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THE IMPACT OF OIL PRICE CHANGES ON EFFICIENCY OF BANKS: AN APPLICATION IN THE MIDDLE EAST OIL EXPORTING COUNTRIES USING SORM-DEA

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Abstract. This paper presents a novel application of Data Envelopment Analysis (DEA) to analyze the impact of oil price changes on the efficiency of banks. Factors that affect the efficiency of banks have been of interest to researchers in various geographical regions. With a special focus on oil price changes, we investigate the determinants of bank efficiency in the Middle Eastern Oil-Exporting (MEOE) countries where macro-financial conditions are substantially affected by swings in oil prices. Our analysis consists of two stages: (i) measuring the efficiency scores of banks using the Semi-Oriented Radial Measure (SORM) DEA model, (ii) investigating the impact of alternative indicators of oil prices on the estimated efficiency scores after controlling for key bank-specific and country-specific variables. The analysis is based on an un-balanced panel data of banks operating in the Middle Eastern Oil-Exporting countries over the period of 2001–2011. Our findings reveal that oil price changes affect the efficiency of banks in the MEOE countries through both direct and indirect channels. In addition, we find that Islamic banks in the region are less responsive to oil price changes than commercial and investment banks.

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1. Introduction

Banks are the most evident financial institutions that provide a range of financial services in their primary role as an intermediary to lenders and borrowers of money. They also provide sophisticated tools concerned with credit and liquidity provision, risk management, and remittance of funds that are vital for the economy of a country. Measuring the efficiency of banks and identifying the factors that affect their efficiency are of major interest to regulators, policy makers, stakeholders, investors, and the general public [55].

Oil price movement, as an external factor that influences the performance of banks, may affect macroeconomic events, which in turn, significantly influence the cash flows in the finance and the banking industries. Examining the performance of banks and how oil price movement impacts their performance is relevant to not only bank managers but also policy makers, particularly those that are operating in oil-exporting countries [123].

Keywords. Data Envelopment Analysis, bank efficiency, oil price changes, the Middle Eastern oil-exporting countries.

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This paper empirically examines the effect of the changes in the price of oil on the efficiency of banks under different operational styles for the first time. We utilize data from eight oil-exporting countries in the Middle East with a relatively large sample of unbalanced panel data comprising 899 observations over 2000–2011. First, we examine and compare the efficiency of commercial, investment, and Islamic banks in the Middle Eastern Oil-Exporting (MEOE) countries. Second, we investigate the impact of oil price changes, namely oil price shocks, oil price volatility, inter-annual changes of oil prices, and oil income dependency on the efficiency of banks in the MEOE countries and explore whether this impact is direct or indirect. Third, we identify if oil price changes impact the efficiency of banks, and subsequently, which type of banks have been affected the most. Therefore, we apply a two-stage methodology to examine the impact of oil price movements on the efficiency of banks. In the first stage, the efficiency scores of banks are calculated by employing the Semi-Oriented Radial Measure Data Envelopment Analysis (SORM-DEA), which is appropriate in the presence of negative input and output values. In the second stage, to find out the impact of oil price changes on the performance of banks, the efficiency scores obtained from the first stage are regressed over the variables representing the oil price changes and the environmental variables.

The main rationale for doing this research is the gap in the literature on both bank efficiency and oil price changes. We review the literature from two perspectives: firstly, the efficiency of banks and factors influencing it and, secondly, the oil price changes and their relationship to economic indicators and financial systems. From the first perspective, there have been several valuable studies on bank efficiency using cross-country panel data, investigating the impact of different environmental variables on bank efficiency alongside a vector of bank-specific and country-specific variables. However, there is only one study [127] on the relationship between oil prices and efficiency banks. In the model applied by Said [127], oil price is considered as a dependent variable and the efficiency of banks as the independent variable where only Islamic banks are included in the sample. The impact of environmental variables is not considered and traditional DEA is applied to obtain the efficiency scores. From the second perspective, the literature is rich with many studies that explore the relationship between oil prices and key economic factors and financial services. However, there is only one paper [123] that studies the influence of positive oil price shocks on the profitability of banks, which is although related, different from the efficiency of banks. Thus, a gap in the literature of oil price studies is observed. This research complements the existing literature by analyzing the impact of oil price changes on the bank efficiency using the SORM-DEA technique.

Moreover, we have objective reasons for being interested in the banks operating in the MEOE countries. Firstly, banks are channels for the transfer of oil funds to companies and households. Therefore, they are influential determinants of financial stability and capital allocations. Secondly, these countries are major oil exporters in the world energy market and the performance of many industries may be susceptible to the oil price movements. Thirdly, oil income injected into the economies of these countries makes the markets of these countries promising for international portfolio diversification. Finally, the banking industry of these countries is the home of Islamic banking in the world, so it is an appropriate sample for studying the impact of oil price changes on the performance of banks with different operational styles (commercial, investment, and Islamic). Therefore, this study identifies the impact of oil income and oil price changes on the efficiency of banks operating in oil-income-dependent countries and explains this impact on the efficiency of banks with different operational styles for the first time.

We summarize our contribution to knowledge in measuring efficiency in the banking field along five dimensions: (i) this is the first study in the bank efficiency (both parametric and non-parametric) considering the influence of both positive and negative oil price changes including oil price shocks, oil price volatility, inter-annual oil price changes, and oil income dependency on the efficiency of banks operating under different operational styles (ii) we employ an innovative step by step two-stage methodology to study the direct and the indirect influence of oil price changes on the efficiency of banks (iii) we consider the possible effects of financial and political crises in the region while studying the impact of oil price changes on the efficiency of banks (iv) this study is the first application of the SORM-DEA technique in the presence of negative data (v) we use a recent sample of banks operating in the Middle East oil income dependent countries.

The reminder of the paper is structured as follows. Section 2 provides a brief literature review on the determinants of bank efficiency. Section 3 describes the data and defines the variables used to calculate the efficiency scores, while Section 4 explains the conceptual framework and specifies the models for estimation. The empirical results are reported in Sections 5 and 6 presents concluding remarks and summarizes policy and managerial implications.

2. Literature review

We review the literature from two different perspectives: firstly, the efficiency of banks and factors influencing it and secondly, the oil price movement and its relationship to economic indicators and financial systems. From the first perspective, the performance of banks has been measured by two approaches in the literature: accounting-based and economic-based. In the first approach, comprehensive information from financial statements such as the return on assets or the return on equity is analyzed to determine the profitability of banks. The second approach uses an efficiency concept that is measured by the distance from the ideal frontier. The ideal frontier is made of the highest profit or the lowest cost banks in the sample.

A large body of literature measures the efficiency of banks operating in specific countries by applying parametric (*e.g.* [9,19,100,142]) and non-parametric techniques [47,57,79,80]; Avkiran, 2006; [17,71,91,118,146] while some studies investigate the efficiency of banks in cross-country studies (*e.g.* [19,25,26,31,32,39–41,122,147]). In a survey, Lampe and Hilgers [97] apply a document co-citation analysis and identify that banking field is one of the most influential application areas of the DEA and the Stochastic Frontier Analysis (SFA). Emrouznejad and Yang [51] state that the banking field is the second application field that uses the DEA methodology in 2015 and 2016. Kaffash and Marra [88] review DEA methods and its applications in financial services. DEA is a non-parametric technique that constructs a piece-wise surface of the best-performing decision-making units (DMU) and the efficiency of other units is measured as the distance from the surface [35]. On the other hand, SFA [1,107], a parametric model, has its starting point in the stochastic production frontier models and assumes that deviations from the frontier include inefficiencies and random errors [3].

Table 1 summarizes 50 recent papers studying the impact of environmental variables on the efficiency of banks using DEA and SFA models from 1999 to November 2016 from the Web of Science (WoS) academic database. Because of the nature of our study we focus only on the country-level studies including both single- and cross-country studies.

Table 1 presents firstly, the key findings of previous studies that examine the impact of environmental factors such as competition, financial regulation, financial liberalization, risk, ownership, and acquisition on the efficiency of banks using DEA, SFA, SDF, and Malmquist Productivity Change Index together with some new models of DEA for measuring the efficiency of banks. Secondly, no matter how the efficiency of banks is measured, the impact of several environmental variables on bank efficiency has been examined. In fact, no study explores the impact of oil price changes on the efficiency of banks despite its impact on the economy and financial services. Thirdly, different approaches are applied for estimating the impact of the environmental variables on bank efficiency. Some early studies simply observe and compare the impact of the environmental variables by grouping the banks. For instance, Sathye [128] studies the impact of ownership on the efficiency of Indian banks or Mukherjee *et al.* [113] study the impact of deregulations on the efficiency of the US banks. In some studies, which SFA is used to measure the efficiency, the exogenous variable is included in the cost function. Lensink *et al.* [100] add a proxy for the environmental variable in transcendental logarithmic cost function and Girardone *et al.* [57] include output variables in the cost function. Tecles and Tabak [142] use Bayesian models to account for the impact of ownership and non-performing loans on the efficiency of banks and Tsolas and Vincent [143] apply the stochastic controllable input variable model for observing the impact of non-performing loans on the efficiency of banks.

However, in most of the DEA studies in Table 1, the approach discussed by Coelli *et al.* [42] is employed to examine the impact of environmental variables on the efficiency. This approach is a two-staged approach, where in the first stage an efficiency score is obtained from DEA and in the second stage the estimated efficiencies are

TABLE 1. A survey of studies examining the impact of environmental factors on the efficiency of banks.

Author and year	Environmental factor	Sample of study	Method	Result
Akhigbe and McNulty [3]	Structure-performance factors, relationship-development factors, and expense-preference behavior	USA, 1990–1996	SFA	Efficiency increases as the size of the bank increases and is negatively related to the conditions associated with expense-preference behavior.
Akhigbe *et al.* [4]	Ownership	USA, 1996–2010	SFA	The difference in profit efficiency between public and private banks in the period of the study is slightly less than one percentage point
Akin *et al.* [5]	Foreign *vs.* domestic	Turkey, 2007–2010	Bootstrapping DEA	Efficiencies of foreign banks are higher than those of domestic banks both before and after managerial inefficiencies are eliminated. Foreign banks are highly efficient during the global financial crisis, once the managerial inefficiencies are removed.
Altunbas *et al.* [9]	Risk	Japan, 1993–1996	SFA	Optimal bank size is considerably smaller when risk and quality factors are considered, the level of financial capital has the biggest influence on the scale efficiency and X-inefficiency estimates, in contrast, it appears less sensitive to risk and quality factors.
Ariff and Can [12]	Ownership	China, 1995–2004	DEA	Joint-stock banks are more cost- and profit-efficient than state-owned banks.
Ataullah *et al.* [13]	Financial liberalization	India and Pakistan, 1988–1998	DEA	During financial liberalization banks are relatively more efficient in generating earning assets than income.
			DEA	Develops foreign bank efficiency models for particular application in data envelopment analysis
Avkiran [15]	Mergers and acquisitions	Australia, 1986–1995	DEA	Acquired banks are more efficient.
Banker *et al.* [17]	Banking system reform	Korea, 1995–2005	DEA	Regulatory changes aimed at strengthening the banks' capital structure and risk management practices do not have a uniform impact on bank productivity.
Barra *et al.* [18]	Risk and Regulation (2008 crisis)	Italy, 2006–2010	DDF	The 2008 crisis was significantly detrimental, in particular for cooperative banks. The deteriorating relative efficiency of cooperative banks attenuates when indicators of territorial diversification is included in the banks' production set.
Beccalli *et al.* [20]	Stock performance	France, Germany, Italy, Spain, the United Kingdom, 2000–2001	SFA, DEA	Changes in efficiency are reflected in changes in stock prices and the stocks of cost efficient banks tend to outperform their inefficient counterparts.

Table 1. Continued.

Author and year	Environmental factor	Sample of study	Method	Result
Beccalli [19]	Investment in information technology (IT)	France, Germany, Italy, Spain, the United Kingdom, 1995–2000	SFA	Little relationship exists between total IT investment and improved bank profitability or efficiency.
Belke *et al.* [21]	Regional growth	Europe, 2000–2013	SFA	Relatively more profit efficient banks foster growth in their region. The link between financial quality and growth is valid in normal and in bad times.
Bonin *et al.* [25]	Ownership	Eleven transition-economy countries; 1996–2000	SFA	Foreign-owned banks are more cost-efficient than other banks.
Bonin *et al.* [26]	Privatization	Bulgaria, the Czech Republic, Croatia, Hungary, Poland and Romania, 1994–2002	SFA	Foreign-owned banks are more efficient than government-owned banks, both the method and the timing of privatization affect performance.
Canhoto and Dermine [30]	New *vs.* old	Portugal, 1990–1995	DEA	New licensed banks dominate the old ones in terms of efficiency
Casu and Girardone [31]	Competition	France, Germany, Italy, Spain, the United Kingdom, 2000–2005	DEA	Increase in the efficiency does not foster market power and monopoly power may have a positive effect on efficiency if it enables banks to operate at lower costs
Casu and Molyneux [32]	Acquisition	Europe, 1995–2000	DEA	Domestic deals are more motivated by cost efficiency considerations than cross-border bank deals.
Chan *et al.* [33]	Risk	East Asia, 2001–2008	DEA	Bank insolvency risk is positively related to profit efficiency, while interest sensitivity, size, equity to total assets and Off-Balance-Sheet (OBS) exposures all impact cost efficiency.
Chen and Yeh [37]	Ownership	Taiwan, 1990–1998	DEA	Publicly-owned banks have a lower level of technical efficiency.
Chiu and Chen [38]	External environmental risk and internal risk	Taiwan, 2002–2004	Three stage super SBM-DEA	The influence of external environmental adjustment toward the efficiency of the mixed banks is the largest, followed by publicly owned banks, and for privately owned banks there is almost no change.
Chortareas *et al.* [41]	Bank supervision, regulation	22 European countries, 2002–2008	DEA	Strengthening capital restrictions and official supervisory powers can improve the efficiency of banks.
Chortareas *et al.* [40]	Financial freedom	27 European countries, 2001–2009	DEA	The higher is the degree of an economy's financial freedom, the higher are the benefits for banks in terms of cost advantages and overall efficiency.

TABLE 1. Continued.

Author and year	Environmental factor	Sample of study	Method	Result
Chortareas *et al.* [39]	Financial deepening	Latin America, 1997–2005	DEA	Financial deepening has in general a positive effect on the efficiency.
Denizer *et al.* [46]	Financial liberalization	Turkey, 1970–1994	DEA	Liberalization programs were followed by an observable decline in efficiency.
Drake *et al.* [47]	Regulatory policies	Hong Kong, 1995–2001	DEA	The failure to account for the impact of external factors can have a marked impact on relative efficiency scores, ranks, and trends in efficiency levels over time, both across the whole sector and across differential size and institutional groupings.
Girardone *et al.* [57]	Risk, Capital, Non-performing loans, Post-regulation period	Italy, 1993–1996	SFA	Inclusion of risk in the cost function seems to reduce the significance of the economies of scale in the estimates.
Guzman and Reverte [61]	Shareholder value	Spain, 2000–2004	Malmquist Total Factor Productivity Change Index	Banks with higher efficiency and productivity changes have a higher shareholder value, even after controlling for the impact of traditional measures of performance, such as return on assets.
Hao *et al.* [67]	Regulatory reform/liberalization	Korea, 1985–1994	SFA	No positive relationship exists between banking reforms and the efficiency of banks.
Hasan and Marton [68]	Development during transition	Hungary, 1993–1998	SFA	Early reorganization initiatives, flexible approaches to privatization, and liberal policies towards foreign banks' involvement with the domestic institutions help to build a relatively stable and increasingly efficient banking system.
Hauner [69]	Private *vs.* State-owned banks	Germany, Austria, 1995–1999	DEA	State-owned banks are found to be more cost-efficient.
Havrylchyk [71]	Foreign *vs.* domestic	Poland, 1997–2001	DEA	Greenfield banks achieve higher levels of efficiency than domestic banks, foreign banks that acquired domestic institutions fail to enhance their efficiency.
Hermes and Nhung [72]	Financial liberalization	Latin America and Asia, 1991–2000	DEA	There is strong support for the positive impact of financial liberalization programs on bank efficiency.
Hou *et al.* [75]	Market structure, risk taking	China, 2007–2011	DEA	The intense market competition compels Chinese commercial banks to develop advanced technical experience and skills, thus improving their technical efficiency.
Isik and Hassan [79]	Financial disruption	Turkey, 1992–1996	Malmquist Total Factor Productivity Change Index	Foreign banks suffer the most from the crisis compared to public banks and crisis affects all sizes of banks dramatically.

TABLE 1. Continued.

Author and year	Environmental factor	Sample of study	Method	Result
Isik and Hassan [80]	Financial deregulation	Turkey, 1981–1990	Malmquist Total Factor Productivity Change Index	Malmquist Total Factor Productivity Change Index explains the productivity growth, efficiency change, and technical progress in Turkish commercial banks during the deregulation of financial markets in Turkey.
Jiang *et al.* [81]	Governance changes	China, 1995–2005	Stochastic Distance Function (SDF)	Joint-stock ownership is associated with better performance than state ownership; strong effects are found for both foreign acquisition and going public.
Lensink *et al.* [100]	Ownership and quality of institutions	105 countries, 1998–2003	SFA	Foreign ownership negatively affects bank efficiency and quality of the institutions in the home country. Higher similarity between home and host country institutional quality reduces foreign bank inefficiency.
Lozano-Vivasa and Pasiouras [101]	Non-traditional activities	87 countries, 1999–2006	SFA	On average, cost efficiency increases irrespective of whether we use OBS or non-interest income.
Lozano-Vivasa *et al.* [102]	Macroeconomic and Bank-specific variables	10 European countries, 1993	DEA	The worse are the macro-economic conditions of a country, the greater are the changes in the efficiency scores.
Matthews [104]	Risk management	China, 2007–2008	Network DEA	There is an indirect relationship between risk management practices, risk management organization and the efficiency scores revealed within a network DEA.
Mukherjee *et al.* [113]	Deregulation	USA, 1984–1990	DEA	Larger asset size and specialization of product mix is associated with higher productivity growth while higher equity to assets ratio is associated with lower productivity growth.
Ozkan-Gunay *et al.* [116]	Regulatory policies	Turkey, 2002–2010	DEA	Regulatory policies have a positive effect on the efficiency of banks.
Pastor [122]	Credit Risk	France, Germany, Italy, Spain, 1988–1994	DEA	A positive relationship is found between the Return on Equity and efficiency.
Rezitis [126]	Mergers	Greece, 1993–2004	SFA	The effects of mergers and acquisition on technical efficiency and total factor productivity growth of Greek banks are rather negative.
Sathye [128]	Ownership	India, 1997–1998	DEA	Efficiency of private sector commercial banks is paradoxically lower than that of public sector banks and foreign banks.
Staub *et al.* [135]	Ownership	Brazil, 2002–2007	DEA	State-owned banks are significantly more cost efficient than foreign, private domestic and private with foreign participation.
Sturm and Williams [137]	Post-deregulation and foreign bank entry	Australia, 1988–2001	DEA, SFA	Foreign banks are more efficient than domestic banks, which however does not result in superior profits. Bank efficiency increases post-deregulation.

Table 1. Continued.

Author and year	Environmental factor	Sample of study	Method	Result
Sun and Chang [140]	Risk	Eight emerging Asian countries, 1998–2008	SFA	Risk measures represent significant effects on both the level and the variability of bank efficiency; also, these effects vary across countries and over time.
Tecles and Tabak [142]	Size, ownership and non-performing loans	Brazil, 2002–2007	SFA	Large banks are the most cost- and profit-efficient ones; foreign banks achieve a good performance through either the establishment of new affiliates or the acquisition of local banks; there is a positive impact of capitalization on efficiency.
Tsolas and Charles [143]	Risk, Non-performing loans)	Greece, 2003	Satisficing DEA	Both limited liability partnerships and haircut losses on Greek bonds are incorporated into the analysis. Greek bonds held by the banks have an important impact on the risk level of the bank portfolio.
Widiatro and Emrouznejad [148]	Microfinance Institutes	Islamic Microfinance Institutes, 2009–2010	Two-stage DEA	Conventional MFIs surpassed Islamic/window MFIs in financial and social efficiency under output-orientated strategy in global, EAP and SA meta-frontiers, in pure overall efficiency in MENA meta-frontiers, and in financial efficiency under input-orientated in SA meta-frontier
Widiarto and Emrouznejad [148]	Regulation status, legal format, choice of loan method	Islamic Microfinance Institutes, 2003–2012	Two-stage DEA	Different frontiers may have different preferences due to different environment and several loan methods and method combinations can exhibit equivalent performance in different frontiers
Weill [147]	Size, Specialization	France, Germany, Italy, Spain, Switzerland, 1992–1998	SFA, distribution-free approach and DEA	A negative relationship exists between competition and efficiency in EU banking sector.
Xiaogang *et al.* [149]	Deregulation	China, 1993–2000	DEA	The financial deregulation of 1995 improves the cost efficiency levels including both technical and allocative efficiency.

regressed on environment variables (*e.g.* [32, 40, 41, 72, 75, 81]). Therefore, in this study we follow the wide-used two-stage DEA where we initially obtain the efficiency scores for the banks in our sample and then regress these efficiency scores on oil price changes variables and environmental variables.

From the second perspective, the changes in the price of oil as a significant source of energy have the highest impact on macroeconomic indicators: economic growth, inflation, unemployment, exchange rate, interest rate, and financial systems (*e.g.* the monetary system and the stock market). Lee *et al.* [99] and Hamilton [64] employ several asymmetric non-linear transformations of oil price changes instead of a simple linear one. Hamilton [63] states that an entirely linear relationship between oil price and economic growth cannot be expected. Gisser and Goodwin [58] find a significant impact of crude oil prices on the US economy. Mork *et al.* [112] study the correlation between oil price increases and GDP in seven OECD countries (Canada, France, Japan, Norway, West Germany, the UK, and the US). Their results show a significant negative correlation for all of these countries, except Norway, which is an oil-income-dependent country. Cunado *et al.* [44] investigate this relationship for six Asian countries. Their results suggest that oil prices have a significant effect on both economic activity and price indexes. Berument *et al.* [23] examine the impact of oil price shocks on the MENA economic growth and find that oil price shocks have statistically significant and positive effects on the growth of countries that are net exporters of oil.

From an empirical point of view, a large body of literature shows that the output and the inflation are affected by oil price changes [64–66, 73, 74, 77, 89, 111, 112, 141]. In these studies, the influence of the changes in the price of oil on the inflation is joined with factors like business cycles, exchange rates, interest rates, and monetary policies. Cologni and Manera [43] study the effects of oil prices on inflation. By implying a co-integrated vector-auto-regressive (VAR) framework for G-7 countries they state that one of the consequences of the oil price shock is an increase in inflation. Cunado *et al.* [44] investigate the impact of the oil price shock on inflation by using two proxies. They find that when oil price is measured using the world oil price index, the impact is higher than when it is measured using the national real price currency, which may be due to the role of exchange rates.

Uri [144] examine the structural stability of the relationship between the volatility of oil prices and the changes in agricultural employment over the period 1947–1997. His results show a stable relationship between oil prices and agricultural employment. Guo and Kliesen [60] examine the impact of oil price volatility on key US macroeconomic indicators such as fixed investment, consumption, and employment over the period 1984–2004 and they reaffirm previous findings. Papapetrou [117] examine the dynamic interactions between real oil prices, interest rates, industrial production, real stock returns, and employment for Greece. In his study, he estimates employment and industrial production and concludes that oil price has a significant effect on economic activities and employment.

Chen and Chen [36] examine the possibility of any long-run equilibrium relation between real exchange rates and real oil prices. Using a monthly panel data for the G7 countries from 1972 to 2005 they discover a co-integrating relationship between oil prices and real exchange rates. Jones and Kaul [86] use the cash flow dividend valuation model to test the reaction of international stock markets to oil price shocks in Canada, UK, Japan, and the US. They find that the stock market reactions in the US and Canada can be entirely accounted for as an impact of oil shocks on cash flows; whereas for Japan and the UK, these test results are inconclusive. Poghosyan and Hesse [123] study the relationship between oil price shock and bank profitability. In the study, the profitability of banks are measured by the simple financial ratio of Return on Assets and the methodology uses dynamic panel data due to the persistent nature of the dependent variable (profitability). Poghosyan and Hesse [123] only study the impact of positive oil price changes and find that oil price shocks influence the performance of banks positively.

3. Sample and variables

In this section, we present the inputs and the outputs used to obtain the efficiency scores and also the contextual variables (bank-specific and country-specific variables) used to control for the type of banks and the changes in the price of oil. Our explanations include how we retrieved and synthesized the necessary data from existing databases.

3.1. Sample

The dataset in this study is composed of unconsolidated statements of individual banks operating in eight oil-exporting the Middle Eastern countries (Bahrain, Iraq, Iran, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates) sourced from the Bank-Scope database of the Bureau van Dijk and the Fitch Ratings. We excluded Jordan from the analysis as it is not an oil exporting country and we excluded Syria, Egypt, and Yemen due to the ongoing political instability in these countries. The database covers information on the

TABLE 2. Operational styles of banks in the Middle Eastern oil exporting countries 2000–2011.

Operational style	Quantity
Central bank	8
Commercial Bank	70
Finance companies (Credit card, factoring and leasing)	9
Investment and trust corporations	4
Investment banks	37
Islamic banks	75
Multi-lateral government banks	1
Other non-banking credit institutions	11
Private banking and asset management companies	3
Real estate and mortgage banks	4
Specialized governmental credit institutions	7

TABLE 3. Number of banks operating under different operational styles in the study.

Country	Total number of banks	Commercial banks	Investment banks	Islamic banks
Bahrain	21	7	5	9
Iraq	9	4	3	2
Iran	8	0	0	8
Kuwait	9	6	0	3
Oman	6	6	0	0
Qatar	10	6	0	4
Saudi Arabia	12	7	2	3
UAE	22	15	2	6
Total	98	51	12	35

Source: Bank-scope

detailed balance sheet, income statement, and 36 pre-calculated financial ratios of 32 000 banks. The country-level aggregate data are retrieved from the World Bank database. Oil price data are obtained from the Bloomberg database. The Bank-Scope provides 18 different operational styles for banks. Table 2 presents 11 of these operational styles as observed in the MEOE countries and corresponding the number of banks in operation.

As Table 2 illustrates, commercial banks, investment banks, and Islamic banks have the highest frequency among all 11 operational styles that are available in the MEOE countries and we focus on the three most common operational styles: commercial banks, investment banks, and Islamic banks with 182 banks accounting for 79% of all banks in the MEOE countries. Following Jiang *et al.* [82] and Zhang and Matthews [150] we also scrutinize the data by selecting the banks that have data for at least 5 consecutive years. This helps to obtain a relatively homogenous dataset. Applying this screening, our data is comprised of 899 observations form 98 banks including 51 commercial banks, 35 Islamic banks, and 12 investment banks. Table 3 presents the distribution of these three operational styles of banks over eight countries.

3.2. Bank efficiency

The DEA is widely used in the efficiency literature in many areas in both public and private sectors. Using DEA in banking enables us to identify the best practice banks from the efficient non-parametric frontier. We specify our model based on the intermediation approach [129], which consists of a combination of the financial intermediation theory and the microeconomics of bank production. Under this approach, banks provide financial services to account holders and are considered as intermediaries between the liability holders and the receivers

TABLE 4. Correlation coefficients between inputs and outputs.

	Inputs			Outputs	
	Deposit	Fixed Asset	Equity	Net Income	Loans
Deposit	1.000				
Fixed Asset	0.630	1.000			
Equity	0.877	0.573	1.000		
Net Income	0.724	0.550	0.796	1.000	
Loans	0.959	0.615	0.876	0.706	1.000

TABLE 5. Descriptive analysis of input and output variables (in Million USD).

Variable	Mean	Standard deviation	Minimum	Maximum
Inputs				
Deposit	7 007 599	10 225 453	3630	69 172 564
Fixed asset	151 290	325 884	27	2 753 051
Equity	1 128 986	1 519 967	7458	9 525 146
Outputs				
Net income	159 489	286 736	−1 302 772	1 967 547
Loans	5 170 535	7 871 008	108	58 438 202

of the bank funds [108]. This approach views banks as intermediaries that employ labor, physical capital and deposits to produce different types of loan accounts and income. However, data on labor is either missing or unavailable for some sample banks, especially for most Iranian and Iraqi banks. Considering the sample size and consistency among eight countries and following the other studies in the emerging markets with the same situation [49, 140] we consider three inputs: (i) fixed assets (property, plant, and equipment), (ii) total deposits (total customer deposits, deposits from banks, other deposits, and short-term borrowings) (iii) total equity (common equity, non-controlling interests, securities revaluation reserves, foreign exchange revaluation reserves, other revaluation reserves), and we use two outputs: (i) total loans (sum of different loans' maturity granted by the bank) (ii) net income (pre-taxed profit). We deflate the data with the consumer price index to convert nominal values into constant 2005 US dollars. Furthermore, to justify the inclusion of these inputs and outputs in the model, we run correlation analysis between inputs and outputs. Charnes *et al.* [34] state that inputs and outputs should meet the isotonicity requirement, *i.e.*, increasing inputs should lead to higher outputs. To test whether this is the case in our data, we conduct correlation analysis between inputs and outputs. The correlation coefficients are reported in Table 4, which shows that the data meet the isotonicity condition since there are positive and significant relationships between each of the three inputs and outputs.

The correlation coefficients reported in Table 4, shows a high correlations between inputs and outputs, the low correlation within inputs (outputs) which illustrates very little multicollinearity and reduces redundancy. The descriptive statistics for the inputs and the outputs are presented in Table 5.

Table 5 shows that the inputs and the outputs vary over the period of study. For instance, the minimum value of fixed assets is USD 27 million whereas the maximum value is USD 2 753 051 million with an average of USD 151 290 million and a standard deviation of USD 325 884 million. This high variation and the high standard deviation for all variables reflect the heterogeneity among the banks included in the data set. Considering the long period of analysis and the data of banks operating in eight countries, such variation is expected. Since the DEA models are sensitive to the values of the observations, it is likely to find significant levels of variation in the efficiencies.

3.3. Oil price changes variables

Following Korhonen and Ledyaeva [95], we define oil price as the ratio of the simple average of three monthly and quarterly crude oil prices: UK Brent (EUCRBREN), Dubai (PGCRDUBAI), and West Texas Intermediate (USCRWTS) in US dollars per barrel to the US GDP deflator (2005). These three crude oil prices are obtained from the Bloomberg database. In the context of the methodology followed here, the definition of real price represents a common shock to all countries. The dependent variable and environmental variables used in this research are yearly data; thus, we use the yearly oil price data. Following Kaffash [87] to proxy the changes in the price of oil in the MEOE countries, we identify four variables: Oil price shock, oil price volatility, inter-annual changes of oil prices, and oil income dependency and explain them as follows.

Oil price shocks

The asymmetric specification proposed by Mork [111] distinguishes between positive and negative oil price changes. Following Mork [111] and Hamilton [64] positive and negative oil price shocks are defined as follows:

$$\mathrm{ROILP}_t^+ = \max(0, \left(\ln \mathrm{oilp}_t - \ln \max\left(\mathrm{oilp}_{t-1}, \mathrm{oilp}_{t-2}, \mathrm{oilp}_{t-3}, \mathrm{oilp}_{t-4}\right)\right) \tag{3.1}$$

$$\mathrm{ROILP}_t^- = \min(0, \ln \mathrm{oilp}_t - \ln \min(\mathrm{oilp}_{t-1}, \mathrm{oilp}_{t-2}, \mathrm{oilp}_{t-3}, \mathrm{oilp}_{t-4})), \tag{3.2}$$

where $\ln \mathrm{oilp}_t$ is the natural logarithm of the quarterly real price of oil at time t, ROILP_t^+ is a yearly positive oil price growth; ROILP_t^- is a yearly negative oil price growth. Mork [111] demonstrates that there is an asymmetry in oil price increases and decreases. Thus, this oil proxy has been used widely in research studies considering the effect of oil price shock on macroeconomic variables.

Oil price volatility

Following Ferderer [54], we measure the oil price volatility by yearly standard deviation of monthly oil price.

$$\mathrm{OILPVOL}_t = \left[\frac{\sum_{i=1}^{n}\left(\mathrm{oilp}_i - \overline{\mathrm{oilp}_t}\right)^2}{n-1}\right]^{1/2} \tag{3.3}$$

where n is the number of months (12) in a year t and $\overline{\mathrm{oilp}_t}$ is the average of monthly oil price in year t.

Inter-annual change of oil price

Following Cuñado and de Gracia [45], we present the evolution of the inter-annual changes of oil price data as

$$\varDelta \ln(\mathrm{OP}) = \ln \mathrm{oilp}_t - \ln \mathrm{oilp}_{t-4}, \tag{3.4}$$

where oilp_t is quarterly oil price data.

Oil income dependency

Oil income dependency, which measures the degree of dependence on oil income, is a ratio of oil export revenues to GDP.

Kaya [93] and later Bhattacharyya and Blake (2010) present the components of oil income dependency (OID) as follows:

$$\mathrm{OID} = \frac{\mathrm{OER}}{\mathrm{GDP}} = \frac{\mathrm{OER}}{\mathrm{OEV}} \times \frac{\mathrm{OEV}}{\mathrm{POS}} \times \frac{\mathrm{POS}}{\mathrm{PEC}} \times \frac{\mathrm{PEC}}{\mathrm{GDP}}. \tag{3.5}$$

In equation (3.5), OER is the oil export revenue (in constant US dollar terms, million); GDP is the Gross Domestic Product (in constant US dollar terms, million); OEV is the oil export volume (Mtoe); POS is the primary oil supply (Mtoe), and PEC is the primary energy consumption (Mtoe).

Table 6. Descriptive statistics of variables employed in the cross-sectional regression.

Contextual variables	Description	Mean	Std. dev	Min	Max
Bank-specific					
LIQ	Liquid assets ratio (% of total asset)	27.79	16.64	0[1]	91.31
EQT	Equity assets ratio (% of total asset)	11.38	10.25	4.77	65.45
LLR	Loan loss reserves ratio (% of total gross loans)	10.79	12.14	0	76.72
SIZE	Natural logarithm of total assets	13.12	1.59	10.09	18.23
Country-specific					
INF	Inflation, consumer prices (annual %)	5.16	6.59	−4.87	53.23
GDPG	GDP growth (annual %)	6.10	5.21	−5.15	26.17
HHI	Herfindahl Hirschman Index (in terms of bank assets) for market structure (%)	20	12	9	84
Oil price changes					
$\Delta \ln(\mathrm{OP})$	Inter-annual changes of oil prices	0.09	0.37	−0.84	0.54
ROILP_t^+	Positive oil price shocks	0.04	0.06	0.00	0.16
ROILP_t^-	Negative oil price shocks	−0.11	0.26	−0.89	0.00
OILVOL_t	Oil price volatility	0.14	0.08	0.06	0.37
OID	Net oil income/GDP (%)	37	13	15	65
Dummy					
GPC	Persian gulf political crisis (2003)				
GFC	Global financial crisis (2007–2009)				

Notes. [(1)]0.002. When the LIQ for a bank is close to zero, the bank may struggle to pay short-term obligations.

3.4. Environmental variables

The environmental variables used in this paper are bank-specific and country-specific. The values of bank-specific variables differ for individual banks over the research period while country-specific variables take the same value for each bank in each country but differ each year. Literature offers some guidelines about the selection of determinants that explain a specific feature of each country's banking industry and economic situation. Following Pasiouras and Tanna [120], Lozano-Vivas and Pasiouras [101], Casu and Girardone [31], and Chortareas *et al.* [41], we select capitalization, liquidity, credit risk and the size of the bank as bank-specific variables and market concentration, GDP growth, and inflation as country-specific variables.

For bank-specific variables, capitalization (EQT) is measured as the ratio of equity to total assets [94, 145], where a higher ratio indicates a lower bank risk. Following Hasan and Marton [68] we apply the ratio of liquid assets to total assets as a measure of liquidity (LIQ). A higher ratio suggests more liquidity, implying that banks are doing a better job in terms of liquidity management. Credit Risk (LLR) is expressed as the ratio of loan loss reserves to total loans [109] and a higher value implies a riskier loan portfolio. The size (SIZE) of the bank is estimated as the natural logarithm of the total assets [92].

Regarding country-specific variables, GDP growth (GDPG) and inflation (INF) are set to annual economic growth and consumer price index respectively. We measure market concentration by applying Herfindahl–Hirschman Index (HHI), which is defined as the sum of squared asset market shares of all banks in each country. In addition, since the period of study covers the Persian Gulf political crisis and the global financial crisis, we include two dummy variables to control for the possible effects of these crises in the results. Table 6 presents the definitions and the descriptive statistics of environmental and oil price change variables.

As Table 6 shows, the proxy variable for liquidity, the liquid assets to total assets, is on average 27.79% and the minimum observed liquidity ratio for the banks in the sample is 0%, which means that the liquid assets contribute to a small proportion of the total assets for a bank with a LIQ close to zero. The lowest EQT for the banks operating in the region in our sample is 11.38% while the highest EQT as a measure of capitalization is 65.45%. The lowest LLR is 0% and the highest is 76.72%, which means that the ratio of loan loss reserve to total gross loans varies between these two values for the MEOE countries over the period of study. In terms of size, the ln Total assetsrange from 10.09 to 18.23. The region's average inflation rate over the period of study is 5.16% and the GDP growth averages at 6.10%. Oil price volatility variable (OILVOL) represents higher fluctuations of oil prices compared to oil price shock variable (ROILP). The average of oil income dependency in the MEOE countries is 37%. GPC takes the value 1 for 2003 and the remaining values are zero whereas GFC takes the value 1 for 2007, 2008, and 2009 and the remaining values are zero.

4. Model specification and hypotheses

To examine the impact of changes in the price of oil on bank efficiency, we apply the widely used two-stage DEA method. DEA has been proven as an excellent data-oriented efficiency analysis method for comparing DMUs with multiple inputs and multiple outputs [10]. In the first stage, we derive an output-oriented variable returns to scale DEA to obtain the bank efficiency scores. DEA can be used to derive efficiency by using the constant returns to scale (CRS) or variable returns to scale (VRS). CRS assumes full proportionality between the inputs and outputs, while VRS does not assume this type of proportionality. Many scholars argue that CRS is only appropriate when all firms are operating at an optimal scale [55]. Since our sample includes banks operating in eight different countries and they may not be able to adjust to the optimal scale of banks operating in the other countries, therefore, we use the VRS approach to assess the efficiency of banks in our sample. For both CRS and VRS models, it is possible to estimate input-oriented or output oriented projections. Output-oriented CRS and input-oriented CRS generate exactly the same efficiency score [76]. The output-oriented model attempts to maximize the proportional increase in the output variables while remaining within the envelopment space. On the other hand, an input-oriented model maximizes the proportional decrease in input variables [46]. Following LaPlante and Paradi [98], Ataullah *et al.* [13], Ataullah and Le [14] we choose output-oriented VRS as input variables are largely uncontrollable. Bank managers have more control over the outputs than the inputs since they focus more on the demand for banks' products rather than controlling inputs. For example, they do not have control over the deposits, but they do control how much loan they lend. Therefore, we decide to use the output-oriented variable returns to scale approach. In the second stage of the analysis, the aim is to uncover, by means of regression methods, the underlying relationship between the bank efficiency scores and oil price changes while controlling for the above-introduced bank- and country-specific variables.

4.1. First stage: Estimating the efficiency using the SORM DEA

Following the work of Farrell [53], Charnes *et al.* [35] developed the DEA as a mathematical linear programming method that constructs a frontier of best performing units and measures the efficiency of other units in relation to this frontier.

As Table 5 illustrates, we have negative values for the net income variable in the output vector. The standard DEA model is applicable only to non-negative inputs and outputs. However, in many occasions, inputs and/or outputs may take negative and positive values. Recently, some approaches are presented in the literature to deal with the presence of negative data. Portela *et al.* [124] propose the Range Directional Measure (RDM), which uses a modified version of the generic directional distance model without the need for any transformation to handle negative variables. Sharp *et al.* [131] introduce the Modified Slack Based Measure (MSBM) which by drawing on the ideas from the range directional model (RDM) handles both "natural" negative outputs and negative inputs and overcomes the lack of translation invariance in the slacks-based measure. Emrouznejad *et al.* [50] propose a Semi-Oriented Radial Measure (SORM) for performance evaluation of the observed production units with negative values. The advantages of SORM over the previous models are that it represents each input–output variable essentially as the sum of two variables, one taking its negative value and the other its positive value. So, the negative part of a variable can be dealt with in absolute value terms and thus as a positive value without arbitrary changes of origin [103]. The SORM-DEA model has been successfully experimented in banking sector studies by Hadad *et al.* [62] and Matin *et al.* [103]. Hence, to apply the most appropriate model with the selected inputs and outputs in this study, we implement the SORM-DEA in the first stage of the analysis concerned with the efficiency elicitation. Consequently, in calculating the efficiency of each bank in a given year, a "common frontier" has been built by pooling the observations from 12 years instead of a "year specific" best-practice frontier. Following Lozano-Vivas *et al.* [102] by creating a pooled frontier, it is possible to measure and compare each of the observations for the 2001–2011 annual periods relative to the same frontier by treating each bank in each period as a different entity. Furthermore, a "common frontier" approach can provide a trend in the efficiency of a bank, which would not be available if a "year specific frontier" approach had been applied. Therefore, the "common frontier" approach provides variations in the efficiency of banks over both time and space. This comparison across time and countries is applied on the same principle as the use of global frontier in Portela and Thanassoulis [125].

We have n DMUs (DMU$_j$ where $j = 1, \ldots, n$) each associated with m *positive* inputs $x_j = (x_{1j}, \ldots x_{mj})$, s positive outputs $y_j = (y_{1j}, \ldots, y_{sj})$ and some outputs that may have negative values in at least one DMU. The related sets are $= \{1, \ldots, m\}$, $R = \{r \in \{1, \ldots, s\}\,;\, y_{rj} \geq 0 \forall j = 1, \ldots, n\}$ and $K = \{k \in \{1, \ldots, s\}\,;\, \exists j \in \{1, \ldots n\} \text{ for which } y_{kj} < 0\}$.

Emrouznejad *et al.* [50] defined y^1_{kj} and y^2_{kj} such that $y_{kj} = y^1_{kj} - y^2_{kj}$ and so that $y^1_{kj} \geq 0\, and\, y^2_{kj} \geq 0$ for each $k \in K$ where,

$$y^1_{kj} = \begin{cases} y_{kj} & \text{if } y_{kj} \geq 0 \\ 0 & \text{otherwise,} \end{cases} \quad \text{and} \quad y^2_{kj} = \begin{cases} -y_{kj} & \text{if } y_{kj} < 0 \\ 0 & \text{otherwise.} \end{cases} \tag{4.1}$$

To assess the DMU j_0 ($j_0 \in \{1, \ldots n\}$) Emrouznejad *et al.* [50] proposed the following output oriented variable returns to scale SORM-DEA model when DMUs have positive and negative values in some output variables.

$$\max \emptyset$$

$$\text{s.t.} \sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{ij_0} \qquad \forall i \in I \tag{4.2}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - \emptyset y_{rj_0} \geq 0 \quad \forall r \in R, \tag{4.3}$$

$$\sum_{j=1}^{n} y^1_{kj}\lambda_j - \emptyset y^1_{kj_0} \geq 0 \qquad \forall k \in K, \tag{4.4}$$

$$\sum_{j=1}^{n} y^2_{kj}\lambda_j - \emptyset y^2_{kj_0} \leq 0 \quad \forall k \in K, \tag{4.5}$$

$$\sum_{j=1}^{n} \lambda_j = 1, \lambda_J \geq 0, \qquad j = 1, \ldots, n \tag{4.6}$$

4.2. Second stage: Bank efficiency and oil price changes

Analyzing the contribution of environmental factors to efficiency differences is an intriguing area of research in DEA [151]. Coelli *et al.* [42] introduce the two-stage DEA, which the efficiency scores obtained of the first stage are regressed on the environmental variables using several regression models including but not limited to Ordinary Least Square, Fixed Effect, Random Effect, Tobit and Generalised Method of Moments. This approach has been widely used in the banking literature with numerous applications. However, Simar and Wilson [132] argue that in the two-stage DEA firstly, the covariates in the second-stage regression are obviously correlated with the one-side error terms from the first-stage. Secondly, the covariates in the second-step are likely to be (highly) correlated with the covariates in the first-stage. Therefore, the covariates and the errors in the first-stage cannot be independent. They proposed a double bootstrap procedure to overcome the drawbacks mentioned above. On the other hand, McDonald [106] demonstrates good arguments that the efficiency scores are not generated by a censoring process and are fractional data and Tobit is an inappropriate estimation procedure since it is an inconsistent estimator. However, it is appropriate for consistent estimators such as OLS, PW, QMLE if White's heteroskedastic-consistent standard errors are calculated, tests can be performed, which are valid for a range of disturbance distribution assumptions.

Therefore, in the second stage of our analysis we report the standard errors by Huber–White robust. To identify which regression model is the most suitable, we use several specification tests. First, we conduct the Lagrangian Multiplier (LM) test developed by Breusch and Pagan [28] to test for the existence of individual unobserved heterogeneity. The LM test enables us to compare the PLS model against the FE and the RE models. Second, we use the Hausman test proposed by Hausman [70] to compare the FE and the RE models. We conduct an F-test to examine the joint significance of all regressors, including the dummy variables. Finally we test for the assumptions underlying our model[4].

Hypothesis 1. *Oil price shocks have a positive impact on the efficiency of banks in the MEOE countries.*

Higher oil prices bolster the liquidity of governments and oil companies in the MEOE countries. This in turn improves the state of the economy [83,99] as well as the financial position of companies and financial institutions in the country [123]. Consequently, the demand for banking services increases while credit and liquidity risks of potential borrowers reduce. Therefore, oil price shocks are expected to be positively associated with bank efficiency in the MEOE countries. To test this hypothesis, we consider the following equation:

$$\begin{aligned} \mathrm{EFF}_{ict} &= \alpha + \beta \mathrm{OIL}_t + \gamma BS_{ict} + \delta D_t + \varepsilon_{ict} \\ \varepsilon_{ict} &= \mu_i + \delta_t + \epsilon_{ict}, \end{aligned} \tag{4.7}$$

where EFF_{ict} is the efficiency score of bank i in country c at time t, estimated in the first stage. OIL_t is oil price shocks for which we consider five different proxies, namely the net oil price increase ($\Delta \ln(\mathrm{OP})$), positive oil price shock (ROILP_t^+), negative oil price shock (ROILP_t^-), oil price volatility (OILVOL_t), and the oil export dependency (OID); BS_{ict} is the vector of bank specific variables; D_t is a vector of two dummy variables to control for the impact of the Persian Gulf crisis and the financial crisis; and ε_{ict} is the error. Equation (4.7) is a two-way error component regression model where $\epsilon_{ict} \approx \mathrm{IIN}(0, \sigma_\epsilon^2)$ and $\mu_i \approx \mathrm{IIN}(0, \sigma_\mu^2)$.

Hypothesis 2. *Oil price changes affect the efficiency of banks in the MEOE countries through both direct and indirect channels.*

Oil price fluctuations may affect the bank efficiency through both direct and indirect channels. In a direct channel, positive oil shocks may reduce the liquidity and the credit risk of borrowers and increase the demand for borrowing due to higher business activity. Furthermore, positive oil shocks are often associated with a rise in stock prices of oil-related companies. Accordingly, banks can benefit from their investments in the shares of oil-related companies as oil prices increase. Indirectly, as oil receipts form a large portion of the government income in the MEOE countries, a positive oil shock increases fiscal spending and improves overall business sentiment and expectations [123]. This in turn leads to higher bank lending, thereby higher corporate and bank profitability. Therefore, oil shocks are expected to affect bank efficiency through both direct and indirect channels. To test this hypothesis, equation (4.8) is developed as follows:

$$\begin{aligned} \mathrm{EFF}_{ict} &= \alpha + \beta \mathrm{OIL}_t + \gamma \mathrm{BS}_{ict} + \theta \mathrm{CS}_{ct} + \delta D_t + \varepsilon_{ict} \\ \varepsilon_{ict} &= \mu_i + \delta_t + \epsilon_{ict}, \end{aligned} \tag{4.8}$$

where CS_{ct} is a vector of country-specific variables, including inflation (INF), GDP growth (GDPG), and banking sector concentration (HHI).

[4]In order to justify that our data satisfies the assumption of our regression model, we firstly, use the normal probability plot of the residuals, to make sure that the residuals are normally distributed. Secondly, we used scatterplot of residuals against each predicted variables to test for independency of residuals against predictor variables. The plots show the random distributions of the data which satisfies the assumption of the regression.

Hypothesis 3. *Changes in oil prices have a non-uniform impact on the efficiency of banks in the MEOE countries depending on the operational style of the banks.*

Due to different missions and regulations, banking practices regarding funding resources, investment strategies, and services provided greatly vary among banks with different operational styles in the MEOE countries. As explained in Section 3, banks are classified as commercial banks, investment banks, and Islamic banks based on their operational style. In this context, different bank operational styles are expected to respond differently to oil shocks. One would expect Islamic banks to be less affected by oil shocks as they use more stable funding resources, such as Sukuk and Sharia-compliant deposits, while other bank types may use less stable funding resources, such as wholesale funding. Similarly, Islamic banks tend to be more risk-averse, compared to other types of banks, as they usually allocate their resources to relatively safer investments. Thus, to investigate whether oil shocks have a different impact on the efficiency of banks controlling for the bank operational style, we insert interaction terms for oil price shocks and operational style dummy variables. Accordingly, equation (4.9) is modified as follows:

$$\begin{aligned}\mathrm{EFF}_{ict} &= \alpha + \beta \mathrm{OIL}_t \times \mathrm{OD}_{ict} + \gamma \mathrm{BS}_{ict} + \theta \mathrm{CS}_{ct} + \delta D_t + \varepsilon_{ict} \\ \varepsilon_{ict} &= \mu_i + \delta_t + \epsilon_{ict},\end{aligned} \tag{4.9}$$

where OD_{ict} represents two dummy variables representing the operational style; $\mathrm{Islamic}_{ict} = 1$ if the bank is an Islamic bank, 0 otherwise; and $\mathrm{Investment}_{ict} = 1$ if the banks is an investment bank, and 0 otherwise.

5. Results and discussion

In this section, first we analyze the efficiency scores of banks operating in the MEOE countries. In the second part, we study the impact of oil price changes on the efficiency of banks.

5.1. First stage: SORM-DEA of bank efficiency

SORM-DEA output-oriented VRS technique is applied to measure the pure technical efficiency of banks in the MEOE countries. An output-oriented technique would be appropriate as the underlying assumption is the desirability of maximizing bank output rather than minimizing the resources used, since the initial inputs which include fixed assets and equity are the result of long term decisions rather than short term ones. Table 7 reports the results of the first stage and Table 8 shows the statistical tests.

Table 7 illustrates the times series of the mean of the efficiency scores for commercial, investment, and Islamic banks in the data set. The results show that the mean efficiency score is the highest for commercial banks and lowest for investment banks.

The results that commercial banks perform better than Islamic banks are in line with the finding of Johnes *et al.* [84, 85]. The literature presents other studies, which apply a non-parametric technique to compare the performance of Islamic *vs.* commercial banks in the region. Bader *et al.* [16] estimate and compare the cost, revenue and profit efficiency of commercial and Islamic banks in 21 countries over the period 1990–2005. They suggest that there are no significant differences between the two groups of banks. However, our findings contradict this conclusion while they support other earlier findings as follows: Some studies use parametric techniques for comparing efficiency of these two types of banks. For instance, Srairi [134] employs SFA and reports that the cost and the profit efficiency of commercial banks operating in the GCC countries are higher than Islamic banks in 1999–2007. Srairi [134] states that the higher level of efficiency of commercial banks *vs.* Islamic banks can be explained by the lack of economies of scale due to smaller size of Islamic banks. Johnes *et al.* [84] suggest that Islamic banks operate under Sharia-law and perform mainly customized contracts of equity-type (profit and loss sharing) or services-type (leasing agreements, mark-up pricing sale), which require conducting costly and time-consuming analysis of feasibility and profitability. Thus, Islamic banks face higher administration costs and operational risks compared to conventional banks. Olson and Zoubi [114] propose that the inefficiency of Islamic banks may be a result of customers' loyalty to Islamic banks regardless of the cost. Regarding the comparison

TABLE 7. Summary of banks' average efficiency by year and operational style.

Year	Commercial banks	Investment banks	Islamic banks	Number of banks
2000	0.66	0.62	0.58	52
2001	0.68	0.59	0.60	54
2002	0.65	0.56	0.61	56
2003	0.69	0.57	0.63	60
2004	0.70	0.57	0.62	63
2005	0.71	0.57	0.62	77
2006	0.73	0.57	0.63	83
2007	0.75	0.58	0.64	96
2008	0.72	0.58	0.64	96
2009	0.70	0.58	0.63	94
2010	0.71	0.58	0.63	91
2011	0.72	0.59	0.62	77
Mean	0.70	0.58	0.66	Total
Std. dev.	0.25	0.31	0.35	899

TABLE 8. Summary of bank efficiency scores by operational style.

	N	Mean	Std. deviation	Minimum	Maximum
Commercial	607	0.70	0.25	0.15	1.00
Investment	109	0.58	0.31	0.07	1.00
Islamic	183	0.66	0.35	0.10	1.00

TABLE 9. Analysis of variance (ANOVA test).

	Sum of squares	df	Mean square	F	Sig.
Between groups	1.784	2	0.0765	19.853	0.000
Within groups	37.186	896	0.039		
Total	39.682	898			

of the efficiency of investment banks with commercial banks and Islamic banks, the literature does not provide any evidence.

Table 8 presents descriptive statistics of bank efficiency scores with respect to bank operational style. It can be concluded from the Maximum column of Table 8 that there is at least one efficient bank in each operational style over the analysis period from 2000 to 2011.

In terms of the mean efficiency, commercial banks have a higher mean than the other two operational styles. Standard deviation of investment banks is higher compared to the other two, showing that the efficiency of investment banks has a higher variance than commercial banks and Islamic banks. To test the impact of bank operational style on the efficiency of banks, we run a one-way ANOVA test (Tab. 9) followed by the post-hoc test of Tukey's HSD (5.2). The results are illustrated in Tables 9 and 10.

For the analysis and interpretation of results, we work at $\alpha = 0.05$ significance level. The analysis of variance presented in Table 9 shows that the effect of bank operational style on the efficiency of banks is significant, $F(2, 896) = 19.853$, $p = 0.000$.

TABLE 10. Multiple comparison (Turkey HSD test).

	(I) Type 1	(J) Type 1	Mean difference $(I - J)$	Std. error	Sig.	95% confidence interval	
						Lower bound	Upper bound
Tukey HSD	1	2	0.17*	0.02	0.00	0.09	0.22
		3	0.08*	0.02	0.00	0.02	0.14
	2	1	−0.17*	0.02	0.00	−0.22	−0.09
		3	−0.10*	0.02	0.02	−0.14	−0.01
	3	1	−0.08*	0.02	0.00	−0.14	−0.02
		2	0.10*	0.02	0.02	0.01	0.14

Notes. (*)The mean difference is significant at the 0.05 level. Type 1: commercial banks, Type 2: Investment banks, and Type 3: Islamic banks.

The post-hoc test results presented in Table 10 suggests that the commercial banks have a statistically significantly higher mean efficiency than both investment and Islamic banks and Islamic banks have a statistically significantly higher mean efficiency than investment banks. This clear difference in the efficiency of banks with specific operational styles justifies controlling the results for operational style variable.

5.2. Bank efficiency and oil price changes

In the second stage of the analysis, we empirically test Hypotheses 1–3 by regressing bank efficiency against alternative proxies for oil price changes as well as the control variables described in Section 3. In doing so, we first test the Hypothesis 1 using model (4.7), and then examine the second and the third hypotheses by estimating models (4.8) and (4.9), respectively.

Table 11 illustrates the empirical results for model (4.7). Five estimated equations are reported, corresponding to five proxies defined for oil price changes. In other words, equations (3.1)–(3.5) in the following tables use OID_t, OILVOL_t, ROILP_t^+, ROILP_t^-, and $\Delta\ln(\mathrm{OP})_t$, respectively, as the proxy for oil price changes. Table 11 shows that oil income dependency has a significant and positive impact on bank efficiency in the MEOE countries. In fact, higher oil income bolsters financial and liquidity position of oil and non-oil companies, thereby reducing their default probabilities. In addition, with higher oil income, the oil-dependent economies of the MEOE countries can lower government debt, avoid budget deficit, and become more resilient to financial shocks. Therefore, more liquidity, combined with rising investor confidence, increases the demand for banking services and improves the financial health of bank customers, which in turn enhances the bank efficiency. Similar results are obtained when ROILP_t^+ and $\Delta\ln(\mathrm{OP})_t$ are considered, indicating that bank efficiency responds significantly to positive oil price changes. However, our empirical results reveal that bank efficiency is negatively associated with oil price volatility. This is not surprising as more volatile oil prices are often associated with less stable political and economic conditions ([54]), thereby undermining the bank efficiency.

In terms of capitalization, Table 11 shows that the estimated coefficient for EQT_{ict} is negative and significant at 5% in Four models and only for oil price volatility model which significant at 10%, meaning that higher capitalization is associated with lower bank efficiency. In other words, more efficient banks use more leverage (less equity) compared to their peers. These results are consistent with the findings of Akhigbe and McNulty [2] and Sufian [138]. One possible explanation for this negative relationship between bank capital and efficiency score is that higher capitalization may discourage a bank from undertaking risky but profitable investments, which makes them less efficient compared to their counterparts [72]. In addition, less efficient banks could be involved in processes that require holding more equity [138].

Furthermore, we don't find any significant relationship between liquidity ratio, LIQ_{ict}, and bank efficiency. Prior studies, such as Sufian and Habibullah [138], report a negative relationship between bank efficiency and the level of liquid assets. Altunbas and Marques [8] and Molyneux and Thornton [110] argue that maintaining a generous liquidity ratio is expensive and that liquidity holdings impose a cost on the bank, which in turn undermines their efficiency.

Table 11. Oil price changes and bank efficiency (bank-specific variables) – Hypothesis 1.

Dependent variable: EFF_{ict}	(1)	(2)	(3)	(4)	(5)
LIQ_{ict}	−0.108	−0.107	−0.098	−0.101	−0.103
	(0.089)	(0.092)	(0.097)	(0.097)	(0.095)
EQT_{ict}	−0.285**	−0.223*	−0.253**	−0.254**	−0.232**
	(0.118)	(0.103)	(0.122)	(0.125)	(0.115)
LLR_{ict}	−0.130**	−0.136*	−0.165*	−0.158*	−0.161**
	(0.199)	(0.203)	(0.185)	(0.184)	(0.201)
$SIZE_{ict}$	0.302**	0.317**	0.345***	0.344***	0.368**
	(0.087)	(0.052)	(0.051)	(0.051)	(0.048)
OID_t	0. 173***				
	(0.051)				
$OILVOL_t$		−0.169*			
		(0.094)			
$ROILP_t^+$			0.343***		
			(0.121)		
$ROILP_t^-$				0.086	
				(0.110)	
$\Delta\ \ln(OP)_t$					0.694**
(0.047)					
GPC_t	0.069**	0.067**	0.068**	0.067**	0.067**
	(0.030)	(0.031)	(0.031)	(0.030)	(0.031)
GFC_t	−0.023*	0.022	−0.029*	−0.022*	−0.029*
	(0.014)	(0.019)	(0.015)	(0.015)	(0.015)
Constant	0.572***	0.598***	0.674***	0.684***	0.575***
	(0.198)	(0.196)	(0.201)	(0.199)	(0.195)
Observations	899	899	899	899	899
R^2 – adjusted	0.251	0.244	0.257	0.248	0.252
Number of banks	98	98	98	98	98
LM test	543.46***	532.64.***	530.04.***	541.18***	517.62***
Hausman test	22.18***	20.13.99***	22.86***	21.39***	19.56***
F test	9.734	10.229	9.846	9.852	9.130

Notes. The dependent variable is bank efficiency (EFF) estimated by using the SORM-DEA output-oriented VRS method. All models are estimated using fixed effect estimators. Huber–White robust standard errors are reported in the parenthesis below the coefficient estimates. The Lagrangian Multiplier test (LM test) is used to test the RE model *vs.* the PLS, while the Hausman specification test is used to test the FE model *vs.* the RE model. (*)Coefficients are statistically significant at the 10% level. (**)Coefficients are statistically significant at the 5% level. (***)Coefficients are statistically significant at the 1% level.

Regarding the credit risk indicator, the results show that LLR_{ict} has a significant and negative impact on bank efficiency in all models. The results suggest that banks which hold lower ratios of loan loss reserves to total loans are more efficient. The amount of loan loss reserves reflects anticipated losses by bank managers and a larger LLR shows that a bank has put aside a higher portion of its assets for possible defaults in loan repayments. Since loan making is the main activity of most banks in the MEOE countries, higher loan losses are directly transmitted to lower bank efficiency. These results are consistent with the findings of Al-Muharrami [6] and El-Moussawi and Obeid [48] who demonstrate that bank efficiency is negatively associated with credit risk.

The estimated results in Table 11 also reveal that bank size has a positive and significant impact on the efficiency of banks in the MEOE countries. The results suggest that the larger the assets of a bank, the higher is its efficiency score. Olson and Zoubi [115] argue that larger banks are better equipped to adjust their optimal mix and scale of outputs, which makes them more efficient than their counterparts. Our empirical evidence regarding the positive relationship between size and efficiency is in line with the findings of Spathis *et al.* [133], Hauner [69], Kosmidou *et al.* [96], and Sufian and Habibollah [138].

Regarding GPC_t, our results show that Persian Gulf Political Crisis in 2003 has a positive and significant impact on the efficiency of banks. This finding could be explained by the fact that policy makers and regulators in the MEOE countries injected more liquidity into their capital markets to combat the crisis and prevent financial bankruptcy. Furthermore, we find that the impact of the global financial crisis, GFC_t, on the efficiency of banks is negative and only significant for models (1), (3) and (5), which indicates that banks operating in the MEOE countries were also affected by the global financial crisis through financial contagion.

So far we have concluded that oil prices have a direct impact on the efficiency scores of banks in the MEOE countries. However, one may expect that oil prices influence bank efficiency indirectly and via macroeconomic channels. Therefore, following Poghosyan and Hesse [123], we now estimate equation (4.8), which includes key country-specific variables to investigate whether oil prices affect bank efficiency through macroeconomic channels. Table 12 presents the empirical results for equation (4.8), which is testing Hypothesis 2. The estimated coefficients for all oil indicators, except for ROILP_t^-, are statistically significant. This again confirms that oil prices have a direct and significant impact on the bank efficiency in the MEOE countries.

More importantly, the results reveal that the estimated coefficients for the main macroeconomic variables, namely GDPG_{ct} and INF_{ct}, are also significant with expected signs. The results show that the estimated coefficient for GDPG_{ct} is positive and statistically significant at the 5% level in all models, meaning that bank efficiency is positively associated with economic growth. This finding is in line with findings of Maudos *et al.* [105], Grigorian and Manole [59], Pasiouras *et al.* [120], and Johnes *et al.* [84]. We also find a positive and significant relationship between inflation and bank efficiency, which is consistent with the findings of El-Moussawi and Obeid [48] in the region. The first implication of these results is that the state of the economy in the MEOE countries has a marked impact on the efficiency of banks operating in that region. Furthermore, since the economies of the MEOE countries are largely dependent on oil revenue, we can conclude that oil prices also have an indirect effect on the bank efficiency through macroeconomic channels. Therefore, our results suggest that the oil price changes affect bank efficiency both directly and indirectly.

Furthermore, Table 12 shows that, after including the country-specific variables into the model, the signs and significance levels of the estimated coefficients of bank-specific variables and crisis dummies do not vary substantially with what we obtained in Table 11. We also find that the estimated coefficient for HHI_{ct} is negative and significant when OID_t is considered as indicators of oil price changes. These results are in line with the findings of Berger and Hannan [22], Yildirim and Philippatos [130], and Chortareas *et al.* [41] who report a negative association between the concentration of banking sector and the bank efficiency.

In summary, our results support Hypothesis 2, which postulates that oil prices affect bank efficiency both directly and indirectly. In addition, the results imply that the economic growth and the inflation are the main indirect drivers of bank efficiency in the MEOE countries. The fact that oil price changes impact bank efficiency indirectly and through macro channels comes as no surprise for several reasons.

Firstly, it is well documented that an increase in government oil revenue in oil-dependent economies results in expansion across the whole economy (see Bright and Okogu [29]; Olson and Zoubi [115]). A key mechanism in the MEOE countries is fiscal expansion, through which oil revenue is injected into the economy. Since state oil companies control the upstream activities in the oil sector of these countries, oil revenues accrue directly and completely to the government. Government uses the oil revenues via public expenditure (capital and current), which consequently increases the income of private households and corporate profits. This results in higher demand for banking services, which in turn leads to higher bank efficiency. In addition, the part of oil revenue that is transformed into domestic currency will increase the foreign assets in the Central Bank or Sovereign Wealth Fund [136].

Secondly, Kandil [90] states that an inflationary pressure was reinforced by oil revenue in the GCC countries after 2003, through higher government spending, growth of credit, aggregate spending and public spending on capital. Also, Fama [52] suggests that banks adjust their interest rates according to the inflation. In other

TABLE 12. Oil price changes and bank efficiency (country-specific and bank-specific variables) – Hypothesis 2.

Dependent variable: EFF_{ict}	(1)	(2)	(3)	(4)	(5)
LIQ_{ict}	−0.312*	−0.317*	−0.318	−0.319	−0.307
	(0.092)	(0.091)	(0.094)	(0.094)	(0.093)
EQT_{ict}	−0.258**	−0.263**	−0.242**	−0.239**	−0.247**
	(0.247)	(0.249)	(0.238)	(0.241)	(0.242)
LLR_{ict}	−0.308*	−0.314*	−0.326	−0.329*	−0.330*
	(0.124)	(0.137)	(0.147)	(0.143)	(0.165)
$SIZE_{ict}$	0.317**	0.322**	0.337**	0.334**	0.325**
	(0.043)	(0.037)	(0.048)	(0.045)	(0.032)
INF_{ct}	0.268**	0.259**	0.239**	0.242**	0.237**
	(0.122)	(0.121)	(0.127)	(0.132)	(0.129)
$GDPG_{ct}$	0.310**	0.312**	0.311**	0.311**	0.308**
	(0.247)	(0.232)	(0.231)	(0.235)	(0.241)
HHI_{ct}	−0.208*	−0.212	−0.213	−0.217	−0.116
	(0.065)	(0.079)	(0.083)	(0.075)	(0.065)
OID_t	0.245***				
	(0.106)				
VOL_t		−0.270***			
		(0.069)			
$ROILP_t^+$			0.167**		
			(0.073)		
$ROILP_t^-$				−0.110	
				(0.083)	
$\Delta\ln(OP)_t$					0.194***
					(0.041)
GPC_t	0.139*	0.172*	0.171*	0.173*	0.142*
	(0.028)	(0.021)	(0.027)	(0.027)	(0.019)
GFC_t	−0.016	−0.012	−0.017	−0.012	−0.016
	(0.015)	(0.019)	(0.016)	(0.014)	(0.015)
Constant	0.659***	0.632***	0.647***	0.639***	0.661***
	(0.199)	(0.201)	(0.193)	(0.191)	(0.201)
Observations	899	899	899	899	899
R^2 – adjusted	0.237	0.229	0.241	0.236	0.222
Number of banks	98	98	98	98	98
LM test	462.56***	417.78 ***	436.14***	432.71***	441.69***
Hausman test	34.51***	29.44***	32.89***	40.32***	38.20***
F test	11.234	11.067	10.678	11.321	10.849

Notes. The dependent variable is bank efficiency (EFF) estimated by using the SORM-DEA output-oriented VRS method. All models are estimated using fixed effect estimators. Huber–White robust standard errors are reported in the parenthesis below the coefficient estimates. The Lagrangian Multiplier test (LM test) is used to test the RE model *vs.* the PLS, while the Hausman specification test is used to test the FE model *vs.* the RE model. (*)Coefficients are statistically significant at the 10% level. (**)Coefficients are statistically significant at the 5% level. (***)Coefficients are statistically significant at the 1% level.

words, a predictable portion of the inflation rate integrates into nominal interest rate, which has been adjusted by the banks. For instance, when there is an increase in oil prices, oil income injected into the economy impacts inflation, which in turn affects the adjusted interest rate of banks, which may result in higher efficiency of banks. This supports the findings of Bourke [27], Molyneux and Thornton [110], who state that in general there is a link between the bank profitability and the interest rate.

TABLE 13. Oil price changes and bank efficiency under different operational styles – Hypothesis 3.

Dependent variable: EFF_{ict}	(1)	(2)	(3)	(4)	(5)
LIQ_{ict}	−0.187	−0.174	−0.189*	−0.183	−0.165
	(0.087)	(0.088)	(0.080)	(0.082)	(0.087)
EQT_{ict}	−0.232*	−0.247*	−0.221*	−0.227*	−0.267*
	(0.207)	(0.238)	(0.216)	(0.228)	(0.231)
LLR_{ict}	−0.342*	−0.357*	−0.393*	−0.368*	−0.389*
	(0.137)	(0.156)	(0.143)	(0.138)	(0.140)
$SIZE_{ict}$	0.323**	0.369**	0.347**	0.348**	0.333**
	(0.065)	(0.064)	(0.063)	(0.063)	(0.065)
INF_{ct}	0.199*	0.180**	0.189*	0.191**	0.203**
	(0.084)	(0.093)	(0.087)	(0.088)	(0.086)
$GDPG_{ct}$	0.317*	0.334**	0.326*	0.317**	0.301*
	(0.252)	(0.221)	(0.234)	(0.239)	(0.253)
HHI_{ct}	0.117	−0.121	0.108	−0.112	0.119
	(0.072)	(0.078)	(0.082)	(0.083)	(0.092)
OIL_t	0.278***	−0.308**	0.357**	0.349**	0.318**
	(0.207)	(0.235)	(0.218)	(0.221)	(0.198)
$OIL_t \times Islamic_{ict}$	−0.221**	0.197*	−0.123**	−0.117*	−0.187**
	(0.098)	(0.132)	(0.078)	(0.084)	(0.151)
$OIL_t \times Investment_{ict}$	−0.198	−0.208	0.152	0.157	0.179
	(0.377)	(0.483)	(0.409)	(0.414)	(0.360)
GPC_t	0.031*	0.029	0.028*	0.028*	0.031*
	(0.025)	(0.023)	(0.022)	(0.024)	(0.023)
GFC_t	−0.022	0.019	−0.021	−0.022	−0.018
	(0.013)	(0.012)	(0.012)	(0.012)	(0.014)
Constant	0.679***	0.672***	0.675***	0.679***	0.681***
	(0.211)	(0.219)	(0.215)	(0.213)	(0.207)
Observations	899	899	899	899	899
R^2 − adjusted	0.239	0.284	0.267	0.245	0.258
Number of banks	98	98	98	98	98
LM test	422.97***	467.43***	398.52***	439.54***	422.05***
Hausman test	28.34***	19.49***	39.04***	41.08***	31.38**
F test	10.492	11.037	9.872	10.285	10.904

The dependent variable is bank efficiency (EFF) estimated by using the SORM-DEA output-oriented VRS method. All models are estimated using fixed effect estimators. Huber–White robust standard errors are reported in the parenthesis below the coefficient estimates. The Lagrangian Multiplier test (LM test) is used to test the RE model *vs.* the PLS, while the Hausman specification test is used to test the FE model *vs.* the RE model. (*)Coefficients are statistically significant at the 10% level. (**)Coefficients are statistically significant at the 5% level. (***)Coefficients are statistically significant at the 1% level

Thirdly, according to Poghosyan and Hesse [123], on the aggregate supply side, a high oil price fuels new public and private investment in oil exporting countries, which drives economic growth rates and results in the expansion of productive capacity of all industries in these countries. Therefore, an increase in the price of oil affects the overall business sentiment and leads to higher domestic demand for credit, higher bank confidence and bank lending, and lower default rates.

We now test the Hypothesis 3, which asserts that the changes in oil prices have a non-uniform impact on the efficiency of banks with different operational styles in the MEOE countries. In doing so, we estimate equation (4.9), which contains the interaction terms between the operational styles of banks and the changes in oil prices per Hypothesis 3. The estimation results of equation (4.9) are reported in Table 13.

equations (3.1)–(3.5) in Table 13, use OID_t, OILVOL_t, ROILP^+_t, ROILP^-_t, and $\Delta\ln(\text{OP})_t$, respectively, as proxies for oil prices (OIL_t).

The results in Table 13 reveal that the sign and the significance of our control variables remain mostly unchanged when we enter the interaction dummies in the equations. More importantly, all oil indicators, except for ROILP^-_t, have a significant impact on the efficiency scores of banks at the 5% significance level. Also, all signs for the estimated coefficients of the oil indicators, OIL_t, remain consistent with those obtained previously. Of the two interaction dummies, the results show that only the estimated coefficients for $\text{OIL}_t \times \text{Islamic}_{ict}$, *i.e.*, the interaction term between oil prices and the dummy variable for Islamic operational style, is significant with negative sign. This indicates that oil prices have a lower impact on the efficiency scores of Islamic banks, compared to commercial banks, in the MEOE countries.

These results reflect the differences between Islamic banks and commercial banks regarding their missions, regulations, and banking practices. Islamic banks vary greatly from commercial banks in terms of their funding resources, investment strategies, and services provided. We offer three main explanations for our finding. Firstly, since commercial banks are not bound by Sharia-law, they can use a wider range of funding resources and investment strategies, compared to Islamic banks. For instance, Islamic banks often use more stable funding resources, such as Sukuk and Sharia-compliant deposits, while other bank types may use less stable funding resources, such as wholesale funding [134]. Secondly, Islamic banks provide and develop less innovative products and modes of finance because of the requirement for compatibility with the Shariah law [11]. Lastly, Islamic banks tend to be more risk-averse than other bank types, as they usually allocate their resources to relatively safer investments [134]. Therefore, Islamic banks tend to be less flexible in offering new banking services in line with changes in macroeconomic conditions. Thus, compared to Islamic banks, commercial banks are more sensitive to higher oil prices as changes in oil prices are strongly associated with changes in the level of economic activity [65, 66], thereby justifying the level and the variety of the required banking services.

Furthermore, our results suggest that there is no significant difference between commercial banks and investment banks in terms of their responses to oil prices. This finding is indeed not surprising as many commercial banks in the region offer a wide range of investment banking services. Overall, our empirical results reveal that the efficiency scores of Islamic banks in the MEOE countries are less responsive to oil prices, compared to those of commercial and investment banks. This finding supports Hypothesis 3, which asserts that banks with different operational styles react differently to oil prices.

5.3. Recommendation for policy makers

The research has several policy implications. The first stage of the study provides further insight to bank management and policymaker of Islamic banks. Islamic banking system in the region should make more effort in attaining optimal utilization, improving in managerial expertise, forcing radical adjustments to new business conditions and fulfilling both the financial and religious needs of their customers.

Second stage of the study provides the evidence of a systemic importance of oil price changes for the efficiency of banks operating in the Middle East oil-exporting countries. These findings have several important implications. First, bank managers and financial regulators should carefully monitor oil prices as a key factor that systematically affects the performance of banks in the MEOE countries. In this context, it is of paramount importance to design a back-up and recovery framework to improve the performance and the stability of banks when oil prices drop. Second, our empirical findings reveal that bank efficiency scores are affected by simultaneous oil shocks in the MEOE countries. This finding is in line with the common practice in the energy sector to finance short-term needs through banks, while securities markets are used for long-term financing. Therefore, the above-mentioned regulatory framework shall be designed in a way that it can adjust the required regulatory capital to the adverse oil shocks in the short-term (*e.g.*, less than two years). Third, to avoid abrupt changes in banks' efficiency scores, financial authorities and policy makers should control the indirect impact of oil prices by monitoring the amount of liquidity injected in the economy in different phases of the oil price cycles. One useful policy tool in this regard is to establish sovereign wealth funds through which central banks can help ensure a smooth economic growth and avoid large ups and downs. Fourth, since most MEOE banks are exposed to the energy sector, and adverse oil shocks can directly or indirectly lead to a systematic drop in the efficiency their scores, oil shocks can be used as an early warning system for banking crisis in the MEOE countries. Finally, regulators should carefully monitor any oil-related exposures of non-Islamic banks operating in the MEOE countries. Non-Islamic banks are very flexible in adjusting their funding and investment policies during a high oil price regime, which can significantly undermine their stability when oil prices drop.

6. Conclusions and direct for future research

We present a novel two-stage application of the SORM-DEA and econometric analysis to investigate the impact of changes in oil prices on the efficiency of banks. We apply this novel method on a sample of banks operating in the MEOE countries over the period 2001-2011 to identify the main bank-specific and country-specific determinants of bank efficiency. We use five different proxies for oil price changes: oil income dependency, positive and negative oil price shocks, oil price volatility, and net oil price increase. The key features of this paper are that it employs an innovative two-stage methodology to assess the efficiency of banks, to study the direct and the indirect influence of oil price changes on the efficiency of banks, and to establish the bank efficiency differences in terms of bank operational style while controlling for bank-specific and country-specific environmental variables. Using an unbalanced panel data, we test three hypotheses about the association between oil price fluctuations and bank efficiency in oil dependent economies of the MEOE countries. More specifically, we first assess the efficiency of 98 banks over a 12-year period, and then examine the direct and the indirect impact of oil prices on the efficiency of banks. Next, we investigate whether the effects of oil prices vary with respect to the operational styles of banks operating in the region.

The results of the first stage of our analysis demonstrate that, on average, the efficiency scores of commercial banks in the MEOE countries are higher than those of Islamic banks and investment banks. In fact, following Shariah-law imposes serious restrictions on Islamic banks regarding their customers, funding resources, and financial products, which in turn makes them less efficient, compared to their counterparts.

With respect to Hypothesis 1, we detect a strong relationship between the changes in oil prices and the efficiency of banks operating in the MEOE countries. Higher oil prices strengthen the liquidity position of the government and the companies in the region. With higher oil income, the oil-dependent economies of the MEOE countries can lower government debt, avoid budget deficit, and become more resilient to financial shocks. Thus, the probability of default reduces, while the demand for banking services increases, which in turn leads to higher bank efficiency. In addition, bank efficiency is negatively affected by oil price volatility. Clearly, high fluctuations in oil prices lead to less stable political and economic environment, thereby undermining bank efficiency.

The test of Hypothesis 2 shows that, in addition to a direct impact, the changes in oil prices affect bank efficiency indirectly and through macroeconomic channels. The oil income injected into an oil-dependent economy leads to a rise in the efficiency of banks via credit expansion, enhanced confidence in the banking sector and lower default rates, and an increase in the demand for banking services.

In terms of Hypothesis 3, our results reveal that the changes in oil prices have a non-uniform impact on the efficiency of banks with different operational styles in the MEOE countries. More specifically, we find that Islamic banks are less responsive to oil price changes, compared to commercial banks and investment banks. Islamic banks often use more stable funding resources and investment strategies, tend to be less flexible in offering new products and have lower probability to be selected to participate in governmental projects.

A further challenge that may emerge in our line of research is to consider the different influence of oil price changes on the scale and the pure technical efficiency. The use of extended data sets, which offers more insights into the influence of oil price changes on the efficiency of banks in the region, would be another future research. Another possible extension of this study can explore the influence of oil price changes on the performance of banks in less oil income economies.

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