

The Evolution of UK Bank Stock Sensitivities to Macroeconomic Conditions following the 2008 Financial Crisis.

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Executive Summary

This dissertation examines how the sensitivity of UK bank stock prices to macroeconomic conditions changed following the 2008 financial crisis. Banks are central to the UK economy, with profitability and lending capacity tightly linked to macroeconomic conditions. Aggregate banking equity thus provides a market-based gauge of sector health and policy transmission. The 2008 crisis saw GDP contract over 6%, necessitating a £137bn government intervention, which severely disrupted this macro-financial relationship, yet existing literature provides minimal evidence on how macroeconomic determinants of UK banking equity evolved post-crisis. This research hypothesises the crisis caused a structural break, fundamentally changing these drivers and slowing the sector's long-run adjustment speed. A Vector Error Correction Model is employed on a bespoke equally weighted index of the UK's 'big four' banks to analyse short- and long-run determinants in pre- and post-crisis periods. A Quandt Likelihood Ratio test identifies December 2008 as the structural break, supporting the hypothesis. Pre-crisis, nominal monetary determinants dominated, with money supply the sole Granger-causing variable. Post-crisis, short-run transmission eroded entirely, with Granger-causality absent. The speed of adjustment halved from 16.8% to 7.4%, whilst GDP became the dominant long-run driver. These findings have direct policy implications. The breakdown of short-run transmission and slower adjustment speed suggests bank stock performance can no longer serve as a real-time signal of sector health. Frameworks monitoring UK financial stability should therefore prioritise internal metrics, including capital ratios and balance sheet quality.

AI Statement

I acknowledge the use of generative AI in asking software-based questions, drafting, code development, structuring, and sense checking in this paper. However, the work reported remains my own.

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1. Introduction

Banks are central to the UK economy, with profitability and lending capacity tightly linked to macroeconomic conditions, such as economic growth and interest rates. Aggregate UK banking equity serves as a real-time, market-based gauge of the sector's health by reflecting how macroeconomic changes are transmitted through the financial system. Understanding how bank stock prices react to macroeconomic conditions is therefore crucial.

The 2008 financial crisis, one of the most severe economic shocks in modern British history, demonstrated this interdependent relationship. Pre-crisis, the UK's banking sector had the largest asset-to-GDP ratio of any major economy (Sentance, et al., 2012), making the UK vulnerable to financial shocks. Consequently, GDP contracted by more than 6% at the peak of the crisis (Loh & Scruton, 2018), and the government injected £137bn to stabilise the financial system (Mor, 2018). The crisis, therefore, demonstrated how deeply the UK's banking sector is embedded within the macroeconomic environment.

However, limited research has assessed how the macroeconomic determinants of UK banking equity have fared in the post-crisis period. The theoretical relationship between bank stock prices and macroeconomic conditions is well established in efficient market and asset pricing literature. However, the post-crisis economic landscape differs from the conditions upon which these frameworks were founded. Whether the transmission mechanism survived or was fundamentally altered by the crisis remains under-researched, which forms the basis for this research.

Answering this question is pertinent for policymakers evaluating whether pre-crisis macroeconomic policy tools still operate as expected in supporting UK financial stability. For investors, it shapes portfolio decisions across different economic regimes. For regulators, it aids in determining whether post-crisis macroeconomic indicators of banking sector health remain meaningful.

2. Literature Review

2.1 Theoretical Framework

This research is underpinned by two foundational pieces of financial economic theory: Fama's Efficient Market Hypothesis (Fama, 1970) and Ross' Arbitrage Pricing Theory (Ross, 1976). Together, these frameworks theoretically outline how UK macroeconomic conditions may influence bank stock prices.

2.1.1 Efficient Market Hypothesis

According to Fama's (1970) Efficient Market Hypothesis (EMH), financial markets are informationally efficient, with asset prices reflecting all available information at a given time. Fama categorised market efficiency into three forms: weak, strong and semi-strong. The weak form suggests that stock prices reflect all previous stock price data. The semi-strong form, most relevant to this research, suggests that all publicly available information, including macroeconomic variables, is rapidly incorporated into stock prices. This implies stock markets, such as bank indices, should adjust instantly to new economic data. The strong form suggests that all public and private information is fully reflected in current stock prices.

2.1.2 Arbitrage Pricing Theory

The EMH theorises the general types of information incorporated into asset prices, and the speed at which they are incorporated, but not the specific factors most relevant for determining returns. Initial efforts to address this came from Sharpe (1964) through the Capital Asset Pricing Model (CAPM), which linked expected asset returns to systematic risk. Addressing CAPM's single-factor limitation, Ross' (1976) Arbitrage Pricing Theory (APT), introduced a multi-factor framework acknowledging that stock returns are sensitive to a wide range of economic factors.

2.1.3 Relevance to this research

Applying these frameworks to the UK banking sector indicates that aggregate banking equity should broadly be driven by macroeconomic conditions and that new economic data should be immediately priced in by the market. Combining the APT's multi-factor framework with the EMH's informational efficiency informs this research's empirical strategy. The modelling of the macroeconomic determinants of bank stock prices across pre- and post-crisis sub-

samples directly tests whether the 2008 financial crisis introduced a fundamental shift in these theoretical relationships.

2.2 Macroeconomic determinants of Banking equity

2.2.1 Micro vs. Macro Determinants

When evaluating UK banking equity, the literature distinguishes between firm-specific (microeconomic) and systematic (macroeconomic) determinants. At the bank-specific level, idiosyncratic microeconomic factors such as capitalisation and ownership structure drive profitability (Demirgüç-Kunt & Huizinga, 1999). However, as this research aims to analyse the aggregate UK banking sector, these firm-specific factors are likely to offset one another. Therefore, systematic, macroeconomic conditions become the main drivers of sector-wide equity prices, with factors such as inflation and cyclical output dictating aggregate banking returns (Athanasoglou, et al., 2008). Hence, focusing on macroeconomic conditions is the optimal approach for evaluating stock market valuations of the UK's aggregate banking sector.

Rather than outlining an exhaustive set, the following section outlines a representative sample of the most significant and under-researched macroeconomic factors used in this research.

2.2.2 Interest Rates and Term-Spread

Whilst interest rates influence all stock prices, bank share prices exhibit greater sensitivity due to their unique balance sheet structure. Flannery & James (1984) formed the maturity mismatch hypothesis, indicating that where banks borrow short-term through deposits and lend long-term through loans, they create maturity mismatches. Consequently, when interest rates rise, the present value of long-duration assets falls more severely than short-duration liabilities, compressing a bank's net asset value and eroding its share price.

Saunders & Yourougou (1990) empirically assessed this differential, employing a three-factor regression model to compare interest rate sensitivity between banks and regular commercial firms across different monetary policy regimes in the US.¹ Banks demonstrated interest rate sensitivities up to ten times higher than those of non-financial firms, enduring across monetary regimes. This provides empirical support for the maturity mismatch hypothesis,

¹ This model included whole market stock returns, unexpected interest rate changes, and rate volatility.

supporting the view that banks' balance sheet structure generates heightened stock price exposure to interest rate changes, relative to non-financial firms.

Therefore, the base rate alone does not fully capture banks' exposure to interest rate movements. More important is the profitability of maturity transformation.² This is best proxied by term-spread, which measures the difference between long-term lending rates and short-term borrowing rates. The larger the term-spread is, the more profitable banks become. However, the margin that banks receive depends on how closely the rates paid on customer deposit accounts align with short-term borrowing rates. Eggertsson et al. (2019) established that retail deposit rates face a strict zero floor, called the 'Deposit Lower Bound', where banks cannot push retail deposit rates below zero, as customers would withdraw their cash. Under normal conditions this constraint is non-binding. However, when policy rates approach zero, further rate cuts cannot be passed onto depositors, squeezing the term-spread.

2.2.3 Real Economic Activity: Economic Growth and House Prices

Theoretically, real economic growth increases bank stock prices through 2 channels, increased credit demand and improved asset quality (Albertazzi & Gambacorta, 2009). As the UK's economy grows, business and consumer confidence improves, driving credit demand, which boosts UK banks' profitability and stock prices (Athanasoglou, et al., 2008). Concurrently, economic growth stabilises and improves incomes, reducing default risk on loan payments, lowering the volume of banks' 'risky' loans (Salas & Saurina, 2002). Despite this theoretical transmission mechanism, empirical research evaluating this relationship remains sparse.

Due to this gap, much of the existing literature centres around broader stock indices, often utilising Industrial Production (IP) as a proxy for economic growth (Nasseh & Strauss, 2000), (Ratanapakorn & Sharma, 2007). However, selecting IP to proxy economic activity in the context of the UK's banking sector would be unlikely to capture a bank's exposure to the macroeconomy due to the UK's reliance on the service economy.

Beyond economic growth, UK banks face direct exposure to the real economy through their central mortgage lending role. Whilst research into the transmission mechanism between housing prices and UK bank equity values remains sparse, Koetter & Poghosyan (2010) provide relevant evidence using German banking data. They demonstrate that house price

² How much they earn by borrowing short-term and lending long-term.

deviations from their fundamental values significantly increased the probability of a bank exhibiting signs of distress, whereas nominal price changes showed no significant relationship. This indicates that structural imbalances in house prices, rather than directional price movements, may determine banking distress and stability.

2.2.4 Monetary Environment: Inflation and Money Supply

The nominal monetary environment, particularly inflation and money supply, can influence banking equity through its impacts on net interest margins, asset values, and loan demand.

Regarding money supply, early studies pointed to a significant positive relationship with general stock prices. Sprinkel (1964), Homa & Jaffee (1971), and Hamburger & Kochin (1972) utilised different models but all found that growth in money supply significantly predicted stock price increases.³ Despite these initial positive findings, later research contested this view, with Pesando (1974) identifying that when measured against real world data, all three of the above models were unsuccessful in reliably predicting stock prices, undermining the potential for a stable causal relationship between money supply and stock prices. Alatiqi & Fazel (2008) reinforced this unreliability. Using Engle-Granger cointegration and Granger-causality tests on US data (1965-2005) they found no long-run relationship and no evidence that money supply Granger-causes stock prices.

The theoretical influence of inflation on stocks is portrayed through the Fisher hypothesis, which posits that nominal interest rates adjust in-line with expected inflation, keeping real interest rates stable over the long-term (Fisher, 1930). Applied to stocks, Bodie (1976) states that economists have traditionally viewed stocks as an inflation hedge as they represent “ownership of physical capital whose real value is assumed to be independent of the rate of inflation”. This implies that a *ceteris paribus* change in inflation should coincide with an “equal change in the nominal rate of return on equity”.

However, this theoretical mechanism remains contested in the literature. Jaffe & Mandelker (1976) found a strong negative relationship between inflation and US stock returns, with every 1% increase in anticipated inflation reducing stock returns by approximately 3%. Lintner (1975) similarly found that expected and unexpected inflation depressed stock performance across several long-run US samples, arguing that heightened inflation increases

³ Sprinkel (1964) utilised a Simple Quantity Theory model; Homa & Jaffee (1971) an EMH model; and Hamburger & Kochin (1972) a Standard Valuation model

a firm's external financing needs, which will therefore reduce the value of its outstanding equity.

Contrastingly, Firth (1979) found a positive relationship using 1955-1976 UK data, suggesting that the British stock market hedged against inflation. Later, Geske & Roll (1983) argued that any negative relationship may result from spurious reverse causality. They suggested that exogenous economic shocks cause stock prices to fall immediately, whilst simultaneously signalling a "chain of events" where lower tax revenues lead to higher deficits, raising Federal Reserve monetisation, all in turn fuelling inflation. Therefore, falling stock prices may signal future inflation rather than being caused by it.

Overall, the literature remains highly contested and mainly focused on broader stock markets. As prior research rarely investigates the banking sector, it is unclear whether these variables impact UK banking equities differently than the wider market. This lack of consensus justifies including these variables in this research to fill the gap in the literature.

2.3 The 2008 Regime Shift

The 2008 financial crisis fundamentally changed the macroeconomic and regulatory conditions banks face, altering the relationships described above.

When in March 2009 the Bank of England slashed policy rates to a then historic low of 0.5% (Harari, 2017), the Deposit Lower Bound became binding. Rather than translating into proportional decreases in borrowing costs, the cuts tightened net interest margins, eroding the term-spread income that drives bank profitability.

Borio et al. (2017) examined 109 large international banks across 14 major advanced economies (of which the UK was one) from 1995-2012, and found this relationship to be non-linear, where the negative impact of low rates and squeezed term-spreads on profitability became more pronounced when interest rates are unusually low. This indicates that small movements in the interest rate or term-spread may have had a disproportionately large impact on bank stock prices compared to historical evidence on this relationship.

The crisis also ushered in stricter capital requirements under the Basel III framework. As outlined by Cohen & Scatigna (2016), the framework was implemented to force banks to build larger buffers of high quality capital and reduce the risk of their portfolios. Examining 101 large banks, including all major UK banks, these new capital ratios were achieved largely through retained earnings, widening lending spreads, and reducing dividends. Whilst widened

lending spreads partially offset the compressed term-spreads, reduced dividends diminish shareholder returns, further harming banking equity beyond macroeconomic predictions.

Collectively, the binding Deposit Lower Bound, non-linear compression of term-spread, and regulatory constraints on capital indicate that the financial crisis represented a fundamental shift in banking, whereby the relationships between macroeconomic conditions and bank share prices may have fundamentally changed.

2.4 Methodological Approach

A wide range of empirical approaches have been implemented in the literature to examine stock price-macroeconomy relationships. Much of the research employs Vector Error Correction Models (VECM) to examine both short- and long-run dynamics. Two such examples of research using this specification are Nasseh & Strauss (2000) and Ratanapakorn & Sharma (2007). They both employ similar approaches, performing relevant prerequisite tests including conducting unit root tests to verify all variables are integrated of the same order, $I(1)$. Both studies find stock prices and macroeconomic variables are not stationary in levels but become stationary in first differences. Then, they apply Johansen cointegration tests to identify long-run relationships amongst their variables. Finally, they estimate the VECM, which distinguishes the long- and short-run dynamics, with both pieces of research emphasising careful lag selection based on residual diagnostics.

However, a weakness of standard VECM and cointegration approaches is their vulnerability to parameter instability. Perron (1989) determined that if underlying data contained stationary fluctuations around a trend with a structural break, then standard univariate unit root tests are heavily biased towards failing to reject the null hypothesis, potentially incorrectly suggesting the presence of a unit root.

Building from this, Gregory & Hansen (1996) expanded the research to examine residual based tests for cointegration in multivariate models. Their research suggested that most researchers rely on standard Augmented Dickey-Fuller (ADF) tests on their multivariate model to search for cointegration. However, Gregory & Hansen stated that “if the model is indeed cointegrated with a one-time regime shift in the cointegrating vector, the standard ADF test may not reject the null and the researcher will falsely conclude that there is no long-run relationship”. Hence, testing for a structural break is necessary to avoid missing valid long-run relationships and misspecifying the final model.

2.5 Research Gaps and Contributions of this Research

This research aims to provide new insights into how UK bank stock prices respond to key macroeconomic indicators, and how these relationships have changed since the 2008 financial crisis. By focusing on UK banks and incorporating underexplored areas like housing market dynamics alongside other macroeconomic indicators, this research provides a more nuanced, up-to-date perspective largely vacant in the literature. Using recent data (2000-2020) and explicitly testing for structural breaks leads to more robust findings, revealing whether the crisis altered any fundamental relationships.

The findings of this research will be particularly valuable for policymakers seeking to understand the impacts of changes to macroprudential and monetary frameworks, as findings will highlight how UK banks' sensitivities to macroeconomic conditions have evolved under new regulatory and monetary regimes. For investors, the findings will aid portfolio allocation decisions by illustrating how the dynamics influencing bank stock performance vary across economic and regulatory environments.

3. Hypotheses and Data

3.1 Research Hypotheses

To test the applicability of both the Efficient Market Hypothesis (Fama, 1970) and Arbitrage Pricing Theory (Ross, 1976), whilst accounting for structural changes following the 2008 financial crisis, this research tests 3 hypotheses:

3.1.1 Preliminary Hypothesis

Before assessing how relationships evolved, it is necessary to establish whether a baseline relationship exists between bank stock prices and the selected macroeconomic variables.

H0: There is no statistically significant long-run cointegrating relationship between UK bank stock prices and the selected macroeconomic variables, in either the pre- or post-crisis period.

H1: There is a statistically significant long-run cointegrating relationship between UK bank stock prices and the selected macroeconomic variables in both periods.

3.1.2 Primary Hypothesis

This hypothesis addresses the core question of this research: whether the 2008 financial crisis caused a significant structural shift in how sensitive bank stock prices are to macroeconomic conditions.

H0: The sensitivity of UK bank stock prices to macroeconomic conditions remains unchanged following the 2008 financial crisis.

H1: The sensitivity of UK bank stock prices to macroeconomic conditions significantly altered following the 2008 financial crisis.

3.1.3 Secondary Hypothesis

This hypothesis tests whether post-crisis regulatory changes (e.g. Basel III) slowed the speed at which UK bank stock prices return to their long-run macroeconomic equilibrium.

H0: The speed of adjustment remains unchanged or increased following the financial crisis.

H1: The speed of adjustment significantly slowed following the financial crisis.

3.2 Data

3.2.1 Sample Period and Sub-Samples

This research uses a self-collated time-series dataset spanning January 2000 to February 2020, comprising 242 monthly observations. The sample begins in 2000, the earliest date with complete data for all variables, and ends in February 2020 to avoid conflating the 2008 crisis impacts with those of the COVID pandemic. The full sample is formally divided into 2 sub-samples (pre- and post-crisis) to empirically determine whether, and how, the relationships between bank stocks and macroeconomic conditions changed due to the 2008 financial crisis

The Quandt Likelihood Ratio (QLR) test, discussed in Section 5.1, is used to empirically identify a structural break in the data. However, economic intuition alongside visual inspections of the variables are also used to exclude the crisis period from the sub-samples to prevent biased estimations. The pre-crisis sub-sample (January 2000-April 2007; 88 observations) ends before early signals of the crisis, (e.g. Northern Rock's September 2007 collapse; Edmonds, 2010) to keep pre-crisis data uncontaminated. The post-crisis sub-sample

(May 2009-February 2020; 130 observations) begins after the crisis, ensuring post-crisis estimations reflect the recovery period, rather than the crisis itself.

This data exclusion is acknowledged as a limitation, as it reduces the overall number of observations in each sub-sample, constraining the degrees of freedom and inflating standard errors, thus potentially reducing the accuracy of parameter estimations. This methodological trade-off is considered a necessity to ensure unbiased estimations of the period-specific relationships.

3.2.2 Variable Descriptions

Table 1 provides an overview of all the variables used in this research, including the dependent variable and 5 macroeconomic independent variables.

Table 1. Variable Outline

Variable	Notation	Description	Source	Transformation
Dependent Variable				
UK Bank Index	<i>Bank</i>	Equally weighted Bank Index consisting of the UK ‘big four’: HSBC, Barclays, Lloyds and NatWest.	Investing.com	Natural Log
Independent Variables				
Term-Spread	<i>Tspr</i>	The difference in yields between long-term 10-year Government bonds and short-term 3-month interbank rates.	3-month interbank rates: FRED 10-year Government bonds: FRED	Levels
Gross Domestic Product	<i>GDP</i>	Monthly chained volume indices of gross value added estimates of GDP.	ONS	Natural Log
Consumer Price Index	<i>CPI</i>	Measures inflation based on changes in the price of a basket of goods and services consumed by households in the UK.	ONS	Natural Log
M4 Money Supply	<i>M4</i>	Total broad money, covering total physical cash and bank deposits.	Bank of England	Natural Log
House Price Index	<i>HPI</i>	Changes in the value of residential properties.	HM Land Registry	Natural Log

3.2.3 Dependent Variable

Due to constraints in UK banking index data availability over the sample period (2000-2020), the dependent variable in this research is a bespoke, equally weighted index of the monthly closing share prices of the UK’s ‘big four’ banks: HSBC, Barclays, Lloyds Banking Group, NatWest Group (formerly RBS). Given these 4 banks account for a high concentration of the UK banking sector, holding a combined market share of 70% of personal current accounts as

of 2023 (Scholle, 2026), this index provides a fair proxy for the aggregate performance of the UK's banking sector.

Equal weighting was favoured because market-capitalisation data across the full sample were unavailable. This is a potential limitation, since a market-capitalisation weighted index would more accurately reflect each bank's size and importance, therefore future research with more complete data could revisit this.

3.2.4 Independent Variables

This research utilises 5 macroeconomic independent variables, motivated by the literature discussed, to capture UK macroeconomic conditions.

Term-Spread: A self-constructed term-spread variable is employed (as outlined in Table 1), to capture the net interest margin banks can earn from maturity transformation (Flannery & James, 1984), and is retained in levels as negative values make logarithmic transformation inappropriate.

GDP: Included to test whether the under-researched theoretical transmission mechanism outlined by Albertazzi & Gambacorta (2009) holds true for UK bank stocks specifically.

CPI: Included to test the Fisher hypothesis in the context of UK bank stocks, with the divided literature making the post-crisis period of low inflation particularly worth analysing.

M4: Included despite contested findings in the literature to directly test this relationship in the context of the UK banking sector across both periods.

HPI: Included to capture the sensitivity of UK banks to the mortgage market, which is an underexplored area in the literature.

3.3 Descriptive Statistics and Preliminary Analysis

Table 2. Descriptive Statistics

Variable	Summary Statistic	Pre-Crisis	Post-Crisis
Dependent Variable			
Bank	Mean	125.192	34.747
	Std. Dev.	14.916	5.762
	Minimum	91.328	22.274
	Maximum	151.079	49.387
Independent Variables			
GDP	Mean	75.242	88.138
	Std. Dev.	3.922	5.837
	Minimum	68.733	78.778
	Maximum	82.341	97.403
Tspr	Mean	-0.002	1.473
	Std. Dev.	0.661	0.934
	Minimum	-1.044	-0.182
	Maximum	1.115	3.466
CPI	Mean	76.082	98.882
	Std. Dev.	2.633	6.070
	Minimum	71.900	86.400
	Maximum	81.600	108.600
M4	Mean	1,102,752.466	2,199,744.615
	Std. Dev.	205,244.985	135,199.398
	Minimum	812,289.000	1,979,365.000
	Maximum	1,555,577.000	2,529,164.000
HPI	Mean	46.181	68.569
	Std. Dev.	10.503	8.977
	Minimum	29.900	55.800
	Maximum	64.300	82.400

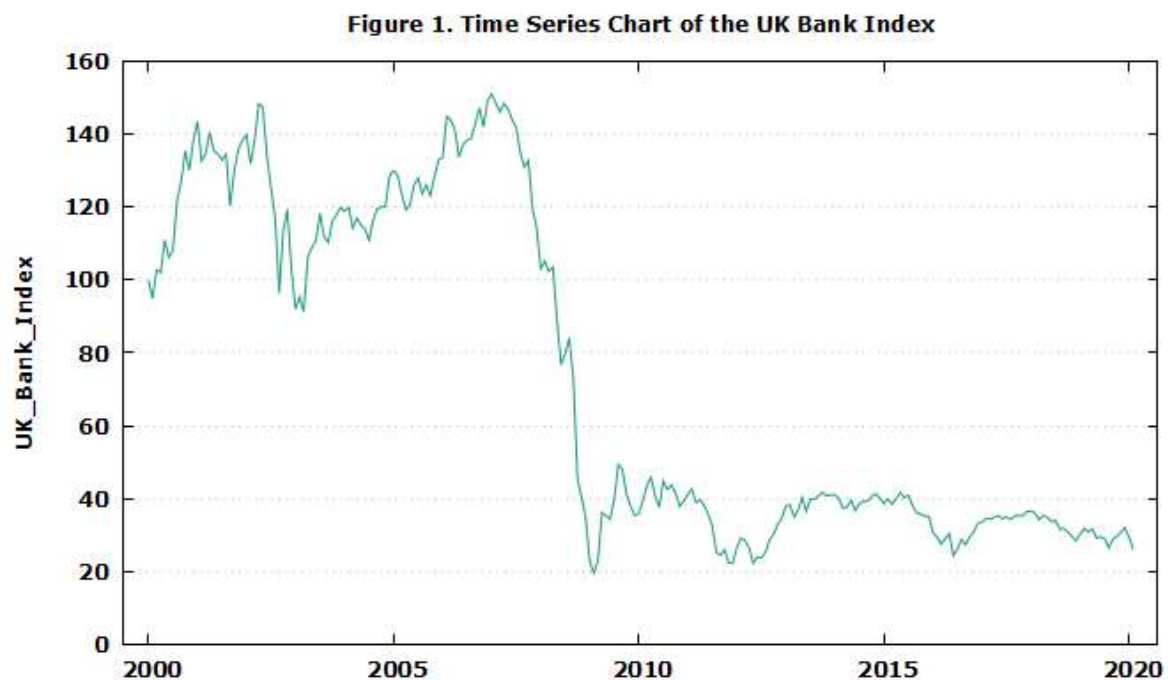
Summary descriptive statistics are presented across pre- and post-crisis sub-samples in Table 2. One of the most notable findings is the behaviour of the UK Bank Index, with both the mean and standard deviation falling sharply following the crisis. This indicates a permanently lower and less volatile level of UK banking equity post-crisis, aligning with general economic intuition. The substantial fall in the minimum value of the Bank Index following the crisis further showcases the extent of the damage the crisis exerted on the UK's banking sector.

The term-spread also warrants attention. Despite the post-crisis term-spread mean being considerably higher than the near-zero pre-crisis mean, UK bank stock prices were far lower post-crisis, indicating that the wider net interest margin failed to offset the structural damages of the financial crisis.

Table 3. Pre- and Post-Crisis Correlation Matrix

Pre-Crisis Post-Crisis	UK_Bank_Index	GDP	Term_Spread	CPI	M4_Money_Supply	HPI
UK_Bank_Index	1.000 1.000					
GDP	0.396 -0.339	1.000 1.000				
Term_Spread	-0.229 0.678	-0.088 -0.833	1.000 1.000			
CPI	0.434 -0.381	0.984 0.953	-0.125 -0.855	1.000 1.000		
M4_Money_Supply	0.467 -0.287	0.980 0.826	-0.178 -0.618	0.994 0.742	1.000 1.000	
HPI	0.301 -0.322	0.985 0.982	-0.052 -0.784	0.975 0.891	0.965 0.844	1.000 1.000

The correlation matrix reveals further features of the data. Most notably, the near 1 correlations across many of the independent variables in both sub-periods suggests the presence of high levels of multicollinearity. This provides initial support for this research's VECM specification, modelling the system jointly rather than isolating individual relationships. This also foreshadows the Variance Inflation Factor (VIF) results discussed in Section 6.2.1.



A visual inspection of the Bank Index in Figure 1 over the full sample period (2000-2020) confirms evidence of a clear structural break around 2008, peaking near 150 in 2007 before

collapsing to approximately 20 by early 2009. The post-crisis portion of the series then stabilises at a permanently lower level, providing the initial motivation for splitting the full sample, formalised by the QLR test in Section 5.1. The time series charts for all independent variables are found in the Annex.

4. Methodology

This research's modelling approach follows Engle & Granger's (1987) foundational framework, which posits that a system of non-stationary variables can be assessed by capturing both short-run dynamics and long-run cointegrating relationships. Engle & Granger accomplished this in two steps: first, by performing a cointegrating regression to identify the long-run equilibrium in levels; then by using the resulting residuals to model the short-term error correction. This framework allows for the examination of how UK bank stock prices respond to immediate changes in macroeconomic conditions, before prices correct towards their long-run trend.

Building on this foundation, Johansen (1988) extended the framework by adopting a maximum-likelihood approach that treats all variables as jointly endogenous. His methodology estimates the number of stable long-run cointegrating relationships within the model, represented by cointegration rank (r). If $r = 0$, no cointegrating equilibrium exists, whereas if $r \geq 1$, at least one long-term trend binds the variables. This is the VECM. The system is split into two main parts: cointegrating vectors, which define the long-run equilibrium relationships, and the adjustment coefficient (error correction term) which measures how quickly the variables correct short-term deviations.

5. Pre-Requisite Testing

Prior to running the final VECM model for each sub-sample, there is a structured sequence of prerequisite tests to determine whether a VECM is the appropriate model, and to identify the exact specification to use for each sub-sample.

5.1 Quandt Likelihood Ratio Test

To formalise the visual evidence of a structural break identified in Section 3.3, the QLR test (Quandt, 1960; Andrews, 1993) is implemented. The test calculates test statistics over a restricted central 70% (Andrews, 1993) of the 2000-2020 sample to identify the date that

maximises the statistic. The QLR test is conducted on an OLS regression consisting of the UK Bank Index and all macroeconomic variables across the full sample period, with all variables in the same specification as they will be in the final VECMs. The QLR test was conducted using the following model:

$$\ln_{Bank} = \alpha + Tspr + \ln_{GDP} + \ln_{CPI} + \ln_{M4} + \ln_{HPI}$$

The QLR test identified December 2008 as the breakpoint, with a chi-square of 358.662. Identifying this break provides initial evidence that the 2008 financial crisis fundamentally changed the relationship between UK banking equity and macroeconomic conditions. This break date formally justifies splitting the full sample into pre-crisis (2000:01-2007:04) and post-crisis (2009:05-2020:02) sub-samples.

The censoring period is intentionally wider than the recession itself, which lasted between Q2 2008 and Q2 2009 (Loh & Scruton, 2018). Whilst the post-crisis sub-sample period corresponds with the end of the recession, the censoring period intentionally precedes the beginning of the recession. This is because the onset of impacts to the banking sector became apparent before the start of the technical recession, for example, with Northern Rock's collapse in September 2007. Therefore, opting to end the pre-crisis period at April 2007 ensures that the sample is not contaminated by early stages of the crisis.

5.2 Augmented Dickey-Fuller Test

The next requirement in the time series prerequisite process is to determine whether the data are non-stationary, displaying the presence of a unit root. If this is the case, then this can cause stochastic trends in the data which introduce the possibility of random walk behaviour, potentially leading to spurious regressions. To confirm whether there is the presence of a unit root, the Augmented Dickey-Fuller (ADF) test is employed. The test specification was determined on a variable-by-variable basis, with an ADF test with constant and trend included for variables showcasing a clear deterministic trend, and only a constant for those with no clear trend. This approach ensures that the ADF specification reflects the properties of each variable rather than imposing a uniform specification across all variables. If the presence of unit roots is found across all variables, then the test will be rerun on the first difference of each variable to determine if that leads to the data becoming stationary.

Table 4. Augmented Dickey-Fuller test results on all variables across both sub-periods

Variable	Pre-Crisis Sample			Post-Crisis Sample		
	Test Used	P-Value (ADF test)	Unit Root (UR) Result	Test Used	P-Value (ADF test)	Unit Root Result
<i>ln_Bank</i>	With constant	0.154	UR present in all variables	With constant	0.193	UR present in all variables
<i>Tspr</i>		0.338		With constant and trend	0.067	
<i>ln_GDP</i>	With constant and trend	0.500			0.438	
<i>ln_CPI</i>		0.986			0.420	
<i>ln_M4</i>		0.999			0.940	
<i>ln_HPI</i>		0.837			0.905	

All six variables were found to be non-stationary. In each case, the p-values failed to reject the null hypothesis of the presence of a unit root. Therefore, each variable was first differenced, then the ADF test was repeated to determine if the data became stationary.⁴

Table 5. Augmented Dickey-Fuller test results on all first differenced variables across both sub-periods

Variable	Test Used	Pre-Crisis P-Value (ADF test)	Post-Crisis P-Value (ADF test)	Unit Root Result across both periods
<i>d ln_Bank</i>	With constant	0.000	0.000	UR not present at 5% significance level
<i>d Tspr</i>		0.000	0.000	
<i>d ln_GDP</i>		0.000	0.000	
<i>d ln_CPI</i>		0.001	0.015	
<i>d ln_M4</i>		0.000	0.000	
<i>d ln_HPI</i>		0.002	0.000	

Table 5 illustrates that upon differencing each variable, all variables become stationary, confirming both series are integrated of order 1, I(1). This uniform level of integration across variables satisfies the conditions necessary to conduct a cointegration test.

5.3 VAR Lag Selection

Time series data exhibit temporal dependencies; therefore, UK bank stock prices are likely influenced by their own previous values, and by historical macroeconomic conditions. Including lags is therefore crucial to capture these insights. A maximum number of lags to test down from must be selected in this test, and given this research uses monthly time series

⁴ A process called the difference-stationary process.

data, 6 lags were chosen. The chosen test criterion is the Akaike Information Criteria (AIC) given its ability to analyse limited sample sizes.

Table 6. VAR Lag Selection test results

Lag	Pre-Crisis Period		Post-Crisis Period	
	AIC	Optimal Lag Order	AIC	Optimal Lag Order
1	-34.604	No	-34.270	No
2	-34.445		-34.430*	Yes
3	-34.611*	Yes	-34.359	No
4	-34.514	No	-34.189	
5	-34.564		-34.018	
6	-34.373		-33.877	

The optimal lag order corresponds with the lowest AIC value. Table 6 highlights that the optimal lag orders are three pre-crisis and two post-crisis.

5.4 Johansen Cointegration Test

Utilising the work of Johansen (1991), a Johansen cointegration test will be conducted to identify any stable long-run relationships among the variables, where at least one cointegrating relationship is required to undertake a VECM specification. The test rearranges a Vector Autoregressive Model into error correction form to isolate the central coefficient matrix, or ‘impact matrix’. The test specifically identifies the rank of this matrix, which represents the number of stable cointegrating vectors (relationships) in the model. The null hypothesis states that there are no more than r cointegrating vectors, while the alternative hypothesis states that further cointegrating relationships exist. Therefore, rejection of the null provides evidence that additional cointegrating relationships exist.

Table 7. Johansen Cointegration Test Results

Cointegration Rank	Pre-Crisis sample		Post-Crisis sample	
	Trace-test P-value	Lmax test P-value	Trace-test P-value	Lmax test P-value
0	0.000	0.001	0.000	0.000
At most 1	0.000	0.004	0.129	0.128
At most 2	0.041	0.053	0.512	0.815
At most 3	0.347	0.326	0.444	0.706
At most 4	0.621	0.657	0.336	0.516
At most 5	0.322	0.322	0.110	0.110

As seen in Table 7, the pre-crisis sample displays three cointegrating relationships, whereas the post-crisis sample displays only one. In the pre-crisis period, although the Lmax test for at most two cointegrating vectors is only narrowly insignificant at the 5% level, the Trace-test provides sufficient statistical evidence to reject the null hypothesis, supporting the inclusion of a third cointegrating relationship. Conversely, the post-crisis period highlights a shift in long-run dynamics. The null hypothesis of at most one cointegrating vector could not be rejected, indicating only one cointegrating relationship persists following the financial crisis.

These findings reject the null hypothesis of the preliminary hypothesis of this research, confirming the existence of at least one cointegrating relationship across both sub-samples. This therefore satisfies the requirements, along with the other preliminary tests discussed above, to use a VECM specification for estimation across both periods.

5.5 Final Model Specifications

The final model for both the pre- and post-crisis sub-samples, use VECM specifications, estimated using the same set of variables but differing in lag length and cointegration rank.

5.5.1 Pre-Crisis sub-sample

For the pre-crisis period, the final model is of lag order three with three cointegrating relationships. In VECM form, this is represented by two lags of first differenced variables with three Error Correction Terms (ECT):

$$\Delta \ln Bank_t = \beta_0 + \sum_{i=1}^2 \Gamma_i \Delta X_{t-i} + \sum_{j=1}^3 \alpha_j ECT_{j,t-1} + \varepsilon_{t-1}$$

In both sub-samples, ΔX_{t-i} represents the vector of exogenous independent variables, including the lagged first differences, while Γ_i represents short-run coefficients. The ECT ($ECT_{j,t-1}$) represents the long-run cointegrating relationships, with their respective α_j coefficients signifying the speed at which the system returns to equilibrium following short-run shocks.

5.5.2 Post-Crisis sub-sample

For the post-crisis period, the final model is of lag order two with one cointegrating relationship. In VECM form, this is represented by one lag of first differenced variables with one ECT.

$$\Delta \ln Bank_t = \beta_0 + \Gamma_1 \Delta X_{t-1} + \alpha_1 ECT_{1,t-1} + \varepsilon_{t-1}$$

To ensure the validity of subsequent outputs, diagnostic tests were performed on both models, testing for autocorrelation and heteroskedasticity. The pre-crisis model showed signs of heteroskedasticity, using White's test (p-value=0.036), whilst the post-crisis model exhibited second order autocorrelation, using Breusch-Godfrey's LM test (p-value=0.012). Conversely, the post-crisis model showed no signs of heteroskedasticity (p-value=0.484), and the pre-crisis model exhibited no signs of autocorrelation (p-value=0.164). To address these violations across both samples, all subsequent models were estimated using HAC Newey-West robust standard errors to mitigate the risk of Type 1 errors.⁵ This ensures that the statistical significance of the resulting findings are valid.

6. Empirical Results

6.1 Model Fit

The post-crisis VECM yields an R-squared of 0.108 and adjusted R-squared of 0.057, with an F-statistic of 2.352, significant at the 5% level (p=0.028). Whilst the model's explanatory power appears low, this likely reflects the innate difficulty of predicting monthly changes in differenced bank stock prices which largely follow a random walk pattern in efficient markets. Nevertheless, the significant F-statistic confirms that the macroeconomic variables jointly explain a statistically significant portion of the UK bank index's variation.

The pre-crisis specification produces an R-squared of 0.244 and adjusted R-squared of 0.080, with an F-statistic of 1.463, which is not significant even at the 10% level (p-value=0.144). Despite this weak overall model fit, likely in part due to the small sample of 85 observations for 16 parameters, it does capture several significant long- and short-run relationships that still provide valuable insights into the pre-crisis relationships.

⁵ A false positive finding of statistical significance

6.2 Long-run Cointegrating Relationships

6.2.1 Pre-Crisis

Before interpreting the cointegrating equations, it should be noted that across both sub-samples the level variables show signs of substantial multicollinearity. VIF values range from 1.422 (*Tspr*) to 183.756 (*ln_M4*) pre-crisis and 3.310 (*ln_M4*) to 177.992 (*ln_GDP*) post-crisis, greatly exceeding the threshold of 10 in most cases. This likely contributes to the large coefficients seen in places, which should be interpreted cautiously.

To interpret the coefficients of the cointegrating equation, the positive and negative signs are flipped, as the equation subtracts the coefficient. Therefore, the pre-crisis cointegrating equation is:

$$\ln_{Bank} = -51.864l_{CPI} + 11.807l_{M4} - 1.271l_{HPI}$$

CPI's large negative coefficient indicates sustained inflation eroded UK bank stock prices pre-crisis, contradicting the Fisher hypothesis. This may suggest UK banks were unable to fully pass through inflationary pressures to borrowers pre-crisis. The positive M4 coefficient implies that the expansion of both credit and broad money pre-crisis supported UK banks' profitability and thus stock prices. The negative HPI coefficient subverts expectations, opposing the expectation that rising collateral values, such as house prices, support the profitability of UK banks.

6.2.2 Post-Crisis

With the cointegration rank falling to 1 post-crisis, the cointegrating equation is:

$$\ln_{Bank} = 0.341Tspr + 52.211l_{GDP} - 18.481l_{CPI} - 0.988l_{M4} - 16.598l_{HPI}$$

Post-crisis, the large positive GDP coefficient indicates that the long-run determinants of UK bank stock prices shifted from monetary factors (CPI and M4) pre-crisis to real economic performance post-crisis. This is consistent with the tightening of lending regulations and supply of credit post-crisis. CPI retains a large negative coefficient, reinforcing inflation's eroding effect on banking equity as a structural relationship rather than a pre-crisis specific relationship. Given the near-zero interest rates post-crisis, term-spread's inclusion in the post-crisis equation indicates that when interest rates tend towards zero, term-spread becomes a more crucial driver of banking profitability and equity.

6.2.3 Speed of Adjustment

Table 8. Summary of Error Correction Terms

Variable	Normalised Variable	P-value	Coefficient
<i>Pre-Crisis</i>			
ECT_1	$\ln_{Bank}$	0.011	-0.168
ECT_2	$\ln_{Tspr}$	0.376	-0.008
ECT_3	$\ln_{GDP}$	0.042	2.999
<i>Post-Crisis</i>			
ECT_1	$\ln_{Bank}$	0.016	-0.074

Pre-crisis, the model had three cointegrating relationships, two of which were statistically significant. ECT_1 was significant, indicating that when bank stock prices deviate from their long-run equilibrium, through short-term macroeconomic shocks, 16.8% of the deviation was corrected per month. ECT_3 was also significant, with a large positive coefficient, suggesting the bank index was diverging from, rather than correcting towards, the equilibrium of the third cointegrating relationship, normalised on GDP. Rather than a meaningful adjustment process, the abnormally large coefficient likely reflects the instability of that relationship.

Post-crisis, these adjustment dynamics slowed considerably. The single post-crisis ECT remained significant; however, the coefficient halved to 7.4%. This provides evidence to reject the null hypothesis of the secondary hypothesis of this research, indicating that bank stock prices became significantly less responsive to long-run imbalances, requiring far longer to correct macroeconomic deviations.

6.3 Short-Run Relationships

Pre-crisis, CPI and M4 were the only significant short-run determinants of UK banking equity. The coefficient of the first lag of M4 implies that a 1% increase in broad money supply last month reduced banking equity by 2.88%, suggesting that short-run money supply expansion was perceived as a warning sign of overheating credit conditions and heightened risk. The second lag of CPI indicates that a 1% increase in CPI two months ago increases banking equity by 5.44% today, in contrast to the negative relationship found in the long-run, indicating a short-run Fisher hypothesis that dissipates over time.

Post-crisis, the few short-run determinants found pre-crisis disappeared, with none of the macroeconomic variables achieving significance at the 5% level. This breakdown in short-run transmission likely reflects the structural changes introduced following the crisis, such as Basel III capital requirements. This contradicts the semi-strong form of the EMH, suggesting that the macroeconomy was no longer being rapidly incorporated into UK bank stock prices in the short-run. This is reinforced by the Granger-causality results discussed below. However, the persistence of a long-run cointegrating relationship confirms that whilst the overall relationship weakened, becoming less complex, it was not severed entirely.

6.4 Granger-Causality and Reverse Causality

Finally, Granger-causality tests were conducted to formally identify causality between each macroeconomic variable and the UK banking index, rather than just a significant linear relationship. The same procedure was applied in the opposite direction to assess whether the Bank Index causes changes in macroeconomic conditions.

Table 9: Granger-Causality Results

Causal Direction	Pre-Crisis p-value	Post-Crisis p-value
Macroeconomic variable à Bank Index		
<i>Tspr</i>	0.248	0.691
<i>ln_GDP</i>	0.212	0.452
<i>ln_CPI</i>	0.091	0.534
<i>ln_M4</i>	0.022	0.079
<i>ln_HPI</i>	0.919	0.415
Bank Index à Macroeconomic variable		
<i>Tspr</i>	0.113	0.125
<i>ln_GDP</i>	0.778	0.730
<i>ln_CPI</i>	0.095	0.625
<i>ln_M4</i>	0.163	0.570
<i>ln_HPI</i>	0.624	0.051

The results of these tests reveal a fundamental shift in the causal relationships between UK bank stock prices and macroeconomic conditions. Pre-crisis, M4 is the only macroeconomic variable that Granger-causes the Bank Index, consistent with the short-run dynamics identified, reinforcing that money expansion was the dominant macroeconomic factor impacting banking equity pre-crisis. Despite CPI falling short of significance at the 5% level, its significance at the 10% level corroborates the evidence of a short-run relationship found

previously. In the reverse direction, the Bank Index displays significance in predicting CPI at the 10% level, indicating an element of bidirectionality between the banking sector and inflation pre-crisis, corroborating Geske & Roll's (1983) reverse causality prediction.

Post-crisis, no macroeconomic variables showcase Granger-causality with the Bank Index in either direction. The only exception is the Bank Index Granger-causing HPI at the 10% level. This indicates a possible feedback channel from the health of the UK's banking sector to property prices post-crisis, which may warrant further investigation in future research. The broader disappearance of short-run causality post-crisis reinforces the structural shift identified thus far that banking equity became detached from short-run macroeconomic fluctuations, with the relationship operating exclusively on a long-run basis post-crisis.

6.5 Robustness Tests

A range of robustness tests were conducted on both pre- and post-crisis models to ensure the validity of findings.

Table 10: Robustness Tests

Test	Pre-Crisis	Post-Crisis
	Statistic (p-value)	
Ramsey RESET	$TR^2=13.374$ (0.573)	$TR^2=11.598$ (0.115)
Jarque-Bera	$Chi^2=0.322$ (0.851)	$Chi^2=5.195$ (0.074)

Both models displayed no sign of misspecification following Ramsey RESET tests, failing to reject the null hypothesis, confirming appropriate functional form across both periods. To ensure the validity of result inferences, residuals were tested for normality using Jarque-Bera tests. Results indicated that the null hypothesis of normally distributed residuals could not be rejected at the 5% level in either sub-sample, supporting the validity of inferences made across both models. However, the post-crisis model rejects the null hypothesis at the 10% level, which may reflect excess kurtosis introduced by a few extreme observations in the post-crisis period, such as observations surrounding Brexit, rather than fundamentally violating the assumption of normality.

As an additional check on the initial concern of autocorrelation in the post-crisis model, an additional specification with three lags was tested. This fully resolved the issue of

autocorrelation.⁶ However, it introduced issues of functional form by failing a Ramsey RESET test, likely due to over-parameterisation given the 129 available observations.⁷ Therefore, the two-lagged specification with robust standard errors was kept as the preferred post-crisis specification.

Finally, VIFs were computed for each variable, to determine whether multicollinearity poses a risk to model interpretation. The VIF values for all the differenced variables used in the final models fell beneath 10, the conventional value to suggest no multicollinearity concern, confirming no risk of multicollinearity across either model. As mentioned in Section 3.3, VIFs were also computed on the raw level of each variable, with many of the variables showcasing severe multicollinearity, far above 10. This provides methodological justification for the use of a VECM, reinforcing the appropriateness of the modelling approach utilised.

7. Conclusion

7.1 Findings and Policy Implications

The empirical evidence produced in this research illustrates signs of a structural shift in the relationship between UK bank stock prices and macroeconomic conditions following the 2008 financial crisis. These findings carry direct implications for monetary and macroprudential policies.

Johansen cointegration tests on both sub-samples support the preliminary hypothesis, confirming at least one long-run cointegrating relationship across both periods. However, the reduction from three to one cointegrating relationship following the crisis provides initial support to the primary hypothesis of a structural change in the relationship.

The empirical results further support the primary hypothesis of a structural shift in the sensitivity of UK bank stock prices to macroeconomic conditions post-crisis. Pre-crisis, UK banking equity was driven by nominal monetary factors (e.g. inflation and money supply), and money supply was the only macroeconomic variable that Granger-caused bank index movements. This indicates that money and credit conditions provided short-run predictive power over UK bank stock prices. Post-crisis, this monetary transmission mechanism eroded. No macroeconomic variables were significant in the short-run, and the sole remaining long-

⁶ Breusch-Godfrey p-value=0.997

⁷ RESET P-value=0.035

run relationship shifted towards real economic activity, with GDP assuming the largest coefficient.

Term-spread's emergence as a long-run determinant of UK banking equity in the post-crisis period is also important, as it indicates that when rates approached zero, the Deposit Lower Bound became a significant determinant of UK banking profitability and equity. These have direct policy implications. In near-zero interest rate environments, further rate cuts may be counterproductive; therefore, policies that protect the term-spread should take priority. More broadly, conventional monetary policy measures, such as expansion of the money supply or adjustments to the base rate, cannot be relied on to support the UK's banking sector valuations through the same channels as pre-crisis.

Results also confirm the anticipated outcome of the secondary hypothesis, that the speed of adjustment significantly slowed post-crisis. Pre-crisis, 16.8% of any deviation from the bank index's long-run macroeconomic equilibrium was corrected each month, indicating that macroeconomic shocks were unlikely to generate prolonged misalignments between UK banking equity and the macroeconomy. Post-crisis, this halved to 7.4%, meaning banking equity was far less responsive in realigning with its long-run macroeconomic equilibrium. For regulators, post-crisis bank stock prices are no longer reliable as immediate indicators of sector recovery. Therefore, monitoring frameworks should prioritise internal metrics, including capital ratios and balance sheet strength, over stock prices.

Finally, post-crisis, the Bank Index Granger-causes house prices at the 10% level, rather than the reverse. This indicates the post-crisis health of the UK's banking sector moderately influenced house prices, potentially reflecting reduced mortgage availability following the reduction in lending. As this result is only significant at the 10% level, it should be treated cautiously. However, it presents an area for future research.

7.2 Limitations and Future Research

Whilst this research offers new insights into the underexplored area of the link between UK banking equity values and the macroeconomy, there are several limitations that warrant attention and provide future avenues of research. Excluding the crisis-period leaves only 88 pre-crisis observations, constraining the degrees of freedom, contributing to the insignificant F-statistic of the pre-crisis model. Future research could extend the sample backwards to improve estimation precision by increasing observations. Alternatively, re-estimating the

VECM across successive sub-samples of a fixed length could highlight more granularly how the relationship between UK bank stocks and the macroeconomy evolves over time, rather than including a binary split point in the data.

Due to data limitations, the dependent variable is a self-constructed index of the largest four banks in the UK. Whilst this captures the dominant banks, it does limit exposure to the wider sector. Future research could seek to extend the index, improving the breadth of coverage. Additionally, going one step further and focusing on the firm level could uncover whether the findings here are common across the broader sector or concentrated in particular banks.

Because the post-crisis period may include additional structural changes (e.g. phased Basel III implementation or Brexit) that are insufficiently captured by a single VECM, a QLR test within the post-crisis sub-sample could formally test for secondary structural breaks in the recovery period. Finally, extending the dataset beyond February 2020 to include COVID and the recent high inflation, rising interest rate environment, could reveal whether the post-crisis structural changes have persisted, or whether the return of higher interest rates since 2022 is restoring pre-crisis transmission mechanisms.

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Annex

