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Trading Behavior During Stock Market Downturns: The Dow, 1915 – 2004*

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Abstract: Stock markets periodically experience sharp falls with some referred to as outright crashes. The extant literature has generally resorted to survey type evidence to determine the behavior of investors during such episodes. These kind of studies come to the conclusion that fundamentals play little role in explaining sharp stock market downturns as in October 1987. We know of no econometric study that asks whether feedback, momentum or trend chasing type behavior might explain the behavior of large stock market downturns. Resorting to a feedback trader model, we estimate a variety of asymmetric GARCH-type models. Based on daily data on the Dow Jones Industrial Average index since 1915 we find that there is evidence of positive feedback trading during episodes of stock market crashes. Hence, the econometric evidence is broadly consistent with findings based on surveys.

JEL classification codes: G14, C22

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1. Introduction

Over the past 90 years of its history the U.S. stock market, as represented by the Dow Jones Industrial Average (DJIA), has experienced a number of major crashes where the largest daily percentage stock price drops were in October 1929 and 1987. The DJIA fell by 13.5% on 28 October 1929, and one day later on 29 October 1929 by a further 12%, while on 19 October 1987 the DJIA fell by 23%. The twenty-five largest daily crashes during the 1885 – 1991 period are listed in Schwert (1992). Mishkin and White (2003) have identified 15 stock market crashes in the twentieth century with different magnitude and duration. Moreover, in the wake of the events of September 11, the DJIA fell 14% in the period from September 10 to 21. Simultaneous and comparable declines in stock markets world-wide can also be documented.

While large stock prices decreases are of central importance to monetary policy makers (Bean (2004), Cecchetti, Genberg and Wadhwani (2003), Goodfriend (2003), Mishkin and White (2003)) and to stock market investors, in view of the enormous decline in the value of assets such downturns produce, surprisingly little is known about their causes once fundamental determinants are excluded. Furthermore, the dynamics and, in particular, the behavior of investors during periods of drastic downturns are rarely investigated and poorly understood. As investors' behavior is not directly observable at least two alternative approaches are available to investigate their behavior during periods of financial distress. For example, surveys of investors inquiring about their behavior during crash periods can provide information on causes and mechanisms. Alternatively, on the basis of a theoretical model of investors' behavior empirical findings based on an econometric model can provide some insights.

Under the heading of surveys, Shiller's (1987) investigation of investor's behavior during the October 1987 U.S. stock market crash stands out. Shiller sent out questionnaires at the time of the October crash and found that no news or any other economic fundamental event appear to be

immediately responsible for the market downturn. Instead the survey results show that investors were reacting to price changes and to each other indicating that stock price declines feedback into further stock price declines. This suggests positive feedback trading and herding behavior among stock market investors during crash periods. Shiller, Konya and Tsutsui (1991) also surveyed Japanese institutional investors via questionnaires following the October 1987 crash and found remarkable similarities between Japanese and U.S. institutional investors in a number of behavioral dimensions.

To the best of our knowledge no study of an econometric nature has been carried out. We build our investigation on the model suggested by Shiller (1984) and Sentana and Wadhwani (1992). On this theoretical basis a testable implication about the behavior of stock market investors during crash periods is obtained. In the Shiller-Sentana-Wadhwani model the presence of feedback traders and rational investors, and their specific behavior, provides the theoretical rationale for the nexus between volatility and stock returns autocorrelation. When stock returns volatility is low, stock returns exhibit positive autocorrelation, while during periods of high volatility the autocorrelations of stock returns turns negative. The reversal in the sign of stock returns autocorrelation is consistent with the presence of positive feedback traders in the stock market during crashes. If our empirical findings show negative stock returns autocorrelation during periods of high volatility we can conclude on the basis of this theoretical prediction that positive feedback trading behavior plays a role during crash periods and influences stock price dynamics.

The paper proceeds as follows. Section 2 briefly outlines the theoretical model which predicts negative stock returns autocorrelation during crash periods due to positive feedback trading. In section 3, we outline the definition of stock market crashes, the data and the

econometric methodology. Section 4 discusses the empirical results while section 5 summarizes and concludes.

2. Feedback Trading Behavior and Volatility

The Shiller-Sentana-Wadhwani model captures the behavior of two distinct types of investors in the stock market. Feedback traders or trend chasers, as a group, do not base their asset decisions on fundamental values, reacting instead to past stock price changes. The second group, smart money investors, responds rationally to expected stock returns subject to their wealth limitation. The investment activities of both groups provides the theoretical prediction about stock returns autocorrelation due to the behavior of investors during stock market crashes.

The relative demand for stocks by feedback traders, F_t, is modeled as:

$$F_t = \gamma R_{t-1}, \tag{1}$$

where R_{t-1} denotes the stock return in the previous period. The value of the parameter γ permits differentiation between the two types of feedback traders. When $\gamma > 0$, this refers to the case of positive feedback traders who buy stocks after a price rise and sell stocks after a price fall. In contrast, $\gamma < 0$ indicates the case of negative feedback trading. Unlike a positive feedback trader, the negative feedback trader sells stocks after price increases and buys stocks after price declines.

The proportionate demand for stocks by smart money traders, S_t, is determined by a mean-variance model:

$$S_t = (E_{t-1}R_t - \alpha)/\mu_t, \tag{2}$$

where E_{t-1} denotes the expectation operator and α the return on a risk free asset. In this model smart money traders hold a higher proportion of stocks, the higher the expected excess return, $E_{t-1}R_t - \alpha$, and the smaller the risk of holding stocks, μ_t. The risk measure is modeled as a

positive function of the conditional variance, σ_t^2, of stock prices $\mu_t = \mu(\sigma_t^2)$. Equilibrium in the stock market requires that all stocks are held:

$$S_t + F_t = 1. \tag{3}$$

Allowing the presence of both groups in the stock market and substituting (1) and (2) in (3) yields, after rearranging and assuming rational expectations in the determination of stock returns, i.e., $R_t = E_{t-1}R_t + \upsilon_t$:

$$R_t = \alpha + \mu(\sigma_t^2) - \gamma\mu(\sigma_t^2)R_{t-1} + \varepsilon_t . \tag{4}$$

As can be seen from equation (4), in a stock market with feedback traders, the return function contains the additional term R_{t-1} indicating that stock returns exhibit autocorrelation of order one. The pattern of autocorrelation in stock returns depends on the type of feedback traders captured by the parameter γ. The presence of positive feedback traders ($\gamma > 0$) leads to negatively autocorrelated stock returns, while negative feedback trading ($\gamma < 0$) implies positively autocorrelated stock returns.

Furthermore, the extent to which stock returns exhibit autocorrelation varies with volatility, σ_t^2. Relying on a linear form, $\gamma\mu(\sigma_t^2)$ in equation (4) can be reformulated as:

$$R_t = \alpha + \mu(\sigma_t^2) - (\gamma_1 + \gamma_2\sigma_t^2)R_{t-1} + \varepsilon_t . \tag{5}$$

Following Sentana and Wadhwani (1992) negative feedback trading dominates at low volatility levels and positive feedback trading dominates at high levels of volatility. At a low risk level σ_t^2, the direct impact of feedback traders is given by the sign of γ_1. Negative feedback trading, $\gamma_1 < 0$, results in positively autocorrelated stock returns. With a rising risk level, the influence of a positive γ_2 increases and might induce negatively autocorrelated stock returns due to the investment activities of positive feedback traders.

Thus, the model predicts that the interaction of smart money traders and positive feedback traders can induce negative autocorrelation in stock returns during periods of high volatility. It is this implication of the Shiller-Sentana-Wadhwani model that allows us to receive deeper insights into investors' behavior during stock market downturns. Given the well-known phenomenon of higher volatility during downward movements relative to upward stock market price movements the theoretical model predicts negative autocorrelation and, hence, the importance of positive feedback trading behavior in periods of financial distress. In contrast, during calm periods the autocorrelation in stock returns is positive.

Generally, positive feedback trading activities are associated with positive stock return autocorrelation because positive feedback traders move stock prices away from fundamental values in the short-run (DeLong et al. (1990)). However, Shiller (1989) points out that positive feedback trading may induce negligible and even negative stock returns autocorrelation. As shown in LeBaron (1992) and Campbell, Grossman and Wang (1993) the autocorrelation pattern of stock returns is more complex than a simple first order autocorrelation coefficient is able to capture. LeBaron's empirical findings show significant non-linear dependencies between autocorrelation and volatility. Campbell, Grossman and Wang (1993) find an inverse relationship between trading volume and stock returns autocorrelation. Furthermore, previous empirical evidence on the Shiller-Sentana-Wadhwani model shows that the finding of negative autocorrelations in stock index returns during periods of high volatility is a fairly robust result (Sentana and Wadhwani (1992), Koutmos (1997), Koutmos and Saidi (2001)).

3. Econometric Methodology, Crash Definition and Data

To provide suggestive evidence on the link between volatility and autocorrelation of index returns, we implement the following regression model:

$$R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 Crash_t R_{t-1} + \varepsilon_t \tag{6}$$

$$h_t = \omega + \beta_0 h_{t-1} + \beta_1 I_{t-1} \varepsilon_{t-1}^2 + \beta_2 \varepsilon_{t-1}^2 \tag{7}$$

$$I_{t-1} = \begin{cases} 1, \text{ if } \varepsilon_{t-1} < 0 \\ 0, \text{ if } \varepsilon_{t-1} \geq 0 \end{cases} \tag{8}$$

or, alternatively:

$$\ln h_t = \beta_0 + \beta_1 g_{t-1} + \beta_2 \ln h_{t-1} \tag{9}$$

$$g_t = \psi z_t + \delta\left(|z_t| - E|z_t|\right). \tag{10}$$

The index return is defined as the logarithmic difference $R_t = \ln P_t - \ln P_{t-1}$ and $\varepsilon_t = N(0, h_t)$ denotes the unpredictable component of index returns. We use the TGARCH model (7) and (8) proposed by Glosten, Jagannathan and Runkle (1993) because a characteristic of stock returns volatility often found in the empirical finance literature is asymmetry in the conditional variance. Alternatively, Nelson's (1991) EGARCH specification (9) and (10) is implemented where in equation (10) $z_t = \varepsilon_t / \sqrt{h_t}$ denotes the standardized innovation. The dummy variable $Crash_t$ is equal to one during the crash period (as defined below) and zero otherwise. According to the theoretical discussion in section 2, we expect a statistically significant negative parameter α_2 and a negative sum $\alpha_1 + \alpha_2$ due to positive feedback trading strategies. This approach enables us to assess the effects of crashes on the autocorrelation properties of stock returns and, in turn, on the behavior of stock market investors.

To implement of the dummy approach we require identification of crash periods. The precise definition and measurement of a crash is difficult and involves necessarily arbitrary elements. The choice of the stock market index, the size of the collapse and the time frame of the stock market decline are the key factors. We examine the behavior of the DJIA which is available on the daily frequency at the close of trading day beginning at the end of the nineteenth century at

www.economagic.com. However, our sample starts January 4, 1915 to circumvent the problem of missing values when all stock markets were closed from the beginning of August to mid of December 1914 due to World War I. We have updated the daily time series of the Dow until December 31, 2004 using Datastream.

The procedure to identify stock market crashes use the size of the October 1929 and 1987 crashes as benchmarks. We define a 20% drop in the Dow as a stock market crash (Mishkin and White (2003)). The beginning and the ending of a crash is determined by the local maximum and the local minimum of the index. The crash periods, their lengths and the percentage drop in the Dow are reported in Table 1. The nature of the crashes varies in terms of length and size. The October 1929 and 1987 and the September 2001 are among the downturns with the shortest periods and highest stock price declines. Longer crash periods are given with the August 1917, November 1919 and August 1937 downturns. The May 1940, April 1962, April 1970 and October 1973 crashes are intermediate cases.

Table 1 about here

Clearly, the simple dummy analysis cannot be fully convincing. The selection of the crash periods is to some extent arbitrary and there is no explicit measure of volatility. These two arguments indicate a more rigorous analysis. As is shown in section 2 of the paper, the index returns autocorrelation may vary over time with the importance of positive or negative feedback traders, which in turn should be a function of return volatility. To introduce a volatility term into the mean equation, we jointly estimate the TGARCH or the EGARCH model with the mean equation (6). This approach results directly from Sentana and Wadhwani's (1992) model.

4. Empirical Results

The estimation results for the dummy approach (7) to (10) are reported in Table 2. The first set of crashes consists of the October 1929 and 1987 crash which represent relatively short periods with a high drop in stock prices. Including the September 11 crash additionally provides the specification of the crash dummy for the second regression. The estimated parameter $\hat{\alpha}_1$ indicate positive stock index returns autocorrelation which is a well-known phenomenon and can be explained by non-synchronous trading (Lo and MacKinlay (1990)), time-varying expected returns (Conrad and Kaul (1988)), transaction costs (Mech (1993)) as well as negative feedback trading. The $\hat{\alpha}_2$ coefficients are negative and statistically significant supporting the theoretical expectation that during crashes stock returns autocorrelation is negative which in turn indicates positive feedback trading behavior in crash periods. This holds also for the third regression where we included the long crash periods although the estimated coefficient $\hat{\alpha}_2$ is lower in absolute terms compared to the parameter values discussed above. However, the fourth set of regression results provide evidence against the hypothesis of negative stock return autocorrelation during crash periods because the estimated parameter $\hat{\alpha}_2$ is positive and significant. The empirical finding are robust across both asymmetric GARCH models. If the theoretical staring point of our analysis is correct, then the findings of the dummy variable approach indicate that in particular during short and intense stock market downturns investors follow positive feedback trading strategies.

Table 2 about here

Table 3 reports the findings of the Sentana-Wadhwani approach for the whole sample period 1915 – 2004 and two non-overlapping samples 1915 – 1959 and 1960 – 2004. While the

evidence on the $\hat{\alpha}$ and $\hat{\mu}$ coefficients provide mixed results, the estimated parameters of interest $\hat{\gamma}_1$ and $\hat{\gamma}_2$ have the theoretically expected sign and are statistically significant in all regressions. The $\hat{\gamma}_1$s are negative and the $\hat{\gamma}_2$s are positive supporting the theoretical considerations that during crash periods there is enough positive feedback trading in the U.S. stock market to produce negative first order autocorrelation. The estimated coefficients are remarkably stable across the different samples and models for conditional volatility. Hence, we have found robust empirical evidence of positive feedback trading during periods of U.S. stock markets downturns.

Table 3 about here

Figures 1 confirms the empirical findings. During clam periods the conditional autocorrelation coefficient $(\hat{\gamma}_1 + \hat{\gamma}_2)\sigma_t$ is positive and around 0.08. Negative conditional autocorrelations coincide to a large extent with the major stock market crashes in the U.S. outlined in Table 1. In particular, the October 1929 and 1987 crashes lead to pronounced conditional autocorrelation coefficients. Furthermore, can be observe a clustering of around the beginning and the end of the thirties.

Figures 1 about here

4. Summary and Conclusions

Stock market crashes are rare, potentially catastrophic and their dynamics are difficult to investigate due to the non-observability of investors' trading behavior during periods of downturns. While survey evidence indicate that investors follow positive feedback trading and herding strategies (Shiller (1987), Shiller, Konya and Tsutsui (1991)), to the best of our

knowledge no studies are available which investigate stock market investors' behavior during crashes empirically based on the estimation of an econometric model. In this paper, we provide empirical findings on investors' trading behavior during stock market crashes in the U.S. relying on a testable implication of the feedback trader model suggested by Shiller (1984) and Sentana and Wadhwani (1992). Accordingly, negative stock returns autocorrelation during periods of high volatility indicate positive feedback trading behavior of investors in stock market downturns. Our empirical findings support the theoretical implication of the Shiller-Sentana-Wadhwani model. In periods of high volatility stock returns autocorrelation turns negative. Periods of negative autocorrelations in stock returns coincide with major crashes in the U.S.

Our results are favorable for the hypothesis that positive feedback trading behavior plays a role during crashes. Selling in a falling market can result from extrapolating expectations about stock prices or trend chasing. Furthermore, portfolio insurance is an example of a positive feedback trading strategy. This strategy implies that in a falling market, a lower proportion of wealth is investigated in stocks by the portfolio insurance strategy, which results in stock sales and stock price decreases. Another form of positive feedback trading is the use of stop loss orders, which prescribe selling after a certain level of losses regardless of future prospects. Moreover, the effects of the liquidation of investors' positions who are unable to meet margin calls are comparable to the impacts of a positive feedback trading strategy. These arguments are consistent with our empirical findings and the survey evidence available in Shiller (1998) and Shiller, Konya and Tsutsui (1991).

There are a number of additional tests that need to be carried out before we can conclude with some confidence that the econometric and survey evidence are consistent with each other. First, sensitivity tests need to be carried in order to determine the impact of Mishkin and White's (2003) choice of a 20% threshold. Thus, for example, Schwert's (1992) calculation of the largest

drops in stock returns include periods in 1930, 1932, 1933 and 1939 that are excluded from the present analysis. Alternatively, we could let the data speak for themselves and ask how many structural breaks, consistent with falls in stock prices, can be detected in the data using say the Bai-Perron (1998, 2003) methodology. Moreover, it may be that investors' behavior may be triggered by a high probability of a crash occurring instead of the approach of this paper which assumes that crash and no crash regimes are known with certainty. In addition, we want to consider the potential interaction of a crash with the duration of the crash since, as noted earlier, this is clearly a relevant consideration. Alternatively, the extent of feedback trading may instead be a function of the time that has elapsed since the last crash as memory of the last stock market downturn begins to fade the longer in the past such an event took place. We are currently pursuing these refinements to our results.

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Table 1: Stock Market Crashes, 1915 – 2004

Crash Period	Approximate Number of Weeks	Stock Price Decline
August 17, 1917 – December 19, 1917	18	28%
November 3, 1919 – December 21, 1920	59	44%
October 10, 1929 – November 13, 1929	5	44%
August 16, 1937 – November 24, 1937	14	40%
May 9, 1940 – June 10, 1940	5	25%
April 23, 1962 – June 26, 1962	5	23%
April 9, 1970 – May 26, 1970	7	20%
October 26, 1973 – December 5, 1973	6	20%
October 2, 1987 – October 26, 1987	3½	32%
August 24, 2001 – September 21, 2001	4	21%

Note: Calculations are based on the Dow Jones Industrial Average which is available on a daily basis at www.economagic.com and Datastream.

Table 2: Empirical Results on the Dummy Variable Approach

Crashes Included	Model	$\hat{\alpha}_1$	$\hat{\alpha}_2$
October 1929, October 1987	TGARCH	0.08 (12.63)***	– 0.22 (5.15)***
	EGARCH	0.07 (10.84)***	– 0.35 (9.78)***
October 1929, October 1987, September 2001	TGARCH	0.08 (12.56)***	– 0.21 (6.63)***
	EGARCH	0.07 (10.80)***	– 0.35 (13.63)***
August 1917, November 1919, August 1937	TGARCH	0.09 (12.79)***	– 0.12 (3.38)***
	EGARCH	0.07 (11.02)***	– 0.12 (3.72)***
May 1940, April 1962, April 1970, October 1973	TGARCH	0.08 (12.23)***	0.15 (4.79)***
	EGARCH	0.07 (10.47)***	0.17 (6.35)***

Note: The results rely on the mean equation $R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 Crash_t R_{t-1} + \varepsilon_t$ which is jointly estimated with the TGARCH model ((7), (8)) and the EGARCH model ((9), (10)). R_t denotes the stock return. The dummy variable $Crash_t$ is equal to one during the crash period and equal to zero otherwise. The crash periods are defined in Table 1. *, **, *** denotes statistical significance at the 10%, 5% and 1% level, respectively.

Table 3: Empirical Results on the Sentana-Wadhwani Approach

Sample	Model	$\hat{\alpha}$	$\hat{\mu}$	$\hat{\gamma}_1$	$\hat{\gamma}_2$
1915 – 2004	TGARCH	– 0.004 (0.27)	0.03 (1.88)*	– 0.17 (9.67)***	0.08 (4.99)***
	EGARCH	0.23 (66.84)***	– 0.25 (29.16)***	– 0.15 (11.41)***	0.08 (7.43)***
1915 – 1959	TGARCH	0.02 (0.89)	0.01 (0.53)	– 0.17 (8.06)***	0.08 (4.79)***
	EGARCH	0.42 (112.91)***	– 0.43 (33.30)***	– 0.12 (7.69)***	0.07 (6.34)***
1960 – 2004	TGARCH	– 0.02 (0.98)	0.06 (1.93)*	– 0.16 (4.07)***	0.07 (1.63)*
	EGARCH	0.27 (81.20)***	– 0.31 (28.95)***	– 0.13 (4.74)***	0.06 (2.15)**

Note: The results rely on the mean equation $R_t = \alpha + \mu(\sigma_t^2) - (\gamma_1 + \gamma_2\sigma_t^2)R_{t-1} + \varepsilon_t$ which is jointly estimated with the TGARCH model ((7), (8)) and the EGARCH model ((9), (10)). R_t denotes the stock return and σ_t^2 the conditional volatility. *, **, *** denotes statistical significance at the 10%, 5% and 1% level, respectively.

Figure 1: Conditional Autocorrelation Coefficient, 1915 - 1959

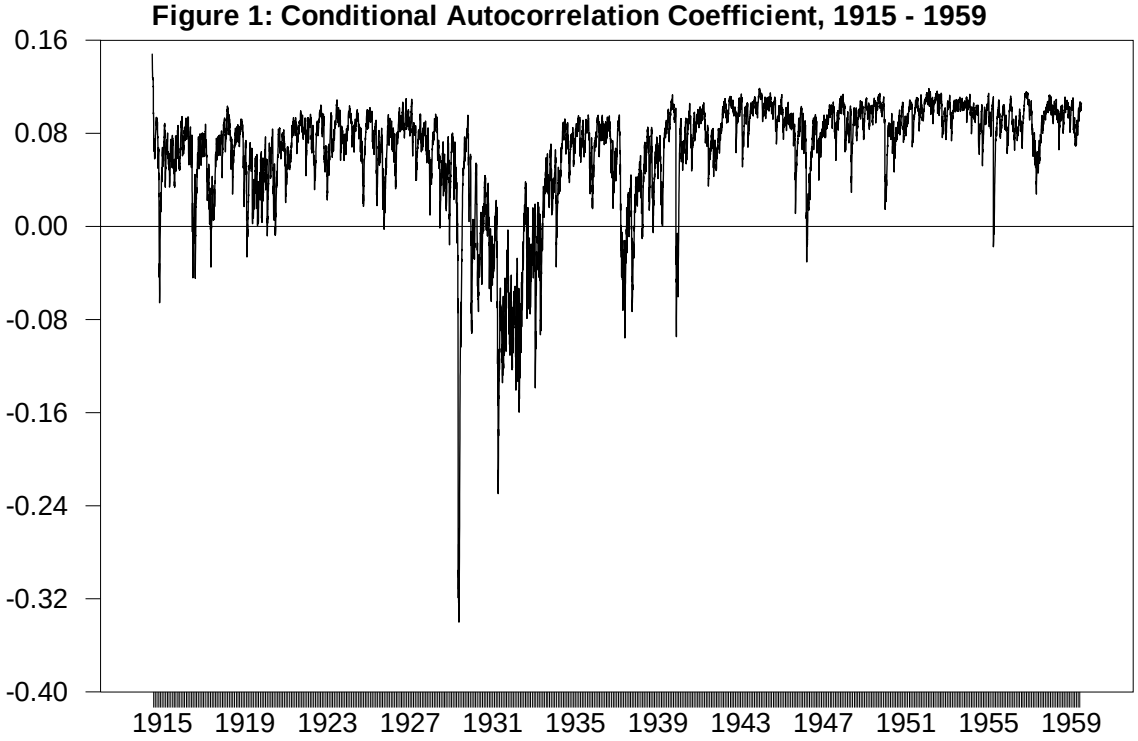
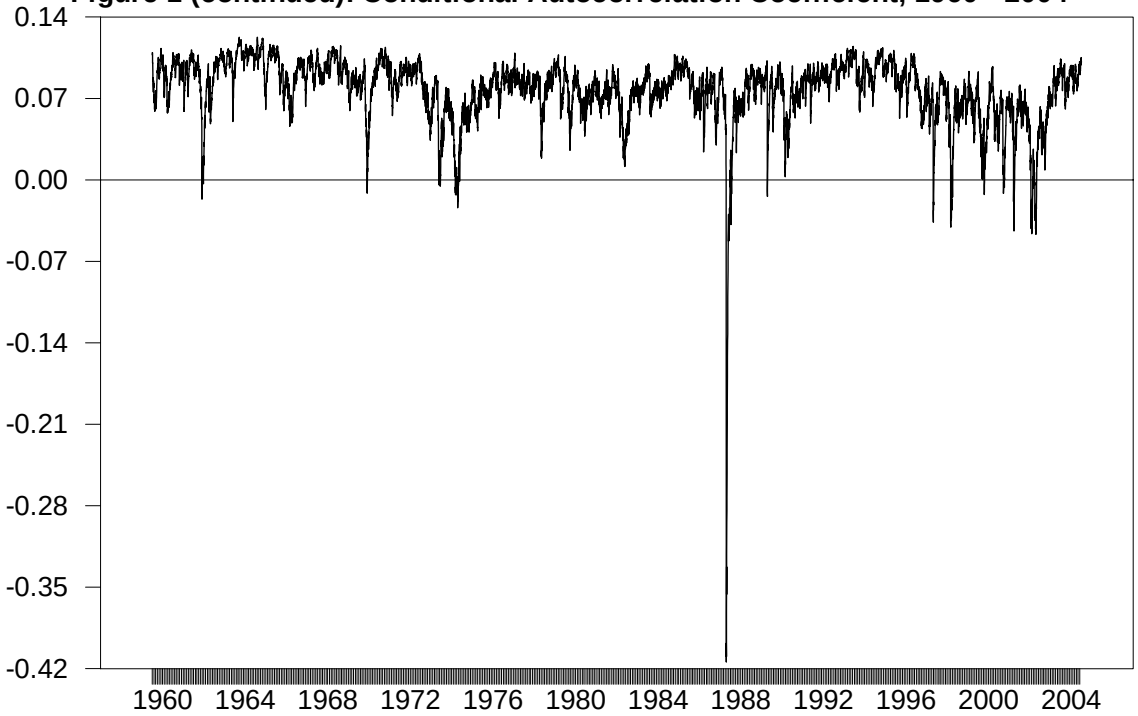


Figure 1 (continued): Conditional Autocorrelation Coefficient, 1960 - 2004



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