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Kenneth Baldwin, Maryam Alhalboni

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A value-based measure of market power for the participatory deposits of Islamic banks

Abstract

Traditional earnings-based measures of market power cannot be applied to Islamic banks since depositors are investors and not creditors. We develop a new market power measure based on the capitalized value of a bank's deposit funds' management fees in which more powerful banks price deposits to create greater long-term value, whilst less powerful banks target short-term earnings or risk management goals. Applying panel VAR and two-step system GMM to international data from 1990-2022, we validate the measure by showing that deposit growth rates (Granger) cause market power and are the only significant determinant across all two-step system GMM model and sub-sample variants.

JEL Classification: G01, G12, G21, L10

Keywords: Market Power; Value-Based Measure; Deposits; Islamic Banking; Optimal Profit-Sharing Ratio

1. Introduction

Islamic banks have reached systemic proportions in 15 countries (IFSB, 2021) out of 72 in which they compete alongside conventional banks (ICD-Refinitive, 2020). Given the importance of market power to bank stability (e.g., Keeley, 1990; Carletti and Vives, 2009; Boyd and DeNicolo, 2005; Berger et al., 2009), and therefore to distress propagation in financial systems in which Islamic banks operate, there is a need to understand how their market power is distributed across distinct markets in which they are most active, namely, the market for loans and the market for deposits. This information serves multiple purposes. These include the pricing strategies of banks to effectively compete in different markets, and the identification by financial regulators of specific markets in which a bank's power is concentrated in order to effectively supervise capital requirements and permitted activities (Danisman and Demirel, 2019).

However, market power studies of Islamic banks almost exclusively apply the Lerner Index (e.g., Ariss, 2010; Weill, 2011; Salma and Younes, 2014; Azzam and Rettab, 2013; Kabir and Worthington, 2017; Risfandy et al., 2019). The Lerner Index measure of market power is based on the (relative) margin between the returns generated by a bank's loan and other assets, and its marginal costs (Lerner, 1934). Marginal costs include those of funding liabilities sourced from the deposit and capital markets. Hence, by construction, the Lerner Index does not isolate the separate pricing power of Islamic banks in the market for loans, nor in particular, the market for deposits, even though this information is increasingly valuable to multiple stakeholders. This inherent shortcoming of the Lerner Index provides the first motivation of our paper, which is to establish a market power measure for the participatory deposits of Islamic banks. This motivation resonates with prior literature that has adapted the Lerner Index to reveal the distribution of market power across a firm's income-generating products (e.g., Gelfand and

Spiller, 1987; Suominen, 1994; Feenstra and Levinsohn, 1995; Shaffer, 1996; Barbosa et al., 2015; Shaffer and Spierdijk, 2020).

A second motivation of the paper arises due to a fundamental misspecification in prior applications of the Lerner Index to Islamic banks (ibid). This misspecification concerns marginal costs, which is a key component of the Lerner Index. For conventional banks, costs include fixed rates of interest paid on deposits and other liabilities that are not (directly) connected to the ex-ante uncertain rates of return of assets originated/acquired for shareholders using those funds (notwithstanding bankruptcy risks). Costs arising on conventional bank deposit liabilities are also a legally enforceable payment obligation. In contrast, a majority of the funds of Islamic banks comprise participatory deposits, in which depositors are investors rather than creditors (Aysan et al., 2018; Baldwin et al., 2019; Baldwin and Alhalboni, 2020). Participatory depositors receive a return on their capital based on a pre-defined profit-sharing ratio (PSR) and the realised performance of assets originated/acquired on their behalf by the bank acting as a funds' manager in return for a profit share. To comply with Islamic law, any losses arising on managed assets fully vest with participatory depositors. In other words, participatory depositors bear rate of return risk, and the risk of losing principal, in return for an *allocation* of the returns generated from assets which they own. Since this allocation is funded by returns generated from assets owned by participatory depositors, the allocation is not a cost to the bank (unlike conventional deposit returns, which are an interest expense).

Applications of the Lerner Index to Islamic banks that treat allocations to participatory depositors as a cost is still misspecified even in light of the discretionary use of smoothing reserves by some banks to pay deposit returns shadowing conventional deposit rates. Smoothing is achieved by releasing a portion of accumulated reserves to supplement the depositors' share of income generated from managed assets, or by making transfers to reserves from depositors' allocations (Chong and Liu, 2009; Hamza, 2016; Aysan et al., 2018).

Smoothing first uses reserves that are within the equity of participatory depositors, i.e., part of the profit equalisation reserve and all of the investment risk reserve (Archer et al., 2009; Baldwin and Alhalboni, 2020). This effects an inter-temporal redistribution of depositors' returns. This is, however, not a cost for the bank, as it is not funded by shareholder-owned reserves. Furthermore, if reserves within depositors' equity are insufficient (to achieve the desired amount of returns' smoothing), then the portion of the profit equalisation reserve owned by shareholders is used to subsidise depositors' returns. However, this subsidy is later reimbursed to shareholders if the depositors' share of returns generated by managed assets exceeds a conventional deposit rate benchmark in subsequent periods (Baldwin and Alhalboni, 2020).

In summary, to avoid misspecifying marginal costs in the Lerner Index, applications of the Lerner Index to Islamic banks should exclude cash flows related to participatory deposits. In other words, the Lerner Index should be calculated without including returns generated from participatory depositors' assets within total revenue ("price" in the Lerner Index is proxied by total revenue/total assets), and without including allocations paid to participatory depositors from managed assets within the bank's marginal costs. By excluding cash flows related to participatory deposits, these deposits would no longer feature in applications of the Lerner Index to Islamic banks. Exclusion of participatory deposits from the Lerner Index provides a second motivation for our paper, namely to establish a market power measure catering to their unique financial characteristics.

The objective of this paper is to develop and validate a new *value-based* measure of market power for participatory deposits, but which is also suited, in general, to managed funds with participatory fee structures (e.g., private equity funds, which include a so-called "back-end carry"). Our measure contrasts sharply with earnings-based measures of market power applied so far to banks, since a value-based measure necessarily internalizes the long-term consequences of pricing decisions beyond only current earnings. Our measure links market power to the actual pricing of participatory deposits relative to a bank's (time-varying) shareholder value-maximizing pricing optimum (i.e., its optimal PSR). We derive an explicit expression for a bank's optimal PSR (which is a component of the market power measure) using dynamic programming techniques and a deposit valuation model that embeds competitive market conditions by invoking elasticities for account switching between Islamic banks and between Islamic and conventional banks. In this measure, more powerful banks are endowed with pricing latitude to set PSRs closer to their idiosyncratic pricing optima, whilst less powerful banks are restricted from doing, for example, due to a need to mitigate spikes in deposit withdrawal risk (by paying higher PSRs to depositors) or pressure to increase earnings (by paying lower PSRs to depositors). Implicit to our market power measure, therefore, is an intertemporal dimension in which less powerful banks emphasize near-term goals over long-term value creation - this dimension is absent from traditional earnings-based market power measures.

To validate our market power measure, we use quarterly data for 117 banks in 28 countries from 1990-2022. The economic basis of our method of validation is the imperfect substitutability of deposits at different banks, which endows greater market power to banks that depositors prefer (White, 2013; Drechsler et al., 2017, 2021). Hence, we empirically evaluate whether market power in our measure is (Granger) caused by deposit growth rates (which are used to proxy depositors' preferences). To test causality, we apply a Panel Vector Autoregression (PVAR) model. In addition to deposit growth rates, our PVAR model includes as covariates an array of bank-specific determinants of market power reported in the banking literature. Furthermore, using a two-step system GMM, we investigate the determinants of market power in our measure using deposit growth rates and other bank, market and country level variables. Findings from the two-step system GMM are checked for robustness against alternative sub-samples.

Our results validate this new measure of market power. We find that deposit growth rates (Granger) cause market power at the 1% significance level with no reciprocal causality. Our system GMM results corroborate this finding. Irrespective of the choice of covariates that are also known to influence market power, and after controlling for potential sample-selection bias in our set of system GMM models, we show that the only independent variable which is significant across all models is the deposit growth rate.

This paper makes several novel contributions. First, we develop and validate a new value-based measure of market power. This is the first value-based measure (as far as we are aware), and is important, since none of the earnings-based market power measures previously reported in the market power literature cater to deposits with a participatory fee structure. Moreover, this measure not only applies to Islamic deposits, but also to participatory fee arrangements used widely in the asset management industry, in which fund managers receive a share of realized fund performance conditional upon exceeding a hurdle rate of return. Second, our measure facilitates the separate measurement of power exerted by Islamic banks in banking intermediation[1] (using, for example, the Lerner Index) versus participatory deposit capital management. Consequently, we open up a new line of research related to the distribution of market power across loan and deposit markets for which the separate impact of each source of market power on economic variables of interest (e.g., bank stability and efficiency) can now be investigated. Third, we derive the first analytic expression for the value of Islamic deposits which recognizes their discrete maturities[2]. This valuation supports pre-acquisition deal pricing in bank consolidations and deposit franchise spin-offs. Fourth, we derive (for the first time) a

[1] By "intermediation" we mean specifically the practice of sourcing funds from creditors to finance the origination of receivables, noting that participatory depositors are investors and not creditors (ibid), and therefore not involved in intermediation activities.

[2] An analytic expression for the value of Islamic deposits with continuous maturities is provided in Baldwin and Alhalboni (2020).

formula based on easily measurable parameters for the optimal profit-sharing ratios of Islamic deposits. This expression, and the market power measure we present which uses it, has useful policy applications. Applications include deposit pricing policies to control pricing hikes intended to attract deposit capital, and earnings policies to control decreases in deposit pricing intended to enhance current earnings. Furthermore, since our optimal pricing formula is parameterized on deposit tenor, we provide a term-structure model for the pricing of Islamic deposits which has so far not been available to academics or practitioners.

The rest of the paper is arranged as follows. Section 2 reviews competition measures used in the banking literature. Section 3 presents a value-based market power measure and derives an analytic expression for the optimal profit-sharing ratio. Section 4 empirically tests the validity of our market power measure. Section 5 concludes the paper and suggests avenues for further research.

2. Competition measures

We briefly review the most popular measures of competition in the banking literature. This provides a theoretical background to the development of a market power measure for Islamic deposits in the next section. It is important to highlight that due to the participatory structure of Islamic deposits in which payments to Islamic depositors are an allocation of returns from managed assets rather than a cost, none of the existing market power measures can be used. However, there are common themes in these measures that inform the basis of assumptions made in developing our measure. Traditional measures reviewed are the Lerner index (Lerner, 1934), the Panzar-Rosse H-statistic (Panzar and Rosse, 1987), and the Herfindahl-Hirschman index (Herfindahl, 1950; Hirschman, 1964). Less commonly used but nevertheless also reviewed are the Boone indicator (Boone, 2008) and the Bresnahan-Lau markup model (Bresnahan, 1982; Lau, 1982).

2.1. Lerner Index

The Lerner index relates market power to the deviation of output price from associated marginal costs. Marginal costs include the cost of deposits and other borrowed funds. In perfectly competitive conditions, in which banks operate at the point where price equals marginal cost, the Lerner index is zero, and banks have no market power. In contrast, if price exceeds marginal cost, then banks have market power by virtue of inelastic demand for their products or lower marginal costs relative to competing banks. In most empirical applications of the Lerner index, price is total revenue divided by total assets, which aggregates pricing power across multiple outputs.

An appealing feature of the Lerner index is a direct mapping of market power to consumer welfare losses due to higher loan prices, lower deposit rates, and reduced output. Its limitations include issues with economies of scale (Spierdijka and Zaourasa, 2018), inefficiency (Koetter et al., 2012) and objectives other than profit-maximization (Spierdijk and Zaourasa, 2017). Multi-output extensions of the Lerner index (e.g., Gelfand and Spiller, 1987; Suominen, 1994; Feenstra and Levinsohn, 1995; Shaffer, 1996; Barbosa et al., 2015; Shaffer and Spierdijk, 2020) disaggregate market power across separate output product categories; these studies most closely align with our paper since we also separate the market power of Islamic banks, albeit between managing Islamic deposits as agent versus intermediating as principal.

2.2. Panzar-Rosse H-statistic

The idea of the Panzar-Rosse H-statistic is that banks alter their pricing strategies in response to a change in input prices depending on market structure. The H-statistic is calculated as the sum of a bank's revenue elasticities with respect to the price of labor, physical capital, and borrowed funds. For a bank in a long-run perfectly competitive equilibrium, $H = 1$, whilst for a monopolist, $H < 0$.

An appeal of the Panzar-Rosse model is that it can be implemented with only modest data requirements. However, it has been reported that the H-statistic is unreliable as a measure of market power because neither the value of H, nor its sign, reliably corresponds to the degree of market power across a range of market structures (Shaffer and Spierdijk, 2015).

2.3. Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (HHI) is a structural measure of concentration equal to the sum of the squares of the market share of each bank in a particular market. It has a lower bound at 1/n (if all banks have equal shares) and an upper bound at unity (monopoly), where n is the number of banks.

Criticisms of HHI resonate with those directed more generally at the ability of structural approaches to capture competitive conduct within a market. For example, Claessens and Laeven (2004) and Beck et al. (2006) find no empirical evidence in support of an inverse relationship between concentration and competition. Moreover, significant market power exists even in highly unconcentrated markets (Claessens and Laeven, 2004). Ultimately, concentration and competition describe different characteristics of banking markets (Schaeck et al., 2009) and therefore structural approaches such as HHI are unreliable (Bikker et al., 2012).

2.4. Boone Indicator

The Boone indicator is a profit-elasticity model which measures the percentage decrease in profits resulting from a 1% increase in marginal costs. Greater absolute values of the Boone indicator (i.e., more negative values) depict higher competition and lower market power. The Boone model assumes that more efficient firms, which can lower their marginal costs to increase profits, achieve higher market shares. Furthermore, intensifying the degree of competition causes a reallocation of market share to more efficient and more profitable firms from their relatively less efficient and less profitable counterparts. Since this reallocation is a general feature of intensifying competition, the Boone indicator is viewed as a robust measure of competition.

2.5. Bresnahan-Lau model

The Bresnahan-Lau model is based on the conjectural variation method of Iwata (1974) which represents a firm's reaction to a change in the market shares and pricing of its rivals. The value of the conjectural variation in the Bresnahan-Lau model is calculated for an average bank by simultaneous estimation of market demand and supply curves. A conjectural variation equal to zero represents a perfectly competitive market, and unity represents perfect collusion. Applications of the model are relatively uncommon due to a lack of micro-data on cost and production functions (Bikker and Haaf, 2002).

A common theme of traditional non-structural market power measures (i.e., those reviewed above other than HHI) which connects them to the value-based measure developed in this paper is the notion that more powerful banks can extract value from markets in which they compete in ways that are unavailable to less powerful banks. Traditional market power models capture various advantages, for example, product pricing levels, the elasticity of prices/revenue to input costs, or marginal costs. Our measure captures pricing advantages.

3. The Market Power of Islamic Deposits

In the first part of this section we explain the structure of Islamic deposits relative to conventional time deposits. We also define a value-based market power measure, justifying our choice from amongst several alternatives which could also be considered. In the second part, we construct a theoretical model of Islamic deposits from which we derive the value of deposits to the bank and an optimal profit-sharing ratio (which is an essential component of our market power measure).

3.1. Islamic deposits vs conventional time deposits

Islamic deposits (other than current accounts) are a limited term funds' management product. Deposited funds are invested in assets which the bank acquires and/or originates on behalf of depositors, e.g., retail and corporate financing receivables. The bank acts as an agent with no principal interest, and shares only positive returns generated by managed assets with depositors. Any losses incurred vest entirely with depositors (unless due to a breach of fiduciary duty by the Islamic bank). Furthermore, the bank does not guarantee the return of principal to depositors, nor does it guarantee a rate of return (Toumi, et al., 2019; Baldwin, et al., 2019). This deposit structure contrasts sharply with conventional time deposits, which are a loan made by depositors to the bank in exchange for a fixed return agreed in advance and a promise made by the bank to return deposit principal. Hence, Islamic depositors are investors who bear rate of return risk and the risk of losing principal, whereas conventional depositors lend to banks to receive interest with a principal guarantee. These differences are manifestly important to the treatment of funding costs within traditional market power measures for each type of deposit.

3.2. A value-based market power measure

We define the power at time t, $\mathrm{MP_t}$, of an Islamic bank in the market for Islamic deposits as follows:

$$\mathrm{MP_t} = \frac{1}{\frac{\left|\theta_t^{act} - \theta_t^{opt}\right|}{\theta_t^{opt}}},\ \theta_t^{act} \neq \theta_t^{opt} \tag{1}$$

$\theta_t^{act} \in (0,1)$ is the actual profit-sharing ratio (PSR) of depositors at time t. $\theta_t^{opt} \in (0,1)$ is the profit-sharing ratio of depositors at time t that maximizes the value of Islamic deposits to the bank[3]. Market power in (1) is undefined at $\theta_t^{act} = \theta_t^{opt}$. Therefore, for empirical applications

[3] Actual PSRs are proxied by total cash returns to investors divided by total deposit volume across all tenors in the immediately preceding deposit period. Actual PSRs therefore include transfers to/from smoothing reserves. Optimal PSRs are calculated for a 3-month deposit, since this is the most frequently occurring tenor.

the argument of the modulus term in the denominator of (1) is modified to $max\left(\theta_t^{act} - \theta_t^{opt}, \varepsilon\right)$ where ε is a constant and $0 < \varepsilon \ll 1$. Also note that since actual PSRs in (1) include any transfers to/from smoothing reserves, our market power measure endogenizes the manipulation of returns paid to participatory depositors occasioned by Islamic banks to shadow conventional deposit rates (Archer et al., 2009; Chong and Liu, 2009; Hamza, 2016; Aysan et al., 2018; Baldwin and Alhalboni, 2020). Stated differently, our market power formulation reconciles to the smoothing practices of Islamic banks by using actual PSRs.

The definition of market power in (1) relates the actual pricing of Islamic deposits to value creation since the optimal PSR is value-maximizing. For a unique optimal PSR between zero and one, market power is higher for banks which are able to price actual PSRs closer to their (time-varying) idiosyncratic optimal PSR, and lower otherwise. However, whilst a monotonic association between market power and deposit pricing is apparent in earnings-based market power measures such as the Lerner Index, this is not necessarily the case for a value-based measure. This is because in our value-based measure, a trade-off exists between strategic pricing (i.e., pricing for the long-term) to build shareholder value, versus a tactical use of pricing to pursue short-term goals, such as mitigating deposit withdrawal risk (by paying higher PSRs to depositors) or boosting current period earnings (by paying lower PSRs to depositors). In other words, market power depends on the *absolute deviation* of actual PSR from optimal (as shown in (1)).

Several remarks are in order concerning alternative value-based market power formulations. First, market power in our measure is positive. In our view this is a desirable property that cannot be guaranteed if market power is instead defined as $1 - \frac{\left|\theta_t^{act} - \theta_t^{opt}\right|}{\theta_t^{opt}}$. Second, another alternative to (1) is to define market power as $1 - \left|\theta_t^{act} - \theta_t^{opt}\right|$, which is bounded between zero and unity given θ_t^{act},$\theta_t^{opt} \in (0,1)$. However, we consider it essential to define the market power measure with respect to the *proportionate* deviation of actual prices from a suitable benchmark. In the Lerner index, this benchmark is marginal costs (at the profit-maximizing level of output), whilst in (1), it is the optimal profit-sharing ratio. A market power measure that ignores the relative size of PSR deviations from optimal is potentially misleading, since equal absolute deviations of actual PSRs from optimal PSRs could have widely varying implications for banks with different optimal PSRs. Third, our definition in (1) uses both actual and optimal PSRs, whereas it is possible to define market power only in terms of optimal PSRs, for example, as $1 - \theta_t^{opt}$. A prohibitive shortcoming of this alternative, however, is the absence of a "realized" market power as such, since actual deposit pricing is ignored. Fourth, because our market power definition invokes an optimization framework, it closely aligns with the Lerner Index, which defines market power at the profit-maximizing level of output.

3.3. Optimal PSRs: modelling assumptions

The definition of market power in (1) is general in the sense that it admits any model set up to derive a bank's optimal PSR. There are, however, two particular aspects of the non-structural measures of competition reviewed in the previous section that inform the modelling of optimal PSRs. The first is the interdependence of banks regarding their pricing and output decisions. The Lerner Index assumes a Cournot market structure in which the output decisions of banks are independent of each other. This contrasts with the Bresnahan-Lau model in which firms react to a change in the market share and pricing of rivals. The second is the role of costs. In the Lerner Index, market power depends on the relative difference between price and marginal costs. In the Panzar-Rosse and Boone indicator models, market power depends on the elasticity of revenue and profit with respect to costs (resp.). For each of these models, costs include those of borrowed funds. However, for Islamic deposits, attributable costs arise only in respect of acquiring/originating/managing assets on behalf of Islamic depositors, and administering deposit accounts. These costs can be recovered within a bank's share of ex-post returns generated by managed assets.

To derive a bank's optimal PSR, we make two assumptions related to the aforementioned considerations:

1. Islamic banks price participatory deposits without taking the anticipated price response of competing banks into consideration.
2. Administration costs incurred in managing depositors' funds are a constant proportion of deposit volume.

Each of these assumptions is motivated by the avoidance of model enlargements (i.e., more complex market and cost structures, which are left for future research). In particular, the first assumption stipulates that an Islamic bank prices its participatory deposits independent of its anticipation of the pricing response of competitors. In other words, this assumption avoids including feedback loops between the bank and its competitors at the time of setting the bank's PSR. However, it should be emphasised that this assumption does not mean PSRs are set independently of either the pricing of Islamic or conventional bank competitors. To the contrary, our derivation of a bank's optimal PSR (presented next) captures the pricing of competitors within the anticipated (i.e., expected) switching of depositors in response to the ex-ante announcement of the bank's profit-sharing ratio (at the start of a deposit period) and the ex-post realisation of deposit returns (at the end of a deposit period). Because future deposit volume depends on price comparisons made by depositors with other banks, an Islamic bank's optimal PSR is derived by incorporating these effects into the discounted value of the bank's fee income earned from managing participatory deposits.

3.4. Optimal PSRs: derivation[4]

In this sub-section we derive the optimal profit-sharing ratio of Islamic deposits in three steps. First, we formulate a general valuation model for deposits with discrete maturities which is independent of the deposit volume process. Second, we impose a specific deposit volume process driven by account switching between Islamic banks and between Islamic and conventional banks. Lastly, we derive the optimal PSR from the resulting Bellman equation.

3.4.1. General valuation model for deposits with discrete maturities

Denote the time t value of one unit of managed assets by s_t which follows a Geometric Brownian Motion process given by

$$\frac{ds_t}{s_t} = rdt + \sigma dz_t \tag{2}$$

where r is the (constant) risk-free rate, σ is the instantaneous asset return volatility (a constant), and dz_t is a wiener process, i.e., $dz_t = \varepsilon\sqrt{dt}$, $\varepsilon \sim N(0,1)$ (standardized normal distribution).

Next, partition the horizon into an infinite number of discrete time intervals of equal length, Δt. Islamic deposits each have a tenor Δt, and deposit periods are from 0 to Δt, Δt to $2\Delta t$, …, $(n-1)\Delta t$ to $n\Delta t$, and so on, where $n \to \infty$. Additionally, changes in the volume of Islamic deposits due to account redemptions and additions coincide with deposit maturities.

If H_{n-1} is the volume of Islamic deposits at the start of Period-n (i.e., the nth period), and $\theta_{n-1} \in (0,1)$ is the corresponding profit-sharing ratio (PSR) of investors, then the pay-off to the bank at the end of Period-n is

$$H_{n-1}\left\{(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}} - 1,0\right) - c\right\} \tag{3}$$

In (3), c is the unit cost of administering depositors' funds accrued to the maturity date of each deposit[5]. In accordance with the contractual requirements of Islamic deposits, (3) states that at

[4] Appendix E provides a glossary of notation.

[5] Empirically, c is the ratio of non-interest costs to total assets of the bank.

the end of Period-n the bank receives a proportion, $1-\theta_{n-1}$ (which is agreed at the start of the n[th] period) of positive asset returns, but shares none of the losses with investors if any arise. For initial Islamic deposit volume H_0, and initial underlying asset value s_0, the value of Islamic deposits to the bank, $V(\theta)$, is

$$V(\theta)=E_0\left[\sum_{n=1}^{\infty}e^{-rn\Delta t}H_{n-1}\left\{(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}}-1,0\right)-c\right\}|s_0\right] \tag{4}$$

where $\theta ≔ \{\theta_{n-1}\}_{n=1}^{\infty}$ is an (infinite) set of PSRs, and $E_u[.|s_u]$ is the (conditional) expectation at time u with respect to a risk-neutral measure.

Invoking the Black-Scholes[6] value of a European call option (Black and Scholes, 1973) and the *Law of Total Probabilities* (see Billingsley 2008), (4) reduces to

$$\begin{aligned}V(\theta)=H_0[(1-\theta_0)\mathbb{C}-\tilde{c}]+E_0\left[e^{-r\Delta t}H_1[(1-\theta_1)\mathbb{C}-\tilde{c}]|s_0\right]\\ +E_0\left[E_1\left[e^{-2r\Delta t}H_2[(1-\theta_2)\mathbb{C}-\tilde{c}]|s_1\right]|s_0\right]\\ +E_0\left[E_1\left[E_2\left[e^{-3r\Delta t}H_3[(1-\theta_3)\mathbb{C}-\tilde{c}]|s_2\right]|s_1\right]|s_0\right]+\dots\end{aligned} \tag{5}$$

$$\mathbb{C}=N(d_1)-e^{-r\Delta t}N(d_2) \tag{6}$$

$$d_1=\frac{\left(r+\frac{1}{2}\sigma^2\right)\Delta t}{\sigma\sqrt{\Delta t}},\ d_2=d_1-\sigma\sqrt{\Delta t} \tag{7}$$

where $N(.)$ is the cumulative normal distribution, and $\tilde{c}:=ce^{-r\Delta t}$.

Proof: See Appendix A

3.4.2. Deposit volume process

We next develop an Islamic deposit volume process which incorporates the administration of Islamic deposits in practice, namely: the setting of a profit-sharing ratio at the start of each deposit period; changes to deposit volumes in response to the bank's PSR; changes to deposit

[6] Whilst the restrictions of the Black-Scholes approach to pricing traded options have been widely challenged in the last decade (e.g., Ivascu, 2021), these criticisms do not apply to our application of the approach to deposit valuation since the derivative contract within participatory deposits is embedded, i.e., not separately traded.

volumes in response to ex-post realised returns; and the distribution of realized returns at the end of each deposit period.

The timeline in Fig. 1 illustrates the sequence of periods $n-1$, n, and $n+1$, which end at $(n-1)\Delta t$, $n\Delta t$, and $(n+1)\Delta t$ respectively.

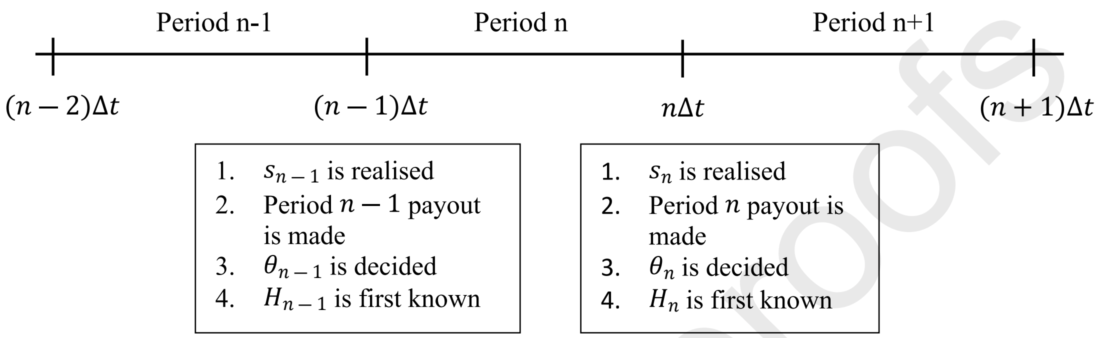

Figure 1: Islamic deposit timeline

In Fig. 1, H_{n-1} is the Islamic deposit volume for Period-n with corresponding investors' profit-sharing ratio θ_{n-1}. H_{n-1} is first known at the start of Period-n, at which time θ_{n-1} is set by the bank.

We explain the deposit volume model with reference to Period-n. At the end of Period-n, the return on managed assets, s_n, is realized. The allocation of gains/losses is as follows:

1. If managed assets are profit-making in Period-n, i.e., $\frac{s_n}{s_{n-1}} - 1 > 0$, then investors encash (i.e., do not reinvest) their profits.
2. If managed assets are loss-making (or break-even) in Period-n, i.e., $\frac{s_n}{s_{n-1}} - 1 \leq 0$, then losses are fully absorbed by investors.

In addition to the above (encashment of profits and loss of invested capital if any), Islamic deposit volume at the start of the next period, Period $n+1$, changes because investors compare their returns, $max\left(\theta_{n-1}\left(\frac{s_n}{s_{n-1}} - 1\right), 0\right) + min\left(\frac{s_n}{s_{n-1}} - 1, 0\right)$, to a conventional deposit rate benchmark, r_d. This comparison causes investors to rebalance deposit capital between Islamic banks and conventional banks (i.e., to switch). The model captures the bank's PSR dependence on the pricing of conventional bank deposits, r_d, as follows:

3. If investors' returns are positive (i.e., managed assets are profit-making), investors scale their invested capital (upwards or downwards) by a factor $1+\eta\left(\theta_{n-1}\left(\frac{s_n}{s_{n-1}}-1\right)-r_d\right)$, where η is the "profit-elasticity".
4. If, however, investors' returns are negative (i.e., managed assets are loss-making), then (in addition to physical loss of capital, 2. above) investors scale their invested capital downwards by a factor $1+\gamma\left(\frac{s_n}{s_{n-1}}-1-r_d\right)$, where γ is the "loss-elasticity" (which can, in general, differ from the profit-elasticity due to the response of investors to gains versus losses).

The bank's PSR dependence on the pricing of other Islamic bank competitors is captured in the next rule:

5. At the end of Period-n, the bank changes its PSR from θ_{n-1} to θ_n. Since Islamic banks commonly shadow the returns of conventional banks (e.g., Chong and Liu, 2009; Hamza, 2016; Aysan et al., 2018), Islamic banks implicitly price deposits in alignment with each other. Therefore, regarding switching due to PSR comparisons, it is sufficient to model only PSR comparisons made by depositors with the bank's own PSR in the previous deposit period. Denoting the price elasticity of demand for Islamic deposits by δ, the volume of Islamic deposits remaining at the end of Period-n *after* the allocation of any losses, or the distribution of profits, is further scaled by a factor $\left(\frac{\theta_n}{\theta_{n-1}}\right)^{\delta}$. The resulting deposit volume is carried forward to the start of the next deposit period.

Combining volume process rules 1-5 above, the change in Islamic deposit volume at the end of Period-n relative to the start of the period is given by

$$\frac{H_n}{H_{n-1}} = \left(\frac{\theta_n}{\theta_{n-1}}\right)^{\delta} f(\theta_{n-1}) \quad (8)$$

for all $n = 1, 2, ...$, where the managed assets' returns' performance scaling factor, $f(\theta_{n-1})$, is defined by

$$f(\theta_{n-1}) := 1 + 1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1\right) + \eta 1_{\{+\}}\left(\theta_{n-1}\left(\frac{s_n}{s_{n-1}} - 1\right) - r_d\right) + \gamma 1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1 - r_d\right) \quad (9)$$

The indicator function $1_{\{-\}} = 1$ if $\frac{s_n}{s_{n-1}} - 1 \leq 0$ (i.e., if losses arise), and zero otherwise. Also, $1_{\{-\}} + 1_{\{+\}} \equiv 1$ (by definition), where $1_{\{+\}} = 1$ if $\frac{s_n}{s_{n-1}} - 1 > 0$ (i.e., if managed assets are profit-making).

The second term in (9) is the percentage change in Islamic deposit capital due to losses. The third term in (9) is the percentage change in Islamic deposit capital as a response to positive returns relative to the conventional deposit rate benchmark. The fourth term in (9) is the percentage decrease in Islamic deposit capital as a response to losses.

By substituting (8) and (9) into (5), it can be shown that the maximal deposit value is given by

$$V = \max_{\theta_0} \frac{{\theta_0}^{\delta}[(1-\theta_0)\mathbb{C} - \tilde{c}]}{1 - e^{-r\Delta t} g(\theta_0)} \quad (10)$$

where $g(\theta_0) := \varphi + \eta\theta_0 e^{r\Delta t}\mathbb{C}$, $\varphi := 1 + (1+\gamma)\left(e^{r\Delta t}(1-\mathbb{C}) - 1\right) + (\gamma - \eta) r_d N(d_2) - \gamma r_d$, and the first-order condition for (10) yields an optimal PSR given by

$$\theta_0^{opt} = \frac{-\rho +/- \sqrt{\rho^2 - 4\delta^2\eta(\mathbb{C} - \tilde{c})(1 - \beta\varphi)}}{2\delta\eta\mathbb{C}} \quad (11)$$

for which we require $\rho^2 - 4\delta^2\eta(\mathbb{C} - \tilde{c})(1 - \beta\varphi) \geq 0$ where $\rho := (1-\delta)\eta(\mathbb{C} - \tilde{c}) - (1+\delta)(1 - \beta\varphi)$[7].

[7] Data used to calculate the optimal profit-sharing ratio is sourced from DataStream for the following variables: r_d, the conventional deposit rate; r, the risk-free rate (used to calculate β) is based on 3-month US T-bill yields; σ, the asset return volatility (used to calculate $\mathbb{C}$, the call option value) is proxied by the deleveraged volatility of stock price returns. We empirically determine δ, η, γ using equations (8) and (9).

Proof: See Appendix B

The optimal PSR in (11) efficiently trades-off the bank's proportionate share of asset returns against deposit volumes – a higher PSR paid to depositors leads to a higher deposit volume and higher managed assets, in respect of which, however, the bank receives a lower share of returns (and vice versa). On the other hand, costs increase monotonically with deposit volume. Provided only one of the values of θ_0^{opt} given by (11) is between zero and one, there exists a unique optimal PSR (we validate this empirically).

3.4.3. Optimal PSRs: numerical illustration

To clarify the calculation of a bank's optimal PSR, we provide numerical examples for banks in two different countries: for Bank-1, optimal PSR > actual PSR; for Bank-2, optimal PSR < actual PSR[8]. Input data values are either stipulated (e.g., deposit maturity), taken directly from databases (e.g., the 3-month T-bill yield that proxies the risk-free rate), or estimated (e.g., the volatility of asset returns and price elasticities of deposit demand). Input data and the output of (non-trivial sub-routine) calculations are shown in Table 1 below.

[8] We wish to thank an anonymous reviewer for having suggested the inclusion of a numerical illustration.

Table 1: Numerical calculation of the optimal PSR

Parameters values and sub-routine output	Symbol	Bank-1	Bank-2
Risk-free rate	r	4.1% p.a.	7.2% p.a.
Deposit maturity	Δt	3-months	3-months
Volatility of asset returns	σ	32.1% p.a.	27.7% p.a.
Conventional deposit rate per quarter	r_d	1.4%	1.9%
PED w.r.t. negative deposit returns	γ	0.15	0.68
PED w.r.t. positive deposit returns	η	0.11	0.54
PED w.r.t. depositors' profit-sharing ratio	δ	2.62	1.03
Administration costs per unit deposit per quarter	c	0.71%	0.49%
Call option premium	$\mathbb{C}$	6.9%	6.4%
Phi (see definition in (10))	φ	0.930	0.909
Rho (see definition in (11))	ρ	-0.298	-0.218
Discriminant (see definition in (10))	N/A	0.074	0.033
Optimal PSR	θ^{opt}	0.65	0.51
Actual PSR	θ^{act}	0.60	0.66
Market Power	MP	12.2	3.3

Notes: "PED" is the price elasticity of deposit demand; "w.r.t." means with respect to; "PSR" means profit-sharing ratio. Only the solution in (11) for which the square root of the discriminant is subtracted gives optimal PSR values between 0.0 and 1.0 (because $\rho < 0$). The second solution in (11), which adds the square root of the discriminant, gives optimal PSR values consistently above 1.0 for all banks in our sample, and is therefore ignored.

4. Empirical validation

This section presents the empirical validation of our market power measure, comprising the economic rationale for our method of validation, a discussion of the data, details of econometric models deployed and model determinants, and the results of our tests.

4.1. Test-basis

The power of banks in the market for deposits derives from their ability to attract and retain depositors' funds by differentiating themselves as a banking institution of choice, for example, by using marketing strategies to create brand/consumer loyalty, and/or differentiating their products (White, 2013). The consequence is that power in the market for deposits is caused by depositors' preferences. However, the reverse is not true, as market power is not an inherent bank characteristic, but is instead conferred to banks by virtue of the extent to which they render their deposits an imperfect substitute – and in more powerful banks, a preferred substitute - for those of other banks (Drechsler et al., 2017, 2021).

Our formulation of market power (1) includes a bank's optimal PSR (11), which itself depends on an array of parameters including various price elasticities of demand for participatory deposits (i.e., δ, η, and γ)[9]. These elasticities are estimated using deposit flows in response to price changes, and therefore depend on deposit growth rates. Consequently, our market power measure aligns with economic theory, in that in our model, market power depends on depositors' preferences. However, since economically the reverse is not true, i.e., there is no economic dependence of depositors' preferences on market power, our empirical validation of the market power measure centres on establishing unidirectional causality. Stated differently, our empirical test of the market power measure must test whether market power also causes deposit growth rates, as this would invalidate the measure given the economic direction of this relationship.

[9] See glossary in Appendix E.

To test (Granger) causality, we use a set of bank-specific variables to run Panel VAR estimations. Additionally, using a two-step system GMM, our second test evaluates the extent to which deposit growth rates explain market power in our measure relative to other possible determinants. This test is necessary because the PVAR model uses only a limited set of bank-specific variables to evaluate (Granger) causality, the inclusion of each being motivated by the market power literature. The two-step system GMM includes a far larger set of variables that also incorporates market structure and macro-economic variables, and includes dummy variables for several crises that occurred in the sample period 1990-2022 which could impact the robustness of our results. From amongst these variables, our measure is validated if the deposit growth rate is found to be a persistently significant determinant across all model and sub-sample variants.

Lastly, we undertake a third test related to the structural form of our market power measure (1). We evaluate the need to invoke the *absolute* deviation between actual and optimal PSRs in (1) by also applying our panel VAR and two-step system GMM models to a corresponding (hypothetical) definition of market power which instead invokes the *signed* difference between actual and optimal PSRs, i.e., where market power equals $\left(\frac{\theta_t^{act}-\theta_t^{opt}}{\theta_t^{opt}}\right)^{-1}$, $\theta_t^{act} \neq \theta_t^{opt}$.

4.2. Data

We collect financial statements for all Islamic banks in the Fitch and Refinitiv Eikon databases (for duplicated bank data we use Fitch). We exclude banks that are not classified as fully-fledged Islamic banks (i.e., "Islamic windows" of conventional banks). We also exclude data intervals for each bank for which not *all* variables required to calculate the optimal PSR in (11), or the variables included in our estimations, are available. We review the data for reporting errors/inconsistencies and winsorize all variables at the 1st and 99th centiles. To mitigate the impact of extreme observations on regression coefficients, the values of variables that lie more than nine standard deviations from their sample mean are deleted. Our final sample consists of 117 Islamic banks in 28 countries covering 1990–2022. Data on macroeconomic and market structure variables are from DataStream. Our sample banks, countries and regions are shown in Table 2.

Table 2: Sample region and country distribution

Region	Country	Number of Banks
Africa	Egypt	2
	Kenya	1
	Mauritania	1
	Sudan	4
	Tunisia	2
Asia	Bangladesh	5
	Brunei	3
	Indonesia	11
	Malaysia	16
	Maldives	2
	Pakistan	6
	Thailand	2
GCC	Bahrain	10
	Kuwait	5
	Oman	1
	Qatar	6
	Saudi Arabia	5
	United Arab Emirates	7
	Yemen	2
Levant	Iraq	4
	Jordan	3
	Lebanon	3
	Palestine	2
	Syria	1
	Turkey	5
Other	Iran	3
	Kazakhstan	1
	United Kingdom	4
Total	28	117

Source: Fitch and Refinitiv Eikon databases.

Table 3 presents the definition of our variables and data sources.

Table 3:Variable definitions and data sources

Variable	Definition	Source
Deposit growth rate (DG)	Growth rate of total deposit volume across all tenors.	Eikon and Fitch
Inefficiency (INF)	Non-interest costs to total revenue.	Eikon and Fitch
Diversification (DIV)	Non-interest income to total revenue.	Eikon and Fitch
Capitalization (CAP)	Total equity to total assets.	Eikon and Fitch
Bank size (BS)	Natural logarithm of total assets.	Eikon and Fitch
Z-Score (ZS)	Return on assets plus the capital-asset ratio divided by the standard deviation of asset returns.	Eikon and Fitch
Credit risk (CR)	NPL to loans	Eikon and Fitch
Liquidity (LQ)	Loans to customer deposits.	Eikon and Fitch
GDP growth (GDP)	Real GDP per capita growth rate.	DataStream
Inflation (INFL)	Change in the consumer price index.	DataStream
HHI	Herfindahl-Hirschman index. [10]	Eikon and Fitch
Market capitalization (MC)	Change in market capitalization of listed domestic companies as a percentage of GDP.	DataStream
GFC	Dummy variable equal to one in years 2007-2009 (Global Financial Crisis) and zero otherwise.	n.a.
AS	Dummy variable equal to one in years 2011-2013 (Arab Spring) and zero otherwise.	n.a.
COV	Dummy variable equal to one in years 2020-2022 (Covid-19 pandemic) and zero otherwise.	n.a.

Descriptive statistics for the variables used in our regressions are shown in Table 4.

Table 4: Descriptive statistics of variables

Variable	Mean	SD	p25	p50	p75
DG	0.053	0.666	-0.034	0.032	0.120
INF	0.706	4.064	0.252	0.377	0.562
DIV	0.600	9.438	0.083	0.163	0.294
CAP	0.133	0.176	0.076	0.105	0.153
BS	21.785	1.869	20.513	22.044	23.155
ZS	17.347	140.626	6.235	8.863	13.445
CR	0.066	0.121	0.014	0.030	0.066
LQ	2.822	69.301	0.748	0.883	1.025
GDP	0.012	0.045	-0.008	0.019	0.039
INFL	0.066	0.701	-0.037	0.000	0.035
HHI	0.082	0.042	0.055	0.077	0.088
MC	0.037	0.276	-0.051	-0.004	0.032

A description of the regression variables is given in Table 3. Bank data are from Fitch and Refinitiv Eikon databases. Macro data are from the DataStream database. The sample period is 1990–2022. "SD" denotes standard deviation; "p" denotes centile.

[10] A country-level indicator of bank concentration, measured by the Herfindahl–Hirschman Deposits Index, with higher values indicating greater market concentration. In our calculation, we include both Islamic and conventional banks.

Figures 2-6 show average optimal PSRs vs average actual PSRs by country for 1990-2022. Fig. 2 is for countries in Africa; Fig. 3 is for countries in Asia; Fig. 4 is for GCC countries; Fig. 5 is for countries in the Levant; Fig. 6 is for all other countries.

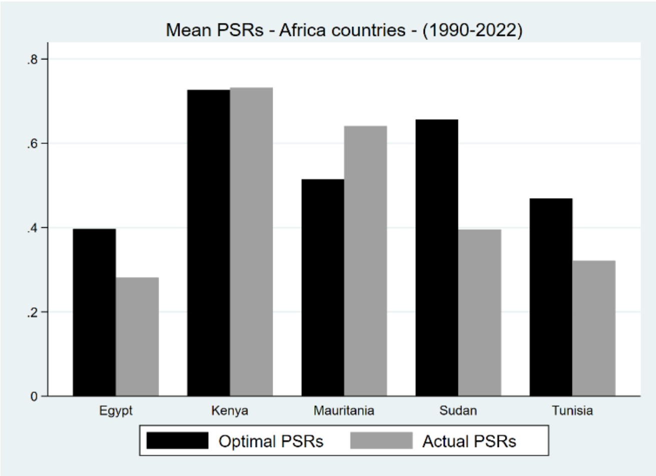

Figure 2: Optimal PSRs vs Actual PSRs for countries in Africa

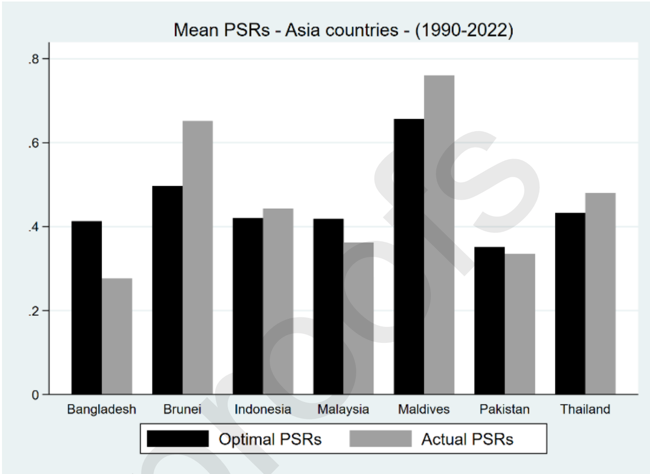

Figure 3: Optimal PSRs vs Actual PSRs for countries in Asia

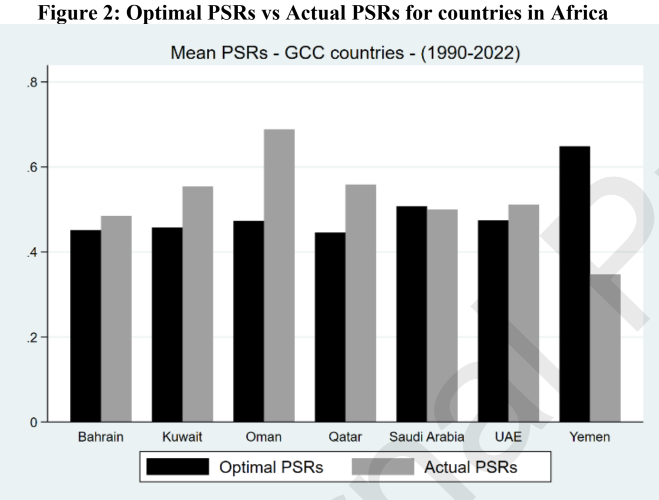

Figure 4: Optimal PSRs vs Actual PSRs for countries in the GCC

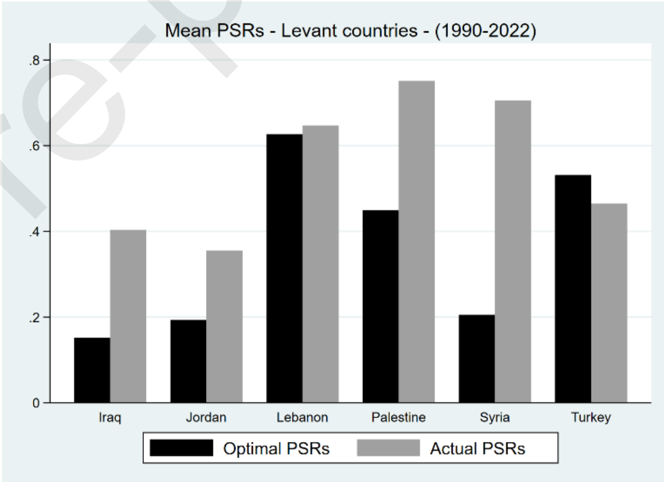

Figure 5: Optimal PSRs vs Actuals PSR for countries in the Levant

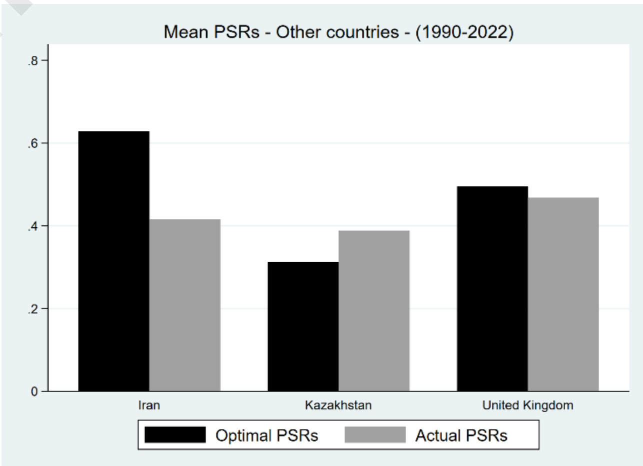

Figure 6: Optimal PSRs vs Actuals PSR for other countries

Inspection of Figures 2-6 shows that, on average, actual PSRs are close to optimal PSRs in some countries (higher market power), whilst diverging from optimal PSRs in others (lower market power). Furthermore, in regions in which actual PSRs diverge from optimal PSRs, there is no consistency as to whether actual PSRs exceed or fall below optimal PSRs.

To formally compare actual PSRs to optimal PSRs, we apply the Wilcoxon matched-pairs signed-rank test[11] (Wilcoxon, 1945) to the difference between actual PSRs in the sample and their corresponding optimums. The test shows no significant difference between the median of these differences and zero. In other words, there is no systematic tendency for actual PSRs to be more or less than optimal PSRs. This result supports our optimal PSR model because optimal PSRs that we calculate converge to actual PSRs in the overall sample. This result also supports the use of absolute differences between actual and optimal PSRs in our market power measure, as opposed to signed differences, since the true proportion of positive (and negative) differences is one-half.

4.3. Estimations

4.3.1. Panel VAR model variables

For our (Granger) causality test, in addition to the deposit growth rate we choose other bank-level variables reported in the literature that are related to market power. According to the efficient–structure hypothesis, banks with higher *efficiency* and superior management or production technologies have lower overhead costs and higher profits, which results in larger market shares and higher market power (e.g., Berger, 1995; Mirzaei, 2019). However, in contrast, Zhang et al. (2013) find that banks with higher market power tend to operate inefficiently ("quiet-life" hypothesis). Banks with higher *capitalization* are also able to generate higher profitability and market power by deploying capital to more risky opportunities

[11] We choose this test as no assumptions are made about the distributions of actual and optimal PSRs. Results are available upon request.

(e.g., Berger et al., 2009; Delis et al., 2016). Concerning *diversification*, Valverde and Fernández (2005), Amidu (2013), and Alexakis and Samantas (2020) find that market power rises significantly in banks with non-traditional banking activities, although De Guevara and Maudos (2007) confirm that specialization increases market power. There is also a considerable literature on the relationship between market power and bank *stability* (e.g., Keeley, 1990; Mishkin, 1999; Boyd and DeNicolo, 2005; Ariss, 2010). Bank stability is included using the Z-score. Furthermore, market power and *bank size* are positively related (e.g., De Guevara et al., 2005; Bikker et. al, 2006).

4.3.2. Panel VAR model

First, we use the Panel Vector Autoregression (PVAR) analysis to investigate the dynamic relationship between bank-specific variables and market power. To develop the PVAR model, Holtz-Eakin et al. (1988) combine the classical VAR model introduced by Sims (1980) with the panel data technique. In the PVAR model, all the variables can be simultaneously treated as endogenous, and each endogenous variable is assumed to depend on lagged values of itself and all other endogenous variables. The PVAR method restricts the underlying structure to be identical for each cross-sectional unit. Nevertheless, this restriction does not hold in practice most of the time. To overcome this issue, we allow for individual heterogeneity in the level of variables by including fixed effects in the model. The panel VAR of order p is estimated using the following system of linear equations:

$$Z_{i,t} = Z_{i,t-1}B_1 + Z_{i,t-2}B_2 + \dots + Z_{i,t-p}B_p + f_i + \varepsilon_{i,t} \quad (12)$$

$$i \in \{1,2,..N\},\ t \in \{1990,.., 2022\}$$

where $Z_{i,t}$ is a $(1 \times k)$ vector of dependent/endogenous bank-specific variables, namely (Market Power (MP), Deposit Growth Rate (DG), Inefficiency (INF), Diversification (DIV), Capitalization (CAP), Bank Size (BS), Z-score (ZS)), f_i is a diagonal matrix of bank-specific time-invariant fixed effects, the $(k \times k)$ matrices B_1, B_2,..., B_p are parameters to be estimated,

i is a bank identifier, N is the number of banks, and $\varepsilon_{i,t}$ is a vector of idiosyncratic i.i.d. errors such that $\varepsilon_{i,t} \sim N(0, \Sigma_i)$. In addition, the error terms are assumed to have the following characteristics: $E(\varepsilon_{i,t}) = 0$, $E(\varepsilon_{i,t}{}^2) = \Sigma$, and $E(\varepsilon_{i,t}, \varepsilon_{i,s}) = 0$ for all $t > s$[12].

In line with Love and Zicchino (2006), forward-mean differencing, known as the Helmert procedure, is used to overcome the bias coefficient resulting from the correlation between the fixed effects and the regressors. This method maintains orthogonality between transformed variables and lagged regressors, allowing us to use lagged regressors as instruments and estimate equation (12) by system GMM (Arellano and Bover, 1995).[13] Since PVAR can only be applied to stationary data, we also check whether our variables are stationary by applying several routine tests[14] for panel data, all of which confirm no unit roots. Moreover, we specify the lag order p in the PVAR specification according to Andrews and Lu's (2001) three model selection criteria. Finally, we check the stability of the PVAR model by computing the modulus of each eigenvalue of the estimated model.[15]

4.3.3. Two-step system GMM model

We use a two-step system GMM to evaluate the extent to which deposit growth rates explain market power in our measure relative to other possible determinants, many of which are excluded from the PVAR model due to their impact on its stability. We use system GMM as it addresses potential endogeneity issues in the explanatory variables typically associated with bank-level data.

It is also notable that we use the lagged market power as an independent variable given that market power might be persistent. However, this approach introduces a complication in the estimations because the lagged dependent variable is correlated with the disturbance term. To

[12] An expanded version of Model (12) for a panel VAR of order p is provided in Appendix C.
[13] We cannot use the first-difference transformation since it amplifies gaps in unbalanced data (Abrigo and Love, 2016). Instead, we use the forward-mean differencing approach that subtracts the average of all future observations and thus limits data losses.
[14] Tests applied for unit roots are: Breitung t-stat; Im, Perasan and Shin W-stat; and Fisher-type (inverse normal).
[15] The stability condition supposes that the PVAR has an infinite-order vector moving average and is invertible (Abrigo and Love, 2016). Results for stationary tests, lag order selection criteria, and stability of PVAR are available upon request.

solve this problem, Arellano and Bond (1991) developed a difference GMM estimator for the coefficients, wherein lagged levels of the regressors are instruments for the equation in the first differences. However, Arellano and Bover (1995), and Blundell and Bond (1998), suggested differences in the instruments instead of the regressors to make them exogenous to fixed effects. This approach develops the difference GMM technique into one which invokes system GMM estimators with a joint estimation of the equation in levels and first differences. Therefore, we use the two-step system GMM estimators.

Given our choice of system GMM, we need to resolve a vital issue in that the asymptotic standard errors of the two-step system GMM estimator tend to have a severe downward bias in small samples. To improve the precision of the two-step system GMM estimators for hypothesis testing, we apply the Windmeijer finite-sample correction (Windmeijer, 2005) to the reported standard errors. The validity of the system GMM estimator approach rests on two testable assumptions. First, for the instruments to be valid, they must be uncorrelated with the error term. To test this, we use the Hansen J-statistic for over-identifying restrictions (where statistically insignificant values confirm the validity of the instruments). Second, the system GMM estimator requires stationarity in the post-instrumentation error terms. This implies the absence of second-order serial correlation in the first difference residual. To test this, we employ Arellano and Bond (1991) to evaluate the lack of second-order serial correlation in the first-difference residual. An insignificant statistic indicates that the model is correctly specified. We run the following two-step system GMM regression equation:

$$\mathrm{MP}_{i,j,t} = a_0 + a_1\mathrm{MP}_{i,j,t-1} + a_2\mathrm{DG}_{i,j,t-1} + a_3\mathrm{X}_{i,j,t-1} + a_4\mathrm{Y}_{j,t} + a_5\mathrm{M}_{j,t} + a_6 GFC_{t} \text{-} COV_{t} + \varepsilon_{i,j,t} \qquad (13)$$

X is a vector of bank-level control variables that include all the variables used in model (12) (i.e., Inefficiency (INF), Diversification (DIV), Capitalization (CAP), Bank size (BS), Z-score (ZS)) and two additional bank-level control variables (Credit risk (CR) and Liquidity (LQ). Y is a vector of macroeconomic control variables (GDP growth (GDP) and Inflation (INFL)). M is a vector of market structure control variables (HHI and Market capitalization (MC)). GFC is the Global Financial Crisis dummy. AS is the Arab Spring crisis dummy. COV is the Covid-19 crisis dummy. Subscripts i, j, and t index bank, country, and time respectively.

In addition to bank-specific control variables used in the PVAR model (12), (13) includes *credit risk* (CR) and *liquidity* (LQ). This is because Berger et al. (2009) finds that banks with higher market power have lower credit risk and better stability, whilst and Acharya Viswanathan (2011) highlight that holding low-yielding liquid assets has an attributable opportunity cost that adversely affects wealth creation in competitive banking markets.

At a macroeconomic level, including *GDP growth* in (13) recognizes that higher GDP growth may provide increased business opportunities for banks. However, the impact of GDP growth on market power can be either positive or negative (e.g., Delis et al., 2016). *Inflation* is also important to market power, although its impact is not clear-cut. In an inflationary environment, banks may demand higher risk premiums (e.g., Demirgüç-Kunt and Huizinga, 1999), but at the same time, banks' costs may also rise (e.g., Angelini and Cetorelli, 2003).

At a market level, we include the Herfindahl–Hirschman Index (HHI) *concentration* measure as it can explain the market power of banks, although evidence is mixed. De Guevara and Maudos (2007) find that concentration has no significant explanatory power. In contrast, Mirzaei and Moore (2014) show that concentration has explanatory value, but only if country income is taken into consideration. Furthermore, Demirgüç-Kunt and Huizinga (1999) identify a substitution effect in relatively well-developed stock markets in which investors more easily allocate capital between equities and deposits. Hence, we control for this effect by including a *market capitalization* (MC) variable.

Lastly, it is notable that application of the two-step system GMM model in (13) could give results for the overall sample that are not consistent for banks of different types. To evaluate the robustness of our results for potential sample selection bias, we also estimate the model for banks with low vs high inefficiency, low vs high diversification, low vs high capitalization, small vs large bank size, and low vs high Z-scores.

4.4. Results

4.4.1. PVAR estimation

The results of the PVAR estimation of equation (12) are reported in Table 5. M1 in Table 5 establishes whether the first lag of the bank-specific variables in (12) Granger cause market power. M1 confirms that the deposit growth rate and lagged market power are the only significant bank-specific variables to Granger cause market power. In contrast, the first lag of market power is insignificant in M2. Thus, market power does *not* Granger cause the deposit growth rate. In other words, our PVAR empirical findings support the hypothesis that depositors' preferences cause market power in our measure (1), and not vice versa.

Table 5: Estimation results of PVAR models

Variables	M1 MP	M2 DG	M3 INF	M4 DIV	M5 CAP	M6 BS	M7 ZS
MP_{t-1}	0.580***	-0.001	0.005	0.005	-0.000	0.000	-0.008
	(0.04)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
DG_{t-1}	3.801***	-0.459***	-0.028	0.030	0.002	-0.009**	0.044
	(0.92)	(0.09)	(0.08)	(0.13)	(0.00)	(0.00)	(0.07)
INF_{t-1}	4.570	0.057	2.195	2.902	-0.038	0.038	-2.013
	(5.02)	(0.15)	(2.47)	(3.53)	(0.06)	(0.06)	(2.36)
DIV_{t-1}	-1.071	-0.001	-0.490	-0.403	0.010	-0.005	0.156
	(1.26)	(0.05)	(0.59)	(0.97)	(0.01)	(0.01)	(0.58)
CAP_{t-1}	-72.829	-0.038	-17.849	-30.365	1.495*	-0.412	20.166
	(60.01)	(1.94)	(25.21)	(33.95)	(0.85)	(0.72)	(22.70)
BS_{t-1}	-1.289	-0.006	-0.930	-1.519	0.028	0.964***	1.020
	(3.05)	(0.11)	(1.27)	(1.70)	(0.04)	(0.04)	(1.13)
ZS_{t-1}	-1.075	0.122	0.306	0.320	0.005	0.015	0.972
	(1.57)	(0.11)	(0.75)	(1.44)	(0.01)	(0.02)	(0.75)
No. of banks	117	117	117	117	117	117	117

This table presents regression results for the estimation of model (12). Market power is defined in equation (1). A description of the regression variables is given in Table 3. *, **, and *** denote statistical significance at the 10%, 5%, and 1% confidence levels respectively. Standard errors are in parentheses. Standard errors reported are obtained by the robust estimator of variance. Bank data are from Fitch and Refinitiv Eikon databases. Macro data are from the DataStream database. The sample period is 1990–2022.

We also apply PVAR to an alternative definition of market power which invokes the signed difference between actual and optimal PSRs. We find that this hypothetical definition of market power is Granger caused by deposit growth rates with *negative* significance and is therefore dismissed as a valid market power measure[16].

4.4.2. Two-step system GMM estimation

The results of the two-step GMM estimation of equation (13) are reported in Table 6. M1 to M3 are model estimation results using different combinations of independent variables. The models in Table 6 account for various determinants of market power at the bank, market, and macroeconomic levels. The results confirm that the deposit growth rate significantly impacts market power across all models.

The results of (13) for different types of banks, i.e., low vs high inefficiency, low vs high diversification, low vs high capitalization, small vs large bank size, and low vs high Z-score, are presented in Table 7. The results in Table 7 confirm that the deposit growth rate is the only variable to significantly impact market power across all types of banks. In other words, our finding that depositors' preferences cause market power (Table 6 system GMM results) is robust to testing against a variety of different sub-samples, whilst the impact of other variables on market power is sensitive to sub-sample selection.

Lastly, our two-step system GMM results for an alternative measure of market power which invokes the signed difference between actual PSRs and optimal PSRs show a significant *negative* relationship between market power and deposit growth rates[17]. This alternative is therefore dismissed as a valid measure.

In summary, the PVAR estimation results in Table 5 validate our market power measure by showing that market power is caused by deposit growth rates and not vice versa. Our two-step system GMM results in Tables 6 and 7 confirm the influence of deposit growth rates on market power, showing that no other bank-specific, market or macroeconomic variables persistently

[16] Results available upon request.
[17] Results available upon request.

significantly influence market power across all model and sub-sample variants. Moreover, impulse response functions show that the direction of causality between deposit growth rates and market power is consistent in the short and longer-run (see Appendix D). Lastly, our results show that it is necessary to invoke the absolute difference between actual PSRs and optimal PSRs in our definition of market power (1) as opposed to a signed difference.

Table 6: Market power determinants

Variables	M1	M2	M3
MP_{t-1}	0.376***	0.182**	0.187**
	(0.08)	(0.08)	(0.09)
DG_{t-1}	0.328**	0.355**	0.376**
	(0.15)	(0.16)	(0.17)
INF_{t-1}	0.950	-0.068	-0.118
	(0.65)	(0.27)	(0.29)
DIV_{t-1}	-0.105**	-0.418	-0.491
	(0.05)	(0.42)	(0.42)
CAP_{t-1}	-0.214	-1.971	-3.030
	(2.60)	(4.13)	(4.05)
BS_{t-1}	0.456**	-0.018	-0.138
	(0.22)	(0.42)	(0.39)
ZS_{t-1}	0.023	0.078***	0.079***
	(0.02)	(0.02)	(0.02)
CR_{t-1}	3.610	1.120	-0.114
	(2.96)	(5.94)	(5.63)
LQ_{t-1}	0.023**	0.656**	0.649**
	(0.01)	(0.32)	(0.30)
GDP		-0.315	-0.686
		(0.85)	(0.81)
INFL		-0.178	-0.338
		(0.57)	(0.55)
HHI		-0.217	-0.402
		(0.91)	(0.90)
MC		-0.166	-0.115
		(0.28)	(0.25)
GFC			-0.397
			(0.63)
AS			0.125
			(0.26)
COV			-0.094
			(0.19)
Constant	-8.315	2.999	6.133
	(5.17)	(10.31)	(9.43)
No. of instruments	46	41	44
AR1 (p-value)	0.00	0.01	0.01
AR2 (p-value)	0.21	0.25	0.26
Hansen-J (p-value)	0.11	0.33	0.37

This Table presents regression results of estimation of model (13). Columns report estimated coefficients. A description of the regression variables is given in Table 3. All regressions employ the two-step system GMM estimator with Windmeijer (2005) corrected standard errors. Robust standard errors are in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% confidence levels respectively. The Hansen test p-value for over-identifying restrictions is for H0: over-identifying restrictions are valid. The Arellano–Bond test p-value for serial correlation of order two in the first differenced residuals is for H0: no autocorrelation. Bank data are from Fitch and Refinitiv Eikon databases. Macro data are from the DataStream. The sample period is 1990–2022.

Table 7: Market power determinants for alternative sub-samples

	Inefficiency		Diversification		Capitalization		Bank size		Z-SCORE	
Variables	Low	High	Low	High	Low	High	Low	High	Low	High
MP_{t-1}	0.229	0.156	0.255**	0.214**	0.277	0.288**	0.392*	0.003	0.164	0.293**
	(0.14)	(0.13)	(0.12)	(0.11)	(0.20)	(0.14)	(0.20)	(0.10)	(0.20)	(0.13)
DG_{t-1}	0.676***	0.402*	0.419*	0.562***	0.153**	0.672***	0.925***	0.371***	0.178*	0.579***
	(0.20)	(0.23)	(0.23)	(0.20)	(0.06)	(0.20)	(0.30)	(0.14)	(0.10)	(0.20)
INF_{t-1}	0.196	1.693	0.176	-0.086	2.189	0.225	0.126	7.187	-2.918	0.147
	(0.19)	(1.40)	(0.19)	(0.76)	(3.73)	(0.31)	(0.26)	(5.06)	(3.86)	(0.35)
DIV_{t-1}	-0.515	-1.052	-0.324	-0.661	-2.965	-0.509	-0.836	-0.901	-1.411	-0.633
	(1.07)	(1.33)	(0.25)	(0.49)	(2.32)	(0.36)	(0.76)	(2.85)	(1.78)	(0.56)
CAP_{t-1}	5.888	-7.100	2.907	1.809	0.091	-4.625	0.051	-17.038	0.963	-2.372
	(6.50)	(6.68)	(6.57)	(4.53)	(6.37)	(8.24)	(5.41)	(13.53)	(8.37)	(9.77)
BS_{t-1}	-0.406	0.468	0.191	0.717	-0.320	0.046	-0.315	-0.958	-0.783	-0.066
	(0.60)	(0.47)	(0.60)	(0.60)	(0.52)	(0.41)	(0.46)	(1.41)	(0.49)	(0.62)
ZS_{t-1}	-0.012	0.109*	0.048	0.054	0.043	0.059*	0.012	0.107	-0.042	0.046
	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.08)	(0.06)	(0.03)
CR_{t-1}	0.737	-4.023	-3.053	7.696	0.739	-9.145*	-0.383	-3.161	-2.470	-4.981
	(9.98)	(11.32)	(5.07)	(9.20)	(4.43)	(5.27)	(6.09)	(7.65)	(8.74)	(8.59)
LQ_{t-1}	0.940***	1.207	-0.190	0.940**	0.218	1.200	0.724	0.227	0.221	0.724
	(0.34)	(0.84)	(1.16)	(0.43)	(0.61)	(1.48)	(0.85)	(0.52)	(0.45)	(1.78)
GDP	-1.001	-0.713	-0.260	1.579	-1.868**	0.388	-0.730	-2.185	-1.954**	-0.343
	(0.96)	(1.19)	(0.75)	(1.13)	(0.78)	(1.25)	(1.47)	(1.44)	(0.80)	(1.19)
INFL	-0.698	0.825	0.432	0.488	-1.430**	0.456	-0.378	0.560	-1.349**	0.077
	(0.87)	(0.64)	(0.57)	(1.09)	(0.59)	(0.62)	(0.39)	(1.14)	(0.55)	(0.92)
HHI	-0.539	0.160	0.825	1.059	-2.406	0.853	0.599	0.219	-2.274	0.917
	(1.03)	(1.23)	(1.33)	(1.31)	(1.55)	(0.68)	(0.53)	(2.44)	(1.80)	(1.06)
MC	-0.488	0.195	-0.201	-0.114	-0.287	-0.334	-0.378	-0.171	-0.629	-0.244
	(0.32)	(0.39)	(0.52)	(0.35)	(0.44)	(0.37)	(0.68)	(0.27)	(0.38)	(0.49)
GFC	-1.274	0.395	-0.207	0.985	0.156	-0.516	0.537	-2.108	-0.204	-0.538
	(0.77)	(0.96)	(0.94)	(2.04)	(0.73)	(1.12)	(0.57)	(1.37)	(0.88)	(1.03)
AS	0.454*	0.184	0.056	-0.385	-0.028	0.242	-0.348	0.056	0.170	0.550
	(0.26)	(0.23)	(0.26)	(0.52)	(0.30)	(0.65)	(0.62)	(0.31)	(0.25)	(0.54)
COV	-0.039	0.056	-0.121	0.227	0.017	-0.018	0.485	0.447	-0.024	-0.323
	(0.32)	(0.28)	(0.15)	(0.49)	(0.21)	(0.22)	(0.51)	(0.34)	(0.25)	(0.28)
Constant	11.760	-9.181	-2.614	-15.665	12.049	0.374	8.117	24.907	24.507**	3.141
	(14.71)	(12.16)	(13.11)	(16.36)	(11.24)	(9.66)	(9.99)	(34.81)	(11.46)	(14.67)
No. of instruments	44	53	44	35	35	35	35	26	35	35
AR1 (p-value)	0.08	0.02	0.01	0.03	0.02	0.06	0.09	0.01	0.04	0.04
AR2 (p-value)	0.29	0.60	0.63	0.29	0.12	0.43	0.87	0.60	0.43	0.29
Hansen-J (p-value)	0.32	0.32	0.40	0.13	0.40	0.47	0.23	0.29	0.42	0.17

This Table presents regression results of estimation of model (13) for low-high inefficiency, low-high diversification, low-high capitalization, low-high bank size, and low-high Z-score. Columns report estimated coefficients. A description of the regression variables is given in Table 3. All regressions employ the two-step system GMM estimator with Windmeijer (2005) corrected standard errors. Robust standard errors are in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% confidence levels respectively. The Hansen test p-value for over-identifying restrictions is for H0: over-identifying restrictions are valid. The Arellano–Bond test p-value for serial correlation of order two in the first differenced residuals is for H0: no autocorrelation. Bank data are from Fitch and Refinitiv Eikon databases. Macro data are from the DataStream. The sample period is 1990–2022.

5. Conclusion

This paper developed and tested a market power measure for participatory deposits. This new measure is value-based, in contrast to earnings-based measures of market power previously presented in the banking literature. Market power in our measure captures the latitude of banks to price deposits for long-term value-creation as opposed to short-term goals, such as managing earnings pressure or liquidity risk. Using deposit growth rates to proxy depositors' preferences, our measure was validated by showing it is (Granger) caused by deposit growth rates and that deposit growth rates are the only significant determinant of market power across all sub-sample and model variants of a two-step system GMM estimation that includes a broad array of control variables.

The value-based measure developed in this paper has useful policy applications. For example, our measure can be embedded within deposit pricing policies to control the extent and duration of hikes in deposit pricing relative to optimal profit-sharing ratios to attract (or retain) deposit capital. Our measure is also important to earnings policies that control management actions to enhance earnings as a response to deteriorating market conditions. In this regard, since our measure internalizes a trade-off between current earnings and long-term value creation, it can be used to limit deposit price decreases that enhance earnings through additional fee income at the expense of shareholders' value.

We make two further comments. First, since the measure developed in this paper is specific to a participatory fee structure for managing third-party assets, it is well-suited to measuring market power for a broad variety of investment funds. For example, in addition to receiving a fixed percentage of assets under management, private equity fund managers are traditionally remunerated with a share of realized returns generated by managed assets if asset returns exceed a pre-defined hurdle rate (so-called "back-end carry"). The market power of fund managers can be evaluated using the market power measure presented in this paper, with the optimal profit-sharing ratio of fund investors derived by taking into consideration the incentives of the fund manager and fund investors.

Second, this paper brings into focus the possibility that a value-based measure of market power for bank intermediation may have the potential to resolve debates in the market power literature that have so far proven inconclusive; by this we mean the impact of market power on bank stability and bank efficiency.[18] Our reasoning is as follows. Intrinsic to a value-based measure is a notion that financial product pricing internalizes a balance between short-term and long-term objectives of the bank. In general, this balance will vary amongst banks given competing priorities. For example, new bank entrants may forego earnings (at least initially) to build their market share in an attempt to create shareholder value over the longer-term compared to more established incumbents. However, earnings-based measures fail to incorporate the "out-of-period" implications of pricing strategies that target positive outcomes beyond current earnings. The development of a value-based measure of market power for bank intermediation is an important topic for future research.

[18] Market power can be stabilizing (Keeley, 1990; Besanko and Thakor, 1995; Cetorelli and Peretto, 2000; Carletti and Vives, 2009) or destabilizing (Mishkin, 1999; Boyd and DeNicolo, 2005; Berger et al., 2009). Market power also improves cost efficiency (Maudos and De Guevara, 2007) but the opposite is also possible (Berger and Hannan, 1998; Delis and Tsionas, 2009; Ariss, 2010).

Appendix A

Islamic deposit valuation for a general volume process

Consider the Islamic deposit value, $V(\theta)$, given by

$$V(\theta) = E_0\left[\sum_{n=1}^{\infty} e^{-rn\Delta t} H_{n-1}\left\{(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}}-1,0\right)-c\right\}|s_0\right] \quad (A1)$$

Expanding (A1),

$$V(\theta) = E_0\left[e^{-r\Delta t} H_0\left\{(1-\theta_0)max\left(\frac{s_1}{s_0}-1,0\right)-c\right\}|s_0\right]$$

$$+ E_0\left[\sum_{n=2}^{\infty} e^{-rn\Delta t} H_{n-1}\left\{(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}}-1,0\right)-c\right\}|s_0\right] \quad (A2)$$

Using the Black-Scholes formula (Black and Scholes, 1973), denote the value of an at-the-money European call option on the managed assets at time zero by $\mathbb{C}$. Then,

$$\mathbb{C} = E_0\left[e^{-r\Delta t} max\left(\frac{s_1}{s_0}-1,0\right)|s_0\right] = N(d_1) - e^{-r\Delta t} N(d_2) \quad (A3)$$

where

$$d_1 = \frac{\left(r+\frac{1}{2}\sigma^2\right)\Delta t}{\sigma\sqrt{\Delta t}}, d_2 = d_1 - \sigma\sqrt{\Delta t} \quad (A4)$$

Substituting (A3) into (A2), and defining $\tilde{c} := ce^{-r\Delta t}$,

$$V(\theta) = H_0[(1-\theta_0)\mathbb{C} - \tilde{c}]$$

$$+ E_0\left[\sum_{n=2}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_0\right] \quad (A5)$$

The second term in (A5) can be written in nested expectation form using the Law of Total Probabilities as

$$E_0\left[E_1\left[\sum_{n=2}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1})max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_1\right]s_0\right] \quad (A6)$$

Then, expanding the expectation at time Δt with respect to s_1 when first revealed, and assuming that the at-the-money call option value, $\mathbb{C}$, is the same in all periods gives

$$E_1\left[\sum_{n=2}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_1\right]=$$

$$e^{-r\Delta t}H_1[(1-\theta_1)\mathbb{C}-\tilde{c}]+E_1\left[\sum_{n=3}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_1\right]$$

(A7)

Using a nested expectation at time $2\Delta t$ with respect to s_2 when first revealed for the second term on the right-hand side in (A7), and substituting (A7) into (A5), gives

$$V(\theta)=H_0[(1-\theta_0)\mathbb{C}-\tilde{c}]+E_0[e^{-r\Delta t}H_1[(1-\theta_1)\mathbb{C}-\tilde{c}]|s_0]$$
$$+E_0\left[E_1\left[E_2\left[\sum_{n=3}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_2\right]|s_1\right]|s_0\right] \quad (A8)$$

However,

$$E_2\left[\sum_{n=3}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_2\right]$$
$$=e^{-2r\Delta t}H_2[(1-\theta_2)\mathbb{C}-\tilde{c}]$$
$$+E_2\left[\sum_{n=4}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_2\right] \quad (A9)$$

Substituting (A9) into (A8) gives

$$V(\theta)=H_0[(1-\theta_0)\mathbb{C}-\tilde{c}]$$
$$+E_0[e^{-r\Delta t}H_1[(1-\theta_1)\mathbb{C}-\tilde{c}]|s_0]+E_0[E_1[e^{-2r\Delta t}H_2[(1-\theta_2)\mathbb{C}-\tilde{c}]]|s_1|s_0]$$
$$+E_0\left[E_1\left[E_2\left[\sum_{n=4}^{\infty} e^{-rn\Delta t} H_{n-1}\left[(1-\theta_{n-1}) max\left(\frac{s_n}{s_{n-1}}-1,0\right)-\tilde{c}\right]|s_2\right]|s_1\right]|s_0\right] \quad (A10)$$

Continuing in the same manner, the general form of the value function is

$$V(\theta) = H_0[(1-\theta_0)\mathbb{C} - \tilde{c}] + E_0[e^{-r\Delta t}H_1[(1-\theta_1)\mathbb{C} - \tilde{c}]|s_0] +$$
$$E_0[E_1[e^{-2r\Delta t}H_2[(1-\theta_2)\mathbb{C} - \tilde{c}]|s_1]|s_0] + E_0[E_1[E_2[e^{-3r\Delta t}H_3[(1-\theta_3)\mathbb{C} - \tilde{c}]|s_2]|s_1]|s_0] + \dots \tag{A11}$$

Appendix B

Islamic deposit valuation for a specific deposit volume process

From (9),

$$f(\theta_{n-1}) = 1 + 1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1\right) + \eta 1_{\{+\}}\left(\theta_{n-1}\left(\frac{s_n}{s_{n-1}} - 1\right) - r_d\right) + \gamma 1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1 - r_d\right) \qquad (B1)$$

We next invoke the following relationships, where the indicator function relates to Period-n asset returns:

$$E_{n-1}\left[1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1\right)|s_{n-1}\right] =$$

$$E_{n-1}\left[\frac{s_n}{s_{n-1}} - 1 - max\left(\frac{s_n}{s_{n-1}} - 1{,}0\right)|s_{n-1}\right] = e^{r\Delta t} - 1 - e^{r\Delta t}\mathbb{C} \qquad (B2)$$

$$E_{n-1}\left[\eta 1_{\{+\}}\left(\theta_{n-1}\left(\frac{s_n}{s_{n-1}} - 1\right) - r_d\right)|s_{n-1}\right] = \eta\left(\theta_{n-1}e^{r\Delta t}\mathbb{C} - r_d N(d_2)\right) \qquad (B3)$$

$$E_{n-1}\left[\gamma 1_{\{-\}}\left(\frac{s_n}{s_{n-1}} - 1 - r_d\right)|s_{n-1}\right] = \gamma\left(e^{r\Delta t} - 1 - e^{r\Delta t}\mathbb{C}\right) - \gamma r_d\left(1 - N(d_2)\right) \qquad (B4)$$

Substituting (B2), (B3) and (B4) into (B1), and defining the (conditional) expectation of f (θ_{n-1}) with respect to s_{n-1} by $g(\theta_{n-1})$, gives

$$g(\theta_{n-1}) := E_{n-1}[f(\theta_{n-1})|s_{n-1}] = \varphi + \eta\theta_{n-1}e^{r\Delta t}\mathbb{C} \qquad (B5)$$

where, for convenience, we define φ, a constant independent of θ_{n-1} which is equal in all periods, by

$$\varphi := 1 + (1+\gamma)\left(e^{r\Delta t}(1-\mathbb{C}) - 1\right) + (\gamma - \eta)r_d N(d_2) - \gamma r_d \qquad (B6)$$

Furthermore, from (8)

$$\frac{H_n}{H_{n-1}} = \left(\frac{\theta_n}{\theta_{n-1}}\right)^{\delta} f(\theta_{n-1}) \qquad (B7)$$

Taking the expectation of H_n conditioned on s_{n-1}, and invoking (B5),

$$E_{n-1}[H_n|s_{n-1}] = H_{n-1}\left(\frac{\theta_n}{\theta_{n-1}}\right)^{\delta} E_{n-1}[f(\theta_{n-1})|s_{n-1}] = H_{n-1}\left(\frac{\theta_n}{\theta_{n-1}}\right)^{\delta} g(\theta_{n-1}) \qquad (B8)$$

Lastly, substituting (B8) into (A11), letting $H_0 = {\theta_0}^{\delta}$ without loss of generality, and denoting the value of deposits maximized over the set of optimal PSRs, $\{\theta_j\}_{j=0}^{\infty}$, by V,

$$V = \max_{\{\theta_j\}_{j=0}^{\infty}} \; {\theta_0}^{\delta}[(1-\theta_0)\mathbb{C} - \tilde{c}] + e^{-r\Delta t}{\theta_1}^{\delta}[(1-\theta_1)\mathbb{C} - \tilde{c}]g(\theta_0)$$

$$+ e^{-2r\Delta t}{\theta_2}^{\delta}[(1-\theta_2)\mathbb{C} - \tilde{c}]g(\theta_0)g(\theta_1) + \dots \qquad (B9)$$

But also,

$$V = \max_{\{\theta_j\}_{j=1}^{\infty}} \; {\theta_1}^{\delta}[(1-\theta_1)\mathbb{C} - \tilde{c}] + e^{-r\Delta t}{\theta_2}^{\delta}[(1-\theta_2)\mathbb{C} - \tilde{c}]g(\theta_1)$$

$$+ e^{-2r\Delta t}{\theta_3}^{\delta}[(1-\theta_3)\mathbb{C} - \tilde{c}]g(\theta_1)g(\theta_2) + \dots \qquad (B10)$$

(B9) and (B10) give the following Bellman equation

$$V = \max_{\theta_0} {\theta_0}^{\delta}[(1-\theta_0)\mathbb{C} - c] + e^{-r\Delta t}g(\theta_0)V$$

Thus,

$$V = \max_{\theta_0} \frac{{\theta_0}^{\delta}[(1-\theta_0)\mathbb{C} - \tilde{c}]}{1 - e^{-r\Delta t}g(\theta_0)} \qquad (B11)$$

From (B11), the first-order condition (FOC) is

$$\delta\eta\mathbb{C}^2{\theta_0}^2 + \mathbb{C}\rho\theta_0 + \delta ab = 0 \qquad (B12)$$

where for convenience, $a{:=}1-\beta\varphi$, $b{:=}\mathbb{C}-\tilde{c}$, $\beta{:}=e^{-r\Delta t}$, $\rho{:=}(1-\delta)b\eta - a(1+\delta)$, and the optimal PSR, θ_0^{opt}, is given by

$$\theta_0^{opt} = \frac{-\rho + / - \sqrt{\rho^2 - 4\delta^2\eta ab}}{2\delta\eta\mathbb{C}} \qquad (B13)$$

Appendix C

Panel VAR of order p

$$
\begin{aligned}
\mathrm{P}_{i,t} = {} & \sum_{j=1}^{P} B_{11,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{12,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{13,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{14,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{15,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{16,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{17,j} ZS_{i,t-j} + f_{1i} + \varepsilon_{1i,t} \\
\mathrm{G}_{i,t} = {} & \sum_{j=1}^{P} B_{21,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{22,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{23,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{24,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{25,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{26,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{27,j} ZS_{i,t-j} + f_{2i} + \varepsilon_{2i,t} \\
F_{i,t} = {} & \sum_{j=1}^{P} B_{31,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{32,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{33,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{34,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{35,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{36,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{37,j} ZS_{i,t-j} + f_{3i} + \varepsilon_{3i,t} \\
\mathrm{V}_{i,t} = {} & \sum_{j=1}^{P} B_{41,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{42,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{43,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{44,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{45,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{46,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{47,j} ZS_{i,t-j} + f_{4i} + \varepsilon_{4i,t} \\
\mathrm{P}_{i,t} = {} & \sum_{j=1}^{P} B_{51,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{52,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{53,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{54,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{55,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{56,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{57,j} ZS_{i,t-j} + f_{5i} + \varepsilon_{5i,t} \\
\mathrm{S}_{i,t} = {} & \sum_{j=1}^{P} B_{61,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{62,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{63,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{64,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{65,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{66,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{67,j} ZS_{i,t-j} + f_{6i} + \varepsilon_{6i,t} \\
\mathrm{S}_{i,t} = {} & \sum_{j=1}^{P} B_{71,j} MP_{i,t-j} + \sum_{j=1}^{P} B_{72,j} DG_{i,t-j} + \sum_{j=1}^{P} B_{73,j} INF_{i,t-j} + \sum_{j=1}^{P} B_{74,j} DIV_{i,t-j} + \\
& \sum_{j=1}^{P} B_{75,j} CAP_{i,t-j} + \sum_{j=1}^{P} B_{76,j} BS_{i,t-j} + \sum_{j=1}^{P} B_{77,j} ZS_{i,t-j} + f_{7i} + \varepsilon_{7i,t}
\end{aligned}
\tag{C1}
$$

Appendix D

Impulse Response Functions

We use the Impulse Response Function (IRF) over 10 quarters to identify the short-run and longer-run relationship between market power and deposit growth rate by shocking one variable to identify the response of the other.

For shocks to the deposit growth rate (DG), Figure D.1 shows a positive relationship between market power (MP) and DG in period-1 after the shock. In period-2, the shock causes a decrease in MP which is not statistically significant (since the confidence interval includes zero). The positive effect of the shock on MP starts to reduce in period-3, and then the impulse response converges to zero. The effect of the shock dies out in period-4, where the lower and upper confidence intervals are close to zero.

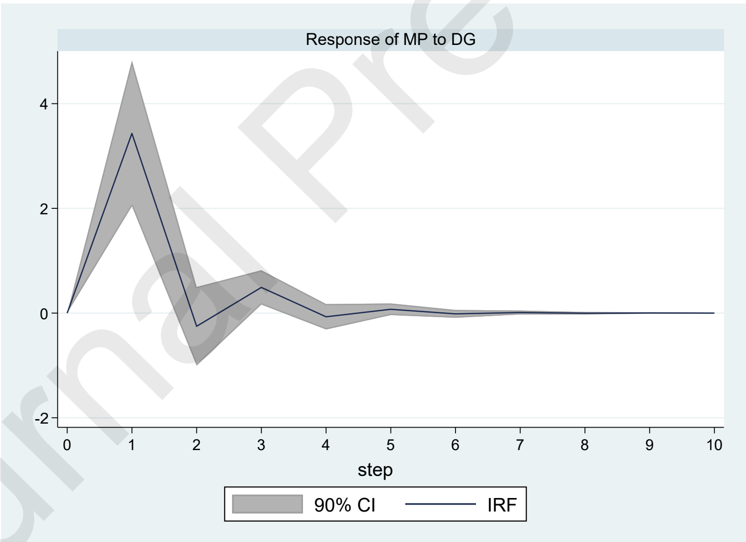

Figure D.1: Market power response to shock in deposit growth rate

For shocks to MP, Figure D.2 shows that a shock to MP does not affect DG in all periods of time. This confirms that the direction of causality between MP and DG is consistent in the short and longer-run.

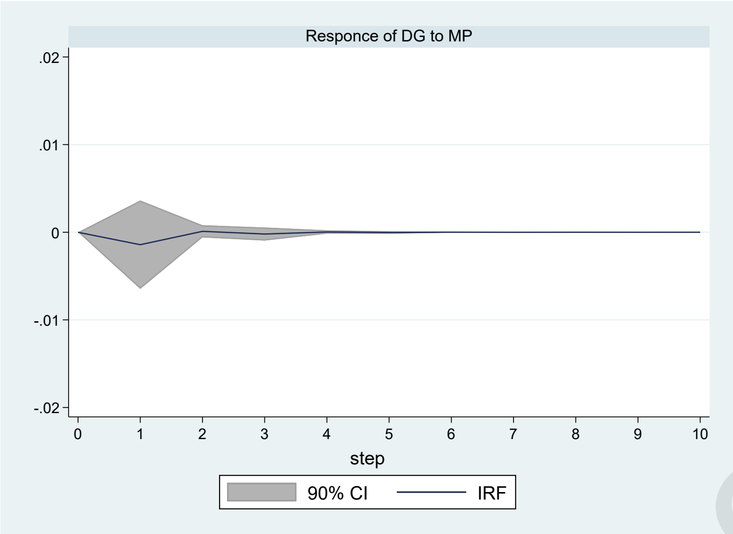

Figure D.2: Deposit growth rate response to shock in market power

Appendix E

Glossary of notation and definitions

Table E.1: Glossary of notation and definitions

Notation	Definition
δ	Price elasticity of deposit demand with respect to the depositors' profit-sharing ratio
η	Price elasticity of deposit demand with respect to positive deposit returns
γ	Price elasticity of deposit demand with respect to negative deposit returns
$\mathbb{C}$	Premium of an at-the-money call option per unit of managed assets
r	Continuously compounded risk-free rate
Δt	Islamic deposit tenor. Also the discrete-time interval used to partition the horizon.
r_d	Conventional deposit benchmark rate
s_t	The value of one unit of managed assets at time t
σ	The instantaneous volatility of returns on managed assets
H_{n-1}	The volume of Islamic deposits at the start of the n^{th} deposit period
θ_{n-1}	The profit-sharing ratio of Islamic depositors at the start of the n^{th} deposit period
c	The unit cost of administering depositors' funds
β	$e^{-r\Delta t}$
ρ	$(1-\delta)\eta\mathbb{C}-(1+\delta)(1-\beta\varphi)$
φ	$1+(1+\gamma)\left(e^{r\Delta t}(1-\mathbb{C})-1\right)+(\gamma-\eta)r_d N(d_2)-\gamma r_d$
$g(\theta_{n-1})$	$\varphi+\eta\theta_{n-1}e^{r\Delta t}\mathbb{C}$

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Kenneth Baldwin: Conceptualization, Methodology, Writing-Original draft preparation, Writing- Reviewing and Editing.
Maryam Alhalboni: Methodology, Data curation, Formal Analysis, Software, Visualization, Writing- Reviewing and Editing

Highlights

- We develop a value-based market power measure for Islamic bank deposits
- The measure is validated by showing it is Granger caused by depositors' preferences
- More powerful banks price deposits to create greater shareholder value
- Less powerful banks price deposits to mitigate risk or enhance current earnings
- An optimal profit-sharing ratio is derived using dynamic programming

A value-based measure of market power for the participatory deposits of Islamic banks

Kenneth Baldwin, PhD
Nottingham Business School
Nottingham Trent University, NG1 4FQ, UK
Emails: kenneth.baldwin@ntu.ac.uk
ORCID ID: 0000-0003-0606-5553

Maryam Alhalboni, PhD
School for Business and Society
University of York, YO10 5DD, UK
Emails: maryam.alhalboni@york.ac.uk
ORCID ID: 0000-0001-8979-5724

This Draft: 23rd May 2023

Correspondence Address: Kenneth Baldwin
Nottingham Business School
Nottingham Trent University
Nottingham, NG1 4FQ
United Kingdom
Email: kenneth.baldwin@ntu.co.uk

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