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Cojumping: Evidence from the US Treasury bond and futures markets

Mardi Dungey [a,b], Lyudmyla Hvozdyk [a,*]

[a] Centre for Financial Analysis and Policy, Judge Business School, University of Cambridge, Trumpington Street, Cambridge CB2 1AG, United Kingdom
[b] School of Economics and Finance, University of Tasmania, Hobart, Tasmania 7001, Australia

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ABSTRACT

The basis between spot and future prices will be affected by jump behavior in each asset price, challenging intraday hedging strategies. Using formal cojumping tests this paper considers the cojumping behavior of spot and futures prices in high frequency US Treasury data. Cojumping occurs most frequently at shorter maturities and higher sampling frequencies. We find that the probability of cojumping is altered by the presence of an anticipated macroeconomic news announcement. The probability of cojumping is particularly affected by news surprises in non-farm payrolls, CPI, GDP and retail sales. However, the two cojumping tests are also more likely to provide contradictory results in the presence of surprises in non-farm payrolls. On these occasions the market does not clearly signal its short term pricing behavior.

1. Introduction

The joint behavior of spot and future prices for a single asset is particularly important in managing hedging positions: Stein (1961), Lien and Tse (2002) and recently Lee (2010). Prices in both contracts are known to move with news for many different asset types, and more recently, evidence from high frequency data strongly suggests that information arrival is often associated with price discontinuities, known as jumps: see Andersen et al. (2007a), Dungey et al. (2009) and Lahaye et al. (2011).[1] Intraday portfolio management involves recognizing and responding to such jumps. In particular, Lai and Sheu (2010) demonstrate that the use of realized volatility measures, which incorporate jump behaviors, compiled from high frequency data delivers measurable improvements in hedging performance, while Todorov and Bollerslev (2010) estimate distinct betas for jump risk on individual stocks. These findings reinforce the potential gains from time varying hedge ratios, such as demonstrated in Brooks et al. (2002). A time-varying hedge ratio will be particularly affected by cases where the basis is changed by non-contemporaneous jump behavior across spot and future markets.

This paper examines the joint behavior of the spot and futures markets for US Treasury bonds using a formal joint test of cojumping recently developed by Jacod and Todorov (2009). Cojumping refers to the occurrence of contemporaneous discontinuities in two price series, although in the formal test procedure the exact timing of cojumps is not identified. The spot and futures prices for US Treasuries are already known to jump individually; see for example Lahaye et al. (2011), Jiang et al. (2011), Jiang and Yan (2009), Dungey et al. (2009), and Andersen et al. (2007a).[2] However, to our knowledge, the question of cojumping across spot and futures markets for the same assets is previously unstudied. In addition to considering the evidence for spot and futures cojumping, we consider the jumping behavior across the term structure for each of the assets, extending the univariate test results in Dungey et al. (2009). Contemporaneous jumps across the term structure are consistent with liquidity preference theory, while more idiosyncratic jumps support segmented markets.

The Jacod and Todorov procedure comprises two tests, conducted on individual price series in which jumps are already known to occur. One test has the null hypothesis of contemporaneous jumps across multiple asset prices (cojumping), while the other has the null hypothesis of disjoint jumps (or no cojumping). The tests build on the standard assumptions of a continuous price process with discrete interruptions (the jumps), where the multi-power quadratic variation of the returns for the chosen time

* Corresponding author. Tel.: +44 (0)1223 760585; fax: +44 (0)1223 760576.
E-mail addresses: mardi.dungey@utas.edu.au (M. Dungey), lh336@cam.ac.uk (L. Hvozdyk).

[1] See Aït-Sahalia (2002) for a discussion of identifying the characteristics of a diffusion process.

[2] The particular univariate testing frameworks include Barndorff-Nielsen and Shephard (2004, 2006), Aït-Sahalia and Jacod (2009), Lee and Mykland (2008) and Jiang and Oomen (2008).

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period, usually one day, can be consistently estimated by realized variance. Jacod and Todorov recognize that under the null of common jumps the ratio of realized variances at different sampling frequencies will be the same, so that the hypothesis can be rejected when this is not the case. Alternatively, in the case of a null of disjoint jumps, the ratio of the realized variance to the square root of product of the quadratic returns of the individual asset returns tends to zero (that is there is no evidence that the movements occur together). We confirm the small sample properties of the Jacod and Todorov tests for highly correlated series with different trading intensities.

High frequency US Treasury spot prices are drawn from eSpeed, one of the two dominant ECNs trading these assets in the post-2000 era. Earlier work, such as Mizrach and Neely (2008) use data from the now superseded GovPX platform, which operated a voice over protocol. Corresponding data for the futures sample are obtained from the Chicago Mercantile Exchange, suitably transformed for nearest contract.

Working with 2, 5, 10 and 30 year maturity contracts we find evidence of cojumping between spot and futures prices, and that cojumping often occurs in response to the surprise component of scheduled US macroeconomic news announcements. There are more jumps in the futures contracts than the spot contracts, however, there are also periods when the spot market jumps but the futures market does not.

Given that the cojumping test proposed by Jacod and Todorov (2009) have two components, we find some periods where these tests are in conflict, so that one test suggests a cojump in the two assets and the other rejects its presence – that is one test suggests that jumps detected in each series occur contemporaneously on a given day, but the other test suggests they are separated in time. The extent of this is far greater than anticipated. Simple tabulations suggest that the conflicting results in the spot and futures pairs occur predominantly in the presence of negative surprises for US non-farm payrolls data. Formal regression analysis confirms the probability of a jump is influenced by macroeconomic news arrival, a result found in previous papers, but also the probability of observing an contradictory result. In these contradictory instances the hedging signals are unclear, as the tests are unable to reveal whether the basis has changed due to a jump in one asset, implying a potential arbitrage opportunity in the other asset, or due to different sized contemporaneous jumps in both assets. In particular, the tests cannot distinguish whether the data are subject to contemporaneous price discontinuities in the two markets, or whether the price discontinuities are separated in time. This likely reflects uncertainty around the news announcement, leading to moves which are inconsistent with the underlying continuous data generating process as the market attempts to establish a new equilibrium. For an intraday speculator or portfolio manager, it is potentially important to recognize that these periods of confusion, and hence opportunity, occur primarily in association with news releases, and particularly in response to the release of surprises in non-farm payrolls data.

The paper is organized as follows. Section 2 presents formal jump test methodologies. The data are described in Section 3 and the results of the cojumping tests are discussed in Section 4. In Section 5 the small sample properties of the jumps test are examined in a Monte Carlo with correlated prices. The relationships between cojumping and news, and contradictory test result occurrences and news are analyzed in Section 6. Finally, Section 7 concludes.

2. Methodology

The jump days for each series are determined using the univariate jumps test of Barndorff-Nielsen and Shephard (2006), henceforth BNS, which is a specific case of the more general proposal of Aït-Sahalia and Jacod (2009). Assume that an individual asset price, x_{it}, is an Itô semimartingale process

$$x_{it} = \int_0^t b_s\,ds + \int_0^t \sigma_s\,dW_s + \sum_{j=1}^{N} c_{jt}, \tag{1}$$

where x_t represents the price of the asset at time t, and the right hand side terms represent a continuous, locally bounded variation process, b_t, a strictly positive stochastic volatility process, σ_t, W_t is Brownian motion and the final term is a jump process where c_{jt} assumes a Poisson arrivals process with N possible jump occurrences. Returns for δ intervals are given by $r_{t+j\delta,\delta} = x_{t+i\delta} - x_{t+(j-1)\delta}$. The realized variance for each period t (one day in the application here) is sum of squared δ period returns which converges as $\delta \to 0$ to the true quadratic variation and squared jumps,

$$RV_{t+1}(\delta) = \sum_{i=1}^{1/\delta} r^2_{t+i\delta,\delta} \to \int_0^t \sigma_s^2\,ds + \sum_{0<s\leqslant t} c_s^2, \tag{2}$$

while the product of absolute adjacent δ period returns, or bipower variation converges to quadratic variation,

$$BV_{t+1}(\delta) = \mu_1^{-2} \sum_{i=2}^{1/\delta} |r_{t+i\delta,\delta}||r_{t+(i-1)\delta,\delta}| \to \int_0^t \sigma_s^2 ds,$$

where $\mu_1 = \sqrt{2/\pi}$ is a normalizing coefficient.

The BNS test recognizes that as $\delta \to 0$ the difference between realized volatility and bipower variation converges to a jumps only component

$$RV_{t+1}(\delta) - BV_{t+1}(\delta) \to \sum_{0<s\leqslant t} c_s^2,$$

which is modified to account for potential negative observations and serial correlation following Huang and Tauchen (2005) as

$$JS_{t+1}(\delta) = (RV_{t+1}(\delta) - BV_{t+1}(\delta)) \Bigg/ \left((\mu_1^{-4} + 2\mu_1^{-2} - 5)\delta \int_t^{t+1} \sigma^4(s)ds \right)^{-1/2} \sim N(0,1). \tag{3}$$

2.1. Bivariate jump test

While Barndorff-Nielsen and Shephard (2004) extend the concepts of bipower variation and realized variance to multivariate equivalents, the corresponding multivariate test is currently incomplete. An alternative is the extension to the bivariate case presented in Jacod and Todorov (2009). The assumed structure for the pricing process of the financial market assets is now expressed for a vector, x_t, where for convenience x_t represents the bivariate case of the current paper. Formally,

$$x_t = x_0 + \int_0^t b_s\,ds + \int_0^t \sigma_s\,dW_s + \int_0^t \int \kappa' \circ \theta(s,x)(\mu - v)(ds,dx) + \int_0^t \int \kappa' \circ \theta(s,x)\mu(ds,dx), \tag{4}$$

where b_t is the deterministic drift coefficient, W_t is a Brownian motion, and μ is a Poisson random measure (the jumps). The intensity of the jumps is v with a truncation function $\kappa(x) = x$ on a neighborhood of 0. Both b_t and θ are 2-dimensional processes in the 2 asset case and the 2×2 variance–covariance matrix of the returns, σ_t, is non-trivially assumed to evolve with the same Itô semimartingale form as (4), that is there are drift and jump terms in the evolution of the volatility.

There are three complementary sets to which the observed price paths may belong: Ω_t^J, when the series cojump (that is both series jump contemporaneously), Ω_t^D when the individual series