
Are Farm Asset Values Too Volatile?

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Abstract

The research reported in this paper examined the volatility of U.S. farm asset values. Specifically, a variance bounds test was applied to real farm asset returns and values over the 1910–1989 period. The results showed that the standard deviation of actual farm asset values was 2.42 times greater than that of its ex post rational counterpart. Hence, a null hypothesis of excess volatility in farm asset values could not be rejected. Further, the results were not sensitive to alternative assumptions regarding the sample period, discount rate, or terminal value.

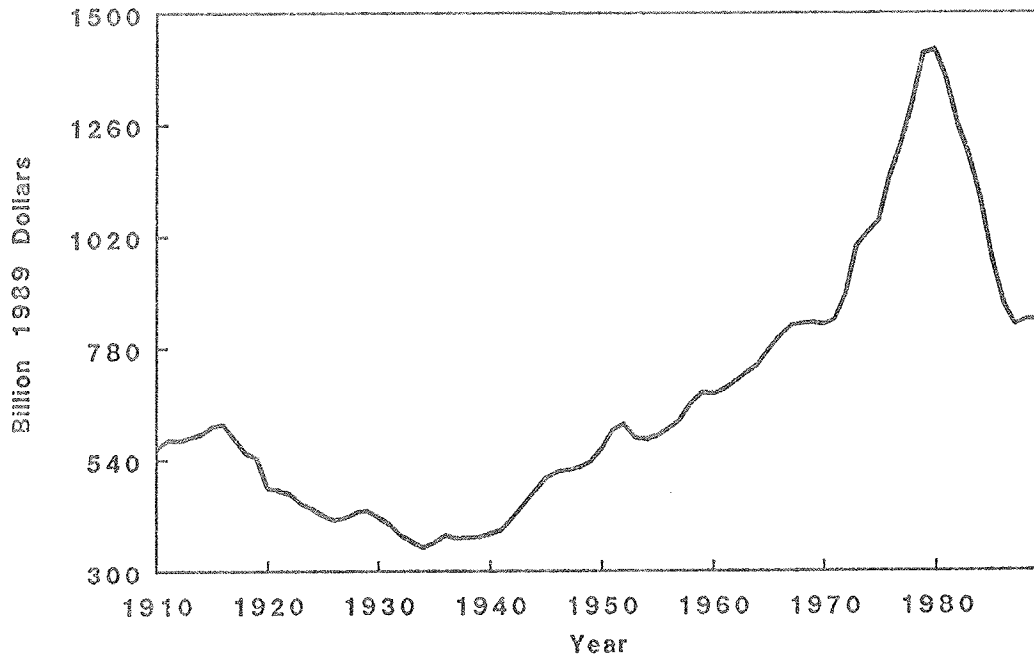
Past research on farm asset values has focused primarily on the economic determinants of those values. Included in this literature are studies of the relationship between farm asset returns and farm asset values (e.g., Melichar; Burt; Alston) and the pricing of farm assets within the framework of the capital asset pricing model (e.g., Barry; Irwin, Forster, and Sherrick). The dramatic boom in real farm asset values in the 1970s and the subsequent bust in the 1980s (Figure 1) have focused interest on a different issue. Specifically, the experience of the recent boom-and-bust cycle has led many observers to suggest that farm asset values are more volatile than justified by market fundamentals (e.g., Harl).

Only one study has addressed the issue of excess volatility in the farm asset market. Using a vector autoregression model, Featherstone and Baker found that a one-standard-deviation shock in real farm asset values leads to an overreaction in asset values which take nine years to return to preshock levels. Similar results were obtained for a one-standard-deviation shock in returns. Featherstone and Baker argued that real farm asset values should return to their preshock level immediately in a rational market reacting only to return and interest-rate fundamentals. The fact that values do not react as expected suggests a market with a tendency for over- and underreaction to market fundamentals and hence, excess volatility.

In this paper, the volatility of the farm asset market will be investigated. Specifically, a variance bounds test developed by Shiller (1981) will be applied to real farm asset returns and values over the 1910–1989 period. The variance bounds test places a theoretical limit on the variance of a price series given the variance of a return series. Since the variance bounds test is derived

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Figure 1. Farm Asset Values, 1910-1989



from a formal theoretical model of an efficient asset market, a direct and rigorous test of the excess-volatility hypothesis is possible.

The next section presents the efficient-market model and resulting variance bounds test. Following sections present the data, results, and summary and concluding remarks.

The Efficient-Market Model and the Variance Bounds Test

The efficient-market model and variance bounds test developed by Shiller (1981) will be presented in this section. Notation will be changed slightly so that it pertains to asset values and income from assets rather than stock prices and dividends.

A simple efficient-market model of the value of an asset A_t at the beginning of time t is given by

$$A_t = \sum_{k=0}^{\infty} \tau^{k+1} E_t I_{t+k}, \quad 0 < \tau < 1, \quad (1)$$

where E_t is the mathematical expectation conditional on information at time t , I_t is income from that asset during time t , and τ is the constant real discount factor. The constant real discount rate is r so that $\tau = 1/(1 + r)$. The discount rate is assumed to be risk adjusted and determined by an equilibrium risk-return model such as the capital asset pricing model (Sharpe; Lintner; Mossin). At time t , known information will include at least A_t , I_t , and their lagged values.

To ensure stationarity of the return and asset-value series, any trend growth must be removed from the series. Hence, the asset-value and income series can be written in terms of the long-run growth factor α :

$$a_t = A_t / \alpha^{t-T}, \quad (2)$$

$$i_t = I_t / \alpha^{t-T}. \quad (3)$$

The growth factor is $\alpha^{t-T} = (1 + g)^{t-T}$, where g is the rate of growth and T is the base year. The exponential growth path is estimated by regressing the natural logarithm of asset values on a constant and time. Then α in (2) and (3) is set equal to e^b , where b is the coefficient of time from the regression. Model (1) can be rewritten

in terms of detrended series by dividing all terms of that model by α^{t-T} :

$$\begin{aligned} a_t &= \sum_{k=0}^{\infty} (\alpha\tau)^{k+1} E_t i_{t+k} \\ &= \sum_{k=0}^{\infty} \lambda^{k+1} E_t i_{t+k}, \end{aligned} \quad (4)$$

where $\lambda = \alpha\tau$ is the discount factor associated with this model for the detrended series.

In order for the efficient-market model to give a finite price, the growth rate must be less than the discount rate. The discount rate for the detrended series (r) is defined by $\lambda = 1/(1+r)$. If we take unconditional expectations of both sides of (4) we get $E(a) = (\lambda/(1-\lambda))E(i)$. Upon substituting $1/(1+r)$ for λ and solving, we find that $r = E(i)/E(a)$. In other words, the appropriate discount rate and the rate used for the variance bounds test are equal to the mean of the detrended income-from-assets series divided by the mean of the detrended asset-value series. As indicated earlier, the estimated discount rate is assumed to be risk adjusted.

At this point, an ex post rational asset-value series can be constructed. The idea is to construct a series of asset values, a_t^* , which would have occurred if market participants had known precisely what income in all future years would be and if they had perceived the constant real discount rate discussed above. In this case, a_t^* is the present value of actual income from assets. This model is

$$a_t = E(a_t^*), \quad (5)$$

$$\text{where } a_t^* = \sum_{k=0}^{\infty} \lambda^{k+1} i_{t+k},$$

Notice that with this model, the conditional expectations operator has been dropped. Because the summation extends to infinity, the ex post rational series a_t^* can never be observed without some error. However, with a series for income from assets that is fairly

long, we can observe an approximate ex post rational series. After assuming a terminal value for a_t^* (usually the average asset value of the series), the previous values of the series can be computed recursively by

$$a_t^* = \lambda(a_{t+1}^* + i_t). \quad (6)$$

To derive the variance bounds test it is useful to briefly review the concept of an optimal forecast (Shiller 1988). The definition of an optimal forecast of a variable is its mathematical expectation conditioned on all available information. An optimal forecast must have a variance less than or equal to the variance of the variable being forecast. In other words, the variance of the conditional mean of a distribution is less than that of the distribution itself.

To begin the derivation, note that equation (5) implies a_t is the mathematical expectation of a_t^* , conditional on information at time t . As noted above, this is the definition of an optimal forecast. Next, define the forecast error as

$$\mu_t = a_t^* - a_t. \quad (7)$$

For a_t to be an optimal forecast, the covariance between a_t and μ_t must be zero. Since the variance of the sum of two uncorrelated variables is the sum of their variances,

$$\text{var}(a_t^*) = \text{var}(\mu_t) + \text{var}(a_t). \quad (8)$$

Since $\text{var}(\mu_t)$ must be nonnegative, (8) implies that

$$\text{var}(a_t) \leq \text{var}(a_t^*). \quad (9)$$

Stated in terms of standard deviations, the inequality becomes

$$\sigma(a_t) \leq \sigma(a_t^*), \quad (10)$$

which is the variance bounds test.

Data

The data used in this study are U.S. aggregate farm asset values and income from farm assets for the period 1910 to 1989. The source for the data from 1910 to 1970 is the June 1987 issue of the

Agricultural Finance Databook published by the Federal Reserve System. The data for the remainder of the sample period were furnished by the Economic Research Service of the U.S. Department of Agriculture and include the latest revisions as of May 1990.

The income-return and asset-value series were converted to 1989 dollars via the personal consumption expenditure deflator. To obtain stationarity, the data were detrended. The exponential growth path of asset values was estimated by regressing the natural logarithm of asset values on a constant and time. Then α in (2) and (3) was set equal to e^b , where b is the coefficient of time from the regression. The detrended series for asset values and income from assets were then computed from (2) and (3). The constant real discount rate was set equal to the average of detrended income from assets divided by the average of detrended asset values. These statistics appear in Table 1.

Results

The detrended farm asset value series and the ex post rational asset value series appear in Figure 2. The ex post rational series was computed recursively from (6), with the terminal value for a_t^* set equal to the average of detrended asset values over 1910–1989 (\$1,067.4 billion). Figure 2 shows that the ex post rational asset value series, a_t^* , is smoother than the detrended actual series, a_t . While there were years when income from assets was very high or low (Figure 3), these times did not last long enough to cause the ex post rational series to move significantly. In contrast, a_t has been quite volatile at times. This seems to be especially true during the 1930s and from the early 1970s to the mid-1980s.

Important assumptions in deriving the ex post rational asset value series are the discount rate and the terminal value. If a

different discount rate had been chosen but the terminal value remained the same, the recursive relationship (6) would cause the new ex post rational price to move further from the original series as we move away from the terminal date. The results of adding and subtracting .01 from the sample discount rate (.0404) are shown in Figure 4, with the middle curve representing the same ex post rational series as in Figure 2. If a different terminal value had been chosen but the discount rate remained the same, the effect would have been to add or subtract an exponential trend to or from ex post rational prices. Figure 5 shows the effect on the ex post rational series of adding and subtracting \$150 billion to the assumed terminal value (\$1,067.4 billion), where the middle curve is again the same as in Figure 2.

Sample statistics relevant to variance bounds inequality (10) appear in Table 2. Statistics are presented for six scenarios to test the sensitivity of the results to alternative assumptions regarding the sample period, discount rate, and terminal value. Statistics in the first scenario are based on the full 1910–1989 sample period as outlined above. Since the standard deviation of a_t is 2.42 times greater than that of a_t^* , the variance bound inequality is violated.

The second scenario is based on the same assumptions as the first, except that the boom and bust of the 1970s and 1980s is excluded from the sample. Despite exclusion of the most-volatile period in the sample, the standard deviation of actual farm asset values is 2.06 times that of its ex post rational counterpart, and again the variance bounds inequality is violated. The final four scenarios alter the discount rate or terminal value assumption for the full 1910–1989 sample period. In all of these scenarios, the variance bound inequality continues to be violated.

Table 1. Sample Statistics for Farm Asset Income and Value, 1910–1989

$E(a)$	Average Detrended Asset Value (billion 1989 dollars)	\$1,067.4
$E(i)$	Average Detrended Income from Assets (billion 1989 dollars)	\$43.1
r	Constant Discount Rate	.0404
$b = \ln(\alpha)$	Slope of Time Coefficient	.0128
$\hat{\sigma}(b)$	Standard Error of b	.0016
R^2	Coefficient of Determination for Trend Regression	.6092

Figure 2. Farm Asset Values and Ex Post Rational Values (Detrended), 1910–1989

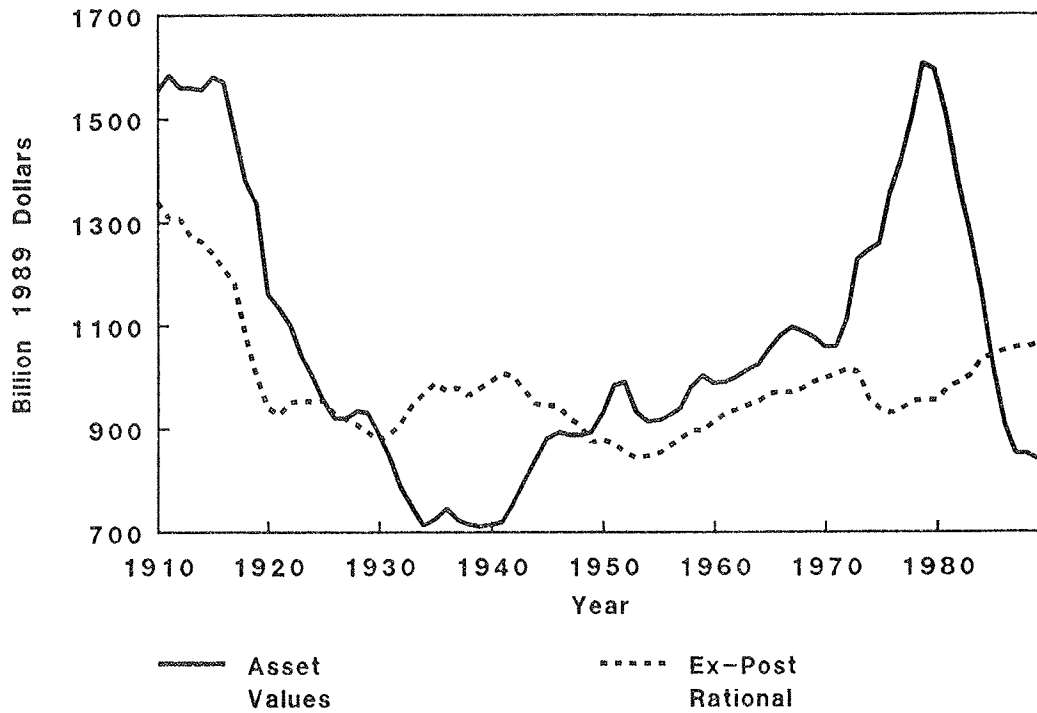
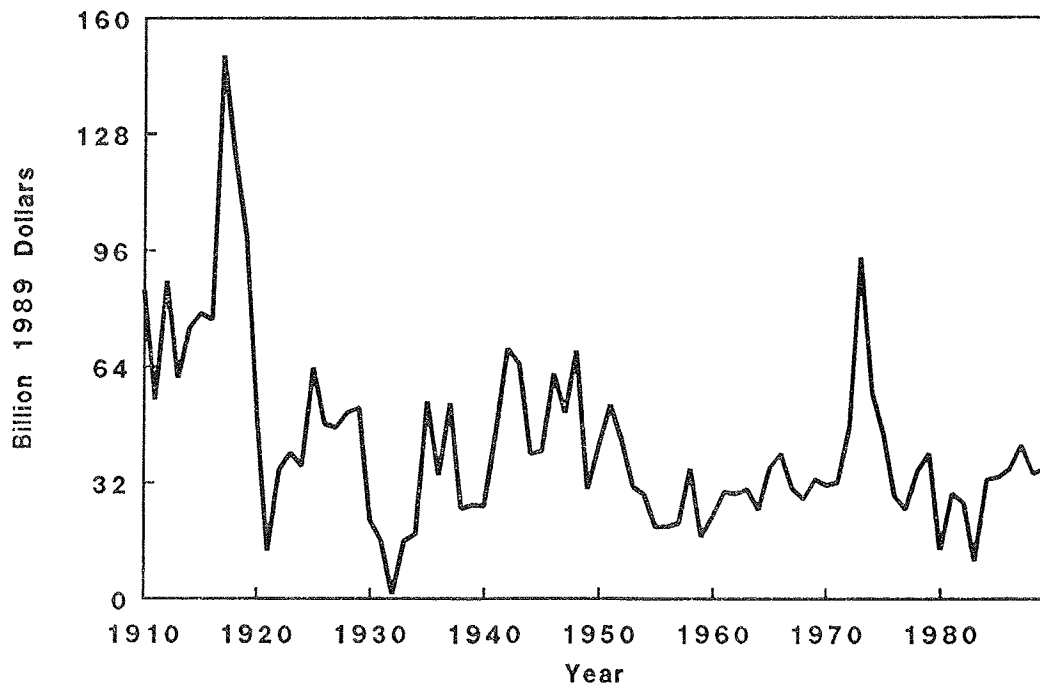


Figure 3. Income from Farm Assets (Detrended), 1910–1989



In sum, the null hypothesis of excess volatility in farm asset values cannot be rejected based on the test procedures and data used in this paper. Further, the

conclusion does not appear to be sensitive to alternative assumptions regarding the sample period, discount rate, or terminal value.

Figure 4. Effect of Different Discount Rates on Ex Post Rational Values

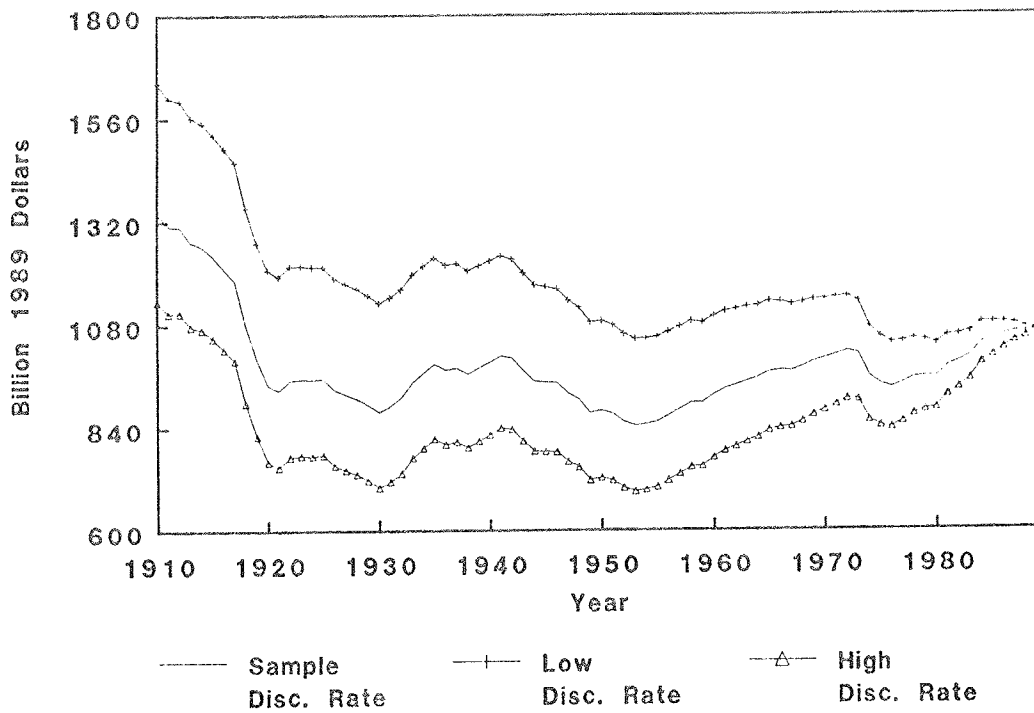
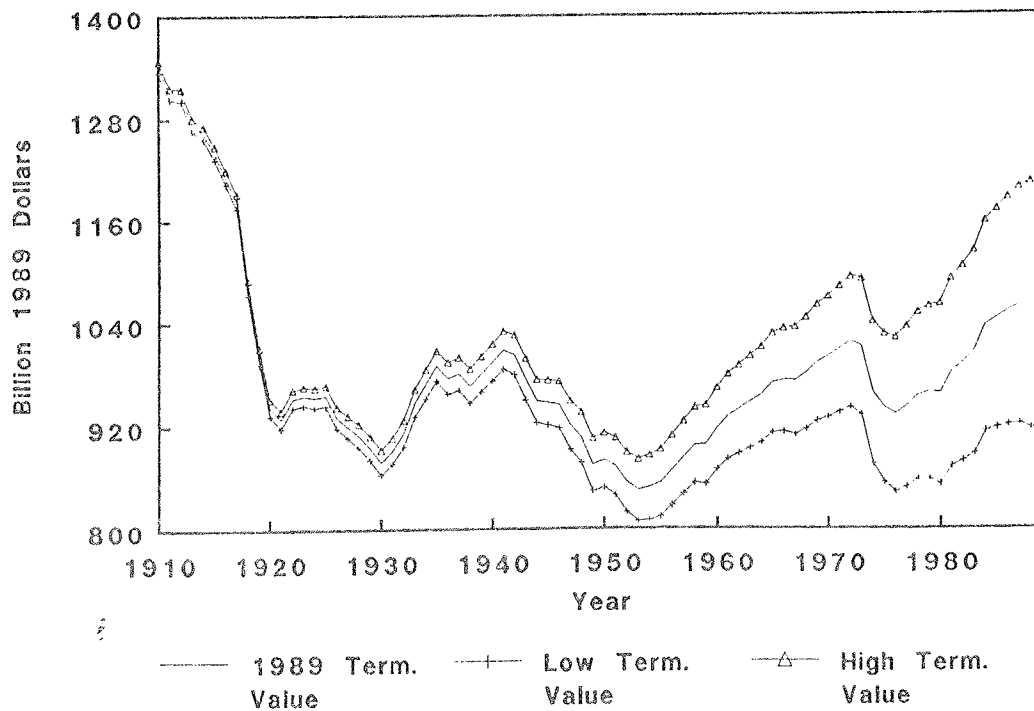


Figure 5. Effect of Different Terminal Values on Ex Post Rational Values



It is interesting to compare the results from farm asset values and the stock market. Shiller (1981) found that the Dow Jones

Industrial Series for the stock market from 1928 to 1979 had a standard deviation thirteen times greater than that of its ex

Table 2. Variance Bounds Inequality Statistics for Farm Asset Values

Scenario	$\sigma(a_t)$	$\sigma(a_t^*)$	Ratio
		<i>Billion 1989 \$</i>	
Sample: 1910–1989	266.3	109.8	2.42
Sample: 1910–1970	254.5	123.6	2.06
Low Discount Rate: ^a 1910–1989	144.7	109.8	1.84
High Discount Rate: ^b 1910–1989	116.2	109.8	2.29
Low Terminal Value: ^c 1910–1989	119.0	109.8	2.24
High Terminal Value: ^d 1910–1989	114.6	109.8	2.32

Note: $\sigma(a_t)$: standard deviation of farm asset values; $\sigma(a_t^*)$: standard deviation of ex post rational farm asset values; ratio: $\sigma(a_t)/\sigma(a_t^*)$.

^aDiscount Rate = 0.304.

^bDiscount Rate = .0504.

^cTerminal Value = \$917.4 billion.

^dTerminal Value = \$1,217.4 billion.

post rational counterpart. The explanation for the relatively low volatility of the farm asset value series likely is due to the fact that a_t actually tracked a_t^* fairly closely for a large number of years and diverged from it substantially only during certain times (during the 1930s and from the early 1970s to the mid-1980s). In contrast, Shiller's Dow Jones Series was rarely close to its ex post rational counterpart. Further, the difference in results also may be related to the fact that companies try to "smooth" dividends over several years despite the fact that earnings may be quite variable. This is discussed in Shiller (1981, 1986), Marsh and Merton, and Kleidon. Because of this smoothing process, dividends will tend to be fairly stable when compared to income from farm assets.

Summary and Concluding Remarks

The research reported in this paper examined the volatility of U.S. farm asset values. Specifically, a variance bounds test developed by Shiller (1981) was applied to real farm asset returns and values over 1910–1989. The variance bounds test places a theoretical limit on the variance of a price series given the variance of a return series. Since the variance bounds test is derived from a formal theoretical model of an efficient asset market, a direct and rigorous test of the excess-volatility hypothesis is possible.

The results showed that the standard deviation of actual farm asset values was 2.42 times greater than that of its ex post

rational counterpart. Hence, the null hypothesis of excess volatility in farm asset values could not be rejected. Further, the results were not sensitive to alternative assumptions regarding the sample period, discount rate, or terminal value.

There are several possible explanations for the results that are consistent with market efficiency. First, discount rates may not be constant. As a result, time-varying discount rates may explain the observed excess volatility. Second, Grossman has argued that excess volatility is in fact the expression of a sophisticated dynamic trading strategy used by relatively uninformed traders. These traders have rational expectations, but because they are relatively uninformed, they must infer information about underlying fundamentals from price movements themselves. If price changes because of changing risk preferences of informed traders, ex post excess volatility may be the result of rational mistakes in the assessment of underlying fundamentals by the uninformed traders.

Third, Shiller (1988) has argued that a small probability of a disaster or windfall may explain the observed excess volatility. New information may evolve from year to year that causes changes in the probability assessment of the disaster or windfall. However, the information has little to do with observed movements in returns.

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