How Far Away is the MENA Banking System?

Efficiency Comparisons with International Banks

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ABSTRACT

This paper compares the efficiency of MENA banks with a large sample of international banking systems. Using an unbalanced sample including 52 countries over the period 2000-2012, both cost and revenue efficiency are compared. Taking into account the heterogeneity of the technology, we estimate meta stochastic frontier models and identify two important inefficiency components, namely managerial inefficiency and technology inefficiency. Overall, in MENA banks costs could be reduced by 15%, while revenue could be increased by 19% if their banking systems undertake the most advanced banking technologies. We did not find any improvement of this inefficiency over time, but we find differences in cost inefficiency compared to the banks of the most advanced nations for several cases. The link between cost inefficiency and revenue inefficiency has also been explored by applying Granger causality tests. A bidirectional relationship has been evidenced, but the long term impact is in favor of managerial efficiency, which could be the driver to improve technology efficiency in the region, a result conditional on the availability of high qualified human capital in the banking sector.

KEYWORDS: Banking efficiency; Metafrontier; Stochastic frontier; Output distance function

JEL CLASSIFICATIONS: G21, D22, D24, P52

1. Introduction

The comparison of banking performances across countries has been widely investigated by researchers in the last years. Most of them have focused on the banking systems of developed countries, which share common regulations, comparable markets characteristics, and probably very similar technologies. In general, both cost and profit efficiencies are analysed, and the main finding is that most of the inefficiency has come from the inability of the banks to make greater revenues, rather than from difficulties in adjusting their costs.

Researchers have later recognized that comparing banks of different countries leads to ignore one important component, that is the technology used. Actually, the latter is usually assumed to be common according to the standard frontier models that evaluate banks performances. In terms of economic policy, the technology issue is also important. For example, it is useful to assess whether a banking system is costly, what is the part of the technology in this inefficiency, otherwise a bank will not reach its cost frontier if it is far from using the best knowledge of the technology. But, even when the technology used is updated, it can happen that most of the inefficiency will be linked to managerial staff and banks' procedures. In the first case, further investments in new technology – but also on human capital – are needed to improve efficiency; in the second case, banks have just to improve their managerial efficiency linked to X-efficiency or product mix.

In the same time, compared to other industries (for example, manufacturing), in the banking sector new technologies can be quite easily copied and adapted by bankers, as there are no patents for new ideas regarding financial firms. For example, considering ATMs, they were introduced in the US in 1967, but later (in the 80s) they were gradually launched by some banks in Western Europe as well. Today they represent a universal service provided by most of the banks all over the world. Similarly, online banking facilities are a much more recent innovation by banks of developed countries, and are expected to follow an analogous pattern in the next years within developing countries.

Even if costly, new technologies in banking normally guarantee a higher quality of services, and are easily accepted by bank customers, due also to the high switching costs they bear. Other technologies that are still in progress – mobile banking, the digital development of banking services, the provision of automated services – will probably contribute to improve the efficiency of the banking system in the world. As a consequence of the new developments in telecommunication technology and their spillovers on banking activities, with reference to the future of mobile banking payment by smartphone some professionals maintain that the days of mass services at the counter are things of the past.

The main question that we aim to address in this paper is: how efficient is the MENA banking system compared to the international context? Efficiency can be decomposed into two components: managerial efficiency, and technology inefficiency. The identification of such factors is relatively easy if we have data on the technology used by banks. For example, expenses on computer systems or financial engeneering, when introduced in a cost function as a determinant of technological progress, could identify its impact on the technology used. Unfortunately, most of these informations are strategic at the bank level, and for such reason there is scarcity of studies regarding this topic.

More recently, people working on frontier modelling have proposed the so called meta-frontier models, which are nonetheless able to decompose the overall inefficiency measure into its managerial and technology components. The intuition is to consider different groups of banks sharing similar technologies; constructing different group frontiers allows the estimation of the inefficiency linked to managerial aspects, while constructing another frontier by pooling all the groups after adjusting the inefficiency of each bank within its group provides the technology inefficiency. In other words, frontier models are able to estimate both the best practice managerial bank and the best practice bank technology state of the art. The more heterogeneous the groups with respect to the technology used, the higher the precision of the technology gap estimation. This methodology has been suggested by O'Donnell et al. (2008), and applied for the first time to banking by Bos and Schmiedel (2007), followed later by other researchers (among others: Kontalaimou et al., 2012; Johnes et al., 2012; Lee and Huang, 2017; Casu et al., 2016).

Another important issue, linked to the efficiency measurement, is the choice of a specific model, called orientation. Most of the studies on banking performances focus on the cost side. This implies the construction of an efficiency index that captures by how much total costs could be reduced when inefficiency is evidenced. In the empirical literature, inefficiency score has come out to be around 20%-30% in most studies. However, this score provides only one specific aspect of the multidimentional banking performance.

For a banker, reducing costs is important for profitability, but making more revenues is often much better. It has been shown that some costly investments (in particular, those in new technologies) are able to provide much higher revenues, and bank customers never complain about the higher prices charged when services quality is assured. So technology advances could be a competitive advantage for banks in order to attract more clients.

Another limit mentioned in the empirical literature on the cost performance indicator is its inability to consider other important factors generating performance differences among banks, like the product mix structure or the quality and/or price differentials (which have also an important impact on banks performances).

A second important efficiency performance measure is based on the so called non-standard profit frontier, proposed by Berger and Mester (1997). Here the frontier is constructed by estimating a non-standard profit model, which assumes that banks have market power and are able to make profit by charging higher prices for their customers. Even if this assumption may be questionable (at least for small- or medium-sized banks), this approach has been quite appealing for many researchers.

There is another methodology, currently used by production economists, based on distance functions, like output distance function (that is dual to the revenue function) or non radial distance function (like the directional distance functions, dual to the profit function), which could also be used and provide others orientations of the banking efficiencies. Unfortunately, the empirical literature employing these models is much more limited.

With reference to comparative studies focusing on MENA banks' efficiency, the literature is relatively more scarce than that considering developed countries' banks. Perhaps, the earlier international study is the one conducted by Chaffai and Dietsch (2007): they consider a large international sample including 5,456 banks observed over the period 1996-2000 in five regions of the world, and estimate first a frontier by region using the output distance model, then the gap between frontiers, a measure that they call 'technology gap'. Their main result is that, compared to European banks, by using the most advanced technology MENA banks could increase their activities by about 30%, keeping their costs unchanged during the studied period.

In another study, Ben Naceur et al. (2011) estimate a non parametric meta frontier model in order to derive 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 contributes by about 35%.

Johnes et al. (2014) use a non parametric model and compare the efficiency of Islamic and universal banks in a sample including 14 MENA countries plus 4 Asian countries. They assume that each bank group has its own technology, and show that most of the inefficiency of Islamic banks comes from technology inefficiency, called “modi operandi” in the paper, while univesal banks are less efficient in terms of managerial efficiency.

Abid and Goaied (2017a, 2017b) also report high levels of technology inefficiency when estimating a meta cost and non standard profit frontier on a very restricted sample including 61 banks.

Chaffai (2017) estimates both a cost and a profit meta frontier by considering a much larger sample of MENA banks, and shows that for such banks the inefficiency coming from the inefficient use of the most advanced banking technology is much more important than the one coming from managerial inefficiency.

It is important to remark that, in order to estimate the meta frontier, most of this literature considers just the MENA region – the only exception is the paper by Johnes et al. (2014), who also includes 4 Asian countries – so the derived results are specific to the region. For example, when Abid and Goaied (2017a) claim that Lebanese and Jordanian banks are close to their meta technology and their technology efficiency is close to 100%, this does not mean that those two banking systems are necessarily using the best banking technology knowledge at the international level.

Another important issue is the fragility of the results – in particular that of the meta frontier results – when researchers make use of a very limited number of banks: it is the case of Abid and Goaied (2017a, 2017b), with 61 banks, and of Ben Naceur et al. (2011), with 49 banks. Finally, except the paper by Chaffai and Dietsch (2006), MENA banks have not been really compared to an international benchmark.

In this paper we intend to contribute in this literature by employing a much larger international sample of banks and countries, which includes also banks operating in the most developed countries. We also consider two orientations, i.e. cost and revenue, for the efficiency measurement, without imposing a strong assumption on the market behavior for the banks. Finally, we also check the causality direction between managerial efficiency and technology efficiency, which could be considered as new in this literature.

The rest of the paper is organized as follows. Section 2 presents the methodology used, Section 3 discusses the data and the results obtained, and Section 4 concludes.

2. Methodology

Figure 1 below illustrates the methodology used to construct the meta frontier. Taking the case of a single output and input, the meta frontier represented by the dashed curve envelops the individual regional frontiers. For a particular bank, the distance with respect to the frontier it belongs to is decomposed into managerial efficiency (revenue inefficiency, *RE*, or cost inefficiency, *CE*), measured by the distance from point *A* to its own regional frontier, and technology inefficiency (*TGAP*), computed as the distance between each regional frontier and the meta frontier. Banks that are on the meta frontier and on their regional frontier are those who succeed both in terms of managerial efficiency and technology efficiency.

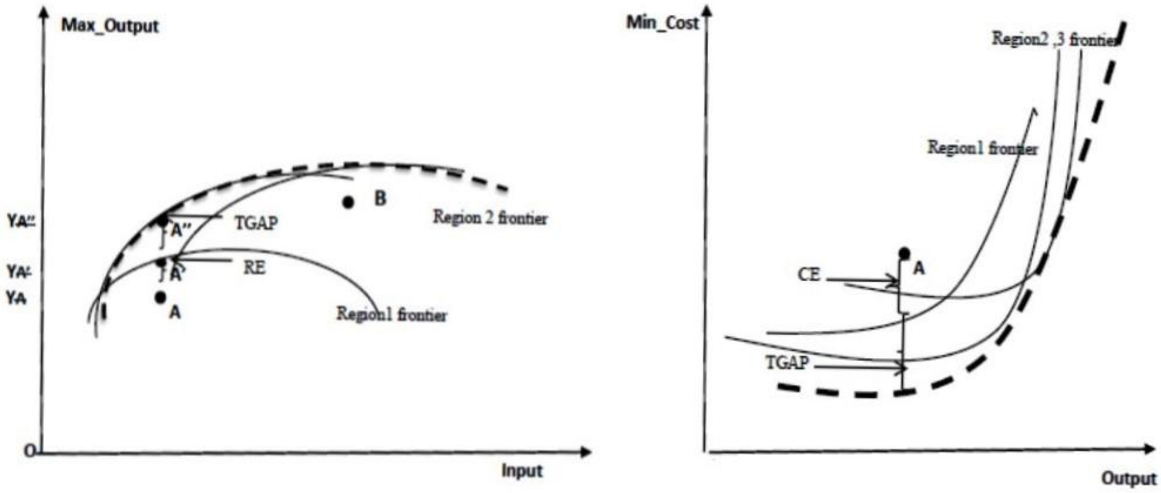

Figure 1 - Meta revenue and cost frontiers

There is no consensus on the characteristic (cost versus revenue) that should be considered while evaluating bank performances. Most of the earlier empirical studies have focused mainly on the cost efficiency side, by applying either non-parametric or parametric methods. However, comparing bank efficiency for heterogeneous banks across countries could not be restricted to the cost side. Bikker and Bos (2005) argue that, due to the presence of imperfect competition, market power or regulatory barriers, both cost efficiency and profit efficiency should be used in order to compare bank efficiency across countries. In the same vein, Berger (2003) maintains that technological progress is an important driver for banks. It may result in improved quality of services that could however increase costs and make them inefficient; at the same time, bank customers could be willing to pay more for such improvements. Hence, banks will be able to charge additional fees and rise their revenues to cover the higher costs linked to technology, which makes them efficient in terms of revenues. Berger also recommends to conduct both cost and profit analysis in any study focused on bank efficiency or productivity comparisons.

It should be noted that the profit function is based on a strong assumption on the behavior of the bank, i.e. the banker is a price taker also if his main objective is profit maximisation. This point may be not valid for public banks, for example when they are involved in finance develoment o social projects that are not necessarily profit-oriented. Moreover, as it has been largely discussed in empirical investigations, there are differences in the competitive environment which suggest that many banks have some market power and are able to increase their profit by charging higher prices for their customers. Here the alternative non-standard profit function of Berger and Mester (1997) could be considered, if all the sampled banks have market power. We think that this assumption might be too restrictive for the banks of the MENA region, where most of the important players are public owned banks that are neither motivated to maximising profit nor to benefitting from their market power in order to increase their profitability.

In this paper we consider two measures of bank efficiency: cost efficiency (based on the estimation of a cost function) and revenue efficiency (relying on the estimation of an output distance function[1] that provides a measure of technical efficiency linked to revenues). The first approach allows to measure by how much the inputs (costs) could be decreased to produce the same level of outputs, while the second method gauges by how much the outputs (revenues) could be increased while using the same level of inputs. We employ the cost function, instead of the input distance function, because most of the empirical literature on meta frontier have used this model, so it will be much easier to compare our results to this literature.

In both orientations, we nonetheless have the same definitions of the outputs and the inputs. Particularly, we consider the intermediation approach, which treats deposits as an input and loans as the output. According to the bulk of empirical literature, banks are assumed to produce two outputs: total loans (Y_1) and other services, here measured by the other earning assets (Y_2). For the purpose, they make use of three inputs: labor (X_1), physical capital (X_2) and financial inputs (X_3). The inputs are measured by total salaries, book values of fixed assets and total deposits, respectively. The distance function delivers the efficiency scores based on outputs and inputs, while the cost function is based on the total costs of producing the outputs and the input prices. Regarding the labor input, since information on total employees is often unavailable, we take the ratio between total salaries and total assets as a proxy of the price of labor. The other input prices are obtained by dividing the associated costs to the input quantities.

The efficiency scores are evaluated based on the estimation of frontier, i.e. through a frontier envelope expressed in terms of total costs for banks producing the aforementioned bundle of products and services (cost frontier), or by enveloping the data in the outputs for a given level of the inputs (output distance function). It is important here to remember the primary objective of this paper, which consists in focusing on MENA banks performances compared to those of other international banking systems. Frontier models provide efficiency scores bounded between 0 and 1 with respect to the benchmark. We assume that the benchmark is different across the banking industries of developed and developing countries, due to potential differences in the technology used as well as to managerial efficiency.

For the US case, Berger (2003) argues that during the 1990s technical progress captured by IT helped the customer switch from paper to electronic payments and contributed to reduce banking costs dramatically, up to 50% in some cases. Using data on 12 European developed banking systems for the period 1987-1999, Humphrey et al. (2006) estimate the cost saving of the shift to electronic payments and the expanded use of ATMs to be 0.38% of GDP. Most of the empirical literature focuses on the role of innovations in information processing technology (ATM, computers, digital technology...) and financial technology (financial engineering used to create new financial derivatives, credit risk and market risk models...) in improving bank performance and the competitiveness of the banking market. Unfortunately, there is no official information available on the related technology expenses in the bank annual statements in MENA region. The meta technology approach adopted in this paper, and applied on an international sample of banks across several regions, could be helpful for this purpose.

2.1. The cost frontier model

In order to determine the unobserved cost technology of the sampled banks, we use the stochastic frontier approach. We assume that, across a particular region, the technology is

[1] Notice that other distance functions could be also used, like input distance functions or directional distance functions (however, the latter need to fix the direction that should be common to all banks).

common to all banks and is represented by a flexible translog functional form. This assumption might be considered as very strong, as within a region each country could have its own technology.[2] For instance, Orea and Kumbhakar (2004) estimate a latent class stochastic frontier model for Spanish banks and find evidence of four different technology classes in the country. Using the same model, Koetter and Poghosyan (2009) detect three different technology classes for a large sample of universal German banks. A similar result has been obtained by Almanidis (2012), who employs a threshold stochastic frontier model and classifies seven different technology groups in the US commercial banks for the years 1984-2009.

In our view, even if across countries the technology used by banks may be heterogeneous, assuming a common technology for a given region means that we look for an average "best of the art of the banking technology". Once investigated, in case a technology gap is evidenced in MENA countries, it is more likely that its impact is much higher if compared to the most technology efficient banks in the world, an issue that could be eventually deepened in another piece of work.

The stochastic frontier model is estimated by pooling the data across countries for each year in order to provide estimates of the cost inefficiency by bank. It must be noted that estimating separate frontiers for each year allows the estimation of the best practice cost frontier and its shift over time, without imposing a particular structure for either the evolution of technical progress and the inefficiency components.

Our estimated cost frontier (by year and region) is the following:

$$TC_{ij,t}^{R} = TL(Y_{ij,t}, P_{ij,t}, Z_{ij,t}\beta^{R})e^{u_{ij,t}^{R} + v_{iij,t}^{R}} \quad (1)$$

where R = 1,..,6 indexes regions, j = 1,...,J indexes countries, i = 1,...,Nc indexes banks, and t = 1,...,T indexes periods.

The estimated model is the standard translog cost function, where TC (total cost) is normalized by the financial input price in order to impose linear homogeneity in input prices. The cost function also includes environmental variables Z that capture differences in the regulations and markets across the regions. Moreover, we assume that the inefficiency components $u \geq 0$, which capture the distance between the observed total cost and the minimum cost on the frontier (called hereafter managerial inefficiency), follow a half normal distribution, while the v error terms represent the random shocks that follow the usual normal distribution. The frontier is estimated by the maximum likelihood method, and we verified that the likelihood function was numerically maximized in each case.[3] This step represents the estimation of regions frontiers in Figure 1.

Once the frontier is estimated for each region and year, we first estimate the minimum cost by country denoted by $T\hat{C}_{ij,t}^{R}$, then in a second step we run a stochastic frontier model by pooling all regions and countries and years. This step corresponds to estimating the dashed curve in Figure 1, which represents the meta frontier:

[2] We do not agree with this solution, the number of countries being very large. Actually, running a frontier model by country requires to check the unobserved heterogeneity in order to find the most appropriate model. Moreover, it would be very hard, if not impossible, to find out whether the likelihood function converges in each case.

[3] This issue is seldom checked in most of the empirical studies on meta frontier (actually, the likelihood function might not attain its maximum, in particular due to possible outliers conducting to erroneous inference).

$$\hat{T}C_{ij,t}^{M} = TL(Y_{ij,t}, P_{ij,t}, Z_{ij,t}\beta^{M})e^{u_{ij,t}^{M} + v_{iij,t}^{M}} \tag{2}$$

The inefficiency scores capture managerial inefficiency in step (1), while they represent technology gap inefficiency in step (2). Actually, if within a particular region a bank is unable to minimize total cost in its group, this is mainly due to technical and allocative inefficiency compared to more efficient banks in that region and conditional on the environment *Z*. However, the inefficiency gap obtained from the estimation of Equation (2) is the gap between the region's bank frontier and the meta cost frontier that envelops all the regions frontiers. Banks of both developed and developing countries are used to estimate the international meta technology frontier.

The larger is the inefficiency score in Equation (2), $u_{ij,t}^{M}$, the less advanced is the technology adopted by the country in its region. The total efficiency score for an inefficient bank is then the product of its managerial efficiency in (1) and the technology efficiency in (2). The decomposition of technical efficiency is usually obtained by the expected conditional value according to Jondrow et al. (1982), or Battese and Coelli (1988):

$$E(e^{-u|\varepsilon}) = \exp(-\mu_* + 0.5\sigma_*^2)\frac{\Phi(\mu_*/\sigma^*)\_\sigma_*}{\Phi(\mu_*/\sigma^*)} \tag{3}$$

The values $\mu_* = -\varepsilon\sigma_u^2/(\sigma_u^2 + \sigma_v^2)$ and $\sigma_*^2 = (\sigma_u^2\sigma_v^2)/(\sigma_u^2 + \sigma_v^2)$ are obtained from the parameters estimates of the maximum likelihood, $\Phi(.)$ is the standard normal cumulative distribution function, while ε is the total residual error terms.

The product of the two efficiency components is usually called the meta frontier score, and is interpreted as an overall index of bank efficiency which includes managerial ability and the efficient use of the technology.

2.2. The output distance function

Being the technology multiproduct, the output distance function has been also used to evaluate banking performances. It measures by how much the outputs could be radially increased while a bank uses a fixed level of inputs (Kumbhakar and Lovell, 2000).

Starting from the particular case of one output, the stochastic production frontier can be written as:

$$Y = f(X, \beta)e^{-u+v} \tag{4}$$

and the radial stochastic output distance function is:

$$\frac{Y}{f(X,\beta)} = D_o(Y, X) + v \tag{5}$$

The latter is called the output distance function, and measures the distance to the frontier called technical efficiency, given by the ratio between observed output and the maximum output on the frontier, with $0 < D_o(Y, X) \leq 1$.

Extending Equation (5) to the multioutput case, and using the property of linear homogeneity with respect to the outputs, which suggests that the efficiency scores remain constant for any change in the unit of the measurement of the outputs, the stochastic version of the output distance function is written as:

$$-\log(y2) = TL(X, Y / y2) + u + v \quad (6)$$

where $u = -\log(D_o(Y, X))$, which is also an asymmetric error term.

The composed error term of Equation (6) is similar to that of the cost frontier model in Equation (1), and is estimated in the same manner. We introduce environmental variables, *Z*, to control for the environment differences across countries, and estimate the meta frontier following the same steps detailed below.

3. Empirical results

We use a sample of 1,477 banks for 52 countries spanning the years 2000-2012. Data are drawn from the Bankscope database. The overall sample is then split into 6 regions: two of them include the most developed country banks, namely US and Europe, while the other regions are MENA countries, Asia, Eastern Europe and Latin America. To our knowledge, this is the largest sample ever used to estimate the meta technology frontier banking system.

3.1. Descriptive statistics

We just focus on some bank characteristics: intermediation ratios (proxied through the loans to deposits ratio), loan business (as a share of total assets), capitalization (quantified by the equity to assets ratio), size (calculated as the logarithm of total assets), average costs (measured by the ratio between total costs and total assets) and average revenue (equal to total revenues over total assets).

Table 1 shows that MENA banks have the lowest intermediation ratio in the world, even compared to European and US banks. Particularly, for MENA countries it is 17.7% lower, meaning that here banks are not efficient in channeling household savings into investments compared to developed country banks. Their loans ratio is also very low: MENA banks are ranked fifth (just before Latin American ones), with their ratio being 11.7% less than that of developed country banks. The equity-to-assets ratio measures the bank's financial cushion for absorbing loan losses: in MENA it ranges between 10 and 11%, similar to most of the regions except European and Asian country banks, where this ratio is 30% lower. However, the equity ratio is not independent from the country regulators, who may impose some restrictions on it. If we now compare the performance ratios, we argue that in MENA the average cost, 4-5%, is in the same order of magnitude compared to developed countries and Asian banks, but very low compared to Latin American or Eastern European banks. Differences in financial costs may explain these higher costs. However, in MENA the average revenue – as well as the return on assets – is close to 4%, slightly less than the US banks but much higher compared to the European and Asian banks. Instead, Latin American banks have the highest average revenue.

To sum up, on average the situation of MENA banks is not bad in terms of average costs and average revenues compared to the international banking systems, in particular to developed country banks, but differences emerge across countries, as shown in the Figures in the Appendix. For example, average costs are much lower than the US in most of the Gulf countries, especially due to the cheap financial resources in these countries, but much higher in Lebanon and Turkey. The latter country is very special, as it has also the highest average revenue, with the US dominating all the remaining countries in MENA. We can also notice the high dispersion in the distribution of the average costs compared to the revenue. Controlling average cost or revenue provides only a partial indication of the banking performance: it does not take into account the efficiency that banks have in minimizing cost or maximizing revenues in their production process, nor the efficiency of the technology used.

Table 1 - Bank indicators by region

Region	Variable	Mean	Median	St.dev.	N.obs.
US	Intermediation	1.024	0.848	5.15	2,354
	Loan ratio	0.627	0.65	0.14	
	Equity ratio	0.101	0.093	0.03	
	Log(assets)	10.91	10.68	1.57	
	AVcost	0.048	0.045	0.02	
	AVrevenue	0.049	0.046	0.03	
Europe	Intermediation	0.952	0.853	0.79	4,310
	Loan ratio	0.59	0.62	0.22	
	Equity ratio	0.073	0.064	0.05	
	Log(assets)	11.4	10.93	1.96	
	AVcost	0.048	0.046	0.02	
	AVrevenue	0.033	0.029	0.02	
Asia	Intermediation	0.767	0.673	1.03	1,897
	Loan ratio	0.553	0.563	0.13	
	Equity ratio	0.076	0.067	0.04	
	Log(assets)	11.37	11.3	1.5	
	AVcost	0.054	0.051	0.03	
	AVrevenue	0.037	0.034	0.02	
Latin America	Intermediation	0.845	0.799	0.35	746
	Loan ratio	0.539	0.546	0.15	
	Equity ratio	0.101	0.095	0.03	
	Log(assets)	10.93	10.76	1.26	
	AVcost	0.101	0.09	0.05	
	AVrevenue	0.085	0.082	0.04	
Eastern Europe	Intermediation	0.785	0.751	0.37	888
	Loan ratio	0.566	0.581	0.15	
	Equity ratio	0.111	0.099	0.06	
	Log(assets)	10.64	10.65	1.18	
	AVcost	0.081	0.069	0.05	
	AVrevenue	0.067	0.057	0.05	
MENA	Intermediation	0.703	0.722	0.26	1,325
	Loan ratio	0.539	0.561	0.17	
	Equity ratio	0.113	0.107	0.05	
	Log(assets)	11.04	10.95	1.19	
	AVcost	0.053	0.046	0.03	
	AVrevenue	0.043	0.04	0.02	

3.2. The position of MENA in terms of efficiency: A regional comparison

In order to have a global picture of the soundness of the efficiency in the MENA banking system, we provide estimates of cost and revenue efficiency by region, and the related measure of the technology gap discussed in the methodology. We also consider the evolution of the above efficiency components for the banks of the developed regions (i.e. US and Europe) over the period under investigation. It is important to remind that the managerial efficiency scores are not directly comparable across regions since we estimate specific regional frontiers, but the scores derived from the meta frontier are based on the pooled regional sample, which makes the comparison of the scores more accurate.

As shown in Figure 2 below, MENA banks have the lowest cost efficiency score (60% as the median value) compared to the most advanced country (US, 72%). However, in terms of revenue efficiency, MENA banks are much more efficient (their score is 79%), just behind the most efficient country banks (Europe, 81%, and the US, 80%).

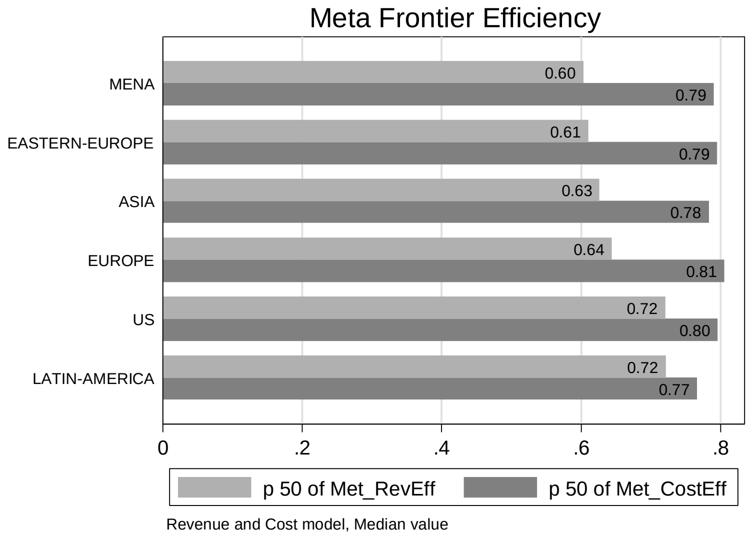

Figure 2 - Cost efficiency scores by region

Recalling that this efficiency is the product of managerial efficiency and technology gap, in Figure 3 we report the technology gap efficiency scores by region. As it is evident, US and European banks are characterized by the highest values of the score, suggesting that in more developed countries banks are operating very close to their meta technology frontier, in terms of both cost optimization and the process of selling services. Overall, at the international level, banks are much more efficient in terms of revenue than in controlling costs. This result is in line with the findings of Berger et al. (2003) regarding managerial efficiency: actually, they observe that a higher quality of financial services increases costs but raises revenues by more than the cost expansion. A similar result is also found for the technology efficiency gap across countries. For the MENA region, the technology gap is on average slightly lower than banks operating in developed countries (1% in terms of cost, 2% in terms of revenue); compared to the meta efficiency score, where the difference is much more important, it suggests important differences in terms of managerial efficiency across countries and regions.

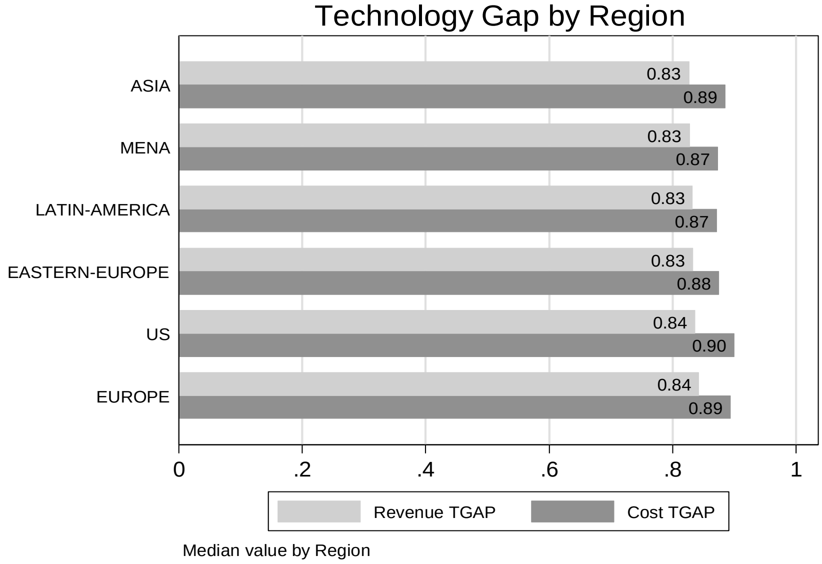

Figure 3 - Technology gap by region

If, in addition to MENA credit institutions, we now focus just on European and US banks, which operate in the most developed and active banking systems, we are able to check whether the technology gap has improved or deteriorated across the observed period. As Figure 4 shows, for MENA banks the cost technology gap has decreased from 93% in 2000 (the starting period) to 80% in 2011 and 60% in 2012. Regarding the banks of the most developed countries, the technology gap has improved: particularly, for Europe we observe a positive trend up to 2011. Casu et al. (2016) notice that the improvement in the technology gap in Europe is primarily driven by technological change. However, we observe that a slight deterioration happened for US starting from 2009, which suggests some role of the financial crisis. This evidence is in line with the findings of Lee and Huang (2017), who, using meta cost frontiers, observe a deterioration of cost efficiency for Western European banks.

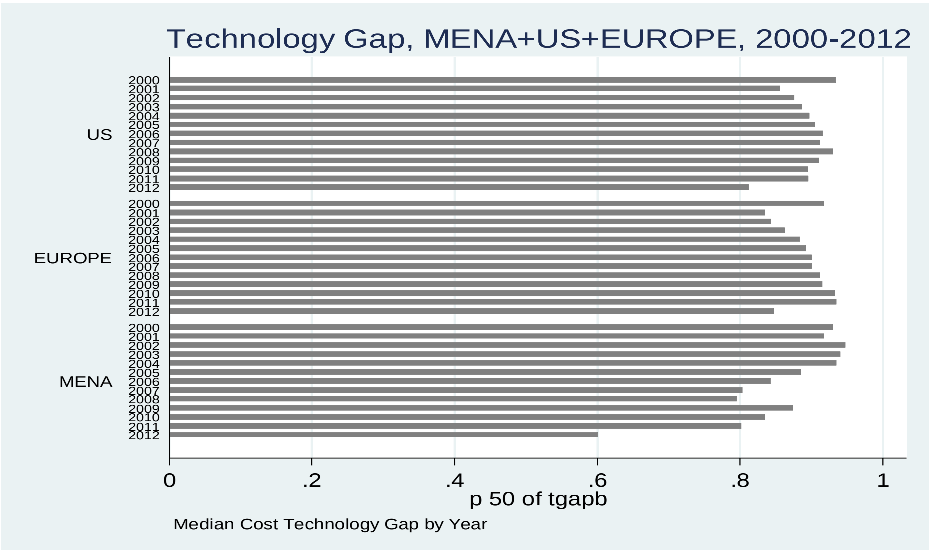

Figure 4 - The cost technology gap for selected areas during time

However, banks from developed countries are still the leader in terms of the technology used to control costs. Instead, some differences can be observed regarding the evolution of the revenue technology gap (see Figure 5): for the US it has improved up to 2006, then we detect the impact of the financial crisis on the gap, which holds also for Europe and MENA region (except the very last year in the latter). Overall, we can conclude that the MENA region is far from improving its banking technology to reach the best practice of the most developed country international banks.

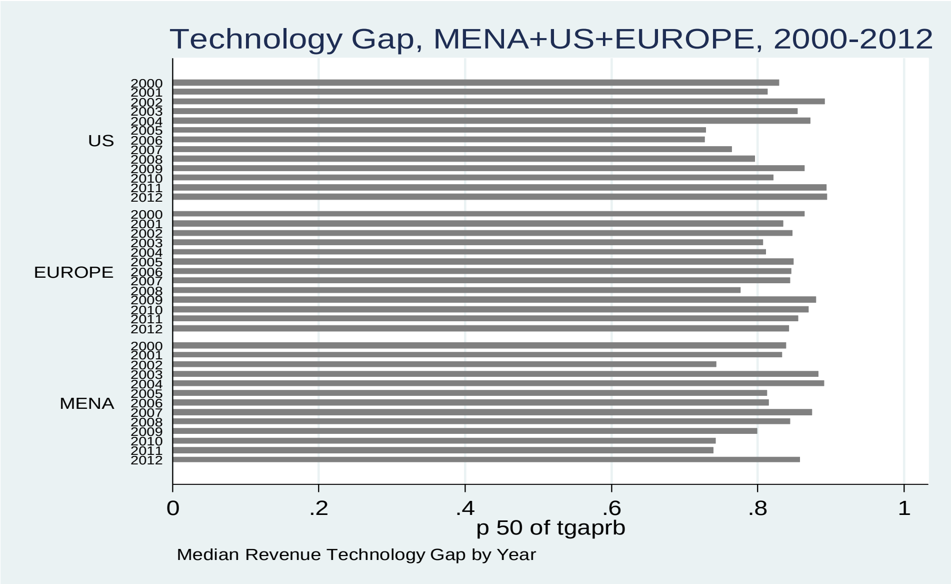

Figure 5 - The revenue technology gap for selected areas during time

3.3. Banking efficiency within MENA

The picture provided for the MENA banking system as a whole is not so negative in terms of the overall efficiency of their banks, even if the evolution of costs efficiency linked to the technology is decreasing. The objective is now to compare what is really comparable, in terms of closer markets, institutions, regulations and customers' behavior. In this section we provide comparisons of bank cost and revenue efficiency components for MENA countries, and also compare them with US and the most efficient countries in Europe (Denmark for cost, and Switzerland for revenue). The comparison takes into account banks' size, since some differences were observed across countries.

As shown in Table 2, the overall cost efficiency score is equal to 78%, but some country banks are far below this average value – Jordan (72.1%), Turkey (74.5%), Oman (75.6%) – when compared to the most efficient banks in the region – Bahrain (82%), Tunisia (81.4%) and Israel (81.2%). Most of this inefficiency is coming from the inability of MENA banks to use the best technology adopted by the banks of international developed countries. For instance, the technology gap efficiency score varies between 88% (in Morocco and Israel) to 83% (in Emirates and Qatar); Gulf country banks seem to be much less efficient to use the best technology to lower their costs. So as to have a closer look of the importance of the two inefficiency components on the cost structure of MENA banks, we have converted the estimated inefficiencies into extra costs and divided them by net income. These quantities therefore proxy the foregone revenue (as a fraction of the net income) associated to each cost inefficiency component. As Graph e in the Appendix shows, for the most part of MENA countries the extra cost (i.e. foregone revenue) due to technology inefficiency is higher than the one due to managerial inefficiency, and reaches values even higher than 20% in a couple of countries (22% in Turkey, 23% in Lebanon). Generally, the first foregone revenue is more than two times higher than the second one (their median values are 15% and 6%, respectively).

However, the technology gap remains the main source of cost inefficiency, since the banks in the region control much better their managerial efficiency, which varies between 96% (in Bahrain) and 93% (in Kuwait and Israel). This finding is in line with the results found by Chaffai (2017), who shows that most of the cost inefficiency in MENA region comes from technology inefficiency rather than from managerial inefficiency. This result is achieved by means of the construction of the meta technology that was restricted to the MENA region only. Instead, adding banks of more developed countries in a larger sample of international banks justifies the different result that MENA region is far away from developed country bank system.

We have also calculated the average growth rate of the technology gap during the period 2000-2012. On average there is a deterioration in the gap by 2.8% per year, leading to an increase in total costs by around 39% in the sample period. This growth rate is negative for nearly all countries. For Turkey and Oman we observe the highest deterioration in cost efficiency (-3.4% and -3.7%, respectively) compared to Israel and Lebanon (-1.6%). In contrast, there is a slight increase on the average technology gap, which improved revenue efficiency by 1.1% per year, corresponding to an increase of 14% over the whole period. Jordan improved its revenue efficiency by 2.3% per year, followed by Qatar and Saudi Arabia (+2%). To sum up, the impact of technology improvement on bank efficiency has been negative and important on costs, but positive and less important on revenues.

Table 2 - Cost efficiency components of banks in MENA countries

Country	Variable	Mean	p25	p50	p75	sd	N
AE	Cost_TGAP	0.827	0.746	0.841	0.945	0.125	187
	ncosteffb	0.917	0.861	0.940	0.985	0.079	187
	Met_CostEff	0.756	0.664	0.751	0.867	0.122	187
	growthtgapb	-0.040	-0.090	-0.032	0.007	0.091	170
BH	Cost_TGAP	0.851	0.804	0.870	0.932	0.103	73
	ncosteffb	0.964	0.944	0.977	0.991	0.037	68
	Met_CostEff	0.820	0.778	0.834	0.895	0.098	68
	growthtgapb	-0.035	-0.062	-0.026	0.011	0.094	67
IL	Cost_TGAP	0.879	0.864	0.895	0.921	0.071	129
	ncosteffb	0.926	0.871	0.955	0.990	0.078	127
	Met_CostEff	0.813	0.768	0.830	0.874	0.081	127
	growthtgapb	-0.016	-0.049	0.002	0.032	0.080	113
JO	Cost_TGAP	0.850	0.818	0.862	0.917	0.095	90
	ncosteffb	0.854	0.747	0.870	0.962	0.113	90
	Met_CostEff	0.722	0.626	0.732	0.799	0.102	90
	growthtgapb	-0.032	-0.054	-0.023	0.010	0.093	82
KW	Cost_TGAP	0.842	0.766	0.859	0.938	0.104	78
	ncosteffb	0.932	0.897	0.942	0.983	0.062	78
	Met_CostEff	0.785	0.696	0.770	0.889	0.113	78
	growthtgapb	-0.030	-0.066	-0.029	0.008	0.090	71
LB	Cost_TGAP	0.876	0.859	0.891	0.920	0.066	153
	ncosteffb	0.925	0.886	0.945	0.986	0.075	153
	Met_CostEff	0.807	0.766	0.813	0.855	0.069	153
	growthtgapb	-0.016	-0.038	-0.005	0.018	0.074	139
MA	Cost_TGAP	0.883	0.864	0.884	0.924	0.055	71
	ncosteffb	0.873	0.785	0.908	0.966	0.107	71
	Met_CostEff	0.768	0.709	0.784	0.820	0.082	71
	growthtgapb	-0.006	-0.034	-0.009	0.015	0.068	60
OM	Cost_TGAP	0.826	0.749	0.840	0.944	0.124	71
	ncosteffb	0.914	0.839	0.946	0.983	0.086	71
	Met_CostEff	0.756	0.639	0.765	0.888	0.140	71

	growthtgapb	-0.037	-0.082	-0.048	0.016	0.100	65
QA	Cost_TGAP	0.835	0.771	0.843	0.907	0.107	54
	ncosteffb	0.949	0.920	0.971	0.991	0.053	50
	Met_CostEff	0.786	0.747	0.793	0.851	0.103	50
	growthtgapb	-0.029	-0.071	-0.033	0.012	0.084	49
SA	Cost_TGAP	0.846	0.782	0.869	0.937	0.101	117
	ncosteffb	0.939	0.899	0.953	0.990	0.055	117
	Met_CostEff	0.793	0.735	0.798	0.856	0.094	117
	growthtgapb	-0.030	-0.076	-0.037	0.003	0.094	108
TN	Cost_TGAP	0.867	0.836	0.881	0.927	0.081	125
	ncosteffb	0.936	0.909	0.951	0.989	0.064	120
	Met_CostEff	0.814	0.791	0.820	0.858	0.073	120
	growthtgapb	-0.026	-0.044	-0.023	0.013	0.083	106
TR	Cost_TGAP	0.847	0.802	0.846	0.935	0.104	191
	ncosteffb	0.883	0.811	0.911	0.974	0.103	188
	Met_CostEff	0.745	0.665	0.741	0.807	0.110	188
	growthtgapb	-0.034	-0.061	-0.024	0.007	0.105	158
Total	*Cost_TGAP*	*0.853*	*0.802*	*0.874*	*0.927*	*0.099*	*1339*
	ncosteffb	*0.915*	*0.869*	*0.942*	*0.985*	*0.085*	*1320*
	Met_CostEff	*0.779*	*0.709*	*0.790*	*0.857*	*0.104*	*1320*
	growthtgapb	*-0.028*	*-0.064*	*-0.020*	*0.013*	*0.089*	*1188*

In contrast, revenue efficiency derived from the meta output distance function is very low compared to the cost efficiency. As Table 3 makes clear, it ranges from 43% in Turkey, to 55% in Tunisia, and to 65%-68% in Bahrain, Kuwait and Saudi Arabia. Much of the inefficiency is linked to managerial inefficiency – technology efficiency being very high – and varies between 80% to 82.7% but slightly much lower than the cost technology gap. Graph f in the Appendix highlights that the correlation between the two technology gap measures is positive but quite low (actually, the correlation coefficient amounts to 0.0413).

To sum up, the inability of the banks in the MENA region to use the best technology of developed country banks penalizes them regarding the possibility to be both competitive in terms of costs and more profitable. Revenue inefficiency comes out to be much more important than cost inefficiency.

Table 3 - Revenue efficiency components of banks in MENA countries

Country	**Variable**	**Mean**	**p25**	**p50**	**p75**	**sd**	**N**
AE	Revenue_TGAP	0.805	0.754	0.818	0.878	0.103	187
	nreveffb	0.801	0.699	0.823	0.959	0.162	186
	Met_RevEff	0.640	0.538	0.632	0.734	0.137	186
	growthtgaprb	0.013	-0.08	0.005	0.076	0.133	170
BH	Revenue_TGAP	0.802	0.746	0.838	0.898	0.124	73
	nreveffb	0.809	0.735	0.839	0.921	0.148	71
	Met_RevEff	0.652	0.561	0.650	0.742	0.114	71
	growthtgaprb	0.029	-0.050	-0.008	0.070	0.208	67
IL	Revenue_TGAP	0.807	0.736	0.826	0.894	0.105	129
	nreveffb	0.772	0.625	0.769	0.969	0.174	128
	Met_RevEff	0.616	0.523	0.595	0.706	0.136	128
	growthtgaprb	0.012	-0.067	0.001	0.099	0.148	113
JO	Revenue_TGAP	0.808	0.734	0.826	0.875	0.092	90
	nreveffb	0.727	0.639	0.730	0.819	0.163	90
	Met_RevEff	0.580	0.519	0.581	0.647	0.120	90
	growthtgaprb	0.023	-0.060	0.003	0.067	0.134	82
KW	Revenue_TGAP	0.819	0.76	0.843	0.880	0.084	78
	nreveffb	0.829	0.78	0.854	0.912	0.123	77
	Met_RevEff	0.673	0.600	0.673	0.740	0.097	77
	growthtgaprb	0.012	-0.069	0.001	0.078	0.132	71
LB	Revenue_TGAP	0.818	0.784	0.830	0.879	0.084	153
	nreveffb	0.748	0.640	0.764	0.830	0.157	153

	Met_RevEff	0.603	0.537	0.613	0.666	0.104	153
	growthtgaprb	-0.001	-0.069	-0.007	0.072	0.110	139
MA	Revenue_TGAP	0.810	0.734	0.808	0.899	0.093	71
	nreveffb	0.807	0.673	0.812	0.980	0.156	71
	Met_RevEff	0.646	0.550	0.646	0.723	0.114	71
	growthtgaprb	-0.005	-0.088	-0.015	0.076	0.145	60
OM	Revenue_TGAP	0.81	0.766	0.823	0.891	0.098	71
	nreveffb	0.808	0.751	0.826	0.903	0.141	70
	Met_RevEff	0.648	0.558	0.647	0.725	0.113	70
	growthtgaprb	0.007	-0.066	-0.008	0.062	0.135	65
QA	Revenue_TGAP	0.815	0.764	0.824	0.891	0.094	54
	nreveffb	0.798	0.706	0.790	0.895	0.124	53
	Met_RevEff	0.645	0.576	0.641	0.697	0.097	53
	growthtgaprb	0.025	-0.087	0.019	0.101	0.154	49
SA	Revenue_TGAP	0.820	0.766	0.819	0.884	0.074	117
	nreveffb	0.847	0.769	0.857	0.952	0.123	116
	Met_RevEff	0.691	0.639	0.692	0.762	0.102	116
	growthtgaprb	0.020	-0.047	0.019	0.084	0.097	108
TN	Revenue_TGAP	0.806	0.747	0.822	0.886	0.104	125
	nreveffb	0.699	0.564	0.687	0.810	0.180	125
	Met_RevEff	0.552	0.473	0.533	0.615	0.122	125
	growthtgaprb	-0.009	-0.093	-0.025	0.048	0.116	106
TR	Revenue_TGAP	0.780	0.687	0.832	0.924	0.173	191
	nreveffb	0.585	0.392	0.580	0.766	0.240	191
	Met_RevEff	0.427	0.324	0.434	0.527	0.142	191
	growthtgaprb	0.019	-0.077	-0.011	0.062	0.191	158
Total	*Revenue_TGAP*	*0.806*	*0.746*	*0.827*	*0.891*	*0.111*	*1339*
	nreveffb	*0.753*	*0.635*	*0.777*	*0.890*	*0.187*	*1331*
	Met_RevEff	*0.599*	*0.513*	*0.601*	*0.692*	*0.145*	*1331*
	growthtgaprb	*0.011*	*-0.071*	*-0.002*	*0.073*	*0.144*	*1188*

We also extend the comparison of the technology by taking into account bank size. The idea is that banks from developed countries perhaps have much larger size compared to MENA region banks, which makes the comparison across countries questionable. We therefore group the sample by country and year according to the quartiles of banks' total assets. Small banks are those up to the first quartile, while those over the third quartile are regarded as large banks. The remaining banks (with total assets ranging between the 25% and 75% percentiles) are considered as medium size banks. In such comparison we focus just on the most efficient developed country banks: we always consider the US banks, while, among the European countries, we focus on Switzerland (the most efficient system in terms of costs) and Denmark (the most efficient banking industry in terms of revenue).

Table 4 reports the results of the cost comparison, and also the mean test differences in the technology gap between each MENA country with respect to the benchmark of each developed country. Overall, small-sized banks in developed countries (US and Denmark) are more able to adopt the more advanced technology in order to reduce their costs; the difference of the technology gap is very low (3.5% in US, and 0.9% in Denmark). In contrast, there is an important difference in the technology gap between small and large banks in some MENA countries (Bahrain +8%, Israel +7.1%, Jordan +5.3%), while it is much more limited in Saudi Arabia and Lebanon. However, small- and medium-sized banks are much more efficient in Qatar, Emirates and Turkey, where technology efficiency seems to have provided much more benefits to little banks. However, when we compare banks from MENA countries with those of similar size in more developed countries, in most cases MENA banks are dominated by US banks and especially by European banks (with whom cost differences reach more than 10%, particularly for large banks of Emirates, Bahrain and Israel).

Table 4 - MENA cost technology gap comparisons with most efficient developed country banks

Country	**Size**	**TGAP MENA**	**TGAP (US)**	**t-test MENA/US**	**Difference**	**TGAP (DK)**	**t-test MENA/DK**	**Difference**
AE	All	0.827	0.883	-6.12***	-6.8%	0.889	-6.48***	-7.5%
	Small	0.863	0.896	-1.95*	-3.8%	0.893	-1.73*	-3.5%
	Medium	0.821	0.884	-4.89***	-7.7%	0.887	-4.86***	-8%
	Large	0.774	0.861	-5.11***	-11.2%	0.884	-6.25***	-14.2%
BH	All	0.851	0.883	-2.68***	-3.7%	0.889	-3.6***	-4.5%
	Small	0.802	0.896	-2.58**	-11.7%	0.893	-2.49**	-11.3%
	Medium	0.845	0.884	-2.29**	-4.6%	0.887	-2.39**	-5%
	Large	0.880	0.861	1.06	-	0.884	-0.25	-
IL	All	0.879	0.883	-0.73	-	0.889	-1.46	-
	Small	0.818	0.896	-3.21***	-9.5%	0.893	-3.05***	-9.2%
	Medium	0.885	0.884	0.12	-	0.887	-0.18	-
	Large	0.892	0.861	3.77***	+3.5%	0.884	0.87	-
JO	All	0.850	0.883	-3.26***	-3.8%	0.889	-3.67***	-4.6%
	Small	0.837	0.896	-3.88***	-10.9%	0.893	-3.57***	-6.7%
	Medium	0.832	0.884	-2.89***	-6.3%	0.887	-2.97***	-6.6%
	Large	0.891	0.861	1.58	-	0.884	0.34	-
KW	All	0.842	0.883	-3.48***	-4.9%	0.889	-3.84***	-5.7%
	Small	-	0.896	-	-	0.893	-	-
	Medium	0.839	0.884	-3.40***	-5.3%	0.887	-3.44***	-1.5%
	Large	0.855	0.861	-0.20	-	0.884	-0.99	-
LB	All	0.876	0.883	-1.36	-	0.889	-2.11**	-1.5%
	Small	0.862	0.896	-2.37**	-3.9%	0.893	-2.09**	-3.6%
	Medium	0.878	0.884	-0.92	-	0.887	-1.13	-
	Large	0.882	0.861	0.93	-	0.884	-0.12	-
MA	All	0.883	0.883	-0.04	-	0.889	-0.79	-
	Small	-	0.896	-	-	0.893	-	-
	Medium	0.884	0.884	-0.04	-	0.887	-0.39	-
	Large	0.863	0.861	0.02	-	0.884	-0.29	-
OM	All	0.826	0.883	-3.83***	-6.9%	0.889	-4.13***	-7.6%
	Small	0.831	0.896	-2.89***	-7.8%	0.893	-2.72***	-7.5%
	Medium	0.823	0.884	-3.05***	-7.4%	0.887	-3.13***	-7.8%
	Large	-	0.861	-	-	0.884	-	-
QA	All	0.835	0.883	-3.30***	-5.7%	0.889	-3.61***	-6.5%
	Small	0.856	0.896	-1.28	-	0.893	-1.18	-
	Medium	0.843	0.884	-2.29**	-4.9%	0.887	-2.38**	-5.2%
	Large	0.769	0.861	-3.29***	-12%	0.884	-4.07***	-15%
SA	All	0.846	0.883	-3.94***	-4.4%	0.889	-4.35***	-5.1%
	Small	-	0.896	-	-	0.893	-	-
	Medium	0.834	0.884	-2.95***	-6%	0.887	-3.02***	-6.4%
	Large	0.852	0.861	-0.78	-	0.884	-2.52***	-3.8%
TN	All	0.867	0.883	-2.16**	-1.8%	0.889	-2.73***	-2.5%
	Small	0.869	0.896	-2.79***	-3.1%	0.893	-2.31***	-2.8%
	Medium	0.866	0.884	-1.64*	-2.1%	0.887	-1.77*	-2.4%
	Large	-	0.861	-	-	0.884	-	-
TR	All	0.847	0.883	-4.67***	-4.3%	0.889	-5.10***	-5%
	Small	0.838	0.896	-3.76***	-6.9%	0.893	-3.46***	-6.6%
	Medium	0.869	0.884	-1.35	-	0.887	-1.49	-
	Large	0.829	0.861	-2.44**	-3.9%	0.884	-3.98***	-6.6%
MENA	*All*	*0.852*	*0.883*	*-10.54****	*-3.6%*	*0.889*	*-9.24****	*-4.3%*
	Small	*0.850*	*0.896*	*-7.19****	*-5.4%*	*0.893*	*-5.76****	*-5.1%*
	Medium	*0.854*	*0.884*	*-7.76****	*-3.5%*	*0.887*	*-5.58****	*-3.9%*
	Large	*0.847*	*0.861*	*-1.98***	*-1.65%*	*0.884*	*-4.46****	*-4.4%*

Similar results are found when we compare the revenue technology gap, but few significant differences in the technology used compared to the most efficient banks emerge for some countries, e.g. Lebanon and Saudi Arabia.

Table 5 - MENA revenue technology gap comparisons with most efficient developed country banks

Country	Size	TGAP MENA	TGAP (US)	t-test MENA/US	Difference	TGAP MENA/CH	t-test	Difference
AE	All	0.805	0.824	-2.39**	-2.4%	0.825	-2.31**	-2.5%
	Small	0.802	0.811	-0.65	-	0.832	-2.17**	-3.7%
	Medium	0.817	0.832	-1.24	-	0.812	0.32	-
	Large	0.781	0.820	-2.79***	-5.1%	0.839	-3.23***	-7.4%
BH	All	0.802	0.824	-1.47	-	0.825	-1.52	-
	Small	0.737	0.811	-1.80*	-10%	0.832	-2.30**	-12.7%
	Medium	0.846	0.832	1.07	-	0.812	2.31**	4.1%
	Large	0.740	0.820	-2.39**	-10.9%	0.839	-2.81***	-13.4%
IL	All	0.807	0.824	-1.80*	-2.1%	0.825	-1.81*	-2.3%
	Small	0.724	0.811	-2.20**	-9.3%	0.832	-2.85***	-12.1%
	Medium	0.841	0.832	0.73	-	0.812	-2.05**	3.5%
	Large	0.805	0.820	-1.23	-	0.839	-2.03**	-4.2%
JO	All	0.808	0.824	-1.54	-	0.825	-1.57*	-2.1%
	Small	0.771	0.811	-2.62***	-5.2%	0.832	-3.83***	-8%
	Medium	0.803	0.832	-1.51	-	0.812	-0.47	-
	Large	0.869	0.820	5.29***	+5.6%	0.839	-2.01**	3.6%
KW	All	0.819	0.824	-0.53	-	0.825	-0.64	-
	Small	-	0.811	-	-	0.832	-	-
	Medium	0.813	0.832	-1.67*	-2.3%	0.812	0.09	-
	Large	0.844	0.820	1.45	-	0.839	0.24	-
LB	All	0.818	0.824	-0.86	-	0.825	-0.94	-
	Small	0.761	0.811	-2.09**	-6.6%	0.832	-2.92***	-9.3%
	Medium	0.829	0.832	-0.43	-	0.812	1.82*	2%
	Large	0.827	0.820	0.38	-	0.839	-0.62	-
MA	All	0.809	0.824	-1.27	-	0.825	-1.32	-
	Small	-	0.811	-	-	0.832	-	-
	Medium	0.808	0.832	-2.08**	-3%	0.812	-0.34	-
	Large	0.868	0.820	3.14***	+5.8%	0.839	1.51	-
OM	All	0.810	0.824	-1.18	-	0.825	-1.24	-
	Small	0.796	0.811	-1.02	-	0.832	-2.34**	-4.5%
	Medium	0.819	0.832	-0.72	-	0.812	0.40	-
	Large	-	0.820	-	-	0.839	-	-
QA	All	0.815	0.824	-0.69	-	0.825	-0.77	-
	Small	0.754	0.811	-1.57	-	0.832	-2.15**	-10.3%
	Medium	0.837	0.832	0.38	-	0.812	1.66	2.9%
	Large	0.749	0.820	-1.80*	-9.5%	0.839	-2.19**	-12.2%
SA	All	0.820	0.824	-0.58	-	0.825	-0.70	-
	Small	-	0.811	-	-	0.832	-	-
	Medium	0.816	0.832	-1.54	-	0.812	0.28	-
	Large	0.822	0.820	0.13	-	0.839	-1.20	-
TN	All	0.806	0.824	-1.84*	-2.2%	0.825	-1.85*	-2.3%
	Small	0.789	0.811	-1.68*	-2.8%	0.832	-3.09***	-5.5%
	Medium	0.827	0.832	-0.32	-	0.812	1.03	-
	Large	-	0.820	-	-	0.839	-	-
TR	All	0.800	0.824	-3.48***	-3%	0.825	-3.45***	-5.8%
	Small	0.812	0.811	0.06	-	0.832	-0.61	-
	Medium	0.855	0.832	1.73*	+2.8%	0.812	2.89***	5.3%
	Large	0.693	0.820	-6.22	-18.3%	0.839	-6.25***	-21.1%
MENA	*All*	*0.807*	*0.824*	*-4.94****	*-2.1%*	*0.825*	*-3.51****	*-2.1%*
	Small	*0.785*	*0.811*	*-3.68****	*-3.3%*	*0.832*	*-5.53****	*-6%*
	Medium	*0.826*	*0.832*	*-1.40*	-	*0.812*	*2.10***	*1.8%*
	Large	*0.786*	*0.820*	*-4.39****	*-4.3%*	*0.839*	*-3.88****	*-6.7%*

Finally, we correlate the two measures of the technology gap for three selected years, i.e. the first, the middle and the last of the period under study (2001, 2006 and 2012, respectively). The idea is to look for the dynamic of the adoption of the more advanced technology over time, both in MENA banks and in those of the most developed countries. In the same graphs we cross the median value of the revenue technology gap with the median value of the cost efficiency gap. Figure 6 shows that in 2001 most of the MENA countries (7 over 12) had a good position with respect to the technology used both in terms of costs and revenues. In contrast, developed country banks seemed to focus more on revenue efficiency. In 2006 and 2012, MENA banks have been notably dominated by those of developed countries in terms of costs. Moreover, as in those years for most of the MENA countries the median cost efficiency is below the sample average value, we conclude that here much effort should be put in introducing new technologies that are able to reduce costs.

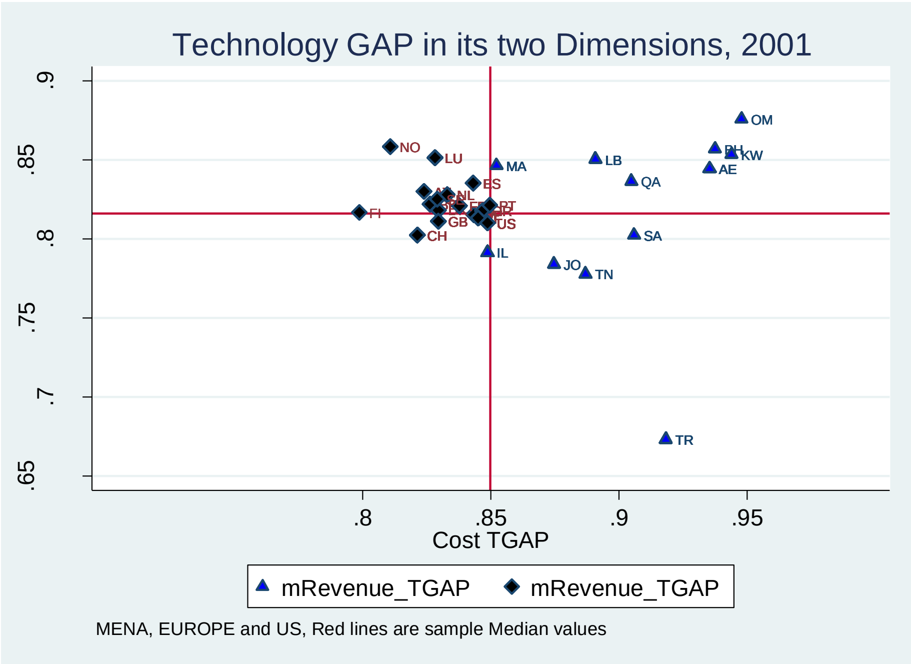

Figure 6 - Banks' revenue and cost technology gap for MENA and most developed countries, year 2001

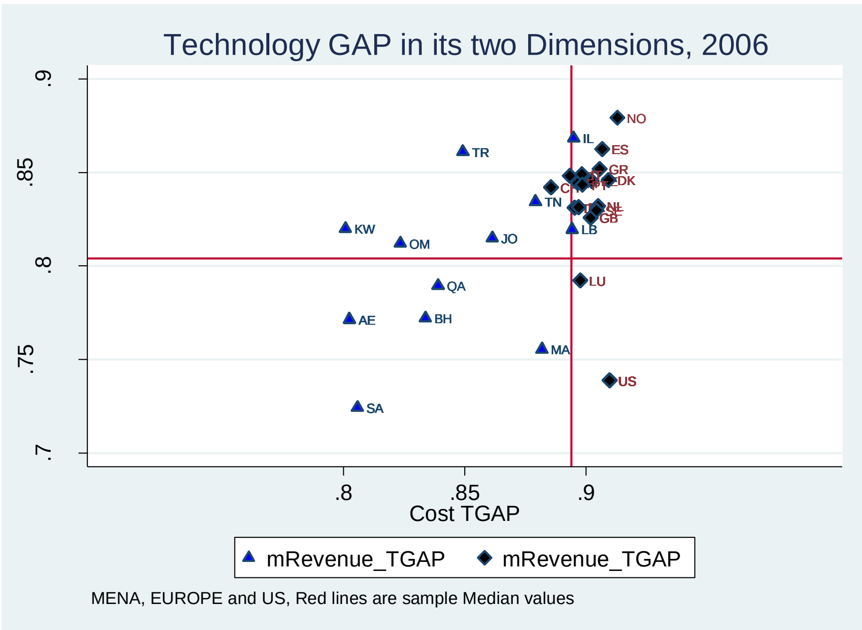

Figure 7 - Banks' revenue and cost technology gap for MENA and most developed countries, year 2006

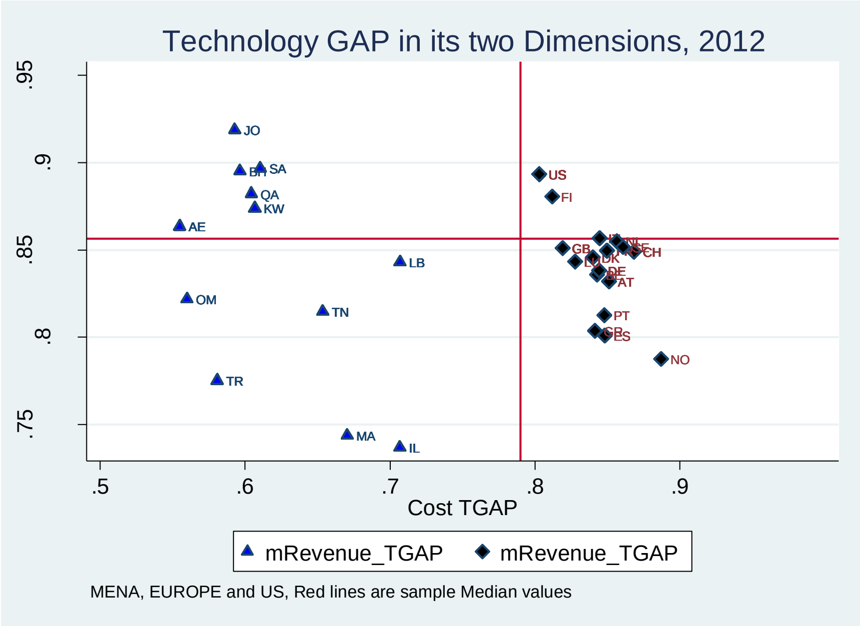

Figure 8 - Banks' revenue and cost technology gap for MENA and most developed countries, year 2012

3.4. Granger causality

In the previous analyses we have found differences in the technology gap both in the cost and in the revenue model. Technology inefficiency is much more important than managerial inefficiency in MENA region. In order to assess the relationship between the two inefficiency components, we attempt to establish whether managerial efficiency is the driver of the technology in banking, or if the technology is the driver for managerial efficiency. For the purpose, we employ a Granger causality test. Such test has been applied in several banking studies. Just as examples, Berger and De Young (1997) test the causality between non-performing loans and cost efficiency, while Fiordelisi et al. (2011) study the causality between bank efficiency, capital and risk in European banks. More recently, Apergis and Polemis (2016) have investigated the link between competition and efficiency in MENA banks. Hence, employing a causality test to assess the direction of the link between technology efficiency and managerial efficiency may be regarded as a further application within the empirical banking literature.

The equations to be estimated for such test are the following:

$$\begin{aligned} TGAP_{it}^{M} &= \alpha_0 + \alpha_1 TGAP_{it-1}^{M} + \alpha_2 TGAP_{it-2}^{M} + \beta_1 MEff_{it-1}^{M} + \beta_2 MEff_{it-2}^{M} + \eta_t + v_{it} \\ MEff_{it}^{M} &= \alpha_0 + \alpha_1 MEff_{it-1}^{M} + \alpha_2 MEff_{it-2}^{M} + \beta_1 TGAP_{it-1}^{M} + \beta_2 TGAP_{it-2}^{M} + \eta_t + v_{it} \end{aligned} \quad (7)$$

Here, M indexes cost and revenue, while *TGAP* and *MEff* are the technology gap and the managerial efficiency estimated from the cost and output distance function, respectively. The maximum lag structure is 2, obtained after estimating higher lag models (which proved not to be significant). Through the Granger causality tests we aim to assess whether improvements in managerial efficiency precede the access to the technology, or whether the reverse happens. This is done by testing $\beta_1 = \beta_2 = 0$ in each equation by means of the Wald test statistics. Due to the lagged endogenous variable in Equation (7), we use the system GMM estimator developed by Blundell and Bond (1988) to control for the endogeneity of the lagged endogenous variables with the unobserved banks characteristics. We remind that each equation of the test can be seen as an ARDL(2,2), autoregressive distributed lag model. When the causality is evidenced in Equation (7), we can estimate the long run impact (*LRI*) of each variable in the causal relationship according to this equation:

$$LRI = \frac{1-\alpha_1-\alpha_2}{1+\beta_1+\beta_2} \tag{8}$$

The causality is tested using data for MENA banks as well as for developed countries banks (i.e. Europe and US). Table 6 reports the results of our tests.

Table 6 - Granger causality tests

	MENA		EUROPE+US	
	Cost	**Revenue**	**Cost**	**Revenue**
TGAP → Eff				
$TGAP_{t-1}$	0.53 (29.33)***	0.80 (17.66)***	0.76 (21.33)***	0.46 (26.42)***
$TGAP_{t-2}$	-0.09 (-6.63)***	-0.08 (-2.72)***	-0.08 (-3.30)***	-0.27 (-17.17)***
Eff_{t-1}	0.16 (13.77)***	0.25 (8.37)***	0.12 (8.71)***	0.15 (14.31)***
Eff_{t-2}	0.07 (9.85)***	0.06 (2.89)***	0.02 (1.69)*	-0.09 (-9.75)***
Sargan	91.98	63.84	160.68	333.02
(p-value)	(0.37)	(0.19)	(0.00)***	(0.00)***
$\beta_1=\beta_2=0$ *(WT)*	252.06	70.05	76.22	311.87
(p-value)	(0.00)***	(0.00)***	(0.00)***	(0.00)***
LRI	0.46	0.21	0.28	0.76
Eff → TGAP				
Eff_{t-1}	0.24 (15.12)***	0.28 (19.40)***	0.50 (15.92)***	0.04 (2.43)***
Eff_{t-2}	-0.21 (-20.85)***	-0.03 (-2.16)***	0.03 (1.74)*	0.01 (0.91)
$TGAP_{t-1}$	0.35 (16.25)***	0.24 (6.80)***	0.35 (5.37)***	0.16 (6.45)***
$TGAP_{t-2}$	0.13 (5.50)***	0.08 (2.20)***	0.08 (2.40)***	0.06(2.62)***
Sargan	96.91	101.36	135.86	303.28
(p-value)	(0.10)	(0.05)**	(0.00)***	(0.00)***
$\beta_1=\beta_2=0$*(WT)*	367.62	50.48	37.36	59.33
(p-value)	(0.00)***	(0.00)***	(0.00)***	(0.00)***
LRI	0.65	0.57	0.33	0.78

The equations have been estimated by System GMM and include time dummies and country specific dummies. Numbers in brackets after the estimated coefficients are the t-test. WT is the Wald test statistic.

The results show that the causality between technology and managerial efficiency is bidirectional, in the sense that any change in managerial efficiency will imply future improvements in the technology used by the banks, and any improvement in the technology used will also impact future managerial efficiency. The result of the Wald test is highly significant for both the cost model and the distance function model, and holds whatever is the banking system (MENA or developed countries banks). Moreover, the long term impact of managerial efficiency improvement on banking technology is much more important than the same impact obtained from improvement in the technology: particularly, the values are 0.65 against 0.46 for the cost model, and 0.57 against 0.21 for the revenue model. This evidence could be explained by the acquired knowledge of bank human capital: higher qualified employees are most likely those who are able to develop new banking technologies and make the system much more efficient (i.e. both less costly and more profitable), while investing only in new banking technology, with less qualified human capital, needs additional training that is costly for the banks, at least in the short run.

In some sense, this is in line with the findings of the model by Nelson and Phelps (1966), according to which there is a link between return to education and technology, and that society should build more human capital relative to tangible capital the more dynamic is the technology. Actually, human capital is able to speed up the process of technology diffusion. In the same vein, Romer (1990) shows that human capital increases capacity of nations to develop new technologies; particularly, being education the key input to the research sector, it helps generating new products and hence significantly determines technological progress.

The same result holds also for the banks of developed countries, but here the long run impact is different according to the model specification: actually, managerial efficiency improvements on technology have much larger effect than the technology effect.

Overall, our evidence highlights the importance of human capital in banking and its role in enhancing banks' growth potentials. Particularly, building human capital fosters innovative capabilities thanks to factors like vision, open-mindedness, execution, imitation ability, receptivity to new ideas, and even customer satisfaction. As Yen (2013) also maintains, human capital is the most basic and important factor to organizational performance of banks, which should push them to cultivate high quality human capital, since it is able to improve internal innovative capabilities.

4. Conclusions

This paper has evaluated and compared the efficiency of MENA banks to a very large group of international banks over the period 2000-2012. It has employed the meta technology frontier methodology, in order to decompose the inefficiency components into managerial and technology gaps. The efficiency measure has not been restricted to the cost side, as it has been done in most of the existing empirical literature, but has been extended also to revenue.

By estimating both stochastic cost and distance function frontiers, we have found that both components contribute to the actual inefficiency of banks in MENA countries. The impact of the technology inefficiency is relatively important, and amounts to 13% in terms of higher costs, and to 17% in terms of less revenues, both of which surely impact on the profitability of the banking system in the region. Other comparisons according to bank size have been also proposed.

By confronting MENA banks within those belonging to US and Europe (i.e. the most advanced countries), we have discovered differences in technology efficiency exceeding 10% for some countries and for banks of similar size. Furthermore, in the MENA region we have not found evidence of any improvement on the efficiency linked to the technology over the studied period. We have also tested for the causality between technology efficiency and managerial efficiency: managerial cost and revenue efficiencies Granger-cause technology efficiency, but also the opposite directions hold; however, in terms of magnitude the long-run impact is much more important in the first route.

In terms of economic policy, regulators and supervisors of MENA banking systems should not focus primarily on the improvement of managerial efficiency, through the usual deregulation or further competition policies, but should especially encourage their banks to adopt and develop the novelties already used by banks that are most advanced in terms of technology (electronic payments, financial engeneering, digital banking services, etc.). Probably, by deregulating their banking systems and allowing telecom operators in the region to compete with banks, incentives for banks could arise for developing at least some of the new technologies. Moreover, any improvement in the infrastructure linked to the use of new IT technologies is likely to help the banking systems to invest and develop new technologies. Finally, since the long term impact of managerial efficiency on technology efficiency is noteworthy, any policy aiming at improving human capital towards IT technologies or financial engeneering would surely help MENA bank to implement and even improve these new technologies.

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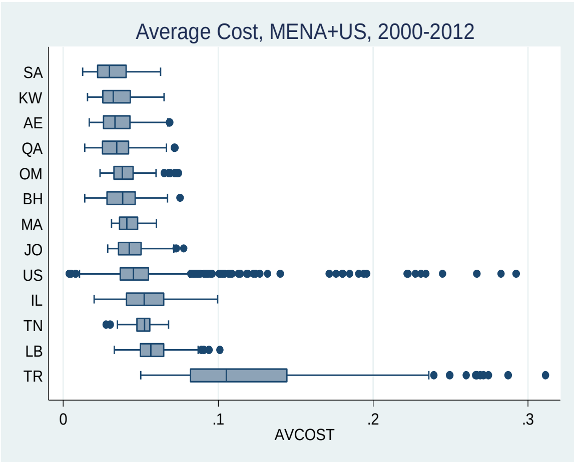
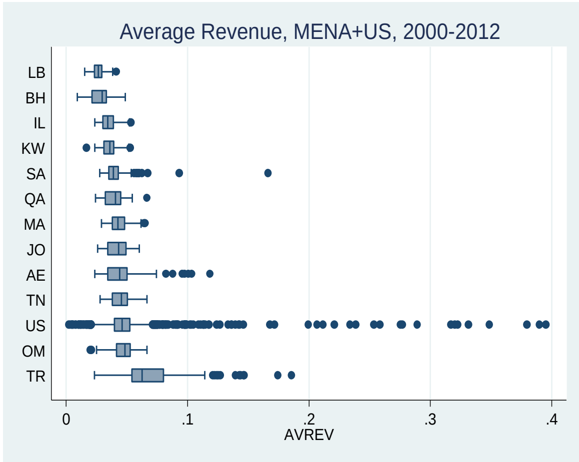
Appendix

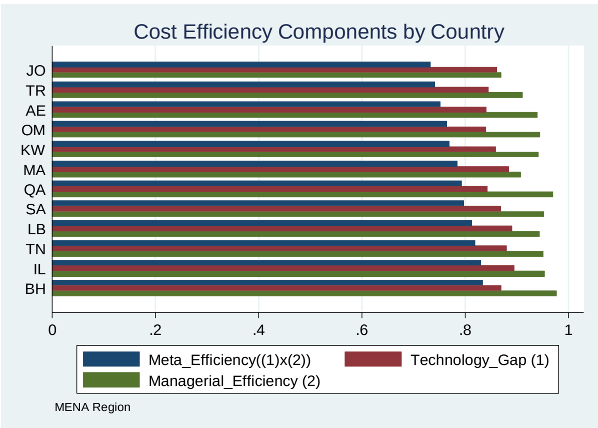
Graphs a and b show the distribution of the average cost and revenue, respectively, by MENA country. We add the US country as a developed country bank in the group. Graphs c and d portray the size of cost efficiency and revenue efficiency components, respectively, for the group of sample banks belonging to each MENA country. Graph e depicts our estimated foregone revenues by type of inefficiency and by country. Graph f summarizes the correlation between the two banks' technology gaps measures.



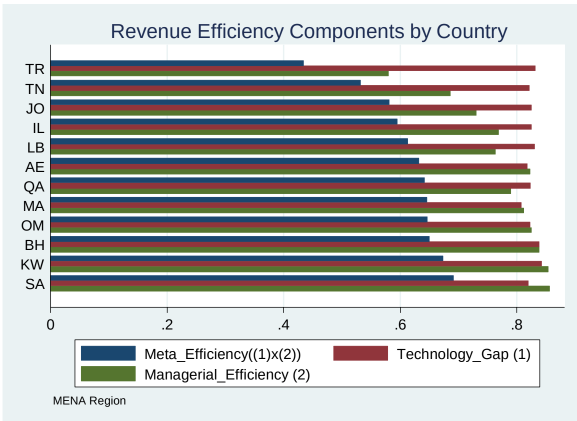
Graph a



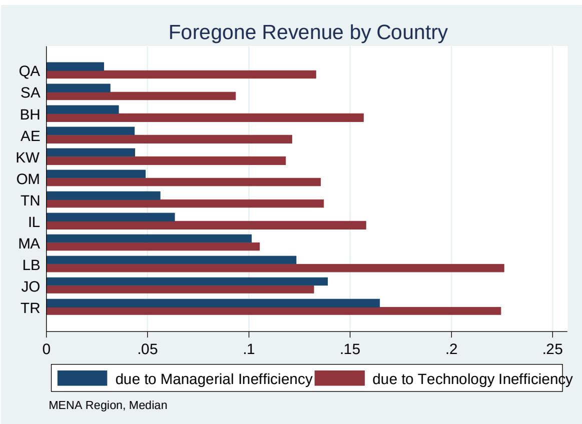
Graph b



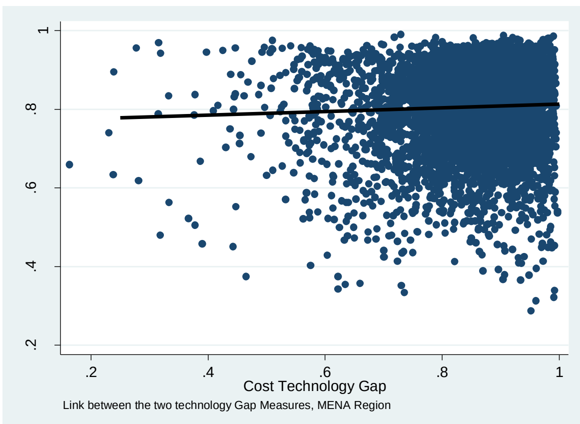
Graph c



Graph d



Graph e



Graph f