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What Are the Main Sources of Bank's Productivity in the GCC:

Some Evidence Using a Semiparametric Cost Model

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What are the main sources of bank's productivity in the GCC: Some evidence using a semiparametric cost model

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Abstract

A semiparametric cost frontier model is used to estimate TFP growth and its components in the GCC banking sector, over the period 2000-2018. Inefficiency component is decomposed into persistent and transient inefficiency. It is shown that annual TFP growth rate is low, quite 0.9% driven mostly by technological change while scale change and efficiency change are quite inexistent. We show that half of the bank cost inefficiency is persistent. We also find significant differences in bank's persistent efficiency between Islamic and conventional banks for some countries, but quite weak differences in TFP's by bank type. We further look at the potential determinants of TFP's and its components including oil prices impact.

JEL classification codes : C14, D24, G21

1. Introduction

This study explores the banking system productivity growth and its determinants of the Gulf Cooperation Countries, GCC. Earlier banking studies in these oil dependent economies and particular financial system focus on several aspects including efficiency Ariss et al. (2007), Mohanty et al. (2016), performance and bank type, Alqahtani et al. (2017), risk and bank stability, Abuzayed et al. (2018), Saif-Alyousfi et al. (2021) or market power, Chaffai and Coccorese (2023). Bank efficiency is usually considered as an important variable in most of these studies, whatever how it is measured. Regarding efficiency, it is a static concept in evaluating bank performance which is well studied in the banking empirical literature. By contrast, much more limited studies have in fact considered total factor productivity, TFP which is a dynamic and long run indicator evaluating bank's performance. Knowing that, bank efficiency is an important component of TFP, several studies have evaluated bank's TFP in the world, starting from the pioneering study of Casu et al. (2004), and followed by several others, we can find similar but very limited studies in MENA region or in GCC, Mansour and El Moussawi (2020), Ariss et al. (2007), Alexakis et al. (2019).

As mentioned by Abuzayed et al. (2018), the GCC countries share a close economic structure and their economies are largely dependent on oil and energy sectors. They also have a relatively under-developed financial markets, with a limited non-bank financial sector and where banks remain the major player. In addition, their banking system is dual (Islamic and conventional banks), highly concentrated, where banks are generally well capitalized and largely domestically owned. Within, all these characteristics, the questions addressed in this study are: How efficient-productive are the GCC banks? What are the main drivers of TFP growth? Which policy should the decision makers and banking regulators target in order to improve the productivity of banks in this region and hence improve the financial sector? Providing some answers to these questions is important for the banking system. Higher productivity for banks implies the possibility to reduce prices and improve the services quality for the customers and greater safety and soundness for the banking system, Casu et al. (2004).

Regarding the GCC banking industry, earlier studies in this field, have investigated banking performance based on either nonparametric data envelopment approach, DEA, or parametric stochastic frontier approach, SFA, Ariss et al. (2007), Alexakis et al. (2019), Kamarudin et al. (2014), Alqahtani et al. (2017). The broad finding is that banking inefficiency is high, and for studies investigating bank's productivity, the conclusions regarding TFP growth are mixed, both in sign, magnitude and also in its sources. What is missing in all these studies is, first, bank inefficiency is not decomposed into its structural or persistent and non-structural time variant components. According to Badunenko and Kumbhakar (2017), Badunenko et al. (2021), persistent inefficiency is linked to structural and managerial long run problems related for example to (regulation, customers habits, slow administrative rules…), while transient inefficiency is related to short run rigidities and suboptimal optimizations of inputs which can be adjusted in the short run. So, each type of inefficiency necessitates specific policy recommendations. It is important to notice, that since persistent inefficiency is time invariant, it does not enter the productivity growth rate estimates. In other word, banks with high level of persistent inefficiency compared to the transient one, are negatively impacted in terms of productivity. Second, all the aforementioned studies ignore off-balance sheet items while evaluating bank's performance. Excluding off-balance sheet activities may introduce some bias when evaluation bank's performance, Rogers (1998) and Vivas and Pasiouras (2014). Third, the studies evaluating bank's TFP in the GCC does not propose any further investigations on the potential determinants of TFP, for example Alexakis et al. (2019) just compare bank's performance by bank type.

The present study tries to fill this gap by exploring several aspects. First, we provide new and more robust TFP growth rate estimates in the GCC region. We use a more recent unbalanced panel of banks over the period 2000-2018 and we employ recent methodological ways. We consider unobservable heterogeneity in the estimation method and employ semiparametric SFA cost model which constitute the most innovative part of the paper. By semiparametric, we mean that we do not impose any specific functional form which add more flexibility and more precision to the estimates. Second, in our sample, off-balance sheet-activities like for example, outstanding letters of credit, acceptances or loan commitments, are important items in the sampled bank's balance sheet. Off-balance sheet to total assets ratio in the sampled banks, varies on average, between 14% in Bahrain to 41% in Qatar, and for some banks this ratio exceeds 100%, which suggests that off-balance-sheet activities are important in the GCC banking system and may impact bank's cost structure. Including this variable in the cost model specification to evaluate bank performance is a second novelty. Third, we also shed light on possible determinants of bank's TFP growth and its components in the GCC, by considering bank-specific variables, market structure, institutions quality, bank type and macro-environmental variables. A special focus is devoted to oil prices and oil rents.

As a preview of our findings, we show that TFP growth rate in the GCC banking sector is very weak, 0.9% per year over the studied period, curiously it decreased from 1.4% in the first decade to 0.9 after 2010. Productivity is mainly brought by technological change, 0.7%, per year. Scale change effect is much lower 0.3% per year while efficiency change is quite null. Furthermore, it is shown that quite half of the cost inefficiency is structural and the second half is non-structural, and for nearly 50% of the sampled banks structural inefficiency dominates the second component. Knowing that only this second half enters the overall TFP growth, improving bank efficiency could be an important source of productivity gain in the region. Furthermore, some differences in TFP and its components between Islamic banks and conventional banks are found, these differences are generally weak even if they are significant in some cases. We also show that among the main bank levers to improve bank's productivity are, higher diversification of the banking activities, greater effort in the intermediation process, while larger size is not recommended at least for large banks. In addition, less bank's concentration and the global increase in oil prices and the GDP growth should offer good opportunities to be seized to improve the banking system productivity.

The remainder of the paper is organized as follows: Section 2 presents a critical review of the literature pertaining to the topic in the GCC and MENA region. Section 3 outlines the methodology used. Section 4 presents and discuss the empirical results. Section 5 concludes and provide some elements for policies issues.

2. An overview of TFP banking studies in the GCC and MENA region

Total factor productivity is a dynamic performance measure and refers to the efficiency of the transformation of the inputs into outputs in any production process. The most employed indexes are the Tornqvist and the Malmquist type index. The latter index is much more appealing and used since it allows the identification of the sources of TFP growth. Usually, TFP is decomposed into two components (efficiency change and technological change), three (with scale change added) or even four components (with allocative efficiency change added), this last decomposition is relatively rare since it needs precise measures for input prices. Furthermore, there are two competing approaches used to calculate the Malmquist index, i.e. the nonparametric data envelopment DEA and the parametric stochastic frontier SFA approach. The first approach envelops the data in a deterministic way but does not need further assumptions on neither the functional form nor the statistical distributions. By contrast, the second approach is not deterministic since it allows noise in the construction of the frontier envelop, but needs further assumptions on both the functional form and the statistical distribution for the inefficiency component in the model specification. This issue is particularly important with panel data, banks unobserved heterogeneity could be assimilated to inefficiency in standard DEA models. However, recent developments on semiparametric and nonparametric SFA models propose new tools to relax the strong functional form assumption on the traditional SFA model.

A vast empirical literature has investigated bank productivity change and its sources in developed countries banking systems, particularly in US and Europe. By contrast, there have been very limited studies if we consider the GCC or even a much larger countries group, MENA region. For the GCC, Ariss et al. (2007) were pioneering in their first study evaluating TFP growth and its components for their banking system over the five year's period 1999-2004. They employ a nonparametric DEA model and TFP growth is decomposed into two components, technical change and efficiency change. Double digit negative rate of TFP growth rate is reported, -12% and this important slowdown is mainly due to the negative technological change rate, -15.7%. However, the second source of TFP growth, is positive 4.48% but not enough to compensate technological change loss. Their conclusions are completely contradicted by Johnes et al. (2009), who employ the same DEA model to decompose TFP in the GCC banking system over 2004-2007 period, they show that TFP growth is weak 0.3%, with as main source technical change 2.3%, while efficiency change contribution is negative -2.3%. We also find a much recent study for the GCC conducted by Alexakis et al. (2019) who also use a nonparametric DEA model for another six year's period 2006-2012. TFP growth is also decomposed into the same two components. Similar conclusion is found, TFP growth is still negative, -1.3% and the primary source of this loss in the GCC banking productivity is technological change, -3.8%. Efficiency change, even if it is positive 2.5%, is still not enough to compensate the negative impact of technical change. Similar conclusion is found even when the authors estimate TFP change in consideration of the potential differences in technologies used across the six studied countries. In another recent study by Mansour and El Moussawi (2020) estimate TFP growth of for a large sample of Arab banks including the 6 GCC countries over the period 2000-2014. They also employ a similar nonparametric DEA based on a radial distance function model but find positive rate of TFP over the studied period 2.4%, with technological change identified as the main driver of TFP, 3.8% while efficiency change component is negative -1.3%. The authors, report in Table 6 detailed information on TFP components by country, which is used here to extract the average TFP components for only the 6 GCC countries, a subsample which includes 45 banks. TFP banking system in the GCC has an average TFP of 3.8%, quite the same average rate they report for Arab banks, but technical change is much higher 4.16%, while efficiency change is negative -0.4%. So, their conclusion is quite opposite to the first two studies who report a deterioration of TFP growth and also for the TFP drivers using the same DEA model. Mansour and El Moussawi (2020) also report similar conclusion on TFP and their components with a different model (non-radial efficiency measure) based on directional distance function. In my view, the difference in the conclusion could mainly be explained by the outputs and inputs choice in Mansour and El Moussawi (2020) study. More precisely, they consider impaired loans as an additional output but exclude other earning assets. Another, explanation is that the frontier envelop is constructed on a much larger sample including a large sample of Arab banks countries. Let's mention that there is also another strand of literature devoted to the evaluation of the efficiency of the GCC banking system by either evaluating productive, cost or profit efficiency. For instance, Kamarudin et al. (2014) evaluate cost, revenue and profit efficiency of the GCC banking system and find high level of inefficiency ranging between 23% and 34%. Alqahtani et al. (2017), also report high level of inefficiencies (profit and cost) ranging between 31% and 42%. Mohanty et al. (2016) also show that GCC banks are both non-efficient in terms of cost and profit, but they do not report any efficiency score.

Two points should be addressed based on the results of all these studies. First, the conclusion on TFP growth in the GCC region as well as on its components differ across studies, particularly with opposite conclusions as regard TFP growth rate and its components. Second, concerning bank inefficiency, most of the reported studies in the region find evidence of high level of inefficiencies, much more linked to transient inefficiency. However, no one in these reported studies have distinguished between structural or long run inefficiency and non-structural or short run inefficiency, which remain an important issue for economic policy.

3. Methodology and Analysis

The methodology used in this paper is based on the estimation of a semiparametric stochastic cost frontier model. Total factor productivity growth TFP is estimated by totally differentiating the cost function with respect to time. Following Denny et al. (1981) the most common standard decomposition of TFP is the sum of three components: technological change, efficiency change and scale change. What differs from Denny et al. (1981) decomposition is that we do not impose any specific functional form for the cost function. This methodology has been recently used to estimate productivity of dairy farms with distance function, Balezentis and Sun (2020), but not yet used to evaluate bank's productivity. We will adapt it to the case of a non-separable cost model in a panel data framework[1].

Following the intermediation approach, we assume that each bank produces two outputs, total loans, other earning assets and uses three inputs, labor, physical and financial inputs. The cost function includes additional controls equity and off-balance-sheet activities and the time trend to capture technological progress. The estimation method is based on what is so called semiparametric two steps stochastic frontier model. More precisely, no specific functional form is imposed to the data, a nonparametric regression method is used as the alternative. It is based on local weighted least squares with sliding weights. This imply that each bank has its own technology i.e. cost function and marginal cost or input elasticities, so there is no potential misspecification bias coming from assuming a common technology for all the sample. Similar nonparametric techniques have been employed in banking literature in different fields, for example to estimate bank efficiency Kumbhakar and Tsonias (2008), returns to scale Kumbhakar and Tsonias (2008), Wheelock and Wilson (2017), Tobón and Kumbhakar (2015), market power Brissimis and Delis (2011), Alexakis and al. (2020). Surprisingly, this appealing methodology has not yet been applied to estimate productivity of banks.

3.1. Cost model specification

Following earlier studies, using parametric cost frontier models to decompose productivity, we will start by considering a general cost frontier model for the GCC banking system.

$$TC_{it} = g(Y_{it}, P_{it}, Z_{it}, t) + \varepsilon_{it} \quad (1)$$

TC is total cost of each bank i observed at period t, Y is the vector of the two outputs produced by each bank, P is the vector of the three input prices, Z is the vector of additional controls which may have an impact on each bank's cost structure, t is the time trend which capture technological change and ε is the error term which represents several components, cost inefficiency, unobserved bank heterogeneity and noise. Additional details on the error term structure will be provided later. We consider that the functional form g(.) is unknown. We then differ from researchers who generally assume a full parametric model, we mean a specific functional form such as the Translog or any other flexible functional form such as (Generalized

[1] Balezentis and Sun(2020) estimate TFP using a standard nonparametric model, i.e. a general additive model and also ignore the panel structure of the data.

Leontief, Fourier functional form …), to estimate the cost frontier. However, this latter strategy remains restrictive to represent the technology of heterogeneous banks. For example, in the Translog model, the second derivatives of the cost function with respect to time and input prices are constant, as a consequence it restricts the technology to be either input saving or input using for all the banks in the sample. By contrast, nonparametric regression model is a more flexible model because it relaxes such assumption.

We consider a general additive nonparametric cost model, which takes the following formulation for the case of two outputs, three inputs and one Z control variable for bank i in year t is given by:

$$ln(TC_{it}/p_{1it}) = \alpha_0 + m(X_{it}) + \varepsilon_{it}\ , i = 1,\ldots N \ and\ \ t = 1,..,Ti \quad (2)$$

Where

$$\begin{aligned} m(X_{it}) = m_1(ln(y_{1it})) + m_2(ln(y_{2it})) + m_3(ln(p_{2it}/p_{1it})) + m_4(ln(p_{3it}/p_{1it})) + m_5(t) \\ + m_6(ln(y_{1it})ln(y_{2it})) + m_7(ln(p_{2it}/p_{1it})ln(p_{3it}/p_{1it})) + m_8(ln(y_{1it})t) \\ + m_9(ln(y_{2it})t) + m_{10}(ln(p_{2it}/p_{1it})t) + m_{11}(ln(p_{3it}/p_{1it})t) \\ + m_{12}(Z_{it}) \quad (3) \end{aligned}$$

Equation (3) is an extended version of the so-called additive model in the nonparametric regression literature and includes cross terms of log outputs, log input prices with time trend to take into account for the non-separability of the technology. This model is called additive non-parametric model with cross additive terms, hereafter we call it as the general additive model. Excluding the cross terms in (3) imposes some restrictions on the banking technology regarding the substitution possibilities between the inputs, called separability restrictions. Notice here that separability assumption can be tested by excluding the cross terms (additive model). In addition, total cost and input prices are normalized to one input price in order to assure the homogeneity property of the cost function with respect to input prices.

Regarding the functional form $m(X_{it})$ is unknown, it is a smooth function, which is estimated nonparametrically using kernel method, see for example Li and Racine (2007). $m(X_{it})$ is a 'local average' which is estimated by locally taking the weighted average of the dependent variable close to a given small interval of values of the regressors, χ. It is based on local weighted least squares with sliding weights. Notice that fully parametric cost models are not local meaning which means that when the cost is estimated in some point, all the sampled observations contribute to the estimate with equal weights, Wheelock and Wilson (2017). To sum, this imply that each bank has its own technology i.e. production function and marginal cost, so there is no misspecification bias coming from assuming a common technology for all the sample. The basic nonparametric kernel estimator if we consider that the error terms are non-correlated and homoscedastic is obtained by:

$$(\tilde{\alpha}^{(0)}(\chi), \tilde{\alpha}^{(1)}(\chi), \ldots, \tilde{\alpha}^{(11)}(\chi)) = \arg\min_{\alpha} \sum_i^N \sum_t^{Ti} \left\{ ln(TC_{it}/p_{1it}) - \alpha_0 - m\left(\frac{X_{it}-\chi}{h}\right) \right\}^2 \kappa_h\,(X_{it}, \chi) \quad (4)$$

$\kappa_h(X_{it}, \chi)$ is the kernel function, h is the smoothing parameter.

We notice that there is no closed form solution of (4), iterative estimation method is used which is available in most of the econometric software. Similar nonparametric techniques have been employed in banking literature, Kumbhakar and Tsonias (2008), Brissimis and Delis (2011), Wheelock and Wilson (2017) among other authors. However, in all these studies, authors ignore the panel structure of their data.

In this study, we have panel data, so unobserved bank heterogeneity linked to several factors should be considered while estimating equation (4). In the standard panel data linear model framework, fixed effects or random effects models are usually employed. Parmeter and Racine (2018) mention that demeaning the variables in (4) and estimating the model by nonparametric method is inappropriate because $m(X_{it})$, is nonlinear. By contrast, in the spirit of the random effect model the estimation is possible. Remind that the error structure in (2) $\varepsilon_{it} = \mu_i + \eta_{it}$, includes two independent error components, the variance covariances matrix is equal to Ω , i.e. (in this case μ_i and $\eta_{it}$are independent random variables with 0 mean and variance σ_μ^2, σ_η^2 respectively, see Baltagi (2008). In the same spirit of the standard random effect panel data model, Parmeter and Racine (2018), propose the nonparametric random effect estimator by transforming the nonspherical disturbances back to spherical form using the following steps:

Step 1 : Premultiply both sides of equation (2) by $\Omega^{-1/2}$

$$\Omega^{-1/2} ln(TC_{it}/p_{1it}) = \Omega^{-1/2}\alpha_0 + \Omega^{-1/2} m(X_{it}) + \Omega^{-1/2}\varepsilon_{it} \quad (5)$$

Step 2 : Add and substract $m(X_{it})$ from the right side in (5):

$$\Omega^{-1/2} ln(TC_{it}/p_{1it}) = \Omega^{-1/2}\alpha_0 + \Omega^{-1/2} m(X_{it}) + m(X_{it}) - m(X_{it}) + \Omega^{-1/2}\varepsilon_{it} \quad (6)$$

Step 3 : Estimate by standard non parametric regression model the following equation :

$$\Omega^{-1/2} ln(TC_{it}/p_{1it}) - \Omega^{-1/2} m(X_{it}) + m(X_{it}) = \Omega^{-1/2}\alpha_0 + m(X_{it}) + \Omega^{-1/2}\varepsilon_{it} \quad (7)$$

Since Ω and $m(X_{it})$ are unknown in the left side of equation (7), Parmeter and Racine (2018) suggest to estimate the nonparametric regression model in (2) calculate the predicted values $\widehat{m(X_{it})}$, and derive the residuals in order to estimate[2] $\widehat{\Omega}$. This is the so-called nonparametric regression random effect model, NPRE. More technical details on the estimation of $\widehat{\Omega}$ are provided in Appendix B. Total factor productivity growth *TFP* is obtained by totally differentiating the cost function (2) with respect to time, following Denny et al. (1981):

$$\frac{dTC}{dt} = \sum_j \frac{\partial g}{\partial y_j}\frac{dy_j}{dt} + \sum_m \frac{\partial g}{\partial p_m}\frac{dp_m}{dt} + \frac{\partial g}{\partial t} + \frac{\partial \varepsilon}{\partial t} \quad (8)$$

Rearranging equation (8) by dividing by TC and using Shephard lemma, yields:

$$TFP = SC + TC + EC \quad (9)$$

SC is the scale, *TC* technical change and *EC* cost efficiency change component.

Each component in equation (9) is obtained by deriving with respect to time equation (3).

We start by calculating the elasticity of the jth output ε_{cy_j} and returns to scale, *RTS*

$$\varepsilon_{cy_j} = \frac{\partial ln(TC)}{\partial ln(y_j)} = \frac{\partial m(X_{it})}{\partial ln(y_j)} \quad j = 1,2 \quad (10)$$

[2] See appendix B for technical details.

$$RTS = \left[\frac{\partial m(X_{it})}{\partial ln(y_1)} + \frac{\partial m(X_{it})}{\partial ln(y_2)}\right]^{-1} \quad (11)$$

Scale change is calculated by:

$$SC = (1 - RTS^{-1}) \sum_{j=1}^{2} \left[\varepsilon_{cy_j}/(\varepsilon_{cy_1} + \varepsilon_{cy_2})\right] \dot{y}_j \quad (12)$$

Technical change is obtained by:

$$TC = -\frac{\partial ln(TC)}{\partial t} = -\frac{\partial m(X_{it})}{\partial t} \qquad (13)$$

and efficiency change by:

$$EC = -\frac{\partial(\varepsilon_{it})}{\partial t} \qquad (14)$$

Hence, the contribution of each factor on total *TFP*, depends on the importance of each component which is an important issue for the decision makers. For example, if the returns to scale are constant (*RTS*=1), *SC*=0, *TFP* is just the sum of *TC* and *EC*. Notice that the derivative $m'(X_{it}) = \partial m(X_{it})/\partial(x_{jit})$, is calculated numerically[3] since the functional form $m(X_{it})$ is unknown. These derivatives are needed to estimate both *SC* in equation (12) and *TC* in equation (13). Regarding *EC* a parametric stochastic frontier model is considered as suggested by Kumbhakar et al. (2014). Coming now to the cost inefficiency specification and following recent developments in the estimation of SFA with panel data, we hypothesize that total cost inefficiency which is a mixture of allocative and technical inefficiency[4], can be both structural i.e. permanent, or transient, also called time invariant and time variant inefficiency. So, the first component has no impact on banking productivity, contrary to transient inefficiency which varies over time. The intuition is, if the banking industry is inefficient, it may be attributed to time invariant inefficiency linked for example to structural rigidities (regulation, customers habits, slow administrative rules…) but also to time variant components much more linked to managerial skills. So, in terms of economic policy, knowing the two sources of inefficiency is important in order to improve the productivity of the banking system. Recent applications of this model in banking can be found for example in Badunenkoa and Kumbhakar (2017), Badunenkoa et al. (2021).

To estimate bank's cost inefficiency some additional assumptions on the error term structure ε_{it} are needed. To address this issue, we will follow the methodology developed by Colombi et al. (2014) who propose a new generation of stochastic frontier model (SFM) where the error term is split into four components:

$$\varepsilon_{it} = \mu_i + \eta_{it} = v_{oi} + u_{oi} + u_{it} + v_{it} \qquad (15)$$

Here, $u_{oi} \geq 0, u_{it} \geq 0$, refer to persistent and transient inefficiency respectively, v_{oi} is a fixed effect to accommodate bank's unobserved cost heterogeneity and v_{it} the standard error term. Furthermore, total cost inefficiency includes two parts, u_{oi} persistent and u_{it}transient component, we also assume that the four errors terms are random variables, homoscedastic and independently and identically distributed. More precisely, we assume that each inefficiency

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[3] Stata for example offers this possibility with the nonparametric estimation model.

[4] As mentioned previously, TFP could be decomposed into an additional component linked to allocative inefficiency which needs precise measure for input prices. In addition, the decomposition of cost inefficiency into transient and persistent components will much more complicate the technical aspects of the paper.

component follows a half normal distribution[5], while the standard error term follows the usual normal distribution. Two estimation methods are proposed to estimate this model, one based on a single stage by maximum likelihood method, the second called a multi-step method which will be adapted to our case. We estimate the inefficiency components in three steps, technical details are provided in the Appendix A. EC is than obtained from the transient inefficiency component by:

$$EC = -\frac{\partial(u_{it})}{\partial t} \qquad (16)$$

u_{it} is estimated by the usual Jondrow et al. (1982) method.

4. Empirical findings

4.1. Data and model specification

We estimate bank's *TFP* by constructing an unbalanced panel data including 76 banks over the period 2000-2018 for six GCC countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates. The data base is collected from Fitch-IBCA BankScope (BSC) database. Furthermore, for the *TFP* determinants, additional data from World bank indicators are collected.

Regarding the cost function specification, we follow the commonly-accepted intermediation approach of Sealey and Lindley (1977) and assume that banks produce two outputs, loans (*Y1*) and other outputs (commissions, investments,..) measured by other income (*Y2*) and use three inputs, labor (*X1*), physical capital (*X2*) and financial inputs (*X3*). Inputs prices are defined by, labor expenses to total assets which usually used as a proxy of labor input when the data on total number of employees are unavailable (*pl*), capital price (*pk*) is the ratio of capital expenditures to fixed assets, and financial input prices (*pf*) is the ratio of interest expenses to total deposits. Total cost, is the sum of capital expenditures, labor and interest expenses. This is the standard specification of the cost function in most the banking studies using the intermediation approach. In addition, total cost and two inputs prices, *pk* and *pf* are scaled by the price of labor, in order to guarantee the linear homogeneity property of the cost function. Some other studies include additional control, like equity to take into account for risk, macro variables like GDP per capita, inflation among other controls. However, we notice that according to banking scholars, excluding off-balance sheet activities may introduce some bias when evaluating bank's performance, Rogers (1998) and Lozano Vivas and Pasiouras (2014). Off-balance sheet activities are usually added as an output in the cost model specification. In our sample, off-balance sheet-activities to total assets ratio is important and varies on average, between 14% in Bahrain to 41% in Qatar, while for some banks this ratio exceed 100%, which suggests that off-balance-sheet activities are important in the GCC banking activities and may impact bank's cost structure. Furthermore, when we consider off-balance sheet as an output, the derivative of the total cost to this output should be positive as it is the case for all other outputs. In other words, increasing the production of one output total cost could not decrease, this belongs to the regularity conditions of any dual cost function representing the technology. In our case, this derivative is negative[6], so off-balance sheet could not be considered as an

[5] Half normal distribution for the inefficiency component, is a standard assumption in SFA modelling even if it could easily relaxed.

[6] Even when we cross off-balance sheet with the two other outputs, the derivative of the cost function to off-balance sheet is negative for the 99% of the observations, so this variable could not be retained as an output. Results could be obtained upon request.

output, we include it as a control. Finally, to moderate the influence of outliers, input prices are winsorized at the 1th and 99th percentiles.

Table 1: Nonparametric estimates of the GCC cost function, 2000-2018

Variables	*(1)* *Nonparametric regression*	*(2)* *Nonparametric regression(NPRE)*
ly1	*0.5437****	*0.5061****
	(0.0723)	*(0.0293)*
ly2	*0.3089****	*0.3192****
	(0.0628)	*(0.0295)*
*ly1 * ly2*	*0.0047*	*0.0049***
	(0.0044)	*(0.0019)*
ln(pk/pl)	*0.0566***	*0.0726****
	(0.0242)	*(0.0101)*
ln(pf/pl)	*0.2873****	*0.1616****
	(0.0828)	*(0.0259)*
ln(pk/pl) ln(pf/pl)*	*0.0192*	*0.0347****
	(0.0177)	*(0.0054)*
tr	*-0.0043*	*-0.0170**
	(0.0155)	*(0.0101)*
*ly1 * tr*	*0.0130****	*0.0138****
	(0.0016)	*(0.0010)*
*ly2 * tr*	*-0.0133****	*-0.0136****
	(0.0016)	*(0.0008)*
*ln(pk/pl) * tr*	*-0.0023*	*-0.0023***
	(0.0017)	*(0.0010)*
*ln(pf/pl) *tr*	*0.0033*	*0.0066****
	(0.0022)	*(0.0009)*
RATOFF	*-0.1395****	*-0.1555****
	(0.0223)	*(0.0144)*
constant	*17.2811****	*17.3124****
	(0.0448)	*(0.0442)*
Observations	*1,053*	*1,053*
R-squared	*0.9845*	*0.9947*
Wald_Separability	*95.68*	*374.4*
P_val_Wald_Separability	*0.000*	*0.000*

*Number between parentheses are the bootstrapped standard errors, *, ** and *** indicate the significance at 10%, 5% and 1% level.*

We estimate the nonparametric random effect model using the econometric approach developed in Section 3. Table 1 reports the two nonparametric model estimates, the standard one which does not consider unobserved heterogeneity of the panel data structure, and the alternative one called the nonparametric random effect model, (*NPRE*). The second estimator provides more precise estimates as reported by comparing standards errors of the two regressions. Hereafter, the *NPRE* will be the estimator used for all the empirical result discussions. As cost variable controls, we introduce equity to total assets ratio, and off-balance sheet to total assets ratio, only the last variable proves significant. The negative sign on off-balance sheet variable (*RATOFF*) in Table 1, suggests that this variable could not be considered as an output[7], since the derivative of the cost function to each output should be positive as it is the case for the other outputs. However, the negative and significant sign on off-balance sheet activities suggests that this item reduces banking costs in the GCC banking system, which is in line of the findings of Berger et al. (2019). The authors show that banks create liquidity on the balance sheet by transforming illiquid assets into liquid liabilities, which in return reduce costs. Furthermore, as discussed in

[7] In some empirical literature, off-balance sheets items has been considered as an output, but the authors did not check the regularity of their cost function to this output, see for example Lozano-Vivas and Pasiouras (2014).

Section 3, the data reject the restrictive additive model specification, the Wald test does not reject the cross terms added, see equation (3), which suggests that the separability assumption between the outputs, inputs and time is rejected by the data. More precisely, technical change is Hicks non-neutral, affecting both outputs and inputs, since interaction terms of time trend and outputs and input prices are significant. We finally check the regularity conditions of the cost function specification, the derivatives of the cost function to input prices are positive as well the derivatives of total cost to each of the two outputs[8].

4.2. Cost efficiency components

We will start by considering the banking GCC performance in terms of cost inefficiency. As discussed in Section 3, cost inefficiency is decomposed into persistent inefficiency and transient inefficiency. To make the interpretation of the scores much easier, we express the figures in terms of cost efficiency scores, i. e. $E(e^{-u_{oi}}), and\ E(e^{-u_{it}}), \in\ [0,1]$, for persistent efficiency (*PRE*), and transient efficiency scores respectively, (*TRE*). The estimation results by bank type and country are presented in Table 2. Overall, the mean persistent efficiency is 1.5% much lower than mean transient efficiency 87.4% and 88.9% respectively, so nearly half of the banking inefficiency of the GCC banking sector is structural or linked to long term inefficiency, while the second half is transient or of short term. By structural inefficiency we mean, bank's business model, customer structure, regulation, sunk costs, etc... . Remind that only this second half enters the TFP measure. In other words, if *EC* contribution to *TFP* growth is one point per year, improving structural inefficiency would double this effect to two points, everything else being equal.

Table 2: Persistent efficiency and transient efficiency by country and bank type

Country	*Efficiency*	*Islamic*			*t-test (1)*	*Conventional*			*All types*		*t-test (2)*
		Mean	*SD*	*N*		*Mean*	*SD*	*N*	*Mean*	*SD*	
Bahrain	*PRE*	.842	.085	*53*	*-3.050****	.887	.046	67	.867	.070	*-3.689****
	TRE	.886	.062	*53*	*-0.188*	.888	.055	67	.887	.058	*-0.218*
	DOM	.604	.494	*53*		.507	.504	67	.550	.500	
Kuwait	*PRE*	.954	.02	*22*	*5.483****	.793	.054	90	.824	.081	*13.645****
	TRE	.894	.048	*22*	*-13.044****	.891	.045	90	.892	.045	*0.331*
	DOM	.091	.294	*22*		.922	.269	90	.759	.430	
Oman	*PRE*	.571	.032	*11*	*-7.209****	.924	.055	99	.880	.069	*-20.904****
	TRE	.852	.126	*11*	*4.663****	.894	.037	99	.891	.044	*-2.533****
	DOM	1	0	*11*		.232	.424	99	.533	.499	
Qatar	*PRE*	.932	.039	*43*	*5.100****	.893	.034	*96*	.905	.04	*6.045****
	TRE	.891	.039	*43*	*0.327*	.891	.043	*96*	.891	.041	*-0.029*
	DOM	.209	.412	*43*		.51	.503	*96*	.417	.495	
Saudi Arabia	*PRE*	.789	.090	*46*	*-6.719****	.884	.033	*142*	.861	.067	*-10.522****
	TRE	.884	.050	*46*	*-3.210****	.896	.030	*142*	.893	.036	*-1.912**
	DOM	.739	.444	*46*		.648	.479	*142*	.67	.471	
UAE	*PRE*	.873	.156	*92*	*-0.452*	.885	.083	*249*	.882	.107	*-0.947*
	TRE	.880	.074	*92*	*-0.317*	.887	.048	*249*	.885	.056	*-1.056*
	DOM	.402	.493	*92*		.462	.500	*249*	.446	.498	
All banks	*PRE*	.856	.132	*267*	*-3.393****	.880	.069	*743*	.874	.091	*-3.714****
	TRE	.884	.064	*267*	*-3.669****	.891	.044	*743*	.889	.050	*-2.008***
	DOM	.468	.500	*267*		.533	.499	*743*	.516	.500	

PRE (persistent efficiency), TRE (transient efficiency) estimated from the residuals and the random effects estimates of the nonparametric cost model. DOM (% of observations for which PRE>TRE).
*t-test(1) mean difference t-test between PRE and TRE by bank type, t-test(2) mean difference t-test between PRE and TRE for all banks. *, ** and *** indicate the significance at 10%, 5% and 1% level.*

[8] We did not check for the additional property of the concavity of the cost function with respect to the input prices. This will need to calculate the second derivatives of the cost function which is time consuming with the nonparametric estimated model.

Furthermore, some significant differences in cost efficiency components across countries are found in four cases. For instance, in Bahrain, Kuwait and Saudi Arabia most of the banking inefficiency is persistent with 2%, 6.8% and 3% difference respectively, but the opposite in Qatar 1.4% percentage point difference in cost efficiency components. In the two other countries, Oman and UAE there is no significant differences between the two efficiency components. We also, construct an inefficiency indicator called dominance (DOM), a dummy variable which takes the value of one if persistent inefficiency is greater than transient inefficiency. Overall, DOM is equal 51.6% on average for all banks, but some differences are found across countries. Most of the banking inefficiency is structural in Kuwait, Saudi Arabia, Bahrain and Oman, with DOM equal to 75.9%, 67%, 55%, 53.3% respectively. This result implies that improving persistent inefficiency remain the challenge in order to boost banking efficiency, and hence the productivity in the aforementioned three countries. By contrast, most of the inefficiency is non-structural in Qatar and UAE with DOM equal to 41.7%, 44.6% respectively.

Regarding cost efficiency components comparison by bank type, Table 2 also provides the mean comparison tests for *PTE* and *TRE*. In the GCC, Islamic banks are shown to be less efficient than conventional banks, the efficiency gap is significant and ranges between 2.4% for persistent efficiency and 0.7% for transient efficiency. The gap in persistent inefficiency is particularly much more important for Islamic banks in Oman, Saudi Arabia and Bahrain, 35.3%, 9.5% and 4.5% respectively. In two countries, persistent inefficiency is significantly much higher than transient inefficiency for Islamic banks, this is the case of Islamic banks in Oman and Saudi Arabia, with an efficiency gap equal to 4.2% and 1.2% respectively, while no difference in persistent inefficiency by bank type is found for the banks in in the remaining four countries. This result contradicts the findings of Alexakis et al. (2019) for the GCC case[9] where no significant differences in bank's efficiency by bank type are found. Remind that what the authors have investigated in their study is very close to transient inefficiency. The difference in the conclusion may be explained by the nonparametric method DEA model used to evaluate cost efficiency which does not allow for noise. Our finding clearly shows that to compare the two banking systems regarding cost inefficiency, the two measures does not provide the same conclusions. On the one hand, persistent inefficiency proves to be much higher between Islamic and conventional banks compared to the transient one in some GCC countries, on the other, banks which are more efficient on one component does not necessarily imply they maintain their position with respect to the second component. This result suggests that policymakers and banking authorities should consider both inefficiency components to promote the efficiency of their banking systems. So, the question addressed is what explains these differences across countries? We will attempt to provide some answers when we will investigate the determinants of *TFP* and its components in the second part of this Section.

4.3. Estimated TFP components using the nonparametric cost function estimates

We now use the parameter estimates column (2) of Table 1, to calculate the *TFP* growth rates which are decomposed into *TC* eq. (13), *SC* eq. (12) and *EC* eq. (14). Table 3 presents in its

[9] Over and beyond the fact that the authors did not decompose the efficiency (persistent-transient), the authors report no significant difference on technical efficiency between Islamic IB, and conventional banks in terms of what they call gross efficiency, this definition is much close to ours, but they found that IB outperform conventional banks in terms of net efficiency. This last measure of efficiency is based on a meta frontier, which explain the difference in the conclusions.

right part, the average *TFP* growth rate over the period 2001-2018 and for two subperiods, 2001-2010 and 2011-2018[10]. Overall, GCC banking *TFP* is very low, quite 0.9% on average per year over the period, but if we look to the subperiods, *TFP* decreased gradually from 1.4% during the first decade, to 0.6% after 2010. The most important contributor of *TFP* in the region is technical change, quite 0.7% per year on average followed by scale change 0.3%, EC has quite any contribution to TFP growth. This conclusion remains even if we consider the two subperiods, but efficiency change is very low, -0.1 % if we consider the entire period, or 0.2% before 2010 and -0.1%, after, for the most recent subperiod. One explanation for the low contribution of scale change to TFP, is that returns to scale is close to one in most the six banking systems, so the contribution of scale economies/diseconomies in the overall *TFP* growth is weak, see eq. (12). By contrast, some differences in *TFP* growth and to lesser extent in its components are found across countries. For instance, the banking systems of some countries are more productive than others, this is the case of Bahrain, 2.2% Saudi Arabia, 1.5%, and Oman, 1.2% if we consider the entire period *TFP*'s. Productivity is relatively still high after 2010 in these three countries. The main source of *TFP* being technical change (1%-1.3%) while efficiency change contributes to *TFP* growth particularly in Oman and Bahrain (0.8%-0.7%), but not in the remaining four countries. We notice that banks in UAE and Kuwait have the lowest *TFP* growth rates in the region, 0.3% far below the average *TFP* growth region level, negative or quite zero if we consider the most recent period. *TC* components, the main driver of *TFP* in the region, is also very low in these two countries.

Two important points have to be noticed. First, even if we are using a different specification for the cost function, different estimation method and a different sample of countries, our findings seem to be close to those of Feng and Serletis (2010) for US banks, they report an average annual growth rate of TFP of 1.98% over the period (2000-2005), with technological change as the main contributor of TFP, 1.39%. However, if we focus on the reported studies in the region, our results are also qualitatively close to those of Mansour and Moussawi (2020) on 12 Arab countries banks including GCC, *TFP* growth is decomposed into two components, technical change and efficiency change. They find a positive growth rate of *TFP*, 2.44% mainly driven by technological change 3.77%, while efficiency change has a negative impact on TFP, -1.3%. However, our study and the one by Mansour and Moussawi (2020) contradict the findings of Alexakis et al. (2019) who report negative *TFP* growth rates for GCC banks over the period (2006-2012), -1.3% and the main source of this drop is technological change which is also negative -3.8%, but efficiency change impact is positive and important 2.4%. Similar contradictions in the reported *TFP* estimates within the same region can be found elsewhere in the empirical literature which can be attributed to the sample used, the methodology employed or even the inputs and outputs selection, for example for European banks case, Lee and Huang (2019) estimate *TFP* growth rate to 0.25% per year, mainly explained by technological change 3.5% which is compensated by efficiency loss 3.04%, while Casu et al. (2016) estimate *TFP* growth by 2% per year, which is mainly driven by technological change, but efficiency change contribution is quite insignificant.

Regarding *TFP* by bank type, we compare in Table 4 its components by applying the mean difference t-test for the two bank groups. The null assumption being whether Islamic banks are as productive as their counterparts. As before with the efficiency comparison particularly with the transient component[11], and as it is shown in the bottom of Table 4, we find a weak difference between Islamic banks and their counterparts in both TFP and its components if we consider all

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[10] To save space, we could not report these figures by year for each country for the studied period, which could be obtained upon request.

[11] Remind here that the persistent component for which we found stronger differences by bank type does not enter TFP growth component.

the banks, while technical change is still the main driver of *TFP* for the bank groups. Across country, Islamic banks are as productive as conventional banks except in Oman where Islamic banks are significantly much more productive than conventional banks 7.7% and 1.2%, respectively. *TFP* of Islamic banks in this country is mainly driven by efficiency change component, 6.5%. In Kuwait Islamic banks are much more productive than conventional banks but the difference is not statistically significant. We also notice, that technical change contribution to *TFP* for Islamic banks is slightly much higher and significant compared to conventional banks but the difference is very weak 0.2%, as it is the case for scale change even if its impact is very low.

Table 3: TFP components by countries and subperiods

Country	*EC*	*TC*	*SCC*	*TFP*
Bahrain				
2001-2010	*.018*	*.013*	*0.003*	*.034*
2011-2018	*.001*	*.013*	*0.002*	*.015*
2001-2018	*.007*	*.013*	*0.002*	*.022*
Kuwait				
2001-2010	*.009*	*.007*	*0.002*	*.017*
2011-2018	*-.009*	*.002*	*0.002*	*-.007*
2001-2018	*-.002*	*.004*	*0.002*	*.003*
Oman				
2001-2010	*-.001*	*.002*	*0.003*	*.004*
2011-2018	*.015*	*.000*	*0.005*	*.018*
2001-2018	*.008*	*.001*	*0.004*	*.012*
Qatar				
2001-2010	*.002*	*.011*	*0.007*	*.021*
2011-2018	*-.004*	*.006*	*0.002*	*.004*
2001-2018	*-.002*	*.008*	*0.004*	*.010*
Saudia				
2001-2010	*-0.002*	*.013*	*0.002*	*.013*
2011-2018	*.002*	*.013*	*0.001*	*.016*
2001-2018	*.000*	*.013*	*0.002*	*.015*
UAE				
2001-2010	*-.001*	*.002*	*0.007*	*.008*
2011-2018	*-.005*	*.004*	*0.002*	*.003*
2001-2018	*-.003*	*.003*	*0.004*	*.003*
All countries				
2001-2010	*.002*	*.007*	*.005*	*.014*
2011-2018	*-.001*	*.006*	*.002*	*.006*
2001-2018	*-0.001*	*.007*	*.003*	*.009*

Table 4: TFP and its components comparison by country and bank type

Country	*TFP*	*Islamic Banks*	*Conventional Banks*	*t-test*
	EC	*.017*	*.005*	*0.926*
Bahrain	*TC*	*.007*	*.017*	*-5.409****
	SCC	*.004*	*.001*	*3.013****
	TFP	*.027*	*.023*	*0.314*
	EC	*-.019*	*.007*	*-1.824**
Kuwait	*TC*	*0.009*	*.004*	*1.982***
	SCC	*.014*	*.001*	*3.740****
	TFP	*.077*	*.012*	*-1.376*
	EC	*.065*	*.005*	*2.479****
Oman	*TC*	*.011*	*.001*	*0.993*
	SCC	*.007*	*.003*	*4.778****
	TFP	*.072*	*.009*	*2.396***
	EC	*-.004*	*.002*	*-0.729*
Qatar	*TC*	*.010*	*.007*	*1.317*
	SCC	*.004*	*.004*	*-0.016*
	TFP	*.009*	*.013*	*-0.487*
	EC	*.000*	*.004*	*-0.479*
Saudi Arabia	*TC*	*.012*	*.014*	*-1.121*
	SCC	*.003*	*.002*	*2.732****
	TFP	*.016*	*.019*	*-0.405*
	EC	*-.007*	*.000*	*-0.774*
UAE	*TC*	*.006*	*.008*	*1.765**
	SCC	*.005*	*.005*	*2.515****
	TFP	*.004*	*.013*	*-0.222*
	EC	*.001*	*.003*	*0.015*
All banks	*TC*	*.008*	*.006*	*2.289***
	SCC	*.005*	*.003*	*4.493****
	TFP	*.013*	*.012*	*0.624*

, ** and * indicate the significance at 10%, 5% and 1% level.*

4..4. The determinants of TFP change in the GCC

Following previous empirical literature in efficiency determinants in banking, which identifies four main factors impacting banking performance, i.e., bank-specific variables, macroeconomic variables, institutions and bank regulation and supervision variables. Unfortunately, for the last factor we were unable to collect data for the six countries over the studied period 2000-2018. For instance, there are no data for the UAE, and some data on bank regulation or supervision are incomplete for the other five GCC countries, in the World bank data survey developed by Barth et al. (2013) and updated by Anginer et al. (2019). So, we will restrict our analysis to the first three main factors for *TFP* growth and its components. In addition, *TFP* growth is a dynamic and long run concept, so it is more appropriate to estimate a dynamic panel data model for *TFP* determinants, i.e. any change in a determinant will have instantaneous effect on the outcome but also future effects. After applying a series of endogeneity tests particularly for the bank specific variables (we used the Hausman and Wu test[12]) as they may be considered as endogenous with bank's performance, we consider the following dynamic model:

$$Y_{it} = \alpha_o + \gamma Y_{it-1} + \alpha_1 ln(Assets_{it}) + \alpha_2 Divers_{it} + \alpha_3 Interm_{it} + \alpha_4 ln(Z_{it}) + \alpha_6 CR3_t + \alpha_5 Age_{it} + \alpha_7 Islamic_i + \alpha_8 Rent\_Oil_t + \alpha_9 ln(Oil\_price_t) + \alpha_{10}(Oil\_Volatility_t) + \alpha_{11} Institutions_t + \alpha_{12} ln(Credit/GDP)_t + \alpha_{13} ln(GDPPC)_t + \alpha_{14} ln(Inflation)_t + \mu_i + v_{it} \quad (17)$$

Where Y_{it} refers to *ln(1+TFP)*, *ln(1+TC)*, *ln(1+SCC)* and *ln(1+EC)*. Transforming the *TFP*'s components into log is used to take into account of potential nonlinearity and to facilitates the interpretation of the estimated coefficients. $ln(Assets_{it})$ stands for bank size and is measured by the log of total assets. $Divers$ stands for bank activity diversification, measured by non-interest income to total income. $Interm$, stands for intermediation ratio which capture the extent to which a bank is able to convert deposits into loans, and is measured by the ratio deposits to total loans. $ln(Z_{it})$ stands for the log of the z-score[13], which is a standard indicator of bank stability, the higher is the index the less risky is the bank. Age stands for the age of the bank which may capture the efficiency gain through learning-by-doing if any. $CR3$ stands for the bank concentration ratio and is measured by the percentage of the assets held by the three largest banks for each year and country. $Islamic_i$ is a dummy variable which takes the value 1 if the bank is Islamic and capture bank type. Regarding, oil impact on TFP and its components, we retain three variables, $Rent\_Oil$ measured by the ratio, oil rents to GDP, $ln(Oil\_price)$ measured by the log of average oil price per year, and $Oil\_Volatility$ which is measured by the square of the difference between oil prices between the last month and the first month of each observed year, which capture observed volatility in Oil prices. $Institutions$, is a global index which measure the quality of the institutions in each country. It includes, the rule of law, voice and accountability, corruption control, political stability, regulatory quality and government effectiveness. The index is calculated as the sum of these six variables. The higher is the index the better is the quality of the institutions. Finally, regarding the macroeconomic environment and its impact on *TFP* components, we test for the impact of three variables, $ln(Credit/GDP)$ an indicator of financial development which is the log of the ratio of private credits to GDP, $ln(GDPPC)$ the log of each country growth rate of GDP per capita and $l(Inflation)$ the log of inflation. Since some values of GDDPC and Inflation are negative, we add one to each variable before taking the log. Equation (17) is estimated by the system GMM method, we also check the validity of the estimates by verifying both the absence of autocorrelation at the second order and the over identification Sargan J-test. Finally, to avoid non-precise estimates regarding the excessive number of potential instruments used, we apply the Roodman (2009) rule which advance that the number of instruments should be less than the number of individuals in the panel. Test Statistics, are provided in the bottom of Table 5.

[12] Three variables prove to be endogeneous, Divers, Interm and ln(Z).

[13] Z-score= (ROA+EQUITR)/ σ(ROA)

Table 5: Determinants of TFP and its components, GMM system estimates

VARIABLES	(1) TFP	(2) TC	(3) SCC	(4) EC
Dependent variable (-1)	-0.15369***	0.43550***	0.18729***	-0.16440***
	(0.01671)	(0.03598)	(0.03745)	(0.01514)
ln(total assets)	-0.02600***	-0.00414***	-0.00102**	-0.01628***
	(0.00519)	(0.00081)	(0.00049)	(0.00516)
Divers	0.00041**	0.00006**	0.00000	0.00021
	(0.00017)	(0.00003)	(0.00001)	(0.00018)
Intermediation	0.00034*	-0.00038***	-0.00013***	0.00077***
	(0.00020)	(0.00004)	(0.00002)	(0.00023)
ln(Z)	-0.03042*	0.00348	-0.00299*	-0.02965*
	(0.01661)	(0.00240)	(0.00168)	(0.01604)
age	-0.00002***	-0.00000	-0.00000***	-0.00001**
	(0.00000)	(0.00000)	(0.00000)	(0.00001)
CR3	-0.00095***	-0.00015***	-0.00002	-0.00061***
	(0.00022)	(0.00004)	(0.00002)	(0.00019)
Islamic	-0.01139*	-0.00058	0.00134**	-0.01627***
	(0.00622)	(0.00118)	(0.00058)	(0.00522)
Rent_oil	-0.00013	-0.00006*	0.00001	-0.00012
	(0.00021)	(0.00004)	(0.00002)	(0.00017)
ln(Oil price)	0.00276	0.00303***	-0.00006	-0.00052
	(0.00542)	(0.00087)	(0.00050)	(0.00541)
Oil prices Volatility	0.00003***	0.00000***	-0.00000*	0.00002***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Institutions Index	-0.00054***	-0.00004**	0.00003**	-0.00040***
	(0.00012)	(0.00002)	(0.00001)	(0.00010)
ln(Credit/GDP)	-0.00019	0.00001	-0.00005***	-0.00016
	(0.00017)	(0.00003)	(0.00001)	(0.00015)
ln(GDPPC)	0.01789***	0.00037	0.00064	0.01567***
	(0.00507)	(0.00107)	(0.00047)	(0.00400)
ln(Inflation)	-0.45509***	-0.03180***	0.03738***	-0.47867***
	(0.06277)	(0.00760)	(0.00676)	(0.05872)
Constant	0.41611***	0.09108***	0.03259***	0.22126**
	(0.09037)	(0.01251)	(0.00641)	(0.08695)
Number of Obs	836	836	836	836
Number of Banks	76	76	76	76
Number of Instruments	42	42	42	42
Ar(1)_pvalue	0.084*	0.008***	0.000***	0.115
Ar(2) p_value	0.328	0.749	0.119	0.315
Sargan p_value	0.191	0.120	0.342	0.164

*Interm, Divers and ln(Z) are considered as endogenous, three additional instruments for these variables are used by taking the average value of all bank competitors by year and country. Numbers below the estimated coefficients are the standard errors . *, ** and *** indicate the significance at 10%, 5% and 1% level.*

Regarding the *TFP* determinants, most of the banking factors prove significant. Bank size, is negative which suggests that small and medium size banks are more productive than large banks. One possible explanation, is large banks are more likely to be in a decreasing return to scale which mechanically impact negatively their *TFP* growth rate eq (12), while the opposite case i.e. small and medium size banks are more likely in an increasing return. Let's notice that bank size has a negative significant effect on all the components of *TFP*'s, particularly as *TC* is the main driver of *TFP* in the GCC banking system, large banks are less productive and neither benefit from investments in new banking technologies to capture more technical progress than the smaller ones. Even if there is no similar evidence in empirical literature regarding *TFP*'s and bank size in the studied region, this finding confirms earlier study on banking efficiency determinants, for example Alqahtani et al. (2017) found that bank size was the most influential factor in improving cost and profit inefficiency in the GCC banking industry over the period 1999-2012. $Divers$ has a positive impact on *TFP*, so bank's which are more engaged in diversified intermediation activities, benefit from scope economies and may diversify their risk, implying lower costs compared to their competitors, which render them more productive and more efficient. *Divers* is also positive and significant for the *EC* component. This result is also in line with the findings of Paltrinieri et al. (2021) who find positive association between diversification and bank's performance measured by ROA in the GCC, while Chaffai and Coccorese (2023) report similar conclusion for MENA banks where performance is measured by cost efficiency indicator using SFA. *Interm*, refers to the channels through which the funds are supplied from depositors to bank's borrowers, this variable has a positive and significant impact on both bank TFP and bank efficiency. However, the impact of *Interm* is negative and significant for both TC and SC components, but the overall impact on TFP is positive. The coefficient of $ln(Z_{it})$ is negative and significant in three regressions, which suggests that banks which take more risk are more productive. This result is partially inline with the finding of Mollah et al. (2017) who find a significant and positive effect of risk on returns on assets in the GCC and explain that by the fact that the governance systems are not strong in this region. We also notice, that if we focus on the two first columns, the results are a little bit mixed, on one hand more stable banks are less productive regarding TFP, but z-score is non-significant in the *TC* equation, knowing that *TC* is the most important driver of *TFP* in the region. The *age* variable should capture the efficiency gain through learning-by-doing. Surprisingly, its impact proves negative and significant for both *TFP* and *EC* while its effect is not significant for *TC* regression. This result means, in the GCC banking system, more recent banks or novo banks are more productive and more efficient compared to older banks in the same market. This may be explained by the fact that new operators come to the market and compete with updated technologies and updated human resources which may explain why they are more productive. To examine the impact of bank type on *TFP* components, we notice that the coefficient of the dummy variable for Islamic banks is negative and significant in three regressions. Specifically, the results show that even if there is no difference in the *TC* components, conventional banks seem to be quite 1.1% more efficient and more productive compared to their counterparts. This result is also in line with the meta-analysis conducted by Chaffai (2021).

Regarding market structure, bank's productivity and cost efficiency decreases with banking industry concentration. The negative and significant coefficient of *CR3*, supports then the "quiet life" hypothesis which argues that banks in more concentrated markets feel less pressure to achieve higher cost saving.

As respect with the relation of oil and *TFP* components in the GCC banking system, we test the impact of three related variables, oil-rent, oil prices and oil-prices volatility. *Rent_oil* has a negative and significant impact only on productivity *TC* component, which is the main source of bank's productivity in the region. This result tends to support the "financial resource curse hypothesis" which argues that natural resources abundance upends financial sector development, particularly when resource related wealth is shifted out of domestic financial system i.e. (foreign investments conduit, foreign financial assets), Beck and Poelhekke (2023). By contrast, both oil-price and/or price volatility, have overall a positive and significant impact, particularly for *TFP*, *TC*, and *EC* equations. The positive and significant coefficient of oil suggests that as oil price increases, it affects positively the growth rates of credits and deposits, contribute to the decline of non-performing loans and improve the bank's assets quality, which in turn affect positively bank's productivity through *TC* and *EC*. Regarding volatility, higher oil volatility may indicate more arbitrage of the banks on oil-assets which may enhance their productivity. Overall, the positive association found between oil price and bank productivity or some of its components seems to contradict again the finding of Alqahtani et al. (2017) who report significant negative impact of oil prices on the cost efficiency of the GCC banks.

When it comes to institutions impact, we find a negative and significant impact on *TFP*, TC and *EC* but a positive impact on *SC* component. This result is somewhat surprising, since better institutions should be associated with higher banking sector performance. This counter intuitive result could be explained first, by the fact that we are using a synthetic indicator which is the sum of six indicators. For example, when we run the regressions replacing this indicator by specific indicators[14], in several cases, individual institution variables prove to have non-significant impact on *TFP* for (voice and accountability, government effectiveness, political stability), positive and significant impact in one case when institution is measured by corruption, and negative and significant impact for regulatory quality. So, taking individually, institution variables do not have a common and significant impact on *TFP*. Second, the unexpected sign could also be explained by the fact that most of the institution's variables have improved if we compare their level before 2010 and after, while in the same time we observe a drop-in banking *TFP* growth mainly linked to other economic and financial factors. So, the relatively rapid improvement in the GCC institutions quality is not yet having a visible impact on bank performance in the GCC.

Regarding the macroeconomic environment, we find no significant impact of financial development on bank's *TFP* or its components in the studied region. However, GDP growth per capita has a positive and significant impact on bank's *TFP* and its *EC* components, which suggests that higher growth imply more deposits and loans for the economy which render the banking system more productive. In addition, inflation has a negative and significant impact in the four regressions, which comfort the overall view of the negative impact of inflation on banking lending activities.

5. Conclusion

Using a new semiparametric approach which does not impose any parametric functional form for the cost function, this paper aims to provide further insights on the TFP growth rate and its components in the GCC banking system for the period 2000-2018. More importantly, evaluating *TFP* growth and its source can be beneficial to bankers and policy makers in the region with a well-developed and active dual banking system. We also propose additional regressions for the *TFP* determinants. We can summarize our findings as follows: The average productivity growth rate is very low 0.9% over the studied period, and this productivity is mainly stimulated by technological change 0.7%. Scale change and efficiency change are quite absent to enhance productivity in the region. Regarding banking cost inefficiency which is relatively important, it is found that quite half of the banking sector inefficiency is structural or persistent, the second half is transient. We also find evidence of some differences in bank efficiency by bank type and *TFP* growth for some countries. Bearing these figures in mind, how

[14] To save space, we could not report these estimates. Results could be obtained upon request.

could the banking sector *TFP* be improved in the GCC? It is shown that larger banks are less productive than small and medium size banks, diversified banks are more productive as long as these banks are highly implicated in the intermediation process, bank concentration also handicap the productivity of the banking system while oil-price and oil-price volatility have a positive impact on bank's productivity. At the macro level, growth is good for bank productivity while inflation is worse. In terms of economic policy, improving bank's structural or persistent cost efficiency, should be a good starting initiative to reduce banking costs and boost their productivity. Any policy from the banking authorities dealing with this point, through improving the macroeconomic environment, reducing structural rigidities, less regulation, soft supervision and barriers relaxations are welcomed. Once saved, these costs could be affected to reinforce additional investments in new technologies and benefit from further technological progress. Such measures should be accompanied by bank's incentive policies to boost transient efficiency. Such improvements, does not need any further investments or any restructuring of the banks through bank's mergers for example, scale effect being already exhausted. Reinforcing competition across the banks or even within the region could also be a challenging policy to improve the efficiency and the productivity of the banks. Finally, diversifying the economy by among other things, benefitting from the oil price change and its volatility could also reinforce the productivity of the GCC banking system.

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Appendix A : Cost inefficiency estimation procedure

We follow the usual standard assumption in both panel data and SFA. The four error terms in equation (2) are decomposed into two groups:

$$\varepsilon_{it} = \underbrace{v_{oi} + u_{oi}}_{\mu_i} + \underbrace{u_{it} + v_{it}}_{\eta_{it}} \quad \text{(a)}$$

We assume that

$$v_{oi} \sim N(0, \sigma_{v_o}^2),\ v_{it} \sim N(0, \sigma_v^2)$$

and each inefficiency component follows a half-normal distribution:

$$u_{oi} \sim |N(0, \sigma_{0u}^2)|,\ u_{it} \sim |N(0, \sigma_u^2)|$$

Average inefficiency components are equal to $E(u_{oi}) = \sqrt{(2/\pi)}\sigma_{0u}$, $E(u_{it}) = \sqrt{(2/\pi)}\sigma_u$

Step 1 : Estimate equation (2) by the nonparametric random effect method described in Section 2 and calculate the residuals and the fixed effects hereafter denoted $\widehat{\eta_{it}}$ and $\widehat{\mu_i}$ respectively.

Step 2 : Estimate the peristent inefficiency components from the $\widehat{\mu_i}$. Run a standard cross-sectional stochastic frontier model to envelop the data using maximum likelihhod procedure, then derive the $\widehat{u_{0i}}$, by the Jondrow et al. (1980) method, using the following equation :

$$\widehat{\mu_i} = a0 + u_{oi} + v_{oi} \quad \text{(b)}$$

Step 3 : Estimate the peristent inefficiency components from the $\widehat{\eta_{it}}$. Estimate again a standard SFM using the following equation :

$$\widehat{\eta_{it}} = b0 + u_{it} + v_{it} \quad \text{(c)}$$

u_{it} is also estimated the Jondrow et al. (1980) method.

Notice here we ignore the difference between the predicted values and the real values in equations (b) and (c) because the nonparametric random effect estimator is consistent. In addition, the added constants a0 and b0 in (b) and (c) are needed because the inefficiency components do not have zero mean, see Kumbhakar et al. (2014) for further details.

Appendix B : Complement on the estimation of the variance components in the matrix Ω

Parmeter and Racine (2018) suggest to estimate the variance components in (a) from the residuals of equation (2) by running a standard nonparametric estimation method following Baltagi (2008). Several estimators have been proposed in the literature.

Step 1: Estimate the cost function equation (2) by standard nonparametric method and calculate the residuals

$$\hat{\varepsilon}_{it} = ln(TC_{it}/p_{1it}) - \hat{\alpha}_O - \hat{m}(X_{it}) \quad (d)$$

Step 2: There are several ways to estimate the error component variances, see for example Baltagi (2008), in our case we use the two following equations:

$$var(\varepsilon_{it}) = \sigma_\mu^2 + \sigma_\eta^2 \quad (e)$$

$$var(\Delta\varepsilon_{it}) = 2\sigma_\eta^2 \quad (f)$$

We estimate the two variance[15] components by solving the two following equations (e) and (f):

$$\hat{\sigma}_\mu^2 + \hat{\sigma}_\eta^2 = \frac{1}{\sum_{i=1}^{N} Ti} \sum_{i=1}^{N} \sum_{t=1}^{Ti} (\hat{\varepsilon}_{it} - \bar{\hat{\varepsilon}})^2 \quad (g)$$

$$2\,\hat{\sigma}_\mu^2 = \frac{1}{\sum_{i=1}^{N}(Ti-1)} \sum_{i=1}^{N} \sum_{t=2}^{Ti} (\Delta\hat{\varepsilon}_{it} - \Delta\bar{\hat{\varepsilon}})^2 \quad (h)$$

Notice that other alternatives for the variance decomposition, all of them provide efficient estimates of the variance components.

Step 3 : Once $\hat{\sigma}_\mu^2$, $\hat{\sigma}_\eta^2$ estimated from (g) and (h), construct the matrix $\hat{\Omega}^{-1/2}$ (see Baltagi (2008)) and estimate equation (7) by running a nonparametric regression model.

[15] There is no need to decompose further these variances into their respective components (noise variances and inefficiecy variances) to estimate the nonparametric random effect model. The decomposition is obtained using Appendix A.