ARDL Modelling of the Nexus between Bank Efficiency, Asset Management, Bank Assets and Solvency Risk among State-Owned and Privately Owned Islamic Banks in Kurdistan

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Abstract— **The present study explores the nexus connecting asset management and solvency risk to uncover their influence on Kurdistan's state-owned and privately owned Islamic banks' efficiency. In that context, two ARDL models were estimated to make comparative examinations of the captured asset management and solvency risk circumstances on bank efficiency between 7 state-owned and 5 privately owned Islamic banks from 2000 to 2020. The results of the study uncovered that banks' asset management strategies were instrumental in enhancing bank efficiency, especially during the 2008, 2014 and 2015 financial crises. The study findings upheld that solvency risks undermine the efficiency of both state-owned and privately owned Islamic banks. The effects of the 2008, 2014 and 2015 financial crises during the period in question were discovered as having restricted bank efficiency. This study, in its integrated efforts to isolate and compare the effects of the financial crisis between publicly held and privately owned Islamic banks, makes an important contribution to the field of Islamic banking. As a result of our study, some of the unvalidated hypotheses aimed at examining empirical relationships between bank efficiency and bank size are now empirically supported.**

Keywords— **Asset management, bank efficiency, financial crisis, Islamic banks.**

I. INTRODUCTION

Both business and economic complications observed over the past years have shown that banks are not spared from the inherent adverse effects. As such, tremendous changes in bank efficiency have accompanied such situations and have left banks in dire need of strategies to curb such adverse effects and boost efficiency. One key challenge that left banks in need of realignment of strategies, especially asset management and solvency risk management strategies is the financial crisis. Studies reckon that a financial crisis crippled several banks (Curado, Guedes & Bontis, 2012; Nazir, Guedes & Bontis, 2014) and bankrupted several banks worldwide (Classens & Van Horen, 2015). Given the fear of either a rise in solvency risk (Iyer, Puri & Ryan, 2016) or closure (Acharya & Yorulmazer, 2007) and/or both, demand for asset management and efficiency enhancement strategies has been high than before and still continues to command spaces in contemporary academic spaces.

Meanwhile, efforts to achieve bank efficiency are instrumental as they aid banks in achieving sound profitability (Haralayya & Aithal, 2021), achieving competitiveness (Garza-García, 2012), innovating operations and services (Batir, Volkman & Gungor, 2017), grow, developing and expanding operations (Alber et al., 2019). Failure by banks to foster efficiency amid rising solvency risks poses disastrous effects on banks, especially at a time when banks are still yet to fully recover from the effects of both the financial crisis and the Covid-19 pandemic (Flögel & Gärtner, 2020). The implications of such effects are hard to ignore as banks are instrumental in achieving sustainable economic growth Eti et al., 2020) and social development (Vetterlein, 2007) goals thereby triggering the achievement of either Sustainable Development Goals,

(Avrampou et al., 2019) and/or Millennium Development Goals, (Classens & Feijen, 2007). These issues are of huge concern to Islamic banks, especially in Kurdistan but have been significantly confined to conventional banks (Elsa, Utami, & Nugroho, 2018; Safiullah & Shamsuddin, 2019; Shawtari, Salem & Bakhit, 2018). In that regard, studies exploring interactions between asset management and solvency risk, and how they interact to influence bank efficiency have not yet matched the complex nature of the banking environment coupled with structural rigidities posed by the pandemic and economic complexities triggered by the financial crisis.

With studies restricted to countries like Brazil (Henriques et al., 2018), Turkey (Partovi & Matousek, 2019), and Nigeria (Muhammad & Salisu, 2019) as well as conventional banks (Elsa, Utami, & Nugroho, 2018; Safiullah & Shamsuddin, 2019; Shawtari, Salem & Bakhit, 2018), it remains an interesting inquiry that there exists no study illustrating the connection (nexus) connecting asset management and solvency risk to bank efficiency at a time when banks are still yet to recoup from the devasting effects of the financial crisis and that of the Covid-19 pandemic. Besides, emerging studies drawing context on Islamic banks are still in their infancy stages (Izzeldin et al., 2021; Saeed et al., 2020). Besides, such interactional effects are subject to differ according to the size of the banks (Sakouvogui, 2020), but this has not be incorporated in the bank efficiency debate, and hence, the incorporation of bank size into this study's aims. Furthermore, attempts to analyse interactive connections between asset management, solvency risk and bank efficiency amid attempts to recoup from the adverse effects posed by the financial crisis in Kurdistan have been placed beyond the scope of numerous academic studies. It is, therefore, in this regard that the present study explores the nexus connecting asset management and solvency risk to uncover their influence on Kurdistan's state-owned and privately owned Islamic banks' efficiency. Amid such discoveries, the study applies panel Autoregressive Distributed Lag (ARDL) models to analyse the uncaptured and validated short-run and long-run integrative effects posed by variations in asset management, solvency risk and bank efficiency amid widespread complexities posed by the financial crisis.

As banks attempt to counter existing challenges posed by the financial crisis, the study takes an integrated approach to isolate and compare changes in bank efficiency between publicly held and privately owned Islamic banks. The study reveals the downsides of limited government involvement in private banks' affairs and emphasizes the need for government support. This study, in its integrated efforts to isolate and compare the effects of the financial crisis between publicly held and privately owned Islamic banks, makes an important contribution to the field of Islamic banking. As a result of our study, some of the unvalidated hypotheses aimed at examining empirical relationships between bank efficiency and bank size are now empirically supported.

1. **2. Literature review on bank efficiency measures**
2.

Efficiency can be defined as the minimisation of wasted time,

effort, and skills, but in banking, efficiency is mainly confined to the reduction in banking costs (Aber et al., 2019). As such, related studies underscore the importance of bank efficiency citing that it is a predominant reflector of the manner and extent banks minimise operational costs (Sakouvogui, 2020). Therefore, the cost theory comprises inherent aspects of bank efficiency with regard to the minimisation of what Robins (1997) highlights as total, average and marginal costs (Robins, 1997). In that regard, total costs were used depict variations in bank efficiency.

Studies have in fact demonstrated numerous tools and methods that can be used to measure bank efficiency over time. For instance, a study by Charenes et al. (1978) denotes that, either parametric or nonparametric methods can be used together with data envelopment analysis to determine bank efficiency. Nonetheless, both theoretical and empirical developments observed during the course of time have further proven that new and different measures of bank efficiency are continuously demanded to cater for changes in business and economic climate. In that manner, Berger and Humphrey (1992) introduced the thick frontier analysis and a subsequent distribution-free approach was introduced by Berger (1993). As a result, the application of numerous bank efficiency indicators cloud judgements about the development of necessary strategies essential for boosting bank efficiency. Consequently, this places a huge demand for modern studies to explore such a topic. Besides, the advent of problems related to the inability of both measurement and estimation methods to yield consistent estimators has always been raised as a major concern (Nkoro & Uko, 2016). It is in this regard that this study proposes to apply an Autoregressive Distributed Lag (ARDL) model to analyse the purported connections linking asset management, solvency risk, bank size and the prevalence of a financial crisis to changes in bank efficiency. The robustness and consistent nature of ARDL models are empirically supported in academic studies (Pesaran & Shin, 1996; Tursoy & Andrea).

Mosko and Bozdo's (2016) attempt to dissect the interaction between bank efficiency, capital and risk in the Albanian banking system, led to observations being made observed that bank-specific indicators like bank size and back capital contribute to the improvement in bank efficiency. However, with the prevalence of the financial crisis that left several banks struggling to maintain efficiency, the importance of asset management in this context is highly called for. This mirrors Aber et al.'s (2019) establishment pinpointing that asset management enhances the effective and efficient use of banks' assets thereby contributing to improved efficiency. Amid such observation, the integration of asset management in the bank efficiency debate is instrumental.

Batir, Volkman and Gungor's (2017) exploration of factors influencing bank efficiency in Turkey explores participation banks versus conventional banks using generic OLS panel data estimation methods, observed the existence of empirical voids with regards to the ascertainment of cointegration among bank efficiency determinants when methods like an OLS approaches are deployed. To which Nkoro & Uko, 2016) underscores this as the base of policymaking and encourages the application of

models that are well posed to provide such inferences. All these notions point to the application of an ARDL model.

To add empirical depth, to this study, Alber et al. (2019), justify and encourages efforts to incorporate bank-specific indicators linked to the size of the bank together with its management. Such advocations direct to the importance of asset management strategies and bank size directives, which this study will incorporate as per Alber and others' recommendations. However, a financial crisis dummy variable will be incorporated as country-specific indicators have an instrumental driving influence on banking efficiency. Along similar lines, Almanaseer (2014) tested the effects of bank size, bank capital and solvency risks on banking efficiency in Albania's Islamic banks.

Drawing further, Sakouvogui (2020) conducted a study aimed at analysing the effects of solvency risk factors on variations in the efficiency of US banks. Again, the significance of factors like bank size and additional country-specific indicators was observed. However, such has not been explored in the context of Islamic banks, especially when asset management ideas are analysed in the context of solvency risks and a financial crisis. In that regard, this study will fill these voids by extending Sakouvogui's examinations to the context of Islamic banks' efficiency.

Despite a number of studies have emphasised the significance of bank regulation in boosting bank efficiency (Zhao & Zhang, 2021), attempts to relate bank efficiency to financial crisis and into the context of Islamic banks are still in their infancy stages (Batir, Volkman & Gungor, 2017; Ghoniyah & Hartono, 2020). For instance, strategies such as liberal standards of basic leadership (Haralayya & Aithal, 2021), and innovation (Lee et al. (2021) are widely proposed as vital measures of enhancing bank efficiency. However, this is problematic as it neglects the vital role of both bank-specific and country-specific factors like a financial crisis that has a huge bearing on banks' profitability (Haralayya & Aithal, 2021), competitiveness (Garza-García, 2012), innovation and operations (Batir, Volkman & Gungor, 2017), and growth and development (Alber et al., 2019). Besides, this contradicts Sakouvogui's (2020) recommendations highlighting that effective bank efficiency strategies revolve around solid improvements in bank-specific indicators together with measures curbing the adverse effects of country-specific indicators. With regards to such observations, connections linking assets management, bank solvency and bank size to bank efficiency amid contemporary problems created by the financial crises were proposed.

3. 3. Methodology
4.

A selection of private and state-owned Islamic banks in Kurdistan is used to draw the study's conclusions. However, empirical research has not yet verified the validity of their propositions, nor has it examined the impact of asset management, solvency risk and financial crisis challenges on Islamic banks' efficiency. Accordingly, an autoregressive

distributed lag (ARDL) was applied in the study in order to identify short-run and long-run connections between asset management, solvency risk, bank size and bank efficiency. A significant number of reasons point to the ARDL model significantly generating efficient and consistent estimators (Nkoro & Uko, 2016) and applies to mixed order of integration and nonstationary time series (Nkoro & Uko, 2016; Tursoy & Andrea, 2021).

In this context, the explanatory variable Bank Efficiency (BE) was measured using banks' total operational cost and presumed to be a function of Asset Management (AM), Solvency Risk (SR) measured using the percentage ratio of loan losses provision to total loan, Bank Size (BS) measured using total assets and the prevalence of the Financial Crisis (FC). Such notions were expressed in a functional form as follows;

$$BE = F(AM, SR, BS, FC) \qquad (1).$$

The category variable DV_{FC} was used in capturing the observed financial crisis effects observed in Kurdistan in 2008, 2014 and 2015. Thus, a value of 0 was used to highlight the absence of a financial crisis and 1 to represent the occurrence of the financial crisis. Caution was observed to avert heteroscedasticity challenges by converting the data to logarithms. Subsequently, stationarity tests comprising the Augmented Dickey-Fuller (ADF) test and the Phillips Perron (PP) test were applied to ascertain the prevalence of unit roots in the data. This served an instrumental purpose in ensuring that the results confine to the stipulated ARDL stationarity requirements demanding that the model variables be integrated of the order (0) or (I), and/or both as denoted by Tursoy and Andrea (2021) and ensure that the obtained results are not spurious by any means (Carrion-i-Silvestre & Sansó, 2006). Consequently, long-run ARDL models were formulated by integrating an error correction term (ECT) with regression analysis precepts to yield the following model:

$$LBE_t = a01 + b11LAM + b22LSR + b33LBS + DV_{FC} + e1tLBE \; cLAM(-1) \; LSR(-1) \; LBS(-1) \; DV_{FCt}(-1) \; ECTt(-1)$$
$$(2).$$

Consequently, both short-run and long-run connections linking asset management, solvency risk and bank efficiency amid the 2008, 2014 and 2015 financial crises were estimated in conjunction with expression (2). The estimation process was conducted using 8 state-owned and 4 privately owned Islamic banks' annual data from 2000 to 2020 with the EViews 12. Data on GDP was retrieved from the official Ministry of Finance and Trade annual publications while that of the Islamic banks was retrieved from the banks' websites. The names of the banks were withheld for confidentiality reasons in line with acceptable research ethics and conduct.

The Ramsey reset test was applied as part of the diagnostics tests to ascertain whether the two ARDL models were linear (Volkova & Pankina, 2013). The heteroscedasticity test was conducted using the Breusch-Godfrey-Pagan and Arch heteroscedasticity tests (Long & Ervin, 2000) while the presence of serial correlation was ascertained using the serial correlation LM tests (Born & Breitung, 2016). Additionally, the normality test in the form of the Jarque-Bera test together with

the Cusum and Cusum of squares tests for stability were also used to examine the validity of the two estimated ARDL models in decision-making and policy-making (Turner, 2010).

5. 4.Results

In line with Narayan and Popp (2010) propositions, unit root tests were applied to ascertain the existence of innovation outlier breaks among the variables' (LBE, LAM, LSR, LBS, and DV_{FC}) order of integration. Table 1 reports that all the variables are stationary at both levels and the first difference. This, therefore, entails that there were no unit roots and structural innovation outlier breaks present (Narayan & Popp, 2010) and the model satisfies the required ARDL unit root conditions (Nkoro & Uko, 2016; Tursoy & Andrea, 2021) and that the results are not spurious (Carrion-i-Silvestre & Sansó, 2006).

Table 1. Innovation structural break unit root test

Variable	@ Level		@ 1st Difference		Decision
	Level	Prob	Level	Prob	
LBE	-4.987	0.000	-7.814	0.000	I(O)
LAM	-6.932	0.000	-9.687	0.000	I(O)
LSR	-4.875	0.000	-8.493	0.000	I(O)
LBS	-5.313	0.000	-10.148	0.000	I(O)

Amid the successful determination of the absence of innovation structural break unit roots, the Chow breakpoint test was deployed as part of attempts aimed at determining whether 2008, 2014 and 2015 financial crises observed in Kurdistan had structural breaks. As per Table 2's reported findings, it was inferred that there were evident traces of structural breaks linked to the 2008, 2014 and 2015 financial crises observed in Kurdistan. Thus, the purported category variable DV_{FC} was utilised in capturing the effects of the 2008, 2014 and 2015 crises observed in Kurdistan.

Table 2. Chow breakpoint test

Test/indicator	Value	Test/indicator	Value
F-stat.	9.69	Prob. F(7,230)	0.00
Wald stat.	13.14	Prob. Chi-square (7)	0.00
Log L.R	12.82	Prob. Chi-square (7)	0.00

Table 3 exhibits that private Islamic banks (-0.441, -0.925 and -0.802) and public Islamic banks (-0.377, -0.292 and -0.565) observed adverse changes in bank efficiency in the short run. Such findings reinforce arguments presented in prior sections of issues undermining bank efficiency and show the need to execute such a study in examining the interactive influence of asset management and bank solvency together with bank size on bank efficiency at a time when banks are still trying to rebound from the challenges triggered by financial crises. Additionally, the harmful effects of solvency risk were observed for both private Islamic banks (-0.457) and public Islamic banks (-0.398) and the enhancement effects caused by increments in bank size on bank efficiency were validated for both private (0.014 and 0.316) and public Islamic banks (0.089 and 0.243) as shown in Table 3.

Table 3. Short-run ARDL results

Variable	Private Islamic banks		Public Islamic banks	
	Coeff.	Prob.	Coeff.	Prob.
D (LBE (-1))	-0.441	0.000	-0.377	0.000
D (LBE (-2))	-0.925	0.001	-0.292	0.001
D (LBE (-3))	-0.802	0.000	-0.565	0.000
D (LAM (-1))	0.734	0.006	0.418	0.023
D (LAM (-2))	0.152	0.218	0.188	0.013
D (LSR (-1))	-0.457	0.000	-0.398	0.000
D (DVFC (-1))	-0.465	0.000	-0.381	0.004
D (DVFC (-2))	-0.123	0.000	-0.226	0.042
D (LBS)	0.014	0.000	0.089	0.000
D (LBS (-1))	0.316	0.023	0.243	0.000
Coint. EqT (-1)	-0.36	0.000	-0.010	0.000
R2 = 0.86		Adjust. R2 = 0.85	R2 = 0.79 Adjust. R2 = 0.78	
Prob. F-stat. = 0.00		DW stat. = 2.06	Prob. F-stat. = 0.00 stat. = 1.98	DW

Significant error correction terms of -0.36 and -0.010 were observed and this denotes respective speeds of adjustments of 36% and 1% in favour of private Islamic banks compared to public Islamic banks. Hence, this answers the questions regarding the short-run connections linking asset management, solvency risk together with bank size and the prevalence of the financial crisis to Islamic banks' efficiency. In addition, the short-run explanatory powers of the two models were in favour of private Islamic banks (86%) as opposed to public Islamic banks (78%). Similar attempts were made to ascertain the long-run nature of connections linking LBE, LAM, LSR, LBS and DV_{FC} in the next section.

6. Bounds test

Given that the study attempted to ascertain the nature of connections linking LBE, LAM, LSR, LBS and DV_{FC}, the bounds test results were retrieved. It can be inferred from Table 4 that there is long-run cointegration among the variables because the obtained F-statistic values of 8.49 and 6.31 exceed both lower and upper bound values at both 1%, 2.5%, 5% and 10%. Furthermore, both models were characterised by high and desirable explanatory power as evidenced by their respective R^2 values of 87.2% and 89.5%. This denotes their high and significant abilities portrayed by significant F-statistics probabilities of 0.000 at 1% that 87.2% of the changes in private Islamic bank's efficiency and 89.5% of the changes in public Islamic bank's efficiency are explained by changes in asset management, solvency risk and the observed 2008, 2014 and 2015 financial crises.

Islamic banks as demonstrated in Table 5.

Table 4. *ARDL cointegration test*

Privat e Islami c banks	Significance level								DW stat.
	1%		2.5%		5%		10%		
	LB	UB	LB	UB	LB	UB	LB	UB	
	3.4 4	4.1 5	3.9 2	5.2 1	4.0 7	5.2 3	2.1 0	2.9 5	2.0 6
F. stat = 8.49; Prob. stat = 0.00				R2 = 0.872					Adjust.
R2 = 0.868									

Public Islami c banks	1%		2.5%		5%		10%		DW stat.
	LB	UB	LB	UB	LB	UB	LB	UB	
	4.1 8	6.3 3	5.5 8	7.2 2	4.9 4	5.0 9	4.2 0	6.7 1	1.9 8
F. stat = 6.31; Prob. stat = 0.00				R2 = 0.895					Adjust.
R2 = 0.881									

Table 5. *Bounds test*

Variable	Private Islamic banks		Public Islamic banks	
	Coefficient	t-statistics	Coefficient	t-statistics
Constant	1.809	1.998**	2.568	4.512*
LSR	-0.413	2.999*	-0.167	3.097*
LAM	1.905	5.740*	0.823	1.987**
LBS	0.501	4.081*	0.364	6.723*
DVFC	-0.272	2.694*	-0.385	4.024*

7. Long-run bounds

After having established the existence of cointegration among the selected variables, the study proceeded in determining the nature of the long-run connections between the variables. It is demonstrated in Table 5 that solvency risks negatively affected private Islamic banks' efficiency by -0.413 and public Islamic banks' efficiency by -0.167. These findings contradict Sakouvogui's (2020) propositions denoting that solvency risk's adverse effects are similarly experienced by all banks in any economy. Given that private banks play a pivotal huge role in lending funds to economic agents in any economy, such decreases are a result of Mosko and Bozdo's (2016) and Batir and Volkman (2017) establishments denoting that financial banks' intermediation roles and operational activities will decline following a reduction in efficiency, huge funding costs and rising high risks forcing investors to withdraw funding from private banks. Furthermore, this is different from his is distinct from public banks that are well guarded by the government against solvency risks. As a result, the study's findings validate ideas about why public banks are more cushioned from the harmful effects of solvency risk.

The positive contributions of banks' asset management strategies towards improving bank efficiency were validated in the context of both private and public banks. Table 5 shows that increases in bank efficiency of 1.905 units and 0.823 units were observed following successive increments in adopted asset management strategies by 1 unit by private and public banks, respectively. Along similar lines, the findings also upheld propositions increments in bank size are essential for boosting bank efficiency as evidenced by improvements in private and public banks' efficiency by 0.501 units and 0.364 units, respectively following successive increments in bank assets by 1 unit. In overall, positive changes in bank efficiency at this stage are inevitable as economies of scale become widely spread across the entire bank. Synonymously, this adds empirical weight to Bellini's (2019) unvalidated bank efficiency model linking changes in bank efficiency to total assets (bank size). Nonetheless, improvements in both banks' asset management and total assets have huge positive contributions on private Islamic banks compared to public
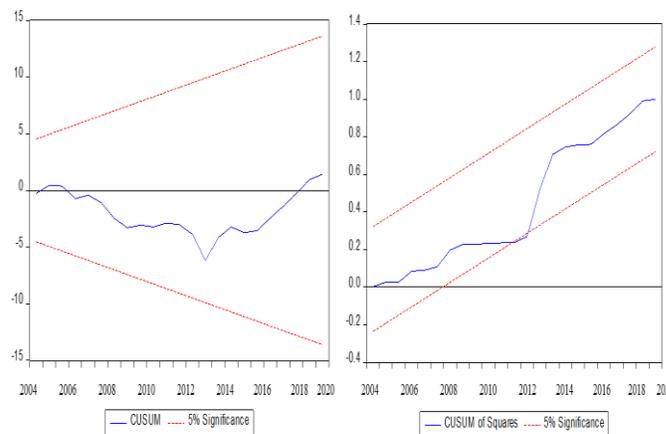
Table 5 satisfies efforts undertaken in exploring the effects of the financial crisis on bank efficiency. Interestingly, the findings uphold that the financial crisis restricted improvements in bank efficiency among private and public Islamic banks by -0.272 and 0.385, respectively.

This reinforces Claessens and Vam Horen's (2015) prior arguments highlighting that a financial crisis adversely restricts bank operations and performance. Additionally, these findings empirically add weight to existing studies by contradicting Sakouvogui's (2020) study findings highlighting that a financial crisis influences bank efficiency positively. This, therefore, offers a distinct angle of examination that cautions banks and underscores them to institute strategies and measures that will cushion against the adverse effects of the crisis. This extends further Dore's (2013) propositions encouraging the adoption of bank structural adjustment safety nets to suit the Islamic banking context and curb the negative consequences of a financial crisis.

In overall, these established connections connecting bank efficiency, asset management, solvency risk and a financial crisis play instrumental purposes in banks and economic management activities. Therefore, this study deployed diagnostics tests to determine the robust nature of such connections in offering reliable and valid and strategic policy formulation and decision-making ideas that are free from bias. Foremost, the Ramsey reset (RR) results exhibit that the private Islamic banks ARDL model (RR =0.82; ρ=0.53) and the public Islamic banks ARDL model (RR =0.76; ρ=0.28) had no non-linearity features (Turner, 2010). Drawing further, the findings show that the two ARDL models were normally distributed (χ^{2N} =0.04; ρ=0.17 and χ^{2N} =0.09; ρ=0.32), had no heteroscedasticity (χ^{2AR} =0.05; ρ=0.82 and χ^{2BR} =0.36; ρ=0.28 and χ^{2AR} =0.09;

ρ=0.32 and χ^{2BR} =0.49; ρ=0.31) and serial correlation (χ^{2SC} =2.02; ρ=0.08 and χ^{2SC} =1.34; ρ=0.09) problems. Hence, we concluded that the estimated ARDL models matched the prescribed sensitivity standards (Nkoro & Uko, 2016; Tursoy & Andrea, 2021) and can be safely used for policy formulation and strategic decision-making purposes.

Table 6. Model diagnostics tests

For private Islamic banks ARDL model				
RR	X2N	$\chi^{2}AR$	$\chi^{2}BR$	$\chi^{2}SC$
0.82	0.04	0.05	0.36	2.02
(0.53)	(0.17)	(0.82)	(0.28)	(0.08)
For public Islamic banks ARDL model				
0.76	0.09	0.07	0.49	1.34
(0.28)	(0.32)	(0.25)	(0.31)	(0.09)
Redundant test on LBS, LBC, LBC, DVFC and DVCOV				
	Private Islamic banks ARDL model		Public Islamic banks ARDL model	
	Value	Prob.	Value	Prob.
F-statistic	9.64	0.00	7.38	0.00

RR, χ^{2N}, χ^{2BR}, χ^{2AR} and χ^{2SC} Ramsey Reset Test, langrage multiplier for normality, Arch test for heteroscedasticity at lag 1, Breusch-Godfrey-Pagan test for heteroscedasticity and serial correlation at 2 lags. The values in parenthesis are the corresponding P-Value.

Given the successful establishment of acceptable diagnostic test results, the study proceeded to ascertain the stability of the established results to offer valid and reliable suggestions using the Cusum and Cusum of squares tests. It can be seen in both Figures 1a and 1b that the estimations are within the required bounds or limits (Turner, 2010). Therefore, this implies that the two estimated ARDL models for private and public Islamic banks are stable and usable for policy formulation purposes (Turner, 2010). As a result, suggestions were subsequently provided.
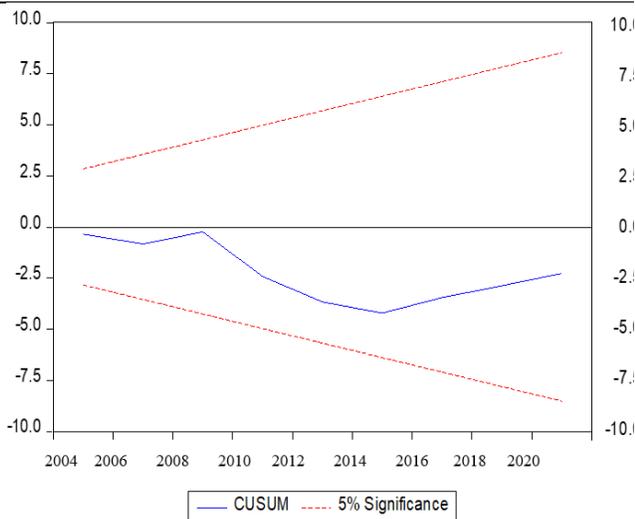
(a) Stability tests for private Islamic banks

(b) Stability tests for private Islamic banks
Figure 1. *Model stability tests*

1.   5. Conclusions

The primary focus of the study was to use integrated models to isolate and compare bank efficiency variations between private and public Islamic banks in relation to changes triggered by asset management and solvency risks amid attempts to rebound from the 2008, 2014 and 2015 financial crises observed in Kurdistan. Apart from infancy and nascent ideas, there has been a lack of studies exploring the underlying connections linking bank efficiency, asset management, solvency risks and a financial crisis and these issues have been demanding studies like the current study to explore them in detail, especially in the widely sidelined academic context of Islamic banks. Consequently, two panel ARDL models were applied to analyse the uncaptured and validated integrative effects posed by variations in asset management, solvency risk and bank size amid the prevalence of challenges caused by the financial crisis. In that regard, ideas provided in this study are instrumental in yielding measures aimed at enhancing banks' operational capacity and performance amid continuing attempts to fully recoup from challenges posed by the financial crisis.

Foremost, the study uncovered the vital importance of governmental intervention in cushioning private banks against the negative effects of solvency risks. This follows long-run establishments denoting that private Islamic banks are more prone to suffer from the adverse effects of solvency risk compared to public Islamic banks. The significance of such problems is widely documented in academic studies denoting that the withdrawal of funding by investors from private banks together with reduced interbank lending activities, rising perceived risks and an increase in funding costs are responsible for compounded solvency and efficiency-related problems triggering operational complexities among private banks. As a result, the novel aspect of this study is the exposure of the drawbacks of limited government intervention in private banking institutions' affairs and commands that private banks be accorded the necessary financial support to avert such problems.

Theoretically, the findings support the notion that asset management is essential in enhancing the effective use of the bank's assets and the allocation of funds towards profitable or high-income generating assets away from loss-incurring assets. As a result, the study's practical implications entail that asset management plays an instrumental purpose in any banking institution, irrespective of whether the banks involved are Islamic banks or conventional banks. Consequently, this calls for bank managers to develop their asset management strategies in line with their working capital management strategies to resolve a long-standing debate about why and how bank size can trigger adverse changes in bank efficiency. Along similar lines, this study's findings add empirical weight to unvalidated suggestions contending that an increase in bank size as measured by total assets can trigger adverse changes in bank efficiency. Nonetheless, the study findings revealed that private Islamic banks are well posed to benefit from an increase in size (total assets) compared to public Islamic banks. As a result, such findings place a huge demand on bank managers to institute effective and practical working capital and asset management measures to enhance the swift utilisation and expansion of banks' assets.

The study's paramount empirical contribution is derived from

the notion that uses an integrated short-run and long-run ARDL approach to isolate and compare the effects of the financial crisis on private and public Islamic banks, which had been empirically sidelined in prior examinations. Moreover, the study notes that the 2008, 2014 and 2015 financial crises observed in Kurdistan hindered more public Islamic banks' efficiency than private Islamic banks. In line with such findings, collective and solid risk management and bank management practices must be directed towards minimising the harmful effects of structural rigidities posed by a financial crisis. This can comprise the introduction of bank structural adjustment safety nets that guard against the harmful effects of the financial crisis.

The study is not immune to limitations, especially when it cannot be generalised outside the context of the Islamic banking context bearing Islamic banking laws and regulations. As a result, the applicability of the findings to conventional is questionable. In that regard, a comparative analysis between conventional and Islamic banks is required in future examinations to enhance empirical depth.

6. References

1. Acharya, V. V., & Yorulmazer, T. (2007). Too many to fail—An analysis of time-inconsistency in bank closure policies. *Journal of financial intermediation*, *16*(1), 1-31.

2. Alber, N., Elmofty, M., Kishk, I., & Sami, R. (2019). Banking efficiency: concepts, drivers, measures, literature and conceptual model. *Drivers, Measures, Literature and Conceptual Model (January 5, 2019)*.

3. Almanaseer, M. (2014). The impact of the financial crisis on the Islamic banks profitability-evidence from GCC. *International Journal of Financial Research*, *5*(3), 176-187.

4. Avrampou, A., Skouloudis, A., Iliopoulos, G., & Khan, N. (2019). Advancing the sustainable development goals: Evidence from leading European banks. *Sustainable Development*, *27*(4), 743-757.

5. Batir, T. E., Volkman, D. A., & Gungor, B. (2017). Determinants of bank efficiency in Turkey: Participation banks versus conventional banks. *Borsa Istanbul Review*, *17*(2), 86-96.

6. Bauer, P. W., Berger, A. N., Ferrier, G. D., & Humphrey, D. B. (1998). Consistency conditions for regulatory analysis of financial institutions: a comparison of frontier efficiency methods. *Journal of Economics and business*, *50*(2), 85-114.

7. Bellini, T. (2019). *IFRS 9 and CECL Credit Risk Modelling and Validation: A Practical Guide with Examples Worked in R and SAS*. Academic Press.

8. Berger, A. N. (1993). "Distribution-free" estimates of efficiency in the US banking industry and tests of the standard distributional assumptions. *Journal of productivity Analysis*, *4*(3), 261-292.

9. Born, B., & Breitung, J. (2016). Testing for serial correlation in fixed-effects panel data models. *Econometric Reviews*, *35*(7), 1290-1316.

10. Carrion-i-Silvestre, J. L., & Sansó, A. (2006). A guide to the computation of stationarity tests. *Empirical Economics*, *31*(2), 433-448.

11. Claessens, S., & Feijen, E. (2007). *Financial sector development and the millennium development goals* (No. 89). World Bank Publications.

12. Claessens, S., & Van Horen, N. (2015). The impact of the global financial crisis on banking globalization. *IMF Economic Review*, *63*(4), 868-918.

13. Curado, C., Guedes, M. J., & Bontis, N. (2014). The financial crisis of banks (before, during and after): an intellectual capital perspective. *Knowledge and Process Management*, *21*(2), 103-111.

14. Dore, R. (2013). *Flexible rigidities: Industrial policy and structural adjustment in the Japanese economy, 1970-1980*. A&C Black.

15. Elsa, E., Utami, W., & Nugroho, L. (2018). A Comparison of Sharia Banks and Conventional Banks in Terms of Efficiency, Asset Quality and Stability in Indonesia for the Period 2008-2016. *International Journal of Commerce and Finance*, *4*(1), 134-149.

16. Eti, S., Kalkavan, H., Dinçer, H., & Yüksel, S. (2020). Predicting the role of Islamic banking on sustainable economic development: An analysis for Turkey with ARIMA model. In *Handbook of research on creating sustainable value in the global economy* (pp. 146-164). IGI Global.

17. Flögel, F., & Gärtner, S. (2020). The COVID-19 pandemic and relationship banking in Germany: will regional banks cushion an economic decline or is a banking crisis looming?. *Tijdschrift voor economische en sociale geografie*, *111*(3), 416-433.

18. Garza-García, J. G. (2012). Determinants of bank efficiency in Mexico: A two-stage analysis. *Applied Economics Letters*, *19*(17), 1679-1682.

19. Ghoniyah, N., & Hartono, S. (2020). How Islamic and conventional bank in Indonesia contributing sustainable development goals achievement. *Cogent Economics & Finance*, *8*(1), 1856458.

20. Haralayya, B., & Aithal, P. S. (2021). Study on Theoretical Foundations of Bank Efficiency. *Journal of Advanced Research in Operational and Marketing Management*, *4*(2), 12-23.

21. Henriques, I. C., Sobreiro, V. A., Kimura, H., & Mariano, E. B. (2018). Efficiency in the Brazilian banking system using data envelopment analysis. *Future Business Journal*, *4*(2), 157-178.

22. Iyer, R., Puri, M., & Ryan, N. (2016). A tale of two runs: Depositor responses to bank solvency risk. *The Journal of Finance*, *71*(6), 2687-2726.

23. Izzeldin, M., Johnes, J., Ongena, S., Pappas, V., & Tsionas, M. (2021). Efficiency convergence in Islamic and conventional banks. *Journal of International Financial Markets, Institutions and Money*, *70*, 101279.

24. Long, J. S., & Ervin, L. H. (2000). Using heteroscedasticity consistent standard errors in the linear regression model. *The American Statistician*, *54*(3), 217-224.

25. Mosko, A., & Bozdo, A. (2016). Modeling the relationship between bank efficiency, capital and risk in Albanian banking system. *Procedia Economics and Finance*, *39*, 319-327.

26. Muhammad, T., & Salisu, A. (2019). Islamic Bank and Economic Growth in Nigeria and Malaysia Similarities. *International Journal of Accounting*, *4*(22), 10-22.

27. Nazir, M. S., Safdar, R., & Akram, M. I. (2012). Impact of global financial crisis on banks' financial performance in Pakistan. *American Journal of Scientific Research, ISSN*, 2301-2005.

28. Nkoro, E., & Uko, A. K. (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *Journal of Statistical and Econometric methods*, *5*(4), 63-91.

29. Partovi, E., & Matousek, R. (2019). Bank efficiency and non-performing loans: Evidence from Turkey. *Research in international Business and Finance*, *48*, 287-309.

30. Pesaran, M. H., & Shin, Y. (1996). Cointegration and speed of convergence to equilibrium. *Journal of econometrics*, *71*(1-2), 117-143.

31. Robbins, L. (1997). Remarks upon certain aspects of the theory of costs. In *Economic Science and Political Economy* (pp. 133-149). Palgrave Macmillan, London.

32. Saeed, M., Izzeldin, M., Hassan, M. K., & Pappas, V. (2020). The inter-temporal relationship between risk, capital and efficiency: The case of Islamic and conventional banks. *Pacific-Basin Finance Journal*, *62*, 101328.

33. Safiullah, M., & Shamsuddin, A. (2019). Risk-adjusted efficiency and corporate governance: Evidence from Islamic and conventional banks. *Journal of Corporate Finance*, *55*, 105-140.

34. Sakouvogui, K. (2020). Impact of liquidity and solvency risk factors on variations in efficiency of US banks. *Managerial Finance*, *46*(7), 883-895.

35. Shawtari, F. A., Salem, M. A., & Bakhit, I. (2018). Decomposition of efficiency using DEA window analysis: A comparative evidence from Islamic and conventional banks. *Benchmarking: An International Journal*.

36. Turner, P. (2010). Power properties of the CUSUM and CUSUMSQ tests for parameter instability. *Applied Economics Letters*, *17*(11), 1049-1053.

37. Tursoy, T., & Simbarashe Rabson, A. (2021). The Nexus between Agricultural Productivity, Oil Prices, Economic Growth, and Financial Development in the USA. *Review of Innovation and Competitiveness: A Journal of Economic and Social Research*, *7*(1), 117-136.

38. Vetterlein, A. (2007). Economic growth, poverty reduction, and the role of social policies: The evolution of the World Bank's social development approach. *Global Governance*, *13*, 513.

39. Volkova, V. M., & Pankina, V. L. (2013). The research of distribution of the Ramsey RESET-test statistic. *Editors: Prof. Boris Lemeshko, Prof. Mikhail*

40. Zhao, L., Zhu, Q., & Zhang, L. (2021). Regulation adaptive strategy and bank efficiency: A network slacks-based measure with shared resources. *European Journal of Operational Research*, *295*(1), 348-362.