Analyzing GDP and stock market dynamics

Studies in Economics and Finance

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Abstract

Purpose – This paper aims to examine whether the forces linking financial markets to real economic activity operate differently across business cycle phases, using quarterly US data from 1990 to 2024, spanning four recession episodes. Specifically, the author asks whether the mechanism that normally keeps equity markets anchored to corporate earnings and real output remains stable between expansions and recessions and what the accumulated output cost is when that mechanism breaks down.

Design/methodology/approach – The author first estimates a vector error correction model among real gross domestic product (GDP), the S&P 500 Total Return Index and Earnings Per Share, using cointegration tests to identify the long-run equilibrium structure and controlling for monetary policy, consumer confidence, market uncertainty and real GDP expectations. The author then extends this to a Bayesian Markov-Switching vector error correction model that holds the cointegrating vectors constant while allowing adjustment dynamics and shock covariance structures to vary across regimes, with regime identification anchored to NBER recession dates.

Findings – The author identifies two stable long-run equilibria anchored by earnings per share. This study finds that the stock market index self-corrects toward its earnings equilibrium in normal expansions, while in recessions, the adjustment coefficient linking the stock market index to earnings reverses sign, with the index moving further from earnings fundamentals; as the Granger causality tests detect predictive content from stock returns and earnings growth to GDP growth but not in the reverse direction, no offsetting predictive force is found within the estimated system. The accumulated output cost amounts to 1.78 percentage points of cumulative GDP growth deficit by quarter 20 following a recession onset.

Originality/value – The author provides direct evidence that the corrective mechanism linking the stock market index to its long-run earnings equilibrium is regime-dependent, reversing during recessions in a way that has not previously been documented within a regime-switching cointegration framework.

Keywords Regime switching, Vector error correction model, Markov-switching, GDP dynamics, Financial markets, Bayesian estimation, Cointegration, Stock market, Economic activity

Paper type Research paper

1. Introduction

Financial variables and real economic activity routinely diverge in their pace of adjustment during downturns: equity markets reprice quickly, while output and employment recover more slowly. In the second quarter of 2020, real gross domestic product (GDP) contracted at an annualized rate of 31.4% and unemployment stood at 8.4% (Bureau of Economic Analysis, 2020; Bureau of Labor Statistics, 2020), while the S&P 500 had returned to its pre-pandemic level by August. A similar pattern followed the 2008–2009 recession: the S&P

JEL classification – C32, E44, G12

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500 recovered to its pre-crisis peak by early 2013, while real GDP growth averaged 1.9% annually through 2013, and employment did not return to pre-crisis levels until 2014 (Center on Budget and Policy Priorities, 2019). In both episodes, financial variables adjusted rapidly, while the real economy followed a slower, more uncertain path, indicating that the relationship between markets and economic activity operates differently during crisis periods than during normal expansions.

Standard linear models, including vector error correction models, routinely applied in macro-financial research, impose constant parameters on data spanning multiple recessions, financial crises and recovery episodes. Under this assumption, crisis episodes represent large shocks within an unchanged adjustment mechanism: the system takes longer to restore equilibrium because the deviation is larger, not because the correction process itself has changed. If, however, adjustment dynamics, shock transmissions and equilibrium co-movements differ systematically between expansion and contraction periods, then constant-parameter estimates represent averages that accurately characterize neither state, and the divergences observed in 2009 and 2020 are not anomalies to be explained away but evidence of a feature that constant-parameter models are not equipped to capture.

Using quarterly US data from 1990 through 2024, we estimate long-run relationships among real GDP, the stock market index and corporate earnings and test whether the dynamics sustaining those relationships differ between expansions and recessions. In expansions, the adjustment coefficient linking the stock market index to earnings is consistent with equity markets functioning as price-discovery mechanisms, with the index adjusting back toward what earnings per share justify when deviations arise. In recessions, this coefficient reverses sign: equity markets appear to stop functioning as price-discovery mechanisms as constraint-driven selling displaces fundamental-value trading at the margin, amplifying deviations from the earnings equilibrium rather than correcting them. As no offsetting predictive relationship from GDP growth to financial variables is detected, the simulated output cost accumulates through the amplifying dynamics estimated for the recession regime rather than through the magnitude of the initial shock.

The above findings sit at the intersection of two strands of literature. Regime-switching studies establish that financial market dynamics and the predictive content of financial variables for real activity shift systematically across business cycle states (Just and Echaust, 2020; Fromentin, 2022; Phoong *et al.*, 2023; Bouteska *et al.*, 2023), while cointegration studies confirm stable long-run equilibrium relationships between stock markets and macroeconomic variables (Humpe and McMillan, 2020; Humpe *et al.*, 2025). The regime-switching literature has primarily characterized how correlations and predictive relationships shift across states rather than how the equilibrium adjustment dynamics themselves change, while cointegration studies have established the long-run equilibrium structure under the assumption of constant parameters, leaving the regime-dependence of the adjustment process unexamined. This paper draws on both by estimating a Bayesian Markov-switching vector error correction model (VECM) that holds the long-run cointegrating relationships among real GDP, the stock market index and earnings per share constant while allowing the adjustment dynamics toward that equilibrium to vary freely across expansion and recession regimes. This combination allows a direct characterization of how the speed and direction of error correction toward the GDP–stock–earnings equilibrium change across business cycle states, enabling an assessment of whether regime-dependent adjustment is a recurring pattern of the expansion–recession transition rather than a feature of any particular downturn, across four distinct US recession episodes from 1990 through 2024 and translating those dynamics into quantified output costs through deterministic counterfactual analysis.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and identifies the research gap. Sections 3 and 4 describe the data and empirical methodology. Section 5 reports results. Section 6 discusses implications and limitations. Section 7 concludes.

2. Previous literature

The theoretical case for a stable long-run relationship between financial markets and real economic activity rests on two complementary channels. The first operates through market valuations: stock prices aggregate forward-looking information about corporate profitability, investment opportunities and discount rates, making them natural leading indicators of real economic activity (Fischer and Merton, 1984; Fama, 1990; Schwert, 1990; Estrella and Mishkin, 1998). The second operates through corporate fundamentals: earnings per share directly reflect the profitability that drives hiring, capital expenditure and production decisions, linking financial performance to real output through the investment channel (Barro, 1990; Cochrane, 2005a). These channels are analytically distinct: a specification that includes only stock returns conflates them, and a finding for returns does not necessarily imply a finding for the fundamentals that ultimately underpin those returns.

Empirical work confirms the long-run dimension of this relationship across a range of economies, time periods and methodological approaches. Cointegration and vector error correction studies consistently establish stable equilibrium relationships between stock markets and real activity (Lee, 1992; Mukherjee and Naka, 1995; Cheung and Ng, 1998; Alexius and Spång, 2018; Humpe *et al.*, 2025), and predictive content analysis shows that both stock returns and bond yields carry complementary forward-looking information about GDP growth, with stock returns being particularly informative at shorter horizons (McMillan, 2021). This body of work establishes the long-run equilibrium framework within which the present analysis is situated.

The assumption of parameter constancy embedded in standard VECM specifications becomes difficult to defend as evidence from time-varying methods, subsample analysis and regime-switching frameworks consistently shows that financial market–GDP relationships shift across business cycle states, with constant-parameter models averaging across fundamentally different data-generating processes.

The most direct evidence comes from studies that use time-varying methods and subsample analyses. Across the US and other economies, the predictive content of financial variables for GDP growth, the causal direction of the stock price–GDP relationship and the co-movement structure between financial and real variables all shift systematically across business cycle phases, with the relationships established in stable periods breaking down or reversing during recessions and acute crisis episodes (McMillan, 2021; Davis *et al.*, 2022; Fromentin, 2022). The regime-switching literature reinforces this: co-movement structures, tail dependencies and shock transmission mechanisms within financial markets are themselves regime-dependent, with crisis periods consistently producing parameter configurations that diverge sharply from expansion-period norms (Just and Echaust, 2020; Liu *et al.*, 2022; Bouteska *et al.*, 2023; Yunus, 2023; Nakajima, 2024). Recent evidence strengthens the case further: financial shocks generate protracted effects on real activity only when they are both negative and large (Forni *et al.*, 2024), business cycle downturns exhibit asymmetric fat-tailed output dynamics that distinguish financial crisis recessions from normal recessions (Jordà *et al.*, 2024) and models incorporating financial stress indices outperform real-variable-only models in identifying business cycle regimes during downturns (Giampaoli *et al.*, 2024).

What remains unexamined is the structure of that instability within a system that jointly captures long-run equilibrium and short-run dynamics. Regime-switching studies characterize how correlations and predictive relationships shift across states, but not how the equilibrium adjustment dynamics themselves change. Cointegration studies establish the long-run equilibrium structure under constant parameters and cannot characterize how adjustment toward that equilibrium varies across regimes. Neither stream has, therefore, asked whether the error-correction mechanism linking the stock market index to its long-run earnings equilibrium operates differently across expansion and recession states or what the accumulated output cost of that regime-dependence is within a cointegrating system. This paper addresses both questions by estimating a Bayesian Markov-switching VECM that holds the cointegrating relationships constant while allowing adjustment dynamics to vary across regimes, documenting the pattern across four distinct US recession episodes from 1990 through 2024 and quantifying the output cost through deterministic counterfactual analysis.

3. Data

3.1 Sample period and variables

The analysis uses quarterly US data spanning 1990:Q1 through 2024:Q1, capturing multiple complete business cycles and two major crises differing substantially in character: the 2008 financial crisis and the 2020 COVID-19 pandemic. The starting point of 1990 reflects the availability of consistent quarterly earnings per share data for the S&P 500 and quarterly Survey of Professional Forecasters data.

The analysis focuses on the US economy for three reasons. The USA hosts the world's largest and most liquid equity market, providing the longest and most reliable quarterly series for the variables required by the MS-VECM specification. The institutional and monetary policy framework is unified across the sample period, avoiding the structural breaks that would accompany a multi-country panel covering events such as the European monetary union. Finally, the Survey of Professional Forecasters, which provides the GDP expectations measure used as an exogenous control, has no direct equivalent for other major economies at quarterly frequency over the full sample.

Three variables form the endogenous core of the analysis. Real GDP is the seasonally adjusted quarterly chain-weighted measure from the Bureau of Economic Analysis, expressed in billions of chained 2017 dollars, and represents the comprehensive measure of aggregate economic activity standard in macro-financial research (Cochrane, 2005b; Alexius and Spång, 2018). Stock market performance is measured through two complementary variables rather than a single price index. The S&P 500 Total Return Index captures both price appreciation and reinvested dividends, providing a more complete measure of equity market performance than price-only indices. Earnings per share represents the end-of-quarter S&P 500 as reported earnings, capturing realized corporate profitability as a fundamental driver of investment, hiring and production decisions (Barro, 1990). Together, these two variables separate the expectational component of market valuations from the fundamental component. Alternative metrics such as dividend yield and price-to-earnings ratios are functions of these two underlying series and would introduce collinearity into the cointegrating system without adding independent information about the GDP–financial market relationship. All three endogenous variables enter the cointegrating relationships in log levels, referred to throughout as real GDP, the stock market index and earnings per share, and enter the short-run dynamics in first differences, referred to as GDP growth, stock returns and earnings growth.

Four variables serve as exogenous controls. The federal funds rate captures the Federal Reserve's monetary policy stance. The Organization for Economic Co-operation and Development (OECD) Composite Consumer Confidence Index reflects household sentiment and forward-looking spending behavior. The Chicago Board Options Exchange (CBOE) Volatility Index measures implied equity market uncertainty and investor risk aversion. GDP expectations are the median real GDP growth forecast from the Survey of Professional Forecasters, controlling for forward-looking information embedded in agents' expectations. Data sources and series identifiers are provided in Table 1.

3.2 Data transformations

All variables are transformed before estimation to ensure stationarity and stabilize variance. Table 1 summarizes the transformation applied to each variable. All variables are log-transformed, with the exception of earnings per share, which uses the inverse hyperbolic sine (IHS) transformation because S&P 500 aggregate earnings occasionally take negative values, most notably during the 2008 financial crisis, when widespread write-downs in the financial sector produced negative aggregate earnings. IHS is defined as $\ln(x + \sqrt{(x^2 + 1)})$, approximates the logarithm for large positive values and yields coefficients interpretable analogously to log coefficients for values sufficiently far from zero. First differences of log-transformed variables approximate quarterly percentage growth rates.

3.3 Summary statistics

Supplementary Material A presents full data visualization: Figures A1, A2 and A3 plot the log-transformed and IHS-transformed endogenous variables in levels, and Figures A4, A5 and A6 plot their first differences. The growth rate series reveal elevated volatility during the four identified crisis episodes, particularly the 2008–2009 financial crisis and the Q2 2020 COVID-19 contraction. These visual patterns in the raw data motivate the parameter stability tests presented in Section 4.4.

Table 1. Variable transformations and data sources

Variable	Abbreviation	Transformation	Seasonal adjustment	Data source
Real GDP	LRGDP	Logarithm	Yes	FRED: GDPC1 (The USA Bureau of Economic Analysis)
S&P 500 Total Return Index	LTR	Logarithm	No	Yahoo! Finance: S&P 500 (TR) (^SP500TR)
Earnings per Share	LLEPS	Inverse hyperbolic sine	No	S&P 500 Earnings and Estimate Report: As reported earnings per share
Federal funds rate	LFFR	Logarithm	No	FRED: FEDFUNDS (board of governors, federal reserve system)
Consumer confidence index	LCCI	Logarithm	Yes	FRED: USACSCICP02STSAM (OECD, Consumer Opinion Surveys: Composite Consumer Confidence for United States)
CBOE volatility index	LVIX	Logarithm	No	FRED: VIXCLS (Chicago board options exchange)
GDP expectations (SPF)	LRGDPE	Logarithm	Yes	Federal reserve bank of Philadelphia, SPF series: RGDP

Note(s): Logarithmic transformation is applied as $\ln(x)$. Inverse hyperbolic sine (IHS) is defined as $\ln(x + \sqrt{(x^2 + 1)})$. First differences of log-transformed variables approximate quarterly percentage growth rates

4. Empirical methodology

The empirical strategy proceeds in five sequential steps: unit root testing to confirm order of integration, Johansen cointegration analysis and baseline VECM estimation, weak exogeneity testing to validate the treatment of control variables, parameter stability diagnostics to motivate the regime-switching extension and MS-VECM specification and estimation.

4.1 Unit root testing

We apply the ADF-GLS test of Elliott, Rothenberg and Stock (1996) to all variables in levels and first differences, with lag length selected by the Bayesian Information Criterion (Schwarz, 1978). The results confirm that all variables are integrated of order one: unit roots cannot be rejected in levels but are rejected in first differences at conventional significance levels. Full results are reported in Supplementary Material Table B1.

4.2 Cointegration and baseline vector error correction model

4.2.1 Baseline vector error correction model specification. Variables are cointegrated if there exists a stationary linear combination among them, indicating a stable long-run equilibrium relationship (Engle and Granger, 1987). We apply the Johansen (1991) maximum likelihood procedure to test for cointegration rank among the three endogenous variables and to estimate the associated VECM. The baseline specification is as follows:

$$\Delta \mathrm{Y}_{\mathrm{t}} = \alpha \beta^{'} \mathrm{Y}_{\mathrm{t}-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathrm{Y}_{\mathrm{t}-\mathrm{i}} + \mu + \varepsilon_t$$

where Y_{t} is a 3 × 1 vector of endogenous variables (real GDP, S&P 500 Total Return Index and earnings per share); α is the 3 × r matrix of adjustment coefficients (the speed of adjustment); β is the r × 3 matrix of cointegrating vectors defining long-run equilibrium relationships; Γ_i includes the coefficient matrices of the short-run effects; μ is a vector of constants; and ε_{t} is a vector of identically and independently distributed error terms. The constant is restricted to the cointegrating space following Johansen (1991, 1995) and Johansen and Juselius (1990), capturing deterministic trends in the long-run equilibrium without inducing quadratic trends in levels. Lag length is selected by BIC applied to the VAR in levels, yielding $p = 2$ (equivalent to one lag of differences in the VECM).

4.3 Extended vector error correction model with exogenous controls

The baseline VECM captures the long-run cointegrating relationship among the three core variables. However, this system operates within a broader macroeconomic environment shaped by monetary policy, risk sentiment, household expectations and forward-looking information that affects short-run dynamics without necessarily being part of the long-run equilibrium among the three core variables. Omitting these external influences risks misattributing variation driven by common external shocks to the three-variable relationship itself. We, therefore, incorporate four control variables: the federal funds rate (LFFR), which affects both GDP growth and equity valuations through discount rate and credit channel effects; the Consumer Confidence Index (LCCI), which reflects household sentiment and forward-looking spending behavior; the Volatility Index (LVIX), which captures implied equity market uncertainty and investor risk aversion; and real GDP expectations (LRGDPE) from the Survey of Professional Forecasters, which controls for forward-looking information embedded in agents' forecasts.

Each control variable is incorporated as an exogenous regressor rather than an endogenous system variable because it represents a persistent external influence rather than a variable jointly determined with real GDP, the stock market index and earnings per share in the long-run equilibrium. Specifically, LFFR is a policy instrument set by the Federal Open Market Committee (FOMC) under a mandate extending well beyond the GDP-stock-earnings system; LVIX reflects global options market activity largely exogenous to domestic GDP-stock-earnings dynamics; and LCCI and LRGDPE are survey-based measures that influence but do not themselves error-correct toward this equilibrium (Johansen, 1992; Pesaran *et al.*, 2000). The empirical validity of this treatment requires formal testing, which we conduct before proceeding to estimation.

4.3.1 Weak exogeneity testing. The treatment of LFFR, LCCI, LVIX and LRGDPE as exogenous regressors rather than endogenous system variables is supported by testing whether these variables adjust to disequilibria in the cointegrating relationship, that is, whether their adjustment coefficients in the error correction term are statistically distinguishable from zero. We test this using the Johansen (1992) weak exogeneity test, which compares the maximized log-likelihood of the unrestricted model, in which all seven variables are endogenous, to restricted models in which the candidate control variable is excluded from the cointegrating adjustment process. The likelihood ratio statistic is as follows:

$$LR = -T\ \sum_{i=1}^{r} \left[ln\ \left(1 - \tilde{\lambda}_i\right) - ln\ \left(1 - \hat{\lambda}_i\right) \right]$$

where T is the number of observations, $\tilde{\lambda}_i$ are eigenvalues from the unrestricted model, $\hat{\lambda}_i$ are eigenvalues from the restricted model and r is the cointegration rank. Under the null hypothesis of weak exogeneity, the LR statistic is asymptotically distributed as chi-squared with degrees of freedom equal to r. Table 2 presents results for each variable individually and for the joint test across all four controls simultaneously.

LCCI, LVIX and LRGDPE are individually weakly exogenous at conventional significance levels. Although LFFR individually rejects weak exogeneity (LR = 24.58 and $p < 0.001$), indicating that its own equation contains a significant adjustment term toward the GDP-stock-earnings equilibrium, we retain it as exogenous to the system because this adjustment is consistent with the FOMC responding to macroeconomic and financial conditions rather than LFFR forming part of that long-run equilibrium. This treatment is supported by Supplementary Material Table B3: when LFFR is included as endogenous in an expanded four-variable system, the cointegration rank remains $r = 2$ and the cointegrating vector coefficients for LRGDP, LTR and LLEPS correlate at 0.999 across specifications, indicating that the long-run cointegrating structure is primarily explained by the three core variables regardless of LFFR's treatment.

Table 2. Weak exogeneity test results

Variable	LR statistic	df	*p*-value	Decision
LFFR	24.58	2	< 0.001	Not weakly exogenous
LCCI	–	2	> 0.10	Weakly exogenous
LVIX	–	2	> 0.10	Weakly exogenous
LRGDPE	0.38	2	0.826	Weakly exogenous
Joint test (all Four)	12.65	8	0.125	Cannot reject joint exogeneity

Note(s): LR statistics for LCCI and LVIX are below zero because of a numerical artifact of restricted eigenvalue estimation in small samples; the test correctly fails to reject exogeneity for these variables, and the statistics are not reported to avoid misinterpretation. The joint test imposes the restriction simultaneously across all four controls

Additionally, the joint test across all four controls simultaneously cannot reject the null of collective weak exogeneity (LR = 12.65, df = 8 and p = 0.125), providing the collective specification test for the conditional VECM. The joint test, therefore, confirms that collectively excluding all four controls from the endogenous system does not compromise inference on the long-run equilibrium parameters.

The joint test result is partly driven by the three controls that individually satisfy exogeneity, so the conclusion that LFFR responds to rather than belongs to the long-run equilibrium should be treated as a maintained assumption rather than a definitively established identification.

4.3.2 Vector error correction model with exogenous controls. Having examined the weak exogeneity of the control variables, we estimate the conditional VECM incorporating all four controls as exogenous I(1) regressors:

$$\Delta \mathrm{Y_t} = \mu + \alpha_{\mathrm{Y}} \beta' \mathrm{Y_{t-1}} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathrm{Y_{t-i}} + \sum_{j=0}^{s} \psi_j \Delta \mathrm{X_{t-j}} + \varepsilon_t$$

where $\mathrm{Y_t}$ represents the vector of endogenous variables (LRGDP, LTR and LLEPS), $\mathrm{X_t}$ denotes the vector of exogenous controls (LCCI, LVIX, LRGDPE and LFFR) and Γ_i and ψ_j are coefficient matrices capturing short-run dynamics. The cointegrating relationship $\beta' \mathrm{Y_{t-1}}$ is defined only among the endogenous variables; the control variables enter only through their first-differenced values $\Delta \mathrm{X_{t-j}}$ in the short-run dynamics. This conditional VECM structure enables efficient estimation of the long-run relationship among real GDP, the stock market index and earnings per share while controlling for persistent external shocks that affect the system in the short run but are not part of its long-run equilibrium (Johansen, 1992; Pesaran *et al.*, 2000).

4.4 Parameter stability diagnostics

Before specifying the MS-VECM, we conduct two complementary diagnostics on the baseline VECM residuals to formally test whether the constant-parameter assumption is consistent with the data.

The first diagnostic is a rolling-window correlation analysis. We compute pairwise residual correlations for all three variable pairs, GDP-Stock (real GDP and the stock market index), GDP-EPS (real GDP and earnings per share) and Stock-EPS (the stock market index and earnings per share), in successive 20-quarter windows across the full sample. If parameters are constant, then these rolling correlations should remain approximately stable around their full-sample values. Figure 1 plots all three pairs alongside their full-sample benchmarks and NBER recession bands.

The results reveal pronounced time variation across all three pairs, with rolling standard deviations substantially exceeding full-sample values in every case (Figure 1). The GDP–Stock correlation ranges from −0.662 to +0.814 against a full-sample value of 0.129, the GDP–EPS correlation from −0.298 to +0.904 against 0.280 and the Stock–EPS correlation from −0.189 to +0.820 against 0.385. This variation is too large to reflect sampling noise alone, indicating the underlying relationships shift systematically across the business cycle.

The second diagnostic directly compares residual correlations between NBER-defined expansion and recession subsamples, using a Fisher Z-test to assess the significance of the difference in correlations (Table 3).

The LRGDP–LTR correlation shifts from +0.389 in expansion to −0.145 in recession, a difference of 0.534, significant at the 10% level (p = 0.057), despite only 16 recession quarters. The LTR–LLEPS correlation strengthens from +0.291 to +0.662 in recession (p = 0.090), reflecting tighter within-quarter co-movement between financial variables under stress. The LRGDP–LLEPS correlation declines but is not statistically significant (p = 0.401), consistent

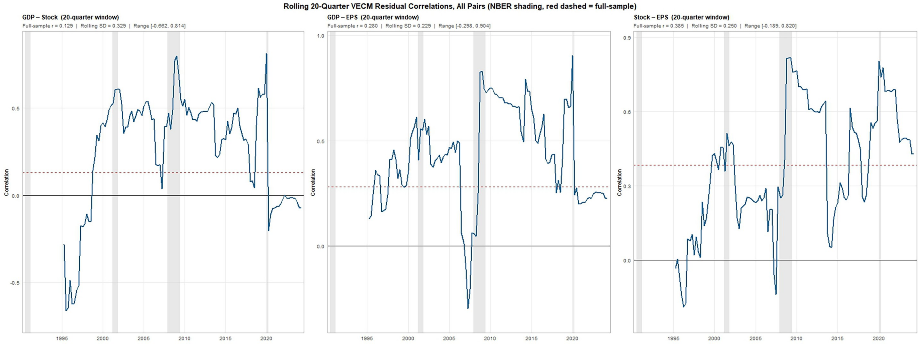

Figure 1. Rolling 20-quarter vector error correction model residual correlations for all variable pairs, 1990:Q1 to 2024:Q1 The solid blue line plots the pairwise residual correlation in successive 20-quarter rolling windows; the red dashed line is the full-sample benchmark; gray shading indicates NBER recession quarters. GDP–Stock, GDP–EPS and Stock–EPS refer to the pairs (LRGDP, LTR), (LRGDP, LLEPS) and (LTR, LLEPS), respectively. Left panel: GDP-Stock, r = 0.129, SD = 0.329 and range [−0.662, +0.814]. Centre panel: GDP-EPS, r = 0.280, SD = 0.229 and range [−0.298, +0.904]. Right panel: Stock-EPS, r = 0.385, SD = 0.250 and range [−0.189, +0.820]

Table 3. Parameter stability: NBER subsample residual correlation analysis

Correlation pair	Expansion (n = 120)	Recession (n = 16)	Difference	Fisher Z p-value
LRGDP, LTR	+0.389	−0.145	−0.534	0.057*
LRGDP, LLEPS	+0.411	+0.189	−0.222	0.401
LTR, LLEPS	+0.291	+0.662	+0.371	0.0895*

Note(s): Pairwise residual correlations from the baseline VECM estimated separately over NBER-classified expansion quarters (n = 120) and recession quarters (n = 16). The Difference column reports recession minus expansion. Fisher Z-test p-values test the null hypothesis that the expansion and recession correlations are equal. *indicates significance at the 10% level

with real GDP being a lagged flow measure that responds to earnings developments more slowly than the stock market index. Together, the two diagnostics confirm that correlations shift systematically across the business cycle, supporting the MS-VECM specification.

4.5 Markov-Switching vector error correction model specification

4.5.1 Model structure. Following the two-stage approach of Francis and Owyang (2005), cointegrating vectors are estimated from the full-sample Johansen procedure under constant parameters and then held fixed in the MS-VECM. This approach yields consistent estimates of the long-run equilibrium even in the presence of regime shifts, as the cointegrating relationships represent structural long-run constraints that are theoretically expected to persist across business cycle phases (Saikkonen, 1992; Saikkonen and Luukkonen, 1997). The MS-VECM allows both adjustment coefficients and shock covariance structures to vary across regimes:

$$\Delta Y_t = \mu + \alpha_S \beta' Y_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$$

where the regime indicator $S_t \in \{1, 2\}$ follows a first-order Markov chain with transition matrix P, and both the adjustment matrix α_S and the covariance matrix Σ_S are regime-dependent. The short-run lag dynamics Γ_i and the cointegrating vectors β remain constant across regimes.

The two-regime specification maps onto the well-documented expansion–contraction distinction, where adjustment speeds, shock transmission and financial-real co-movements all differ systematically across business cycle phases (Hamilton, 1989; Diebold and Rudebusch, 1996). Regimes are anchored to National Bureau of Economic Research (NBER) recession dates, aligning the high-volatility, low-growth regime to NBER-classified recession quarters so that estimated regime probabilities and transition dynamics can be interpreted directly in terms of expansion and contraction rather than as unlabeled statistical states.

Statistically, the validity of the regime-switching specification over the linear VECM is confirmed by a likelihood ratio test. Because the MS-VECM introduces parameters that are unidentified under the null hypothesis of a single regime, conventional LR critical values are invalid. We, therefore, follow Davies (1977, 1987), who derives an upper bound on the *p*-value in the presence of unidentified nuisance parameters, and Ang and Bekaert (2002), who approximate the distribution using a chi-squared with r + n degrees of freedom where r is the number of restricted parameters and n is the number of nuisance parameters. The LR statistic is as follows:

$$LR = 2[L(\theta_{MSVECM}) - L(\theta_{VECM})]$$

where $L(\theta_{MSVECM})$ and $L(\theta_{VECM})$ are the maximized log-likelihoods under the two-regime and single-regime specifications, respectively. The computed statistic of 146.68 strongly rejects the null of parameter constancy under both the chi-squared approximations and the Davies upper bound ($p < 0.001$), confirming that allowing intercepts and adjustment dynamics to vary across regimes captures features of the data that the linear model cannot accommodate.

4.5.2 Bayesian estimation. The MS-VECM is estimated via Bayesian Gibbs sampling, which jointly estimates the model parameters and the hidden regime states over time, with cointegrating vectors fixed from the full-sample Johansen procedure serving as the foundation for all subsequent estimation. The regime indicator S_t, which determines which set of parameters is active at each point in time, is treated as an unobserved random process following a first-order Markov chain.

Given the fixed cointegration space, the Gibbs sampler cycles through four sequential draws. First, the full regime sequence $\{S_t\}$ is drawn via forward-filtering backward-sampling (FFBS), which combines forward likelihood recursions with backward simulation to ensure global coherence of the regime path rather than relying on local information alone. Second, the regime-specific adjustment matrices $\alpha_{(St=1)}$ and $\alpha_{(St=2)}$ are drawn from their conditional posterior distributions. Third, the regime-specific covariance matrices $\Sigma_{(St=1)}$ and $\Sigma_{(St=2)}$ are drawn from inverse-Wishart posteriors. Fourth, the transition probabilities governing the likelihood of switching between regimes are drawn from β posteriors.

Priors are uninformative with respect to regime ordering, with adjustment coefficients centered at 50% of full-sample Ordinary Least Squares (OLS) estimates and covariance priors asymmetric across regimes ($S_0(\text{recession}) = 4 \times S_0(\text{expansion})$) to reflect the empirically documented volatility asymmetry across business cycle phases. Regime identification combines a permutation constraint with hard NBER anchoring, constraining NBER-classified recession quarters to the high-variance regime to ensure economic interpretability.

Following a burn-in of 5,000 iterations, we retain 10,000 posterior draws from which we compute parameter estimates, standard errors and smoothed regime probabilities. Convergence is assessed using the Geweke (1991) diagnostic, which compares the posterior mean of the log-likelihood across the first 10% and last 10% of retained draws; the estimated ratio of 0.009 is well below the conventional threshold of 2, confirming that the sampler has converged to its stationary distribution. CUSUM stability tests and cross-validation results are reported in Table B5 in the Supplementary Material. The recursive parameter estimates in Supplementary Material Figure A7 show that the regime transition probabilities and regime-specific GDP means stabilize well before the end of the sample.

4.6 Granger causality tests

To examine the directional structure of predictive relationships within the system, we conduct joint Granger causality tests in a companion VAR(2) in levels. The joint test is appropriate in a cointegrated system where pairwise tests would ignore the system-wide information structure, with the null hypothesis that all lags of the excluded variable have zero coefficients in the remaining equations. Three tests are conducted: LTR and LLEPS jointly causing LRGDP; LRGDP jointly causing LTR and LLEPS; and LLEPS jointly causing LRGDP and LTR.

5. Results

5.1 Cointegration analysis

The Johansen maximum eigenvalue test identifies $r = 2$ cointegrating relationships among real GDP, the stock market index and earnings per share at the 5% significance level: the nulls of no cointegration and of at most one cointegrating vector are both rejected, while the null of at most two is not (Table 4). This rank is robust to re-estimation with exogenous controls and to re-estimation with the federal funds rate included as an endogenous variable, with cointegrating vector coefficients correlating at 0.999 across specifications (Tables B2 and B3). Full results for both alternative specifications are reported in Tables B2 and B3 in the Supplementary Material.

Table 5 presents the normalized cointegrating vectors (CVs) from both the baseline and extended models. In the baseline model, CV1, normalized on LRGDP, identifies earnings per share as the primary anchor of the long-run GDP equilibrium: a 1% increase in earnings per share is associated with a 0.352% increase in real GDP, while the near-zero LTR coefficient of −0.002 indicates that the stock market index does not primarily drive this relationship. CV2, normalized on LTR, captures the long-run stock-earnings equilibrium, with a 1% increase in earnings per share associated with a 1.379% increase in the stock market index. Introducing exogenous controls leaves this cointegrating structure intact, with the earnings–GDP and stock–earnings relationships estimated with marginally greater precision (LLEPS shifting

Table 4. Johansen maximum eigenvalue cointegration test

H_0	Test statistic	10% critical	5% critical	1% critical	Decision
$r = 0$	67.36	19.77	22.00	26.81	Reject H_0
$r \leq 1$	34.71	13.75	15.67	20.20	Reject H_0
$r \leq 2$	2.71	7.52	9.24	12.97	Fail to reject

Note(s): Maximum eigenvalue test without linear trend, constant in cointegrating vector. Lag length $p = 2$ selected by BIC; Eigenvalues: 0.391, 0.225 and 0.020

Table 5. Normalized cointegrating vectors: Baseline and extended models

Vector	Model	LRGDP	LTR	LLEPS	Constant
CV1 (GDP eq.)	Baseline	1.000	−0.002	−0.352	−8.634
CV2 (Stock eq.)	Baseline	0.000	1.000	−1.379	−3.033
CV1 (GDP eq.)	Extended	1.000	−0.001	−0.375	−8.559
CV2 (Stock eq.)	Extended	0.000	1.000	−1.566	−2.092

Note(s): ML estimates; CV1 normalized on LRGDP; CV2 normalized on LTR. The extended model includes four exogenous controls. Vectors from the extended model are held fixed in the MS-VECM estimation

from −0.352 to −0.375 in CV1 and from −1.379 to −1.566 in CV2), confirming that the long-run cointegrating structure is not driven by omitted external influences. These vectors are held fixed in the MS-VECM estimation.

5.2 Vector error correction model adjustment dynamics

Table 6 presents coefficient estimates from both the baseline three-variable VECM and the extended model with exogenous controls. The baseline establishes the core adjustment structure among real GDP, the stock market index and earnings per share in isolation; the extended model refines these estimates by conditioning on monetary policy, risk sentiment, household confidence and growth expectations. Comparing the two specifications directly allows us to assess whether the adjustment dynamics are a genuine feature of the GDP–stock–earnings relationship or are driven by omitted external influences.

The real GDP equation shows consistent estimates across both specifications. Error correction toward CV1 is significant and stable: the coefficient is −0.040 ($p < 0.01$) in both the baseline and extended models, implying that approximately 4.0% of any deviation from the GDP–earnings long-run equilibrium is corrected each quarter, corresponding to a half-life of approximately 17 quarters. The CV2 coefficient of +0.008 to +0.010 across models indicates a smaller offsetting adjustment through the stock–earnings equilibrium. In the baseline, lagged GDP shows significant mean-reverting behavior (coefficient = −0.263 and $p < 0.05$), though this becomes insignificant in the extended model, suggesting that part of the mean reversion in the baseline reflects variation subsequently associated with the control variables rather than intrinsic GDP dynamics.

Among the short-run dynamics in the extended model, LFFR has a positive short-run GDP effect (coefficient = 0.013 and $p < 0.01$), consistent with monetary policy tightening during periods of strong economic conditions rather than a direct effect of rate increases on growth. LVIX exerts a negative short-run effect on GDP growth (coefficient = −0.005 and $p < 0.10$) and a strongly negative effect on stock returns (coefficient = −0.195 and $p < 0.01$), consistent with elevated uncertainty being associated with dampened real activity and market performance. LRGDPE enters negatively in the GDP equation (coefficient = −0.239 and $p < 0.05$), consistent with the rational expectations result that upward revisions to growth forecasts are already incorporated in current-period outcomes. LCCI positively predicts stock returns (coefficient = 0.124 and $p < 0.05$) but not GDP directly, suggesting consumer sentiment influences financial market valuations before transmitting to real activity.

The stock returns equation adjusts significantly to CV1 disequilibrium in both models, with the adjustment coefficient tightening from −0.135 in the baseline to −0.101 in the extended model (both $p < 0.05$). Given LVIX's strong short-run relationship with stock returns reported above, this reduction is consistent with the baseline coefficient partly

Table 6. Vector error correction model coefficient estimates: Baseline and extended models

Term	Baseline LRGDP	Baseline LTR	Baseline LLEPS	Extended LRGDP	Extended LTR	Extended LLEPS
ECT1 (α_1)	−0.040*** (0.006)	−0.135** (0.048)	0.235 (0.399)	−0.040*** (0.005)	−0.101** (0.034)	0.944** (0.324)
ECT2 (α_2)	0.010*** (0.002)	0.025. (0.015)	0.562*** (0.124)	0.008*** (0.001)	0.015* (0.007)	0.331*** (0.070)
$\Delta LRGDP_{-1}$	−0.263** (0.079)	0.074 (0.638)	3.702 (5.343)	−0.096 (0.089)	0.873 (0.597)	−0.889 (5.783)
ΔLTR_{-1}	0.049*** (0.012)	−0.067 (0.093)	1.610* (0.775)	0.042*** (0.010)	0.105 (0.068)	1.398* (0.655)
$\Delta LLEPS_{-1}$	0.002 (0.001)	0.016 (0.011)	−0.017 (0.090)	−0.001 (0.001)	−0.003 (0.008)	−0.069 (0.078)
$\Delta LFFR$	–	–	–	0.013*** (0.002)	−0.008 (0.013)	1.001*** (0.121)
$\Delta LCCI$	–	–	–	0.005 (0.008)	0.124* (0.052)	0.875 (0.503)
$\Delta LVIX$	–	–	–	−0.005 (0.003)	−0.195*** (0.019)	−0.292 (0.182)
$\Delta LRGDPE$	–	–	–	−0.239** (0.075)	−0.325 (0.503)	3.264 (4.869)

Note(s): Standard errors in parentheses. ***, **, * and . indicate significance at 0.1, 1, 5 and 10% levels, respectively. Baseline model includes three endogenous variables only. Extended model adds four exogenous controls in first differences. AIC = −2,257.5, BIC = −2,173.3 and SSR = 36.12 (extended model). Residual diagnostics for both models are reported in Table B4 in the Supplementary Material; the Shapiro–Wilk test yields p = 0.078 and Box-Ljung tests show no significant serial correlation across all three equations capturing the effect of elevated uncertainty rather than the stock market's response to CV1 disequilibria alone. The earnings per share equation shows strong and significant adjustment to both vectors across specifications, with the CV1 coefficient rising from 0.235 in the baseline to 0.944 in the extended model ($p < 0.01$), indicating the central role of earnings in anchoring both long-run equilibrium relationships and the greater precision with which this is estimated once external influences are controlled.

Across both models, lagged stock returns positively and significantly predict GDP growth (baseline: 0.049, extended: 0.042 and both $p < 0.01$). This finding is robust to the inclusion of all four control variables, consistent with stock returns carrying leading information about GDP growth rather than serving as a proxy for monetary conditions or risk sentiment.

5.3 Granger causality

Table 7 presents results from the joint Granger causality tests in the companion VAR(2). The results reveal a unidirectional pattern. The joint null that LTR and LLEPS do not Granger-cause LRGDP is strongly rejected (the individual test for LTR: F = 7.74, df = 4, 387 and $p < 0.001$; for LLEPS: F = 2.61 and $p = 0.035$), consistent with financial market variables containing predictive information for GDP growth. By contrast, the null that LRGDP does not Granger-cause LTR and LLEPS jointly cannot be rejected (F = 0.234 and $p = 0.919$), indicating that past GDP growth does not systematically predict future stock returns or earnings growth beyond the information already contained in their own lags.

5.4 MS-vector error correction model results

5.4.1 Regime characteristics and transition dynamics. Table 8 summarizes the characteristics of the two estimated regimes. The expansion regime (Regime 1) is the predominant state, accounting for 120 of 136 quarters in the sample (88%). It exhibits a mean quarterly GDP growth rate of approximately 0.71% and low GDP growth volatility (standard deviation 0.009). The expected duration is 22.5 quarters (approximately 5.6 years), reflecting the well-documented tendency of US expansions to be long-lived relative to recessions.

The recession regime (Regime 2) covers 16 quarters (12%) and is characterized by sharply elevated volatility across all three variables. GDP growth volatility is 3.7 times higher than in expansion (0.035 vs 0.009), stock return volatility is 1.8 times higher (0.086 vs 0.047) and earnings growth volatility is 5.1 times higher (1.311 vs 0.256). The expected duration is 4.6 quarters, reflecting the model's hard anchoring to NBER recession classifications, which tend toward well-defined, relatively brief downturns.

Table 9 presents the estimated transition probability matrix. The expansion regime is highly persistent, with a quarter-to-quarter probability of remaining in expansion of 0.956,

Table 7. Granger causality tests (VAR(2) in levels)

Null hypothesis (H_0)	F-Statistic	df_1	df_2	p-value
LTR does not granger-cause LRGDP	7.738	4	387	< 0.001***
LLEPS does not granger-cause LRGDP	2.609	4	387	0.035**
LRGDP does not granger-cause LTR and LLEPS	0.234	4	387	0.919

Note(s): VAR(2) estimated in levels. Each test is a joint F-test of whether all lags of the excluded variable (s) have zero coefficients in the remaining equations. ***$p < 0.01$ and **$p < 0.05$. The unidirectional structure from financial variables to GDP is consistent with stock markets functioning as leading indicators of economic activity (Fama, 1990; Stock and Watson, 2003) and mitigates the concern about simultaneity bias in the VECM results

Table 8. Markov-switching vector error correction model regime characteristics

Characteristic	Expansion (Regime 1)	Recession (Regime 2)
Quarters in regime (sample)	120 (88%)	16 (12%)
GDP growth volatility (σ)	0.0094	0.0349
Stock return volatility (σ)	0.0469	0.0865
Earnings growth volatility (σ)	0.2562	1.3107
Expected duration (quarters)	22.5	4.6
Persistence probability (p_{ii})	0.956	0.781

Note(s): Posterior means from 10,000 Gibbs draws after 5,000 burn-in. Volatility is reported as the posterior mean standard deviation of quarterly shocks. Convergence confirmed by Geweke ratio = 0.009 (threshold: < 2)

explaining the expected duration of 22.5 quarters in Table 8. The recession regime is less persistent, with a continuation probability of 0.781 and an expected duration of 4.6 quarters, consistent with the well-documented asymmetry of US business cycle phases whereby expansions are substantially longer-lived than contractions. The probability of transitioning from expansion to recession in any given quarter is 0.044, while the probability of exiting recession back to expansion is 0.219.

5.4.2 Regime identification and visual evidence. Figure 2 plots the smoothed posterior probabilities of both regimes alongside GDP growth with recession shading. The model identifies four main recession episodes: 1990–1991, 2001, 2008–2009 and 2020, all aligning closely with NBER recession classifications. The model identifies 19 quarters with a recession probability above 0.5, compared to 16 NBER recession quarters in the sample, a modest extension of the identified crisis periods relative to the official classification.

The GDP growth panel confirms the economic coherence of regime classifications. The most dramatic episode is Q2 2020, when GDP contracted sharply because of COVID-19 lockdowns; the model identifies this as the onset of the recession regime. The 2008–2009 crisis appears as a sustained recession episode across multiple quarters, while the 2001 recession and 1990–1991 downturn are identified as shorter episodes.

5.4.3 Regime-dependent correlations. Table 10 and Figure 3 present the regime-dependent correlation matrices from the regime-specific $\mathbf{\Sigma}$ posteriors (residual covariance matrices). These matrices measure correlations between contemporaneous residual shocks: the unpredicted components of LRGDP, LTR and LLEPS within each quarter after removing all systematic dynamics, including error-correction forces, lag effects and regime-specific means. In the expansion regime, residual shocks are modestly and positively correlated: LRGDP with LTR (+0.063), LRGDP with LLEPS (+0.127) and LTR with LLEPS (+0.163), consistent with unexpected shocks to financial variables and real GDP tending to arrive together within the same quarter during normal times.

Table 9. Estimated transition probability matrix

From \to	Expansion (Regime 1)	Recession (Regime 2)
Expansion (Regime 1)	0.956	0.044
Recession (Regime 2)	0.219	0.781

Note(s): Posterior means of transition probabilities. Row sums to 1. Expansion persistence: p_{11} = 0.956; and recession persistence: p_{22} = 0.781. Model-identified recession quarters (P(recession) > 0.5): 19; NBER recession quarters in sample: 16

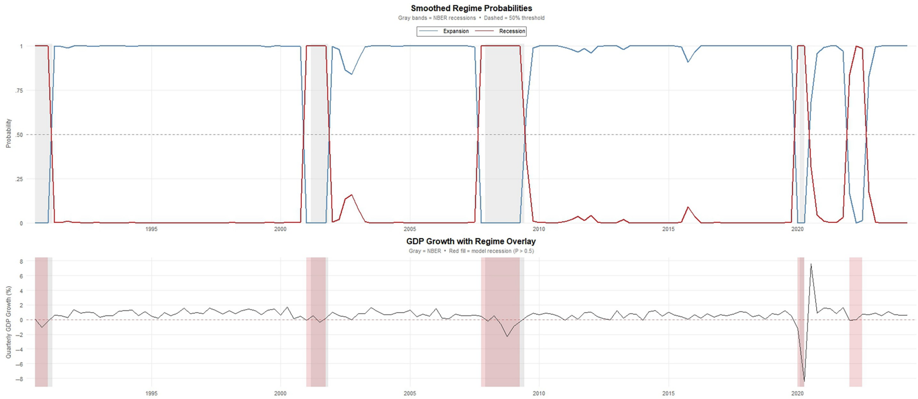

Figure 2. Markov-switching vector error correction model smoothed regime probabilities and gross domestic product growth, 1990:Q1-2024:Q1 Upper panel: posterior smoothed probabilities of the expansion regime (blue) and recession regime (red) from the Bayesian Gibbs sampler (10,000 post-burn draws). The dashed horizontal line marks the 50% classification threshold. Gray bands indicate NBER recession quarters. Lower panel: quarterly real GDP growth (annualized percentage change) with NBER recession bands in gray and model-identified recession quarters (P(recession) > 0.5) shaded in red

Table 10. Regime-dependent correlations

Pair	Expansion	Recession	Difference	Sign reversal
LRGDP, LTR	+0.063	−0.121	−0.184	Yes
LRGDP, LLEPS	+0.127	−0.150	−0.276	Yes
LTR, LLEPS	+0.163	+0.394	+0.231	No

Note(s): Posterior mean correlations from regime-specific $\mathbf{\Sigma}$ matrices (residual shocks). These measure co-movements of the unpredicted within-quarter components of each variable after removing error-correction, lag dynamics and regime means, not correlations between the variables in levels. Sign reversal indicates the residual shock correlation changes sign across regimes

During recessions, the residual shock correlations between LRGDP and the financial variables reverse sign: LRGDP–LTR from +0.063 to −0.121 and LRGDP–LLEPS from +0.127 to −0.150. This reversal does not indicate that GDP and financial variables move in opposite directions in levels during recessions; both decline together over longer horizons as the cointegrating relationships pull the system toward its long-run equilibrium. The negative residual shock correlations are consistent with a timing mismatch at the quarterly frequency. The stock market index reprices continuously as new information arrives, and earnings can register a shock within the same quarter through write-downs, impairment charges and restructuring charges, while LRGDP accumulates real economic activity gradually over the full quarter. When LTR or LLEPS registers a large negative shock within a recession quarter, the within-quarter GDP measurement has not yet registered a proportional response, as real-side adjustment across firms, households and sectors accumulates gradually rather than instantaneously. This mismatch in the stock market index is likely amplified during acute stress, when equity price movements are increasingly associated with balance sheet

Figure 3. Regime-dependent correlations and volatility Variable labels in the figure follow the shorthand GDP (LRGDP), Stock (LTR) and EPS (LLEPS). Upper panel: posterior mean correlation matrices for the expansion (left) and recession (right) regimes. Red shading indicates positive correlations; blue shading indicates negative correlations. During recessions, the GDP–Stock correlation reverses from +0.063 to −0.121 and the GDP–EPS correlation reverses from +0.127 to −0.150, while the Stock–EPS correlation strengthens from +0.163 to +0.394. Lower panel: posterior mean standard deviations of quarterly shocks by variable and regime. EPS volatility rises 5.1-fold in recession (0.256 vs 1.311); GDP volatility rises 3.7-fold (0.009 vs 0.035); Stock volatility rises 1.8-fold (0.047 vs 0.087)

pressures rather than fundamental reassessments of economic conditions, further decoupling within-quarter equity shocks from their informational content about real activity. Earnings shocks are not subject to the same distortion: write-downs and impairments recognized during stress reflect a genuine reassessment of fundamentals, so their faster-than-GDP timing reflects accelerated recognition of real conditions rather than a loss of informational content. The mechanism underlying this shift is developed in Section 5.4.4.

The LTR–LLEPS residual shock correlation does not reverse; it strengthens from +0.163 to +0.394 in recession, consistent with both financial variables showing heightened co-movement within recession quarters in response to the same within-quarter distress signals, even as both decouple from the quarterly GDP measurement.

5.4.4 Regime-dependent adjustment dynamics. Table 11 presents the posterior mean α (adjustment) matrices for each regime. Three patterns emerge.

The first pattern concerns real GDP. LRGDP adjusts significantly to CV1 disequilibria in both regimes, correcting 3.4% of the disequilibrium per quarter in expansion ($\alpha_1 = -0.034$)

Table 11. Markov-switching vector error correction model adjustment coefficients (α matrices) by regime

Variable	α_1 (expansion)	α_2 (expansion)	α_1 (recession)	α_2 (recession)
LRGDP	−0.034	+0.009	−0.014	+0.005
LTR	−0.137	+0.003	+0.068	−0.008
LLEPS	+0.203	+0.200	+0.760	+0.164

Note(s): Posterior means from 10,000 draws after 5,000 burn-in, with hard NBER anchor post-FFBS. α_1 and α_2 correspond to CV1 (LRGDP–LLEPS equilibrium) and CV2 (LTR–LLEPS equilibrium) and 1.4% in recession ($\alpha_1 = -0.014$). The adjustment slows by more than half across regimes but remains directionally unchanged. In expansion, this correction can be attributed to the wealth and investment channel: deviations from the GDP–earnings equilibrium are associated with asset price adjustments that feed into investment and household consumption, gradually closing the gap. In recession, the results indicate a weakening of this channel, which can be explained by tightening credit conditions, extended planning horizons under uncertainty and household spending becoming more sensitive to current income than to wealth. The directional adjustment persists but at a substantially reduced pace. The CV2 coefficient is negligible in both regimes (+0.009 and +0.005), indicating that GDP does not respond meaningfully to stock–earnings disequilibria, consistent with GDP adjusting through the earnings channel rather than directly through market valuations.

The second pattern concerns the stock market index, where the estimated adjustment coefficient for CV1 reverses sign across regimes, from −0.137 in expansion to +0.068 in recession. Mechanically, the negative expansion coefficient indicates that the stock market corrects back toward the long-run GDP–earnings equilibrium following a deviation, whereas the positive recession coefficient indicates that deviations are amplified rather than corrected within the regime. In expansion, this correction is consistent with equity markets functioning as price-discovery mechanisms: when the stock market index trades above the level consistent with earnings per share, selling pressure builds; when it trades below, buying pressure builds, continuously pulling the stock market index toward the CV1 equilibrium at 13.7% per quarter, the fastest adjustment in the system.

The estimated sign reversal in recessions is consistent with a fundamental shift in the nature of trading at the margin, from fundamental-value investors whose transactions are disciplined by assessments of where prices stand relative to earnings to constraint-driven sellers whose transactions are determined by balance-sheet necessity rather than valuation. Under value-at-risk-based balance-sheet management, falling prices raise intermediary leverage above target, compelling further asset sales into the declining market and generating an effectively upward-sloping demand curve in which selling increases as prices fall further below equilibrium rather than providing a corrective stabilizing force (Adrian and Shin, 2014). The arbitrage mechanism that would ordinarily absorb this selling and restore the stock–earnings relationship is simultaneously impaired: capital managed by performance-based arbitrageurs contracts under the redemption pressures that accompany adverse market moves, and arbitrageurs facing funding constraints may be compelled to liquidate in the direction of the mispricing precisely when deviations from fundamental value are largest (Shleifer and Vishny, 1997). Brunnermeier and Pedersen (2009) formalize the interaction between these forces as a margin and loss spiral in which falling prices reduce collateral values, raise margin requirements and force further de-leveraging and selling, such that prices become driven by funding liquidity considerations rather than by movements in fundamentals. Brunnermeier and Sannikov (2014) embed these dynamics in a macroeconomic framework that generates exactly the two-regime structure estimated here: a stable, self-correcting region around the long-run equilibrium in which the adjustment coefficient is negative, and a crisis region in which intermediary net-worth losses produce nonlinear amplification and endogenous risk, with the stabilizing force turning destabilizing as the system moves away from the steady state. The positive α_1 is the coefficient-level expression of this estimated regime transition, consistent across all four recession episodes in the sample and supported by the within-quarter correlation evidence in Section 5.4.3, where the informational link between stock market index and real activity also breaks down during recessions.

It should be noted that the reduced-form regime-switching specification can neither identify which of these structural channels is operative in any given episode nor does the sign reversal establish causality. It is an empirical regularity consistent with a transition from fundamental-value arbitrage to constraint-driven selling across the business cycle, with the structural interpretation drawn from the theoretical literature rather than from the model itself. The CV2 coefficient is negligible in both regimes (+0.003 and −0.008), consistent with the stock market index being the normalizing variable in CV2 rather than adjusting to it.

The third pattern concerns earnings per share. LLEPS adjusts significantly to both CV1 and CV2 disequilibria across both regimes, underscoring the central role of earnings in anchoring both long-run relationships. The CV1 coefficient strengthens sharply in recession (α_1 = +0.203 in expansion versus + 0.760 in recession), while the CV2 coefficient remains relatively stable across regimes (α_2 = +0.200 in expansion versus + 0.164 in recession). The positive sign on both coefficients across both regimes indicates earnings continue to adjust toward both equilibria regardless of the business cycle state. What changes is the speed and source of CV1 adjustment: in expansion, earnings adjust gradually as corporate profitability responds to economic conditions over several quarters; in recession, this adjustment accelerates as widespread write-downs, revenue contractions and deteriorating profit margins materialize within a compressed timeframe. The stable CV2 coefficient indicates that the stock–earnings relationship is restored at a relatively consistent pace regardless of the business cycle state. The estimated recession-regime coefficients are, therefore, consistent with a configuration in which the stock market index, the variable that adjusted fastest in expansion, now amplifies deviations rather than correcting them; real GDP, the slowest-adjusting variable, adjusts at a further reduced pace; and earnings, the anchor variable, correct sharply but through a channel that is, in the estimated dynamics, insufficient on its own to offset the amplifying adjustment in the stock market equation. Each quarter, this configuration persists in the simulation, the cumulative deviation from equilibrium widens rather than closes, which is the basis for the output cost quantification in Section 5.5.

The MS-VECM results above are supported by a suite of validation checks reported in the Supplementary Material. Recursive parameter estimates (Supplementary Material Figure A7) show that the regime transition probabilities and regime-specific GDP means all stabilize well before the sample endpoint, confirming that the regime identification is not driven by late-sample observations. CUSUM stability tests and five-fold cross-validation (Supplementary Material Table B5) confirm that the regime identification is consistent across sub-periods and generalizes reasonably to held-out data. These diagnostics support the reliability of the regime-dependent adjustment structure estimated over the 1990–2024 sample for the US economy.

5.5 Transition dynamics and historical episode analysis

5.5.1 Deterministic transition costs. To quantify the economic cost of regime transitions, we simulate the deterministic dynamics of the MS-VECM under two scenarios: a path in which the economy remains in the expansion regime over a 20-quarter horizon (the counterfactual benchmark) and a path that switches to the recession regime at quarter 10 (the treatment scenario). Both paths are initialized from a mild disequilibrium of 0.25 standard deviations below the CV1 equilibrium.

Figure 4 presents the results. The two paths are identical through Quarters 1–9, as they face identical expansion-regime dynamics. At Quarter 10, the paths diverge. By Quarter 20, the regime-switching path accumulates a GDP growth deficit of 1.78 percentage points relative to the continuous-expansion path, a stock return deficit of 9.60 percentage points and an earnings growth deficit of 6.61 percentage points. As the positive recession-regime α_1 amplifies deviations from the earnings equilibrium rather than correcting them, the gap widens

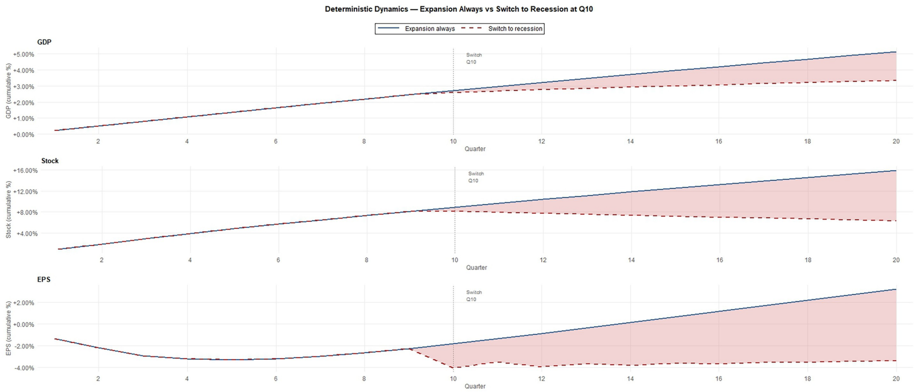

Figure 4. Deterministic transition dynamics: continuous expansion versus switch to recession at Q10 Variable labels in the figure follow the shorthand GDP (LRGDP), Stock (LTR) and EPS (LLEPS). Both paths are initialized from a mild disequilibrium of 0.25 standard deviations below the CV1 equilibrium. The solid blue line shows the cumulative growth path under a continuous expansion regime over 20 quarters. The dashed red line shows the path when the economy switches to a recession regime at Q10 (vertical dotted line). The shaded area represents the cumulative deficit resulting from the switch. By Q20, the switching path accumulates deficits of 1.78 percentage points in GDP, 9.60 percentage points in Stock and 6.61 percentage points in EPS relative to continuous expansion

each quarter the recession regime persists, the mechanical implication of the compounding dynamics documented in Section 5.4.4.

Figure 5 presents the path dependence analysis, comparing two paths that both switch to the recession regime in Quarter 10 but differ in their prior history: one preceded by 9 quarters of expansion and one in which the recession regime prevails throughout the entire 20-quarter horizon. The economy with prior expansion history consistently outperforms: by Quarter 20, the expansion-legacy path achieves GDP growth 1.99 percentage points above the recession-legacy path, stock returns 10.75 percentage points above and earnings growth 5.95 percentage points above. This documents that entering recession from a position of prior expansion and, therefore, from a smaller initial disequilibrium, produces lower accumulated output costs even under identical recession-regime dynamics.

5.5.2 Historical episode counterfactuals. Figure 6 presents historical episode counterfactuals for each of the four identified crisis episodes (1990–1991, 2001, 2008–2009 and 2020). For each episode, we simulate the expansion-regime counterfactual path forward from the recession onset quarter and compare it to realized growth. The difference between the realized and counterfactual paths represents the estimated cost of the regime transition.

The four episodes produce substantially different counterfactual deviations. The 2008–2009 crisis, which originated within the financial sector, produces the largest and most persistent GDP deviation from the expansion counterfactual. The magnitude and persistence of this deviation point to a larger initial disequilibrium at recession onset, with the amplifying adjustment dynamics estimated for the recession regime compounding the gap over an extended period. The 2020 COVID-19 episode shows the sharpest initial contraction in both GDP and stock returns, with realized stock returns plunging roughly 20 percentage points below the expansion counterfactual at peak deviation, but the recovery is faster than the 2008–2009 episode, narrowing the gap by Quarter 8. The faster recovery is in line with a shock that originated

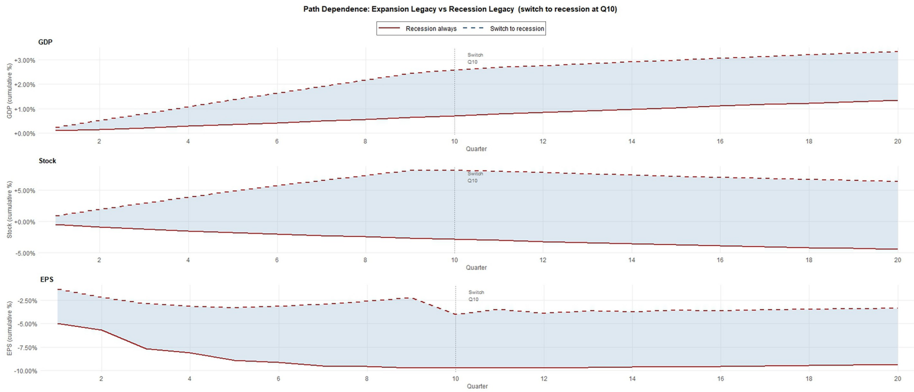

Figure 5. Path dependence: expansion legacy versus recession legacy at regime switch (Q10) Variable labels in the figure follow the shorthand GDP (LRGDP), Stock (LTR) and EPS (LLEPS). The dashed blue line shows the path preceded by nine quarters of expansion before switching to the recession regime at Q10. The solid red line shows the path where the recession regime prevails throughout the entire 20-quarter horizon. The shaded area is the advantage attributable to prior expansion. By Q20, the expansion-legacy path outperforms the recession-legacy path by 1.99 percentage points in GDP, 10.75 percentage points in Stock and 5.95 percentage points in EPS

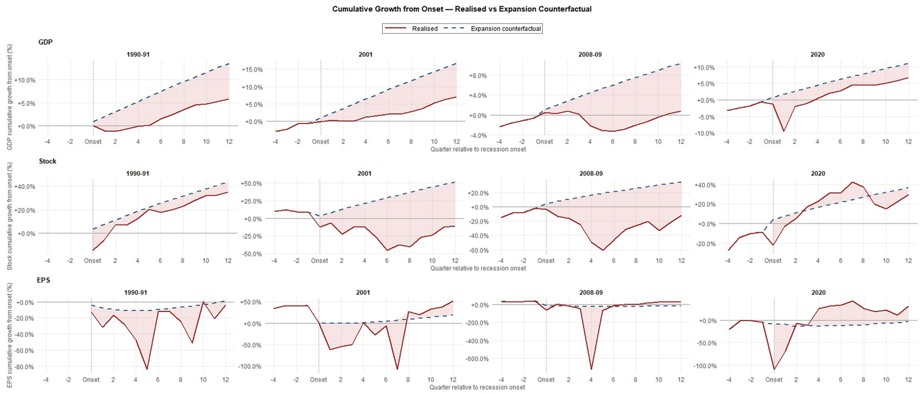

Figure 6. Historical episode counterfactuals: realized versus expansion counterfactual, 1990–1991, 2001, 2008–2009 and 2020. Each column shows one recession episode. Variable labels in the figure follow the shorthand GDP (LRGDP), Stock (LTR) and EPS (LLEPS). The solid red line represents cumulative growth in gross domestic product (top row), stock returns (middle row) and EPS (bottom row), all indexed from zero at the onset of the recession. The dashed blue line is the simulated expansion-regime counterfactual initialized at the same starting conditions. The shaded area is the realized shortfall. The *x*-axis shows quarters relative to the recession onset, with four pre-onset quarters shown where available (the 1990–1991 episode has no pre-onset quarters, as it begins the sample period)

outside the financial intermediation system: absent the systemic balance sheet constraints that characterized 2008–2009, the correction mechanism appears to have reasserted once the acute phase of the shock passed. The 2001 recession shows the largest cumulative stock market deviation, reflecting the depth and duration of the dot-com unwinding and its concentrated impact on equity valuations relative to earnings. The 1990–1991 episode is the mildest across all three variables, attributable to its relatively brief duration and the absence of systemic financial sector distress.

The earnings growth counterfactuals show that in all four episodes, realized earnings growth falls dramatically below the expansion counterfactual, with the 2008–2009 and 2020 episodes showing cumulative deviations exceeding 200 and 100 percentage points, respectively, at the trough. The extent of these deviations, associated with widespread write-downs, revenue contractions and deteriorating profit margins, points to corporate profitability as a key transmission channel between financial market conditions and real GDP, a relationship formalized in the framework through the CV1 cointegrating relationship between real GDP and earnings per share.

6. Discussion and implications

The regime-dependent adjustment dynamics documented in Section 5.4.4, together with the path dependence and episode heterogeneity results in Section 5.5, point to a system in which the corrective relationship between equity markets and earnings fundamentals is not a fixed feature of the economy but one that is estimated to operate differently across business cycle states. A structure of this kind, in which one regime is equilibrium-restoring and another is non-correcting or destabilizing, is not without precedent. Psaradakis, Sola and Spagnolo (2004) develop a Markov error-correction model of US stock prices and dividends that allows deviations from the long-run equilibrium to be nonstationary in one regime and find that periods of weak or absent adjustment correspond to periods of high price-dividend ratios. The present findings extend this type of regime dependence to the relationship between equity markets and earnings fundamentals, with the regime switch tied explicitly to the business cycle rather than to the size of the deviation alone. The remainder of this section considers what this pattern implies for monetary policy, financial conditions measurement and early warning and the role of pre-recession conditions and shock origin in determining recession severity.

Monetary policy and the earnings channel: The sign reversal of the stock market adjustment coefficient in recession (Section 5.4.4) has consequences for monetary policy. Lower interest rates raise stock prices by raising the present value of future earnings, and in expansion, this brings the stock market index closer to its earnings equilibrium, transmitting into investment and consumption. In recession, the index and earnings are estimated to move apart rather than together, so a policy-driven rise in stock prices does not have this effect, and the asset price channel loses traction.

Policies that work through earnings and corporate cash flow instead, such as credit facilities for corporate liquidity or fiscal transfers to households and firms, act on the GDP–earnings relationship directly, which remains intact in both regimes. This is consistent with the financial accelerator framework (Bernanke, Gertler and Gilchrist, 1999), in which weak balance sheets raise the cost of external finance and weaken asset-price-dependent channels in particular.

Financial conditions measurement and early warning: Financial conditions indices that assign fixed weights to equity signals implicitly assume that a given movement in the stock market index carries the same informational content about real economic conditions regardless of the business cycle phase. The results in Section 5.4.3 indicate that this assumption does not hold uniformly: within-quarter correlations between the stock market index and GDP reverse sign in recession, consistent with equity market movements becoming decoupled from their informational content about real activity during periods of stress. A fixed-weight index may, therefore, overstate tightening in recessions and understate recovery momentum early in expansions. Regime-sensitive weighting, which reduces the equity signal when the corrective mechanism has reversed and restores it once correction resumes, would improve the diagnostic value of financial conditions measurement when accurate real-time assessment matters most.

This regime dependence may also serve as an early warning signal. Growth-at-risk analysis shows that the lower quantiles of GDP growth fall as financial conditions tighten, while the upper quantiles remain stable (Adrian, Boyarchenko and Giannone, 2019); a transition in the sign of the adjustment coefficient or of within-quarter equity–GDP correlations offers a structural counterpart to this asymmetry and could complement growth-at-risk measures and coincident financial conditions indices. A sign reversal is a stronger basis for such a signal than a rise in correlation magnitude, as Forbes and Rigobon (2002) show that magnitude increases during turbulent periods can reflect volatility-conditioning bias rather than a genuine change in the relationship, a concern that does not apply to a reversal in sign. Any real-time monitor built on these signals would require out-of-sample validation before operational use.

Pre-recession conditions and the case for earlier intervention: The path dependence result in Section 5.5.1, where entering recession after nine quarters of expansion produces a 1.99 percentage point GDP advantage over entering with the recession regime already prevailing, indicates that a recession's output cost depends on the disequilibrium present at its onset. This has a counterpart in the financial cycle literature. Borio (2014) characterizes the financial cycle as a self-reinforcing interaction between valuations, risk-taking and financing conditions that produces booms followed by busts and notes that policy ignoring the buildup phase may contain a downturn while contributing to a larger one later. Jordà, Schularick and Taylor (2013) find that more credit-intensive expansions are followed by deeper, slower recoveries, with credit overhang associated with a recession trough roughly two percentage points deeper, in line with the 1.99 point estimate here. The disequilibrium accumulated before a downturn is, therefore, itself a determinant of its cost, pointing toward policy that addresses this buildup during expansions rather than only managing the downturn once it begins.

Shock origin and the severity of recessions: The heterogeneity in Section 5.5.2, where the 2008–2009 recession produced the largest and most persistent deviation from the expansion counterfactual, while 2020 showed a sharp initial deviation that narrowed quickly, matches a distinction in the financial crisis literature. Reinhart and Rogoff (2009) document that financial crisis recessions are typically protracted, with output declines and elevated unemployment persisting for years, unlike the more contained profile of recessions originating outside the financial sector. Jordà, Schularick and Taylor (2013) similarly find that financial-crisis recessions are deeper and slower to recover. The 2008–2009 episode, in which the disturbance originated within the financial sector, fits this profile; 2020, in which the disturbance originated outside it, resembles the more contained non-financial recession path. The appropriate policy channel may depend on shock origin: where the corrective mechanism is impaired from the outset, balance sheet channels are more relevant; where it reasserts quickly, bridging income and cash flow during the disruption may be sufficient.

Limitations: Several limitations warrant acknowledgment. The analysis is restricted to the USA, reflecting the availability of consistent quarterly earnings data over the full sample period. A two-regime specification is used throughout, reflecting the constraints of the sample: with only 16 NBER-classified recession quarters available, the data do not support reliable estimation of a more granular regime structure. A three-regime model distinguishing moderate stress from acute financial crisis may better capture the heterogeneity visible across the four episodes documented in Section 5.5.2, but would require either a longer time series or higher-frequency macroeconomic data. The two-regime finding should, therefore, be understood as documenting the expansion-recession boundary specifically, and future work with richer data may reveal further structure within what this paper treats as a single recession regime.

7. Conclusion

This paper asks whether the process linking stock markets to the real economy is stable across the business cycle. The evidence across four US recession episodes spanning more than three decades consistently points in the same direction: it is not. The estimated adjustment coefficient linking the stock market index to earnings is negative during expansion, consistent with equity markets correcting back toward the earnings equilibrium when they drift from it, and reverses sign in recession, a pattern that holds consistently across all four episodes in the sample. The simulated output cost accumulates through the amplifying dynamics estimated for the recession regime rather than through the magnitude of the initial shock.

The findings indicate that policy instruments operating through corporate earnings retain traction across both regimes, while instruments operating through asset price revaluation depend on a corrective relationship that is estimated to reverse in recession. This regime dependence extends beyond monetary policy: it bears on how financial conditions are measured in real time, on the role of pre-recession imbalances in shaping the eventual cost of a downturn, and on why crises originating within the financial sector prove more persistent than those originating outside it. The same adjustment process that anchors the stock market to earnings fundamentals in expansions is estimated to amplify deviations from them in recessions, a pattern with implications beyond any single episode or policy tool.

Several questions remain open for future research. Whether this pattern holds in economies with less liquid equity markets, over longer time horizons that would support finer regime distinctions or under different monetary policy frameworks are questions this paper cannot answer with US quarterly data alone. They are, however, questions this paper makes it possible to ask precisely.

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Data availability

All data used in this study are publicly available. Real GDP and GDP expectations are obtained from the US Bureau of Economic Analysis (BEA; www.bea.gov) and the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters (www.philadelphiafed.org/surveys-and-data/real-time-data-research/survey-of-professional-forecasters), respectively. S&P 500 Total Return Index and Earnings Per Share data are from Yahoo Finance (https://finance.yahoo.com) and S&P Global (www.spglobal.com/spdji/en/documents/additional-material/sp-500-eps-est.xlsx). Federal funds rate, Consumer Confidence Index and VIX data are available from the Federal Reserve Economic Data (FRED) database (https://fred.stlouisfed.org). The replication code for all analyses reported in this paper is available from the author upon request. The data that support the findings of this study are openly available from the sources identified in the paper at Federal Reserve Economic Data | FRED | St. Louis Fed and Markets: World Indexes, Futures, Bonds, Currencies, Stocks and ETFs – Yahoo Finance.

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Supplementary material

The supplementary material for this article can be found online.

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