Technology Gap, Managerial Efficiency and Ownership: Evidence From the Banking System in MENA

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Abstract

In this paper we compare technology gap and managerial efficiency between Islamic banks and conventional banks in 15 MENA countries. Using a unbalanced panel data, that covers the period 2002-2013, we estimate a stochastic meta cost frontier and find evidence of important technology heterogeneity in the region banking systems. It appears that the inefficiency coming from the inefficient use of the most advanced banking technology is much more important than the one coming from managerial inefficiency. As well, the technology gap is higher for Islamic banks but also for foreign banks, compared to conventional domestic banks. We also investigate the determinants of these cost inefficiencies. Our results show that online banking is an important driver to reduce the technology gap across banks and also to improve managerial efficiency, while size prove to have a negative impact on technology gap. Bank concentration has a positive impact on managerial efficiency restricted to Islamic banks.

Keywords: Banking efficiency, meta frontier, cost function, technology gap

JEL Classifications. G21 . D22 . D24 . P52

1. Introduction

An extensive empirical literature has been devoted to the comparison of banking efficiency in MENA countries in the last two decades. Most of this literature compare technical cost or profit efficiency of these banks, and assume that all the sampled banks share a common technology frontier. Even if the methodologies used to evaluate banking performances differ, i.e. parametric stochastic frontier modeling or non parametric Data Envelopment Analysis, DEA, there is no consensus on the superiority of one bank group against the other, Abedifar et al. (2015). An important drawback in most of this literature is the assumption used concerning the common technology across bank types. An exception, is the study of Johnes et al. (2014) who find evidence of inefficiency differences linked to technology, called in the paper "modus operandi", Islamic banks being much more inefficient compared to conventional banks in a sample including MENA and Asian countries. In terms of economic policy, there is a difference between cost inefficiency associated to managerial inefficiency and technology

inefficiency related to non optimal use of the technology. The first component could be improved by reducing technical and allocative inefficiency with the same technology used by the banks, this issue is generally cost free for the inefficient banks. However, the banks with high levels of technology inefficiency necessitates investigations on changing and injecting more innovations, following the most dynamic banks in their market. Hughes investments in human and physical capital with additional costs are generally needed to achieve this goal.

As discussed in Kontolaimou et al. (2012) technology heterogeneity of the banking system may be attributed to both external and internal factors. Internal factors include firm's underlying knowledge characteristics and strategic orientation, while external factors comprises environments specific characteristics and banking infrastructure. These authors identify two potential banking technology drivers, the current stock of knowledge and the expected gain anticipated from exploring the opportunities in new technologies. Unfortunately, banking technology is complex and unobservable, so from econometric point of view it is quite impossible to identify homogeneous banks groups using a common technology. Banking technology needs a control of real time information accounts, products, markets and also risk management. Real time information is now possible with automatic teller machines, ATM, or online banking services which are conditioned on huge investments in human and physical capital and a good knowledge of information technology. For retail banks, ATM and online banking services are not necessarily common across banks and countries. For example, in Tunisia, ATM service is just restricted to cash acquisition or accounts balance inquiry, it should be the case in other MENA countries, while in other developed countries with high technological banking system, sophisticated ATM are able now to scan checks, to apply for loan or to make transfer between accounts among other services. Improving the technology in this segment allow banks to reduce their operating costs. For example, in a study conducted by Humphrey et al. (2006), they estimate the cost saving of the shift to electronic payments and the expanded use of ATM, to be 0.38% of GDP in 12 European developed banking systems.

In order to estimate the impact of the new technologies on the efficiency of the MENA banking system, we adopt the meta frontier methodology. It is assumed that each country banking system has its own technology. So, estimating country specific cost frontiers, bank inefficiency components are interpreted as managerial inefficiency, which is a mixture of technical and allocative inefficiency with respect to the technology used in the country. The technology being heterogeneous and unobservable, the meta cost frontier proceeds in two steps. Country specific technology frontiers are estimated first, then a meta frontier envelop is constructed for all the sampled MENA countries, using the minimum estimated bank's cost technically feasible obtained from the first step. Then, the inefficiency score of each sampled bank derived is interpreted as the technology gap, which measures the difference between the minimum cost between the own best practice technology and the totality of all the countries technologies, this score is also between zero and one. Technology gap is a measure of the country-specific cost frontier boundary with the region meta frontier boundary. Inefficiency is then different from managerial inefficiency, banks with high level of technology gap means that their technology is less advanced compared to the meta-frontier technology.

The purpose of this paper is twofold. First, to evaluate the technology gap in MENA banking region and compare it across banking groups. Three banking groups are retained, Islamic banks, domestic banks and foreign banks[1]. The decomposition of conventional banks into two subgroups, follow a commonly admitted intuition by scholars, assuming that foreign banks can provide spillover benefit to the financial sector by improving competitive efficiency and by upgrading work culture, and also could be a driver of technology transfer from their parent banks. We also evaluate by bank status, the efficiency linked to managerial efficiency. Although, efficiency comparisons between Islamic and conventional banks is voluminous, only a handful of studies examined the technology gap issue in the evaluation of banking efficiency. Second, we analyze the determinants of each inefficiency component, focusing on institutional factors, banks characteristics and also a variable linked to technology constructed from the bank's website, the online banking service. In the absence of precise information on bank expenses on innovation technologies, it is assumed that this variable capture a substantial part of the internal and external factors of the newer banking technology already discussed above.

The results obtained indicate that over banking costs related to the use of non advanced technology is two time more important than the over cost due to managerial inefficiency in MENA banking system. There is evidence that conventional domestic banks have on average lower inefficiency, 6% related to the technology than foreign or Islamic banks. We also establish the importance of online banking service as a driver in the reduction of the technology gap, its impact being beneficial for both inefficiency components, but stronger for Islamic banks.

The rest of the paper is organized as follows. Section 2, presents a critical summary of the empirical related literature. Section 3, describes the methodology of the stochastic meta frontier used. Section 4, presents the data, the empirical results and also conduct the robustness checks and Section 5 concludes.

2. Related Literature

Numerous studies compare bank efficiency across countries between Islamic banks and conventional banks using frontier modeling. Either parametric or non parametric models are used, but in most of the cases there is few evidence on the superiority of one bank type over the other. In the case of MENA region, this literature includes, the pioneering work of Al Jarrah and Molyneux (2004), Ariss (2007) and Srairi (2010). Most of these studies consider that the banking technology across countries is common to the sampled banks, the inefficiency measures deduced overestimate the inefficiency of the banks operating with less advanced technologies. The heterogeneity of the technology is an important issue in banking in particular when we compare countries which may have different markets, customers payment habits with respect to financial services or risk, this issue is less relevant if we consider more homogeneous groups of countries. For example, Bos and Schmedial (2007),

[1] Our definition of foreign banks, is restricted to banks whose parents are international banks which belong to a developed country (HSBC,CITI-BANK, BNP-PARIBAS,SOCIETE GENERALE,...). Those banks are more likely to use the most advanced technology.

using meta frontier approach, find few banking technology gaps across the Union European countries while Huang et al. (2015) find empirical evidence of strong banking technology differences in Central and Eastern European countries, a dynamic but less developed banking system. To sum up, ignoring technology differences, may confuse the inability of the banks to use the most efficient technology as a pure managerial inability. Table 1, reports the handful of studies dealing with meta frontier modeling in banking. The first study by Bos and Sehmiedel (2007) consider the case of 15 European countries from the European Union, they estimate both a cost and a non standard profit meta frontier. A stochastic frontier is estimated for each country, then a linear programming deterministic frontier is constructed for the meta frontier. These authors find few evidence of technology gap across the sampled European Union countries during the period 1993-2004, however, they show that most of the inefficiency across countries is related to only managerial inefficiency. This results is contradicted by Kontolaimou et al. (2012), which show, for a smaller sample of 12 European Union country banks, including only a restricted sample of 1379 observations, (9544 observations for the sample used by Bos and Schmedial (2007)), that most of the inefficiency is coming from the technology gap across countries, evaluated between 40% to 60%. In addition to the difference in the sample sizes, one possible explanation of the two European banking studies contradictory conclusions, is that the second study by Kontolaimou et al. (2012) employs DEA type frontier model in both steps of the meta frontier construction, which may exaggerate the technology gap compared to Bos and Schmiedel (2007) who use stochastic frontier model when they estimate each country specific technology frontier. However, significant technology gaps are evidenced in 17 Central and Eastern European countries in a an empirical study conducted by Huang et al. (2015). They show that the under use of the most advanced technology is a much more important source of banking inefficiency compared to managerial inefficiency in these countries. In another more recent study, Nyugen et al. (2016) estimate a stochastic meta cost frontier in three Asian countries focusing on only domestic banks and obtain the same conclusion. They also find evidence of a U shaped relationship between competition and technology gap, while other bank characteristics such as deposit to total asset ratio or capital ratio have a positive and a significant impact on the reduction of the technology gap across the sampled countries.

Unlike prior aforementioned MENA studies which focus only on managerial efficiency, two recent studies also investigates the impact of technology differences on bank efficiency. Ben Naceur et al. (2011) use non parametric meta frontier method to estimate bank efficiency and its determinants in a small sample including 49 banks in 5 MENA countries, they find strong evidence of the importance of the technology impact on bank inefficiency which contribute by about 35%. They also show that bank characteristics, capitalization, portfolio, financial structure and institutional variables have a significant impact on bank inefficiency. The main limits of this study is the aggregation of labor and physical capital input into one input which reduces the chance of each bank of being selected as efficient, so the inefficiency scores may be overestimated, and also the limited size of the sample size used. More recently, Johnes et al. (2014), employ meta frontier approach to compare bank efficiency between Islamic and conventional banks. They consider a larger sample including 252 banks from 13 MENA and 5 Asian countries, estimate a DEA meta frontier model and find evidence that conventional

banks are more efficient in terms of technology efficiency. Notice that the authors employ the term "modus operandi" to refer to technology gap efficiency. They estimate that on average, technology efficiency score is about 89% for Islamic banks while it is close to 100% for conventional banks. However, when they evaluate the net efficiency score, another term employed to designate managerial efficiency, they find evidence that Islamic banks are 8% more efficient than conventional banks. An important issue in their study is to run a regression model in order to identify the covariates of each type of inefficiency components, the authors consider both bank level characteristics variables and country specific macro economic variables. They find few significant variables explaining technology inefficiency, most of the employed variables are significant in explaining managerial inefficiency but not technology inefficiency. This result is not surprising since there is no evidence of technology inefficiency for 82.35% of the sampled banks. The main limits of this study are, first when they employ the meta frontier methodology the heterogeneity of the technology is only partially investigated. In fact, the authors consider two groups of banks, i.e. Islamic and conventional in the first step, so they implicitly assume that within each group the bank technology is common to all the countries instead of estimating 18 country specific frontiers. To sum up, the meta technology is just the frontier envelop of two frontiers, one for Islamic banks the other for conventional banks. Technology differences should be higher if they take into account the potential heterogeneity of the technology across countries.

Table 1: Summary of the contributions related to Meta frontier in banking

Authors	Countries	Period	Technology-representation	Empirical Findings
Bos and Schmiedel (2007)	15 European Union countries	1993-2004	Cost function & non standard profit function (P)	Few technology gap inefficiency
Ben Naceur et al. (2011)	5 MENA countries	1994-2008	Distance Function (NP)	Important technology gap inefficiency (35%)
Kontolaimou et al. (2012)	15 European Union countries	1997-2004	Distance function (NP)	Important technology gap inefficiency, 40%-50%
Johnes et al. (2014)	18 MENA and Asian countries	2004-2009	Distance function (NP)	Significant technology gaps inefficiency 11% for Islamic banks
Huang et al (2015)	17 Central and Eastern European countries	1995-2008	Directional distance function (P)	The main source of banking inefficiency is linked to the technology
Nyugen et al. (2016)	3 Asian countries, Vietnam, China, India	1995-2011	Cost function (P)	Technology inefficiency varies between 9% (India) to 39% (Vietnam)

(NP) non parametric , (P) parametric

Our study differs from the two last mentioned studies for MENA region in three ways. First, we consider a much larger sample of countries for MENA. Second, we propose a more

accurate measure of the technology gap, the meta frontier is constructed as the meta technology boundary of 15 country specific frontiers of the MENA region. In addition, the technology gap measure is derived from a meta stochastic frontier which takes into account of potential noise in the data structure. Finally, we try to identify which bank structure or ownership type determine bank inefficiency in MENA region, but also we add other bank characteristics as additional covariates in the inefficiency determinants equation. An important variable linked to the technology is also included, online banking services. We focus particularly on cost efficiency comparison between Islamic banks commercial banks and foreign banks, by decomposing cost inefficiency into managerial inefficiency and technology inefficiency. Profit efficiency is also added in the comparison for robustness checks. We think that this paper may add a contribution on this comparative literature in this field.

3. The Methodology

Several models have been developed in the frontier literature to cope with the question of the heterogeneity of the technology. These models can be decomposed in two strands according to whether the technology groups are observed or not. For example, if we consider the efficiency measurement of a sample of firms within an industry, it is quite impossible to distinguish homogeneous technology groups according to a specific criteria. In this particular case, latent class stochastic frontier models are a useful methodology to estimate the frontier and the inefficiency components, Greene (2005), Orea and Kumbhakar (2004). However, if homogeneous groups are observed, meta frontier methodology is the adequate methodology to evaluate the efficiency of the firms and its components. This last approach is interesting to evaluate banking efficiency across countries, where it is commonly assumed by most scholars that each country has its own technology. The main argument being that each country has its own regulation, economic and financial and regulatory environment which reinforce the assumption that within each country the banking system has its own technology. This methodology has been formulated by O'Donnell et al. (2008) for the case of meta production frontier and extended later to the cost or distance functions, Huang et al. (2014), (2015). The meta frontier technology is constructed in two steps, first a specific frontier for each group is constructed and technical inefficiency are evaluated. A second frontier called meta frontier, is re-estimated by enveloping the data on the efficient units of each frontier group obtained in the first step, and technology inefficiency is derived. The main advantage of this model is the decomposition of technical inefficiency into pure technical inefficiency component and technology gap. Figure 1, illustrates the meta frontier for the case of a cost frontier of three countries.

Each country technology is represented by its own cost frontier, for the case of one output. Banks B, A and C belong respectively to their countries 1,2,3. However, banks A and B are costly compared to bank C since they are producing the same level of output. The meta technology frontier is the meta boundary of the three country frontiers. Country C has the advanced technology since it generates the lowest costs to produce the same output level, compared to country 1 and 2. For bank A which belongs to country 2, its level of cost efficiency, hereafter called managerial efficiency, is measured by the ratio OJ/OI, commonly

called pure cost efficiency. However, the ratio OK/OJ measures the gap between the technology boundary of this bank to the meta technology boundary, which is called the technology gap. When the technology gap is lower than one, it means that the technology used by the country is less advanced compared to the meta technology.

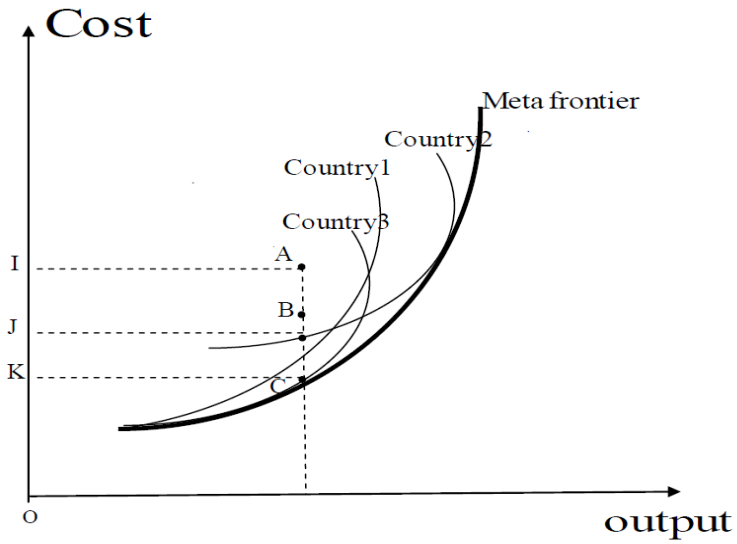

Figure 1: Meta cost frontier

Meta frontier can be estimated by applying either, parametric frontier models or non parametric DEA (Data Envelopment Analysis) models. The first approach considers the possibility that within each frontier group the production process is not fully under the control of the managers, so a two error components structure model is usually used, capturing both inefficiency and statistical noise, so stochastic frontier can be considered for this step.

To resume, estimating the meta frontier needs to proceed in two steps. Construct the groups frontiers and then estimate the frontier boundary of all the groups frontiers. The methodology has been proposed by Battese and Rao (2004) and O'Donnell et al. (2008), they consider a deterministic type of meta frontier, which has been recently extended by Huang et al. (2014) to the stochastic meta frontier case. We summarize below the procedure to construct the meta cost frontier and the measure of the technology gap.

If we assume that each country has its own technology which is common to all the banks, in a first step, we need to estimate each country specific cost frontier, for example, if we retain a stochastic cost frontier model,

$TC_{it} = C(Y_{it}, P_{it}, \beta^c)e^{u_{it}^c + v_{it}^c}$, c=1,2,.., C Countries, i=1,...,Nc banks, t=1,2,..T_i periods (1)

C(.) represents the cost functional form, β^c is the technology parameter vector of each country, Y is the output vectors, P is the vector of the input prices, v represents the statistical noise and u the asymmetric error term which capture total cost inefficiency, hereafter

managerial inefficiency. It usually assumed that u follow a half normal distribution. The frontier (1) is then estimated by maximum likelihood method, and the inefficiency components u is estimated following the Jondrow et al. (1982) method in order to derive total cost efficiency. Remind that this efficiency score is usually called pure cost efficiency and, one minus the score, measures by how much the banks could reduce their costs while using their own technology.

To construct the meta frontier, we need to envelop again all the banks in all the countries. To do that, if we denote $\hat{TC}^{*}_{it} = C(Y_{it}, P_{it}, \hat{\beta}^{c})$ as the predicted minimum cost derived from the first step, the stochastic meta frontier a la Huang et al. (2014) is estimated according to the following equation:

$$\hat{TC}^{*}_{it} = C(Y_{it}, P_{it}, \beta^{M}) e^{u^{M}_{it} + v^{M}_{it}} \quad (2)$$

which is again a stochastic frontier specification. Notice that, if we drop the noise v in equation (2) we find the O'Donnell et al. (2008) deterministic meta frontier type which is estimated by the linear programming method. Huang et al. (2014) mention that the statistical properties of deterministic meta frontier are unknown because the minimum costs are not observed but estimated, so adding random error structure in equation (2), may improve the estimation procedure of the meta frontier. Once the meta frontier is estimated, the inefficiency score u^{M}_{it} will just measure the gap between the country specific technology boundary and the meta technology boundary, which is interpreted as the technology gap. For the deterministic meta frontier model, this gap is just the residual term, while it needs to be decomposed according to the Jondrow et al. (1982) for the stochastic meta frontier specification. Notice that there is no reason to prefer the deterministic version versus the stochastic version of the meta frontier, but according to the parametric frontier literature, the deterministic frontier model usually provide higher level of the inefficiency scores compared to the stochastic frontier model as it confuse "random bad luck" with inefficiency. This issue is important, since the technology gap measure could be exaggerated, in particular for studies comparing technology gap across banks type or even to determine the determinants of the technology gap. To sum up, it is important to conduct some deep robustness checks when using parametric meta frontier models, with respect to the functional form of the technology, the frontier type stochastic or deterministic, among other checks.

4. Data and empirical results

To estimate the technology gap, we consider a sample of 2400 observations in MENA region using Bankscope data. The sample includes 393 banks in 15 countries[2] over the period 2002-2013. In total, the sample is an unbalanced panel of banks which have been classified in two categories according to their activities: Commercial banks (1861 observations, 246 banks), and Islamic banks (539 observations, 94 banks). Following the intermediation approach, we assume that the banks use three inputs to produce there outputs. Inputs are, labor measured by

[2] The country list includes Algeria, Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia,Syria, Tunisia, United Arab Emirates and Yemen.

personnel expenses, physical input measured by book value of fixed assets, and financial input measured by interest expenses. The outputs are lending activities measured by total loans, and all other financial services (commissions, trading, investments), measured by other earning assets, and deposits. The technology in MENA banks is represented by a stochastic cost frontier. Total costs is measured by interest expenses plus all other expenses related to labor input and physical capital input. Financial input price is measured by total interest expenses to deposit plus other purchased funds, capital input price is measured by the ratio of other expenses to the book value. Finally, for the labor input price, we use a proxy defined by total labor expenses to total assets, since BANKSCOPE data do not report the number of employees of the sampled banks. Remind that, this is the commonly used labor price measure in most of the empirical literature evaluating cost efficiency in banks with this kind of data. Translog functional form is retained to represent the MENA banking technology, we later use the Cobb Douglas functional form for robustness test purpose. All the monetary variables have been deflated by each country price index, 2000 being the base year.

First, we need to verify the assumption that the technology is heterogeneous across the banking system of the 15 MENA countries, a likelihood ratio test, LR is then conducted. Under the null hypothesis the technology is common across countries, while under the alternative it is heterogeneous, the LR statistics is 9714.6682 with p-value equal 0.00. The test suggests that the banking technology across countries is heterogeneous which allow us to estimate the meta frontier and decompose the total cost inefficiency components into managerial inefficiency and technological inefficiency.

To construct the meta cost frontier, we estimate the 15 country specific cost frontiers in a first step. The model used is a standard stochastic frontier, the cost inefficiency component is assumed to follow a half normal distribution, while the cost frontier includes year dummy variables to capture the shift of the frontiers over the sampled period. We then estimate cost efficiency scores, hereafter called pure managerial efficiency, which is linked to the technical and allocative efficiency of each banking system. In the second step, we construct the meta cost frontier, which is a cost frontier envelop of all the efficient banks groups, called the meta frontier technology. A stochastic frontier is again estimated, the same specification used in the first step, the frontier also includes country dummy variables to take into account of country specific effects linked to the different regulation or bank systems and also for other differences linked to country environments and macroeconomic activities. Later and for robustness check we also re-estimate the meta frontier by applying the linear programming method. The cost efficiency measure obtained at this step is what is called the technology gap which measure the distance between each domestic bank's country frontier and the most efficient technology MENA region frontier. The interpretation of this score is similar to the cost efficiency score, the lower is the score the higher is the gap between the technology used in the country compared what could be used with more advanced countries technologies. Finally, the product of the two efficiency scores obtained in the two steps is what it is commonly called global cost efficiency.

Table1: Mean managerial efficiency by country and year (Translog)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	mean
Algeria	81.8	70.4	86.1	88.4	72.5	84.5	91.8	84.7	82.2	87.3	84.7	81.6	83.7
Bahrain	88.8	88.8	86	83.6	80	77.8	78.5	85.7	82.6	79.3	80.5	80.8	81.7
Egypt	92.7	91.7	90.7	91.5	91.5	90.6	90.6	91.5	92.3	92	92.7	92.4	91.7
Iran	82.8	80.7	84.8	79.4	84.4	83.8	86.6	81.2	83	84.5	85.8	74.4	82.7
Jordan	93.6	93	92.5	93.1	94.6	94.3	95.3	94.1	93.8	93.7	93.9	93.7	93.8
Kuwait	94.3	91.3	92.8	87.8	90.2	90.6	87.1	87.2	94.3	93.8	96	93.4	91.3
Lebanon	93.9	93.8	93.8	93.5	93.8	93.8	95	94.4	94.6	95.2	94.6	95.2	94.2
Morocco	91.4	93.9	92.1	92	89.2	90.3	93.2	92.5	92.4	86.5	86.4	88.9	90.8
Oman	98.1	97.8	97.5	97.4	97.2	98	98.1	97.8	97.7	97.6	97.5	97.7	97.7
Qatar	90.6	92.2	92.2	94.8	96	93.4	87.2	96.3	92.7	95.1	92.1	93.9	92.9
Saudi A.	93.2	91.2	94	93.6	92.4	93.8	94	91.2	94.6	95.4	93.1	93.9	93.4
Syria	-	-	-	100	90.7	95.4	94.5	94.5	92.9	95.1	96.5	92.1	94.2
Tunisia	94	94.2	94.2	94.3	94.3	94.3	94.1	93.6	93.9	94.1	93.9	93.7	94.1
U.Emirates	85.4	83.2	83	90.1	88.7	90.7	89	92.5	90.6	88.1	88.4	86.6	87.9
Yemen	-	98.4	95.9	98.5	95.7	99.1	94.8	97.8	93.8	97.6	97.7	96.1	96.4
Mean	91	90	90.5	90.8	90	90.4	90.8	91.6	91.3	91.3	91	90	90.7

Table 1 reports the average cost efficiency scores measures by country and also by year. Average managerial efficiency in MENA is relatively high 90.7% but varies across countries from 81.7% in Bahrain to 97.7% in Oman. The evolution of average cost efficiency over time does not suggest any real evolution of the managerial efficiency during 2002-20013 period. However, Omanete and Yemenite banks, and to a lesser extent Tunisian, Jordanian, Lebanese and Egyptian banks seem to be the only country banks' systems who succeed to maintain a high level of managerial efficiency, over the mean level in the region. In contrast, banking systems in Algeria, Bahrain and Iran are far under the mean level of the managerial cost efficiency during the studied period which suggest that in these countries efforts are needed to reinforce the cost efficiency of banks in order to render them more competitive.

The second efficiency component linked to technology gap shows another aspect of the cost inefficiency of MENA banking systems. Table 2, reports much lower value of efficiency (82.7%) compared to managerial efficiency (90.7%). On average, banks in MENA seem to compensate the inefficiency coming from costly used technology by making efforts in improving their managerial efficiency while using their own technology. These results are similar to those obtained in other studies for MENA countries, Ben Naceur et al. (2011) and Johnes et al. (2014). In contrast, the banking technology in MENA is far from being homogeneous as it is the case of European banks, Bos and Sehmiedel (2007). Table 2 reports differences in technology inefficiency across countries. The banking system in Egypt and also in Bahrain have the highest value of technology gap compared to the other countries, which suggests that their respective banking system use the most advanced technology in comparison to the region meta technology. However, banks in Algeria, Iran have the highest level of technology inefficiency, the average costs of its banking system is up to 32.4% and 26.4% higher than those of the best technology frontier. Moreover, this inefficiency is increasing since 2007 in Algeria but have a U shaped form in Iran. By contrast, there is no clear trend suggesting that the banking system in MENA is making efforts to incorporate measures in order to improve its banking technology. The average technology score follow a

constant level around 82-83%. To get a better idea of the importance of the two inefficiency components, we compute the foregone revenue as a fraction of net income due to each inefficiency component. Foregone revenue due to technology and managerial inefficiency is estimated to 12.7% and 5.3% respectively. The forgone revenue coming from technology inefficiency being much higher, it varies across countries from 5.5% in Emirates to 23.2% in Algeria.

Table 2: Mean technology gap by country and year (Translog)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	mean
Algeria	73.2	84.8	71.5	69.8	77.2	69.7	65.8	62.6	63.1	60	64.8	65	67.6
Bahrain	87.9	84.8	89.6	90.5	88.6	83.6	86.9	85.9	85.5	86.2	83	73.3	85.2
Egypt	85.9	85.2	85	85.8	83.5	83.3	85.1	87.8	89.3	89.2	88.7	87.7	86.3
Iran	75.6	76.1	70.4	69.1	74.5	77.1	81.9	71.9	69	69.1	71	73.7	73.6
Jordan	82.5	82.4	79.3	82.2	82.1	82.5	83.3	85.9	86.3	84.1	85.1	83.4	83.3
Kuwait	83.1	84.8	79	86.9	82	83.6	78.3	78.4	87	84.8	81.9	81.3	82.3
Lebanon	82.4	80.1	80.4	81.4	79.6	83.9	85.9	86.4	85.5	85.9	87.2	86.6	83.4
Morocco	79.1	75.2	77.2	76.7	78.1	79.7	77	81.5	79.6	79.2	76.7	77.1	78.2
Oman	79.7	80.3	82.6	85.4	84.8	83.2	83.9	84.4	82.4	82.8	80.5	78.3	82.3
Qatar	89.6	80.1	80	81.2	76	77.1	76.2	87.3	89.1	87.6	91	89.5	83.5
Saudi A.	82.8	83.5	82.7	85.3	85.5	86.4	88.3	88.2	80	77.8	82.6	81.7	83.6
Syria	-	-	-	28.6	77.1	67.7	74.3	82.9	83.5	81.9	79.7	82.5	78.5
Tunisia	84.3	84.3	85.7	85.7	84	85.4	85.3	80	81.3	87.1	83.1	88.4	84.6
U.Emirates	88.4	91	91.7	89	88.3	88.7	88.2	88.3	89.8	89.8	89.9	90.2	89.5
Yemen	-	67.2	91.2	90.3	87.1	87.9	89	88.4	88.9	79	78.4	88.5	85
mean	83.1	82.8	82.2	82.6	82.3	82.2	82.8	83.2	83.2	82.8	83	82.5	82.7

4.1. Cost efficiency components by ownership

Table 3 presents average cost efficiency components according to bank status, Islamic versus conventional. Overall, conventional banks dominates Islamic banks in terms of both managerial efficiency (+5.7% points on average) and also technological efficiency (+5.1% points on average) during the period 2002-2013. However, differences across countries exists. Among the 12 countries who have the two bank status, conventional banks control better their technical and allocative efficiency in Bahrain (+9.8%), (+5.7%) in United Emirates and Kuwait (+4.4%), but Islamic banks perform better only in Qatar (+4%). We have some reservations regarding the results for Lebanese banks gap, the results reported for Islamic banks concerns only one bank. For the two other sampled countries, there are no Islamic banks in Morocco, and BANKSCOPE do not report financial costs for Islamic banks in Oman.

Table 3: Efficiency components by bank type

Country	Managerial Efficiency		Technology Gap	
	Conventional	Islamic	Conventional	Islamic
Algeria	83.6	84.3	68.3 *	62.4
Bahrain	**86.6*****	**76.8**	**88.8*****	**81.5**
Egypt	91.7	92	86.3	86.3
Iran	-	82.7	-	73.6
Jordan	93.7	94.7	**83.8*****	**80.5**
Kuwait	**93.9****	**89.5**	**87.5** ***	**78.6**
Lebanon	**94.4*****	**70.7**	**83.6*****	**48.6**
Morocco	90.8	-	78.2	-
Oman	97.7	-	82.3	-
Qatar	**91.8****	**95.8**	83.1	84.3
Saudi A.	93.3	93.8	**86.9** ***	**74**
Syria	94.1	95.2	**79.8** **	**69**
Tunisia	94.1	94.3	**84.2*****	**93.2**
U.Emirates	**89.4*****	83.7	**89.8****	**88.7**
Yemen	96.2	96.6	**88.1***	**83.7**
mean	**92*****	**86.3**	**83.7*****	**79.3**

* significantly different from Islamic average scores at (*** 99%), (** 95%), (* 90%)

The comparison of cost efficiency related to technology show that conventional banks are significantly more efficient in 9 countries, Islamic banks being more efficient in Tunisia. These results suggest, if we exclude the countries for which there is only one bank system (Iran and Morocco), in most of the MENA countries which have the two banks groups, conventional banks are much closer to the region meta frontier than Islamic banks. In other words, conventional banks seem to have better knowledge in choosing the less costly technology in the intermediation process, in particular with respect to their markets compared to Islamic banks.

The outcome of the superiority of conventional banks in terms of technology gap compared to Islamic banks seems to comfort the recent findings of Jhones et al. (2014). By contrast, their estimates of the technology gap between the two bank's groups (+10%), is much higher than our estimates (+4.4%) on average. However, our results contradicts the authors findings of the superiority of Islamic banks in terms of managerial efficiency.

Some noticeable differences emerges when we cross technology gap measure with managerial cost efficiency by bank type as depicted in Figures 2 and 3, below. The red axes being the overall average efficiency scores of the sampled banks. An interesting result from these Figures, is that most conventional banks in MENA countries have both a high level of technology efficiency and managerial efficiency, those banking systems located in the upper part of Figure 2. The associated banking systems could be considered as the champions. By contrast, Algerian conventional banks are the only bank's country located in the lower left part suggesting both, a low level of technology efficiency and managerial efficiency. The situation is quite different with Islamic banks, only 4 countries occupy the most upper part of the Figure 3, but much more countries are located in the lower left part of the Figure suggesting very low level of the two efficiency components. Algerian, Moroccan, Syrian

banks and to a lesser extent Omani conventional banks have the lowest technology which is an important component of the inefficiency of their banking systems. The situation is quite different for Islamic banks group, in most of the countries the average value of technology gap is lower than the sample mean in eight countries, Figure 3.

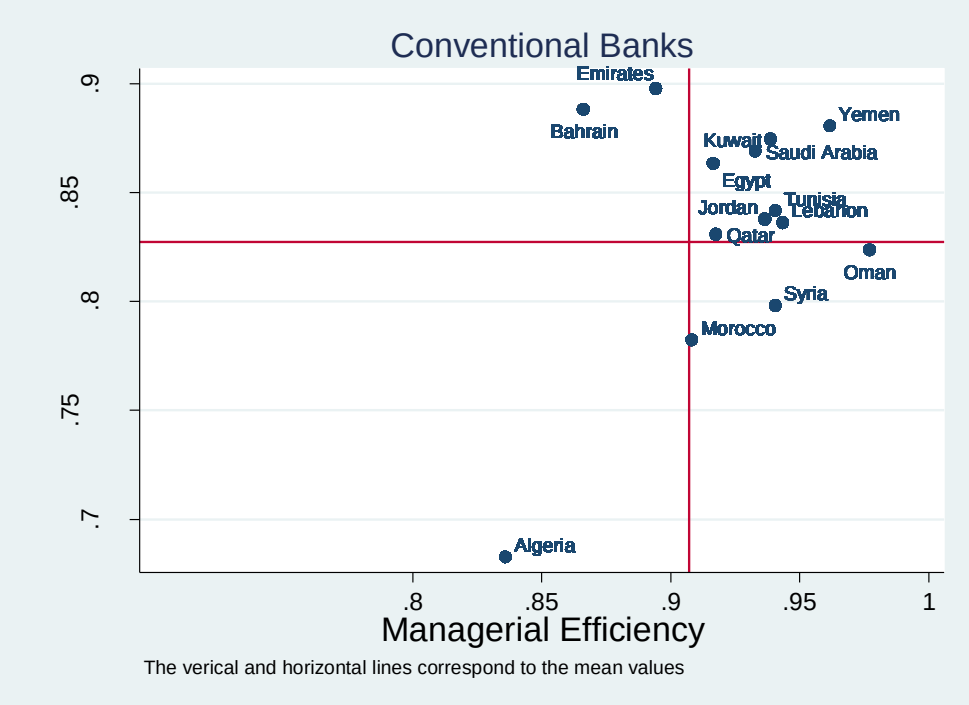

Figure 3: Technology gap and managerial efficiency of conventional banks in MENA

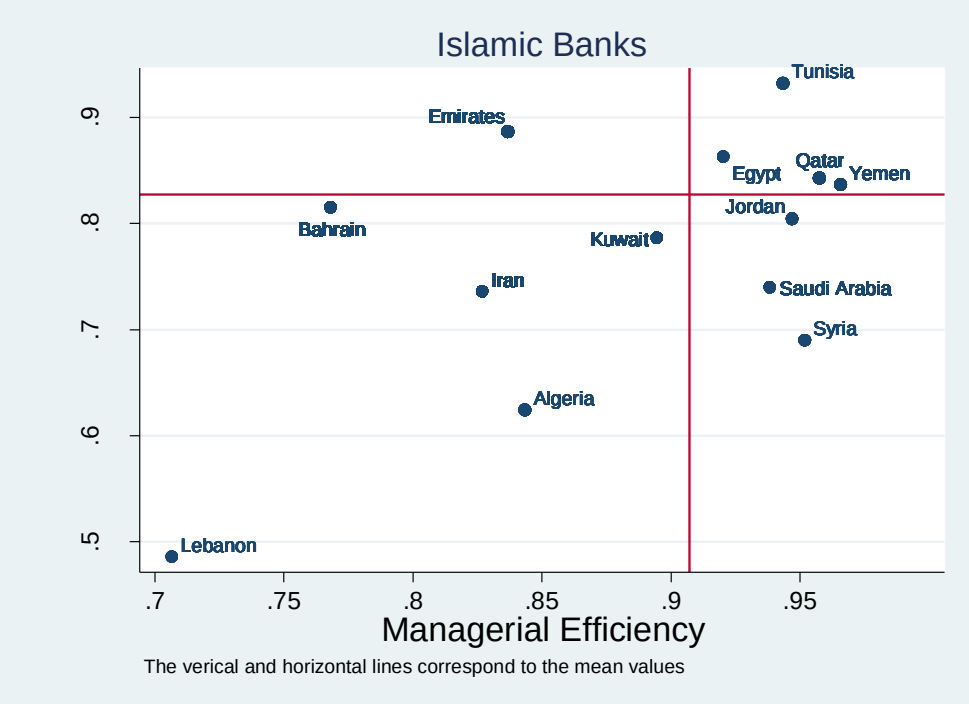

Figure 3: Technology gap and managerial efficiency of Islamic banks in MENA

This result suggests that Islamic banks in most of the MENA region need to adapt the technology used by most of the efficient conventional banks in order to improve their cost efficiency. The right upper quadrant represents the champions country banks in terms of technology and managerial efficiency which contribute to their cost efficiency. Nonetheless, the opposite lower left quadrant represents the country banks most costly banking systems who need to improve both their technology and also their managerial efficiency in order to reduce their banking costs. Whatever is their bank group, on average Tunisian, Qatari's, Egyptian and Yemenite banks are the champions since they are in the higher right side quadrant. A second interesting quadrant, is the higher left side one, where banks are efficient in terms of technology choice but in the same time have a low level of managerial efficiency, in other word within this quadrant technology efficiency seems to compensate the low level of managerial efficiency, conventional banking systems of Emirates and Bahrain belong to this quadrant. Islamic banks are below the horizontal red line, the average technology efficiency score in MENA, in six countries, Algerian and Iranian banks are in the lowest quadrant suggesting both higher managerial inefficiency and technology inefficiency, while in the other four countries, Islamic banks are compensating their level of technology inefficiency by more managerial efficiency, the case of the banking system in Jordan, Yemen, Lebanon[3], Syria and Saudi Arabia.

4.2. The determinants of the inefficiency components

The regression results are shown in Table 4. Three group of variables have been retained as covariates of the inefficiency components. Institutional variables related to ownership structure of the banks, size, other bank variables characteristics and a variable related to the technology advance of the bank, measured by a dummy variable which is equal 1 if the bank offer E-banking services and 0 otherwise. This last variable has been constructed from the website information of each sampled bank in 2016. There is no possibility from the banks' websites to obtain information on the date where these banks started to offer this service. However for banks where it is mentioned on the website's that the E-banking service is upcoming, we consider that the service is not available. It is assumed that once a bank has an online banking service, it has sufficient human capital staff and also an updated technology which allow lowering the loaded costs of the currents customers accounts. In the same time, for retail banks, the online banking service is not restricted to the opening branch working hours since customers can use the service 24h/7d (view transactions and accounts, moving money from accounts, pay bills,...). Finally, the bank allowing these services are able to extract information's on customers payments and expenses habits which could be useful for the bankers in order to propose them adapted services and also to evaluate their risk which assume a good management staff. In fact, there is no other available information related to ATM services or related expenses for the banks, we think that that E-banking services, could be a good proxy of the technology used of the banks in the region. To sum up, the impact of this variable should be positive on managerial efficiency and also the technology efficiency. Another variable linked to institutions and technology is foreign banks status. It has been largely discussed in the empirical banking literature that foreign owned banks are generally

[3] Care should be taken for this country with only one sampled Islamic bank.

less efficient than domestic banks. These last banks have some organizational home advantage, for example small business lending is highly sensitive on local practices which rely on informal mechanisms which need more local expertise in order to avoid adverse selection problems, Amel et al. (2004). However, foreign owned banks may have better knowledge of the international markets and may benefit more easily of the technology used from their parent banks. To our knowledge, the impact of foreign banks on technology efficiency, has never been tested in empirical studies. Moreover the determinants of the two efficiency components in the regressions include several bank variables related to other bank characteristics. The list of covariates being very large, we will just focus on the most common ones: the size variable, measured by the logarithm of total assets, captures some scale factors in the production process, the ratio of loans on total assets and a variable which measure the market power measured by the share of each bank total assets on total all banks assets each year. In fact, concentration can be associated with lower costs if the management staff is superior, which imply a positive association between bank market share and cost efficiency. In the same time, if concentrated banks are much more related to public sector, and due to high level of bureaucracy, the impact of this variable on technology gap may be reversed or not significant. Since three covariates, the institution variables and the determinant of the technology are time invariant, all the models in Table 4 have been estimated by using the random effect panel data method, the alternative specification of fixed effect being non feasible to estimate the impact of the aforementioned variables. For each efficiency component three regressions have been conducted, one for the overall sample, and two other regressions by bank group. The first regression, will allow to test whether Islamic banks are more or less efficient than commercial banks, while the two other regressions are useful to verify whether the impact of the covariates is different or not according to the bank status. From Table 4, the dummy Islamic variable is negative and significant, in both regressions (1) and (1b) indicating that Islamic banks in MENA are less cost efficient than conventional banks (-5.7%) and also there is a substantial technology gap between Islamic banks and conventional banks which penalizes them in terms of costs by about (-6.8%). This last result is consistent with the empirical evidence found by Johnes et al. (2014). The dummy variable for foreign bank status is also negative and significant with respect to the technology gap, but not significant if we consider managerial efficiency, implying also that foreign banks are not operating close to the MENA meta frontier. This result is somewhat surprising in so far as this outcome is contrary to the expected result. One possible explanation is that foreign banks in MENA are not an important player in the financial market, their average loan and profit share does not exceed 5% in the sampled period. The second explanation is, even if foreign banks are more likely to transfer knowledge and technology more easily from their parent international banks, technology choice is also dependent from the regulations and the supervision authorities which impose some restrictions on the market functioning, and also on human capital. Domestic banks seem to be more able to operate close to the meta frontier in the MENA region. However, unlike Islamic banks, foreign banks are not doing worse in terms of managerial efficiency compared to domestic banks.

Table 4: Cost efficiencies components and their determinants

variables	Technology gap determinants			Managerial efficiency determinants		
	All banks (1)	Commercial (2)	Islamic (3)	All banks (1b)	Commercial (2b)	Islamic (3b)
Islamic	-0.057 *** (-4.51)	-	-	-0.068*** (-6.25)	-	-
Foreign	-0.061*** (-4.09)	-0.052*** (-4.15)	-	-0.012 (-0.87)	-0.014 (-1.22)	-
Log assets	-0.011*** (-3.79)	-0.014*** (-4.70)	-0.008 (-1.04)	0.001 (0.28)	-0.002 (-0.56)	0.005 (0.67)
Loan ratio	0.124*** (8.34)	0.089*** (5.77)	0.185*** (5.14)	0.056*** (3.85)	0.042*** (2.79)	0.076** (2.14)
Market Share	0.003 (0.06)	0.057 (1.25)	-0.180 (-1.16)	0.106** (2.26)	0.066 (1.53)	0.34** (2.31)
Internet Banking	0.022** (2.04)	0.004 (0.057)	0.066** (2.24)	0.027*** (2.69)	0.030*** (3.27)	0.007 (0.28)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
obs	2400	1861	539	2400	1861	539

numbers in parentheses are t-ratios

With respect to size and technology gap, this variable is negative and significant for commercial banks but not for Islamic banks. So, growing commercial banks may face great difficulties to adapt new banking technology and thus, may have disadvantage with respect to small size banks. However, there is no evidence for the impact of size on managerial efficiency whatever is the bank group. The loans to assets ratio is positive and significant which suggests that banks which are more engaged in lending activities are more likely to benefit from using the more advanced technology and also are more intensive to improve their managerial efficiency. This coefficient is positive whatever is the bank group, but the magnitude of the coefficient is two times higher for Islamic banks. There is no evidence for the impact of concentration on technology, in other words, banks with high levels of market share are not those who will try to adopt new banking technology, a kind of "quiet life" with respect to the technology used. However, more concentration is significantly correlated with managerial efficiency only for Islamic banks. As expected, the dummy online banking variable is positive and significant, confirming that this variable has a positive impact on improving cost efficiency. Remind that we have only one variable which capture technology which is the bank online service through the website, 79% of the sampled conventional banks in MENA offer this service against only 58% for Islamic banks, and the mean difference test is highly significant. One possible explanation, since most of the conventional banks have this service, it could have long been used, its significant impact being only relevant in managerial efficiency. However, for Islamic banks online banking service has a significant and positive

impact for both efficiency components, while its magnitude is two times more important to reduce the technology gap with respect to the meta frontier.

5. Robustness checks

In order to check for the validity of the aforementioned findings, we conducted a number of robustness checks. First, the frontier model approach being parametric, to check for the sensitivity of our results to other functional forms, we re-estimate the model by assuming a Cobb Douglas functional form for the cost frontier. The level of efficiencies are slightly lower than those obtained with the translog cost specification. However overall conclusions are consistent with the earlier analysis, i.e technology inefficiency is more important than managerial inefficiency and Islamic banks are both less efficient in terms of technology (80% for conventional banks, versus 73.7% for Islamic banks) and managerial efficiency(85.8% for conventional banks, versus 79.3% for Islamic banks). Thus, the conclusions are not sensitive to the functional form specifications of the cost function. Second, we also estimated the meta frontier in the second step à la O'Donnell et al. (2008), by using the linear programming (LP) method instead of the stochastic frontier meta frontier. This method is assumption free on the inefficiency distribution, so it is important to check how sensitive are our findings to this assumption. Overall, Islamic banks are still less efficient than conventional banks in terms of technology, even if average efficiency scores obtained by the LP method are lower than those obtained using the stochastic meta frontier. The average efficiency linked to technology gap with the LP method, being 70.8% for conventional banks and 66.7% for Islamic banks. Also, instead of using the two steps method in the determinants of the technology gap Table 4, we estimate the stochastic frontier meta frontier and its determinants in one step using the Battese and Coelli (1992) one step method[4]. The meta inefficiency component is assumed to follow a half normal distribution where the mode depends on the covariates listed in Table 4. Bank efficiency related to the technology inefficiency is 90.4% for conventional banks against 84.6% for Islamic banks, indicating that technology play an important role in global cost inefficiency of Islamic banks compared to the managerial inefficiency. Overall, the difference in the technology gap between conventional and Islamic banks is significant and varies between 4%-6% whatever is the estimation method used for the meta frontier. With respect to the determinants of the technology gap, Table 5 reports all the regression robustness checks with respect to alternative methods used to evaluate the technology gap. All our results obtained in Table 4 still hold qualitatively with respect to the functional form or the method used to estimate the meta frontier. Foreign status has a negative impact on technology efficiency for conventional banks, internet banking has a positive impact on the technology for Islamic banks. Moreover, there is no significant change in the results for the other bank characteristic covariates, the conclusions being particularly strong with the one step approach, i.e. when the frontier and the inefficiency determinants are estimated in one step.

[4] This method estimate the frontier and the determinants of the inefficiency in one step by maximum likelihood. The inefficiency component is assumed to follow a truncated half normal distribution.

Table 5: Technology gap determinants robustness checks by bank status

variables	Conventional banks			Islamic banks		
	Translog(LP) (1)	CobbDouglas(ST) (2)	Battese & Coelli (3)	Translog(LP) (4)	CobbDouglas(ST) (5)	Battese & Coelli (6)
Foreign	-0.092*** (-5.43)	-0.035* (-2.27)	12.276*** (5.85)	-	-	-
Log assets	0.002 (0.44)	-0.013*** (-3.58)	-8.823*** (-9.05)	0.003 (0.32)	-0.035*** (-4.45)	0.060* (1.81)
Loan ratio	0.165*** (8.08)	0.151*** (8.16)	5.782** (2.01)	0.231*** (5.59)	0.091** (2.73)	-2.763*** (-7.72)
Market Share	0.104 (1.71)	-0.006 (-0.11)	52.033*** (6.34)	-0.056 (-0.30)	0.020 (0.13)	0.070 (0.24)
Internet Banking	0.02 (1.43)	0.000 (0.01)	-7.787*** (-5.01)	0.054 (1.37)	0.081* (2.37)	-0.084 (-1.46)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
obs	1861	1861	1861	539	539	539
average efficiency	70.7%	80%	90.4%	66.7%	73.7%	84.6%

numbers between parentheses are the asymptotic t-ratios. Notice that with respect to the Battese and Coelli (BC) one step estimation method, the sign of the coefficients are interpreted as the impact of each covariate on the inefficiency, so they should have opposite signs with respect to the two steps method. Notice we only report the inefficiency determinants for (BC). (LP), the meta frontier is estimated by the linear programming method. Translog, Cobb-Douglas the meta frontier is estimated according to the translog and Cobb Douglas specification for the cost frontier respectively. (ST) stochastic meta frontier specification. Equations (1), (2), (4) and (5) are estimated using the panel data random effect method, using the two steps method.

Finally, following Bos and Schmiedel (2007) who use both cost and profit frontier models, we also estimate the alternative profit frontier model. This specification uses the same explanatory variables as the cost function, but there is no need to add the linear homogeneity on the input prices. However, the total cost is replaced by the profit reported of each bank. Some banks reported negative profit for some years, the absolute value of the minimum observed profit plus one, is then added to the profits of all banks in the sample. This is the solution used by most of the researchers estimating the translog profit function in order to include banks with negative profits in the estimation. To save space, only the translog form results are reported here. Net profit efficiency score, obtained from the estimation of each country frontier, is very high 96.86% compared to cost managerial efficiency. Islamic banks being 1.2% less efficient than conventional banks (97.1% for conventional, 95.9% for Islamic banks). In contrast, the technology gap efficiency score estimated from the meta profit frontier is high, 87.1% on average, conventional banks being more efficient 87.9% than Islamic banks, 84.5%. This result is in line with the previous results with the cost model and suggests that improving the banking technology in MENA region remain a challenge for policy makers to render them more competitive. We also consider a regression of each profit efficiency score on the list of determinants explored with the cost model, the conclusions are still robust, Islamic banks being less efficient than conventional banks, foreign banks do not dominate conventional banks in terms of technology gap, while internet banking has a positive impact

on profit efficiency components, but its magnitude is less important compared to the cost model.

Table 6: Profit efficiencies components and their determinants

Variables	Technology gap determinants			Managerial efficiency determinants		
	All banks (1)	Commercial (2)	Islamic (3)	All banks (1b)	Commercial (2b)	Islamic (3b)
Islamic	-0.038 *** (-4.98)	-	-	-0.012*** (-3.33)	-	-
Foreign	-0.031*** (-3.12)	-0.029*** (-3.38)	-	-0.003 (-0.53)	-0.004 (-0.73)	-
Log assets	-0.003 (-1.35)	-0.002 (-1.07)	-0.007 (-1.56)	-0.005*** (-4.35)	-0.004*** (-3.26)	-0.007*** (3.06)
Loan ratio	0.021** (2.05)	0.038*** (3.21)	-0.027 (-1.27)	-0.020*** (-3.27)	-0.020*** (-2.73)	-0.020 (-1.58)
Market Share	-0.144*** (-4.32)	-0.154*** (-4.63)	-0.051 (-0.56)	-0.014 (-0.75)	-0.044** (-2.24)	0.121** (2.52)
Internet Banking	0.010 (1.51)	0.002 (0.28)	0.035** (2.09)	0.012*** (3.31)	0.011*** (2.87)	0.012 (1.58)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
obs	2400	1861	539	2400	1861	539

numbers in parentheses are t-ratios

6. Conclusion and implications

Several empirical studies have compared the inefficiency of Islamic and conventional banks, focusing mainly on technical, scale or allocative inefficiencies. Most of these studies assume that the technology is common to all the banks, implicating that they share the same technology, inefficiency being exclusively linked to managerial inefficiency. In this paper we employ the meta frontier approach and decompose total cost inefficiency into managerial inefficiency and technology gap. Using an updated sample of 15 countries in MENA, we estimate separate country frontiers and then re-estimate the meta frontier envelop using stochastic frontier model and derive estimates of managerial efficiency and technology gap. Conventional banks in MENA are found to be more efficient compared to Islamic banks, both in terms of managerial efficiency, i.e. technical and allocative efficiency but also in terms of technology choice adapted to the market. Therefore, our evidence suggest that managerial inefficiency is far lower than the technology gap, (8%, 16.8%) for conventional banks and higher levels (13.7%, 21.9%) for Islamic banks respectively. The forgone revenue associated to these inefficiencies is evaluated to 13.2% (technology inefficiency) and 5.2% (managerial inefficiency). There is no clear improvement in both inefficiency components during the studied period for any studied country. This result suggests that banking systems in MENA

need to make much more efforts to develop more innovative products and switch from paper based transactions to electronic transactions, online banking service has a positive impact for both cost efficiency components. Monetary authorities should encourage these changes, by reinforcing competition and allowing for example telecommunication operators to compete with banks through exploring the benefits of the mobile banking and also by making pressure on financial institutions to create an immediate payments systems as it is becoming a standard in developed countries. At the bank level, these changes are conditioned on an adapted human capital but also on reducing prices on electronic transactions, a challenge for the MENA banking systems in the coming years.

We also investigated the determinants of the inefficiency components. Our empirical analysis has produced interesting findings. First, larger size banks are not operating close to their meta frontier, implying higher inefficiency due to the use of an inefficient technology. In other words, small or moderate sized banks are more advantaged in terms of technology use compared to the largest banks. This result suggests that it would be more difficult for large banks, due to bureaucracy and probably to the importance of their personal staff to adapt new technologies, the switching cost from one technology to another being more important. Larger sized banks may also be linked to the public bank ownership, as in many MENA countries the largest banks are state-owned banks. Second, foreign bank status has a negative impact on technology efficiency, foreign banks being 5% less efficient than domestic banks, a level comparable with Islamic banks. So foreign international banks in MENA are not a driver to facilitate the transfer of banking technology from their parent international banks. Finally, there is evidence that online banking is an important driver for improving the cost efficiency of MENA banks in its two dimensions managerial and technology efficiency, its impact on Islamic banking being largely more important to reduce the technology gap.

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Appendix: Robustness Check Complements

Table 7. Correlation matrix of different technology efficiency measures

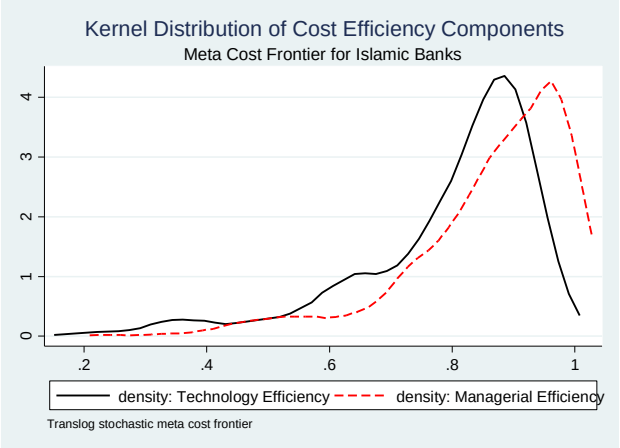
	*Trans*log(*Stoc*)_*Cost*	*Trans*log(*LP*)_*Cost*	*CobbDouglas*(*Stoc*)_*Cost*	*CobbDouglas*(*LP*)_*Cost*	*Trans*log(*Stoc*)_*Cost*
*Trans*log(*Stoc*)_*Cost*	1				
*Trans*log(*LP*)_*Cost*	0.769***	1			
CobbDouglas(*Stoc*)_*Cost*	0.676***	0.703***	1		
CobbDouglas(*LP*)_*Cost*	0.596***	0.707***	0.924***	1	
*Trans*log(*Stoc*)_*Profit*	0.183***	0.201***	0.201***	0.155***	1

*** significant at 99% level

(stoc): is the stochastic meta frontier estimated by maximum likelihood method

(LP): is the deterministic meta frontier estimated by linear programming method

Kernel distributions of various efficiencies measures by ownership structure



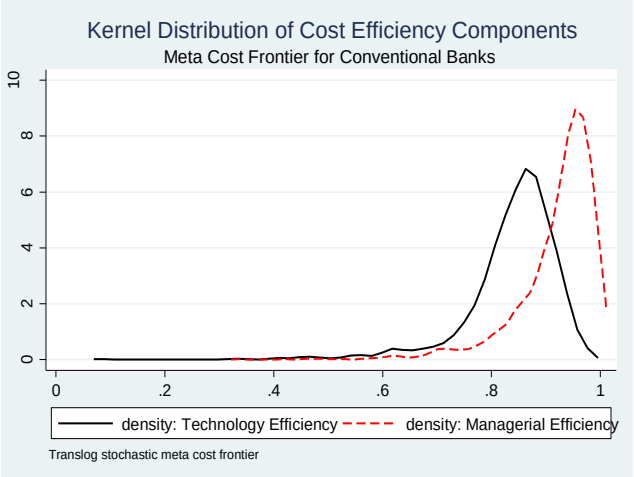


Table 8: Cost efficiencies components and their determinants

Variables	Technology Efficiency		Managerial Efficiency	
	Cost Model	Profit Model	Cost Model	Profit Model
Islamic	-0.086 (-1.09)	0.131** (2.43)	-0.256*** (-3.39)	0.016 (0.51)
Foreign	0.557*** (4.15)	0.215** (2.24)	-0.107 (-0.80)	0.112 (1.87)
Log assets	-0.008*** (-2.38)	0.002 (0.67)	-0.003 (-0.79)	-0.004*** (-2.65)
Loan ratio	0.111*** (5.61)	0.046*** (3.35)	0.045** (2.32)	-0.018** (-2.27)
Market Share	0.032 (0.58)	-0.170*** (-4.57)	0.078 (1.49)	-0.051*** (-2.41)
Internet Banking	0.005 (0.38)	0.002 (0.30)	0.032*** (2.79)	0.010*** (2.42)
Foreign ∗ Log assets	-0.037*** (-3.77)	-0.016** (-2.32)	0.007 (0.73)	-0.009 (-1.95)
Foreign ∗ Loan ratio	-0.181*** (-3.12)	-0.028 (-0.68)	0.013 (0.22)	-0.022 (-0.88)
Foreign ∗ Market Share	0.396 (1.00)	0.094 (0.32)	-0.456 (-1.12)	0.537*** (2.73)
Islamic ∗ Log assets	-0.003 (-0.52)	-0.012*** (-2.90)	0.013** (2.30)	-0.002 (-1.06)
Islamic ∗ Loan ratio	0.073*** (2.34)	-0.063*** (-2.80)	0.024 (0.76)	-0.004 (-0.26)
Islamic ∗ Market Share	-0.222 (-1.83)	0.039 (0.48)	0.242** (2.10)	0.162*** (3.47)
Islamic ∗ Internet Banking	0.068*** (2.65)	0.037** (2.33)	-0.030 (-1.33)	0.000 (0.06)
Year Dummies	Yes	Yes	Yes	Yes
obs	2400	2400	2400	2400

numbers in parentheses are t-ratios.

Cost meta Translog stochastic frontier model, Non standard meta profit Translog stochastic frontier model