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Inflation and the Efficiency of Capital Markets

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The recent period of inflation resulted in a dramatic rise in yields on long-term debt securities. The rise in yields was accompanied by a change in the spreads between different grades of corporate and municipal bonds, and in the spreads between yields on prime-grade corporates and yields on long-term U.S. Government securities. In this paper we investigate the question of whether the bond markets were "efficient" in establishing yield differentials between different grades of bonds and between prime corporate and long-term Government bonds. In addition, we consider to what extent "inefficiencies" were related to the recent period of inflation, more specifically, related to the unanticipated portion of the recent inflation.

Our analysis suggests that while the market was efficient in removing any systematic profits available by arbitraging across different grades of securities (for example, between Aaa and Baa bonds), the market was not efficient in establishing the differential between prime grade corporates and long-term Government bonds. The significant rise in unanticipated inflation caused the market to demand much greater premiums for prime corporates over Governments than the underlying risk would have justified. Long-term Governments appear to have lost at least in part their role as a "safe asset" in long-term portfolios, and this has impaired the market's ability to determine the appropriate spread of prime corporates over long-term Governments.

Defining capital market "efficiency"

The concept of capital-market efficiency in modern finance theory concerns the extent to which the price of a security "reflects" the "information" the "market" has available to it. An efficient market is one in which the price always incorporates all of the information available to the market.[1] It is obvious that this concept of efficiency is a loose one and needs to be more rigorously stated in order to make it operational. (See Appendix I for a technical treatment of the concept of market efficiency.) There is, however, a more intuitive corollary to this notion of capital market efficiency. If a market is efficient it should not be possible for participants to exploit the available information to make above-normal profits on the basis of some "trading rule." More precisely, an efficient market is one in which the history of the price of the security, other than the current price, provides no useful information for knowing what the expected value of tomorrow's (or next year's) price will be. All the information is "fully reflected" in the current price. This notion of efficiency leads to the equation of an efficient market with a concept of a "fair game," in which there is an equal expectation of gain or loss—or in which the expectation is for a zero gain.

Tests of the efficient market hypothesis are implicitly "joint tests," that is, they are both a test of the hypothesis that the market is efficient and a test of a particular hypothesis regarding how investors' expected returns on the security are formed to establish equilibrium in the market for the security. This complication creates some ambiguity in deriving implications regarding the efficiency of markets. If the hypothesis is rejected, it may imply either (1) that the market is efficient and that the theory of the formation of the expected return is in error or

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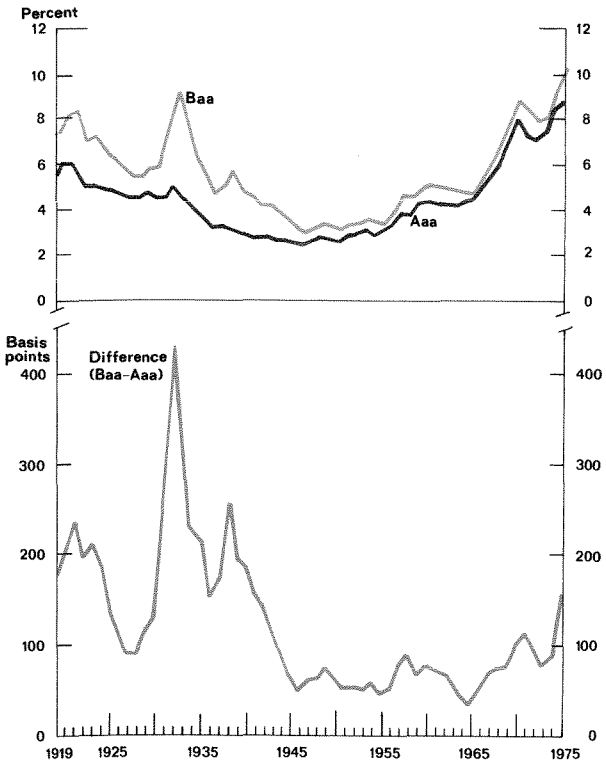
Chart 1
Corporate Bond Yield and Yield Spreads



(2) the reverse, that the expected return model is correct but the market is inefficient.

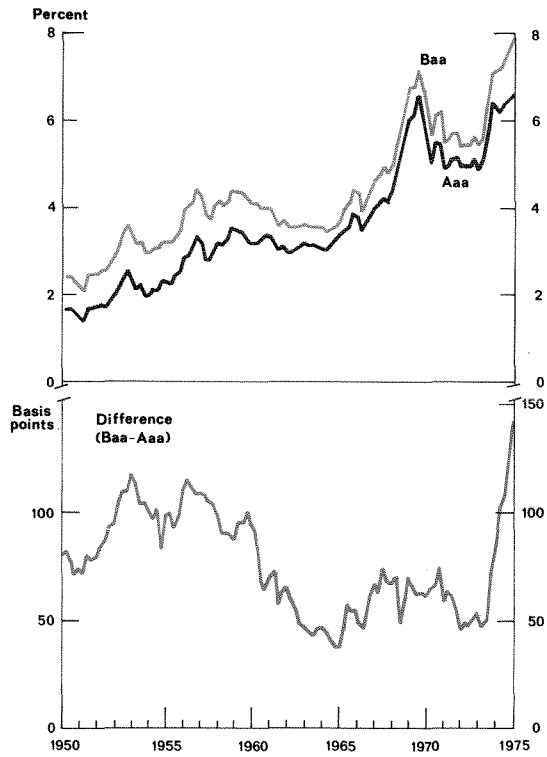
Our interest in the efficient markets hypothesis first centers on the question of whether the yield spread between various "grades" of rated bonds adequately incorporates all the market information which reflects substantive differences in the quality of the securities. To test this hypothesis, we assume at the start that the underlying quality differential between Aaa and Baa bonds remained constant in the corporate and municipal markets in the period since 1950. Thus, our test of the efficiency of these markets is made "conditional" on this assumption. Interpretation of our statistical results should recall this conditionality. Simply stated, our argument is that if bond markets are operating efficiently, it should not be possible to gain arbitrage profits systematically between different security markets (e.g., corporate vs. Governments), and similarly, it should not be possible to arbitrage systematically between risk classes of securities in the same market (e.g., Aaa vs. Baa corporates).

Measuring risk spreads

A glance at the postwar data indicates that the Baa-Aaa "quality differential" was very stable for the corporate sector and fairly stable for the municipal market, except for the last few years. The Baa and Aaa market yields and their spreads are shown in Charts 1 and 2, while the numerical averages, standard deviations, and coefficients of variation (standard deviation divided by the mean) are shown in Tables 1 and 2.

Between the 1950's and the 1960's, corporate bond yields rose significantly but the average Baa-Aaa corporate yield spread and its variation remained almost unchanged, averaging about 65 basis points, with a standard deviation of 16 basis points. This quality yield differential remained stable even though both Baa and Aaa corporate rates rose by about 170 basis points during the 1960's. Assuming an efficient mar-

Chart 2
Municipal Bond Yield and Yield Spreads



ket, we can interpret this stability as indicating an unchanged quality differential over this period.

Market yields on municipals rose about 100 basis points during the 1960's, while the Baa-Aaa yield differential narrowed appreciably, from 95 to 61 basis points, but with greater relative variability. These data would indicate, assuming an efficient market and constant quality of rating services, that the average quality of Baa issues may have improved significantly, relative to Aaa municipals, over this period.

The evidence concerning the quality differential between Aaa and Baa bonds gives rise to a question of market efficiency. Did the markets in the 1950-69 period utilize information in an efficient manner, such that knowledge of past movements in the Baa-Aaa differential provided little or no help in predicting each subsequent monthly change in the differential? To answer this question, we should consider the auto-correlations of the Baa-Aaa market yield spread over that period, assuming constancy in the underlying Baa-Aaa quality differential.

Table 3 shows the autocorrelations for twelve lagged periods, although 50 autocorrelations were estimated.[2] The test statistics indicate that there was very little serial dependence in the changes in the Baa-Aaa yield spread during the 1950-69 period. The autocorrelations were all quite low, and only the first-order autocorrelation in the corporate bond spreads was statistically significant. This latter result is not unexpected, however. As Holbrook Working has shown, the monthly averaging of daily random increments will often produce a first-period autocorrelation of +0.25.[3]

Table 1

Corporate Yields and Yield Spreads

1919 — 1975

(percent)

	Average Market Yield		Yield Spread: Baa-Aaa		
Period	Aaa	Baa	Mean	Standard Deviation	Coefficient of Variation
1919-1929	5.11	6.72	1.61	0.51	0.31
1930-1939	3.89	6.32	2.43	0.98	0.40
1940-1949	2.71	3.73	1.02	0.46	0.45
1950-1959	3.30	3.93	0.63	0.16	0.25
1960-1969	5.00	5.65	0.65	0.16	0.24
1970-1975 III	7.90	8.97	1.06	0.29	0.27

Table 2

Municipal Yields and Yield Spreads

1950 — 1975

(percent)

	Average Market Yield		Yield Spread: Baa-Aaa		
Period	Aaa	Baa	Mean	Standard Deviation	Coefficient of Variation
1950-1959	2.34	3.29	0.95	0.13	0.13
1960-1969	3.59	4.20	0.61	0.16	0.27
1970-1975	5.61	6.31	0.70	0.25	0.35

Since the remaining autocorrelations were all small and statistically insignificant, we can conclude that past changes in the Baa-Aaa spread —for both the corporate and municipal markets —were of no use in predicting the change in the spread. This can be interpreted, loosely, as saying that people cannot profitably arbitrage between different grades of securities in the same market.

Decomposition of risk exposure

The notion of risk is a relative one. The Baa-Aaa spread represents only the marginal risk—not the total risk—that a Baa bond holder

Table 3

Estimated Autocorrelations for the Change in the Baa-Aaa Yield Spread

1950 — 1969

Lag: (months)	1	2	3	4	5	6	7	8	9	10	11	12
Corporate Bonds	0.20*	0.07	0.06	0.01	—0.05	—0.06	—0.04	—0.02	0.02	—0.04	0.07	0.00
Municipal Bonds	0.07	—0.08	—0.13	—0.08	—0.10	0.00	—0.04	0.12	0.12	—0.03	—0.06	—0.12

*Coefficient is more than twice its standard error.

Box-Pierce Q-statistic: Municipals 50.95; Corporates 40.49
Critical χ^2 95% value: 67.5

assumes by not holding a prime grade bond. A Baa bond holder's total risk can only be measured with reference to the most default-free long-term debt instrument, a government bond. To capture this total risk, we divide the differential between the market yield on a Baa bond and that on a long-term U.S. Government security into two components—the spread between a Baa and Aaa, and the spread between a Aaa and a long-term U.S. Government. (Table 4) The sum of these two components we have defined as the "total risk differential," on the grounds that this can only be defined with respect to a "safe" long-term asset, in terms of default risk and marketability.

Given this definition of "total risk differential," the Baa-Aaa differential can be regarded as equivalent to a Baa default premium only if the two assets are alike in every other respect (marketability, price variability, and so on). Although the total risk differential may reflect other institutional factors, such as liquidity and call protection, we assume that it is dominated by default considerations. The differential between the Aaa corporate bond and the long-term U.S. Government bond—the premium over the safe asset—can then be thought of as the additional risk one assumes by purchasing the highest quality corporate long-term debt. Let us refer to the Baa-Aaa spread as the "Baa quality premium." The decomposition of the "total risk differential" provides some interesting insights into the risk one assumes with a Baa corporate security.

Table 4 indicates that, between the 1940's and the 1950's, the total risk differential between a Baa corporate bond and a long-term government security declined from 128 basis points to 94 basis points. Most of this decline was due to a 29 b.p. decline in the "Baa quality premium," compared to only a 6 b.p. decline in the average Aaa risk premium over the "safe asset," U.S. Government securities. During the 1960's there was only a modest change in these spreads. However, the 1970-75 period witnessed a dramatic swing in these premiums, with the total risk differential growing from 114 to 262 basis points. But in this case, most of the higher differential (104 b.p.) was due to an increase in the Aaa risk premium over long-term governments, while only 44 basis points was due to the increased risk of holding a Baa corporate security. The recent rise in the risk structure of interest rates thus seems to reflect the perceived greater risk of corporate securities generally, rather than the greater riskiness of less than premium rated corporate securities.

After the mid-1960's, quite atypically for the postwar period, the risk premium between Aaa corporates and long-term Governments began to increase greatly and with much more variability (Chart 3). Indeed, in early 1968, this risk premium exceeded the Baa-Aaa quality differential for the first time in the postwar period. This shift may be best understood in terms of an increased public demand for greater risk premiums on corporate securities. As Edward S. Shaw has emphasized in a previous

Table 4

Decomposition of Risk Exposure
Corporate Bonds
(basis points)

	Baa-Aaa "Baa Quality Premiums"			Aaa-U.S. Gov't "Aaa Risk Premium"			Baa-U.S. Gov't "Total Risk Differential"		
Periods	Means	Standard Deviations	Coefficient of Variation	Means	Standard Deviations	Coefficient of Variation	Means	Standard Deviations	Coefficient of Variation
1941 — 1949	92	37	.40	37	13	.35	128	44	.34
1950 — 1959	63	16	.25	31	7	.23	94	21	.23
1960 — 1975	81	31	.38	89	57	.64	169	84	.49
1960 — 1969	64	16	.25	50	25	.51	114	37	.33
1970 — 1975	108	31	.28	154	30	.19	262	55	.21

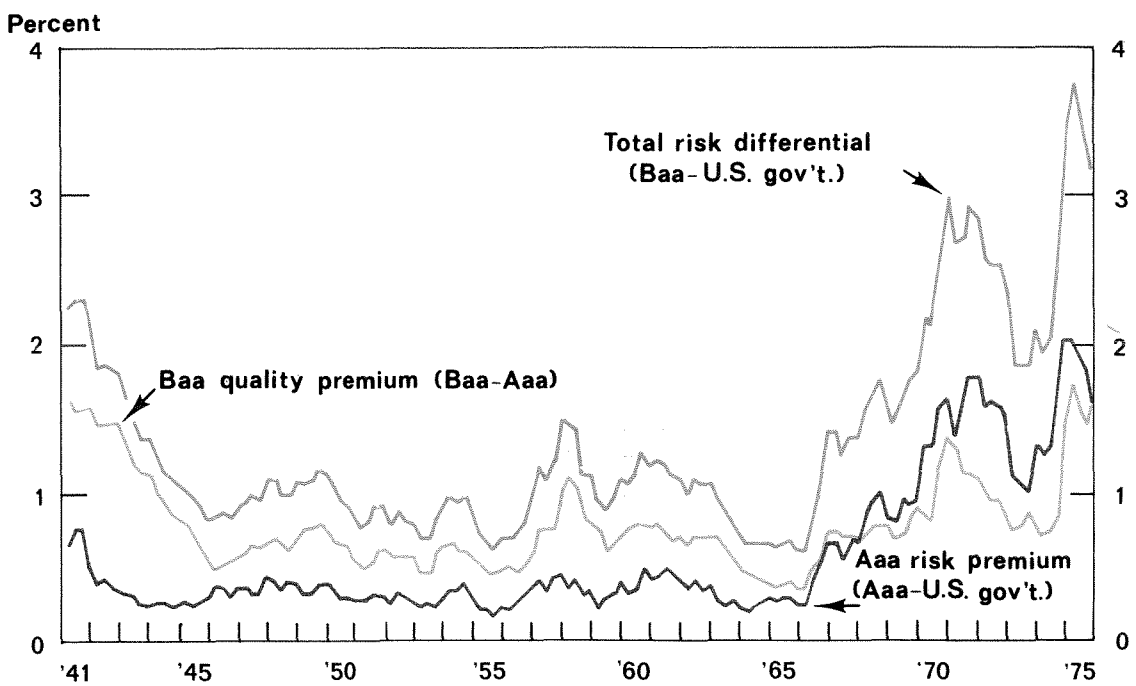
article in this *Review*,[4] price inflation can play havoc with so-called "safe assets"—i.e., assets which have real yields with small unanticipated variance. The existence of safe assets normally permits risk-averse individuals to increase their expected returns by forming portfolios of safe and risky assets. In Shaw's words, "accumulation of safe assets is complementary with accumulation of productive and risky assets, reducing the supply price of savings to riskier uses."[5] However, the gradual erosion of U.S. Government securities as safe assets during the late 1960's and 1970's, due to a rise in unanticipated inflation, led investors to demand greater premiums for purchasing corporate securities rather than Governments.

The hitherto strong correlation between different types of bond rates also disappeared during the 1970's. Long-term Governments and Aaa corporates were very strongly correlated in the two preceding decades, with a simple correlation of 0.98, but this correlation fell to a modest 0.34 in the 1970-75 period. A similar but less dramatic fall occurred in the municipal bond market. In the 1970's Aaa corporate bond holders demanded three times' the 50-basis point premium that these securities commanded over long-term Governments during the 1960's. There are a number of possible explanations for this phenomenon, but the very rapid (and atypical) rise in unanticipated inflation may be crucial. The rate of unanticipated inflation reached 8 percent in 1974, and this increased uncertainty was reflected in the premium demanded on corporate securities.

The risk premium between Aaa corporates and long-term Governments went from an average of 50 basis points in the 1960's to 154 basis points in the first half of the 1970's. In contrast, the Baa-Aaa corporate spread increased by only 44 basis points between these periods. Thus, the capital markets in recent years have been demanding greater interest yields on Baa corporate securities, more because of the loss of the safe asset than because of the increased inherent risk of Baa bonds.

Our previous results concerning the 1950-69 constancy of the Aaa-Baa risk differential, sug-

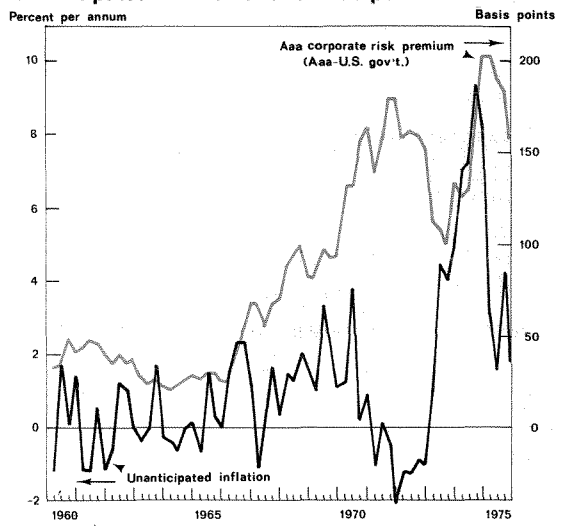
Chart 3
Corporate Bond Yield Differentials



gested that the capital markets operated efficiently in incorporating available information in the differential, so that knowledge of past changes in the Baa-Aaa spread was of little more use than knowledge of the most recent change. Was the market equally efficient in removing the potential for arbitrage profits between U.S. Governments and Aaa corporates? The autocorrelations for the change in the Aaa-U.S. Government spread have a substantial amount of statistical significance, and the chi-square statistic rejects the hypothesis of random fluctuations in the monthly change in this series (Table 5). Similar results were evident for the municipal-bond market. This evidence supports the argument that the loss of the safe asset during the late 1960's and 1970's led to inefficient capital markets.

For most periods, the capital markets efficiently used available information in determining the Baa-Aaa corporate and municipal bond spreads. Some evidence suggests, however, that the market had difficulty properly determining the premium between Aaa bonds and long-term Governments. As we stated earlier, autocorrelation results provide only tentative information on capital-market efficiency, because they are really a joint test of the hypotheses that the market is efficient and that the true underlying risk premium between the two securities is constant. Significant autocorrelations may indicate that either or both of these hypotheses are false, so that we are unable, with these simple statistics, to distinguish which of them is rejected.[6] However, our evidence indicates (at least conditionally) that the capital market properly assessed default-risk differentials between Aaa and Baa bonds but was inefficient in capturing the risk differential between Aaa bonds and long-term Governments. This supports Shaw's suggestion that the rise of "dirty inflation" (i.e., unanticipated inflation) helped distort relative financial prices in recent years.

Chart 4
Unanticipated Inflation and Aaa Corporate Risk Premium



A rough estimate of unanticipated inflation may be obtained by the following procedure. Following a definition developed by Irving Fisher, we may calculate the anticipated portion of price inflation by subtracting an estimate of the real rate of interest from the nominal (market) rate of interest—specifically, by subtracting Standard and Poor's composite dividend yield from S&P's high grade bond yield. Then we can obtain a rough estimate of "unanticipated inflation"[7] by subtracting this estimated "anticipated rate of inflation" from the observed inflation rate calculated from the Consumer Price Index.

Table 5

Estimated Autocorrelations of the Change in the Aaa-long-term U.S. Government Yield Spread

1950 — 1969

Lag (months)	1	2	3	4	5	6	7	8	9	10	11	12
Aaa-U.S. Gov't	—0.17*	—0.27*	0.06	—0.02	0.00	0.16*	—0.10	—0.16*	0.15*	—0.05	—0.05	0.12

*Coefficient is more than twice its standard error.

Box-Pierce Q-statistic: 117.6

Critical χ^2 95% value: 67.5

Table 6

Aaa Corporate Risk Premium and Unanticipated Inflation

1960 — 1975

Period	Aaa corporate-Long-term U.S. Gov't. Bond Spread	Unanticipated Inflation
	(basis points)	(annual rate of change)
1960-1964	35	0.06
1965-1969	65	1.23
1970-1975	154	2.32

Table 6 provides estimates of unanticipated inflation for the 1960-75 period, together with the spread between the Aaa corporate bond rate and the long-term U.S. Government bond rate. The Aaa corporate risk premium increased from 35 basis points between 1960 and 1964, when the average rate of unanticipated inflation was only 0.06 percent, to 154 basis points between 1970 and 1975, when unanticipated inflation grew to over 2 percent annually.

Chart 4 shows that the Aaa corporate risk premium over long-term U.S. governments remained quite stable during the early 1960's, but then rose rapidly when the rate of unanticipated inflation began to climb after 1965. However, the two series did not always move together. The fall in unanticipated inflation between 1970 and 1972 failed to show up in the Aaa corporate risk premium until 1973. But then, as unanticipated inflation increased, the Aaa corporate risk premium responded as expected by rising rapidly. From the third quarter of 1973 to the fourth quarter of 1974 the Aaa risk premium rose by 104 basis points, reflecting the 11-percent increase in unanticipated inflation which began in 1972.

The unprecedented demand for risk premiums on high-rated corporate bonds is yet another example of the so-called "rush for quality" seen in both short-term and long-term debt markets in recent years. Unanticipated inflation is but one ingredient in the premium demanded by the holders of private debt instruments. Nonetheless, the distortion in financial markets caused by unanticipated inflation, here described in terms of the efficiency of capital markets, deserves to be considered as an important cost of the recent U.S. inflation.

Conclusion

The period of tranquil stability in bond markets experienced during the 1950's and early 1960's was replaced by an entirely different situation after 1965. Yield spreads increased between different grades of bonds in both the corporate and municipal market, as did their variability. While the bond markets apparently were efficient in incorporating available information in the spread between Aaa and Baa securities, this was not the case for the market's determination of the appropriate spread between Aaa corporates and long-term U.S. Government bonds. The difficulty in determining this spread appears to be related to the unprecedented rise in unanticipated inflation experienced since the late 1960's.

It should be emphasized that the conclusions of this paper are strongly conditional on the assumption of long-term constancy of the underlying risks between different grades of rated securities—a somewhat questionable assumption in light of the severity of the recent recession and inflation. Further work needs to be done on an alternative hypothesis, namely, that capital markets were efficient throughout the post-war period in assessing risk differentials, but that the underlying risk differentials widened significantly because of substantive and pervasive changes in the economic environment. This Bank's Research Department is continuing an extensive study of the impact of these changes on the capital market's perception of financial risks.

FOOTNOTES

1. The most thorough review of efficient markets theory is Eugene F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work," **Journal of Finance** (May 1970).
2. See G. E. P. Box and G. M. Jenkins, **Time Series Analysis: Forecasting and Control,** Holden-Day, San Francisco (1970), for a discussion of the estimation and statistical tests conducted in the text.
3. Holbrook Working, "Note of the Correlation of First Differences of Averages in a Random Chain," **Econometrica** (October 1960).
4. Edward S. Shaw, "Inflation, Finance and Capital Markets," **Economic Review,** Federal Reserve Bank of San Francisco (December 1975).
5. Ibid. p. 7.
6. With regard to the joint hypothesis nature of efficient

market tests, see Eugene F. Fama, "Short-term Interest Rates as Predictors of Inflation," **American Economic Review** (June 1975).

7. For a further discussion of unanticipated inflation, see Joseph Bisignano, "The Effect of Inflation on Savings Behavior," Federal Reserve Bank of San Francisco, **Economic Review** (December 1975).

8. See, for example, Burton G. Malkiel, **A Random Walk Down Wall Street,** W. W. Norton and Company, Inc., New York (1973).

9. For an insightful clarification of Fama's concept of market efficiency, see Stephen F. LeRoy, "Efficient Capital Markets: Comment," **Journal of Finance,** March 1976, and Fama's reply.

APPENDIX I

The Concept of Efficient Markets

One form of an efficient market (the so-called "weak form"), in which the "information" is only the history of the price itself, can be stated quite simply as:

$$E(P_{t+j} | P_t, P_{t-1}, P_{t-2}, \ldots) = E(P_{t+j} | P_t) \quad (1)$$

Equation (1) states that the mathematical expectations (denoted by E) of the price (P) to prevail j periods hence, P_{t+j}, given our knowledge of the current price and the previous history of this price, is precisely equal to the expected value of the price j periods hence given only the knowledge of the current price. In other words, knowledge of past prices is irrelevant. Alternative definitions of market efficiency differ primarily by extending the range of information upon which the expectation of the future price in (1) is made conditional. In addition, a more concrete notion of market efficiency would suggest that the probability density function of the future security price, given the market's set of information, is equal to the true density function of the future price given the available information.

The efficient market theory, however, says more than (1). Let us define the information available to the market at time t as Z_t. Then, if the market is efficient,

$$E(P^*_{t+j} | Z_t) = P_t \quad (2)$$

where the * denotes that the future price is a random variable; that is, not known with certainty. If we define the change in the future price from time t, we have

$$\Delta P^*_{t+j} \equiv P^*_{t+j} - P_t \quad (3)$$

From (2) and (3) it is clear that the expected price change, given the information available, Z_t, is equal to zero,

$$E(\Delta P^*_{t+j} | Z_t) = 0 \quad (4)$$

While the above concepts of market efficiency may appear somewhat esoteric, they are important concepts for enhancing our general understanding of financial markets. Equation (2), for example, states that in an efficient market the current price is an unbiased estimate of the future price. It also implies that successive changes in the price of the security ought to be uncorrelated, that is, statistically unrelated. Indeed, a wealth of information on stock-market prices indicates that the equity market is efficient under these definitions. In recent years, a number of non-technical publications have stressed this notion that prices in the stock market follow a "random walk;" that is, successive price changes are independent.[8] Although this concept is not formally equivalent to the statement that the stock market is an efficient market, it says something very similar. The general point is the same—the market incorporates price information in such a manner that one cannot exploit this information in a systematic fashion to make a profit.[9]

Data Sources

Yield data for Aaa and Baa corporate bonds and the long-term U.S. Government bonds were obtained from the Federal Reserve *Bulletin, Banking and Monetary Statistics,* and the *Supplement to Banking and Monetary Statistics* (Money Rates and Security Markets). All are Federal Reserve publications.

Data on municipal yields were obtained from Moody's Municipal and Government Manual.