Explosive Rational Bubbles in Stock Prices - Diba & Grossman

Diba and Grossman (1988) investigate the existence of rational bubbles in asset prices by proposing a time series-based empirical test grounded in the stationarity and cointegration properties of stock prices and dividends. The key theoretical foundation is that under rational expectations, asset prices reflect the present discounted value of expected future dividends. If this fundamental pricing relationship holds and dividends follow a nonstationary process, then prices should also be nonstationary but cointegrated with dividends. In contrast, the presence of a rational bubble component—defined as an explosive term that grows at the gross discount rate—would cause the price series to diverge from dividends, breaking the cointegration relationship. Importantly, rational bubbles, by their construction, are not mean-reverting and hence imply nonstationarity in asset prices even if dividends are stationary.

To operationalize this idea, the authors model prices with and without a bubble component, showing that in the presence of a bubble, price dynamics include an explosive term that grows multiplicatively over time. Using standard unit root and cointegration tests available at the time, they examine historical U.S. stock market data, particularly from the S&P Composite Index. Their findings indicate that stock prices and dividends are both integrated of order one and, crucially, cointegrated. This result is interpreted as evidence against the existence of rational bubbles over the sample period, since cointegration implies a long-run equilibrium relationship consistent with fundamental valuation.

The authors also critique alternative methods proposed by West and others that rely on fully specified structural models, arguing that such approaches are sensitive to omitted variables and unobservable expectations. Their reduced-form strategy, by contrast, focuses on directly observable statistical properties and avoids reliance on complete information about investors' beliefs. Through both theoretical derivations and empirical tests, Diba and Grossman demonstrate that the absence of cointegration between prices and dividends is a necessary condition for bubbles to exist, while its presence serves as strong evidence in favor of fundamental-driven pricing. Their contribution remains a cornerstone in empirical asset pricing and has influenced the design of many subsequent econometric tests for bubble detection.

Bubble Detection for Inter-War EU HyperInflation – Chan & Woo

This paper investigates the existence of inflationary bubbles during the inter-war hyperinflation episodes in Germany, Hungary, Poland, and Russia by employing a residual-based threshold cointegration framework, specifically the threshold autoregressive (TAR) unit root test developed by Caner and Hansen (2001). Traditional linear cointegration methods, as originally proposed by Diba and Grossman (1988a), assume that asset prices and their fundamental values (e.g., money supply) are linearly related. However, such approaches are shown to be inadequate for detecting periodically collapsing bubbles, which exhibit nonlinear behavior due to repeated bursting and re-emergence, as described in Evans (1991). Furthermore, standard tests may falsely attribute nonlinear shifts in economic fundamentals (such as regime changes from monetary reform) to speculative bubbles. The authors address these shortcomings by adopting a TAR framework, which can distinguish between true nonstationarity (due to bubbles) and nonlinear stationarity (due to structural shifts in fundamentals).

The theoretical model is grounded in Cagan’s (1956) monetary model of hyperinflation, in which real money balances depend on expected inflation. If expectations are rational, then prices should reflect discounted future money supplies plus a possible bubble term. The transversality condition ensures that bubbles are excluded; if violated, bubble terms enter the price equation. Evans’ bubble model allows bubbles to survive with some probability and collapse at random intervals, producing a nonlinear process. The TAR methodology models this regime-switching behavior directly by splitting the cointegration residuals into two regimes around a threshold and testing whether the series is stationary within those regimes.

Monte Carlo simulations show that the TAR test statistics, especially the one-sided RIT and two-sided R2T statistics, significantly outperform standard cointegration tests like the Augmented Dickey-Fuller (ADF) and the Gregory-Hansen ADF\* and Z\* statistics, particularly in finite samples with nonlinear features. The TAR tests are less prone to falsely rejecting cointegration in the presence of periodically collapsing bubbles and are also more powerful in distinguishing between nonlinear stationarity and genuine nonstationarity.

Empirically, the study analyzes monthly price and money supply data for the four countries over extended sample periods that include the often-ignored monetary reform phases. In contrast to earlier work which truncated these periods, the authors argue that excluding them a priori risks missing key bubble collapses. Standard cointegration tests fail to reject the null of no cointegration in most cases, suggesting potential model misspecification. However, TAR cointegration tests find evidence of cointegration with threshold effects in both key regressions: one between real money balances and inflation, and the other between real money balances and money growth. The results consistently reject the presence of explosive bubbles and instead support the existence of stationary regime-switching processes in money demand dynamics—likely reflecting anticipated policy shifts rather than speculative deviations.

In conclusion, the paper provides strong evidence that inflation during these hyperinflation episodes was not driven by speculative bubbles but rather by structural changes in fundamentals, such as monetary reform and regime switching in expectations. By applying a nonlinear cointegration approach to a historically important dataset, the study not only resolves empirical biases in previous literature but also highlights the superiority of threshold methods in distinguishing explosive dynamics from nonlinear but stationary adjustments in economic time series.

A test for rational bubbles in NASDAQ – Cunado, Gracia

This paper explores the presence of rational bubbles in the NASDAQ Composite Index from June 1994 to November 2003 using a novel methodology based on fractional integration rather than traditional I(1)/I(0) unit root or cointegration techniques. Motivated by the sharp rise and collapse in technology stocks during the late 1990s, and acknowledging earlier work by Campbell & Shiller (1987), Diba & Grossman (1988), and others, the authors adopt a flexible time-series framework that permits the order of integration to take fractional values (I(d), d ∈ ℝ), thereby avoiding rigid dichotomies. They begin by developing the rational bubble model in the context of the present value framework, where prices should equal the discounted expected stream of dividends unless a rational bubble component exists. Under the assumption that stock prices and dividends are both I(1), the price-dividend ratio should be stationary in the absence of bubbles. However, if the ratio contains a unit root or exhibits long memory (d ≥ 1), it would indicate a bubble.

To empirically test this, the authors use Robinson’s (1994a) parametric LM test and his (1995a) semiparametric QMLE estimator in the frequency domain. They evaluate the order of integration for prices, dividends, and the price-dividend ratio using monthly, weekly, and daily data obtained from Bloomberg. Classical unit root tests (ADF and PP) fail to reject the I(1) null across all series and frequencies. However, the fractional integration tests reveal more nuanced results. Specifically, when monthly data are used, the price-dividend ratio cannot reject the unit root null, suggesting the possible presence of a bubble. In contrast, when higher-frequency weekly and daily data are analyzed, the estimated integration order falls below one (and even below 0.5 when allowing for autocorrelated errors), indicating mean reversion and thus no persistent bubbles.

The authors explain these differences through the lens of the **temporal aggregation problem** (Working, 1960; Schwert, 1989; Taylor, 2001) and **sample size limitations**, arguing that low-frequency data can artificially mask mean-reverting behavior. Their semiparametric results show that estimates of the differencing parameter d cluster around 0.5 for daily and weekly data, while monthly data lie within the I(1) range. Visual tools such as correlograms and periodograms also support the long-memory but stationary nature of the price-dividend ratio in high-frequency data.

In conclusion, the study finds **no strong evidence of rational bubbles in the NASDAQ when using daily or weekly data**, despite the explosive growth of the index in the late 1990s. However, **monthly data suggest persistence** that may falsely indicate bubbles due to aggregation effects. The paper highlights the importance of using flexible methods such as fractional integration and stresses the influence of data frequency and sampling assumptions on bubble detection. The authors call for future research into fractional cointegration, structural breaks, and nonlinear dynamics to more accurately detect asset price deviations from fundamentals in financial markets.

Testing for Co-explosive Behaviour in Financial TS – Harvey, Leybourne, Sollis

The authors’ contribution is centered on extending the traditional stationarity framework, specifically the KPSS (Kwiatkowski–Phillips–Schmidt–Shin) test, to the co-explosive setting. Unlike existing approaches (e.g., Phillips, Shi, and Yu, 2015), which date bubbles independently in each series and compare the timelines, this method directly tests whether the linear combination of two series that each contain explosive episodes is stationary. In doing so, it accounts for asynchronous bubble timings by allowing one series to lead or lag the other. The proposed test is operationalized through a regression of one series on the other and examination of the residuals' stationarity. If the residuals are I(0)I(0)I(0), the series are said to exhibit co-explosive behaviour.

A key innovation of this work is the use of a **wild bootstrap** method to address heteroskedasticity—an inherent feature of financial data. The asymptotic distribution of the KPSS-type statistic depends on the variance structure of the errors, making standard critical values unreliable. The wild bootstrap, which re-samples residuals using randomly generated standard normal multipliers, replicates the heteroskedastic pattern and ensures size control. Simulation studies confirm that the bootstrap procedure performs well in both homoskedastic and heteroskedastic environments, with rejection rates close to nominal size under the null, and good power under the alternative.

The model for individual explosive series builds on Harvey et al. (2017) and allows for various regimes, including unit root, explosive, stationary collapse, and return-to-unit-root phases. The test statistic, SSS, is constructed from the partial sums of residuals and scaled by the estimated short-run variance. Under the null, its asymptotic distribution matches a variance-transformed Brownian bridge, and under the alternative, SSS diverges. The statistic is consistent across a wide range of explosive strengths.

Monte Carlo simulations demonstrate the effectiveness of the test across different scenarios. When the true lag between explosive episodes is unknown, the authors propose estimating it by minimizing the residual variance across a grid of candidate lags. This approach is shown to successfully recover the true lag in most cases.

Empirically, the test is applied to monthly real prices (both spot and futures) of precious metals (Gold, Silver, Platinum, Palladium) and non-ferrous metals (Copper, Lead, Nickel, Tin, Zinc, Aluminium) from July 1993 to May 2019. Preliminary testing with the PSY test confirms the presence of explosive autoregressive episodes in most of these series, except Aluminium. When the new co-explosive test is applied, co-explosive behaviour is detected only among certain combinations of non-ferrous and precious metals (e.g., Lead–Gold, Copper–Platinum) and between non-ferrous pairs (e.g., Zinc–Nickel), but not between pairs of precious metals. This result is consistent with the hypothesis that some bubbles may migrate between markets, although fundamental co-movements cannot be ruled out.

Overall, the authors provide a robust, easy-to-implement test that enhances the econometric toolkit for analyzing speculative bubbles. It is particularly useful when data on fundamentals are missing, as the test detects whether bubble episodes in different series are connected via a stationary linear combination. Importantly, it advances the literature by formally accounting for both heteroskedasticity and dynamic lag structure in co-bubble detection, offering insights into bubble spillovers, market interdependence, and the transmission of systemic risk.

Price Bubbles in Commodity Market – Panel Data – Marcin Portrykus

This study comprehensively analyzes the presence of price bubbles across 35 commodities spanning three sectors: energy, metals, and agriculture & livestock, over a long time horizon from January 1980 to December 2021, using 504 monthly observations per series. The primary goal is to evaluate both the occurrence and duration of speculative price bubbles, identify the beginning and end of bubble episodes, and distinguish sectors most prone to speculative behavior. Potrykus applies the rational bubble model based on Diba and Grossman (1988), where prices are decomposed into a fundamental component and a bubble component, and uses the GSADF test developed by Phillips et al. (2015) to detect bubbles. The backward SADF (BSADF) test is further used for dating the bubbles, while panel GSADF methods based on Vasilopoulos et al. (2020) enable sector-level inference under cross-sectional error dependence. Critical values are derived from 10,000 Monte Carlo simulations to ensure robust inference.

The study finds no evidence of bubbles for bananas, cocoa, and orange juice, suggesting that these commodities—predominantly from the agriculture & livestock sector—are relatively immune to speculative excess and could serve as stable portfolio additions for diversification during crises. On the other hand, 32 of the 35 commodities exhibit significant bubble behavior, with commodities like tin, tobacco, and gold showing the highest frequency and duration of bubbles. Surprisingly, gold—often considered a safe-haven asset—exhibited nine bubble episodes totaling 66 months, with the longest single continuous bubble lasting 48 months. Other frequently affected commodities include plywood, nickel, copper, natural gas, silver, and palm oil, reflecting vulnerability to external shocks and macroeconomic crises.

The analysis also distinguishes short-lived (under six months) from long-duration bubbles, with 49 identified episodes meeting the six-month threshold. Sectoral panel tests reveal the energy sector (coal, crude oil, natural gas) and metals sector (copper, zinc, iron ore, etc.) are particularly prone to bubbles, both in frequency and duration—typically triggered by macroeconomic stress such as the 2008 financial crisis and the 2010–2011 European debt crisis. Interestingly, no long-term bubble episodes were detected during the COVID-19 pandemic, underscoring the crisis-specific nature of speculative bubbles. Agriculture & livestock commodities as a group experienced fewer and shorter bubbles, with the total bubble duration not exceeding two years—compared to over four years in the energy and metals sectors.

By combining individual GSADF tests and sectoral panel GSADF evaluations, the study bridges a major empirical gap in bubble detection across a broad set of commodities. Its methodological rigor, extended temporal scope, and sectoral breakdown provide significant implications for investors, analysts, and policymakers. In particular, the findings support using agriculture & livestock commodities as defensive assets during periods of market instability, while emphasizing that investment in energy and metals requires heightened vigilance due to their speculative nature. The paper concludes that commodity bubbles are both widespread and heterogeneous, linked strongly to financial crises and global uncertainty, and reinforces the utility of econometric bubble-detection frameworks in commodity risk management.

Real-Time Monitoring for Explosive Financial Bubbles – Harbey, Leybourne, Taylor

The paper *"Real-Time Monitoring for Explosive Financial Bubbles"* by Astill, Harvey, Leybourne, Sollis, and Taylor (2018) proposes novel and theoretically grounded procedures for detecting asset price bubbles as they emerge in real time, rather than retrospectively. Motivated by the limitations of existing one-shot tests like the right-tailed ADF (Phillips et al., 2011), the authors aim to detect bubbles at the time they form, which is crucial for policymakers and investors. Traditional one-shot procedures, if sequentially applied, often result in inflated false-positive rates (FPR), making them ill-suited for real-time monitoring. This study builds on earlier work by Astill et al. (2017, AHLT), which proposed an end-of-sample bubble detection test using sub-sample statistics of first differences estimated over a short window and whose critical values are obtained via subsampling (Andrews, 2003; Andrews and Kim, 2006). However, AHLT was still essentially a one-shot test.

To address the multiple testing problem inherent in real-time settings, the authors extend the AHLT framework and propose two sequential monitoring procedures: **MAXm** and **SEQm**. MAXm flags a bubble as soon as any test statistic in the monitoring period exceeds the maximum test statistic observed during a designated "training period." SEQm, on the other hand, triggers a signal if the length of a run of exceedances in the monitoring period surpasses the maximum such run in the training period. Importantly, both procedures allow for exact control over the FPR via analytical derivations. This is achieved through rigorous application of uniformity arguments (Harvey et al., 2018) and subsampling-based critical values. The paper also introduces a **union-of-rejections procedure** (Um), which combines the strengths of MAXm and SEQm, although it does not control the FPR as tightly.

A major contribution is the extensive Monte Carlo simulation framework used to assess finite-sample properties. The results demonstrate that both MAXm and SEQm accurately maintain the nominal FPR, even under time-varying volatility, serial correlation, and when training periods contain short-lived prior bubbles. This robustness makes the procedures superior to the Homm and Breitung (2012) CUSUM test, whose empirical FPR inflates significantly under heteroskedasticity or serial correlation. The authors further show that MAXm excels at early detection—important for short-lived bubbles—while SEQm becomes more effective as bubbles mature. The union approach (Um) effectively captures both types of bubbles at the cost of a slightly elevated FPR.

The authors test their method empirically using monthly real (inflation-adjusted) stock index data from five major markets (DAX 30, FTSE All Share, Nasdaq Composite, Nikkei 225, and S&P 500) over 1973–2002, with monitoring beginning in January 1995. Pretests, including Jarque–Bera for normality, Engle's LM for ARCH effects, and Cavaliere and Taylor’s (2008) volatility stationarity tests, confirm significant non-normality and heteroskedasticity, justifying the use of robust procedures. The MAXm and SEQm procedures both detect explosive behaviour consistent with the Dot-Com bubble period (1995–2001) in most indices, especially Nasdaq and S&P 500, with detection occurring as early as May 1995 (S&P 500, MAXm, m=5). Interestingly, the earliest warning was for the S&P 500 and not Nasdaq, suggesting the bubble was broader than just the tech sector. These detections occurred with low empirical FPRs (as small as 0.023), validating the procedure’s reliability in practice.

In summary, the authors provide a comprehensive and empirically validated framework for the real-time monitoring of explosive asset price bubbles using extensions of the AHLT subsampling methodology. Their proposed MAXm and SEQm procedures not only offer analytic control over the false positive rate, but also prove robust in finite samples and under realistic data conditions such as volatility shifts and serial correlation. The framework is easily extendable to other domains requiring regime detection and holds promise for proactive economic policy and financial risk management.

Panel Approaches to Econometric Analysis of Bubble Behaviour – Yanbo Liu

The paper by Yanbo Liu proposes advanced econometric methodologies to detect explosive financial bubbles within mixed-roots panel autoregressions featuring latent group structures. It addresses the well-known challenge of detecting financial bubbles, which are explosive deviations in asset prices from their underlying fundamental values, particularly difficult to detect due to the non-observable nature of these fundamentals. Traditional augmented Dickey-Fuller (ADF) tests, although useful, suffer from low power, particularly when bubbles are short-lived or slow-growing.

To enhance the power and accuracy of bubble detection, Liu introduces two distinct post-classification panel data methods: a recursive k-means clustering algorithm based on Bonhomme and Manresa (2016) for purely explosive panels, and a modified k-means clustering technique following Lin and Ng (2012) for mixed-roots panels (containing both stationary and explosive time series). These methods classify panel data into latent groups based on shared characteristics of explosive behavior, achieving consistency and demonstrating optimality (oracle properties). The post-classification estimators, derived after group classification, are shown to be asymptotically equivalent to infeasible estimators, which would be computed if true group identities were known.

The study introduces two powerful Wald statistics based on these post-classification estimators. These Wald tests significantly outperform conventional ADF statistics by offering greater inferential power, as they diverge faster under alternative hypotheses of explosive roots, and possess pivotal chi-square distributions under the null hypothesis, simplifying critical value determination. Monte Carlo simulations illustrate that the empirical power of the Wald statistics is nearly twice that of traditional ADF statistics in realistic conditions.

Liu also addresses real-time detection of bubble origination dates, extending earlier approaches such as Phillips et al. (2011, 2015a,b) by integrating the classified panel methodology. The study rigorously derives asymptotic theories to ensure accuracy and consistency in detecting the onset of bubbles. The practical value of these methods is demonstrated through an empirical application to China's real estate market, corroborating the view of rational speculative bubbles in Chinese housing markets.

Methodologically, the paper makes several significant contributions. Firstly, it enhances inferential power in bubble detection through uniformly consistent group classification and robust Wald statistics. Secondly, it innovatively adapts clustering algorithms, particularly for mixed-roots panels where explosive and stationary roots coexist, an approach not previously thoroughly explored. Thirdly, the paper contributes to the broader statistical and machine learning literature by developing novel concentration inequalities specifically tailored for mixed-root scenarios.

Overall, Liu's research establishes rigorous theoretical foundations and practical econometric tools to improve bubble detection, particularly enhancing reliability and power through sophisticated panel clustering techniques and advanced inferential statistics.

Explosive Behaviour in NASDAQ – SADF Test - Phillip Shi Wu

The paper "Explosive Behavior in the 1990s Nasdaq: When Did Exuberance Escalate Asset Values?" by Peter C. B. Phillips, Yangru Wu, and Jun Yu investigates the explosive behavior of asset prices in the context of the Nasdaq index during the 1990s, specifically addressing the identification and dating of financial exuberance, often referred to as "irrational exuberance." The authors introduce a robust econometric framework that allows the recursive testing of unit roots and explosive characteristics, providing a method to precisely timestamp the origination and conclusion of explosive periods in asset prices.

The study primarily leverages a recursive implementation of the Augmented Dickey-Fuller (ADF) unit root test and proposes a sup test that significantly enhances the capability of detecting explosive behavior, particularly addressing the limitations of earlier econometric techniques that lacked the power to consistently detect periodically collapsing bubbles. The authors also introduce a novel asymptotic distribution theory tailored for mildly explosive processes, enabling precise confidence intervals for growth rates associated with financial bubbles.

Applying their methodology to the Nasdaq composite index between 1973 and 2005, the authors empirically validate explosive growth specifically during the 1990s DotCom bubble. Their analysis successfully dates the initiation of financial exuberance to July 1995, predating Alan Greenspan's well-known "irrational exuberance" remark of December 1996. The recursive tests provide clear evidence of explosive behavior continuing until around early 2001, closely aligned with the actual peak and subsequent crash of the Nasdaq index.

The authors further demonstrate that conventional unit root tests, typically employed to detect such bubbles, tend to fail because periodically collapsing bubbles often mimic stationary or random-walk behavior. However, their recursive method significantly improves detection power, robustly identifying explosive periods that standard tests miss.

Additionally, the authors conduct finite-sample simulations to evaluate the performance and consistency of their proposed methods. These simulations confirm superior performance in detecting explosive episodes, even under conditions of periodically collapsing bubbles, thereby validating their approach as practical and effective in empirical finance applications.

Overall, the paper significantly contributes to the financial econometrics literature by providing powerful econometric tools for bubble detection and analysis. It not only confirms the presence of exuberance during the Nasdaq bubble period but also effectively links theoretical econometric advancements with empirical financial market behaviors, enhancing our understanding of speculative financial dynamics.

Detecting Multiple Bubble in S&P-500 – Phillip Shi Wu

The paper by Phillips, Shi, and Yu introduces a sophisticated econometric approach, termed the Generalized Sup Augmented Dickey-Fuller (GSADF) test, to identify and date-stamp multiple episodes of explosive financial bubbles in historical time series. Recognizing the limitations of previous methods in detecting multiple bubbles within the same dataset, the authors propose an advanced recursive flexible-window technique, significantly extending prior methodologies, notably the Sup Augmented Dickey-Fuller (SADF) test by Phillips, Wu, and Yu (2011).

The methodological innovation lies in the flexible window size used in recursive regressions, which contrasts with fixed-starting-point approaches. The GSADF test recursively adjusts both the beginning and end points of the sample windows, effectively maximizing the ADF statistic across all feasible sample ranges. This enhancement significantly improves detection power, especially in datasets featuring multiple bubble episodes, as it prevents the dominance of earlier explosive behavior or collapses from masking subsequent bubble occurrences.

The authors thoroughly outline their approach beginning with a standard asset pricing model that identifies bubble conditions based on explosive asset price movements relative to fundamentals. They develop rigorous asymptotic theory to support the validity of their GSADF approach, demonstrating consistency and improved statistical properties through simulations. These simulations confirm that the GSADF test significantly outperforms earlier recursive methods (like SADF and cumulative sum methods) by reliably detecting multiple historical bubbles.

Additionally, the paper outlines a sophisticated backward recursive procedure for real-time date-stamping of bubbles. This approach identifies bubble origination and termination dates by recursively testing subsamples backward in time, thereby pinpointing transitions from stationary or random-walk behavior into explosive regimes and vice versa. The date-stamping method significantly enhances practical usability for real-time surveillance and regulatory purposes.

Empirically, the authors apply their GSADF-based methods to the S&P 500 price-dividend ratio from January 1871 to December 2010. Their analysis successfully identifies well-known bubble episodes such as the 1929 crash, post-war boom in 1954, Black Monday in 1987, and the dot-com bubble. In comparison, previous methods, such as the SADF approach, fail to detect multiple bubble episodes accurately within the same historical dataset.

In summary, the paper makes a substantial methodological contribution to econometric literature by enhancing bubble detection and dating mechanisms, rigorously backed by theoretical justification and empirical validation. The GSADF test is presented as a powerful tool for regulators, policymakers, and market analysts concerned with timely identification and management of speculative market exuberance.

Bursting the Bitcoin Bubble – Andrea Podhorsky

The paper titled "Bursting the Bitcoin Bubble: Do Market Prices Reflect Fundamental Bitcoin Value?" by Andrea Podhorsky proposes an innovative theoretical and empirical framework for analyzing Bitcoin's price behavior, emphasizing the methodological approach used to understand its explosive and volatile nature. The primary methodological contribution of the paper is the development of a rigorous theoretical model that integrates Bitcoin mining processes, the Bitcoin protocol's mechanisms, and market equilibrium concepts. According to the model, Bitcoin's fundamental value is explicitly defined as the marginal cost of mining the target supply of bitcoins. This concept is critical because Bitcoin, unlike traditional financial assets or fiat currencies, is neither backed by tangible assets nor government guarantees, and thus cannot be valued using conventional methods applied to stocks or bonds. Instead, its value is grounded in equilibrium market conditions and the dynamics of its supply-side mechanics.

The author carefully models the supply side of Bitcoin, where miners engage in a competitive rent-seeking tournament, incurring costs for computational resources and electricity. Miners’ expected profits and entry dynamics into mining activities are modeled explicitly, incorporating the crucial role played by the Bitcoin protocol's difficulty adjustment mechanism. This mechanism regularly recalibrates mining difficulty, ensuring a consistent rate of block formation and a predictable supply of new bitcoins. The theoretical framework highlights how changes in demand directly impact miners' behavior and consequently the difficulty level, which is characterized as a sufficient statistic summarizing supply and demand dynamics. As the model demonstrates, when Bitcoin’s market price deviates from its equilibrium (fundamental) value, the protocol's adjustment of mining difficulty gradually realigns the market toward equilibrium.

Methodologically, the paper employs advanced econometric tests to empirically validate the theoretical model. Specifically, the study uses cointegration techniques (Engle-Granger tests) to empirically verify the existence of a long-run equilibrium relationship between Bitcoin prices and the marginal cost of mining bitcoins. Moreover, the analysis employs bubble detection methodologies such as the Supremum Augmented Dickey-Fuller (SADF) test and the Generalized SADF (GSADF) test. These econometric tools effectively identify whether apparent explosive behaviors in Bitcoin prices represent genuine speculative bubbles or merely reflect explosive movements in Bitcoin's nonstationary fundamental values. The empirical findings, utilizing nearly five years of detailed market and mining data, strongly indicate cointegration between Bitcoin's market price and its marginal mining cost, confirming the model's theoretical assertion of fundamental valuation. Importantly, while raw Bitcoin price data shows signs of explosive periods, these periods disappear once the fundamental value—based on the marginal cost of mining—is considered, implying that the explosive dynamics in Bitcoin prices stem from its nonstationary fundamentals rather than speculative bubbles.

This paper methodologically bridges the gap between theoretical economic modeling and advanced econometric testing, providing significant insights into how Bitcoin should be valued. The methodological robustness lies in clearly defining and empirically validating Bitcoin's fundamental value and carefully distinguishing between speculative bubbles and fundamental-driven volatility. Consequently, the approach and findings offer critical insights into asset pricing for cryptocurrencies, emphasizing the importance of explicitly modeling cryptocurrency-specific supply and protocol-driven dynamics.

Long-Run Relationship between House Prices & Rents – Gallin

The paper by Joshua Gallin titled "The Long-Run Relationship between House Prices and Rents" focuses on examining whether the rent-price ratio can effectively predict future changes in real house prices and rents, employing a rigorous econometric methodology to assess long-run relationships and error-correction mechanisms within the housing market. Gallin investigates the predictive capability of the rent-price ratio using two distinct approaches: standard error-correction models and long-horizon regression models.

The methodology initially involves standard error-correction models that utilize quarterly data from 1970 to 2003. Although this method indicates a long-run equilibrium between house prices and rents, the resulting coefficients from these models are statistically insignificant, thereby yielding inconclusive evidence regarding short-run dynamics and the speed of error correction at quarterly intervals.

To overcome the limitations of short-term error-correction approaches, Gallin employs a long-horizon regression framework similar to methodologies previously used by Campbell and Shiller (2001) for stock markets and Mark (1995) for exchange rates. This approach involves regressing three-year-ahead changes in real rents and house prices against the current rent-price ratio and an adjusted measure of the user cost of housing capital. The long-horizon regressions suggest that periods with low rent-price ratios—indicating high house prices relative to rents—tend to be followed by periods where real rents rise more rapidly, and house prices appreciate more slowly. These findings imply that house prices and rents eventually converge over longer horizons.

Recognizing a critical methodological challenge, Gallin demonstrates that long-horizon regression models produce biased estimates when house prices exhibit unit-root behavior but deviate from a pure random walk. To address this issue, the author introduces a sophisticated bootstrap approach, constructing artificial datasets under the null hypothesis that rents alone adjust to restore equilibrium. The bootstrap methodology rigorously corrects for bias arising from serial correlation in shocks to prices, providing valid statistical inference despite the complexity of the data-generating processes.

Gallin's empirical results from the bootstrap tests robustly reject the null hypothesis that rents alone perform the adjustment, indicating that house prices also adjust toward equilibrium, albeit slowly. Additionally, the inclusion of the user cost of housing capital in the regressions does not significantly alter the predictive relationship identified by the rent-price ratio.

In conclusion, Gallin’s paper methodologically advances understanding by providing strong empirical evidence that the rent-price ratio serves as an effective indicator of valuation and predicts long-term adjustments in the housing market. The bootstrap-enhanced long-horizon regression approach notably addresses and mitigates the biases inherent in standard econometric techniques, establishing a more accurate framework for analyzing the long-run dynamics of housing prices relative to rents.