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Output Efficiency and Liquidity Risk of Islamic Banks

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Abstract: This study analysed the relation between efficiency and liquidity risk of worldwide Islamic banks from 1986 to 2015. Bank efficiency was estimated based on output efficiency by using stochastic frontier approach (SFA), while liquidity was calculated by using liquidity ratio (LR) and net stable funding ratio (NSFR) to examine the short-term and long-term liquidity risks. A two-stage analysis was conducted: 1) output distance function was used to estimate the scores of bank efficiency, and 2) system generalised method of moments (GMM) was employed to investigate the relation between output efficiency and liquidity. Finding showed that high output efficient banks had an inverse relation with LR, but a positive relation with NSFR. This implied that increasing output efficiency only jeopardised liquidity in the short-term, but increased liquidity in the long-term, conjecturing that being efficient is beneficial in the long-term period. Regulators and bank executives should consider the diverse effect of bank efficiency with the aim of having a holistic liquidity risk management framework.

Keywords: Output efficiency, output distance function, liquidity risk, Islamic banks, Net Stable Funding Ratio (NSFR), Stochastic Frontier Approach (SFA).

JEL Classification: A1, D02, G1, G21

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Introduction

Liquidity risk comes from the unexpected outflow of funds and insufficient liquidity to cover the short-term obligation (Abdul-Rahman et al., 2018; Archarya et al., 2017). Notwithstanding the role of banks in channelling fund from surplus to deficit economic units, they usually take short-term deposits to provide long-term financing. The mismatched maturities between financing and deposits may cause banks to have either liquidity excess or shortage (Adrian & Boyarchenko, 2018), depending on the economic conditions, liquidity regulations, and liquidity risk management strategy of the bank. Despite the complexity of liquidity, Islamic banks face additional limitations in managing liquidity risk (Abdul-Rahman et al., 2019; Aziz et al., 2019). Constraints related to marketability and fund raising in the financial market have increased the funding cost to Islamic banks (Al-Harbi, 2020), and thus reducing bank profitability as compared to conventional banks (Mohd Amin et al., 2017), which may indirectly encourage Islamic banks to be efficient to sustain in the market (Khalib et al., 2016).

In addition, services in the banking industry, which have switched dramatically across the globe, have caused diversification of bank portfolio and products, and resulted in new challenges to bank efficiency (Mohd Amin et al., 2017; Othman et al., 2018) and risk management (Abdul-Rahman et al., 2019; 2018; 2017). Banks have to increase their efforts to balance between efficiency and risk as well as satisfy both depositor and shareholder groups as the main sources to allocate their need of funds. The main concern of banks is to raise efficiency at a certain level of risk (Hoseininassab et al., 2013). Improper risk management will cause the bank to face bankruptcy in the end and possibly collapse. There are five major risks that banks face, namely credit risk, operational risk, liquidity risk, market risk, and interest rate risk (Abdul-Rahman, 2012). In comparison to other types of risks, liquidity risk has not been a priority. However, the crisis totally changed market conditions; hence, showed the importance of banks in having adequate liquidity (Vodova, 2011a). Despite the urge for banks to become efficient and effectively manage risks, research that investigates the efficiency-risk relation is still limited, especially that focuses on efficiency-liquidity risk relation. Therefore, the aim of this study is to investigate the impact of output efficiency on bank liquidity risk for the case of worldwide Islamic banks.

This paper is structured as follows: Section 2 provides a review of past literature on efficiency, liquidity risk, and theory of efficiency and bank risk-taking. Section 3 explains the data collection, methodology, and model specification, while Section 4 discusses the findings and results. Lastly, Section 5 concludes the research.

Literature Review

Overview of Efficiency and Liquidity Risk

Liquidity refers to the capability of a bank to meet obligations as they come and due to fund increases in assets, without causing unreasonable losses (BCBS, 2008). A bank is said to be illiquid if it cannot resolve obligations on time (Abdul-Rahman & Mohd Amin, 2019; Abdul-Rahman et al., 2019; Abdul-Rahman et al., 2018; Abdul-Rahman et al., 2017; Galletta & Mazzù, 2019; Grundke & Kühn, 2019; Hryckiewicz & Kozlowski, 2018; Pagratis et al., 2017; Rashid et al., 2018). The problems with inadequate liquidity not only trigger insecurity of the whole financial system, but may also cause the failure of a bank (Othman et al., 2018; Tamadonejad et al., 2017; 2016). In the banking sector, liquidity is one of the economic tools of the financial market. The banking system alters liquid liabilities (deposits) into liquid claims (loans) (Amin et al., 2021). This basic transaction leaves banks to funding liquidity risk and market liquidity risk (Amin & Abdul-Rahman, 2020; Bonfim & Kim, 2014). Market liquidity risk refers to the incapacity of banks to easily offset or remove a financial transaction at market price due to inadequate market depth. Funding liquidity risk refers to the incapacity of banks to shield unexpected and expected current and future cash flow needs and collateral requirements (Ab-Hamid et al., 2018a; Yaakub et al., 2017).

Efficiency acts as an indicator towards the performance of the bank as it appraises the progress, accomplishment, and success of the bank (Ab-Hamid et al., 2018b; Mokhtar et al., 2008). Efficient banks are important to sustain the stability of the financial system and its offered services (Ab-Hamid et al., 2017; Ngo, 2012). Extensive literature which investigated into the efficiency characteristics of banking sectors in the USA (Almanidis, 2019; Liu, 2019; Glass & Kenjegalieva, 2019; Sapci & Miles, 2019), European countries (Barbu & Boitan, 2019; Coccorese & Ferri, 2020; Nosheen & Rashid, 2019; Turati, 2003), and Asian markets (Ahn et al., 2020; Karray & Chichti, 2013; Othman et al., 2010; Rashid et al., 2018) have existed. Meanwhile, some researchers conducted cross-country studies (Ab-Hamid et al., 2018; Abdul-Majid et al., 2010), and some considered country-specific environmental conditions of bank efficiency (Abdul-Majid, et al., 2011; Cabrera-Suárez & Pérez-Rodríguez, 2020; Islam, 2015; Ismail et al., 2013; Karimzadeh, 2012; Mat-Nor et al., 2006; Mohamad & Wahab, 2016; Mokhtar et al., 2008). At the same time, another researcher compared the efficiency scores of domestic-owned banks with foreign-owned banks (Azad et al., 2017; Chaffai & Hassan, 2019; Chronopoulos et al., 2019; Cupic & Siranova, 2018; Isik & Hassan, 2002; Kamarudin et al., 2019; Lin et al., 2016; Mamonov & Vernikov, 2017; Ouenniche & Carrales, 2018; Sarmiento & Galán, 2017).

In terms of functional forms of the efficiency estimates, three popular categories were analysed by previous researchers, namely, profit function (Chen et al., 2018; Gallizo, 2016; Prior et al., 2019; Partovi & Matousek, 2019; Zhu et al., 2019; Tsionas, 2017), cost function (Gallizo, 2016; Huang et al., 2017; Partovi & Matousek, 2019; Yap et al., 2019), and output function (Huang et al., 2017; Othman et al., 2017; Tamadonnejad et al., 2017). The major advantage of estimating output function as compared to cost function and profit function is that distance functions allow characterising the structure of production technology when multiple inputs are used to produce multiple outputs without the information of input prices. Moreover, an output distance function takes an output-expanding approach to the measurement of the distance, which is the maximal proportional expansion of the output vector, given an input vector (Lee et al., 2009).

Theory of Efficiency and Bank Risk-Taking

Berger and DeYoung (1997) presented an initial work in determining the efficiency-risk relation. The study tended to support a negative relation between cost efficiency and bank risk-taking based on four hypotheses - moral hazard behaviour, skimping behaviour, bad luck, and bad management. Firstly, bad management hypothesis suggests that low efficiency causes high credit risk due to failure in managing bank operations. Inferior quality managers, who lack skills in selecting potential investments, screening credit scoring, and monitoring borrowers, are subjected to adverse selection and moral hazard problems, which may create high liquidity risk. Secondly, cost-skimping hypothesis suggests that managers tend to 'skimp' resources allocated for underwriting and monitoring financing, and thus increase the probability of default. This skimping behaviour, although deemed efficient in short-term, increases bank risks over time. However, the positive efficient-risk relation (in cost-skimping hypothesis) contradicted the negative relation predicted in bad management hypothesis. Thirdly, bad luck hypothesis predicts that exogenous unfavourable event reduces bank efficiency, (i.e: 1) increases operating cost due to additional recources required for monitoring delinquent borrowers and disposing/storing collateral; 2) maintaining the soundness of the bank record to market participants and regulators; and 3) diverting senior management away from their daily responsibilities), which finally leads to high liquidity risk. In summary, the explanation for the negative efficiency-risk relation is that when exogenous shocks (economic downturns) occur, it reduces asset quality, causing banks to experience high operating costs or lose some income and deteriorating bank efficiency, which may increase liquidity risk. Finally, moral hazard hypothesis indicates that low capitalised banks are less risk averse as they have relatively less capital to lose (Mollik & Bepari, 2015). When poorly capitalised banks with low efficiency embark into risky activities, moral hazard occurs, which end up increasing liquidity risk. In summary, the negative efficiency-risk relation is expected to exist based on bad management, bad luck, and moral hazard hypotheses, while cost-skimping hypothesis suggests the opposite. Since then, a number of empirical research studies have examined the impact of diverse bank efficiency measures on various types of risk, such as market risk (Ab-Hamid et al., 2021; Ab-Hamid et al., 2018a); credit risk (Bitar et al., 2018; Le, 2018: Luo et al., 2016), and insolvency risk (Luo et al., 2016; Othman et al., 2017; Tamadonejad et al., 2016).

However, there are only a few studies that examined the efficiency-liquidity risk relation. For instance, Khalib et al. (2016) focused on the effect of cost inefficiency on liquidity risk for Islamic and conventional banks in Malaysia. The study used Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) to measure liquidity risk, stochastic frontier approach (SFA) to compute cost inefficiency, and static panel techniques to test the liquidity risk determinants regression models. The findings showed that cost inefficiency had no significant effect in the short-term, but positive effect on liquidity risk in the long-term. Conversely, Amin et al. (2017) investigated the effect of cost efficiency on the liquidity risk of Islamic and conventional banks in 16 Organisation of the Islamic Cooperation (OIC) countries. The study employed the DEA to compute cost efficiency and system generalised method of moments (GMM) to test the liquidity risk determinant models. The findings suggested that cost efficiency had a positive effect on liquidity risk. In the seminal works, Amin et al. (2018) used static panel regressions and found consistent findings.

On the other hand, other studies captured the effect of liquidity risk on efficiency. Lotto (2019) investigated the determinants of operating efficiency of 36 commercial banks in Tanzania by using static panel regressions. The results showed that liquidity had a positive relation with bank operating efficiency. Recently, Bitar et al. (2020) analysed the effect of liquidity on efficiency for both conventional and Islamic banks in 28 countries. The study applied liquid assets to deposit in measuring liquidity and DEA to compute technical efficiency. The study found that higher liquidity ratios increased the efficiency of conventional and Islamic banks. Also, by using conditional quantile regressions, the study discovered that the effect was stronger for highly efficient, small, and highly liquid conventional banks. Moreover, liquid banks were found efficient during the Arab Spring and 2008/2009 financial crisis.

Data and Methodology

The study focused on worldwide Islamic banks, which comprised 180 Islamic banks from 36 countries. The data were collected annually from 1986 to 2015, covering a period of 30 years. The year 1986 was the starting point as it was the earliest time to obtain data of major Islamic banks from Bankscope that had consistently published financial statements over the last 30 years. All data were based on the US denominated currency. For macroeconomic variables, data were gathered from the World Bank (WB). Two-stage estimation method was employed in this study. Firstly, output distance function was analysed to estimate the scores of banks output efficiency by using SFA. Secondly, based on the estimation results, the efficiency scores obtained were used as one of the independent variables to see whether efficiency-liquidity risk relationship existed by using dynamic panel data regression.

The Econometric Specification for Output Efficiency Estimations

Following Abdul-Majid et al. (2011), the general form of a stochastic output distance function can be shown as follows:

$$1 = D_0(Y_{n,t}, X_{n,t}, Z_{n,t}, \beta)h(\varepsilon_{n,t}) \tag{5}$$

Where, $h(\varepsilon_{n,t})$ = exp $(u_{n,t} + v_{n,t})$ β is a vector of parameters, $Z_{n,t}$ is an exogenous factor vector, $X_{n,t}$ is an input vector, and $Y_{n,t}$ is a vector of outputs. Efficiency is assimilated in the specification of $h(.)$. Represents random, uncontrollable error that affects the nth firm at time t, and $u_{n,t}$ is presumed to be attributable to technical efficiency, and $\varepsilon_{n,t}$ is a composed error term included in $v_{n,t}$.

Implying that $D_0(Z, X, \pi Y) = \pi D_0(Z, X, Y), \pi > 0$, this study followed the standard practice of imposing homogeneity of degree one in outputs of the distance function in accelerating the estimation. By choosing the M-th output, it can be defined and written a

$$D_0\left(Z, Y, \frac{Y}{Y_M}\right) = \frac{D_0(Z, X, Y)}{Y_M} \tag{6}$$

Where, after assuming $Y^*_{n,t} = (Y_{1,n,t} / Y_{M,n,t}, Y_{M,n,t}, \ldots, Y_{M-1,n,t} / Y_{M,n,t})$ and adjusting terms yields the general form,

$$\frac{1}{y_{M,n,t}} = D_0\left(Y^*_{n,t}, X_{n,t}, Z_{n,t}, \beta\right)h\left(\varepsilon_{n,t}\right) \quad (7)$$

Lastly, the output distance can be illustrated as follows after taking up a standard translog functional form to represent the technology change.

$$\begin{aligned} -InY_{M,n,t} &= \varphi + \sum_{k=1}^{K}\alpha_k InX_{k,n,t} + \sum_{m=1}^{M-1}\beta_m InY^*_{m,n,t} + 0.5\sum_{k=1}^{K}\sum_{s=1}^{K}\alpha_{k,s} InX_{k,n,t} InX_{s,n,t} \\ &+ \frac{1}{2}\sum_{m=1}^{M-1}\sum_{j=1}^{M-1}\beta_{m,j} InY^*_{m,n,t} InY^*_{j,n,t} + \sum_{k=1}^{K}\sum_{m=1}^{M-1}\theta_{k,m} InX_{k,n,t} InY^*_{m,n,t} + \sum_{k=1}^{K}\tau_{k,t} InX_{k,n,t}t + \\ &\sum_{m=1}^{M-1}\Psi_{m,t} InY^*_{m,n,nt} + 0.5\lambda_2 t^2 + \sum_{h=1}^{H}\xi_h Z_{h,n,t} + v_{n,t} + u_{n,t} \end{aligned} \quad (8)$$

Where, $Y^*_{m,n,t}=Y_{m,n,t}/Y_{M,n,t}$, m=1,2,...M and j=1,2,..M are indicators for output; k=1,2,..K and s=1,2,..K are indicators for input; h=1,2,...H is an index for the total of H environmental Z variables that are included to account for differences in operating environment, and the Greek letters (except $_v$ and $_u$) represent unknown parameters to be estimated. t represents a time trend and accounts for technology changes over time. Standard symmetry is used to the second order parameters by inflicting the constraints $\alpha_{ks} = \alpha_{sk}$ and $\beta_{mj} = \beta_{jm}$. Equation 8 defines the parameters in the translog function. Meanwhile, the composed error parameters and are estimated by using maximum likelihood estimation (MLE) techniques.

The Output and Input Variables for Efficiency Scores

This study employed the intermediation approach in defining output of the bank as it was the most suitable approach with the concept of Islamic banking (Abdul-Majid et al., 2010) and has been widely used in Islamic banking studies (Arjomandi et al., 2014; Bahrini, 2017; Mohamad & Wahab, 2016), conventional banking studies (Karimzadeh, 2012; Karray & Chichti, 2013), and comparative Islamic and conventional banks' studies (Abdul-Majid et al., 2011; Islam & Kassim, 2015; Ismail et al., 2013). This study included two outputs, (*Y1*) loans, (*Y2*) fees, and three inputs, (*X1*) deposits, (*X2*) fixed assets, and (*X3*) equity, as well as three environmental variables, (*Z1*) equity ratio, (*Z2*) GDP growth, and (*Z3*) inflation. It was noted that linear homogeneity in outputs was imposed by using *Y2* as a numeraire and these variables were mean-corrected prior to estimation (Abdul-Majid, 2010). Bank is assumed as a financial institution which plays a role of intermediation between customers who deposit money in the bank and customers who need financing from the bank. In other words, total deposits are inputs and total loans are outputs, while the fixed assets and equity are also inputs (Panah et al., 2014; Sufian, 2011). The frontier is controlled for variation in economic variables between countries that may justify differences in efficiency by including gross domestic product (GDP) growth and inflation as environmental variables. GDP is used to reflect the general income level. A higher income level is more likely to be associated with a more developed banking sector. Inflation is an indicator of macroeconomic stability, and is directly related to the interest rate level. Inflation is deflated by using the GDP deflator provided by the International Monetary Fund (IMF) and is aimed to cater differences in purchasing power between these countries. Table 1 summarises the description of input, output, and environmental variables.

Table 1

Description of Input, Output, and Environmental the Variables

Variables	Symbol	Operational Definition
Outputs		
Loans	y1	Gross loans
Fees	y2	Off balance sheets
Inputs		
Deposits	x1	Total deposits + customer funding + short term funding
Fixed Assets	x2	Property, plant and equipment
Equity	x3	Total equity
Environmental variables		
Equity ratio	z1	Total equity to total assets
GDP growth	z2	Value of GDP growth (annual %)
Inflation	z3	Value of GDP deflator (annual %)

Unbalanced Dynamic Panel Regression Analysis for Efficiency-Liquidity Risk Relationship

This study employed dynamic panel data methodology by using system GMM estimations introduced by Arellano and Bover (1995). Since then, the GMM model has been supported by many researchers such as Blundell and Bond (1998), Blundell et al. (2000), Hayakawa (2007), and Heid et al. (2012). This method is more competent to constraints between the dependent variable, the endogeneity of variables in the model, and other explanatory variables as compared to the ordinary least squares (OLS) method. The lagged dependent variable in the right of the equation generates a correlation between specific individual effects and explanatory variables. Moreover, it controls these obstacles through the combination of a set of equations in which their own lagged values instrumentalised the variables in first difference and expressed in levels, and the second set of equations in levels using fundamental differences as instruments. This system provides more efficient estimators than the difference GMM because the tools used in the level equation adequately predict the endogenous variables in the model (Blundell & Bond, 1998).

The study used Sargan/Hansen specification test to solve the overidentication problem. The null hypothesis was that the restrictions of over identification were valid. It verified the total validity of the variable instruments employed in the model estimation, which tested the null hypothesis, which was "asymptotically distributed moment conditions as chi-square" or valid moment conditions (Arellano & Bover, 1995; Blundell & Bond, 1998). Autoregressive test (AR) was used to ensure that the errors (residuals) were not autocorrelated. The AR(1) measured first-degree while AR(2) verified second-degree serial correlations. Andres and Vallelado (2008) suggested that at least the second-order serial correlation {AR(2)} must not be present.

As a rule of thumb in GMM estimation, the number of instruments used should not exceed the number of groups of cross-section units, i.e. the number of banks in the research. The model is formulated as follows:

$$LQ_{it} = \alpha_i + \beta_0 LQ_{it-1} + \beta_1 OE_{it} + \beta_2 SIZE_{it} + \beta_3 CAR_{it} + \beta_4 ROA_{it} + \beta_5 ROE_{it} + \beta_5 GDP_{it} + \beta_7 INF_{it} + \alpha_{it} + \mu_{it}$$

Where, *LQ* = alternate measure of liquidity risk, namely 1) traditional measure: liquidity ratio (*LR*) = liquid asset/deposit and short-term funding or 2) BASEL III measure: net stable funding ratio (*NSFR*) = available amount of stable funding/ required amount of stable funding,[1] *OE* = output efficiency scores, *ROA* = Net income/Total Assets, *SIZE* = natural logarithm of total assets, *CAR* = Total capital/ Total assets, ROA = Total non-performing loans/ Total Loan, GDP = Growth of Gross Domestic product, INF = Inflation rate. Table 2 summarises the independent and dependent variables of the study with expected relation towards liquidity levels and their respective operational definition. The interpretation of the relation towards liquidity risk was opposite from the expected relation in Table 2. The expected relation was based on the country level and cross-country empirical findings summarised by Amin et al. (2017).

1 The study did not obtain the data for the short-term liquidity measure of BASEL III, which was the liquidity coverage ratio (LCR) due to data limitation that involved multiple Islamic countries.

Table 2

Description of the Variables and their Expected Relation with Liquidity

Variables	Symbol	Operational Definition	Expected relation	Sources
Dependent Variables				
Liquidity Ratio	*LR*	Traditional measure of Liquidity risk: Liquid Asset / Deposit and Short-term funding. High *LR* shows high liquidity; thus, low liquidity risk. It represents short-term liquidity risk		Own
Net Stable Funding Ratio	*NSFR*[2]	BASEL III measure of liquidity risk: Available amount of stable funding (ASF) / required amount of stable funding (RSF). High *NSFR* shows high liquidity, and thus low liquidity risk. It represents long-term liquidity risk		Own
Independent Variables				
Bank Efficiency			Positive/ Negative	Own
Bank Specific Variables:				
Return on Equity	*ROE*	Net income / Total Equity	Positive/ Negative	Bankscope
Return on Asset	*ROA*	Net Income / Total Assets	Positive/ Negative	Bankscope
Capital Adequacy Ratio	*CAR*	Tier 1 Capital+ Tier2 Capital / Risk Weighted Assets	Positive/ Negative	Bankscope
Bank Size	*SIZE*	The natural logarithm of total assets	Positive/ Negative	Bankscope
Macroeconomic Variables:				
Gross Domestic Product	*GDP*	Value of GDP growth (annual %)	Positive/ Negative	WDI
Inflation	*INF*	Value of inflation (annual %)	Positive/ Negative	WDI

2 ASF is the funding structure share of a bank that is trustworthy for one year, while the RSF is the assets proportion of a bank and off-balance sheet exposures that are perceived as illiquid for a year, thus should be supported by stable funding sources. Gobat et al. (2014) was used for the calculation of NSFR.

Findings and Discussions

Table 3 provides the summary statistics of input, output, and environmental variables adopted in estimating the output efficiency scores. Table 4 summarises the maximum likelihood estimates of parameters of the translog output function. Firstly, out of the 23 regressors, the output estimates reported 19 regressors as statistically significant. Secondly, the sigma-squared was significant at the 1% level and indicated highly significant parameter estimates. Thirdly, the parameter was also significant for the output function (0.693). Last and most importantly, the value of the loglikelihood functions of the output estimates was high (-32940.24) and statistically significant at the 1% level.

Table 3

Descriptive Statistics of Output Efficiency Variables, 1986–2015

Symbol	Variables	Mean	Std. Dev	Min.	Max.
Outputs					
Y_1	Financing (USD, million)	722.07	418.74	1	1446
Y_2	Fees (USD, million)	576.46	342.51	1	1167
Inputs					
X_1	(Equity (USD, million	$601.4x10^{-3}$	$119.1x10^{-4}$	$268.8x10^{-3}$	$1.30x10^{7}$
X_2	(Fixed Asset (USD, million	685.81	408.93	1	1393
X_3	(Deposits (USD, million	616.99	354.44	1	1231
Environmental Variable					
Z_1	(%) Equity/Asset	2.84	1.76	0	7.06
Z_2	(%) GDP growth	1.54	0.76	-4.02	4.05
Z_3	(%) Inflation	2.11	1.23	-3.08	7.30

Table 4
Maximum Likelihood Estimates for Parameters of the Output Distance Function for Islamic Banks: 1986–2015

Parameters	Coefficient	Estimated value	Standard error
φ_0	Constant	66.480***	10.74
α_1	$\ln X_1$	0.318***	0.015
α_2	$\ln X_2$	0.074***	0.016
α_3	$\ln X_3$	0.139***	0.012
$\alpha_{1,1}$	$(\ln X_1)^2$	-0.062***	0.016
$\alpha_{2,2}$	$(\ln X_2)^2$	-0.011***	0.017
$\alpha_{3,3}$	$(\ln X_3)^2$	0.330***	0.022
$\alpha_{1,2}$	$\ln X_1 \ln X_2$	-0.021	0.025
$\alpha_{1,3}$	$\ln X_1 \ln X_3$	-0.111***	0.028
$\alpha_{2,3}$	$\ln X_2 \ln X_3$	-0.120***	0.031
β_1	$\ln Y_1$	-40.040**	15.810
$\beta_{1,2}$	$(\ln Y_1)^2$	40.190**	15.810
$\theta_{1,2}$	$\ln X_1 \ln Y_1$	-0.116	0.608
$\theta_{2,1}$	$\ln X_2 \ln Y_1$	0.078***	0.029
$\theta_{3,1}$	$\ln X_3 \ln Y_1$	0.039**	0.018
λ_1	t	-3.402*	1.923
λ_{11}	t^2	1.750***	0.016
τ_1	$\ln X_1\, t$	0.062***	0.020
τ_2	$\ln X_2\, t$	-0.065***	0.025
τ_3	$\ln X_3\, t$	0.187***	0.017
ψ_1	$\ln Y_1\, t$	0.042*	0.023
ζ_1	Equity/Assets	0.040**	0.016
ζ_2	GDP growth	-0.066	0.416
ζ_3	Inflation	0.025	0.074
μ	mu	785.910***	46.780
π	eta	-0.098***	0.003
σ^2	Sigma2	116623.4***	10334.05
γ	Gamma	0.693***	0.027
Log Likelihood			-32940.24
LR test of one side error			7898.51***

Table 5 reports the estimated mean efficiency scores, *LR*, and *NSFR* of all Islamic banks by country, respectively. The mean efficiency scores for Islamic banks ranged from 0.538 (Saudi Arabia) to 0.861 (Brunei). In terms of short-term liquidity, Brunei banks held the lowest *LR* (3.45) while Bahraini banks had the highest *LR* (485.5).

For long-term liquidity, banks in Tunisia had the lowest *NSFR* (0.056) and banks in Indonesia had the highest *NSFR* (223.2). This implied that Islamic banks in Brunei and Tunisia had the highest exposure towards short-term and long-term liquidity risks, respectively. Table 6 presents the descriptive statistics for the variables used in the dynamic panel regression analyses. Throughout the study period, the average liquidity of the Islamic banks for *LR* was 60.95 and *NSFR* was15.69. As for efficiency, Islamic banks had an average of 0.730 output efficiency scores.

Table 5

Average Efficiency Scores, LR, and NSFR for Islamic Banks by Country

No.	Country	Mean Efficiency	Mean LR	Mean NSFR
1	Bahrain	0.747	485.5	33.12
2	Brunei	0.861	3.45	0.678
3	Bangladesh	0.738	20.67	10.81
4	Cayman Islands	0.748	11.40	0.068
5	Egypt	0.689	31.78	0.953
6	England	0.746	206.3	36.06
7	Gambia	0.749	10.11	0.110
8	Indonesia	0.739	146.3	223.2
9	Iran	0.693	166.0	69.63
10	Iraq	0.744	184.8	17.84
11	Jordan	0.731	59.91	42.41
12	Kenya	0.775	10.77	1.751
13	Kuwait	0.775	147.6	16.02
14	Lebanon	0.700	70.31	0.336
15	Malaysia	0.738	59.62	48.63
16	Maldives	0.723	24.96	13.19
17	Mauritania	0.679	32.08	2.164
18	Nigeria	0.750	13.93	5.157
19	Oman	0.735	16.50	0.762
20	Pakistan	0.773	107.8	20.37
21	Philippines	0.725	52.8	2.700
22	Palestinian	0.777	29.95	4.667
23	Qatar	0.735	95.46	33.28
24	Russia	0.814	25.75	0.123
25	Saudi Arabia	0.538	127.4	5.691
26	Senegal	0.734	11.94	0.576
27	Singapore	0.702	20.74	24.95
28	South Africa	0.814	9.642	0.571
29	Sudan	0.661	440.4	53.28
30	Syria	0.812	46.49	14.24
31	Tanzania	0.731	14.70	0.067
32	Thailand	0.659	13.28	2.049
33	Tunisia	0.814	35.39	0.056
34	Turkey	0.724	20.05	0.257
35	United Arab Emirates	0.654	76.56	24.11
36	Yemen	0.689	73.99	98.39

Table 6
Descriptive Statistics

Variables	Mean	Std. Dev	Min.	Max.
LR	60.95	97.27	0.16	997.72
NSFR	15.69	78.05	-3.069	1268.87
OE	0.730	0.109	0.351	0.963
SIZE	13.82	2.027	7.125	18.38
CAR	5.455	0.954	0	6.484
ROA	6.274	0.985	0	7.294
ROE	5.285	0.962	0	6.421
GDP	1.545	0.765	-4.029	4.057
INF	2.118	1.233	-3.084	7.306

Table 7 shows the results of dynamic panel regression estimates based on system GMM. The statistical results for Hansen test suggested that the instruments were valid. The results did not reject the over identification of restrictions, which suggested that the instruments used were not correlated with the residuals. The Arellano-Bond (AR Bond) tests showed that the absence of first order correlation was rejected and the absence of the second order correlation was not rejected for the LR model. However, in the NSFR model, both the absence of first order and second order correlations were not rejected, conjecturing that the model specifications did not suffer from autocorrelation problems. It was consistent with Andres and Vallelado's (2008) findings, and suggested that at least second-order serial correlation {AR(2)} must not be present.

The findings showed that output efficiency had a negative relation with *LR*, but a positive relation with *NSFR*. It showed that higher output efficiency decreased liquidity, and thus increased liquidity risk in the short run; and vice versa in the long run. This inferred that in the short-term, output efficient banks (in offering financing and fee-based activities) had lower liquidity (higher liquidity risk). Consistent with the cost skimping hypothesis, high output efficient Islamic banks might have less resources in monitoring business operations, which increased liquidity risk exposure in the short run. Nonetheless, supporting the bad management hypothesis, an inverse efficiency-liquidity risk relation existed in the long run, conjecturing that output efficient banks were capable of holding high liquidity (i.e. efficient banks with skilful managers can boost profitability) in long-term to buffer against uncertainties. This was consistent with the objective of regulation in imposing high stable funding liquidity to reduce liquidity risk in the long run. Perhaps, the need to comply with *Syariah* principle (i.e. prohibition in short selling and speculations) might naturally limit the Islamic banks to embark into risky investments. In addition, most current financing products (sale-based financing - *murabahah, istisna* and *tawarruq*, and hire-purchase financing – *ijarah thummal bay'*) offered quite a stable income with manageable risk (Mohamad & Wahab, 2016).

Table 7

Regression Analysis

	Expected sign.	***LR***	***NSFR***
LQ_{it-1}		0.217(0.001)*	0.297(0.134)*
OE	+/-	-0.369(0.103)***	0.599(0.258)**
SIZE	+/-	-0.108(0.017)***	-0.163(0.090)*
CAR	+/-	0.060(0.032)*	-0.016(0.085)
ROA	+/-	0.140(0.033)***	-0.186(0.168)
ROE	+/-	-0.122(0.040)**	0.051(0.185)*
GDP	+/-	-0.021(0.020)	-0.009(0.061)
INF	+/-	-0.031(0.015)*	-0.045(0.047)
Constant		2.088(0.449)***	1.883(1.321)
Hansen test: *p*-value		0.939	0.362
AR1: *p*-value		0.014	0.369
AR2: *p*-value		0.840	0.405

Notes:

1. Numbers in parentheses are standard errors. The sign ***, ** and * denoted significance at the 1%, 5% and 10% confidence level.
2. The sign of coefficients is towards liquidity (either *LR* or *NSFR*), and thus, the inference towards liquidity risk is reverse.
3. In analysing the financial crisis, the study runs separate regression based on Leaven and Valencia (2012). The results show that Islamic banks have not been affected by the financial crisis. The findings are in support of Bala and Nafis (2007) and Chazi and Syed (2010), conjecturing that Islamic banks are somehow resilient during crisis.
4. The study used two-step robust specification, and thus Hansen test is appropriate for testing over identification problem.

The other determinant, *SIZE* had a significant negative relation with *LR* and *NSFR*. The findings indicated that bigger banks decreasesd liquidity, which increasesd liquidity risk. The scenario might be due to the "too big to fail" theory, since bigger banks thought that even if they did not sufficient liquidity, in cases of emergency they would be saved from the lender of last resort. This result was consistent with the findings by Berger et al. (2016), Bonfim and Kim (2014), and Chen et al. (2015), but contradicted with the studies by Amin et al. (2017), Cucinelli (2013), and Ghemini and Omri (2015).

For *CAR*, the findings showed significant positive relations with *LR,* but were significant for *NSFR*. It implied that increasing capital buffer for Islamic banks would increase the liquidity position, which decreases liquidity risk in the short-term, but the desired effect did not prolong in the long-term. Perhaps, the ability of banks to convert the high liquid asset into cash helped in decreasing the liquidity risk exposure (Adalsteinsson, 2014). The results were in line with the findings by Ghemini and Omri (2015), Jedidia and Hamza (2015), and Mohamad et al. (2013). However, they contradicted the ones by Chen et al. (2015) and Roman and Sargu (2015).

With regard to *ROA*, the results showed a significant positive relation with *LR,* but not *NSFR*. It indicated that higher *ROA* increased bank liquidity and thus decreased short-term liquidity risk. The negative profitability-liquidity risk relation could result from the strong good will and high credit worthiness in obtaining funds during liquidity shortage (Amin et al., 2017). The result was parallel with previous research conducted by Amin et al. (2017), Ghemini and Omri (2015), and Mohamad et al. (2013). Nonetheless, it was in contrast to Chen at al. (2015) and Roman and Sargu (2015).

Interestingly, *ROE* showed a significant negative relation with *LR,* but a postive relation with *NSFR*. Even though both *ROA* and *ROE* measured bank profitability in general, they slightly differed in terms of *ROA*, indicating bank performance as a whole while *ROE* was specific to the shareholders' wealth. The study findings showed that increasing market value of the banks reduced bank liquidity ratio (when investors sold their stock, they deposited the cash or capital gain in the banks), which increased liquidity risk of the bank in short-term (the denominator - deposit and short-term funding of *LR* increased). Nonetheless, as deposits increased, banks gradually needed to increase the required reserve accordingly to fulfil the regulatory capital, which finally increased the available stable funding (ASF - the numerator of *NSFR*) in the long run.

With respect to macroeconomic variables, inflation posited a significant negative relation with *LR*. The negative coefficient indicated that during recession or high inflation, the Islamic banks had lesser holding of liquid asset to absorb the rising costs incurred, which at the same time exposed them to higher short-term liquidity risk. High inflation rates during inflation might increase the financing default; hence, reducing profitability of the banks' and cash holding. The result was in support of the outcomes of the study by Cucinelli (2013) and Vodovà (2011a), but contradictory to Amin et al. (2017) and Ghemini and Omri (2015).

Conclusion

This study provides empirical evidence on the impact of output efficiency and the other determinants of liquidity risk in Islamic banks worldwide. By using the dynamic panel regression, the findings infer some new perspectives. Firstly, the efficiency-liquidity risk relations are sensitive towards the liquidity risk measures, either the traditional versus BASEL III measures or the short versus long-term measures. Secondly, regardless of the liquidity measures, output efficiency seems to have a significant impact towards liquidity risk, conjecturing an important role of bank efficiency in managing both short and long-term liquidity shortage. Thirdly, notwithstanding the contradicting findings for the traditional and BASEL III measures, the inconclusive findings demand further comparative research on efficiency-liquidity risk relation by using other liquidity measures, such as financial ratios (i.e. loan-to-deposit ratio, deposit-to asset-ratio, and cash to-asset ratio) as well as complex bank liquidity measures (i.e. funding liquidity risk, market liquidity risk, market maturity mismatch, liquidity transformation, liquidity transmission, and interbank market liquidity imbalance).

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