Multivariate Stock Returns Around Extreme Events: A Reassessment of Economic Fundamentals and the 1987 Market Crash

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Abstract

This paper reassesses the role of economic fundamentals in the 1987 stock market crash using a two factor common-component model of returns. The model decomposes returns into idiosyncratic components, a common white noise component, and a common source of Poisson jumps. Among three two-year sample periods for Major Market Index stocks, only a 1987-88 sample results in an estimated jump component with low frequency and large size. Using Bayes' rule, we infer *ex post* jump probabilities for each sample day. In contrast to an analogous univariate model for an index return, the multivariate model captures information in the cross-section of returns. Leading financial news on the most likely jump days from the multivariate model is compared with news on a control group of high index return days. Days with high jump probabilities under the multivariate model contain systematically more news related to the dollar, trade deficits, and financing of the U.S. budget deficit. This suggests that the common jump component proxies for economic fundamentals related to this cluster of news events, and that the unexpectedly large U.S. trade deficit news released on the Wednesday prior to the crash provided an economic catalyst for the event.

1 Introduction

The global equities crash of October 1987 sparked a flurry of interest into its causes. The Brady Report of the Presidential Task Force (Brady, 1988) and the financial press emphasized market institutions and mechanisms, including program trading, institutional investors, rapid growth of futures and options markets, and particularly feedback effects induced by dynamic trading strategies such as portfolio insurance. In the academic literature, theoretical models (Grossman, 1988; DeLong et al., 1990) extended the existing microstructure literature (Shiller, 1984; Kyle, 1985; Black, 1986) to incorporate positive feedback traders, and empirical papers (Brennan and Schwartz, 1989; Genotte and Leland, 1990) attempted to quantify the effect of portfolio insurance during the crash. Asymmetric information during the crash is investigated by Seyhun (1990), who finds that corporate insiders outperformed the market. Moreover, corporate insiders outperformed a naive contrarian strategy, suggesting that the crash was not purely a matter of market overreaction. Kim and Kim (1996) more recently attempt an econometric test for transient fads or bubbles during the crash. Researchers also looked to futures and options markets to provide clues about perceived systemic risk prior to the crash. Schwert (1990) and Bates (1991), find that the crash was not anticipated in either index futures prices or implied volatilities of futures options, although Bates does find evidence of negative implied skewness and high implied volatility from October 1986 to August 1987.

The role of economic fundamentals during the crash raised difficult questions for proponents of market efficiency since it seemed unlikely that any news event could account for the extreme fluctuations experienced by the market. Fama (1989) points out that "lack of knowledge about how markets absorb information about business conditions" makes any assessment of the role of economic fundamentals difficult, while Roll (1989) argues that the crash must have had some fundamental component, since it occurred globally independent of market structure.

After intensive scrutiny of the economic news surrounding the crash, several articles singled out specific fundamentals for empirical investigation. Mitchell and Netter (1989) find that takeover candidates had significant abnormal returns on event dates related to takeover tax legislation, including two dates during the week immediately preceding the crash. Limmack and Ward (1990) use a panel of UK equities and find mixed evidence that pre-crash market risk and international sales exposure relate to crash returns. Finally, Thorbecke (1994) uses an APT framework with monthly data and finds that unexpected movements in U.S. trade deficit data have significant effects on stock returns between 1984 and 1988.

In this paper, we reexamine the issue of economic fundamentals related to the crash by using a two-factor common component model (Stock and Watson, 1988) to decompose a panel of daily stock returns into idiosyncratic components and two unobserved common components. The first common factor is a white noise that proxies for market risk, while the second component is an independent jump process that proxies for an unobserved source of potentially infrequent and extreme variation. We allow factor loadings on the two latent components to differ, and can thus test the hypothesis that the unobserved economic factors related to the jump component differ from normal market risk. We use three separate samples of the twenty Major Market Index ("MMI") stocks over the time periods 1985-86, 1987-88, and 1989-90. In both the 1985-86 and 1989-90 sample periods, the estimated parameters for the common jump component favor a jump frequency of about one per day and jump size comparable to the white noise component. Thus, in both of these periods, the jump component appears very much like a second source of white noise. In contrast, the estimated jump frequency for the 1987-88 sample is about once every sixty days and jump size is approximately seven times the size of the white noise component. Thus, only the crash sample period favors a specification with large, infrequent jumps.

Using the estimated parameters, Bayes' theorem allows us to calculate, for each trading day, the *ex post* probability that a jump occurred. We note that the estimated jump probability in the multivariate model depends not only on the size of price changes on each trading day, but also the pattern of returns across stocks. This is due to the difference in factor loadings between the jump component and the white noise component. To emphasize this point, we estimate a univariate jump-diffusion model on the MMI index, and calculate daily jump probabilities. For the univariate model, the estimated jump probability is monotonically increasing in the size of the index return. The results demonstrate that the ordering of daily jump probabilities from most likely to least likely are quite different under the multivariate and univariate models. We hypothesize that the multivariate model captures the influence of crash related economic fundamentals in the cross-section of stock returns.

To test this hypothesis, we select the most likely jump dates from both the multivariate and univariate models, and analyze financial news from the *Wall Street Journal* that was reported as significant on each set of trading days. In a comparison with the likely jump dates from the univariate model, the likely jump dates from the multivariate model have a disproportionate amount of news relating to trade imbalances, level of the dollar, and financing of U.S. debt. This supports claims that the release of worse than expected trade deficit data on the Wednesday prior to the crash provided a catalyst for the extreme fluctuations in the following week.

The plan of the paper is as follows: Section 2 presents the multivariate model and the data, and shows that *ex post* jump probabilities can be recovered using Bayes' rule. Section 3 discusses the results for the multivariate and univariate models, and analyzes news events on the set of estimated most likely jump dates. Section 4 concludes.

2 The Model

The empirical model is a first-differenced version of a vector auto-regression with common trends. Letting ΔX_t be an n-vector of continuously compounded asset returns,

$$\Delta X_t = \mu_X + \beta\zeta_t + \gamma\tilde{\mathcal{Y}}_t + \nu_t, \qquad \nu_t \sim N(0,\Sigma) \tag{1}$$

$$\zeta_t \sim N(0,\sigma_z), \qquad \tilde{\mathcal{Y}}_t \sim N(0, J_t\sigma_Y^2), \qquad J_t \sim \text{Poisson}(\lambda\Delta t) \tag{2}$$

Each of X_t, ν_t, μ_X, β, and γ are $n \times 1$ vectors, and all stochastic variables are i.i.d. in time. The two component structure allows us to exploit information in the covariance pattern of returns to infer jump probabilities that differ substantially from a rank ordering based on index returns, as discussed in Section 2.2.

The discrete representation above can be derived from a continuous-time model for a matrix of stock prices, S, from which the continuously compounded returns ΔX are calculated. The appropriate stochastic differential equation for the model above is

$$\frac{dS}{S} = \mu dt + \beta\sigma_z dW_z + \gamma\sigma_Y dq + \text{chol}\left\{\Sigma\right\} dW_V$$

$$\mu \equiv \mu_X + \text{diag}\left\{\beta\beta'\right\}\sigma_z^2/2 + \text{diag}\left\{\Sigma\right\},$$

where *diag* denotes the column vector obtained from the diagonal elements of a square matrix and *chol* the Cholesky decomposition; where Wz is a one-dimensional Wiener process; where q is a one-dimensional Poisson jump process with jump frequency λ and Gaussian distributed jumps of unit variance; and where W_V is an n-dimensional Wiener process.

The model thus corresponds to a two-factor model of asset prices with idiosyncratic noise. The first common component follows a Gaussian white noise. In a one-factor model, the individual stocks' factor loadings, β, are interpreted as market risk. The second factor is a jump process: Jumps occur at a Poisson distributed frequency, and have a Gaussian distributed size with variance distinct from the first component. The jump component has increments with thick tails relative to the Gaussian distribution. For jump parameters with low frequency and large variance relative to the white noise component, the model captures the effect of systematic asset risk to a rare but extreme source of variation.

In a large economy, the two factor model we have proposed generates additional restrictions on expected returns under absence of arbitrage. The two-component model conforms to APT assumptions, and APT restrictions would require that drifts are a linear combination of factor loadings. Scaling terms in the linear combination would be interpreted as required return on a unit of each of the two systematic risk factors. While these restrictions could be imposed in estimation, they generate additional non-linearities in the likelihood function that substantially complicate estimation. Additionally, our cross section of data is not particularly large, sample means are generally difficult to estimate, and a formal test of the APT is not essential to the focus of the paper. Thus, we do not impose restrictions on the means.

2.1 Estimation

For identification, the two common components of returns are assumed independent. The covariance matrix of residual returns is assumed diagonal, $\Sigma = \text{diag}\{\sigma_i^2\}$, so that ν_t represents pure idiosyncratic noise. Idiosyncratic risk is also assumed independent from the two common components. Identification also requires a normalization of the sizes of either β or ζ and of either γ or $\tilde{\mathcal{Y}}$. Normalizing the factor loadings allows direct comparison of the size of the Brownian component and the jump-component via their estimated standard deviations σ_z and σ_Y. The mean of estimated β_i and γ_i are thus assumed equal to one.

Conditioning upon j jumps occurring in the interval $\triangle t$, returns have a Gaussian distribution with variance

$$\begin{aligned} \Omega_j &\equiv \mathbb{E}\left[(\Delta X_t - \mu_X)(\Delta X_t - \mu_X)'\right] \\ &= \sigma_z^2 \beta\beta' + j\sigma_Y^2 \gamma\gamma' + \Sigma. \end{aligned}$$

The probability of j jumps occurring is

$$\mathbb{P}(J = j) = \frac{e^{-\lambda \Delta t}(\lambda \Delta t)^j}{j!}. \tag{3}$$

For $\theta = (\beta, \gamma, \sigma, \sigma_Y, \sigma_z, \lambda, \mu_X)$, the likelihood function is then

$$\begin{aligned} \ln L(\Delta X; \theta) &= \frac{-nT}{2} \ln(2\pi) + \sum_{t=1}^{T} \ln \left[\sum_{j=0}^{\infty} \mathbb{P}(J_t = j|\lambda) \quad \times \right. \\ & \left. |\Omega_j|^{-\frac{1}{2}} \exp\left\{ -\frac{1}{2} \xi_t' \Omega_j^{-1} \xi_t \right\} \right], \end{aligned} \tag{4}$$

where $\xi_t = \Delta X_t - \mu_X$.

In the empirical work that follows, this likelihood function is maximized using the method of Broyden, Fletcher, Goldfarb, and Shanno. We use different starting values to test for multiple local maxima, and find good convergence properties with reasonable starting values.

2.2 Recovering Jump Probabilities

In the absence of jumps, the only systematic component of returns is variation in the white-noise market risk factor, which works into returns through its factor loadings, β. The jump component of returns has separate factor loadings, γ. Thus, while larger asset returns should increase the estimated probability of a jump event, asset returns that are substantially 'closer to' a linear combination of γ and β than a rescaled β alone should also increase the estimated probability of a jump event.

Considering the particular example that the crash relates to trade deficit news, different assets should have varying different exposures to this type of news. Our key assumption is that factor loadings on crash related news events are constant over time, so that if news related to this risk factor is released on other dates, then that information is recoverable through a pattern of returns that appears to contain a linear component related to γ.

A potential advantage of this methodology is that we need not specify *ex ante* a particular economic cause as the crash risk factor. Instead, we allow the data to identify a set of event dates that seem to be driven by a unified source of rare but potentially extreme variation. These dates can then be analyzed for a pattern of containing news releases related to a particular type of economic risk.

Moreover, we need not *ex ante* specify one or more dates as ‘event dates’ or ‘crash dates’ . Again, the data alone can identify the complete set of likely event dates. For a sample period containing the crash, we expect that extreme variation alone will generate estimated jump-risk factor loadings that favor the patterns observed on October 19. Nonetheless, in other circumstances one might specify beforehand one or more dates on which jumps occurred.

The intuition developed above is formalized by using Bayes’ Theorem to calculate daily jump probabilities. If we assume an estimated parameter vector $\hat{\theta}$, applying Bayes’ rule for densities yields

$$\begin{aligned}\mathbb{P}\left(J_t = j|\Delta X_t, \hat{\theta}\right) &= \frac{L\left(\Delta X_t, \hat{\theta}; J_t = j\right)}{L\left(\Delta X_t, \hat{\theta}\right)} \\ &= \frac{2\pi^{-n/2}\mathbb{P}\left(J = j|\hat{\lambda}\right)\left|\hat{\Omega}_j\right|^{-\frac{1}{2}}\exp\left\{-\frac{1}{2}\hat{\xi}_t'\hat{\Omega}_j^{-1}\hat{\xi}_t\right\}}{L\left(\Delta X_t, \hat{\theta}\right)}.\end{aligned}$$

We use this relation to calculate the probabilities $\mathbb{P}(J_t > 0)$ for each day in the sample at the estimated parameter values. To generate confidence bands, we use Monte Carlo draws from the estimated asymptotic distribution of the parameter vector. With a large number of draws, the simulated distribution of jump probabilities converges to the asymptotic distribution for each date.

2.3 Data

We estimate the model above on the Major Market Index (“MMI”) stocks, which represent the twenty largest stocks on the New York Stock Exchange. The number of stocks (or portfolios of stocks) included in the sample is somewhat constrained by the fact that we must estimate $4n + 1$ parameters, none of which is linear in the likelihood function. The MMI sample has the advantage of being less subject to concerns about asynchronous trading than would a sample that included less liquid stocks. During the crash period, this is an important consideration. Additionally, because of size homogeneity in the sample, we may expect to find a stronger source of common jump risk. On the other hand, the same fact may limit dispersion in the jump factor loadings, which diminishes ability to extract information on the occurrence of jump related events. Future work may consider incorporating a greater variety of equities, perhaps by forming portfolios of similar stocks.

We estimate the model using three separate two-year samples of daily MMI returns data. In addition to a 1987-88 sample period which covers the crash, we also use the surrounding 1985-86 and 1989-90 sample periods. This allows some comparison of different types of behavior observed with this model.

3 Results

Tables 1, 2, and 3 show common-component model estimates for the MMI samples in chronological order. Asymptotic standard errors, derived from the estimated information matrix, are in parentheses.

Across all sample periods, idiosyncratic risk is relatively similar. Most stocks have residual risk estimated with some precision, clustering around values of about one. There is some tendency towards correlation in the levels of individual stock's residual risk across samples.

Mean returns are not generally precisely estimated, and most are not significantly different from zero. The levels in the first sample period are generally higher, and there is little apparent tendency for correlation of an individual stock's drift level across periods. As in most empirical work, the drifts appear difficult to estimate and inconstant over time. It does not appear in any sample period that the drifts are substantially correlated with either risk factor, although if estimated drift precision is weak enough, this need not imply rejection of APT restrictions.

The white noise component, which is associated with 'normal' market risk, has a substantially larger estimated size in the crash period (1.39) than in either 1985-86 (0.83) or 1989-90 (0.63). Since factor loadings have been normalized to a mean of one in all periods, this component has absorbed substantial additional variance in the crash period.

This effect was not apparent for the idiosyncratic components, which are of relatively the same size across periods, as discussed above. Also, with variance levels that cluster around one, the idiosyncratic components contribute more to total variance than the market white noise factor in the first and third sample periods, and less in the crash period. The size of the white noise risk factor is uniformly precisely estimated, and its factor loadings are fairly precisely estimated, but over half are not significantly different from one. Finally, market white noise factor loadings appear somewhat correlated for individual stocks across periods, although substantially more dispersed in the third period.

3.1 Estimated Jump Components

In each period, the common jump component displays markedly different properties. Jump frequency is very low in the crash period (.017), but precisely estimated and significantly different from zero. With this frequency, jumps should occur on average once in about 57 periods. This component thus captures the notion of a rare source of risk, although the frequency is large enough to correspond to more than a single event date.

In contrast, for the first and third periods the estimated jump frequency is fairly close to one per period. Because the number of jumps is random, increments of these estimated jump processes still have distributions that are thick-tailed relative to the Gaussian. Nonetheless, the tails decrease with λ, and these processes will appear much more like a second source of 'normal' market risk than the estimated crash jump process.[1]

The estimated factor loadings on the jump component are very widely dispersed in the 1985-86 sample period, ranging from -8 to 32. In addition, eight of twenty are not significantly different from zero, so this component is arguably diversifiable in a large sample. Estimated jump size is very small (.036) and not significantly different from zero. Nonetheless, a likelihood ratio test of significance for the component as a whole rejects a hypothesis of no jumps. Scaling the jump size up to the size of the white noise component while scaling factor loadings down by a compensating amount, the jump component appears to be a substantial source of variation for only about four stocks.

In contrast, jump size and dispersion of factor loadings in 1989-90 are about the same as size and dispersion of the white noise component. All factor loadings are significantly different from zero, so this component represents non-diversifiable risk. Except for the somewhat thicker tailed increments induced by the random number of jumps per period, the jump component in this period looks much like a second 'normal' source of market variation.

Finally, jump size in the 1987-88 crash sample is very large – at 9.722, about seven times the size of the white noise component – and precisely estimated. Jump factor loadings have about the

[1] As jump frequency grows, the distribution of jumps per period converges to Gaussian.

same dispersion as white noise factor loadings, and although standard errors are about four times as large, all are significantly different from zero. This is thus the only sample period that captures the notion of a non-diversifiable source of rare but extreme variation.

All samples strongly reject a hypothesis of no jump component in a likelihood ratio test, and the Chi-square statistic is about twice as high in the crash period relative to the other two samples. In addition, all samples strongly reject the hypothesis that $\beta = \gamma$, although for individual stocks, factor loadings are not always significantly different.

3.2 Univariate Jump-Diffusion Estimates

For comparison with the common component model, we also estimate a univariate jump-diffusion model on an index of the MMI stock returns. The index is rebalanced daily to maintain an equal weighting among the component stocks. The details of the univariate jump-diffusion model are discussed in Chapter One. Estimated parameters for the 1987-88 sample are

Univariate Jump-Diffusion, MMI Index			
μ	σ_z	λ	σ_Y
0.11	1.06	0.088	4.68
(0.05)	(0.06)	(0.03)	(0.47)

The main difference in comparison with the multivariate model is a higher jump frequency and lower jump size.

3.3 Inferred Jump Probabilities

Using estimated parameters from the two-component model, we estimate the *ex post* probability of jump occurrences by using Bayes' rule, as outlined in Section 2.4. Since only the crash period has an estimated jump component that is rare and results in potentially extreme return variation, only this sample is discussed.

Figure 1 plots daily jump probabilities from the common component model. The upper 95% confidence band, calculated via 3000 Monte Carlo draws from the asymptotic distribution of the parameters, is also shown when greater than 0.05 jump probability. There is a small cluster of large jump probability event dates immediately around the crash, and a larger more diffuse cluster of large probability event dates following the crash. Finally, a scattering of event dates prior to the crash have larger than normal jump probabilities.

The diffuse cluster of high probability event dates following the crash may be partly attributable to model misspecification. As discussed previously, the present specification is time homogeneous. A model that allowed stochastic volatility in the white noise component would be more likely to absorb post-crash variation through this component, and less likely to attribute post-crash variation jumps. In addition, if a separate liquidity-risk factor became important as a result of the crash, this would again account for additional post-crash variation and reduce the estimated probability of post-crash jumps. In general, both types of misspecification are likely to result in overestimated post-crash jump probabilities and underestimated pre-crash jump probabilities. Our analysis of high probability pre-crash jump dates thus considers the pre-crash environment as a relevant comparison, rather than the overall data set.

Figure 2 shows estimated *ex post* jump probabilities calculated from the univariate jump-diffusion model. This model contains less information because it conditions only upon the size of index movements rather than both size and the multivariate pattern of returns. The correlation coefficient between jump probabilities calculated under the two-component model and the univariate model is 0.55, showing the approximate weighting of size relative to direction of returns in determining the common-component model jump probabilities.

This relationship can also be seen in Figure 3. This shows scatter plots of index return size versus multivariate jump probability, and univariate model versus multivariate model jump probability. These plots appear both in levels and in log-log coordinates, in order to emphasize large and small probability event-dates respectively. In all cases the relationship is positive, though not exceptionally strong.

Higher jump-frequency in the univariate model results in generally larger estimated jump probabilities, with numerous large probability event dates. In contrast, the multivariate model selects a small set of event dates as having a larger than normal jump probability. We focus on the multivariate model results in the analysis of likely jump dates.

3.4 Analysis of Likely Jump Dates

Table 4 presents the twenty most likely common-component model jump dates. The table includes date (t), common-component model jump probability $\mathbb{P}_C(t)$, its upper 95% confidence interval $P_{95}(t)$, index return $R_M(t)$, size rank of index return $Z_M(t)$, univariate model jump probability $\mathbb{P}_U(t)$, and leading financial news reported in the *Wall Street Journal* the following day. Table 5a presents corresponding information for the eight largest index return days with low common-component jump probabilities. Table 5b shows four additional pre-crash dates with large jump probabilities relative to the pre-crash environment.

3.4.1 Likely Pre-Crash Jump Dates

For the six most likely pre-crash jump dates, two are among the twenty most likely jump dates overall. The other four are large relative to the pre-crash environment, and included for reasons discussed in Section 3.4. Four dates are strongly related to significant news about the dollar: release of U.S. trade deficit data, stability of the Louvre accord, G-7 intervention in currency markets, participation of foreign investors in U.S. treasury auctions, and to a lesser extent, the U.S. federal budget deficit.

In particular, the most likely pre-crash jump date is May 6, 1987, during which the most significant financial news was an ongoing U.S. Treasury auction. The auction was a large $29 billion refinancing that spanned May 5-7. Short term notes were sold on the first day, 10-year notes on the second, and thirty year bonds on the third. The financial markets approached this event cautiously, with significant speculation in the days and even weeks beforehand about demand, and particularly the participation of major Japanese investors. The dollar had been fluctuating significantly, there were doubts about the stability of the Louvre accord, and the U.S. trade deficit had increased substantially the previous month.

On May 6, the bond and stock markets climbed as the short-term note sale went well. The *WSJ* indicated a great deal of remaining uncertainty about the longer term auctions. The following day (our event date), the bond market plunged as the ten year note sale went poorly. Financial news noted specifically that participation from Japanese investors was "virtually non-existent," and that this was relevant above and beyond the final price. In assessing the usefulness of the common-component model, we note that aggregate stock returns were very moderate – the return on our MMI index was about 0.6%. Thus, the multivariate pattern of returns, rather than their average size, is what drives the estimated high jump probability.

The second most likely pre-crash jump date is April 21, 1987. Analysts attributed the rise to relief that the dollar and bond markets stabilized in late trading after central bank intervention to support the dollar. Earlier, a Federal Reserve Board official made comments suggesting that rates should be eased in Japan rather than raised in the U.S. in order to relieve trade and currency pressure. The news report states that the comments came "as economic tensions between the U.S. and Japan continued to hold the attention of world financial markets, which gyrated wildly."

October 14, 1987 is also identified as one of the more likely pre-crash event dates. This is sometimes viewed as the beginning of the crash, since it began the aggregate 12% index decline in the four trading days preceding the crash. The overwhelming focus of the financial news coverage in the *Wall Street Journal* is the announcement of a larger than expected trade deficit. Previous days had noted the importance of this upcoming announcement, and that traders were attempting to cover open positions in the dollar.

On April 15, 1987 the major news was financial markets regaining much of the previous day's losses. The initial losses were attributed to a release of trade deficit figures. The gains were attributed to a Japanese official's statement that the G-7 would maintain its Louvre accord policy, and corresponding intervention to support the dollar.

The only likely pre-crash event date that appears unrelated to this cluster of news events is August 31. Strengthening in the dollar and bond markets is credited with stock gains, but no specific news is mentioned.

It appears clear that news events on the likely pre-crash jump dates are dominated by trade imbalances, exchange rates, and U.S. debt. The challenge to this method is whether the sample of likely-event dates selected by the common-component model is unusual in this respect. This is examined via a group of dates with large index movements, but low estimated jump probabilities, presented in Section 3.5.3. We first examine likely post-crash jump dates.

3.4.2 Likely Post-Crash Jump Dates

A similar cluster of news events is prevalent in likely post-crash jump dates. Twelve of the eighteen most likely jump dates appear to have significant news related to trade imbalances, exchange rates, and U.S. debt.

The analysis is somewhat complicated by the crash, which was a news event in itself and tends to obscure other news. This is particularly pronounced for the three most likely jump dates, which are the crash and the two following days. The crash itself was judged to have significant news on the basis of Treasury Secretary Baker's comments over the weekend that the U.S. would let the dollar fall unless West Germany eased credit. On Tuesday, West Germany cut its rates, and President Reagan announced that he would enter into budget negotiations with Congress in a reversal of administration position.[2] This was also judged to be significant news. Wednesday was judged not to have significant news, although additional information on the administration's budget negotiation position was released.

Of the fifteen remaining dates, three contained releases of trade-deficit figures, two contained statements on trade-deficit figures by federal officials, and two contained market generated rumors on trade-deficit figures that were reported to have driven the markets.[3] In addition, two dates contained major central bank intervention in support of the dollar, one contained significant comments on exchange rates, and one contained a rumor on Louvre accord stability. One date contained a rumor on a budget-deficit agreement.[4]

Of the six dates that were judged not to have significant news, most had significant fluctuations in the dollar or bond markets, and the dollar moves were frequently credited with moving the stock market. At the very least, markets seemed to be fixated on exchange rates in the months following the crash. To determine whether the set of likely jump dates is unusual in containing so many related news events, we analyze a sample of large index return dates with low estimated jump probabilities in the common component model.

3.4.3 High Index-Return Dates with Low Jump Probability

The possibility remains that the results of the previous two sections are a result of a general prevalence of news events in our identified cluster. To test this, we could draw a random sample of dates and analyze its news contents. A stronger test is obtained by analyzing dates with high

[2]This was largely viewed as a concession to the financial markets' anxieties over budget deficits.

[3]In general, statements and rumors were counted as significant only if the *Wall Street Journal* indicated, either through its own commentary or a quote from an analyst, that this was a major factor in the markets on that day.

[4]One date contained a statement on bond rates that was judged not to be significant.

index return, but low estimated jump probability under the common component model. Table 5a presents the eight highest index return dates that are not among the top twenty in estimated common jump probability. Inspection shows that these dates have comparable, if not generally higher, index returns than the dates in the previous two sections.

Among the eight dates, there are no releases of trade deficit data, nor comments nor rumors on these data. There are also no significant exchange rate interventions. One date contains the significant news that the Fed left the discount rate unchanged. Another contains a potentially significant statement by the Fed on intentions to maintain liquidity in the system after the crash. On the other hand, this date is very unlike the high probability jump dates in that the bond market moved in opposition to the stock and dollar markets. The high probability jump dates show much more of a focus on dollar news, and a very strong corresponding tendency for all three markets to move together.

Among the other dates, one contains a potential rumor on exchange rate stabilization, although it is acknowledged to contain no shift in policy, and is identified as a weak rumor in the report. The rest are either weak news, no news, or different news: a budget agreement rumor that is a continuation of a story judged not to be significant in the previous sample, unexplained movements in the dollar, a date that is almost surely driven by developments within OPEC that drove oil prices down.

Summarizing these results, we conclude that the common jump component model has uncovered a significant pattern in return variation. Those dates that appear to have high jump probabilities under the multivariate model show a disproportionate pattern of news related to the level of the dollar and trade deficits.

4 Discussion

The 1987 stock market crash stimulated great academic interest in its causes. While a variety of interesting developments in market microstructure came out of the event, the issue of whether the crash had any foundation in economic fundamentals is still largely unresolved. This can largely be attributed to the fact that highly singular events are difficult to study empirically. As a result, numerous potential 'triggering events' occurring around the time of the crash have been proposed, and their effects have been difficult to disentangle empirically.

This paper attempts to uncover potential fundamental factors related to the crash be exploiting information in the cross-section of stock returns. We model stock returns with a two-factor common component process, where one common component is a Poisson jump process of Gaussian distributed size. Factor loadings are constant over time, so that when a jump occurs, it produces a noisily recognizable pattern in multivariate returns. Using Bayes' rule and estimated parameters of the empirical model, we recover a set of dates with large *ex-post* jump probabilities. The news content of these dates is compared with a sample of high-index-return, low-jump-probability dates. The high jump probability event dates from the multivariate model are found to have a disproportionate number of news stories related to exchange rates, the trade-deficit, and the financing of U.S. debt. This supports claims that the unexpectedly large U.S. trade deficit figures released on the Wednesday prior to the crash provided a catalyst for the crash rooted in economic fundamentals.

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TABLE 1

ML Estimates of the Two-Component Model for MMI Stocks: 1985-1986

	σ		β		γ		μ	
AMEX	1.230	(0.042)	1.283	(0.085)	-8.012	(3.478)	0.101	(0.073)
Chevron	0.951	(0.052)	0.851	(0.125)	31.977	(2.790)	0.061	(0.066)
DuPont	1.058	(0.035)	0.963	(0.067)	1.409	(2.741)	0.121	(0.059)
Dow	1.068	(0.036)	1.085	(0.072)	-5.956	(2.993)	0.174	(0.063)
Kodak	1.239	(0.040)	0.954	(0.075)	-0.472	(2.898)	0.090	(0.065)
GE	0.834	(0.031)	1.275	(0.065)	-5.599	(3.247)	0.103	(0.060)
GM	1.013	(0.034)	0.942	(0.065)	-4.001	(2.705)	0.003	(0.057)
IBM	0.905	(0.030)	0.894	(0.060)	-4.623	(2.515)	0.013	(0.052)
IP	1.155	(0.038)	0.915	(0.074)	-6.938	(2.782)	0.091	(0.062)
J&J	1.299	(0.042)	1.056	(0.080)	-1.514	(3.285)	0.130	(0.070)
Coke	1.151	(0.039)	1.143	(0.079)	-8.240	(3.249)	0.142	(0.067)
3M	0.760	(0.027)	0.951	(0.055)	-5.186	(2.502)	0.100	(0.049)
PMorris	1.318	(0.043)	0.995	(0.083)	-6.152	(3.169)	0.139	(0.070)
Mobil	1.027	(0.051)	0.847	(0.121)	29.583	(2.508)	0.071	(0.067)
Merck	1.002	(0.033)	0.987	(0.065)	-3.493	(2.671)	0.206	(0.058)
P&G	1.033	(0.034)	0.912	(0.066)	-3.756	(2.568)	0.079	(0.057)
Sears	1.115	(0.038)	1.277	(0.077)	-5.814	(3.322)	0.069	(0.069)
AT&T	1.172	(0.039)	1.161	(0.076)	-3.642	(3.166)	0.074	(0.068)
USX	1.928	(0.062)	0.593	(0.117)	12.499	(3.154)	-0.034	(0.090)
Exxon	0.807	(0.033)	0.918	(0.083)	17.931	(2.411)	0.092	(0.054)

σ_z		σ_Y		λ	
0.829	(0.018)	0.036	(0.654)	0.896	(0.000)

lnl = -16124

TABLE 2

ML Estimates of Two-Component Model for MMI Sample: 1987-1988

	σ		β		γ		μ	
AMEX	1.589	(0.053)	1.307	(0.070)	1.120	(0.335)	0.007	(0.107)
Chevron	1.367	(0.044)	0.901	(0.054)	0.704	(0.213)	0.027	(0.082)
DuPont	1.084	(0.036)	1.005	(0.049)	0.691	(0.210)	0.030	(0.079)
Dow	1.222	(0.042)	1.183	(0.058)	0.683	(0.210)	0.096	(0.091)
Kodak	1.315	(0.045)	0.910	(0.057)	1.533	(0.449)	0.024	(0.082)
GE	1.003	(0.035)	1.164	(0.051)	0.807	(0.240)	0.026	(0.085)
GM	1.184	(0.039)	0.796	(0.049)	0.980	(0.291)	0.080	(0.072)
IBM	0.989	(0.033)	0.841	(0.044)	0.982	(0.291)	0.024	(0.068)
IP	1.545	(0.052)	1.322	(0.069)	0.871	(0.267)	0.060	(0.107)
J&J	0.985	(0.034)	1.002	(0.047)	0.830	(0.247)	0.067	(0.076)
Coke	1.134	(0.038)	1.036	(0.054)	1.265	(0.373)	0.058	(0.082)
3M	1.099	(0.037)	1.059	(0.052)	1.120	(0.333)	0.033	(0.082)
PMorris	1.164	(0.039)	0.942	(0.049)	0.510	(0.159)	0.088	(0.078)
Mobil	1.356	(0.044)	0.893	(0.057)	1.130	(0.331)	0.054	(0.082)
Merck	1.086	(0.037)	0.924	(0.047)	0.421	(0.136)	0.078	(0.075)
P&G	1.056	(0.036)	0.840	(0.048)	1.344	(0.398)	0.050	(0.071)
Sears	1.393	(0.046)	1.082	(0.063)	1.081	(0.316)	0.033	(0.091)
AT&T	1.143	(0.038)	0.914	(0.051)	1.042	(0.306)	0.053	(0.076)
USX	1.745	(0.058)	0.938	(0.073)	1.704	(0.501)	0.091	(0.098)
Exxon	1.064	(0.036)	0.941	(0.051)	1.182	(0.344)	0.072	(0.075)

σ_z		σ_Y		λ	
1.385	(0.012)	9.722	(0.07)	0.017	(0.008)

lnl = -17187

TABLE 3

ML Estimates of Two-Component Model for MMI Stocks: 1989-1990

	σ		β		γ		μ	
AMEX	1.604	(0.053)	1.690	(0.167)	1.082	(0.164)	-0.031	(0.090)
Chevron	0.906	(0.041)	-0.060	(0.149)	1.505	(0.092)	0.119	(0.057)
DuPont	0.976	(0.033)	0.937	(0.128)	1.101	(0.103)	0.067	(0.059)
Dow	1.231	(0.041)	1.422	(0.130)	0.801	(0.135)	-0.019	(0.071)
Kodak	1.418	(0.046)	0.972	(0.139)	0.835	(0.120)	0.008	(0.072)
GE	0.905	(0.032)	1.376	(0.123)	0.992	(0.123)	0.068	(0.062)
GM	1.189	(0.039)	1.213	(0.129)	0.925	(0.120)	-0.005	(0.067)
IBM	0.898	(0.029)	0.780	(0.103)	0.773	(0.087)	0.007	(0.050)
IP	1.117	(0.036)	0.977	(0.110)	0.771	(0.100)	0.046	(0.060)
J&J	0.879	(0.031)	1.327	(0.124)	1.074	(0.118)	0.118	(0.061)
Coke	0.963	(0.035)	1.679	(0.133)	1.050	(0.143)	0.160	(0.069)
3M	0.730	(0.025)	0.931	(0.096)	0.775	(0.090)	0.083	(0.046)
PMorris	1.026	(0.035)	1.330	(0.128)	1.001	(0.124)	0.160	(0.065)
Mobil	0.671	(0.038)	-0.114	(0.140)	1.420	(0.079)	0.076	(0.048)
Merck	0.861	(0.031)	1.428	(0.112)	0.818	(0.123)	0.102	(0.059)
P&G	0.940	(0.033)	1.363	(0.118)	0.908	(0.121)	0.153	(0.061)
Sears	1.184	(0.038)	0.961	(0.123)	0.837	(0.108)	-0.068	(0.063)
AT&T	1.198	(0.040)	1.211	(0.139)	1.094	(0.124)	0.029	(0.069)
USX	1.426	(0.046)	0.417	(0.148)	1.105	(0.107)	0.032	(0.071)
Exxon	0.825	(0.031)	0.159	(0.125)	1.133	(0.075)	0.059	(0.048)

σ_z		σ_Y		λ	
0.625	(0.029)	0.687	(0.026)	1.147	(0.000)

LnL= -15623

Table 4: Top Twenty Jump Dates and News Stories

Date	$\mathbb{P}_C$	$\mathbb{P}_{95}$	R_M	$\mathbb{P}_U$	Z_M	*Wall Street Journal* News
19Oct-87	1.000	1.00	-25.72	1.00	1	Market crashes; Treasury Secretary Baker reiterates that U.S. may let dollar fall unless Bonn eases credit – latest sign of weakening Louvre accord; Dollar falls to Y142 in early trading; Index futures disconnect; Story on takeover tax legislation
20Oct-87	1.000	1.00	9.93	1.00	2	Dollar soars; West Germany cuts rates, solidifies Louvre accord; Reagan reverses stance to cooperate in budget reduction with Congress – countering criticism that administration intransigence increased market jitters
21Oct-87	1.000	1.00	9.26	1.00	3	Stocks rebound; More movement by administration on budget cutting; Dollar increased, bond rally slowed – new gov't borrowing next week; Curbs on program trading and index markets proposed
08Jan-88	0.998	1.00	-7.70	1.00	5	Stocks plummet, bonds fall, dollar down 1.5% to 128; Late selling linked to negative anticipation of Friday trade report; Strong employment report dashes lower interest rates hopes; Brady report says portfolio insurance triggered crash, major firms and specialists made chaos worse by protecting own interests ahead of small investors, front-running ahead of corporate buy-backs
14Apr-88	0.976	1.00	-5.41	1.00	6	Financial markets rattled by worse than expected swelling of trade deficit to $13.83 billion; January was $12.4 billion, fourth month down; Interest rates surged; Despite intervention, dollar fell 2.3% to Y123.6; Slide possibly worsened by new circuit breakers
08Dec-87	0.590	0.95	3.30	0.60	19	Stock prices rally late when dollar slump steadies – rumors that October trade deficit considerably lower ($14-15 billion) than forecast Monday ($16 billion)
04Nov-87	0.440	0.95	-1.01	0.03	181	Dollar falls to Y135.75; Stock drop not as bad as expected; Bonds rise on Baker comments about keeping liquidity in system
15Jan-88	0.398	0.89	2.47	0.17	40	Narrowing of November trade deficit to $13.22 billion rallies markets; Dollar to Y131; Bond yields lowest since July; Investors may soon focus on other issues
16Oct-87	0.383	0.98	-5.22	1.00	7	Record stock plunge leaves analysts divided over market's course and economic outlook; Portfolio insurance concerns
06May-87	0.187	0.87	0.59	0.02	274	(Previous day: bonds & stocks climb as Treasury successfully launches $29 billion refinancing; Concern still widespread about participation, particularly from Japanese, in longer term note auctions today and tomorrow); Bond prices skid as investors cool to 10-year note sale; Analyst says Japanese buyers virtually non-existent; (Next day: 30-year auction goes smoothly, Japanese buy, analysts confused, dollar rises, bonds flat)
17Dec-87	0.108	0.43	-3.10	0.61	22	Dollar falls below Y126 after ex-Reagan-aide says Louvre accord essentially dead, dollar's long run level is Y100; With slow in oil decline, contributes to lower stocks & bonds
04Jan-88	0.090	0.52	4.06	0.94	10	Dollar rebounds to Y123 after Friday low of 120 on massive intervention by central banks; Stocks climb correspondingly; Higher oil prices slow bond rally
18Dec-87	0.087	0.34	2.58	0.21	38	Stocks & bonds rally as dollar surges 1%, G-7 rumored planning to reaffirm Louvre accord; Possibility that budget deficit accord could be reached over weekend; Greenspan says October trade deficit was aberration; Triple witching
30Nov-87	0.079	0.37	-4.16	0.98	9	Dollar tumbles to Y132 depressing stocks and speeding plans for G-7 meeting; Bonds up; 'We aren't getting much on reducing the budget deficit, there isn't a dollar policy, and there's still a fear of inflation'; 'When foreigners finance a huge deficit and the country doesn't seem concerned about its exchange rate, you have disorderly markets'
10Dec-87	0.061	0.36	-2.70	0.36	31	Stocks and bonds plunge as trade gap swells to record $17.63 billion; Raises trade legislation fears; Bonds could approach 10% yield again; Drop in stocks not as bad as could have been – some analysts think market focusing too much on deficits and dollar and want to turn attention to other variables
23Oct-87	0.042	0.33	-0.46	0.02	318	Markets calmer but fall again; Foreign investors pulling out; Specialist system criticized; Proposed ban on index options and futures; Turf fighting between markets evident
07Jan-88	0.041	0.17	1.29	0.04	138	Brady report calls for unified margin requirements and regulation, trading limits, and revamped clearing & settlement; Criticized by traders; Dollar recovers after Fed official says economy in an export boom, warns speculators of further intervention – traders had been pessimistic about upcoming trade report
11Jan-88	0.037	0.22	2.26	0.12	49	Stocks rebound after intervention resumes and dollar recovers from mild decline; Portfolio insurance 1/3 pre-crash amount
21Apr-87	0.035	0.16	2.98	0.39	27	Stocks soared reflecting relief that dollar stabilizing with intervention; Traders concerned about Japanese participation in Treasury's next quarterly refinancing – Speculated that intervention intended to ease concern; Fed refuses to raise rates to keep easing pressure on Japan; Positive earnings reports and news of federal budget deficit narrowing also fuel stocks
28Dec-87	0.034	0.17	-3.02	0.56	25	Dollar falls to Y123.5 despite White House call to stabilize currency; Traders say cure takes more than words; Proposed SEC rule restricting takeovers opposed by three federal agencies heads; Year end window dressing and tax selling

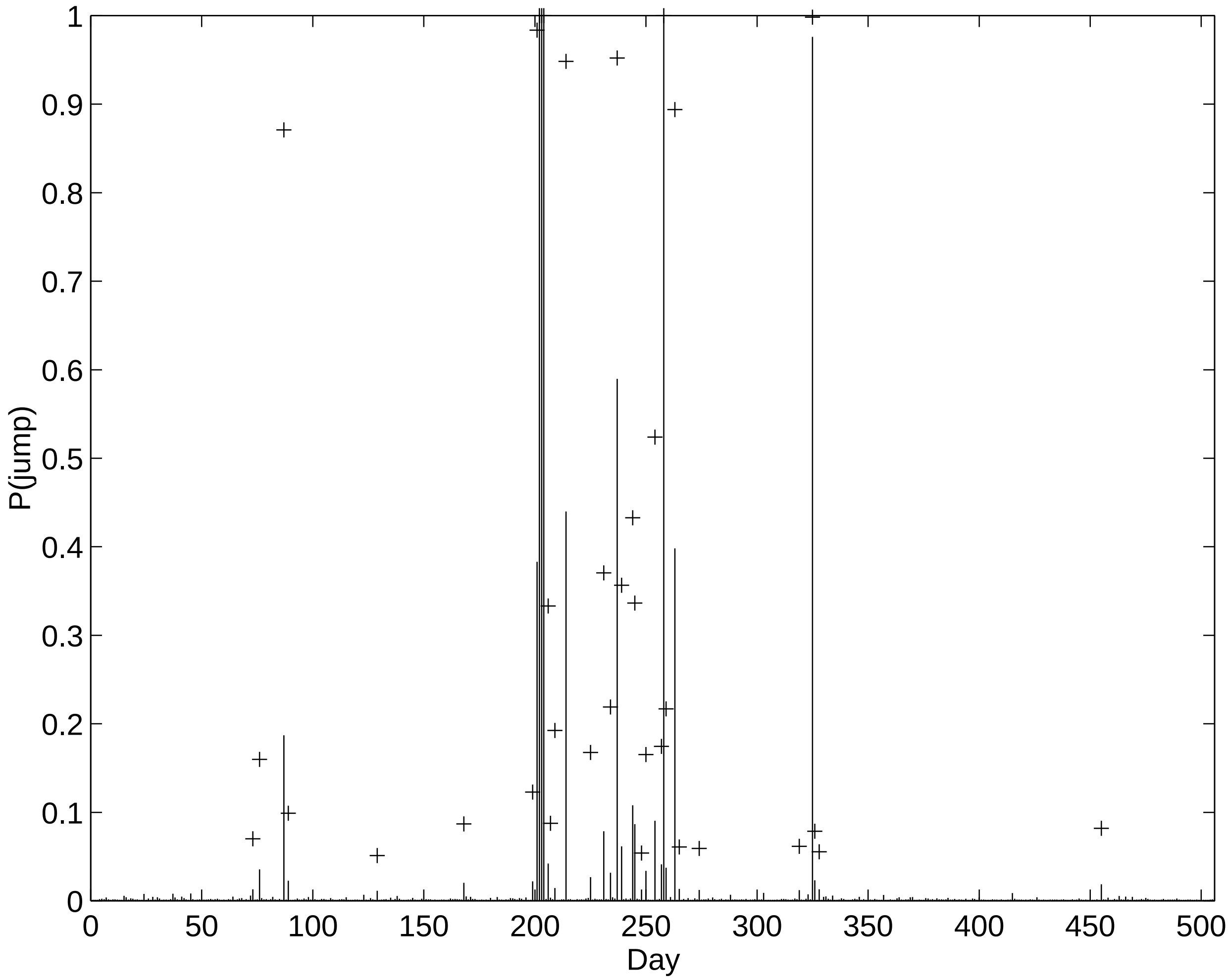
Table 5a: Other Large Index Return Dates

Date	$\mathbb{P}_C$	$\mathbb{P}_{95}$	R_M	$\mathbb{P}_U$	Z_M	*Wall Street Journal* News
26Oct-87	0.004	0.09	-9.04	1.00	4	Stocks fall to crash day level; Bonds rise on easing expectations (Fed shows concern about liquidity and recession); Dollar falls to Spring low (Y142.5); Budget talks begin with added pressure
29Oct-87	0.001	0.01	4.89	1.00	8	Stocks rose sharply on speculation that dollar slide may benefit rather than hamper economy; Before crash, weak dollar prompted tightening to keep down inflation, but with confidence down and recession possibility, weak dollar helps trade deficit; Dollar at Y138.4
22Oct-87	0.002	0.01	-3.98	0.96	12	Fall in stocks but signs of stability; Budget agreement seems certain
31May-88	0.007	0.03	3.87	0.89	13	Stock prices surged as investors shrugged off inflation worries (Commodity prices had biggest rise since 1979 on Midwest drought); Fed expected to raise discount rate, and inaction viewed as indication that fears are overdone; Dollar extends mini-rally amid caution
06Apr-88	0.012	0.06	3.85	0.88	14	Stocks & bonds surged in reaction to stronger dollar; G-7 confirmation of currency stabilization at 125 expected; 'The markets picked up a rumor and turned it into a top quality rumor, but I don't think anything has happened really'; 'It's likely the G-7 had a target in that range all along'; 'It just goes to show how currency sensitive the markets are'
14Dec-87	0.003	0.01	3.84	0.88	15	OPEC showing weakness; Oil prices sink; Sparks bond & stock rally
27Oct-87	0.002	0.01	3.75	0.84	16	Stocks rebound; Increased foreign buying; More takeovers scratched due to crash
22Sep-87	0.004	0.03	3.75	0.84	17	Stocks rebounded sharply fuelled by stronger dollar and bond market; U.S. finds mines on Iranian ship that it attacked

Table 5b: Additional Pre-Crash Jump Dates

Date	$\mathbb{P}_C$	$\mathbb{P}_{95}$	R_M	$\mathbb{P}_U$	Z_M	*Wall Street Journal* News
08May-87	0.023	0.10	0.02	0.02	503	Q1 corporate profits high; Stocks declined as investors ignored news of April unemployment drop, firm bonds, and higher dollar; Despite economic news, markets jittery about dollar and interest rates said one analyst
14Oct-87	0.022	0.12	-4.01	0.96	11	(Previous day: Stock index futures higher as traders cover short positions ahead of trade deficit figures); Financial markets rocked by smaller than expected improvement in August trade deficit; Stocks, dollar, and bonds tumble; Recent stock declines may be more than a correction
31Aug-87	0.020	0.09	1.18	0.03	152	Iranian gunboats attacked Kuwaiti freighter; Dollar strengthened and bonds rebounded helping stocks recover ground; Dollar's recent decline has raised inflation concerns and worries that foreign investors might lose huge appetite for U.S. securities
15Apr-87	0.013	0.07	1.71	0.06	87	Dollar, bonds, and stocks regain much of previous day losses (from release of U.S. trade deficit data) after Japan indicated recommitment of G-7 to dollar

Figure 1. Multivariate Model Daily Jump Probabilities (Solid Line), 1987−88



(+) upper 95% confidence band, if greater than .05

Figure 2. Univariate Model Daily Jump Probabilities, 1987−88

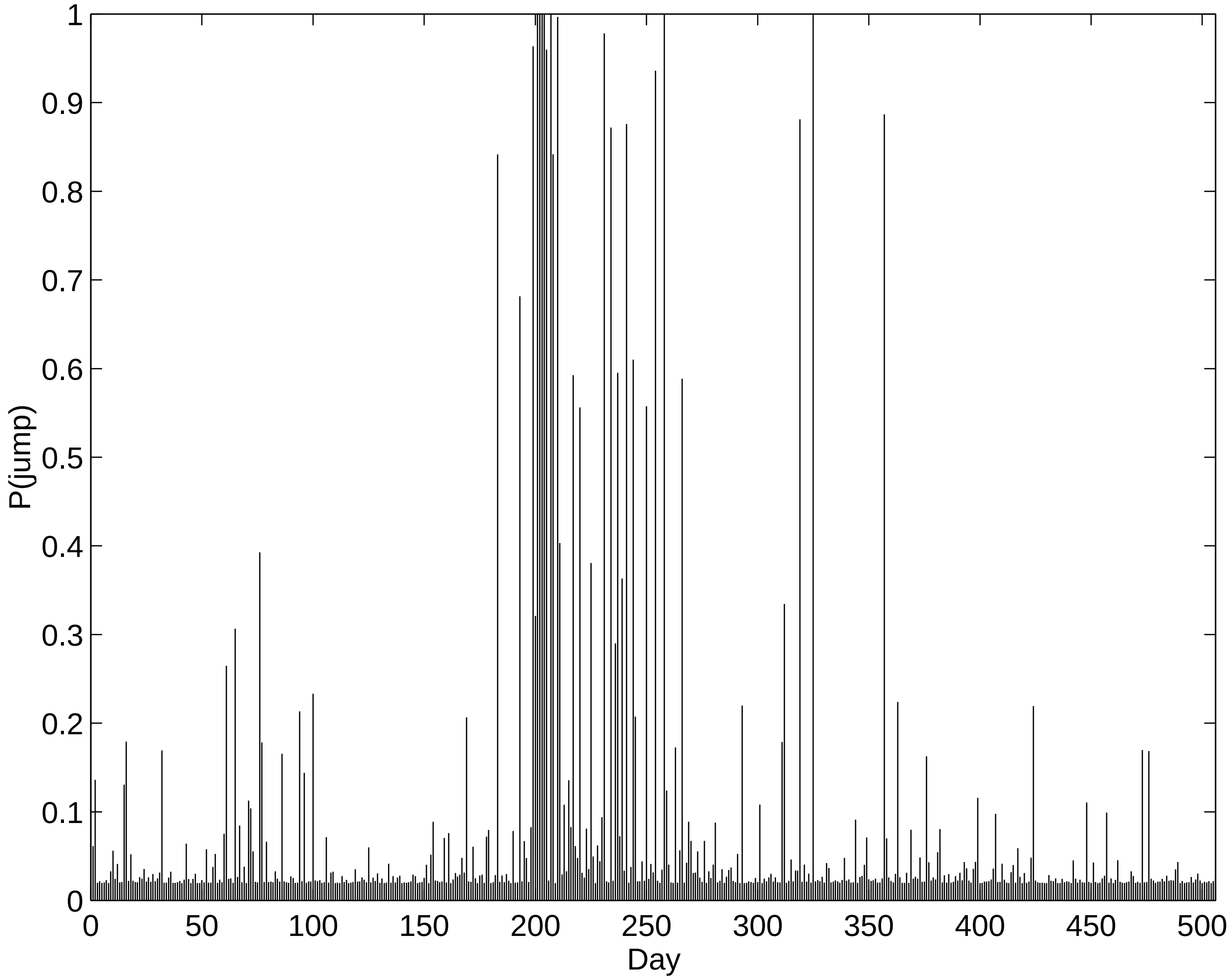


Figure 3. Inferred Jump Probabilities and Index Return Size