

Semiparametric Threshold Cointegration with Endogenous Regime Switching: A Penalized Spline Augmented Error-Correction Framework for Nonlinear Macroeconomic Adjustment

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Abstract. This study develops a semiparametric threshold error-correction model (STECM) that integrates penalized spline smoothing with endogenously determined regime-switching boundaries to capture asymmetric long-run adjustment dynamics in macroeconomic panel data. Conventional linear cointegration frameworks systematically misattribute regime-dependent heteroscedasticity and structural instability, yielding inconsistent parameter estimates under nonlinear equilibrium reversion. Employing a generalized cross-validation bandwidth selector and a sup-Wald threshold identification procedure, the proposed estimator achieves uniform consistency under mild mixing conditions. Monte Carlo simulations confirm substantial finite-sample efficiency gains over Hansen–Seo and Enders–Granger benchmarks. Empirical application to OECD current-account–output-gap nexuses (2000–2023) reveals significant asymmetric half-life differentials across expansion and contraction regimes, with meaningful implications for fiscal consolidation policy design and external-balance surveillance mechanisms.

Keywords: threshold cointegration, semiparametric error-correction model, endogenous regime switching, penalized spline estimation, nonlinear macroeconomic adjustment, panel threshold autoregression, asymmetric long-run dynamics, sup-Wald identification, current account adjustment

Introduction

The empirical modeling of long-run equilibrium relationships in macroeconomics has historically rested upon the assumption of linear, symmetric adjustment toward cointegrating attractors. While this paradigm—rooted in the foundational contributions of Engle and Granger (1987) and Johansen (1991)—continues to underpin a substantial share of applied policy analysis, accumulating evidence from post-global-financial-crisis data

vintages decisively challenges its empirical adequacy. In particular, macroeconomic time series exhibit pronounced regime-dependent behavior: agents and institutions demonstrably adjust their portfolios, fiscal positions, and external balances at differential speeds depending on whether deviations from equilibrium are positive or negative, large or small, and whether prevailing financial conditions are accommodative or restrictive. This observation is not merely of theoretical interest. As of 2024–2025, international organizations including the IMF and OECD have explicitly acknowledged that standard linear external-balance assessments may produce misleading sustainability diagnostics precisely because they abstract from threshold and asymmetric dynamics. The practical stakes are therefore considerable: erroneous inference about equilibrium reversion speeds can directly distort fiscal consolidation recommendations, exchange-rate misalignment assessments, and sovereign risk pricing in emerging and advanced economies alike. Existing nonlinear cointegration estimators—most notably the threshold vector error-correction models of Hansen and Seo (2002) and the momentum-threshold autoregressive specifications of Enders and Granger (1998)—represent important advances but share a critical limitation: the transition between regimes is governed by a step function, implicitly imposing discontinuous adjustment that is economically implausible in markets characterized by heterogeneous agents and transactions costs that vary continuously across the wealth distribution. Smooth-transition cointegration models (Kapetanios et al., 2006) partially address this discontinuity but require the analyst to pre-commit to a logistic or exponential transition function whose shape parameters are notoriously difficult to identify in samples of macroeconomic length. The framework proposed in the present article resolves this identification tension by endogenizing both the threshold location and the transition profile within a unified penalized spline augmented error-correction structure, thereby nesting linear, discrete-threshold, and smooth-transition specifications as limiting cases. The paper proceeds as follows. Section 2 formalizes the semiparametric threshold error-correction model, defines the penalized spline approximation to the unknown adjustment function, and establishes the identifying assumptions required for asymptotic inference. Section 3 derives the sup-Wald threshold test statistic under the null of linear cointegration and characterizes its limiting distribution under heteroscedastic errors. Section 4 reports the finite-sample properties of the proposed estimator via extensive Monte Carlo experiments calibrated to OECD macroeconomic panel dimensions. Section 5 presents the empirical application to current-account–output-gap dynamics across thirty-eight OECD member states over the 2000–2023 period, with particular attention to asymmetric half-life estimation and its implications for external-balance surveillance. Section 6 concludes and outlines extensions to high-dimensional factor-augmented settings.

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