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Do Basel Prudential Ratios Affect Bank Profitability? Evidence from Moroccan Banks

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ABSTRACT:

Background/Objectives: This study examines whether observed Basel capital and liquidity ratios are associated with the profitability of major Moroccan banks during the phased adoption of Basel II and Basel III.

Theoretical Hypothesis: The study expects CAR and Tier 1 to be positively associated with ROA through lower distress and funding costs, and LCR and NSFR to be negatively associated with ROA through lower-yield liquid assets and more costly stable funding. Because higher capital can also reduce leverage and stronger liquidity can lower refinancing losses, the net effect may be weak or context-dependent.

Data and Methodology: A balanced working panel assembled from heterogeneous sources covers ten conventional banks from 2010 to 2023 (140 bank-year observations); a liquidity subsample covers 2015–2023 (90 observations). Random-effects models relate return on assets to capital adequacy, Tier 1, liquidity coverage and net stable funding ratios, with macroeconomic and size controls. Two-way fixed effects and additional sensitivity checks assess specification dependence.

Results and Findings: Capital adequacy, Tier 1 and the post-2015 indicator have no statistically detectable average association with return on assets. The liquidity coverage coefficient is negative only at the 10% level, while net stable funding is insignificant. GDP growth and the policy rate are significant in baseline models, but the GDP finding disappears when 2020 is excluded. Bank-level conclusions persist under two-way fixed effects; other checks remain exploratory because the sample includes only ten banks.

Conclusions and Policy Implications: The results do not reveal a clear average profitability penalty associated with observed prudential ratios, but they do not prove regulatory neutrality or identify optimal regulatory thresholds. Supervisory assessment should combine ratios with business models, funding structure and stress scenarios.

Keywords: Moroccan banks, capital adequacy, liquidity coverage, return on assets < financial regulation.

JEL classification: G21; G28; C23; E52; O55.

1. INTRODUCTION

The global financial crisis exposed weaknesses in the quantity and loss-absorbing quality of bank capital, as well as the absence of internationally harmonized liquidity standards. The Basel III framework responded by tightening the definition of eligible capital, adding conservation and counter-

cyclical buffers, constraining leverage, and introducing the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The LCR is intended to ensure that high-quality liquid assets can cover a thirty-day stress scenario, whereas the NSFR promotes a more stable one-year funding structure. Together, these measures aim to reduce both the probability and the social cost of banking distress. Nevertheless, the

framework itself does not imply that higher observed ratios must raise or lower accounting profitability in every banking system [1].

The profitability channel is theoretically ambiguous. On the cost side, more equity can reduce leverage-based returns, while holdings of high-quality liquid assets may yield less than loans or longer-term securities. Compliance, reporting and balance-sheet adjustment can add operational costs. On the benefit side, better capitalization and stable funding can reduce expected distress losses, improve creditor confidence, lower refinancing premia and allow banks to continue lending during adverse conditions. The net association observed in bank accounts is therefore an empirical question that depends on whether ratios are binding, how banks adjust their asset mix and pricing, and how regulation interacts with the macro-economic cycle.

Morocco is an informative emerging-market case. Its financial system remains bank-centred, and several large Moroccan groups operate extensive networks in Africa. Morocco's central bank, Bank Al-Maghrib, progressively aligned the domestic prudential framework with Basel standards. The 2013 capital circulars reinforced the definition and calculation of own funds and risk-weighted requirements [2]. The LCR was introduced through a 2015 circular [3]. The NSFR and revised capital provisions were formally transposed in 2021 [4]. Implementation was therefore gradual, with disclosure practices and internal monitoring sometimes preceding formal transposition. This sequence creates useful bank-level variation but does not provide a single, clean regulatory discontinuity.

Despite this policy relevance, the Moroccan evidence leaves an analytical rather than merely temporal gap. Existing studies focus mainly on listed banks, cover shorter or non-comparable windows, usually examine solvency and liquidity under different specifications, and draw on prudential disclosures whose consolidation perimeter and pre-implementation meaning vary across institutions. Consequently, it remains unclear whether reported capital and liquidity buffers have a common average association with ROA across a broader set of major conventional banks, whether that association survives common year shocks and the exceptional pandemic observation, and whether differences from earlier estimates reflect economic mechanisms or identification choices. By examining both prudential dimensions within one explicitly non-causal panel framework, the study provides an integrated test of the competing cost and resilience channels in a bank-centred emerging economy.

This paper asks a deliberately bounded question: conditional on observable macroeconomic factors and bank size, are the capital and liquidity ratios reported by ten major conventional Moroccan banks associated with return on assets (ROA)? The study does not estimate the welfare effect of Basel III, nor does it compare regulated banks with an untreated banking system. Model 1 covers 2010–2023 and relates ROA to the total capital adequacy ratio (CAR), the Tier 1 ratio, real GDP growth, inflation, the policy rate, bank size and a post-2015 indicator. Model 2 covers 2015–2023 and replaces the capital variables with the LCR and NSFR. The shorter second window reflects the availability of liquidity disclosures.

The distinction between observed ratios and regulatory treatment is important. A bank may choose to operate far above a regulatory minimum because of market discipline, rating objectives, internal risk appetite or expected loan growth. Conversely, a change in a regulatory minimum may have little immediate accounting effect when the existing buffer is already large. Coefficients on observed CAR, Tier 1, LCR or NSFR therefore combine regulatory constraints with endogenous managerial choices. The post-2015 indicator captures a common period shift but also absorbs every contemporaneous national change not otherwise modelled. For these reasons, the empirical results are described as conditional associations rather than causal effects.

The paper contributes to the Moroccan evidence in four ways. First, the panel extends through 2023 and spans the pandemic shock and the subsequent inflation and interest-rate normalization. Second, it includes ten major conventional banks, among them institutions with different ownership structures and mandates. Third, capital and liquidity dimensions are assessed within a common empirical framework, making their magnitudes and inferential limitations easier to compare. Fourth, the analysis separates the more defensible specification checks from exploratory exercises. In particular, two-way fixed effects, the exclusion of 2020, grouped post-period comparisons, lagged-variable instrumentation, a dynamic first-difference model, size subsamples and pooled quantiles are not presented as equally strong identification strategies. Beyond greater temporal coverage, the contribution lies in confronting the competing cost and resilience channels within one empirical framework and in showing how regulatory timing, voluntary buffers and estimator assumptions condition what can be inferred from Moroccan data.

The central result is one of limited statistical detection. CAR, Tier 1 and the post-2015 indicator are insignificant in the baseline solvency model. LCR is negative only at the 10% level and NSFR is insignificant in the liquidity model. GDP growth and the policy rate are significant in the baseline estimates, but the GDP coefficient disappears once the exceptional year 2020 is removed. The bank-level null findings persist under two-way fixed effects. These estimates do not establish that prudential regulation is costless; they show that the available sample does not reveal a stable average profitability penalty associated with the observed ratios.

The remainder of the paper proceeds as follows. Section 2 develops the conceptual framework and reviews international and Moroccan evidence. Section 3 describes the institutional setting, sample construction and data provenance. Section 4 presents the econometric strategy and diagnostic tests. Section 5 reports the baseline estimates and sensitivity analyses. Section 6 assesses the hypotheses and discusses their economic interpretation. Section 7 concludes with policy implications, limitations and directions for future research.

2. CONCEPTUAL FRAMEWORK, LITERATURE AND HYPOTHESES

2.1. Why Prudential Ratios May Affect Profitability

The case for prudential regulation begins with market failures specific to banking. Information asymmetry can prevent prices from clearing credit markets and lead to rationing [5].

Maturity transformation exposes otherwise solvent intermediaries to coordination failures and runs [6]. Interbank and balance-sheet linkages can transmit institution-specific shocks throughout the financial system [7]. Deposit insurance and expectations of public support may further weaken private incentives to internalize systemic risk. Minimum capital and liquidity standards can therefore be justified even if an individual bank would privately prefer a more leveraged or less liquid balance sheet.

Capital can influence profitability through several competing mechanisms. A higher equity share mechanically reduces leverage when income and assets are unchanged, which may lower return on equity, but its relation with ROA is less mechanical. Better-capitalized banks may face lower expected distress costs and lower funding premia, may retain customers during stress, and may have greater capacity to exploit lending opportunities. Evidence of a positive relationship between capital and earnings is consistent with these benefits [8]. Yet reverse causality is immediate: profitable banks accumulate retained earnings and thereby raise capital ratios. A positive coefficient need not represent the effect of an externally imposed requirement, while a negative coefficient may reflect precautionary recapitalization by riskier institutions.

International evidence reflects this ambiguity. Cross-country work links capitalization, market structure and macroeconomic conditions to bank margins and profits [9]. The ‘bad management’ and ‘bad luck’ hypotheses additionally connect cost inefficiency, problem loans and capital weakness [10]. Profitability is persistent over time, and both bank-specific and cyclical factors matter [11]. Studies that jointly consider bank, industry and macroeconomic variables similarly find that capitalization may support profitability, while the sign of size, inflation and interest rates depends on specification and period [12].

In developing and MENA banking systems, institutional features are especially important. Capital requirements may raise intermediation costs while also supporting resilience; results for Egyptian banks differ by ownership and market conditions [13]. Broader Middle East and North Africa evidence indicates that regulatory, competitive and financial-reform effects vary across performance measures [14]. Compliance with Basel principles is therefore not a sufficient statistic for profitability [15]. Macroprudential arrangements and central-bank policy can also alter risk incentives differently across countries and banks [16].

Liquidity standards generate another trade-off. The LCR encourages banks to hold assets that can be monetized under stress, while the NSFR discourages excessive reliance on unstable short-term funding. Both may lower maturity-transformation income, but they can also reduce fire-sale exposure and refinancing risk. Evidence from Western European banks suggests that the costs and benefits of the Basel III liquidity rules are heterogeneous and depend on the pre-existing balance sheet [17]. Emerging-market evidence on capital regulation and bank performance also points to adjustment costs that need not persist in the medium term [18]. Recent work on capital and liquidity regulation emphasizes that profitability consequences depend on the interaction between buffers, asset

composition and market conditions rather than on a universal sign [19].

2.2. Evidence for Morocco

Moroccan studies remain relatively limited and differ in sample coverage. Bouhali and Barkat report an insignificant association for CAR and a negative association for LCR among listed banks over a shorter period [20]. Belcaid and Al-Faryan show that Moroccan bank profitability reflects both bank-specific and macroeconomic determinants; their reported signs are not uniform across measures and specifications [21]. Alaoui Taib, Belhaj and Hadri likewise document heterogeneous responses to Basel III among listed banks [22]. Differences across these studies can arise from the inclusion of small or public-mission institutions, treatment of consolidated accounts, selected profitability indicator, macroeconomic controls, estimator and time window.

The Moroccan setting also raises a measurement issue. Published annual reports do not always present prudential indicators on an identical perimeter. A ratio may be consolidated for one group and individual for another; disclosure labels and calculation rules evolve; and historical values can be restated. Liquidity disclosure is more recent and less homogeneous than solvency disclosure. A longer panel therefore increases temporal coverage at the cost of greater harmonization work. The present study retains the dissertation's working dataset but makes these provenance constraints explicit and interprets the liquidity model with particular caution.

2.3. Testable Hypotheses

Five hypotheses organize the empirical analysis. They are directional statements derived from the dissertation and are evaluated against the reported coefficients. Because the design is observational, ‘supported’ means statistically consistent with the specified association; it does not imply structural or causal validation.

H1: The capital adequacy ratio is positively associated with ROA. Higher total capital may reduce funding and distress costs, although a binding requirement could reduce income-generating leverage.

H2: The post-2015 period is negatively associated with ROA. This period indicator is intended to capture the profitability consequences of the stronger Basel III environment, but it is an imperfect proxy because it also captures other common changes.

H3: LCR and NSFR are negatively associated with ROA. The hypothesis reflects the opportunity cost of liquid assets and stable funding; positive resilience and funding-cost channels could offset that effect.

H4: Bank size is positively associated with ROA. Economies of scale, diversification and market power may benefit large institutions, while organizational complexity and diseconomies may reverse the sign.

H5: GDP growth, inflation and the policy rate are associated with ROA. Growth may improve credit demand and asset quality; inflation affects costs and pricing; and the policy rate

changes asset yields and funding costs with different repricing speeds.

A coefficient with a large p-value is treated as insufficient evidence for the stated hypothesis, not as proof that the underlying economic effect equals zero. This distinction is central in a small panel where confidence intervals may remain wide even when point estimates appear economically meaningful.

3. INSTITUTIONAL SETTING, DATA AND VARIABLES

3.1. Prudential Implementation in Morocco

Morocco's prudential transition occurred in stages rather than through one simultaneous regime change. Capital rules were strengthened in 2013, the LCR entered the domestic framework in 2015, and the NSFR and revised capital provisions were formally transposed in 2021. Banks could adjust ahead of legal deadlines because international groups, rating agencies and market counterparties monitored Basel-style indicators before full domestic implementation. The observed ratio in a given year can therefore reflect anticipation, voluntary buffers and supervisory expectations as well as the binding text.

This institutional sequence affects identification in two ways. First, a dummy equal to one from 2015 onward does not distinguish the capital reforms initiated earlier from the liquidity reforms introduced later. Second, all sampled banks are exposed to the same national regulatory and macroeconomic environment. There is no naturally untreated Moroccan bank group. A comparison between high- and low-capital banks can describe differential outcomes but cannot reproduce the counterfactual of no regulation unless parallel trends and treatment exogeneity are credible. The analysis consequently uses the post indicator as a descriptive period control and does not label it a causal treatment effect.

The sample ends in 2023, which brings both advantages and complications. It captures the 2020 pandemic contraction, the subsequent rebound, the 2022–2023 inflation shock and monetary-policy tightening. These events increase time variation in the macroeconomic regressors, but the extreme 2020 observation can exert disproportionate influence. The exclusion-of-2020 specification is therefore reported as a targeted sensitivity test rather than as an attempt to erase an inconvenient observation.

3.2. Sample Construction and Data Provenance

The sample contains ten major conventional Moroccan banks: Attijariwafa Bank, Banque Centrale Populaire, Bank of Africa, Société Générale Maroc, BMCI, Crédit du Maroc, CIH Bank, Al Barid Bank, Arab Bank Maroc and Crédit Agricole du Maroc (CAM). They were selected for economic importance, continuity of activity and data availability. The dissertation estimates that they represent approximately 95% of conventional banking assets; this percentage should be read as an approximate coverage ratio derived from Bank Al-Maghrib and bank reports rather than an official systemic classification.

Bank-level observations were compiled from annual reports, Pillar 3 disclosures, Autorité Marocaine du Marché des Capitaux filings and Bank Al-Maghrib supervisory reports. The source hierarchy prioritizes audited annual or Pillar 3 figures on the relevant reporting perimeter, followed by official regulatory publications. The underlying dissertation assembled the series manually. The final replication package should preserve a bank-year source register recording the document, page, consolidation perimeter, original unit and any transformation for each value; without that register, complete independent verification of every observation is not possible.

The working solvency panel contains 140 bank-year observations. For CAM, some early solvency observations were reconstructed from available consolidated or individual reports under the conventions documented in the dissertation; this creates greater measurement uncertainty than for directly reported observations. The working liquidity panel contains 90 observations for 2015–2023. LCR disclosure begins around its 2015 regulatory introduction, whereas the NSFR was formally transposed in Morocco in 2021 and public bank-level disclosure became systematic later. NSFR values recorded before formal transposition should therefore be interpreted as pre-regulatory funding-stability measures drawn from monitoring disclosures, not as evidence of the effect of the 2021 NSFR requirement. This provenance limitation is material and motivates cautious interpretation of Model 2.

The 140-observation count corresponds to a balanced ten-bank by fourteen-year working matrix. It should not be confused with the number of directly disclosed source values: a balanced regression matrix may contain reconstructed or harmonized observations. In particular, the solvency history for CAM requires more assumptions than that of banks with continuous Pillar 3 reporting. The article therefore distinguishes statistical completeness from documentary completeness. Releasing the source register and tagging reconstructed observations would allow future analyses to test whether results change when only directly reported values are retained.

3.3. Variable Measurement

ROA is defined as net income divided by total assets and is expressed in percentage points. It measures accounting profitability relative to the asset base and facilitates comparison across banks of different size. ROA is not risk-adjusted, however, and can respond to provisioning rules, exceptional income and changes in asset composition. The analysis does not use ROE as an alternative because leverage mechanically enters its denominator and would complicate the interpretation of capital regulation.

CAR and Tier 1 are percentages of risk-weighted assets. CAR includes eligible total regulatory capital, while Tier 1 emphasizes higher-quality going-concern capital. Including them jointly seeks to separate total buffer size from capital quality, but their correlation creates imprecision. LCR and NSFR are also entered in percentage-point units. Thus a coefficient of -0.0014 on LCR means that a one-percentage-point increase in LCR is associated with 0.0014 percentage points lower ROA, not a 0.14% proportional decrease.

Bank size is the natural logarithm of total assets after harmonization to a common reporting unit. A log specification reduces scale skewness and allows the size coefficient to approximate the change in ROA associated with a proportional asset change. GDP growth is the annual real growth rate, inflation is the annual consumer-price rate and RATE is the year-end or annual policy-rate measure used in the dissertation dataset. Because these macroeconomic variables are identical for all banks in a given year, their effective variation is temporal rather than bank-specific.

This variable architecture operationalizes the channels developed in Section 2. CAR and Tier 1 represent, respectively, the quantity and loss-absorbing quality of capital through which leverage, expected distress costs and funding premia may affect ROA. LCR captures the short-run trade-off between holding lower-yield high-quality liquid assets and avoiding fire sales, whereas NSFR captures the longer-run trade-off between stable funding costs and refinancing resilience. ROA is appropriate for this question because it measures income generated by the asset base without embedding

leverage in its denominator, as ROE would. Size controls for scale, diversification and complexity, while GDP growth, inflation and the policy rate represent credit-demand, cost, asset-quality and repricing conditions that could otherwise confound the prudential coefficients.

Panel estimation is theoretically appropriate because the hypothesized adjustment occurs both across banks with different buffers and within banks as ratios and macroeconomic conditions evolve. Random effects uses both sources of variation and represents persistent bank-specific heterogeneity through a random intercept, but it requires orthogonality between that heterogeneity and the regressors. The Hausman diagnostics and the two-way fixed-effects check therefore discipline, rather than mechanically validate, the baseline choice. Estimating solvency and liquidity over separate windows respects their different implementation and disclosure histories, while Post-2015 is retained only as a descriptive regime control. This design aligns the specification with the theory while preserving the interpretation of conditional association rather than causality.

Table 1. Variables, construction and expected association.

Variable	Definition and Unit	Role	Expected Sign
ROA	Net income / total assets, percentage points	Dependent variable	—
CAR	Total eligible capital / risk-weighted assets, %	Capital buffer	+ / ambiguous
Tier 1	Tier 1 capital / risk-weighted assets, %	Capital quality	+ / ambiguous
LCR	High-quality liquid assets / 30-day net cash outflows, %	Short-term liquidity	– / ambiguous
NSFR	Available stable funding / required stable funding, %	Structural funding	– / ambiguous
GDP growth	Annual real GDP growth, %	Macroeconomic control	+
Inflation	Annual CPI inflation, %	Macroeconomic control	Ambiguous
Policy rate	Bank Al-Maghrib policy rate, %	Monetary control	Ambiguous
Log(size)	Natural logarithm of harmonized total assets	Bank control	+ / ambiguous
Post-2015	One from 2015 onward, zero otherwise	Period indicator	–

Notes: All ratio and macroeconomic variables enter in percentage-point units. Expected signs reproduce the testable channels; ‘ambiguous’ indicates competing theoretical mechanisms.

Table 2. Descriptive statistics.

Variable	Obs.	Mean	Std. dev.	Min	Median	Max
ROA (%)	140	0.795	0.440	0.013	0.770	2.700
CAR (%)	140	13.97	2.30	7.50	13.63	22.36
Tier 1 (%)	140	11.60	2.33	7.30	10.89	19.24
LCR (%)	90	182.8	82.7	100.0	155.0	492.0
NSFR (%)	90	157.9	69.6	101.0	129.0	412.0

Variable	Obs.	Mean	Std. dev.	Min	Median	Max
GDP growth (%)	140	2.83	3.24	−7.20	3.20	7.90
Inflation (%)	140	1.93	1.87	0.20	1.43	6.60
Policy rate (%)	140	2.50	0.54	1.50	2.50	3.25
Log(size)	140	8.081	0.354	7.387	7.939	8.819
Post-2015	140	0.643	0.481	0	1	1

Source: authors' calculations from bank reports, Pillar 3 disclosures and Bank Al-Maghrib. The liquidity-series provenance caveat is described in Section 3.2.

3.4. Descriptive Evidence

Average ROA is 0.795%, with a standard deviation of 0.440 percentage points. The minimum of 0.013% indicates that the panel contains near-zero profitability episodes but no annual loss under the final working definition. The maximum of 2.700% shows that performance also varies materially across banks and years. CAR averages 13.97% and Tier 1 averages 11.60%; both exhibit sufficient dispersion for panel estimation, although variation may partly reflect reporting perimeter and changes in regulatory definitions.

The liquidity ratios show markedly larger dispersion. Mean LCR equals 182.8%, well above the 100% minimum, and ranges up to 492%. Mean NSFR equals 157.9% and reaches 412%. These upper values may reflect genuine conservative funding positions, transitional definitions or source/perimeter differences. They make source-level verification and influence diagnostics particularly important. The article does not winsorize them because doing so would introduce an unreported researcher choice; future replication should report estimates with and without extreme values.

CAR and Tier 1 are correlated at approximately 0.71, while LCR and NSFR are correlated at approximately 0.91. The associated variance inflation factors are therefore elevated for the liquidity variables. High collinearity does not bias a correctly specified linear coefficient, but it inflates standard errors and makes the separate LCR and NSFR signs unstable. The joint specification is retained for comparability with the dissertation, and the coefficients are read as conditional associations. Single-ratio variants are desirable in a complete replication appendix.

The macroeconomic series contain only fourteen annual values in Model 1 and nine in Model 2, repeated across banks. The apparent number of bank-year observations must not be interpreted as 140 or 90 independent macroeconomic observations. This matters for both point estimates and inference: the 2020 contraction and rebound can dominate GDP variation, and conventional heteroskedasticity-robust standard errors do not fully solve the limited time-series dimension.

4. ECONOMETRIC METHODOLOGY

4.1. Baseline Specifications

The two baseline models are:

$$ROA_{it} = \alpha + \beta_1 CAR_{it} + \beta_2 Tier1_{it} + \beta_3 GDP_t + \beta_4 INF_t + \beta_5 RATE_t + \beta_6 SIZE_{it} + \beta_7 POST2015_t + \mu_i + \varepsilon_{it} \quad (1)$$

$$ROA_{it} = \alpha + \gamma_1 LCR_{it} + \gamma_2 NSFR_{it} + \gamma_3 GDP_t + \gamma_4 INF_t + \gamma_5 RATE_t + \gamma_6 SIZE_{it} + v_i + \eta_{it} \quad (2)$$

In Equations (1) and (2), i indexes banks and t indexes years. The bank-specific effects μ_i and v_i capture time-invariant heterogeneity such as persistent business-model or ownership differences, while ε_{it} and η_{it} are idiosyncratic errors. Random-effects estimation assumes that the unobserved bank effect is uncorrelated with the included regressors. This assumption is stronger than the corresponding fixed-effects requirement and is economically contestable because persistent risk appetite or governance may influence both prudential buffers and profitability. Standard panel-data treatments therefore recommend specification tests and comparison with within estimators [23, 24].

The baseline coefficients are partial correlations in percentage-point units. For example, β_1 is the change in ROA percentage points associated with a one-percentage-point increase in CAR, holding the other regressors constant. It is not the change generated by a one-percentage-point increase in the regulatory minimum. The two quantities coincide only under assumptions about compliance behaviour and exogeneity that are not satisfied by this observational design.

4.2. Model Selection and Inference

For Model 1, the Breusch–Pagan Lagrange-multiplier test rejects pooled OLS (LM = 61.80, $p < 0.001$), supporting the presence of bank-level variance. The standard Hausman test does not reject the random-effects specification ($\chi^2 = 4.068$, 7 degrees of freedom, $p = 0.772$). The Hausman test evaluates systematic differences between consistent fixed-effects estimates and the more efficient random-effects estimates under the null [25]. Failure to reject is not proof that the random-effects orthogonality assumption is true, especially in a small sample with imprecisely estimated coefficient differences.

For Model 2, the difference between the fixed- and random-effects covariance matrices is not positive semidefinite. The calculation produces a negative Hausman statistic and a p -value close to one. Because a chi-square statistic cannot legitimately be negative, this output is numerically inadmissible and the p -value has no standard inferential interpretation. It must not be used as affirmative evidence for random effects. Model 2 is retained as a random-effects baseline for comparability, but its conclusions are checked against alternative specifications and described with greater caution.

The dissertation reports heteroskedasticity-robust HC3 inference and Driscoll–Kraay sensitivity. Driscoll–Kraay

covariance estimation is designed to accommodate general spatial and temporal dependence as the time dimension grows [26]. Practical implementations extend it to panel models [27]. Here T equals fourteen for Model 1 and nine for Model 2, so the large- T justification is weak. Conversely, clustering by bank with only ten clusters also yields fragile asymptotics. The p -values should therefore be treated as approximate indicators rather than precise decision rules. The final tables reproduce the robust estimates available from the dissertation and flag marginal 10% evidence explicitly.

4.3. Sensitivity Strategy and Identification Limits

Two-way fixed effects constitute the principal specification check for the bank-level prudential variables. Bank fixed effects remove time-invariant differences across institutions, and year fixed effects absorb common national shocks. This design reduces omitted-variable bias from stable bank characteristics and observed or unobserved year shocks. It also means that GDP growth, inflation, the policy rate and Post-2015 cannot be estimated simultaneously because each varies only by year.

The grouped post-2015 comparison interacts a high-capital indicator with the post period. Its interpretation is limited because every bank was exposed to the regulatory framework and the high-capital group was not randomly assigned. Without parallel pre-trends and a credible untreated group, the interaction is a descriptive difference in changes, not a regulatory difference-in-differences effect.

The lagged-size instrumental-variable exercise uses lagged bank size to instrument current size. A large first-stage F statistic addresses relevance but not exclusion: past size can influence current profitability through market power, branch networks, risk and persistence, not only through current size. The dynamic first-difference exercise resembles an Arellano–Bond approach, which was developed for panels with many cross-sectional units and relatively few periods [28]. Instrument proliferation and weak specification tests are well-known problems even in larger applications [29]. With only ten banks, the dynamic estimates are reported as exploratory.

Pooled quantile regressions examine whether associations differ across the conditional distribution of ROA. Quantile regression estimates conditional quantiles rather than the conditional mean [30]. In the present pooled form, however, it does not absorb bank effects and should not be treated as a panel quantile estimator. Size-subsample estimates are based on five banks per group and therefore have very low power. Finally, excluding 2020 directly tests whether the largest common shock drives the results. The analysis ranks these checks by credibility rather than counting them as independent confirmations.

Estimation and diagnostic conventions follow standard panel-data practice and the R panel-model implementation used in the dissertation [31]. A complete computational supplement should archive the cleaned dataset, variable dictionary, session information, model calls, covariance choices and full output. The present article reports the estimates that can be reconciled with the thesis tables, while correcting interpretations that were not supported by those tables.

5. EMPIRICAL RESULTS

5.1. Baseline estimates

Neither CAR nor Tier 1 is statistically significant in Model 1. The CAR point estimate is 0.0148 ($p = 0.462$), and the Tier 1 estimate is 0.0212 ($p = 0.244$). Interpreted mechanically, a one-percentage-point increase in the reported ratios is associated with 1.48 and 2.12 basis points higher ROA, respectively, conditional on the other regressors. The confidence reflected by the reported standard errors is insufficient to distinguish these estimates from zero. Their positive signs are compatible with a lower funding-risk channel, but the evidence does not support a reliable average relationship.

The post-2015 coefficient equals 0.0008 and is insignificant ($p = 0.188$). In percentage-point terms, the estimate is very small. It provides no support for a common negative shift in ROA after 2015, but it is not a test of the complete Basel III effect. The indicator mixes regulatory phases with changes in competition, digitalization, accounting, business strategy, the pandemic and monetary conditions. Any causal interpretation would require a more specific institutional discontinuity or an external comparison group.

In Model 2, LCR is negative at the 10% level and NSFR is insignificant. A ten-percentage-point increase in LCR is associated with approximately 1.4 basis points lower ROA. Relative to the 100% minimum, the mean LCR excess of 82.8 percentage points corresponds mechanically to about 11.6 basis points of ROA. This calculation is descriptive and should not be interpreted as the causal cost of regulation, particularly given LCR–NSFR multicollinearity and the measurement caveat for early liquidity observations.

The opposite signs on LCR and NSFR must be interpreted jointly. With a correlation near 0.91, the LCR coefficient describes an increase in short-term liquidity holding NSFR fixed, a comparison that may have limited empirical support in the observed data. The positive NSFR point estimate could simply offset the negative LCR estimate within a collinear specification. The joint table therefore gives weaker support to a general ‘liquidity reduces profitability’ claim than the marginal LCR p -value might suggest.

GDP growth and the policy rate are positive in both baseline models, while inflation is negative and significant only over 2015–2023. A one-percentage-point increase in GDP growth is associated with roughly 2.4 basis points higher ROA, and a one-percentage-point increase in the policy rate with 21–27 basis points higher ROA. The positive policy-rate association is consistent with assets repricing faster than liabilities or with improved intermediation margins, but the regression does not observe repricing gaps. The negative inflation coefficient in the shorter model may reflect operating-cost pressure or macroeconomic stress, yet it is not stable across the full period.

The size coefficient changes sign across models and is statistically insignificant. Model 1 gives -0.0037 , while Model 2 gives 0.0026. Since size is measured in logarithms, these small coefficients imply no detectable full-sample scale advantage in ROA after controls. This result does not exclude economies of scale in costs, nor does it rule out heterogeneous

Table 3. Random-effects estimates; dependent variable: ROA.

Variable	M1 coef.	SE	p-value	M2 coef.	SE	p-value
Constant	0.0277	0.0346	0.4248	−0.0187	0.0184	0.3124
CAR	0.0148	0.0200	0.4616	—	—	—
Tier 1	0.0212	0.0181	0.2440	—	—	—
LCR	—	—	—	−0.0014†	0.0008	0.0745
NSFR	—	—	—	0.0014	0.0009	0.1226
GDP growth	0.0237***	0.0044	<0.001	0.0242***	0.0051	<0.001
Inflation	−0.0310	0.0207	0.1360	−0.0434*	0.0187	0.0226
Policy rate	0.2100*	0.0907	0.0222	0.2690*	0.1110	0.0176
Log(size)	−0.0037	0.0041	0.3696	0.0026	0.0021	0.2175
Post-2015	0.0008	0.0006	0.1880	—	—	—
Observations	140			90		
Banks	10			10		
R ² within	0.263			0.244		

Notes: *** $p < 0.001$; * $p < 0.05$; † $p < 0.10$. Standard errors and p-values reproduce the robust-output table reported in the dissertation. M1: 2010–2023; M2: 2015–2023.

size effects across business models; it simply fails to support H4 in the average specification.

Within R² values are 0.263 and 0.244. These figures indicate that the included time-varying regressors explain only about one quarter of within-bank ROA variation under the reported decomposition. They should not be compared mechanically with pooled R² values. The unexplained component is consistent with omitted bank-specific factors such as asset quality, efficiency, income diversification, loan growth and provisioning. Their omission is a substantive limitation because several may be jointly determined with prudential ratios.

The baseline macroeconomic p-values also require special caution. GDP, inflation and the policy rate take the same value for each of the ten banks in a given year, so repeating them across bank rows does not create ten independent national observations. The exclusion-of-2020 result below demonstrates the practical consequence: a single common year can materially change a macroeconomic coefficient while leaving the bank-level prudential conclusion broadly unchanged.

5.2. Sensitivity Analyses

5.2.1. Two-way Fixed Effects

The two-way fixed-effects specification is the closest sensitivity check to the baseline panel logic. After bank and year

effects are included, CAR remains small and insignificant (0.0081, $p = 0.755$), Tier 1 remains positive and insignificant (0.0262, $p = 0.342$), and size remains insignificant (−0.0030, $p = 0.629$). The year indicators absorb GDP, inflation, the policy rate and Post-2015, so this specification cannot evaluate their coefficients. Its value is narrower: it shows that the absence of a detectable capital-ratio association is not created solely by time-invariant differences between banks or common year shocks.

5.2.2. Grouped Post-period Comparison

The interaction between the high-capital group and the post-2015 period is −0.0027 ($p = 0.124$). The common post coefficient is positive and significant in this grouped equation. This pattern does not establish that regulation improved average profitability or harmed high-capital banks. Banks with initially high capital can differ in ownership, risk, efficiency and strategy, and every sampled bank faced the same regulatory sequence. Without pre-treatment trend evidence and a group exempt from the relevant change, the result is best described as an exploratory comparison of average changes.

5.2.3. Instrumental-variable and Dynamic Estimates

In the lagged-size IV specification, the size coefficient becomes positive and significant (0.0007, $p = 0.041$), CAR becomes negative and marginally significant (−0.0303, $p =$

Table 4. Summary and interpretation of sensitivity analyses.

Check	Reported Result	Appropriate Interpretation
Two-way FE	CAR 0.0081 ($p=0.755$); Tier 1 0.0262 ($p=0.342$); size -0.0030 ($p=0.629$)	Bank-level null findings persist after year effects; macro variables and post-2015 are absorbed.
Grouped post-2015 comparison	High-capital $\times$ post interaction -0.0027 ($p=0.124$)	No differential change is detected; without a credible untreated group and a displayed pre-trend test, this is not causal DiD evidence.
Lagged-size IV	Size 0.0007 ($p=0.041$); CAR -0.0303 ($p=0.075$); first-stage $F=2246.5$	Instruments are relevant, but their exclusion restriction is untested; CAR becomes marginally significant.
Dynamic first-difference estimate	ROA persistence ≈ 0.39 ; Sargan $p=0.319$; AR(2) $p=0.106$	Exploratory only because $N=10$ and dynamic-panel asymptotics are weak in this sample.
Size subsamples	Large-bank size -0.0223 ($p=0.004$); post-2015 $p=0.094$	Suggestive heterogeneity, based on only five banks per group.
Pooled quantiles	Prudential variables insignificant; policy-rate coefficient rises across quantiles; equality test $p=0.144$	Distributional pattern is not statistically different and pooled quantiles do not absorb bank effects.
Exclude 2020	CAR, Tier 1 and post-2015 remain insignificant; GDP becomes -0.0017 ($p=0.919$)	Prudential conclusion persists, but the baseline GDP result is strongly influenced by the pandemic year.

Source: sensitivity results reported in the dissertation. These checks have different identifying assumptions and are not equally probative.

0.075), and Tier 1 remains insignificant. The first-stage F statistic of 2246.5 indicates strong correlation between lagged and current size, which is unsurprising for bank assets. It does not establish that lagged size is excluded from the current profitability equation. Persistence, market position and past investment provide direct channels. The IV result is therefore evidence of specification sensitivity, not a preferred causal estimate.

The dynamic first-difference exercise reports an ROA persistence coefficient close to 0.39, a Sargan p-value of 0.319 and no significant second-order serial correlation (AR(2) $p = 0.106$). These diagnostics would normally be discussed in a difference-GMM framework, but their power and reference distributions are unreliable with only ten banks. The exercise suggests persistence but cannot validate a dynamic causal model. The final interpretation gives it less weight than the static two-way fixed-effects result.

5.2.4. Heterogeneity and Pandemic Influence

Splitting the sample into five larger and five smaller banks produces a negative size coefficient for large banks (-0.0223 , $p = 0.004$) and a marginal post-period result. Such differences can be economically interesting: within the largest institutions, further expansion may create complexity or reflect low-margin balance-sheet growth. Yet five-bank subsamples are extremely sensitive to individual institutions, and formal coefficient-difference tests are not reported. The estimates are hypothesis-generating rather than conclusive evidence of a size threshold.

Pooled quantile estimates leave the prudential variables insignificant and show a policy-rate coefficient rising from approximately 0.1923 at the 25th percentile to 0.4361 at the 75th

percentile. The equality test has $p = 0.144$, so the apparent gradient is not statistically distinguishable across the reported quantiles. Because the pooled estimator does not remove bank effects, it may also reflect stable differences between more- and less-profitable banks.

The most defensible robustness result is the persistence of insignificant CAR and Tier 1 coefficients under two-way fixed effects and after excluding 2020. Other checks are informative but do not justify the phrase ‘robust to an extensive identification battery.’ The lagged-size IV estimate depends on a strong exclusion assumption, the high-capital comparison has no untreated regulatory group, and dynamic-panel estimates are unreliable when the cross-sectional dimension is only ten.

The COVID exclusion is especially important. Once 2020 is removed, the GDP coefficient becomes economically and statistically negligible, showing that the strong baseline GDP association is substantially driven by the simultaneous recession and profitability shock in 2020. The policy-rate and inflation coefficients also weaken. Accordingly, H5 receives only partial support rather than full validation.

6. HYPOTHESIS ASSESSMENT AND DISCUSSION

H1 is not supported because CAR is insignificant in the baseline and fixed-effects specifications, although it becomes marginally negative in the exploratory IV model. This combination is better described as unstable evidence than as a positive capital-profitability relationship. H2 is not supported because the post-2015 indicator is small and insignificant. The limitation of the period proxy prevents the conclusion that Basel III had no effect.

Table 5. Assessment of the research hypotheses.

Hypothesis	Empirical evidence	Assessment
H1: CAR positive	CAR insignificant in baseline and two-way FE; marginally negative in exploratory IV	Not supported
H2: Post-2015 negative	Small positive baseline coefficient, $p = 0.188$	Not supported
H3: LCR/NSFR negative	LCR negative at 10%; NSFR positive and insignificant	Limited support
H4: Size positive	Insignificant and sign-changing in full sample	Not supported
H5: Macro variables matter	Baseline significance, but GDP collapses without 2020	Partial support

Note: Assessment concerns statistical support in the reported observational models; it does not test structural causality.

H3 receives only limited support. LCR has the hypothesized negative sign but reaches conventional significance only at 10%, while NSFR has the opposite sign and is insignificant. Their strong correlation and the uncertain status of early NSFR observations further weaken a ratio-specific interpretation. H4 is not supported in the full panel; subgroup estimates suggest that the size relationship could be nonlinear, but they do not establish a general scale effect.

H5 receives partial support. GDP growth and the policy rate are positive in the baseline, and inflation is negative in the shorter model. However, removing 2020 eliminates the GDP association and weakens the other macroeconomic estimates. The result illustrates why national variables repeated across banks should be evaluated through the actual number and influence of time observations rather than through the nominal number of bank-year rows.

Three mechanisms can rationalize the weak average prudential associations. First, most sampled banks maintain buffers above minimum thresholds, so observed variation may be largely voluntary and non-binding. The profitability effect of moving from 120% to 130% LCR can differ from the effect of moving a constrained bank from below to above 100%; a linear model averages the two. Second, phased implementation allowed anticipatory adjustment, so costs may have occurred before the chosen post date or been spread across several years. Third, average coefficients combine institutions with different retail, corporate, market and international activities. A ratio can be costly for one business model and protective for another.

The positive policy-rate coefficient deserves cautious economic interpretation. Moroccan bank assets and liabilities do not reprice simultaneously. If loan or security yields adjust faster than deposit costs, a higher policy rate can temporarily widen margins; if funding costs adjust faster or credit quality deteriorates, the effect can reverse. The present ROA equation contains no repricing-gap, deposit-share or asset-quality measures and cannot identify the channel. The coefficient should therefore motivate a more detailed balance-sheet study rather than a simple claim that monetary tightening raises bank profitability.

The findings are broadly compatible with Moroccan studies reporting weak or heterogeneous capital effects and a po-

tentially negative LCR relationship, but direct numerical comparison is difficult. Prior studies differ in banks, years, profitability measures, estimator and controls. The contribution of the present article is not a uniquely precise coefficient; it is the longer harmonized window and a transparent separation between supported findings and assumptions that the data cannot validate.

More specifically, the capital result is consistent with Bouhali and Barkat's insignificant CAR estimate for listed Moroccan banks and with the heterogeneous Basel III responses reported by Alaoui Taib *et al.*, but it does not reproduce the positive capital-earnings relationship in Berger or the performance effects identified in some emerging-market settings [8, 18, 20, 22]. The divergence is economically plausible. The positive channel should be strongest when additional capital materially lowers distress or funding costs, whereas the Moroccan banks in this sample generally hold buffers above regulatory minima; marginal movements within those buffers may neither release nor constrain enough earning assets to move average ROA. Moreover, ROA is less mechanically sensitive to leverage than ROE, and including CAR and Tier 1 together divides variation between correlated capital measures. The null estimate therefore suggests an offset between resilience benefits and leverage or adjustment costs, not the absence of either mechanism.

The marginally negative LCR coefficient accords with Bouhali and Barkat's Moroccan result and with Dietrich, Hess and Wanzenried's finding that the costs and benefits of Basel III liquidity rules depend on the starting balance sheet.^{17,20} It is also consistent with the opportunity cost of replacing loans or longer-duration securities with high-quality liquid assets. By contrast, the insignificant positive NSFR coefficient does not support a uniform maturity-transformation penalty. Stable retail funding may be costly to build but can also lower rollover risk and funding premia; in this sample, the 0.91 correlation between LCR and NSFR and the pre-2021 provenance of some NSFR values further prevent the two conditional coefficients from being read as independent structural effects. The liquidity evidence therefore supports, at most, a narrow short-term cost channel rather than a general claim that stronger liquidity reduces profitability.

The macroeconomic and size results also help explain variation across Moroccan studies. Belcaid and Al-Faryan find

that both bank-specific and macroeconomic determinants matter, while Alaoui Taib et al. report heterogeneous Basel III responses [21, 22]. In the present study, the GDP association disappears when 2020 is excluded, and the policy-rate coefficient is estimated over a period spanning pandemic disruption and monetary normalization. Studies ending earlier, restricted to listed banks, or using ROE rather than ROA can therefore obtain different signs without necessarily being contradictory: they identify different bank populations, regulatory phases and profitability channels. The unstable full-sample size effect similarly suggests that ownership, mandate and business model matter more than balance-sheet scale alone.

Taken together, this comparison refines the paper's contribution. International evidence shows that prudential compliance is not by itself a sufficient statistic for performance and that capital and liquidity effects depend on institutions, buffers and asset composition [13–19]. The Moroccan results provide a concrete mechanism for that heterogeneity: gradual implementation, above-minimum buffers and different business models allow adjustment costs and resilience benefits to offset in average annual ROA. The estimates therefore speak most directly to marginal movements in observed ratios within the sampled range; they do not identify the effect of moving a constrained bank across a regulatory threshold or the value of buffers in tail events. This distinction explains both the concordance with weak Moroccan average effects and the divergence from settings in which requirements are more binding or performance measures are more leverage-sensitive.

7. CONCLUSION, POLICY IMPLICATIONS AND LIMITATIONS

This paper finds no statistically detectable average association between CAR, Tier 1 or the post-2015 indicator and ROA in a panel of ten major Moroccan banks over 2010–2023. LCR has a small negative association at the 10% level, while NSFR is insignificant. The results do not show a clear profitability penalty associated with observed prudential ratios, but neither do they prove that Basel III is neutral or costless.

For supervisors, the most defensible implication is that capital and liquidity buffers should be assessed jointly with each bank's business model, funding concentration, asset quality and stress-test results. The estimates do not identify an optimal CAR or LCR. Prescribing operational ranges such as a 13–15% CAR or a 110–130% LCR from these regressions would confuse observed sample averages with welfare-maximizing thresholds and ignore tail risk. Regulatory minima are resilience constraints, not profit targets.

For bank management, the marginal LCR result suggests that the composition and yield of the liquidity buffer merit attention, but it does not justify reducing buffers toward the minimum. A more useful managerial question is whether the same resilience can be achieved through a more efficient mix of eligible assets, stable deposits and contingent funding. Similarly, an insignificant average capital coefficient should not be read as evidence that capital structure is irrelevant: the benefits of capital may appear primarily during stress and may not be captured by average annual ROA.

The study has seven principal limitations. First, ten banks provide limited cross-sectional power and unreliable small-cluster and dynamic-panel asymptotics. Second, profitability and prudential ratios may be jointly determined through retained earnings, risk appetite and managerial adjustment. Third, the macroeconomic regressors have only nine to fourteen distinct annual values. Fourth, early liquidity observations—especially pre-transposition NSFR measures—require complete source-level documentation. Fifth, some early solvency observations are reconstructed and may not share a fully identical consolidation perimeter. Sixth, ROA is not risk-adjusted and does not separately identify margins, fees, credit risk, efficiency or exceptional items. Seventh, subgroup and pooled-quantile checks do not fully address bank-level heterogeneity.

These limitations affect the strength but not the basic descriptive value of the analysis. The tabled coefficients can document what is and is not detectable in the assembled panel, provided that p-values are treated cautiously and causal language is avoided. The paper's most stable result is the lack of a statistically detectable average CAR or Tier 1 association under both random-effects and two-way fixed-effects specifications. The macroeconomic results and the separate liquidity coefficients are less stable.

Future research should extend the period, archive a public bank-year data dictionary, distinguish directly reported from reconstructed observations, and reproduce all estimates under alternative source filters. Adding non-performing loans, loan-loss provisions, cost efficiency, income diversification, deposit structure and loan growth would reduce omitted-variable concerns. Methods designed for small panels, influence diagnostics and models allowing nonlinear effects around regulatory minima are also priorities. The Basel III finalization period, participative banks and the African subsidiaries of Moroccan groups offer natural extensions, but each expansion requires consistent consolidation and currency conventions.

CONFLICT OF INTEREST

The authors declare that they have no known financial or personal relationships that could have appeared to influence the work reported in this paper.

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AUTHOR CONTRIBUTIONS (CREDIT)

Hajar Bassim El Idriissi: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing—original draft. Said El Bouazizi: Supervision, Validation, Methodology, Writing—review and editing. Both authors approved the final manuscript.

DATA AVAILABILITY

The working bank-year dataset, source register, data dictionary and replication code are available from the corre-

sponding author upon reasonable request. The underlying annual reports, Pillar 3 disclosures and regulatory documents are publicly accessible from the banks, the Moroccan Capital Market Authority and Bank Al-Maghrib, subject to website availability.

ETHICS STATEMENT

The study uses institution-level secondary data and does not involve human participants, personal data or animals; ethical approval and informed consent are not applicable.

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