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The sources of productivity change and efficiency in Islamic banking: Application of Malmquist productivity index

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Abstract:

Aim: This paper aims to explore performance of Islamic banks in 13 countries from the period 2005 to 2014 and investigates sources of productivity change over the time.

Design / Research methods: The present study gather data on the 31 Islamic banks. The productivity is examined using the Data Envelopment Analysis-based Malmquist productivity index. That we decompose into scale efficiency, technological change and technical efficiency. Source of productivity change in Islamic banks is then identified. We use intermediation approach and production approach to select inputs and outputs of banks.

Conclusions / findings: Although the two approaches are different, our empirical implementation shows that they yield very similar results regarding productivity, efficiency and source of productivity change. Islamic banks are productive and efficient over the study period, but they did not show to be scale efficient and they suffer from technological change evolutions. Moreover, we are able to show that Subprime crisis had a slightly negative effect on productivity in Islamic banking industry.

Originality / value of the article: Empirical studies are still rare and findings are controversial on productivity and efficiency of Islamic banks. This study intends to fill the gaps with a specific focus on measuring productivity index using two different intermediation approach and production approach to select input and output variables.

Implications of the research (if applicable) – Islamic banks are scale inefficient and must improve size of their activities, one possible suggestion is meagering small banks.

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Limitations of the research (if applicable) – Further research can use bootstrapping techniques to correct total factor productivity estimates for bias and to assess the uncertainty surrounding such estimates.

Keywords: Islamic banks, Productivity, efficiency, Data Envelopment Analysis, Malmquist index decomposition
JEL: D24, G21

1. Introduction

Islamic banking refers to a system of banking that is consistent with Islamic law *"Sharia'h"* principles and guided by Islamic economics. The main difference between Islamic and conventional banking is that Islamic teaching says that money itself has no intrinsic value, and forbids people from profiting by lending it, without accepting a level of risk. In other words, interest known as *"Ribaa"* cannot be charged. In fact, to make money from money is prohibited. Wealth can only be generated through legitimate trade and investment. Any gain relating to this trading is shared between person providing the capital and person providing the expertise. Institutions offering Islamic financial services constitute a significant and growing share of the financial system in the world. Since the inception of Islamic banking about three decades ago, the number and reach of Islamic financial institutions worldwide has risen from one institution in one country in 1975 to over 300 institutions operating in more than 75 countries. Islamic banks are concentrated in the Middle East and Southeast Asia, but they are also present as niche players in Europe and the United States. Reflecting the increased role of Islamic finance, the literature on Islamic banking has grown. A large part of the literature contains comparisons of instruments used in Islamic and commercial banking, and discusses the regulatory and supervisory challenges related to Islamic banking. Several studies in recent years focused on the efficiency analysis of Islamic banks using simple and advanced methodologies, and testing several interesting hypotheses (see eg. Wanke, Azad, Barros, Kabir Hassan 2016; Wanke, Azad, Barros 2016; Rosman et al. 2014; Said 2013; Onour, Abdallah 2011). Empirical works dealing with productivity are very rare. Literature on existing studies can be classified into two groups. The first group of studies includes performance assessment and determinants of Islamic

banks, whereas the second group of studies includes the comparative analysis of performance level between Islamic and conventional banking sectors.

El Moussawi and Obeid (2011) used Data Envelopment Analysis (DEA) model to decompose the productive efficiency into technical efficiency, allocation efficiency, and cost efficiency of Islamic banks. They found an increase of production efficiency of the Islamic banks over the study period. Assaf et al. (2011) analysis technical efficiency of Saudi banks using two-stage DEA approach, following intermediation approach. Saudi banks improved their efficiency since 2004. Following intermediation approach, Bahrini (2015) used the bootstrapped Malmquist index to a sample of Islamic banks operating in 10 MENA countries. He found a decrease in productivity, technical efficiency and technological efficiency. However, scale efficiency found to be a source of productivity amelioration. Johnes et al. (2015) decompose Malmquist index into technical efficiency change and technological change to detect productivity variation source in Islamic banks. Following intermediation approach, they found positive technical efficiency change and negative technology change, which are allowed to differ between groups of banks. Kamarudin et al. (2017) examined the productivity of Islamic banks in Southeast Asian Countries from the period 2006 to 2014. They found that banks have been operating at the wrong scale of operations and world financial crisis have significantly influenced productivity level of Islamic banks.

Bilal et al. (2011) apply intermediation approach to select inputs and outputs and use DEA model to compare efficiency of Islamic banks and conventional banks. He found that scale inefficiency is dominated by the pure technical inefficiency effects in determining Islamic banks' overall or technical inefficiency. Kamarudin et al. (2014) used intermediation approach to assess performance of banks. They found that Islamic banks are more efficient than conventional banks. Mobarek and Kalonov (2014) investigate the performance of Islamic banks versus conventional banks around the recent financial crisis. Their major finding was that overall Islamic banks are less efficient than Conventional banks and this superiority varies depending on bank size and the impact of recent crisis is not visible on both banking sectors.

From a review of studies, it is obvious, that literature suffers from the lack of empirical research focused on productivity analysis and sources of productivity in Islamic banking sector. Moreover, several studies that have been devoted to assess the performance of Islamic banks generally examine the productivity following either the intermediation approach or the production approach. The intermediation approach is the common used approach to assess performance of Islamic banks. In summary, numbers of studies have shown that Islamic banks demonstrate performance and there is still no evidence of the effect of Subprime crisis on Islamic banks productivity. Therewith, there is no evidence of sources of productivity variation in literature.

This paper attempts to fill the gap in the empirical literature in this area by providing an empirical analysis of productivity measurement using the total factor productivity Malmquist index and its decomposition into technological change, scale change and technical efficiency change components. The estimation method is non-parametric relying on DEA. To model an Islamic bank two approaches may be followed: intermediation approach and production approach. The basic difference between these two approaches is that in intermediation approach deposits are treated as input whereas it has output status in production approach. In this paper, we estimate efficiency of Islamic banks using DEA by adopting production approach for a first model and intermediation approach for a second model. We use a non-parametric Kruskal-Wallis test to examine the differences in productivity, efficiency and productivity components derived from the two suggested models. Furthermore, we study the evolution of technical efficiency under variable returns to scale and scale returns to scale. This study has three major contributions to existing literature. Firstly, we show that the approach chosen for the definition of Islamic banking inputs and outputs does not have impact on the level of efficiency and productivity scores. Secondly, while technical efficiency change and technological change present sources of productivity amelioration, the scale efficiency change is a source of productivity deterioration. Finally, we show that Subprime crisis had a slight effect on productivity of Islamic banks following intermediation approach.

The remainder of the paper is organized as follows. Section 2 explains the methodology focusing on the Malmquist productivity index. Data is described in

section 3. Results are reported in section 4. Finally, conclusions are formulated in section 5.

2. The Malmquist productivity index

Basing on distance function estimation, non-parametric frontier approaches are used to measure efficiency and productivity of Decision Making Units (DMUs). The total factor productivity Malmquist index has been developed by (Caves et al. 1982) from the notion of "proportional scaling" introduced by (Malmquist 1953). In what follows, we consider the production set S^t which models the transformation of inputs $x^t \in \mathbb{R}_+^N$ into outputs $y^t \in \mathbb{R}_+^M$ at time t :

$$S^t = \left\{ \left(x^t, y^t \right) : x^t \text{ can produce } y^t \right\} \qquad (1)$$

S^t is the set of all feasible output-input vectors in period *t*. It is assumed to be closed, bounded, convex, and to satisfy strong disposability of outputs and inputs.

As provided by Shephard (1970), in an output based approach, the production technology is completely characterized by the output distance function:

$$D_{out}^t \left(x^t, y^t \right) = \min \left\{ \theta : \left(x^t, y^t / \theta \right) \in S^t \right\} \qquad (2)$$

The output distance function is simply the inverse of the Farrell (1957) output-oriented measure of technical efficiency and is less than or equal to one (i.e. $D_{out}^t \left(x^t, y^t \right) \leq 1$) if and only if $\left(x^t, y^t \right) \in S^t$. Note that the distance function is equal to the unit (i.e. $D_{out}^t \left(x^t, y^t \right) = 1$) if $\left(x^t, y^t \right)$ belongs to the "frontier" of the production technology set and the DMU is technically efficient.

Computing the Malmquist productivity index between time period's $t_1 < t_2$, requires two additional distance functions to be defined. One measures the maximum proportional change in outputs required to make $\left(x^{t_2}, y^{t_2} \right)$ feasible in relation to the technology at t_1, i.e.:

$$D_{out}^{t_1} \left(x^{t_2}, y^{t_2} \right) = \min \left\{ \theta : \left(x^{t_2}, y^{t_2} / \theta \right) \in S^{t_1} \right\} \qquad (3)$$

The second refers to the maximum proportional change in output required to make $\left(x^{t_1}, y^{t_1}\right)$ feasible in relation to the technology at t_2 :

$$D_{out}^{t_2}\left(x^{t_1}, y^{t_1}\right) = \min\left\{\theta : \left(x^{t_1}, y^{t_1} / \theta\right) \in S^{t_2}\right\} \qquad (4)$$

A Malmquist productivity index between periods t_1 and t_2 where $t_1 < t_2$, can be defined as:

$$M_{out}\left(x^{t_2}, y^{t_2}, x^{t_1}, y^{t_1}\right) = \left[\frac{D_{out}^{t_1}\left(x^{t_2}, y^{t_2}\right)}{D_{out}^{t_1}\left(x^{t_1}, y^{t_1}\right)} \frac{D_{out}^{t_2}\left(x^{t_2}, y^{t_2}\right)}{D_{out}^{t_2}\left(x^{t_1}, y^{t_1}\right)}\right]^{1/2} \qquad (5)$$

It presents the geometric mean of the output-based Malmquist productivity indices for t_1 and t_2 defined by Caves et al. (1982). Several decompositions are developed in the literature, but the most widely used in empirical studies is the decomposition of Ray and Desli (1997) that we use in this paper. It's defined as follows:

$$\begin{aligned} M_{out}^{t_1/t_2}\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) &= \underbrace{\left[\frac{D_{out}^{t_2}\left(x^{t_2}, y^{t_2} \mid VRS\right)}{D_{out}^{t_1}\left(x^{t_1}, y^{t_1} \mid VRS\right)}\right]}_{technical\ \ efficiency\ change\ (TE\Delta)} \\ &\times \underbrace{\left[\frac{D_{out}^{t_1}\left(x^{t_2}, y^{t_2} \mid VRS\right)}{D_{out}^{t_2}\left(x^{t_2}, y^{t_2} \mid VRS\right)} \times \frac{D_{out}^{t_1}\left(x^{t_1}, y^{t_1} \mid VRS\right)}{D_{out}^{t_2}\left(x^{t_1}, y^{t_1} \mid VRS\right)}\right]^{\frac{1}{2}}}_{technological\ change\ (T\Delta)} \\ &\times \underbrace{\left\{\left[\frac{D_{out}^{t_1}\left(x^{t_2}, y^{t_2} \mid CRS\right) / D_{out}^{t_1}\left(x^{t_2}, y^{t_2} \mid VRS\right)}{D_{out}^{t_1}\left(x^{t_1}, y^{t_1} \mid CRS\right) / D_{out}^{t_1}\left(x^{t_1}, y^{t_1} \mid VRS\right)}\right] \times \left[\frac{D_{out}^{t_2}\left(x^{t_2}, y^{t_2} \mid CRS\right) / D_{out}^{t_2}\left(x^{t_2}, y^{t_2} \mid VRS\right)}{D_{out}^{t_2}\left(x^{t_1}, y^{t_1} \mid CRS\right) / D_{out}^{t_2}\left(x^{t_1}, y^{t_1} \mid VRS\right)}\right]\right\}^{\frac{1}{2}}}_{scale\ efficiency\ change\ (SE\Delta)} \\ &= TE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \times T\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \times SE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \end{aligned} \qquad (6)$$

Where VRS and CRS in the definitions of the distance functions in equation 6 refer to the type of returns to scale exhibited by the technology, variable return to scale for VRS and constant returns to scale for CRS.

In this decomposition technical efficiency change $TE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right)$ is measured relative to the best practice technologies. The technical change $T\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right)$ is defined on the best practice technologies. The scale change factor $SE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right)$ is the geometric mean of a pair of scale efficiency ratios,

one measured on period t_1 technology and the other measured on period t_2 technology.

This decomposition had the intuitive appeal of identifying of sources of productivity growth in terms of the technical efficiency change $TE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \begin{matrix} < \\ = \\ > \end{matrix} 1$ according as total factor productivity change is enhanced, unaffected or retarded. The technical change $T\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \begin{matrix} < \\ = \\ > \end{matrix} 1$ according as total factor productivity change is enhanced, unaffected or retarded and the technical change $SE\Delta\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right) \begin{matrix} < \\ = \\ > \end{matrix} 1$ according as total factor productivity change is enhanced, unaffected or retarded.

Now to compute the Malmquist productivity index, we consider a set of L DMUs observed at two different periods t_1 and t_2, $Z = \left\{\left(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}\right);\ t_1 = 1,...,T_1;\ t_2 = 1,...,T_2;\ i = 1,...,L\right\}$.

We use DEA approach to estimate the components of the Malmquist productivity index. These components can be estimated via linear programming techniques. For this, we should consider the following linear programs for each DMU i, $i = 1,...,L$:

The first program, for an arbitrary DMU0 is as follows:

$$\left[\hat{D}_{out}^{t_1}\left(x_0^{t_1}, y_0^{t_1} \middle| CRS\right)\right]^{-1} = \max\theta$$

s.t.

$$\theta y_{0m}^{t_1} \le \sum_{i=1}^{L} \lambda_i^{t_1} y_{im}^{t_1},\ m = 1,...,M$$

$$\sum_{i=1}^{L} \lambda_i^{t_1} x_{in}^{t_1} \le x_{0n}^{t_1},\ \ n = 1,...,N$$

$$\lambda_i^{t_1} \ge 0,\ \ i = 1,...,L \qquad (7)$$

The linear program (7) calculates the distance function $\hat{D}_{out}^{t_1}\left(x_0^{t_1}, y_0^{t_1} \middle| CRS\right)$ under the assumption of CRS, to obtain the distance function $\hat{D}_{out}^{t_1}\left(x_0^{t_1}, y_0^{t_1} \middle| VRS\right)$ under the

assumption of VRS, it is sufficient to add the constraint $\sum_i \lambda_i^{t_1} = 1$ in the program (7). Computing the distance function $\hat{D}_{out}^{t_2}\left(x_0^{t_2}, y_0^{t_2}\right)$ is exactly like (7), where t_2 is substituted for t_1.

The second program, for an arbitrary DMU0 is presented as follows:

$$\left[\hat{D}_{out}^{t_1}\left(x_0^{t_2}, y_0^{t_2} | CRS\right)\right]^{-1} = \max \theta$$

s.t.

$$\theta y_{0m}^{t_2} \leq \sum_{i=1}^{L} \lambda_i^{t_1} y_{im}^{t_1},\ m = 1,...,M$$

$$\sum_{i=1}^{L} \lambda_i^{t_1} x_{in}^{t_1} \leq x_{0n}^{t_2},\ n = 1,...,N$$

$$\lambda_i^{t_1} \geq 0, i = 1,...,L \qquad (8)$$

The linear program (8) computes the distance function $\hat{D}_{out}^{t_1}\left(x_0^{t_1}, y_0^{t_1} | CRS\right)$ under the assumption of CRS, the distance function $\hat{D}_{out}^{t_1}\left(x_0^{t_1}, y_0^{t_1} | VRS\right)$ under the assumption of VRS is obtained by adding the constraint $\sum_i \lambda_i^{t_1} = 1$ in the program (8). Computing the distance function $\hat{D}_i^{t_2}\left(x_i^{t_1}, \mathrm{y}_i^{t_1}\right)$ is exactly like (8), where t_2 is substituted for t_1 and conversely.

Finally for the sake of simplicity, the distances involved in these linear programs will be noted $\hat{D}_{out}^{t_1/t_1}$, $\hat{D}_{out}^{t_2/t_2}$, $\hat{D}_{out}^{t_2/t_1}$ and $\hat{D}_{out}^{t_1/t_2}$ respectively.

3. Data and input/output specification

We use DEA to estimate the production function of Islamic banks and to assess their efficiency. Despite the increasing interest in studying the banking industry, there is still no coherent definition of inputs and outputs. It is commonly acknowledged that the choice of variables in efficiency studies significantly affects

results. Two approaches dominate the banking theory literature: the production and intermediation approaches. According to production approach, banks provide services to customers by administering customers' financial transactions, keeping customer deposits, issuing loans, cashing cheques and managing other financial assets (Berg et al. 1993). Productivity and efficiency can be analyzed by comparing the quantity of services given with the quantity of resources used. Five activities are performed by a bank: supplying demand, facilitating deposit services, short and long-term loan services, brokerage and other services, property management and the provision of safe deposit boxes. They pointed out that a bank incurs positive operating costs in terms of labor, machines, materials, and buildings. However, according to intermediation approach, bank accepts deposits from customers and transforms them into loans to clients. Thus, inputs are labor, materials and deposits, and outputs are loans and other income generating activities such as banking services (Mester 1997). In the intermediation approach, banks performing two major roles of mobilizing and distributing resources efficiently in order to smoothen investment activities in the economy. Following El Moussawi and Obeid (2011), none of the two approaches dominates the others. Therefore, in modeling Islamic bank behavior ensuring the robustness of results, this paper follows two different approaches to measure the efficiency. We present a detailed literature review in Table 1.

Table 1. A survey of DEA research in banks

Paper	Inputs	Outputs	Approach
(Assaf et al. 2011)	Total employees Fixed assets Total deposits	Total customer loans securities Interbank loans	Intermediation approach
(Shahid et al. 2010)	Total deposits Capital Price of capital Price of deposits	Investments Loans & advances	Intermediation approach
(Bilal et al. 2011)	Total assets Total deposits Labor	Total loans Total income	Intermediation approach

Table 1. Continuation

Paper	Inputs	Outputs	Approach
(Johnes et al. 2009)	Deposit and short-term funding Fixed assets General and administrative expenses Equity (used as a proxy for risk)	Total loans Other earning assets	Intermediation approach
(Yaumidin 2007)	Overheads costs Fixed assets Total deposits	Total loans Other income Total earning Assets	Intermediation approach
(Mostafa 2009)	Total assets Equity	Net profit ROA ROE	Intermediation approach
(Kazemi Matin, Azizi 2011)	Total assets Total deposits Equity	Loans ROE	Intermediation approach
(Amirteimoori & Emrouznejad 2011)	IT Budget Fixed assets Number of employees	Deposits Profit earned	Production approach
(Bagherzadeh Valami 2009)	Payable interest Staff Non- performing loans	The total sum of the four main of deposits Other deposits Loans granted Received interest Fee	Production approach
(Chiou 2009)	Staff Fix asset Total deposits Salary expenses	Provision of loans Investment Interest revenue Non-interest revenue	Intermediation approach
(Sufian 2009)	Capital Total of deposits Labor Labor Capital Interest expenses Interest expenses Labor Other operating expenses(-operating expenses)	Loans Investment Deposits Loans investments Interest income Non-interest income	Intermediation approach Value added approach Operating approach
(Isik, Kabir Hassan 2003)	Labor=number of full- time employee Capital Loanable funds	Short-term loans Long-term loans Risk-adjusted off-balance sheet items Other earning assets	Intermediation approach

Table 1. Continuation

Paper	Inputs	Outputs	Approach
(Isik, Kabir Hassan 2002)	Labor Capital Funds	Short-term loans Long-term loans Risk-adjusted off-balance sheet items Other earning assets	Intermediation approach
(Das, Ghosh 2006)	Deposits Labor :number of employees Capital=fixed assets Equity	Loans and advances Investments Other income	Intermediation approach
(Staub et al. 2010)	Operational expenses net of personnel expenses Personnel expenses Interest rates expenses	Total loans net of provision loans Investments Deposits	Production approach
(Kohers et al. 2000)	Labor Physical Capital Time and saving deposits Purchased funds	Demand deposits Time and saving deposits Real estate loans Other loans Net non-interesting income	Intermediation approach
(Havrylchyk 2006)	Deposits Fixed assets Labor	Loans Treasury bonds Off-balance items	Intermediation approach
(Luo 2003)	Profitability efficiency: Employee Total assets Equity Marketability efficiency: Revenue Profit	Profitability efficiency: Revenue Profit Marketability efficiency: Market value Stock price EPS	Production approach
(Assaf et al. 2011)	Deposits Number of FTE Total assets	Loan Securities	Intermediation approach
(Wanke, Azad, Barros 2016)	Personnel expenses Total operating expenses	Total earning assets Total deposits Net interest income	TOPSIS criteria
(Wanke, Azad, Barros, Kabir Hassan 2016)	Equity Provisions Personal expenses Number of employees	Assets Deposits Operational results Banking products	Positive negative criteria
(Said 2013)	Labor cost Fixed assets Total deposits	Total loans Liquid assets Other income	Intermediation approach

Table 1. Continuation

Paper	Inputs	Outputs	Approach
(Onour, Abdallah 2011)	Salaries and wages expenses Total deposits	Total loans Net income	Intermediation approach
(Rosman et al. 2014)	Deposits Short-term funding Fixed assets and Personal expenses	Loans Other earning assets	Intermediation approach
(Johnes et al. 2015)	Deposits and short-term funding Fixed assets General and administrative expenses Equity	Total loans Other earning assets	Intermediation approach
(Kamarudin et al. 2014)	Deposit Labor	Loan Income	Intermediation approach
(Mobarek, Kalonov 2014)	Deposits Equities Personnel expenses Fixed assets	Total loans Other earning assets	Intermediation approach
(Johnes et al. 2014)	Total loans Other earning assets	Short term funding Fixed assets General and administration expenses	Intermediation approach
(Sufian 2009)	Deposits Labor Physical capital.	Loans Investment	Intermediation approach
(Yudistira 2004)	Staff costs Fixed assets Total deposits	Total loans Other income Liquid assets	Intermediation approach

Source: Authors' own elaboration.

In this paper, we use two models, the first one following the production approach, the second the intermediation approach. Data includes input and output variables for 31 Islamic banks operating in 13 countries all over the world for the year 2005 to 2014. The period chosen for the study was to catch the effect of Subprime crisis on efficiency and productivity in Islamic banks. Data is extracted from statements and balance sheets which are made available by the Islamic Banks and Financial Institutions Information (IBIS). Then, basing on the above literature review presented by Table 1, we select the following variables (see Table 2). Indeed, following intermediation approach, labor and capital are used to intermediate deposits into loans and other earning assets (Yudistira 2004). Whereas, following

production approach, deposits are considered as outputs since it is assumed that they are proportionate to the output of depositors services provided, following (Staub et al. 2010). Furthermore, loans and other earning assets are important outputs to be considered in the Islamic banking case.

Table 2. Inputs/outputs matrix

	Inputs	**Outputs**
Model 1: Production approach	Employee expenses Fixed assets Equity	Total deposits Total loans
Model 2: Intermediation approach	General and administrative expenses Fixed assets Total deposits	Total loans Other earning assets

Source: Authors' own elaboration.

All input and output variables are converted into US dollars using end of year market value, and deflated by the Consumer Price Index of each country, in order to take account of macroeconomic differences across countries during the study time period.

4. Empirical results

Following Ray and Desli (1997) paper, we decompose Malmquist index (MI) productivity changes to include scale efficiency (SE), technical efficiency change (EC) and technological change (TC) as described above using two approaches. Note that the feature of Malmquist index is the infeasibility of several DMUs programs (Essid et al. 2014). Thus, all results and percentage presented in this section are calculated for feasible DMUs only.

4.1 Production approach results

From Table 3, the last row show that the productivity of Islamic banking sector has increased by an average of 6.73% during the period 2005-2014. It is clear that

Islamic banks show considerable productivity amelioration across sample period. We can identify the source of this productivity gain in the components of the Malmquist index. We observe that efficiency gains and technological gains have been of the order of 2.48% and 10.84% respectively. However, results show a stagnation of scale efficiency during the whole period of study. These results suggest that despite the existence of necessary investments and the improvement of transformation the new resources in outputs, Islamic banks must increase the size of activities by encouraging mergers. It is important to note that average productivity, technical efficiency, technological efficiency and scale efficiency differ substantially across Islamic banks.

Table 3. Average annual productivity measures and index components of 31 banks (production approach)

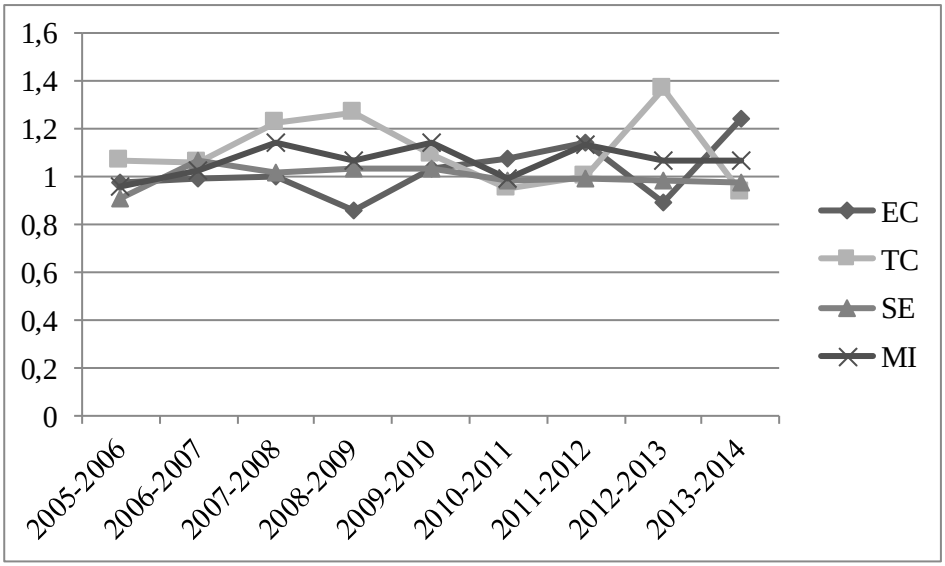
Period	Years	EC	TC	SE	MI
1	2005-2006	0.9777	1.0693	0.9095	0.9568
2	2006-2007	0.9948	1.0613	1.0674	1.0274
3	2007-2008	0.9985	1.2287	1.0209	1.1467
4	2008-2009	0.8552	1.2716	1.0318	1.0704
5	2009-2010	1.0375	1.0885	1.0337	1.1464
6	2010-2011	1.0762	0.9490	0.9831	0.9909
7	2011-2012	1.1467	1.0012	0.9941	1.1305
8	2012-2013	0.8959	1.3701	0.9850	1.0682
9	2013-2014	1.2404	0.9363	0.9784	1.0688
	Mean	1.0248	1.1084	1.0004	1.0673

Source: Authors' own elaboration.

Figure 1 shows that Islamic banks have shown productivity gains during the periods 2006-2010 and 2011-2014. However, the period 2005-2006 and 2010-2011 are marked by productivity deterioration. The greatest gain in productivity (15%) is marked during the period 2007-2008. This period is marked by the financial Subprime crisis, then we can link Islamic banks productivity gain by the Subprime crisis consequence. This improvement can be mostly attributed to technical technological improvement ranging around 23%. In fact, this result can be explained

by the improvement of Islamic banks know-how to produce services in a critical environment of conventional banks during this crisis period.

Figure 1. Evolution of Malmquist index and its components over the period 2005-2014 (production approach)



Source: Authors' own elaboration.

We perform the Kruskal-Wallis test to assess the difference between Malmquist index and productivity. Based on the P-values presented in Table 4, there is no significant difference between Malmquist index and its components.

Table 4. Kruskal-Wallis test results (productivity vs. index components)

		Efficiency Change	Technological Change	Scale Efficiency
Malmquist Index	Chi-2	8	8	6.313
	P-value	0.4335	0.4335	0.2769

Source: Authors' own elaboration.

Table 5. 2007-2008 banks results following production approach

ID	Bank	Country	EC	TC	SE	MI
BK1	Al Baraka Bank (Pakistan) Limited	Pakistan	0.7176	1.3945	0.9586	0.9592
BK2	Al Baraka Bank (Sudan) Limited	Sudan	0.8701	1.1831	1.0329	1.0633
BK3	Al Baraka Bank Egypt	Egypt	1.1987	1.0324	1.0119	1.2523
BK4	Al Rajhi Bank	Saudi Arabia	1.0000	1.1512	0.9469	1.0901
BK5	Al Shamal Islamic Bank	Sudan	0.8644	1.0925	1.0645	1.0053
BK6	Arab Islamic Bank	Palestine	0.8363	1.2768	0.9543	1.0189
BK7	Bahrain Islamic Bank B.S.C.	Bahrain	0.6590	1.3078	0.6527	0.5625
BK8	Bank Aljazira	Saudi Arabia	1.0691	1.0963	1.2386	1.4517
BK9	Bank Alkhair	Bahrain	1.5325	1.0940	0.5571	0.9339
BK10	Bank Islam Malaysia Berhad	Malaysia	1.0000	0.9933	0.9174	0.9112
BK11	Bank Islami Pakistan Limited	Pakistan	0.6018	1.4808	0.8017	0.7144
BK12	Bank Sepah	Islamic Republic of Iran	1.3326	0.9015	1.0132	1.2172
BK13	Blue Nile Mashreq Bank	Sudan	0.9005	1.0338	0.9852	0.9171
BK14	Boubyan Bank	Kuwait	0.8750	1.4330	1.0444	1.3097
BK15	CIMB Islamic Bank Berhad	Malaysia	1.0000	1.7309	0.9999	1.7307
BK16	Dubai Islamic Bank	United Arab Emirates	1.0000	1.0172	1.0185	1.0361
BK17	Emirates Islamic Bank	United Arab Emirates	1.0370	1.6811	1.0697	1.8648
BK18	Faisal Islamic Bank of Egypt	Egypt	1.0000	0.6446	1.0300	0.6640
BK19	Faysal Bank (Pakistan)	Pakistan	0.9662	1.1565	1.0844	1.2118

Table 5. Continuation

ID	Bank	Country	EC	TC	SE	MI
BK20	Gulf Finance House	Bahrain	2.4997	1.0982	0.7032	1.9303
BK21	International Investment Bank	Bahrain	0.3767	2.6019	0.8590	0.8419
BK22	Investors Bank B.S.C.	Bahrain	0.4664	1.5238	3.1039	2.2057
BK23	Islami Bank Bangladesh Limited	Bangladesh	0.9381	1.0358	0.8650	0.8406
BK24	Jordan Islamic Bank	Jordan	0.8020	1.2735	0.9676	0.9883
BK25	Karafarin Bank	Islamic Republic of Iran	Infeasible	Infeasible	Infeasible	Infeasible
BK26	Kuwait Finance House	Kuwait	1.0000	0.9854	0.9337	0.9201
BK27	Kuwait Finance House Bahrain	Kuwait	1.3508	1.1867	0.9088	1.4567
BK28	Meezan Bank	Pakistan	1.0928	1.0248	0.9935	1.1126
BK29	Qatar Islamic Bank	Qatar	1.0000	1.0987	0.8870	0.9746
BK30	Saman Bank	Islamic Republic of Iran	Infeasible	Infeasible	Infeasible	Infeasible
BK31	Sharjah Islamic Bank	United Arab Emirates	0.9689	1.1023	1.0021	1.0702
MEAN			0.9985	1.2287	1.0209	1.1467
MIN			0.3767	0.6446	0.5571	0.5625
MAX			2.4997	2.6019	3.1039	2.2057
S.D			0.3771	0.3513	0.4232	0.3844

Source: Authors' own elaboration.

In Table 5, we present results[1] of 31 banks during the period 2007-2008. From this table we note that 29 programs have feasible solutions and two programs have unfeasible solutions. 19 banks have shown a productivity improvement and 10 banks have exhibit productivity deterioration. Investors Bank B.S.C. in Bahrain has marked the highest productivity improvement (120.06%). This rise is principally due

[1] Other period's results are available upon request from corresponding author.

to the improvement of scale change of the order of (210.4%). However, Bahrain Islamic Bank B.S.C. in Bahrain has shown the highest productivity recession (43.7%) that is attributed to technical efficiency decrease (34.1%) and scale efficiency decrease (34.7%). Decomposition of Malmquist index values results and its dispersions around the mean show obviously that is difficult to identify a typical behavior shared by all Islamic banks.

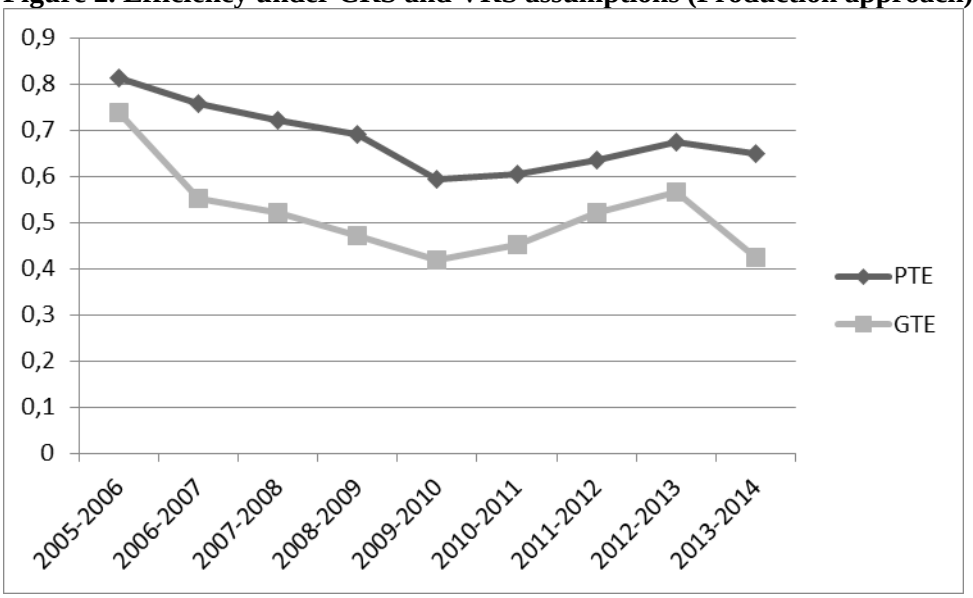
In Table 6, we present measures of technical efficiency calculated under the assumption of constant returns to scale (CRS), called global technical efficiency (GTE), and the assumption of variable returns to scale (VRS), called pure technical efficiency (PTE). A positive difference between GTE and PTE measurements shows that economies of scale do exist in the sector of Islamic banking.

Table 6. Average annual technical efficiency for the period 2005-2014 (Production approach)

		PTE		GTE	
Period	Years	Mean	S.D	Mean	S.D
1	2005-2006	0.8121	0.2406	0.7377	0.2763
2	2006-2007	0.7585	0.2779	0.5529	0.2902
3	2007-2008	0.7224	0.3039	0.5214	0.3167
4	2008-2009	0.6910	0.3127	0.4708	0.2965
5	2009-2010	0.5927	0.3034	0.4184	0.2365
6	2010-2011	0.6060	0.3108	0.4508	0.2596
7	2011-2012	0.6361	0.3053	0.5220	0.2799
8	2012-2013	0.6748	0.2969	0.5663	0.2610
9	2013-2014	0.6495	0.3278	0.4240	0.2505
	Mean	0.6826	0.2977	0.5182	0.2741

Source: Authors' own elaboration.

Figure 2. Efficiency under CRS and VRS assumptions (Production approach)



Source: Authors' own elaboration.

Assuming VRS (CRS), the average technical efficiency has shown the highest level in the period 2005-2006, it was of the order of 81% (74%). then, we can note that Islamic banks in this period have, on average, to increase their production by 19% (26%) to become efficient. However, the period 2009-2010 was marked by the lowest level of technical efficiency. It was of the order of 59% (42%) under VRS (CRS) assumptions. Therefore, Islamic banks have, on average, to increase their production by 41% (58%) to become efficient. Besides, we find that technical efficiency dispersion is relatively stagnant, which means that Islamic banks have used the same technology during the ten years of study period. These results are shown by Figure 2.

Following production approach, Islamic banks were productive during the period 2005-2014. Furthermore, Subprime crisis had a positive effect on productivity of Islamic banking sector. This result contradicts Mobarek and Kalonov (2014) and Kamarudin et al. (2017) findings. Moreover, we find that technical change is the main source of productivity gains, which confirms (Johnes et al. 2015) findings.

4.2 Intermediation approach results

Assuming intermediation approach, we find that the total factor productivity has improved by 54.36% during the period 2005-2014. This productivity increase is due to technological gains of the order of 11.86% and to technical efficiency gains of the order of 36.33%. However, Islamic banks have shown scale efficiency losses of the order of 0.526%. This finding indicates that there are diseconomies of scale for Islamic banks which suggest that mergers should be encouraged to improve size of activities.

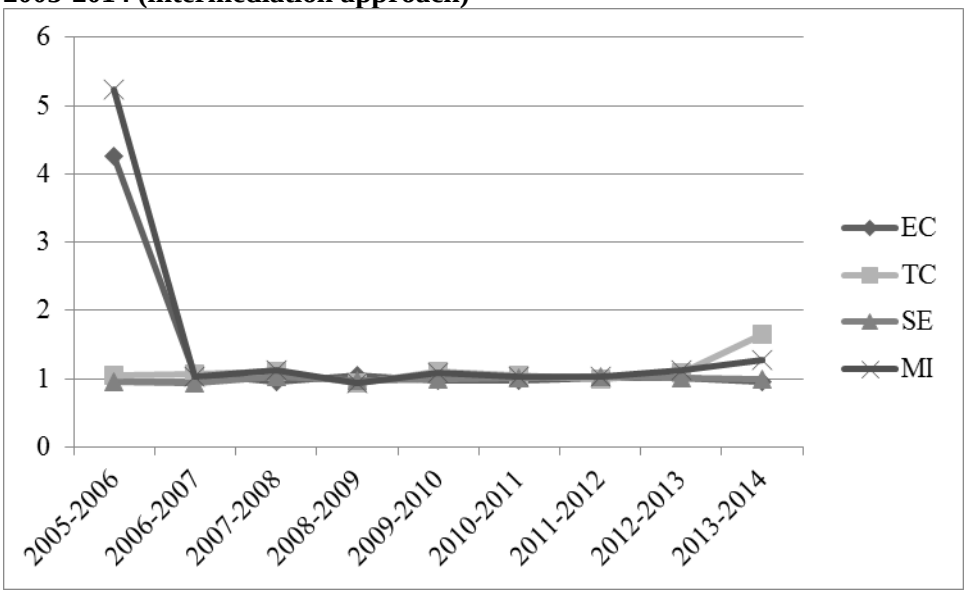
Table7. Average annual productivity measures and index components of 31 banks (intermediation approach)

Period	Years	EC	TC	SE	MI
1	2005-2006	4.2656	1.0529	0.9619	5.2396
2	2006-2007	1.0631	1.0638	0.9343	1.0301
3	2007-2008	0.9633	1.1126	1.0263	1.1293
4	2008-2009	1.0431	0.9439	0.9675	0.9462
5	2009-2010	0.9836	1.1106	0.9925	1.0921
6	2010-2011	0.9726	1.0470	1.0197	1.0292
7	2011-2012	1.0064	0.9976	1.0303	1.0294
8	2012-2013	1.0128	1.0894	1.0205	1.1293
9	2013-2014	0.9589	1.6499	0.9993	1.2669
	Mean	1.3633	1.1186	0.9947	1.5436

Source: Authors' own elaboration.

Moreover, Table 7 shows that Islamic banks are productive during the whole study period except (2008-2009), which is the period post Subprime crisis. In fact, the Malmquist index has taken the worst value (0.9462) during the period (2008-2009). Thus, we can note that Islamic banks were slightly sensitive to crisis just during these two years of crisis (Figure 3). Despite the fact that Islamic banks are productive during the study period, there is a deep fall in productivity since the second period. Thus, Subprime crisis may have noxious consequence on productivity of Islamic banking industry following intermediation approach. However, productivity has shown a rise after 2013. This rise is due to the improvement of technological change of the order of 65%.

Figure 3. Evolution of Malmquist index and its components over the period 2005-2014 (intermediation approach)



Source: Authors' own elaboration.

Using Kruskal-Wallis test, table 8 shows that there is no significant difference between Malmquist index and its components following intermediation approach.

Table 8: Kruskal-Wallis test results (productivity vs. index components)

		Efficiency Change	Technological change	Scale Efficiency
Malmquist Index	Chi-2	8	8	8
	P-value	0.4335	0.4335	0.4335

Source: Authors' own elaboration.

Table 9 presents banks productivity and components results[2] during 2008-2009, post Subprime crisis period. Two programs from 31 have infeasible solutions. 17 banks from 29 have shown productivity gains and 12 have shown productivity losses. A typical behavior about productivity, shared by Islamic banks could not be identified, following intermediation approach.

[2] Other period's results are available upon request from corresponding author

Table 9. 2008-2009 banks results following intermediation approach

ID	Bank	Country	EC	TC	SE	MI
BK1	Al Baraka Bank (Pakistan) Limited	Pakistan	0.7176	1.3945	0.9586	0.9592
BK2	Al Baraka Bank (Sudan) Limited	Sudan	0.8701	1.1831	1.0329	1.0633
BK3	Al Baraka Bank Egypt	Egypt	1.1987	1.0324	1.0119	1.2523
BK4	Al Rajhi Bank	Saudi Arabia	1.0000	1.1512	0.9469	1.0901
BK5	Al Shamal Islamic Bank	Sudan	0.8644	1.0925	1.0645	1.0053
BK6	Arab Islamic Bank	Palestine	0.8363	1.2768	0.9543	1.0189
BK7	Bahrain Islamic Bank B.S.C.	Bahrain	0.6590	1.3078	0.6527	0.5625
BK8	Bank Aljazira	Saudi Arabia	1.0691	1.0963	1.2386	1.4517
BK9	Bank Alkhair	Bahrain	1.5325	1.0940	0.5571	0.9339
BK10	Bank Islam Malaysia Berhad	Malaysia	1.0000	0.9933	0.9174	0.9112
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BK27	Kuwait Finance House Bahrain	Kuwait	1.3508	1.1867	0.9088	1.4567
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BK30	Saman Bank	Islamic Republic of Iran	Infeasible	Infeasible	Infeasible	Infeasible
BK31	Sharjah Islamic Bank	United Arab Emirates	0.9689	1.1023	1.0021	1.0702
MEAN			0.9985	1.2287	1.0209	1.1467
MIN			0.3767	0.6446	0.5571	0.5625
MAX			2.4997	2.6019	3.1039	2.2057
S.D			0.3771	0.3513	0.4232	0.3844

Source: Authors' own elaboration.

We present technical efficiency levels in Table 10. Assuming VRS (CRS) assumption, the average technical efficiency has shown the highest gains level 92.08% (80.70%) in period 2009-2010. Thus, Islamic banks become more efficient during the period post crisis. This increase may be due to the failure of conventional

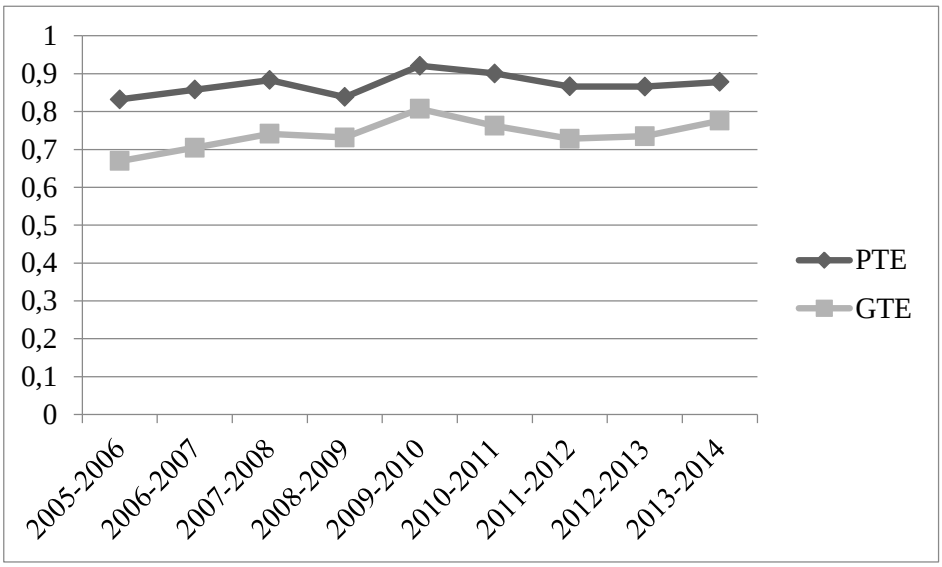
banking sector. In total, Islamic banks have to increase on average their efficiency by 12.86% (26.05%) to become efficient.

Table 10. Average annual technical efficiency for the period 2005-2014 (intermediation approach)

	PTE		GTE	
	Mean	S.D	Mean	S.D
2005-2006	0.8319	0.2615	0.6696	0.2709
2006-2007	0.8578	0.2052	0.7046	0.2402
2007-2008	0.8833	0.1832	0.7413	0.2572
2008-2009	0.8383	0.1837	0.7315	0.2189
2009-2010	0.9208	0.3448	0.8070	0.3095
2010-2011	0.9003	0.3612	0.7622	0.2769
2011-2012	0.8660	0.3131	0.7280	0.2641
2012-2013	0.8658	0.3040	0.7348	0.2723
2013-2014	0.8781	0.3376	0.7760	0.3101
Mean	0.8714		0.7395	

Source: Authors' own elaboration.

Figure 4. Efficiency under CRS and VRS assumptions (Intermediation approach)



Source: Authors' own elaboration.

The efficiency dispersion is not stagnant, which means that Islamic banks have used different technologies during the 10 years. Average technical efficiencies under CRS and VRS assumptions are presented in Figure 4.

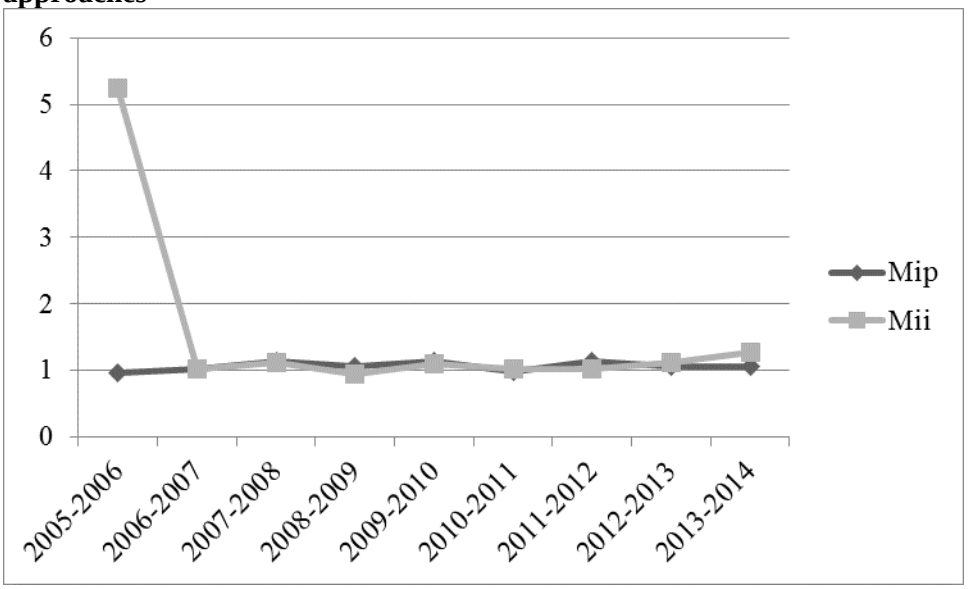
Following intermediation approach, Islamic banks have seen productivity rise during the study period. However, the period post subprime crisis was marked by a decrease in productivity. In addition, we find that Islamic banks were operating at the wrong scale of operations. These results are in line with Kamarudin et al. (2017) findings.

4.3 The Malmquist index decomposition: intermediation vs. Production approaches

Since the definition of outputs and inputs in Islamic banking studies is controversial, this paper uses two different approaches. In this section, we try to identify if the banking profession could have an effect on the measure of its performance. Let ECp, TCp, Sep, MIp and PTEp be the measurements of technical efficiency change, technological change, scale efficiency change, Malmquist index and pure technical efficiency respectively obtained using the production approach.

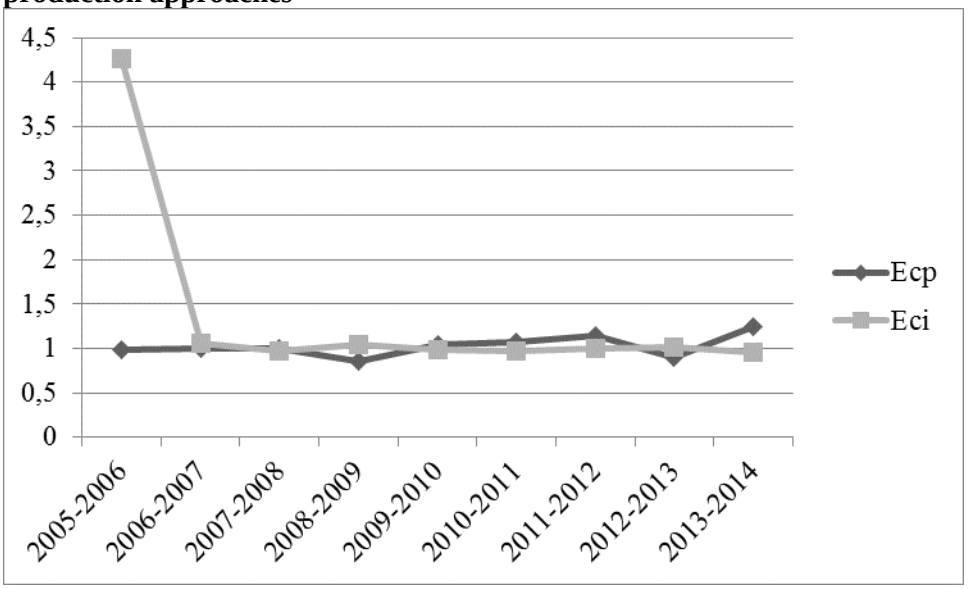
Similarly, ECi, TCi, SEi, MIi and PTEi are measures of technical efficiency change, technological change, scale efficiency change, Malmquist index and technical efficiency respectively obtained using the intermediation approach. Whatever the choice of inputs and outputs, we find that Islamic banks are productive and efficient for most of the study period. More specifically, using intermediation approach, the productivity drops during the period 2008-2009 while it keeps a stable pace assuming the production approach (Figure 5). Similarly, using production approach, evolution of efficiency change does not much change compared to the case when we assume intermediation approach during the period 2007-2014 (Figure 6). In the other hand, the two models give different results about technological change and scale efficiency change (Figure 7 and Figure 8). Figure 9 shows that Islamic banks were more efficient following intermediation approach, (PTEi average scores are greater than 80%), than following production approach (PTEi average scores are less than 80%).

Figure 5. Evolution of the Malmquist index: intermediation vs. production approaches



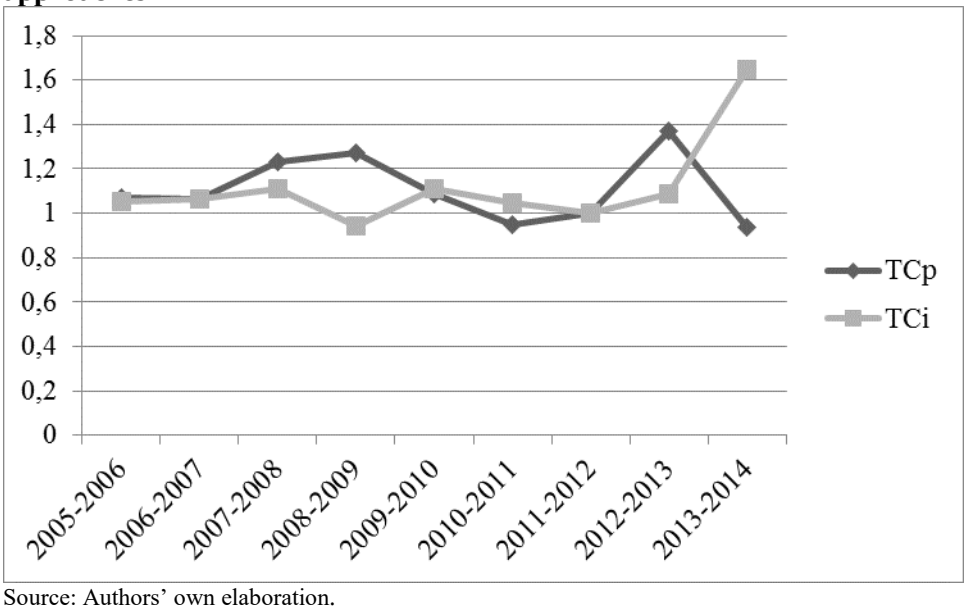
Source: Authors' own elaboration.

Figure 6. Evolution of the technical efficiency change: intermediation vs. production approaches



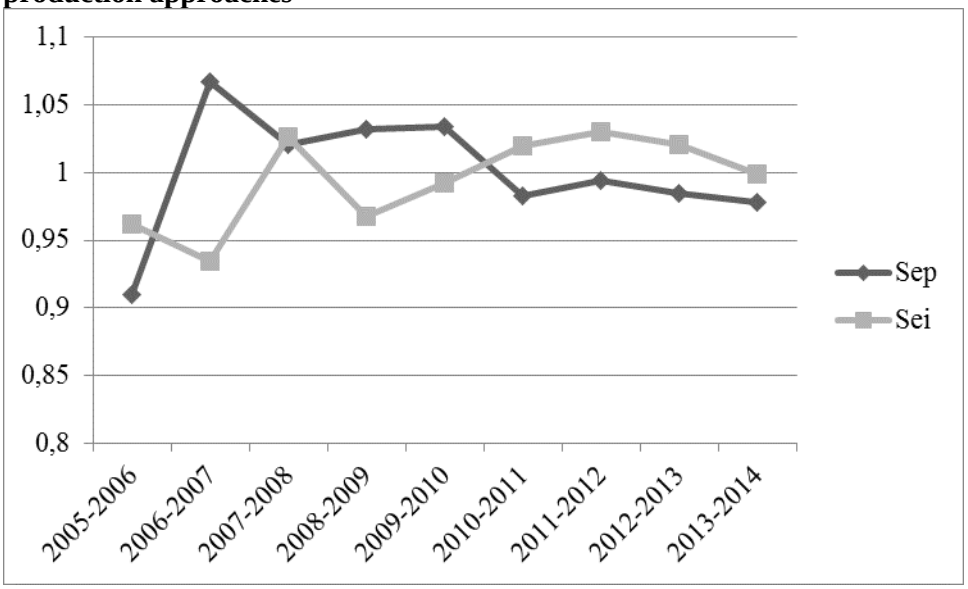
Source: Authors' own elaboration.

Figure 7. Evolution of the technological change: intermediation vs. production approaches



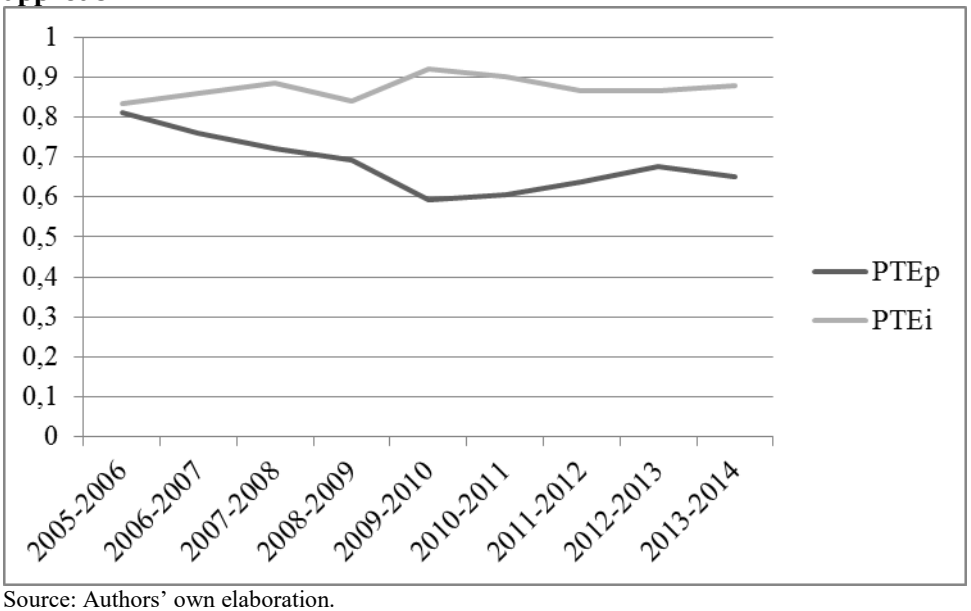
Source: Authors' own elaboration.

Figure 8. Evolution of the scale efficiency change: intermediation vs. production approaches



Source: Authors' own elaboration.

Figure 9. Evolution of pure technical efficiency: Intermediation vs. production approach



Source: Authors' own elaboration.

Table 11. Kruskal-Wallis test P-values

	P-values									
	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
MI	0.414	0.4159	0.4896	0.4395	0.4268	0.4069	0.3797	0.4208	0.4113	0.4335
TC	0.3918	0.3852	0.5776	0.4615	0.4793	0.5052	0.4896	0.4822	0.5879	0.4335
EC	0.5889	0.3138	0.3885	0.3288	0.2283	0.4553	0.2635	0.282	0.4672	0.4335
SE	0.5658	0.4484	0.4258	0.4692	0.4177	0.4069	0.3656	0.4312	0.4974	0.4335
PTE	0.2045	0.3432	0.7442	0.6356	0.6318	0.8083	0.8078	0.8821	0.7599	0.4373

Source: Authors' own elaboration.

To ensure that the choice of banks profession does not matter for performance measurement, we use the Kruskal-Wallis test. We try to assess the difference between results given by different approaches (intermediation and production approaches). The null hypothesis test is Performance scores (MI, EC, TC, SE and PTE) found following both approaches are identical populations. It states that the population medians are all equal. To determine whether any of the differences between the medians are statistically significant, we compare the P-value to significance level (1%, 5% and 10%) to assess the null hypothesis. Table 11 does not confirm the statistical significance of difference of the attained results. Indeed, basing on the P-values, we don't reject the null hypothesis implying that performance scores given from both approach are identical populations. Thus, production approach and intermediation approach give similar results and Islamic bank profession does not significantly matter in its performance measurement.

5. Conclusion

In this paper, we decompose Malmquist productivity index into three components, namely technical efficiency change, technological change and scale efficiency change; which may determine the sources of improvement or deterioration of Islamic banks productivity. We analyzed productivity of Islamic banks using two approaches: intermediation and production approaches. Findings of

two models are very close in terms of productivity and efficiency. However, there are different results concerning sources of productivity change. In fact, Islamic banks have shown gains of productivity during the whole period of study except 2008-2009 using intermediation approach, this can be explained by the sensitivity of Islamic banks to subprime crisis. In addition, technical efficiency improvement and technological change are the principal sources of productivity improvement under both approaches. Besides, we find that Islamic banks industry suffer from insufficient size of activities. These results can then be used to improve size of banks activities by encouraging mergers. In fact, scale efficiency presents a source of productivity losses assuming the both approaches. Moreover, we do not find a significant difference between evolutions of Malmquist index components under intermediation and production approaches. However, technological change and scale efficiency analysis may be sensible to the function of Islamic bank. Our results collaborate with the findings by, among others, Kamarudin et al. (2017). Finally, it would be a great interest to use a bootstrapped Malmquist index to know whether the indicated changes in productivity, technical efficiency; technological change and scale efficiency are significant in a statistical sense.

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Źródła zmiany produktywności i wydajności w islamskiej bankowości: zastosowanie indeksu produktywności Malmquista

Streszczenie

Cel: Niniejszy artykuł ma na celu zbadanie kondycji islamskich banków w 13 krajach w okresie 2005-2014 oraz określenie źródeł zmian produktywności w czasie.

Metodyka badań: Dla celów niniejszego artykułu zebrano dane dla 31 banków islamskich. Produktywność sprawdzono w oparciu o indeks produktywności Malmquista, bazujący na metodzie obwiedni danych (ang.: Data Envelopment Analysis (DEA)). Indeks zdekomponowano na takie elementy, jak wydajność skali, zmianę technologiczną oraz wydajność technologiczną. Następnie zidentyfikowano źródła zmian produktywności w islamskich bankach. Wykorzystano podejście pośrednictwa oraz produkcyjne, aby wyodrębnić nakłady i wyniki banków.

Wnioski: Mimo że obydwa wykorzystane podejścia różnią się od siebie, implementacja empiryczna autorów wskazuje, że prowadzą do bardzo podobnych wyników dotyczących produktywności, wydajności oraz źródeł zmian produktywności. Banki islamskie były w analizowanym okresie produktywne i wydajne, ale nie charakteryzowała ich wydajność skali i cierpiały na ewolucji zmian technologicznych. Co więcej, autorzy są w stanie wykazać, że kryzys dotyczący kredytów hipotecznych typu subprime w niewielkim stopniu negatywnie wpłynął na produktywność w islamskim sektorze bankowości.

Wartość artykułu: Studia empiryczne nadal są rzadkie, a ich wyniki są kontrowersyjne z punktu widzenia produktywności i wydajności islamskich banków. Niniejsze badania mają na celu wypełnienie tej luki ze szczególną uwagą skupioną na pomiarze indeksu produktywności, używając dwóch różnych podejść – pośrednictwa oraz produktywności – aby wyróżnić zmienne nakładów i wyników.

Implikacje: Banki islamskie cechuje niewydajność skali, muszą więc zwiększyć skalę działalności, a jedną z możliwych sugestii jest łączenie małych banków.

Ograniczenia: Dalsze badania mogą wykorzystać samoczynne techniki, aby skorygować szacunki dotyczące całkowitej produktywności czynników z punktu widzenia błędów, a także aby ocenić niepewność związaną z takimi szacunkami.

Słowa kluczowe: banki islamskie, produktywność, wydajność, metoda obwiedni danych, zastosowanie indeksu produktywności Malmquista
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