency				**Risk Efficiency**			
	VRS		CRS		VRS		CRS	
	Small	Large	Small	Large	Small	Large	Small	Large
1998	0.231	0.247	0.004	0.024	0.934	0.935	0.999	0.999
1999	0.216	0.264	0.005	0.026	0.800	0.774	0.999	0.995
2000	0.173	0.170	0.026	0.005	0.955	0.939	0.999	0.998
2001	0.170	0.179	0.005	0.022	0.890	0.859	0.999	0.999
2002	0.093	0.126	0.004	0.029	0.918	0.896	0.999	0.999
2003	0.152	0.217	0.004	0.034	0.908	0.871	0.999	0.998
2004	0.197	0.227	0.006	0.035	0.814	0.769	0.999	0.999
2005	0.306	0.399	0.005	0.038	0.927	0.947	0.998	0.990
2006	0.246	0.310	0.006	0.041	0.946	0.967	0.997	0.987
2007	0.269	0.258	0.008	0.052	0.951	0.938	0.997	0.986
2008	0.197	0.194	0.009	0.058	0.936	0.950	0.998	0.992
2009	0.235	0.241	0.009	0.073	0.877	0.884	0.998	0.987
2010	0.242	0.223	0.011	0.073	0.882	0.894	0.997	0.990
2011	0.204	0.252	0.010	0.105	0.886	0.893	0.997	0.981
2012	0.188	0.201	0.012	0.129	0.923	0.953	0.997	0.979
2013	0.161	0.205	0.011	0.129	0.927	0.973	0.997	0.990
2014	0.166	0.160	0.013	0.096	0.932	0.962	0.998	0.993
Mean	0.199	0.228	0.007	0.058	0.906	0.906	0.998	0.992
St.dev	0.177	0.157	0.011	0.096	0.101	0.086	0.003	0.002
Min	0.000	0.000	0.000	0.000	0.411	0.522	0.965	0.695
Max	0.791	0.848	0.070	0.748	1.000	1.000	1.000	1.000

Table 3: Comparison between models with and without undesirable output.

	With Undesirable output				Without Undesirable output			
	CRS		VRS		CRS		VRS	
	Mean Efficiency	Efficient	Mean Efficiency	Efficient	Mean Efficiency	Efficient	Mean Efficiency	Efficient
1998	0.239	14	0.014	13	0.330	4	0.014	11
1999	0.240	12	0.015	16	0.628	7	0.018	10
2000	0.145	13	0.015	16	0.215	5	0.016	12
2001	0.174	13	0.013	16	0.357	4	0.014	11
2002	0.109	12	.017	15	0.229	6	0.017	13
2003	0.184	16	0.019	16	0.347	5	0.020	11
2004	0.212	11	0.020	12	0.550	2	0.021	9
2005	0.352	7	0.022	17	0.450	2	0.028	12
2006	0.278	11	0.023	19	0.338	4	0.031	12
2007	0.263	9	0.030	18	0.340	3	0.039	13
2008	0.195	13	0.033	22	0.271	6	0.038	18
2009	0.238	9	0.041	18	0.413	4	0.049	14
2010	0.233	10	0.042	15	0.393	3	0.048	10
2011	0.228	9	0.057	15	0.389	2	0.070	8
2012	0.194	12	0.070	18	0.285	5	0.085	11
2013	0.183	14	0.070	22	0.257	6	0.076	14
2014	0.163	16	0.054	22	0.234	6	0.059	14

Table 4: Results of Mann Whitney tests concerning the efficiency differences between models with and without undesirable output

Year	CRS	VRS
1998	3.365 (0.008)	4.361 (0.001)
1999	6.057 (0.000)	4.274 (0.000)
2000	3.550 (0.000)	3.563 (0.000)
2001	5.249 (0.000)	3.634 (0.000)
2002	4.309 (0.000)	4.871 (0.000)
2003	6.812 (0.000)	6.651 (0.000)
2004	2.062 (0.037)	6.700 (0.000)
2005	2.653 (0.003)	4.311 (0.000)
2006	2.415 (0.0015)	4.345 (0.000)
2007	2.584 (0.009)	2.961 (0.000)
2008	4.863 (0.000)	3.531 (0.000)
2009	5.277 (0.000)	4.720 (0.000)
2010	5.363 (0.000)	4.851 (0.000)
2011	5.222 (0.000)	5.342 (0.000)
2012	2.363 (0.003)	4.080 (0.000)
2013	4.207(0.000)	4.862 (0.000)
2014	2.637 (0.008)	3.999 (0.000)

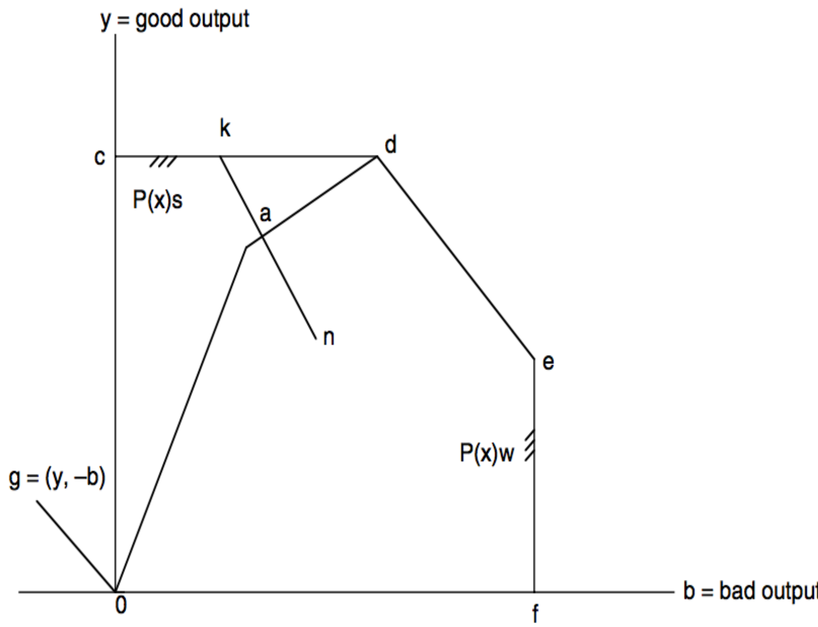
Table 5: Metatechnology ratio and risk efficiency metatechnology ratio by banks' size and year.

	Metatechnology Ratios				**Risk Efficiency Ratios**			
	CRS		**VRS**		**CRS**		**VRS**	
	Small	Large	Small	Large	Small	Large	Small	Large
1998	0.999	0.871	0.999	0.987	0.998	0.988	0.999	0.997
1999	0.999	0.877	0.999	0.985	0.999	0 .829	0.999	0.999
2000	0.997	0.947	0.999	0.992	0.994	0.994	0.999	0.999
2001	0.998	0.925	0.999	0.993	0.983	0.923	0.999	0.999
2002	0.989	0.977	0.998	0.992	0.973	0.992	0.999	0.999
2003	0.991	0.938	0.999	0.983	0.974	0.977	0.999	0.999
2004	0.977	0.944	0.999	0.981	1.000	0.823	1.000	0.994
2005	0.999	0.848	0.999	0.988	0.999	0.976	1.000	0.994
2006	0.997	0.908	0.999	0.985	0.996	0.991	0.999	0.993
2007	0.948	0.947	0.997	0.984	0.974	0.989	1.000	0.999
2008	0.960	0.981	0.999	0.984	0.979	0.996	0.999	0.999
2009	0.959	0.966	0.999	0.978	0.967	0.979	0.999	0.999
2010	0.967	0.946	0.998	0.980	0.997	0.961	0.999	0.996
2011	0.968	0.940	0.999	0.970	0.994	0.949	0.999	0 .998
2012	0.930	0.994	0.998	0.975	0.989	0.991	0.999	0.996
2013	0.948	0.985	0.999	0.979	0.985	0.995	0.999	0.998
2014	0.954	0.988	0.999	0.984	0.989	0.996	0.999	0.993
Average	0.975	0.940	0.999	0.983	0.988	0.962	0.999	0.998
Std. dev	0.035	0.064	0.002	0.018	0.023	0.067	0.000	0.000
Min	0.819	0.628	0.959	0.855	0.822	0.608	0.988	0.925
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 6: Results of Mann Whitney tests concerning the Technological gap differences of under the year specific technologies and metatechnology

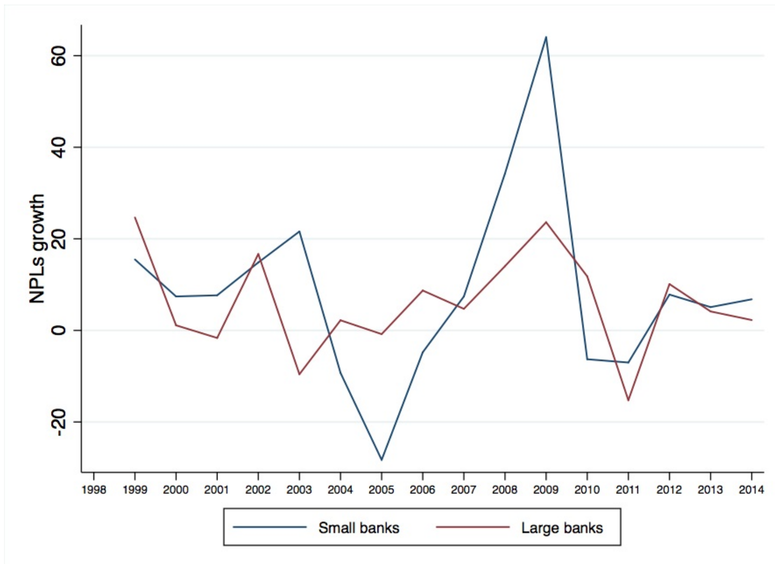
Year	CRS	VRS
1998	4.596 (0.000)	4.203 (0.001)
1999	4.969 (0.000)	4.537 (0.000)
2000	3.200 (0.000)	3.241 (0.000)
2001	3.554 (0.000)	5.554 (0.000)
2002	4.147 (0.000)	3.127 (0.000)
2003	6.162 (0.000)	4.232 (0.000)
2004	6.676 (0.000)	3.756 (0.000)
2005	4.377(0.000)	4.201 (0.000)
2006	4.627(0.000)	4.368 (0.000)
2007	2.961(0.000)	2.967 (0.000)
2008	3.948(0.000	3.861 (0.000)
2009	4.708(0.000)	5.706 (0.000)
2010	4.558(0.000)	3.957 (0.000)
2011	5.222(0.000)	5.101 (0.000)
2012	4.718(0.000)	3.578 (0.000)
2013	4.983(0.000)	4.601 (0.000)
2014	3.789(0.000)	3.002 (0.000)

Figure 1: Output sets for strongly and weakly disposable bad outputs, and directional output distance function



APPENDIX B

Figure 2: Mean growth of non performing loans by year for small and large banks



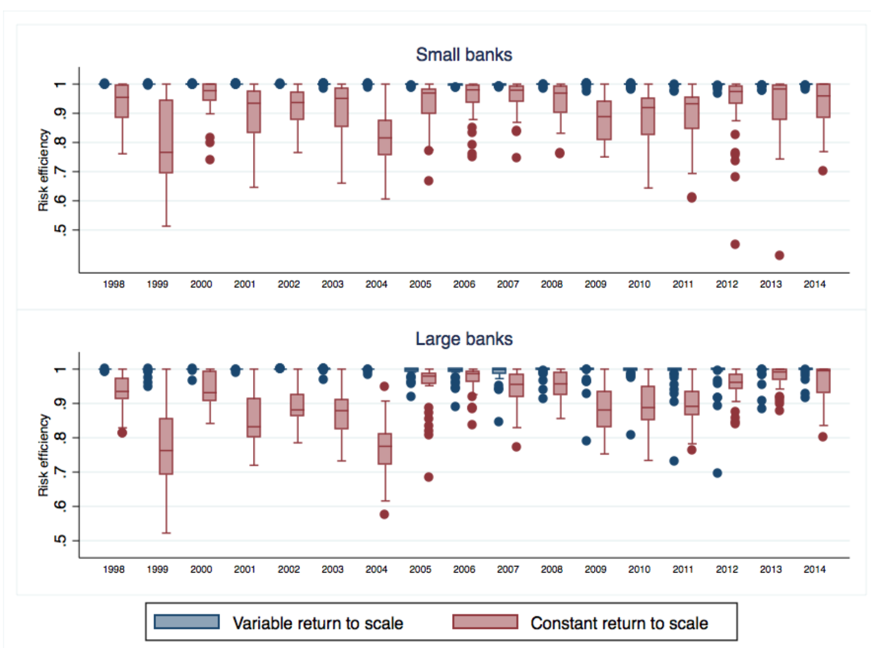


Figure 3: Risk efficiency distribution of small and large banks with respect to common technology.

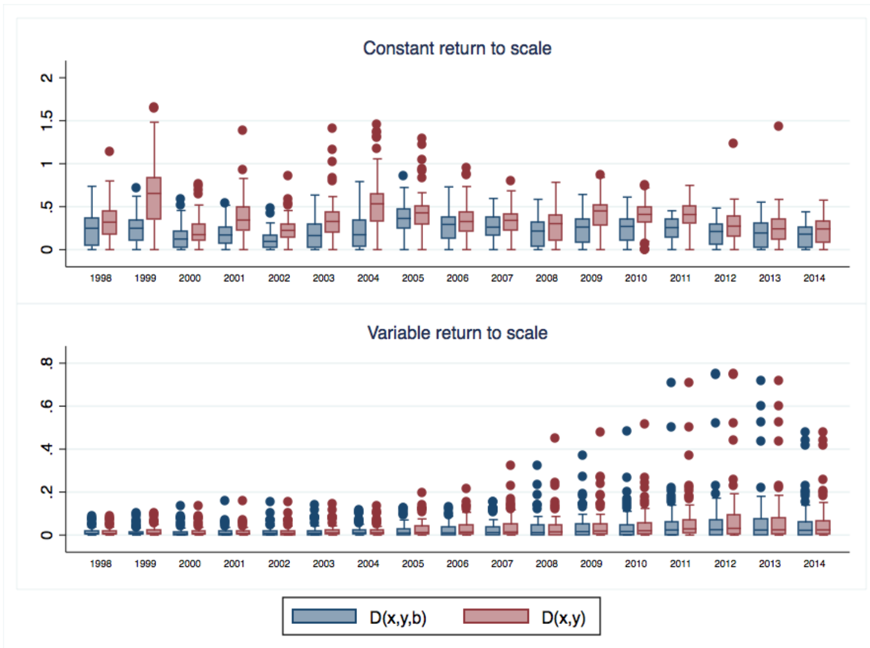


Figure 4: Performance distributions of simple and risk adjusted model for by year.

Figure 5: Metatechnology ratio distribution for size groups.

Figure 6: Distribution of risk efficiency metatechnology ratio by year and bank size.