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Technical Efficiency of Bank Liquidity Creation For Malaysian Commercial Banks From 2011 to 2018

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Abstract

One of the most important roles of banks in the economy is the provision to create liquidity. Bank liquidity creation incorporates all on- and/or off-balance sheet financial activities to foster long-term investments that contributes to growth. This study focused on measuring technical efficiency of bank liquidity creation for Malaysian commercial banks based on the on-balance sheet financial activities. Liquidity creation was measured using the 'catnonfat' approach introduced by Berger and Bouwmann (2009). In the 'catnonfat' approach, all on-balance sheet items of each bank evaluated in this study were classified as: liquid, semi-liquid and illiquid to obtain the total liquidity creation for the respective year. The sample data in this study covered 22 commercial banks in the Malaysian banking sector from 2011 to 2018. The banks in this study were split into: large, medium and small sizes. It was observed that large banks were the greatest contributors to liquidity creation in the economy. They were followed by medium-sized banks which comprised many banks and the lowest contributors to liquidity creation were small-sized banks. Bank technical efficiency measurement was performed by employing non-parametric Data Envelopment Analysis (DEA) in relation to the size of the banks. DEA is the common approach for efficiency evaluation in the banking sector as the method is able to accommodate a multiple inputs and outputs. Therefore, the efficiency of decision-making unit (DM)U can be measured and the levels of efficiency of different DMUs can be compared. It is observed that medium sized banks were the most efficient in creating liquidity throughout the period. Small banks averagely less efficient than large and medium banks in creating liquidity. Since this study only measured liquidity creation from the on-balance sheet financial activities, further research is suggested to employ another approach that inclusive of the off-balance sheet to examine the overall interplay between banks and growth.

Keywords: Liquidity Creation, Malaysian Banks, Liquidity Creation Approach, Technical Efficiency And Dea.

Introduction

According to Maudos and de Guevara (2007) bank efficiency is considered as one of the aspects that representing the quality of bank management. Numerous of studies on banking efficiency have pointed out the performance of the bank depends on efficiency such as (Akhtar, 2002; Liu, 2010; Assaf *et al.*, 2011). The importance of efficiency has been researched extensively such as (English *et al*., 1993; Berger and Mester, 1997; Drake and Hall, 2003; Hassan and Marton, 2003; Hussein, 2004; Sufian, 2004; Sufian, 2007; Sufian, 2008; Bader, 2008; Tahir *et al.*, 2008; Hassan *et al*., 2009; Das and Kumbhakar, 2012; Sufian *et al.*, 2016). Commercial banks are the main component in the banking system and their efficiency level affects a country's economic development Levine (1998) and at the same time providing the needed liquidity to the system as and when it is required. As suggested by Akhtar (2002) the banking sector is an essential part in the intermediation of modern trade and commerce in which the link between banking sector and economic growth focuses on the saving-investment growth nexus. Further justification on the importance of efficiency of the banking sector to the economy of a nation has been studied for instance by (Griffiths and Wall, 2000 Carvallo and Kasman, 2005; Zimkova, 2014; Omankhanlen, 2012; Rozzani and Rahman, 2013). Banks should be efficient in transforming their resources into various financial products and services as it is argued that banks which fail to run efficiently will be driven off the market by the more efficient banks Karim (2001) and also it will create disturbances in the process of economic development (Tahir *et al.*, 2008).

Different factors could influence the different level of bank efficiency. Some of the factors that could influence bank efficiency level may be inherent in the internal structure of the bank such as managerial factors, skill and experience of workers, bank's policy objectives, laxity, disruption in the production technology and incapability to adopt to changes. Whereas, some of the factors may be external or influenced by the environment factors such as regulatory interventions, macroeconomic shocks, business cycles and structure of the market in which the bank is operating. The combination of these internal and external factors may account for a significant amount of variability and differences in the performances level of the banking sector. Internal factors are bank-specific characteristics which within the control of the bank while external factors are beyond the control of the bank. The existing literature that has investigated on the possible influence factors of bank efficiency such as Sufian and (Chong, 2008; Athanasoglou *et al*., 2008; Ben Naceur and Omran, 2011; Agoraki *et al*., 2011; Sun and Chang, 2011; Masood and Ashraf, 2012; Beck *et al*., 2013).

Studies on banks' technical efficiency have been aplenty as bank efficiency level evolves over time and changes in any factors could have impact on the efficiency level of the banking sector. As suggested by Singh *et al* (2008) in a cross-country study to compare the level of bank technical efficiency in the Asia Pacific region that includes Malaysia, they point out the critically important of banking efficiency and it should be constantly analysed and compared as to help bankers in making better decisions and direction as well as to stay competitive in the industry. For instance, a study on the post-effect of merger and acquisition of the Malaysian commercial banks by Majid and Sufian (2005) show that the sources of technical inefficiency of large banks comes from the scale inefficiency since large banks do not gain the benefits of scale effects but the benefits are enjoyed by small banks. Other studies on the technical efficiency of the Malaysian commercial banks driven by bank ownership by Tahir *et al* (2008) reveal that domestic banks experienced higher percentage of technical efficiency than the foreign banks due to different access to technologies and environment. However, a study by Sufian and Habibullah (2010) provide contrary results that foreign banks exhibited higher technical efficiency compared to domestic banks in Malaysia.

The concept of banking efficiency is based on the definition of how well the bank transforms inputs into a set of outputs based on a given set of technology and economic factors (Aigner *et al*., 1977; Kumbhakar and Lovell, 2000). Two main components of efficiency are technical efficiency and allocative efficiency. Technical efficiency in the banking sector reflects the ability of the bank to produce maximum output with minimal inputs. Allocative efficiency reflects the ability of the bank to reduce its costs if the bank uses the right mix of inputs. Decomposing the technical efficiency into pure technical efficiency and scale efficiency allows for further insight into the sources of inefficiencies if it is existing. Other study on technical efficiency in the dual banking system in Malaysia between Islamic banks and conventional banks by Wahid (2016) point out that large-sized Islamic banks are technically efficient than the large-sized conventional banks. In contrary, small-sized conventional banks are technically efficient that small-sized Islamic banks. Studies on the effects of crisis on the Malaysian commercial banks by Majid *et al* (2003); Hisham (2003) reveal that there is no significant difference on the level of commercial banks' technical efficiency before and after the crisis. Among the studies that focus on the relationship between efficiency level and banking competition such as by Rahim (2016) suggests that Malaysian commercial banks experienced increased concentration rate with lower competition level and competition has a positive effect on technical efficiency.

Studies that investigate the relationship between bank efficiency and competition such as by Rahim (2017) investigated the performance of Malaysian commercial banks in the context of the increasing presence of foreign banks. Results reveal that competition leads to a higher efficiency gain for the Malaysian banks. Sufian *et al* (2016) examined the impact of origins on bank efficiency of the Malaysian banking sector for the period of 1999 to 2008 and provide evidence that the Malaysian banking sector has exhibited increase in efficiency over the sample period. Studies conducted to determine bank profitability and banks' performance in Malaysia have been performed by many researchers such as (Wasiuzzaman and Tarmizi, 2010; Vejzagic and Zarafat, 2014).

Given the competitive environment in which the banking industry operated and the functions performed by banks exposed them to several risks such as bank run and liquidity risk, efficiency of banks is frequently discussed in literature. Hasan and Soula (2017) investigate the level of bank efficiency in creating liquidity using banks' data in the US by employing Stochastic Frontier Approach (SFA) in analysing the efficiency level of banks in creating liquidity. Taking liquidity creation as the output and inputs such as financial capital, non-performing loans, physical capital and total assets, their findings reveal that large banks are not technically efficient as compared to the medium banks. Further justification on the importance of efficiency of the banking sector to the economy of a nation has been studied for instance by (Griffiths and Wall, 2000; Carvallo and Kasman, 2005; Zimkova, 2014; Omankhanlen, 2012; Rozzani and Rahman, 2013). Banks should be efficient in transforming their resources into various financial products and services as it is argued that banks which fail to run efficiently will be driven off the market by the more efficient banks Karim (2001) and also it will create disturbances in the process of economic development (Tahir *et al.*, 2008).

The ability of banks to create liquidity depends on the assets and liability items on their balance sheet. Banks provide financial instruments by issuing deposit products that allow the bank to pool funds on the liability side. According to Madura (2007), the main sources of banks' funds are: i) deposit accounts that include; demand deposits, savings and time deposits; ii) borrowed funds that includes loans from other banks and repurchase agreements and iii) long term funds, such as bonds. The size of funds and the ease of access to such funds affect the amount of liquidity a bank can create. The balance of customers' deposits held in their accounts will be invested by the banks as loans to businesses and households. Banks play the role of financial intermediaries to finance projects by using the money from depositors to offer long-term financial assistance through loans. In contrast, at the same time, they still provide liquidity to depositors with the ready availability of their deposits when needed. Such loans create assets and liabilities for the banks and the borrowers. When loans are credited to borrowers' accounts as deposits, the borrowers incur liabilities for the loans. On the other hand, the banks have assets equal to the amount of the loans and liabilities equal to the deposit. Bryant (1980); Diamond and Dybvig (1983) were among the pioneers that viewed the idea that channelling funds from savers to borrowers appeared like the banks were creating liquidity because they replaced illiquid assets with liquid assets. Liquidity creation refers to a bank as a liquidity provider by funding illiquid assets (loans) with the liquid liabilities (deposits) (Holmstrom and Tirole, 1998; Kashyap *et al*., 2002).

Banks are responsible for creating liquidity and managing their funding liquidity. Banks opt to hold liquid assets to decrease their liquidity risk when managing their funding liquidity. However, holding more liquid assets has an opportunity cost concerning the level of liquidity a bank can generate for the economy during normal times. Banks facilitate smooth consumption by providing liquidity to the economy, thereby yielding significant welfare gains for the entire economy. This function is important; the modern theory of financial intermediation describes that banks exist because of liquidity creation (Bhattarcharya and Thakor, 1993). Commercial banks, which are the main component of the banking system, provide needed liquidity to the system as and when it is required. As suggested by Akhtar (2002), the banking sector is an essential part of the intermediation of modern trade and commerce. The link between the banking sector and economic growth focuses on the saving-investment growth nexus. Given the importance of bank liquidity creation to generate smooth consumption and payment systems in the economy, the magnitude of a very high level of liquidity may put pressures on the solvency of Malaysian banks. The pressures can be explained by looking at the liquidity creation process itself. Banks have to deal with various issues, such as; maturity mismatches between assets and liabilities, the premature withdrawal of deposits and information asymmetries. Banks may expose themselves to multiple risks when dealing with these issues and eventually pressure their solvency. Banks may create excessive liquidity for the economy by transforming their short-term liabilities into long-term loans, in contrast, the balance sheets of banks which are not performing well in liquidity creation may have higher long-term deposits and short-term loans assets. In the latter case, banks have been said to destroy liquidity to minimize risk on their balance sheet. These issues may have consequences on the real economy. Since bank liquidity creation has been claimed to be one of the crucial roles of banks' existence, this study has assessed the level of liquidity created by Malaysian commercial banks. In addition, this study has examined how liquidity creation has changed over time, using the approach by Berger and Bouwman (2009), and whether the size of banks played a significant role in liquidity creation. In addition, some questions have been asked regarding which bank has performed well in liquidity creation and how liquidity creation has varied by each bank.

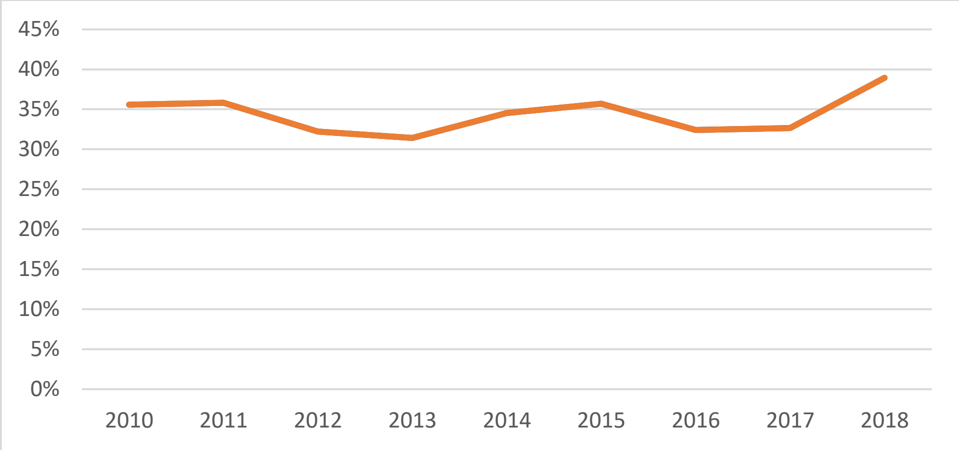

Figure 1: Liquid Assets Ratio as a Percentage of Total Assets of Malaysian Commercial Banks, 2010-2018
Source: Monthly Statistical Bulletin, Bank Negara Malaysia

Banks in Malaysia must hold enough liquidity to withstand various stress events. Therefore, they must maintain a store of liquid assets to meet unexpected demands for liquidity. A liquid asset ratio is defined as the obligation of commercial banks to maintain a predetermined percentage of total deposits and certain other liabilities in the form of liquid assets (Gulde *et al.*, 2006). The eligible range of assets includes; cash, deposits with the central bank, correspondent accounts and government securities. Figure 1 shows the ratio of liquid assets to total assets held by commercial banks in Malaysia from 2010 to 2018. The figure shows that banks have held a stable share of their balance sheets in liquid assets. There was a slight decline in the ratio in 2016 and 2017, but it continued to increase in 2018. The sufficient liquid assets in Figure 1 have been largely supported by stable funding sources comprising deposits and long-term borrowings, as shown in Table 1. This situation was reflected in the banking system's loan to fund (LTF) and loan to fund and equity (LTFE) ratios which have been sustained at levels around 80% and 70%, respectively. As of 2018, the loan to fund and loan to fund and equity ratios stood at 82.7% and 72.4%, respectively, indicating that the liquidity of Malaysian banks has remained ample and stable. The loan to fund and equity ratios are alternatives to the commonly used loan to deposit ratio as an indicator for assessing liquidity. The loan to deposit ratio does not consider diversity in banks funding structures.

Table 1
Liquidity Metrics

Year	Loan to Fund Ratio (%)	Loan to Fund and Equity Ratio (%)
2011	77.4	70.6
2012	78.3	71.1
2013	80.7	73.3
2014	82.1	74.2
2015	83.0	74.6
2016	84.2	75.2
2017	83.9	73.5
2018	82.7	72.4

Source: Bank Negara Malaysia (BNM)

Commercial banks play a major role in the Malaysian banking sector by supplying liquidity to stimulate the economy. Continuous liquidity management by banks, constant supervision by Bank Negara Malaysia (BNM) and the evolution of liquidity management tools have contributed to the current state of liquidity in the Malaysian banking sector. Therefore, it is reasonable to assess bank liquidity creation in the Malaysian banking sector. Even though the issue of liquidity creation in Malaysia has not been discussed often, most likely since banks in Malaysia are strictly regulated to avoid unnecessary shocks to the banking system, this study's findings will nonetheless add knowledge to the existing literature. In conclusion, most studies on the banking efficiency in Malaysian banking have investigated on the improvement of the technical efficiency in different aspects of observations. This study extends the work of Hasan and Soula (2017) which have examined the nexus between technical efficiency and liquidity creation. Therefore, this study will assess the level of liquidity creation in Malaysian commercial banks and examine the banks' technical efficiency in creating liquidity in regards to the size of bank. The extension of this study on the technical efficiency of the Malaysian commercial banks in creating liquidity will add knowledge to the existing literature of the studies of bank efficiency in Malaysian banking.

Literature Review

Earlier studies concerning liquidity creation have mostly emphasised the importance of banks as liquidity creators (Bryant, 1980; Diamond and Dybvig, 1983; Holmstrom and Tirole, 1998; Kashyap *et al.*, 2002). Banks create liquidity using relatively liquid liabilities, such as demand deposits, to fund relatively illiquid assets such as loans. One of the vital services banks provide to the economy is creating liquidity to satisfy the demands for liquidity by savers and longer-term financing by firms (Diamond and Dybvig, 1983; Gatev and Strahan, 2006). According to Boot *et al* (1993); Kashyap *et al* (2002), when banks create liquidity off the balance sheet by providing loan commitments and standby letters of credit, it enables businesses to develop and strategize on their long-run investments efficiently. In a similar vein, the importance of liquidity creation to the macroeconomy has been discussed in many studies, such as; (Bernanke, 1983; Detragiache *et al.*, 2009; Acharya *et al.,* 2009; Fidrmuc *et al.,* 2015). Berger and Sedunov (2017) suggested that the positive impact of liquidity creation on economic growth was larger than the growth effects of other services provided by banks.

Earlier studies on bank liquidity creation have been dealt with theoretically Bryant (1980); Diamond and Dybvig (1983); Boot *et al (*1993); Holmstrom and Tirole (1998); Kashyap *et al.*, (2002); Thakor (2005) since there has been no conclusive method to measure liquidity creation. Similar studies examining liquidity creation have focused on the role of banks as risk transformers while linking this function to liquidity creation (Diamond, 1984; Ramakrishnan and Thakor, 1984). The literature on this topic has become more prominent with the development of methods to measure liquidity creation pioneered by Deep and Schaefer (2004), known as the LT-Gap and followed by Berger and Bouwman (2009), known as the BB-measure of liquidity creation. Initially, the methods mentioned above were performed on banks in the US. Deep and Schaefer (2004) constructed a measure of liquidity transformation, defined as the difference between liquid liabilities and liquid assets over total assets. They analysed the 200 largest banks in the US from 1997 to 2001. Their findings revealed that the banks in the sample did not create much liquidity during the study period.

Berger and Bouwman (2009) constructed an approach to measure liquidity creation known as the BB measure. Berger and Bouwman (2009) employed this approach to measure bank liquidity creation in the US from 1993 to 2003. They also divided banks based on their total assets to compare large, medium and small banks in creating liquidity. The inclusion of off-balance sheet items in the banks' liquidity creation exhibited half of the liquidity creation was created from off-balance sheet activities. Their findings revealed that liquidity creation increased every year. Large banks created the most liquidity, creation was insignificant for medium-sized banks and negative liquidity creation was seen for small banks. Four alternative methods were developed in the BB measurement of liquidity creation, namely; i) 'catfat' refers to the classification of loans according to their category and inclusive of off-balance sheet items; ii) 'catnonfat' refers to the classification of loans based on its category but excludesoff-balance sheet items; iii) 'matfat' refers to the classification of loans based on its maturity inclusive of off-balance sheet items, and iv) 'matnonfat' refers to the classification of loans based on maturity but excluded off-balance sheet items.

Based on the Berger and Bouwman (2009) approaches, liquidity creation has been touted as a comprehensive measure of bank output since it includes; all assets, liabilities, and equity and/or off-balance sheet activities. Every on- or off-balance sheet item is assigned with a different theoretically driven weight to measure liquidity creation. Following the LT gap and liquidity creation measurement, the literature on bank liquidity creation has grown rapidly. Several studies have discussed the determinants of bank liquidity creation (Rauch *et al.*, 2009; Pana *et al*., 2010; Berger and Bouwman, 2009; Chen *et al.*, 2010; Grover and Sinha, 2019). Their analyses have included the unemployment rate, the interest rate, gross domestic products (GDP), return on equity (ROE), return on assets (ROA), operating profit, bank capital, credit risk, market power, profitability, the business cycle, gross savings, lending rate and regulatory policy. Fidrmuc *et al* (2015) provided evidence that liquidity creation was critical for economic growth in Russia based on their analysis covering the period from 2004 to 2012. Their findings revealed that liquidity creation increased the volume of credit, improved financial sector development and lead to higher economic growth. Based on their US banks data analysis, Berger and Sedunov (2015) asserted that higher levels of bank liquidity creation were associated with higher GDP. Liquidity creation was also viewed as improving financing conditions and facilitating transactions between economic agents (Berger *et al.*, 2010; Fungacova and Weill, 2012; Horvath *et al.*, 2014). However, in a study conducted by Halova (2013) regarding liquidity creation in the Czech Republic, large banks were the greatest contributors. Still, the off-balance sheet activities in the Czech banking sector only comprised about 10% of liquidity creation.

Berger and Bouwman (2009) examined the impact of monetary policy on liquidity creation in the US banking system from 1984 to 2008. Their analysis covered normal periods and financial crises. Their findings revealed that tightening monetary policy only allowed small banks to create less liquidity during normal times and less during financial crises. In addition, liquidity creation was detected at higher levels before financial crises. Therefore, they suggested that crises could be predicted by measuring bank liquidity creation. Berger *et al* (2010) postulated that regulatory interventions and capital injections influenced liquidity creation in German universal banks and reduced both bank risk-taking and liquidity creation. Rauch *et al* (2009) explored the potential determinants of liquidity creation using monetary policy and the unemployment rate with bank-specific factors, such as bank size and financial performance. Their findings showed that tightening monetary policy reduced liquidity creation, while bank-specific factors did not significantly impact. While Pana *et al* (2010) examined the level of liquidity creation during US bank mergers, the results showed that bank mergers positively impacted banks' liquidity creation.

Rogowski (1999) pointed out that measuring technical efficiency is a very popular approach used to estimate firm's efficiency. The study of measuring technical efficiency of a firm in an industry was pioneered by Farrell (1957) by estimating production function of firms to identify which firm is fully efficient. Technical efficiency means that a firm is able to maximize output with the given inputs (Cooper et al., 2006). The condition where a firm may become technically efficient is when banks able to produce more outputs with the actual less inputs (Sherman and Zhu, 2006). Sherman and Zhu (2006) classified overall productivity of a bank into four components of efficiency: i) technical efficiency that measures the ability of banks to produce actual outputs with less resources that indicates higher efficiency, ii) scale efficiency of a bank in achieving optimal level in order to avoid additional fixed cost, iii) price efficiency that focuses on bank efficiency in obtaining inputs at lower prices without sacrificing the quality, and iv) allocative efficiency which measure the optimal mix of several inputs in producing services or products such as banks resort to internet banking to reduce personnel expenses. Bhattacharyya *et al* (1997) evaluated the technical efficiency of Indian commercial banks and banks are evaluated based on the ownership; publicly owned banks, foreign-owned banks and privately-owned banks. In the study, interest expense and operating expense are the inputs and the outputs are advances, deposits and investments. Publicly-owned banks have the highest efficiency level and foreign-owned and privately-owned banks have the lower efficiency level.

Meryem and Jackson (2000) examined the efficiency of 36 Turkish commercial banks as the guidance in selecting bank inputs and outputs. The inputs used are total employees and non-labour operating expenses while the outputs are total loans and deposits. Using DEA under the CRS assumption, the findings show that there is high variability in efficiency with the efficiency scores ranged from 16% to 100%. Also, the results show foreign banks have less efficiency level as compared to state banks. Salleh *et al* (2001) found that the foreign banks are technically efficient than domestic banks in the Malaysian commercial banks sector. The study has been evaluated by utilizing input variables of capital and reserves, total assets, branch, a number of employees and a number of automated-teller machines and the outputs are loans, advances, deposits and profit before tax. Several studies have discovered mix findings on the efficiency level between domestic and foreign banks (such as Salleh *et al*., 2001; Bhattacharyya *et al*., 1997; Meryem and Jackson, 2000). Several studies discovered that the foreign banks are significantly more efficient than domestic banks while some reported contrary findings (such as Jemric and Vujcic, 2002; Salleh *et al.,* 2001; Sufian *et al*., 2016; Cevik *et al*., 2016).

Ragan *et al* (1998) evaluated the technical efficiency of 215 independent banks with deposits less than USD400 million in the US by applying non-parametric frontier using the intermediation approach with labour, capital and purchased funds as the inputs while loans (real estate loans, commercial and industrial loans, consumer loans) and deposits (demand, time and saving deposits) as the outputs. Under the constant return to scale (CRS) model, the findings show that average technical efficiency level is 70% which implies that on average that banks only used 70% of their inputs to produce the same level of outputs. This implies that most of the banks faced technical inefficiency like wasting resources when operating under the CRS. Miller and Noulas (1996) tested on the efficiency of 201 banks with assets exceeding to USD1 billion with the selection of inputs consists of deposits, interest expense and non-interest expense and the outputs are loans, investments, interest income and non-interest income using the CRS approach. Their findings show that the most profitable banks. The highest technical efficiency scores are 97% for the most profitable banks and 40% of pure technical efficiency.

Jemric and Vujcic (2002) adopted the operating and intermediation approaches in DEA analysis between bank efficiency and customer type. With the number of employees and total deposits as the inputs and total loans and securities as the outputs, they found evidence that foreign banks with business customers are more efficient. Weill (2003) tested on 47 banks in Poland and the Czech using a sample data from year 1997 find evidence that foreign banks are more efficient. Sahyouni and Wang (2018) investigated the liquidity creation of conventional and Islamic banks across 18 MENA countries from 2011 to 2016 and the relationship between bank performance and liquidity creation. Findings showed that conventional banks created the most liquidity than Islamic banks. Also, it is revealed that there is a significant and negative correlation between bank performance and liquidity creation using the return on equity variable.

Data envelopment analysis (DEA) approach is undertaken in the context of the microeconomic theory of production that can be applied to assess the efficiency of a variety of firms or institutions. Firms combine observable inputs to produce measurable outputs and the process can be described by engineering formulas that specify how inputs are to be combined with one another at each stage in the production process. The end product which is the output can then be expressed as a function of all the inputs used to produce it and the equation is called as a production function. The production function defines the frontier of the production possibility set such as the well-known Cobb-Douglas production function. The assumption made about production function is that it is technological efficient which implies that if one input is increased and all other inputs are held constant, output must increase. If output did not increase, then the increased input would be wasted. Firms whose input-output combinations lie on the frontier of the production function by equation 1 are said to be technologically efficient and firms are said to be technologically inefficient when their input-output combinations located inside the frontier.

According to Sufian (2004, 2007) there are six reasons for adopting the DEA in estimating efficiency. Firstly, each DMU is assigned a single efficiency score allowing ranking among the DMUs in the sample. Secondly, DEA focuses on the areas to improve for each single DMU whether the input has been excessively used or output has been under produced by the DMU so that they could improve on efficiency level. Thirdly, it is possible to make inferences on the

DMU's general profile by offering the opportunity to compare the production performances of each DMU with a set of efficient DMUs called as reference set. As such, the owner of the DMUs may show interest in knowing which DMU frequently appears in this set. A DMU appearing more than others in this set is called the global leader. Fourthly, plenty of studies have suggested that DEA does not need a priori or a particular function form to be mandatory on the data to identify and determine the efficient frontier, error and inefficiency structures of the DMUs (Bauer *et al.*, 1998; Grifell-Tatje and Lovell, 1997). Fifthly, there is no requirement to standardise DEA, thus allowing researches freedom in the selection of the kind of input and output of managerial interest and despite the different measurement units (Ariff and Can, 2008; Berger and Humphrey, 1997). Finally, DEA is appropriate for small samples and therefore suited to this study of the commercial banks in the Malaysian banking sector, for which total number of the banks is small.

The relationship between bank size and bank efficiency to date remains inconclusive. According to Jemric and Vujcic (2002), there was a relationship between bank size and efficiency. Previous studies on determinants of bank efficiency suggests large sizes banks are more efficient than smaller banks due to the former are able to achieve wider market penetration at relatively less cost (Sufian *et al*., 2012a; Perera *et al*., 2007; Berger *et al*., 1993b; Hassan and Marton, 2003). Hassan and Marton (2003) in their study of efficiency in Hungary on a sample data from 1993 to 1998, suggested that larger banks are more efficient. There are also studies that showed contrary findings that small size banks might achieve higher efficiency (Sufian, 2009; Girardone *et al*., 2004; Berger and Mester, 1997). Findings from the study by Yin *et al* (2013), there is a negative relationship between bank size and bank efficiency at certain point to the lower end and banks' experience less efficient as banks' size grow. Repkova (2013) used dynamic data envelopment analysis to estimate productive efficiency of Czech commercial banks during the period of 2000 to 2011 and the results showed that the three largest banks had the lowest efficiency score under the assumption of constant returns to scale technology. Similarly, Stavarek and Repkova (2012) showed that efficiency of large Czech commercial banks is comparable with efficiency of small banks only if it is assumed that bank technology has decreasing returns to scale.

The DEA approach has been employed in many recent studies especially to measure the bank's efficiency, for example; Drake (2001); Isik and Hassan (2002); Saaid *et al* (2003); Hassan and Hussein (2003); Mostafa (2007); Sufian and Chong (2008); Bader (2008); Tahir *et al.* (2009); Sufian (2012); Othman *et al* (2016) and many others. Charnes *et al* (1978) develop the DEA to estimate the efficiency of public sector non-profit organizations. In the analysis of efficiency on banking sectors, the first application of DEA was employed by Sherman and Gold (1985) that describe DEA as a tool that calculates the relative efficiency scores of various DMUs in a particular sample. DEA measures the overall ethical efficiency (OTE) or technical efficiency (TE), the decomposition of the pure technical efficiency (PTE) and scale efficiency (SE) of the DMUs.

Technical efficiency (TE) measures the proportional reduction in input usage that can be attained if a bank operates on the efficient frontier or the effectiveness of the limited set of inputs used to produce maximum outputs. According to Isik and Hassan (2002a), TE is related to managerial factors, while pure technical efficiency (PTE) is the measurement of technical efficiency devoid of the scale efficiency or firm's size efficiency (SE) effects (Sufian, 2004 and Coelli *et al.*, 1998). The estimation of PTE represents managerial efficiency while the SE represents the scale or size of operation efficiency. The DMUs in any analysis could include firms, institutions, farms and banks. The DEA measurement will compare each of the DMUs in the sample with the best-practice in the sample and identified which of the DMUs in the sample are efficient and which are not. The capability of the DEA to identify possible peers or role models as well as simple efficiency scores gives it an edge over other methods. Moreover, the DEA does not require the explicit specification of the form of the underlying production relationship since it is formed as the piecewise linear combinations that connect the set of these best-practice observations which yielding a convex production possibilities set (Berger and Humphrey, 1997).

Methodology

Data

This study's empirical analysis used annual bank data from 2011 to 2018. The annual data were extracted from the annual reports of the sampled banks in Malaysia. The data included the annual reports' income statements and statements of financial position. Only commercial banks data in the Malaysian banking sector were considered to maintain homogeneity. Table 2 describes the distribution of the sample of Malaysian commercial banks used in this study versus the actual number of commercial banks in the Malaysian banking sector. The sample of banks selected in this study exhibited good coverage, including 84.62% of all Malaysian commercial banks.

Table 2
Distribution of the sampled banks

	Commercial banks
Total Number of banks	26
Sampled banks	22
Percentage of the sample (%)	84.62

Liquidity Creation Approach

The objective of this study was to measure the liquidity created by commercial banks in the Malaysian banking sector. Therefore, the method of measurement for liquidity creation used followed the approach of Berger and Bouwman (2009) is discussed below. The liquidity creation measures in this study were constructed using the three-step approach developed by (Berger and Bouwman, 2009). In the first step, all balance sheet items from all sampled banks were grouped according to the; ease, cost and time it took for the banks to turn them into actual cash or liquid funds. All items were classified as; liquid, semi-liquid and illiquid. From the assets side of the balance sheet cash, correspondent accounts with other banks, investments in debt securities, investments in stocks and all securities held by banks, which could be turned into cash easily and at low cost, were classified as liquid assets. All other types of loans, such as households' loans, loans to governments, including foreign governments and interbank loans, were grouped as semi-liquid assets. Other assets, such as; fixed assets, intangible assets and other loans, were grouped as illiquid assets since they required more time or higher costs to turn into cash. Following the literature, corporate loans were considered illiquid assets since banks lack the option of selling them to meet their liquidity needs. On the liability side, items that customers could easily withdraw, such as settlement accounts and all securities issued by banks, were classified as liquid liabilities. Savings, term and other deposits were classified as semi-liquid liabilities. Other liabilities were classified as illiquid liabilities as well as equity.

In the second step, weights of either 0.5 or -0.5 were assigned to all items and multiplied by each group's Ringgit Malaysia-denominated volume. 0.5 was applied to the groups that were seen to create liquidity by transforming illiquid assets into liquid liabilities. One-unit face value of liquidity was created when a unit of liquid liabilities such as current account deposits (weights is 0.5) was used to finance a unit of illiquid assets, such as long-term loans (weights is 0.5). Illiquid assets and liquid liabilities were multiplied by 0.5. -0.5 was assigned to groups that were seen to extract liquidity from the economy. For example, if banks held liquid assets, such as cash, they were said to be extracting liquidity from the economy because other economic subjects couldn't use the cash. Thus, -0.5 was assigned to liquid assets and illiquid liabilities. Following Berger and Bouwman (2009), semi-liquid assets and semi-liquid liabilities were assigned with a weight of 0, assuming that semi-liquid items fell halfway between liquid and illiquid items. In this sense, funding property loans using time deposits would yield approximately zero created liquidity. This situation would occur because the; ease, cost and time with which depositors may access their funds would equals the; ease, cost and time with which a bank could securitize and sell the loans to provide funds.
In the third step, all the calculated groups for both assets and liabilities were summed up to yield the total amount of created liquidity, as expressed in Equation (1) as follows:

$$
\begin{aligned}
&Liquidity\ creation(catnonfat) \\
&\quad = \left\{\frac{1}{2} \times illiquid\ assets + 0 \times semi - liquid\ assets - \frac{1}{2} \times liquid\ assets\right\} \\
&\quad + \left\{\frac{1}{2} \times liquid\ liabilities + 0 \times semi - liquid\ liabilties - \frac{1}{2} \times illiquid\ liabilites\right\} - \frac{1}{2} \times equity
\end{aligned}
\tag{Eq.1}
$$

The construction of the liquidity creation measure in this study was based on categorizing balance sheet items by category. All on-balance sheet items of each bank evaluated in this study were classified as liquid, semi-liquid or illiquid. On the assets side, cash and short-term funds, deposits and balance with other financial institutions, and all financial securities, regardless of maturities, derivative assets, and trading assets, were classified as liquid assets. Loans to governments, household loans, loans to other financial institutions, housing loans, other consumer loans, commodity loans and loans to foreign governments were classified as semi-liquid assets. Other assets, such as; investment properties, investments in subsidiaries, intangible assets, fixed assets, goodwill and corporate and commercial loans, were classified as illiquid assets. On the liability side, deposits from customers in current and savings accounts, derivative liabilities, bill and acceptance payables, claims of banks and securities debt were classified as liquid liabilities. Term and other deposits, other borrowed money from other banks, deposits from other banks and short-term borrowings were classified as semi-liquid liabilities. Other liabilities, subordinated obligations, total equity, deferred tax and senior debt were classified as illiquid liabilities. Table 3 presents the classification of bank assets and liabilities based on category.

Table 3
Classification based on Category and Assigned Weights

Classification of assets		
Liquid asset (weight= -0.5)	**Semi-liquid assets (weight=0)**	**Illiquid assets (weight=0.5)**
Cash and short-term funds	Loans to governments	Other assets
Deposits and balance with other FI	Loans to households	Investment properties
All financial securities (regardless of maturity)	Loans to other FI	Investment in subsidiaries
Derivative assets	Commodity loans	Intangible assets
Trading assets	Loans to foreign entities	Goodwill
	Other consumer loans	Fixed assets
		Corporate loans
		Commercial loans
Classification of liabilities + equity		
Liquid liabilities (weight=0.5)	**Semi-liquid liabilities (weight=0)**	**Illiquid liabilities (weight= -0.5)**
Savings deposits	Term deposits	Other liabilities
Current deposits	Other deposits	Subordinated obligations
Bill and acceptance payables	Other borrowed money from other banks	Deferred tax liabilities
Claims of banks	Deposits from other banks	Senior debt
Securities debt	Short-term borrowings	Total equity
Derivative liabilities		

Finally, for the construction of liquidity creation measures, all items were multiplied by the assigned weights and summed up to obtain the total Ringgit Malaysia value of liquidity creation at a particular bank using Equation (1). The liquidity creation for a bank was then summed up with the liquidity creation of other banks in a given year to obtain a total liquidity creation for Malaysia's banking sector during the year. For analytical purposes, banks were divided by bank size into large, medium and small banks. This study only applied the 'catnonfat' approach to measuring liquidity creation as there was a lack of detailed breakdown of off-balance sheet data.

Data Envelopment Analysis for Bank Efficiency

The objective of this study is to examine banks' level of technical efficiency using Data Envelopment Analysis (DEA) developed by Charnes, Cooper and Rhodes (CCR) (1978). The first DEA model in evaluating the performance of firms uses input orientation with constant returns to scale (CRS) assumption. The basic idea of DEA is to identify the most efficient bank or decision-making unit (DMU) among all the banks or the DMUs. The DMU is the evaluation unit that transforms inputs into outputs. Thus, DEA computes the efficiency of the DMU in using those multiple inputs and outputs that enable the DMU to produce the maximum level of output or inputs. DEA transforms established a benchmark efficiency scores range from 0 to 1. The value of 1 means efficient and less than 1 means inefficient. The second model of DEA proposed by Banker, Charnes and Cooper (BCC) (1984) with a variable return to scale (VRS) assumption. Figure 2 shows the effect of the returns to scale assumption applied in the DEA.

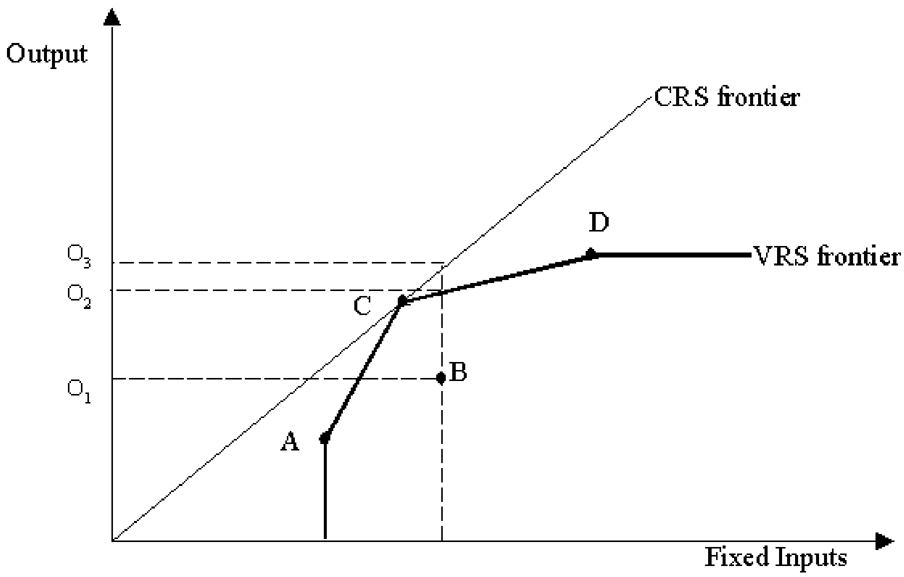

Figure 2: CRS and VRS frontier

There are four points shown in the Figure 1: point A, B, C and D. Those points are used to estimate the efficient frontier and the level of capacity utilization under both scale assumptions. Inputs are taken into account as fixed and the frontier defines the full capacity output given the fixed inputs. With CRS, the ratio between the addition of input and output is the same. That is, output will increase by *X* times if there is an additional *X* times of input. In the figure, point C meets the assumption of CRS and therefore is efficient, while other points indicating capacity underutilization. Points A, C, and D lies on the VRS frontier and are efficient if VRS is assumed. Whereas point B lies below frontier indicates capacity underutilization. With VRS, the ratio between the addition of input and output is not the same. That is, an additional inputs *X* times will not increase the output by *X* times as it can be smaller or greater than *X* times. From the figure, capacity utilization is estimated as the ratio of the actual output to the frontier level of output. At point C, capacity utilization is at 100% under both CRS and VRS assumptions. The measure of capacity utilization is lower or more underutilization for the rest of the points when assuming CRS. Under the CRS assumption, all DMUs are at an optimal scale. But in practice, not all DMUs are operating at the optimal scale. Furthermore, CRS estimates on overall technical efficiency without taking into consideration on the scale of the operations. Thus, it would be unfair to compare against the most productive scale size as it would be under CRS. Also, under the VRS assumption, the actual level of efficiency can be obtained without being limited by a constraint as it would be under CRS and VRS usually refers to short-term period (Siriopoulos and Tziogkidis, 2009). Therefore, this study employs estimates of efficiency levels under the assumption of VRS.

Further discussions on the technical efficiency led to the decomposition of the measurements into two: pure technical efficiency (PTE) and scale efficiency (SE) as shown in Figure 3. PTE refers to the deviations from the efficiency frontier resulting from the lack of an efficient use of the resources and related to TE. SE suggests that the scale of the operational level of bank has an important role that determines its relative efficiency or inefficiency. SE can be calculated from the ratio of the efficiency of the CCR model and BCC model. This is because CCR model reflects on the technical efficiency and the scale efficiency, while BCC model only reflects on the technical efficiency. This means, an efficient DMU with a BCC model but not efficient with the CCR model means the DMU is having scale inefficiency. This is because, the DMU is technically efficient but the inefficiency exists from the scale. Figure 3 illustrates the SE and PTE measurements. Line 0E represents CRS frontier and points GBAH represents VRS frontier. PTE is measured as $PTE = \frac{FJ}{FC}$ and $SE = \frac{FK}{FJ}$. Using both CCR and BCC models allows measuring the scale efficiency of the DMU by dividing TE over PTE, that is $SE = \frac{TE}{PTE}$. SE measures may inform whether the DMU is efficient or inefficient in terms of scale but it does not provide information on how the DMU should scale its operation to become efficient (Kamarudin *et al.*, 2016).

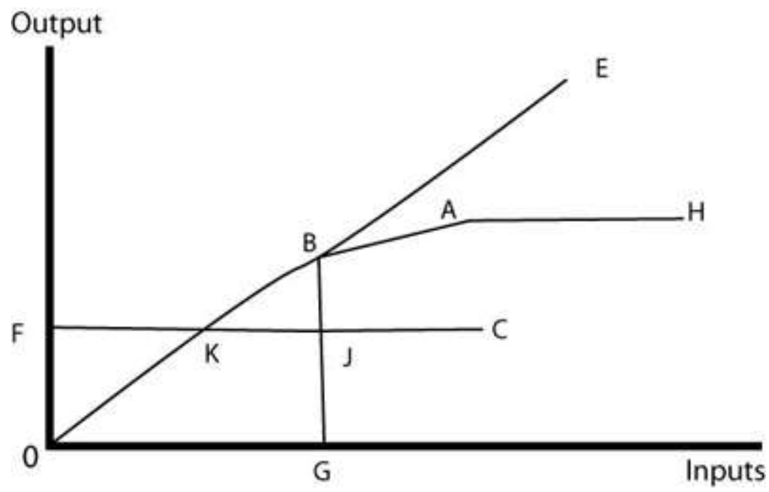

Figure 3: Scale Efficiency (SE) and Pure Technical Efficiency (PTE)

The technical efficiency can be illustrated mathematically through the basic idea of DEA. Suppose a set of technical efficiencies on *n* DMUs to be evaluated, denoted by DMU_j (j=1, 2, .., n); each DMU has *m* inputs, denoted by x_i (i = 1, 2, .., m) and the input weight s represented as v_i (i=1, 2, …, m); each DMU has q outputs denoted by y_r (r=1, 2, .., q) and the output weight is denoted as u_r (r = 1, 2, .., q). The DMU to be measured is denoted by DMU_k, then its ratio of output to input is represented as:

$$h_k = \frac{u_1 y_{1k} + u_2 y_{1k} + \cdots + u_q y_{qk}}{v_1 x_{1k} + v_2 x_{2k} + \cdots + v_m x_{mk}} = \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad \text{(Eq. 2)}$$

Where: $v \geq 0$; $u \geq 0$; i = 1, 2, …, m; r = 1, 2, …, q

Next, a condition is added to the technical efficiency values to be measures and all efficiency values are limited in the interval [0, 1]. This can be given as:

$$maximise\ h_k = \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad \text{(Eq. 3)}$$

Subject to condition:

$$\frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \leq 1 \qquad \text{(Eq. 4)}$$

where: $u \geq 0$; $v \geq 0$; $i = 1, 2, \ldots, m$; $r = 1, 2, \ldots, q$; $j = 1, 2, \ldots, n$

The nonlinear programming model above maximizing the efficiency value of the evaluated DMU under the condition that all efficiency values of DMU are less than 1. In this sense, the weights of u and v that was determined from the CCR model estimates the inefficient situation of the evaluated DMU and all efficiency values obtained using any other weights will be no more than the efficiency value obtained by this set of weights. When both input and output of the evaluated DMU_k are increased to as t times from their original values, the CCR model will be equivalent to the original model and the efficiency values obtained will remain unchanged which is consistent with the assumption of the constant returns to scale as shown in equation (5) as follows:

$$\max \frac{\sum_{r=1}^{q} u_r t y_{rk}}{\sum_{i=1}^{m} v_i t x_{ik}} = \frac{t\sum_{r=1}^{q} u_r y_{rk}}{t\sum_{i=1}^{m} v_i x_{ik}} = \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad \text{(Eq. 5)}$$

However, there are problems in the equation (4) that is it is a nonlinear programming and infinitely many optimal solutions exist. Assuming vectors *u** and *v** are a set of optimal solutions of the equation (5), then *tu** and *tv** must also be optimal solutions (t>0) of the model. Given,

$$\sum_{i=1}^{m} v_k x_{ij} > 0 \qquad \text{(Eq. 6)}$$

the constraint of the equation (5) is subject to:

$$\sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad (3.7)$$

Let $t = \frac{1}{\sum_{i=1}^{m} v_i x_{ik}}$, then the objective function of the equation (5) will turn into

$$\max\ t\sum_{r=1}^{q} u_r y_{rk} = \sum_{r=1}^{q} t u_r y_{rk} \qquad \text{(Eq. 8)}$$

Let μ = *tu* and v = *tv;* then the nonlinear of equation (5) will be transformed into an equivalent linear programming objective function:

$$\min \quad \sum_{i=1}^{m} v_i x_{ik} \qquad \text{(Eq. 9)}$$

Subject to:
$$\sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$
$$\sum_{r=1}^{q} u_r y_{rk} = 1$$

where: v ≥ 0; μ ≥ 0; *i* = 1, 2, …, m; *r* = 1, 2, …, q; *j* = 1, 2, …, n

Equation (9) is a linear programming used to express the output-oriented CCR model. Its dual model is established as

$\max \emptyset$
Subject to: $\sum_{j=1}^{n} \lambda_j y_{rj} \leq x_{ik}$
where: λ ≥ 0; i = 1, 2, …, m; r = 1, 2, …, q; j = 1, 2, …, n (Eq. 10)

The dual model as in equation (10) referred to as the output-oriented CCR model because it is used to measure the inefficient situation by the degree of proportional increase of all its outputs under the condition of a given input. The optimal solution of the model is ψ^* indicates the largest ratio of the output of the evaluated DMU_k can increase without increasing the input is ψ^* - 1 that is under the current technical level. A greater ψ^* represents a larger increasing range of the output and a lower efficiency. In BCC linear programming model, the constraint condition $\sum_{j=1}^{n} \lambda_j = 1$ is added on the basis of the CCR dual model of equation (10). This added constraint acted as to make the production scales of both projection point and the evaluated DMU ranged in the same level.

$$\max \phi$$

Subject to:
$$\sum_{j=1}^{n} \lambda_j y_{ij} \leq x_{ik}$$
$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi y_{rk}$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
where: λ ≥ 0; i = 1, 2, …, m; r = 1, 2, …, q; j = 1, 2, …, n (eq. 11)

Equation (11) is the output-oriented BCC linear programming. Its dual programming is expressed as:

$$\min \sum_{i=1}^{m} v_i x_{ik} + v_0$$

Subject to:
$$\sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - v_0 \leq 0$$
$$\sum_{r=1}^{s} u_r y_{rk} = 1$$
where: v ≥ 0; μ ≥ 0; i = 1, 2, …, m; r = 1, 2, …, q; j = 1, 2, …, n (Eq. 12)

Since DEA is widely used to measure the efficiency level of the DMUs, this study uses this method in the measurement of technical efficiency. By calculating the technical efficiency level of the Malaysian commercial banks, this study will be able to assess the efficiency level those banks in creating liquidity.

This study opted for the intermediation approach since it is a widely approach employed in the analysis of banking sector (Bader *et al*., 2008; Isik and Hassan, 2002 and Hassan *et al.*, 2009). Another reason why intermediation approach is preferable is because the inputs selection under this approach normally employ labor and physical capital in producing earning assets (Sealey and Lindley, 1977). Even though there is no definite approach in the selection of the bank inputs and outputs (Bader *et al*., 2008), the choice of inputs and output in this study are guided by the choices made in previous studies (Fare *et al.,* 1994; Bader *et al*., 2008; Sufian , 2012). The three input vector variables used in this study consist of; x1: labor that is measured by personnel input; x2: physical capital measured by book value of fixed assets; and x3: financial capital measured by total equity of the bank. The output vector variable is y1: bank liquidity creation measured from Berger and Bouwman's (2009) approach. All the variables used in DEA models are listed in Table 4.

Table 4
Variable of Inputs and Outputs

Variable	Symbol	Variable Name	Definition
Inputs	x1	Labour	Personnel expenses
	x2	Physical capital	Book value of fixed assets
	x3	Financial capital	Total equity
Output	y1	Bank liquidity creation	Total liquidity created by banks measured using Berger and Bouwman's (2009) approach

Results and Discussion
This section depicts that the objectives of this study were fulfilled by measuring Malaysian commercial bank liquidity creation over time and examining the categories of banks that created the greatest and least liquidity over the sample period. This study applied the 'catnonfat' approach introduced by Berger and Bouwman (2009) to measure the liquidity created from 2011 to 2018. The sample of banks was divided into three categories according to their size of total assets, namely; large, medium and small banks, since size matters, as has been argued in the existing literature, such as; (Berger et al., 2005; Berger and Bouwman, 2009; Rauch *et al*., 2009; Distinguin *et al*., 2013; Imbierowicz and Rauch, 2014; Chatterjee, 2015).
Berger and Bouwman (2009) argued that differently sized banks had different ways of handling various credit information enabling them to extend different types of loans to their customers. They found this evidence by splitting their sample of banks into large and small-sized banks. Berger and Bouwman (2009) split the sample of banks in their analysis into three; large, medium and small, with large banks having total assets exceeding $3 billion, medium banks having total assets between $1 billion to $3 billion and small banks having total assets below $1 billion. Distinguin *et al* (2013) divided their sampled banks into two groups: large and small, considering that a bank was small if its total assets were less than $1 billion. Imbierowicz and Rauch (2014) divided their sampled banks into: large, medium and small by dividing the total assets of the sampled banks into three quantiles. The first quantile represented small banks, the second quantile represented medium banks, and the third quantile represented large banks. Therefore, to test the hypothesis that bank liquidity creation depends on the bank's size, the banks in the present study were classified into three sizes: small, medium and large. Banks were considered small if the sum of their total assets was less than the 25-percentile of the overall total assets. A bank was considered large if the sum of its total assets was equal to or larger than the 75-percentile of the overall total assets. All other banks were classified as medium. Table 5 represents the number of banks according to bank size based on total assets for the respective year.

Table 5
Large, Medium and Small Size Banks based on Total Assets, 2011-2018

Bank size group	2011	2012	2013	2014	2015	2016	2017	2018
3rd quantile: upper 75%								
Large banks	4	5	5	5	5	5	5	5
Total Assets (RM billion)	>102.84	>128.03	>140.73	>141.60	>150.53	>153.94	>153.85	>154.73
2nd quantile								
Medium banks	12	12	13	14	14	12	12	14
Total Assets (RM billion)	in between	in between	in between	in between	in between	in between	in between	in between
1st quantile: lower 25%								
Small banks	6	5	4	3	5	5	5	3
Total Assets (RM billion)	<34.28	<42.68	<46.91	<47.20	<50.18	<51.31	<51.28	<51.58

The ‘catnonfat’ liquidity creation measurement was computed using Equation (1) reveal the amount of liquidity creation created between 2011 and 2018. Figure 4 exhibits the total liquidity created annually by commercial banks in Malaysia during the sample period. The figure shows that liquidity creation showed an increasing trend during the sample period primarily due to increases by large banks, whereby the total liquidity created by the commercial banks amounted to RM608.12 billion and RM1010.89 billion in 2011 and 2018, respectively. In 2011, there were four large banks, 12 medium-sized banks and six small banks. However, the total liquidity created by these four large banks still dominated the total liquidity creation for the whole year, which was valued at RM351.18 billion. Medium banks created about RM251.19 of the liquidity, and small banks created about RM5.76 billion of the liquidity.

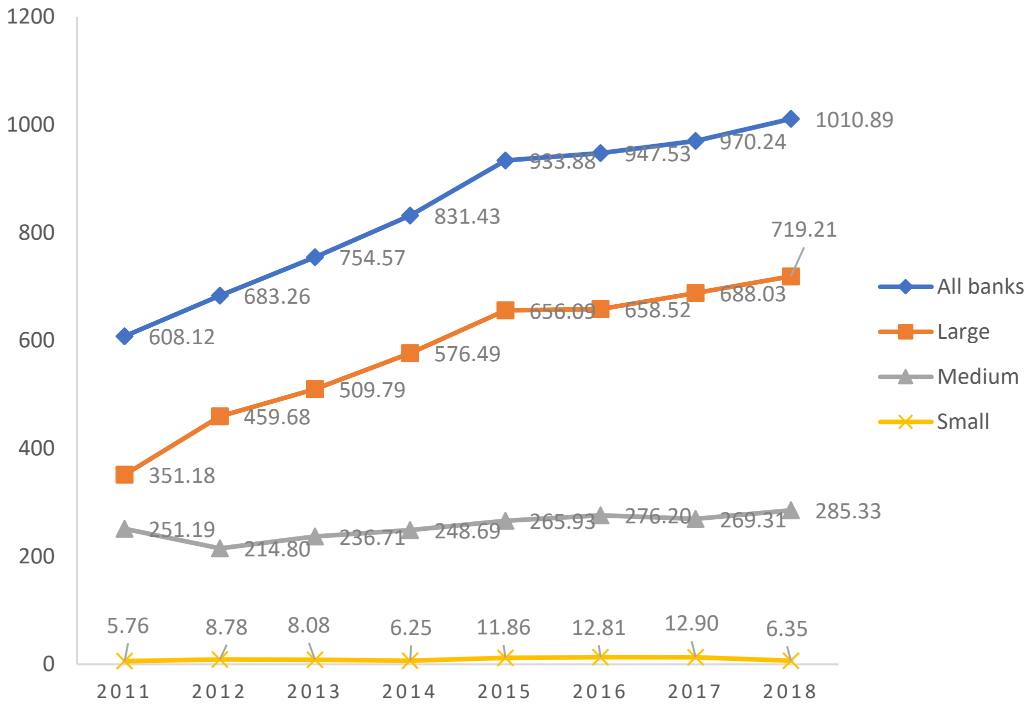

Figure 4: Liquidity Creation over time

In 2012, total liquidity creation increased to RM682.26 billion, with five large banks creating RM459.68 billion (about 67.3% of total liquidity creation) of the liquidity. In the same year, 12 medium-sized banks created about RM214.80 billion and five small banks created about RM8.78 billion of liquidity. Large banks were the most contributors to the liquidity creation of the economy, even with a small number of banks. They still dominated the production of liquidity, with the amount of liquidity they created amounted to RM509.79 billion (67.6%), RM576.49 billion (69.3%), RM656.09 billion (70.2%), RM658.52 billion (69.5%), RM688.03 billion (70.9%) and in 2013, 2014, 2015, 2016 and 2017 respectively. In 2018, large banks created RM719.21 billion (71.1%) of liquidity despite representing only 22% of the sampled observations. Large banks have competitive advantages from economies of scale, which reduce their costs of operation and economy of scope resulting in more product diversifications and better customer access. Therefore, large banks can offer competitive rates for their products, penetrate markets more fully, offer promotions and create awareness of their range of products to the customers compared to medium and small-sized banks.

Medium-sized banks constituted a large number of banks, as can be seen in Table 6. Still, they were below the large banks in creating liquidity with the amount of liquidity created RM236.71 billion, RM248.89 billion, RM265.93 billion, and RM276.20 billion. RM269.31 billion and RM285.33 billion in 2013, 2014, 2015, 2016, 2017 and 2018, respectively. The lowest contributors to liquidity creation were the small banks, with the amount created at RM8.08 billion, RM6.25 billion, RM11.86 billion, RM12.81 billion, RM12.90 billion and RM6.35 billion in the years 2013, 2014, 2015, 2016, 2017 and 2018 respectively.

The increase in overall liquidity creation was driven by substantial growth in illiquid assets. Table 5 represents the summary statistics of liquidity creation standardised to total assets (LC/TA), liquidity creation to total gross loans (LC/GL), liquidity creation to total deposits (LC/TDep) and liquidity creation to total equity (LC/Eq). The overall liquidity creation in2011 equalled 44% of the overall total assets in the commercial banking sector. Liquidity creation to total equity (LC/Eq) represented RM5.37 of liquidity had been created per RM1 equity capital. Liquidity creation in 2011was 74% as large as gross loans and 54% as large as total deposits. These results indicated that liquidity creation grew faster than gross loans and total deposits. Liquidity creation as a fraction of total assets exhibits a fluctuating trend but was stable during the sample period. The highest percentage of liquidity creation over total assets was 49% in 2018, and the lowest was 40% in 2013. The findings of this study showed an increasing trend in the growth of liquidity creation in Malaysia. By dividing banks into three groups: large, medium and small, according to the size of their total assets, strong growth liquidity creation was largely driven by the large banks, followed by medium banks and small banks.

Table 6
Summary of Liquidity Creation, 2011-2018

Year	Bank Types	No. of Obs.	LC/TA (%)	LC/TDep(%)	LC/GL (%)	LC/Eq (RM)
2011	All banks	22	0.44	0.54	0.74	5.37
	Large	4	0.26	0.31	0.43	3.10
	Medium	12	0.18	0.22	0.31	2.22
	Small	6	0.00	0.01	0.01	0.05
2012	All banks	22	0.41	0.54	0.74	4.90
	Large	5	0.27	0.36	0.50	3.30
	Medium	12	0.13	0.17	0.23	1.54
	Small	5	0.01	0.01	0.01	0.06
2013	All banks	22	0.40	0.56	0.73	4.96
	Large	5	0.27	0.38	0.50	3.35
	Medium	13	0.13	0.17	0.23	1.56
	Small	4	0.00	0.01	0.01	0.05
2014	All banks	22	0.44	0.54	0.72	4.81
	Large	5	0.31	0.38	0.50	3.34
	Medium	14	0.13	0.16	0.22	1.44
	Small	3	0.00	0.00	0.01	0.04
2015	All banks	22	0.47	0.60	0.75	4.93
	Large	5	0.33	0.42	0.53	3.46
	Medium	14	0.13	0.17	0.21	1.40
	Small	5	0.01	0.01	0.01	0.06
2016	All banks	22	0.46	0.60	0.74	4.51
	Large	5	0.32	0.42	0.51	3.14
	Medium	12	0.13	0.17	0.21	1.32
	Small	5	0.01	0.01	0.01	0.06
2017	All banks	22	0.47	0.62	0.75	4.23
	Large	5	0.34	0.44	0.53	3.00
	Medium	12	0.13	0.17	0.21	1.17
	Small	5	0.01	0.01	0.01	0.06
2018	All banks	22	0.49	0.46	0.82	4.26
	Large	5	0.35	0.46	0.59	3.03

Medium	14	0.14	0.18	0.23	1.20
Small	3	0.00	0.00	0.01	0.03

This study followed the rule of thumb on the number of inputs and outputs variables as suggested by (Cooper *et al.,* 2002). Two rules of thumb available in DEA literature that can be jointly expressed as: i) n ≥ m × s which implies that the sample size should be greater or equal to the product of inputs and outputs or ii) n ≥ 3(m + s) which implies that the number of observations in the data set should be at least three times the sum of input and output variables. Given the total number of the DMUs in this study, n = 22 banks, then, 22 > (3 x 1 @ 3[3+1]). Therefore, the selections of variables are valid as it is consistent with the rule of thumb and allows for the efficiencies of DMUs to be measured. The objective of this study is to examine the scores of technical efficiencies in liquidity creation based on the bank's sizes. The descriptive statistics of the data used to construct the efficiency frontiers in creating liquidity are given in Table 7. The variables are expressed in millions of Ringgit Malaysia. It can be observed that the average values of all the variables in the sample are smaller than the median values indicating that there are significant differences among the banks in the sample. Financial capital and liquidity creation show a high standard deviation indicating high variances among the banks' data which is also observed by the difference between the maximum and minimum value.

Table 7
Descriptive Statistics of Output and Input Variables in 2011 to 2018 (RM million)

Variables	Minimum	Maximum	Median	Mean	Std. Dev.
Inputs					
Financial capital (x1)	100,800,444	238,222,843	171,166,804	170,052,064	48,717,378
Labour (x2)	15,889,812	29,901,354	18,228,767	12,986,450	4,567,965
Physical capital (x3)	3,795,063	7,704,302	5,056,836	5,238,907	1,078,925
Output					
Liquidity creation (y1)	1,239,201,719	2,426,006,881	1,996,441,517	1,946,935,391	449,352,906

Table 8 showed the panel analysis on banks technical efficiency and exhibited the total number of banks in operation, three categories of banks namely large, medium and small banks, total number of banks that are operating with full efficiency level, average technical efficiency, percentage of banks that operate within interval of 1 standard deviation around the mean and banks which under performed with regard to the technical efficiency on the whole. Overall, the statistical means of the commercial banks' technical efficiency record a highest level (73.9%) in 2017 and the lowest (54.1%) in 2015. In other words, banks experienced the inefficiency of 26.1% (2017) and 45.9% (2015) given the same amount of resources during those years. The trend in the dispersion of technical efficiency scores which is measured by standard deviation remains imprecise. The percentage of overall banks wherein technical efficiency lies within the interval of one standard deviation around mean hovered around 77% in 2011 to 95% in 2015.

Table 8
Panel Analysis on Banks Technical Efficiency

Group	Total Banks	Efficient Banks	Mean (E)	Std. Dev. (σ)	Interval (ϑ)		(%) Efficient Banks in ϑ	(%) Banks 1 Std. Dev. Below (E)
					I=E-σ	*I=E+σ*		
Year 2011								
All	22	3	0.664	0.275	0.389	0.939	77	23
Large Banks	4	1	0.733	0.184	0.549	0.916	100	0
Medium Banks	12	2	0.794	0.128	0.666	0.922	83	17
Small Banks	6	0	0.256	0.144	0.112	0.399	100	0
Year 2012								
All	22	4	0.700	0.180	0.520	0.880	82	18
Large Banks	5	0	0.692	0.109	0.583	0.802	80	20
Medium Banks	12	3	0.763	0.170	0.593	0.933	83	17
Small Banks	5	1	0.617	0.244	0.374	0.861	80	20
Year 2013								
All	22	3	0.751	0.171	0.580	0.922	91	9
Large Banks	5	0	0.699	0.087	0.612	0.786	80	20
Medium Banks	13	3	0.824	0.140	0.684	0.965	77	23
Small Banks	4	0	0.627	0.263	0.364	0.890	100	0
Year 2014								
All	22	3	0.683	0.180	0.503	0.863	91	9
Large Banks	5	0	0.610	0.052	0.558	0.662	80	20
Medium Banks	14	3	0.740	0.212	0.527	0.952	86	14
Small Banks	3	0	0.646	0.089	0.556	0.735	67	33
Year 2015								
All	22	3	0.541	0.212	0.329	0.753	95	5
Large Banks	5	0	0.471	0.068	0.403	0.539	80	20
Medium Banks	12	3	0.602	0.254	0.348	0.856	92	8
Small Banks	5	0	0.555	0.198	0.357	0.753	80	20
Year 2016								
All	22	3	0.579	0.195	0.384	0.774	91	9
Large Banks	5	0	0.497	0.052	0.445	0.549	80	20
Medium Banks	12	3	0.657	0.222	0.435	0.879	92	8
Small Banks	5	0	0.558	0.193	0.365	0.752	80	20
Year 2017								
All	22	4	0.739	0.171	0.568	0.910	91	9
Large Banks	5	0	0.687	0.069	0.618	0.756	80	20
Medium Banks	12	3	0.817	0.143	0.674	0.960	92	8
Small Banks	5	1	0.655	0.251	0.404	0.906	80	20
Year 2018								

All	22	4	0.596	0.241	0.355	0.837	91	9
Large Banks	5	0	0.526	0.153	0.373	0.679	100	0
Medium Banks	14	3	0.645	0.242	0.403	0.888	86	14
Small Banks	3	1	0.618	0.391	0.227	1.009	67	33

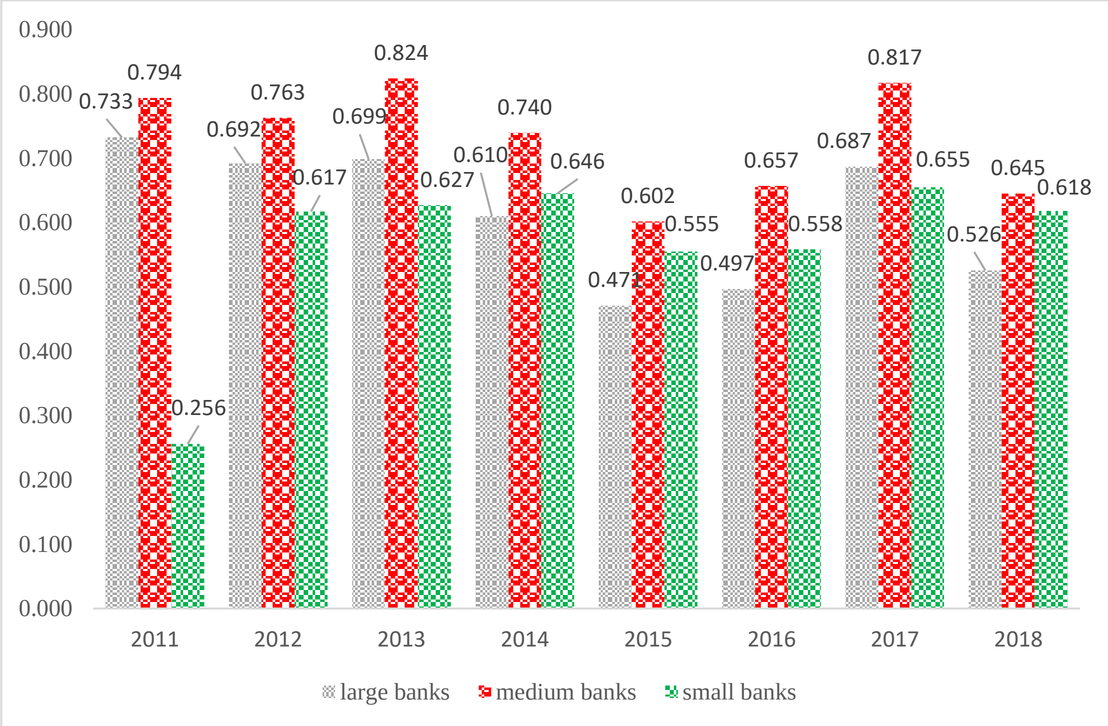

Figure 5: Technical Efficiency Scores for large, medium and Small-sized Banks in 2011 to 2018

The mean technical efficiency scores for the three different sizes of banks were compared based on the DEA result. Figure 5 illustrated the relationship between the technical efficiency in creating liquidity with the bank size. Earlier result on liquidity creation showed that large banks produced the most liquidity to the economy as compared to medium and small banks. However, the statistical efficiency means of the large banks throughout the period show that large banks was not the most efficient in creating liquidity. The highest level of efficiency for large banks is 73.3% in 2011 and the lowest level of efficiency is 47.1% in 2015, suggesting an inefficiency of 26.7% and 52.9% respectively during those years. The highest percentage of large banks that operate under performance is 23% in 2011. Medium banks are found to be statistically efficient in overall liquidity creation throughout the period. The highest level of efficiency for medium banks is 82.4% (17.6% inefficiency) in 2013 and the lowest is 60.2% (39.8% inefficiency) in 2015. The highest percentage of medium banks' technical efficiency that operate within the interval of one standard deviation around mean are in year 2015, 2016 and 2017 that recorded at 92% whereas the lowest is in 2013 (77%). The percentage of the number of medium banks that operate under performance is highest during that year (23%).

In 2011, 2012, 2013 and 2017, small banks averagely less efficient than large and medium banks in creating liquidity. Nevertheless, small banks have showed more efficient in creating liquidity than large banks in 2014, 2015, 2016 and 2018. The highest level of efficiency for small banks is 65.5% in 2017 and the lowest level of efficiency is 25.6% in 2011 suggesting inefficiency of 34.5% and 74.4% respectively during those years. The highest percentage of small banks that operate under performance is 33% in 2014 and 2018. As a conclusion, the overall statistical mean of technical efficiency level in relation to the size of banks shows that medium banks are the most efficient in creating liquidity throughout the period. Banks with technical efficiency scores equal to 1 is considered to be most efficient amongst the banks in the sample. It is observed that the most efficient banks are in the medium banks' category with averagely about 3 medium banks are found to be the most efficient banks in creating liquidity for each year over the period of 2011 to 2018. This suggesting that these banks fully loaned out from the deposits they received from the customers.

The remaining banks with technical efficiency scores less than 1 imply that they are technically inefficient and they can improve their efficiency with closely focusing on the operational and managerial issues as well as the planning and strategy in the industry of banking sector (Cullinane, K *et al*., 2005). The finding of this study is consistent with Hasan and Soula (2017) that investigating the efficiency level of the US banks in creating liquidity. In their analysis they employed the parametric method of Stochastic Frontier Analysis (SFA) and point out that medium banks are the most efficient in creating liquidity. Technical efficiency then can be decomposed into two components namely pure technical efficiency and scale efficiency. Decomposing technical efficiency permits an insight into the sources of inefficiencies and determine which region of the economies of scale the banks are operating in. Tables 9 and 10 show the panel analyses of the pure technical and scale efficiencies. These tables exhibit the total number of banks in operation, three categories of banks namely large, medium and small banks, total number of banks that are operating with full efficiency level, average technical efficiency, percentage of banks that operate within interval of one standard deviation around the mean and banks which under performed with regard to the pure technical efficiency (PTE) and the scale efficiency (SE) on the whole.

Overall, the highest PTE scores of banks in creating liquidity are 92.2% in year 2013 and 2014. The lowest PTE scores is 82.6% in 2018. This reflecting inefficiency of 7.8% and 17.4% respectively in those years resulted from the managerial inefficiency in managing the inputs (Kumar and Gulati, 2008). In DEA literature, the banks achieving the PTE scores equal to 1 known as locally efficient banks. In 2011, there are overall 13 banks that have experienced locally efficient banks under VRS assumption as recorded in the table which more than half of the banks achieved PTE score equal to 1. It can be observed that the numbers of locally efficient banks are higher than the number of the most technically efficient banks indicates that on average banks are relatively better off in pure technical efficiency and they are locally efficient but not globally efficient due to their scale size. PTE exhibit a gradual decline from 2013 to 2018 implies that banks are becoming more adept in controlling expenses.

Table 9

Panel Analysis on Banks Pure Technical Efficiency

Group	Total Banks	Efficient Banks	Mean (E)	Std. Dev. (σ)	Interval (ϑ)		(%) Efficient Banks in ϑ	(%) Banks 1 Std. Dev. Below (E)
					I=E-σ	*I=E+σ*		
Year 2011								
All	22	13	0.921	0.234	0.687	1.155	86	14
Large Banks	4	4	1.000	0.000	1.000	1.000	100	0
Medium Banks	12	9	0.941	0.099	0.842	1.041	75	25
Small Banks	6	0	0.692	0.382	0.310	1.074	83	17
Year 2012								
All	22	11	0.885	0.169	0.716	1.054	86	14

Large Banks	5	3	0.975	0.055	0.920	1.030	75	25
Medium Banks	12	6	0.908	0.126	0.782	1.033	75	25
Small Banks	5	2	0.763	0.269	0.494	1.032	80	20
Year 2013								
All	22	11	0.922	0.102	0.820	1.024	77	23
Large Banks	5	4	0.960	0.089	0.871	1.049	80	20
Medium Banks	13	6	0.918	0.106	0.811	1.024	77	23
Small Banks	4	1	0.907	0.120	0.787	1.028	75	25
Year 2014								
All	22	12	0.922	0.175	0.747	1.097	91	9
Large Banks	5	4	0.987	0.028	0.959	1.016	80	20
Medium Banks	14	7	0.888	0.212	0.676	1.100	86	14
Small Banks	3	3	1.000	0.000	1.000	1.000	100	0
Year 2015								
All	22	10	0.871	0.183	0.688	1.054	91	9
Large Banks	5	4	0.973	0.057	0.916	1.030	80	20
Medium Banks	12	3	0.824	0.195	0.629	1.019	92	8
Small Banks	5	3	0.907	0.209	0.698	1.115	80	20
Year 2016								
All	22	11	0.873	0.194	0.679	1.067	86	14
Large Banks	5	3	0.942	0.084	0.858	1.026	80	20
Medium Banks	12	5	0.890	0.177	0.713	1.067	92	8
Small Banks	5	3	0.790	0.297	0.492	1.087	80	20
Year 2017								
All	22	10	0.894	0.168	0.726	1.062	91	9
Large Banks	5	3	0.985	0.022	0.963	1.007	80	20
Medium Banks	12	5	0.935	0.075	0.860	1.009	92	8
Small Banks	5	2	0.728	0.288	0.439	1.016	80	20
Year 2018								
All	22	10	0.826	0.231	0.595	1.057	82	18
Large Banks	5	3	0.888	0.111	0.777	1.000	80	20
Medium Banks	14	5	0.834	0.219	0.615	1.053	79	21
Small Banks	3	2	0.740	0.451	0.289	1.191	67	33

Table 10
Panel Analysis on Banks Scale Efficiency

Group	Total Banks	Efficient Banks	Mean (E)	Std. Dev. (σ)	Interval (ϑ)		(%) Efficient Banks in ϑ	(%) Banks 1 Std. Dev. Below (E)
					I=E-σ	*I=E+σ*		
Year 2011								
All	22	3	0.723	0.226	0.497	0.949	86	14
Large Banks	4	1	0.733	0.184	0.549	0.916	100	0
Medium Banks	12	2	0.842	0.085	0.757	0.926	92	8
Small Banks	6	0	0.444	0.229	0.215	0.673	83	17
Year 2012								
All	22	4	0.794	0.121	0.673	0.915	91	9
Large Banks	5	0	0.712	0.116	0.596	0.827	80	20
Medium Banks	12	3	0.835	0.106	0.729	0.941	92	8
Small Banks	5	1	0.818	0.139	0.679	0.957	80	20
Year 2013								
All	22	3	0.813	0.149	0.664	0.962	86	14
Large Banks	5	0	0.731	0.091	0.640	0.823	80	20
Medium Banks	13	3	0.895	0.077	0.818	0.972	85	15
Small Banks	4	0	0.682	0.242	0.440	0.924	100	0

Year 2014								
All	22	3	0.753	0.160	0.593	0.913	86	14
Large Banks	5	0	0.618	0.054	0.564	0.673	80	20
Medium Banks	14	3	0.842	0.146	0.696	0.988	86	14
Small Banks	3	0	0.646	0.089	0.556	0.735	67	33
Year 2015								
All	22	3	0.630	0.190	0.440	0.820	95	5
Large Banks	5	0	0.486	0.080	0.407	0.566	80	20
Medium Banks	12	3	0.726	0.195	0.531	0.921	92	8
Small Banks	5	0	0.616	0.162	0.454	0.778	80	20
Year 2016								
All	22	3	0.675	0.169	0.506	0.844	91	9
Large Banks	5	0	0.527	0.027	0.501	0.554	80	20
Medium Banks	12	3	0.740	0.179	0.561	0.918	100	0
Small Banks	5	0	0.733	0.137	0.596	0.871	80	20
Year 2017								
All	22	4	0.834	0.127	0.707	0.961	86	14
Large Banks	5	0	0.697	0.064	0.634	0.761	80	20
Medium Banks	12	3	0.869	0.097	0.772	0.966	92	8
Small Banks	5	1	0.920	0.135	0.785	1.055	80	20
Year 2018								
All	22	4	0.732	0.184	0.548	0.916	77	23
Large Banks	5	0	0.589	0.127	0.462	0.716	100	0
Medium Banks	14	3	0.772	0.169	0.603	0.941	79	21
Small Banks	3	1	0.877	0.210	0.667	1.087	67	33

The results of scale efficiency (SE) exhibit a fluctuation throughout the period of study. The highest SE score for banks in creating liquidity is 83.4% in 2017 and the lowest SE score is 63% in 2015. SE score < 1 indicates that banks are experiencing technical inefficiency because they are not operating at their optimal scale size. Most of the banks in this study operated under conditions of decreasing return to scale (most of these banks are large and medium banks) and most of the banks operated under the conditions of increasing return to scale are the small banks. In conclusion, bank management faces a trade-off between the advantages and disadvantages of liquidity creation as well as the possible negative relationship between liquidity creation and bank performance when making their decisions.

Table 11 summarized the technical efficiency scores of the Malaysian commercial banks that was estimated using the DEA test in creating liquidity and also the decomposition of technical efficiency of the banks into pure technical and scale efficiencies. It is observed that overall commercial banks in Malaysia are technically inefficient with the average TE scores of 65.7% during the period 2011 to 2018. This result implies that in average overall banks experienced a 34.3% level of technical inefficiency. From the table the scores of pure technical efficiencies (PTE) are higher than the scores of technical efficiencies (TE). These results are consistent with Banker *et al.* (1984) that state PTE scores obtained the under variable returns to scale (VRS) are higher than or equal to those obtained under constant returns to scale (CRS) assumptions. Small banks exhibit lower efficiency score on PTE. The mean of TE for banks in creating liquidity is lower than the mean of SE which indicates some of the factors of inefficiency is due to liquidity is created below the production frontier rather than on an inefficient scale.

Table 11
Summary Mean of Technical, Pure Technical and Scale Efficiency, 2011-2018

	Mean		
anks Size	**TE**	**PTE**	**SE**
All	0.657	0.889	0.744
Large Banks	0.614	0.964	0.637
Medium Banks	0.73	0.892	0.815
Small Banks	0.567	0.816	0.717

Given the importance of liquidity creation in the banking sector, further analysis of its magnitude and intertemporal trends is required. Any additional information would be useful in promoting economic growth. Also, a comprehensive analysis examining the level of liquidity creation and its potential determinants is required to promote the economic growth that channelising savings could realise into productive investments. This study adopted the 'catnonfat' approach that excluded off-balance sheet items. Therefore, it is suggested that future studies employ other methods such as 'catfat' inclusive of off-balance sheet items, 'matfat'using maturity on loans classifications with off-balance sheet items or employ all methods together. In addition, the improvement of the technical efficiency in Malaysian banking is essential to a country's economic growth since the economy depends on banking institutions. The effect of liquidity creation level on the technical efficiency in the banking sector may further improve the operation of the banks. This study has also explored the potential bank–specific characteristics and macroeconomic conditions that could influence technical efficiency. The results of this study will add knowledge to the literature of bank efficiency by displaying the influence of bank liquidity creation to the economy. The present study only employs one of non-parametric frontier analysis, Data Envelopment Analysis (DEA) to measure the efficiency levels in liquidity creation on the commercial banks. Therefore, it is suggested that future studies to use the other frontier analysis methods such as Stochastic Frontier (SFA), distribution free approach (DFA), free disposal hull (FDH) and thick frontier approach (TFA). The traditional method of measuring the efficiency levels by using financial ratios may also be adopted.

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