Where Standard Theory of Efficiency Falls Short of Reality: Three International Capital Markets

by

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Submitted to the Department of Economics on April 30, 1982 in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Economics

ABSTRACT

International capital markets, by virtue of the size and sophistication of participants and the magnitude of the funds at stake, might be expected to realize the efficient markets, rational expectations theory of economic activity. Yet imperfections not only exist but are found to persist in such markets, offering a profitable income stream to the knowledgeable.

Three such capital markets, all of recent origin and rapid growth, were examined; disequilibrium and its causes were identified and a model developed which outperformed market capabilities. Simple ignorance, together with the monopoly power of lenders, as the sole source of funds on a large scale, was responsible for the disbalance in the Eurocredit Market. The divergence of goals between managers and owners accounted for unexploited arbitrage opportunities in the Eurobond/Yankee Bond Market. An influx and outflow of unitiated investors created incorrect pricing of individual options and a speculative bubble on the aggregate level in the Select Sales Market for Thoroughbred Yearlings which typifies a new kind of financial asset.

However, signs of change which heralded future optimality were also observed. Rather than the instantaneous adjustment, predicated by theorists, a time lag of years rather than months, and decades rather than years, proved to be a real world phenomenon.

Thesis Supervisor: Dr. Franco Modigliani

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More than three wise men assisted at the birth of this work. There was the astute critique of Franco Modigliani, made doubly memorable by the views at Martha's Vineyard, the happy circumstance of a visiting year for Robert Shiller, and the early encouragement and final review of Stanley Fischer. There was the generous giving of the fruits of experience in the marketplace, of personal time and private data, by John H. Gutfreund, Managing Partner of Salomon Brothers Inc, Humphrey S. Finney, the patriarch of the thorougbred auction ring, and his son John Finney, both of Fasig-Tipton and Co., Dr. Arthur Davidson, veterinarian, and John Clark who has schooled so many skilled horsemen at "Clark College". Much more has been learned than can be encompassed in these brief pages.

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In a discipline whose primal assumption is the inevitable and instantaneous trend toward perfection, even a transient inefficiency affronts. The imperfection that endures, or persists, if only in the medium term, is suspect.

Financial markets provide an intriguing terrain for a challenge to this efficient markets, rational expectations approach to economic activity. The speed of information flows, the centralization of the marketplace, the number of people employed and, most importantly, the size of the pecuniary sums involved, would seem to demand an equilibrium virtually indistinguishable from one where price is fully revealing. Yet, economists who have developed this theoretical background and come to its logical conclusion of quasi-efficiency often ignore the impact of certain phenomena of the asset markets which may cause empirical results to fall short of the dictates of theory. Delays in information diffusion, investor ignorance and inertia, a divergence of goals between principals and agents, geographical boundaries, and lack of arm's length transactions, are all real world features which have been set aside as minor in influence.

Actual participants in the financial markets are surprised and somewhat bemused by this stance. True, there may be markets, the most highly developed and liquid such as that of U.S. Treasury Bills, which provide evidence of efficiency, but these are the least profitable to participants and employ a relatively small number of people. As a partner in one of the major Wall Street firms quipped, "... if it were not for all these 'minor influences', we would probably be jobless and certainly not as rich as we are".

In this thesis, three as yet unexplored capital markets have been sought out for analysis in an attempt to gauge the significance of these peripheral factors in the functioning of asset marketplaces. Each fulfilled the major theoretical preconditions for efficiency and yet provided empirical evidence against such optimality. Each market had an understandable justifying cause for the persistent disequilibrium, but <u>persistent</u> the disequilibrium had been!

Youth was a quality common to all three markets. They were new in terms of the calendar or new in their present form. Recent growth at an exponential rate was another common denominator, as was the backdrop for this development -- a time of high and violently fluctuating costs of money. Ignorance, the inevitable outcome of rapid change, abounded; its partner, excess profits, was annexed by the skilled few.

For each one of the triad, evidence of inefficiency was clear and

the source identified. For each, the opportunity to develop a profitable income stream appeared. For each, a model was derived from readily available information which was found to predict far in excess of market capabilities. But, also for each, a small trend emerged as a harbinger of change. Excess profits began to decline; industry practices began to alter; even within a mania, aggregates began to track a rational, though divergent path.

However, the transition time was far longer than most proponents of the perfect market believe possible. Years instead of months, decades rather than years, delimit the evolutionary cycle. In this era of information which is international in scope and instantaneous in electronic processing, it might be expected that this time lag between the young, imperfect marketplace and its mature counterpart will grow ever shorter.

THE SYNDICATED EUROCREDIT MARKET:

FAULTY FORECASTS AND EXCESS PROFITS

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What is now the world's principal source of external finance is a market virtually unknown to the public, inaccessible to investors, and the private province of large universal banks. It is the Syndicated Eurocredit marketplace which plays the key role in the recycling of funds from oil-rich surplus countries to less-developed nations attempting to expand in an environment of world-wide recession and high energy costs, as well as to industrialized nations seeking to mitigate the decline in domestic economies.

The rise to preeminence of the Eurocredit dates to the 1970's, a time when it mushroomed from U.S. $21 billions in 1973 to U.S. $ 74 billions by 1978, a compound annual rate of twenty-nine percent before leveling off at the decade's end. During the past eight years, it has provisioned U.S. $347 billions or sixty percent of all international borrowings from private sources. (See Table I.)

The importance of the Eurocredit to developing economies cannot be overemphasized. Private financial markets, as a group, have played ov ever-increasing role in funding ldc's, with a contribution to

TABLE I

THE DOMINANCE OF EUROCURRENCY CREDITS IN THE INTERNATIONAL CAPITAL MARKETS 1973-80

	1973	1974	1975	1976	1977
		(U.S. $ Millions)			
Foreign Bonds	5,347	7,763	12,301	18,943	16,610
International Bonds	4,702	4,512	10,520	15,368	19,483
Eurocurrency Credits	20,801	28,508	20,554	28,703	34,185
Eurocurrency Credits as % of Total International Borrowings	67%	70%	47%	46%	49%

	1978	1979	1980
		(U.S. $ Millions)	
Foreign Bonds	21,542	19,965	15,753
International Bonds	15,940	17,799	22,506
Eurocurrency Credits	73,695	70,249	70,386
Eurocurrency Credits as % of Total International Borrowings	66%	65%	65%

Source: Borrowing in International Capital Markets, 1973-80 IBRD.

collective external public debt which rose from twenty-four percent in 1973 to forty-eight percent in 1980, while responsibility for net flows rose from forty-six percent to sixty-six percent over the 1973-79 interval. The obligations of upper and middle income idc's reveal an even greater dependence: here, the private capital sector's share of external debt increased from thirty-seven percent in 1973 to sixty-three percent in 1980, while in terms of net flows, the portion grew from fifty-six percent to eighty percent. (See Table II.) It was the Eurocredit market which provided in excess of ninety percent of all this non-concessionary financing to idc's. (See Table III.) Viewed from another vantage point, these borrowers continued to consume an ever-growing share of total Eurocredit loans, which climbed from thirty-seven percent in 1973-74 to fifty-eight percent in 1979-80. (See Table IV.) In this frame of reference, the efficiency of the Eurocredit market's performance is of prime significance.

On another level, market efficiency is vital to the internal profitability of major commercial banks in a world where U.S. participants derive more than fifty percent of their profits from international operations. A list of the principal players and their dollar involvement points to the Eurocredit vehicle as a present source of large revenues. (See Table V.) Looking to the future, industry pressure to permit trading in loan participations is growing

TABLE II

THE MAJOR ROLE OF FINANCIAL MARKETS IN FUNDING LESS DEVELOPED COUNTRIES (1973-1980)

	1973	1974	1975	1976	1977	1978	1979	1980
All LDCs								
as % Total Disbursed Debt	24.3	27.8	32.0	36.1	39.6	43.0	46.7	47.5
% Disbursements	42.2	44.3	44.1	51.4	54.8	60.7	64.7	N.A.
% Net Flows	46.0	47.2	47.7	56.8	58.1	60.1	65.9	N.A.
Upper & Middle Income LDCs								
as % Total Disbursed Debt	36.8	40.7	45.7	50.1	54.6	57.5	61.0	62.5
% Disbursements	52.1	56.8	59.1	63.7	68.7	71.2	74.9	N.A.
% Net Flows	55.7	61.6	65.9	70.4	75.6	72.7	79.5	N.A.

Source: World Debt Tables, 1973-80, IBRD.

TABLE III

THE PARTICIPATION OF EUROCURRENCY CREDITS IN TOTAL INTERNATIONAL BORROWING BY CLASS OF ISSUER

	1973	1974	1975	1976	1977	1978	1979	1980
Industrialized	66%	73%	24%	25%	33%	58%	44%	53%
LDC	91	96	94	91	81	86	92	93
Other*	22	22	34	28	26	32	46	27
All Borrowers	67	70	47	46	49	66	65	65

* Centrally Planned Economies, International Organizations and Others.

Source: Borrowing in International Capital Markets, 1973-80 IBRD.

TABLE IV

MARKET SHARES IN THE EUROCURRENCY CREDIT MARKET BY CLASS OF ISSUER

	1973	1974	1975	1976	1977	1978	1979	1980
Industrialized	56%	61%	25%	27%	32%	43%	27%	42%
LDC	40	34	61	61	59	52	62	53
Other	4	5	14	12	9	5	11	5

Source: Borrowing in International Capital Markets, 1973-80 IBRD.

TABLE V

EUROCURRENCY CREDIT MANAGER RANKINGS

JANUARY-DECEMBER 1980, loans signed

Position	Lead Managers	No. of loans	Amount ($m)
1.	Citicorp	89	4111.41
2.	Chase Manhattan	101	4090.15
3.	Bank of Montreal	62	2748.18
4.	Bank of America	70	2737.42
5.	National Westminster	63	2629.50
6.	Credit Lyonnais	91	2291.99
7.	Manufacturers Hanover	51	2263.81
8.	CIBC	40	2114.29
9.	Morgan Guaranty	42	1985.63
10.	WestLB	36	1788.19
11.	Lloyds	74	1711.92
12.	Merrill Lynch Int Bnkg Grp	11	1559.25
13.	Societe Generale	48	1556.08
14.	Dresdner Bank	46	1508.36
15.	Credit Suisse First Boston	20	1497.06
16.	Shearson Loeb Rhoades Int	13	1404.00
17.	Royal Bank of Canada	48	1389.17
18.	Midland Bank	57	1308.55
19.	Societe Generale Banque Grp	36	1191.33
20.	Banque Nationale Paris	38	1168.81
21.	Bank of Nova Scotia	26	1150.01
22.	Bank of Tokyo	38	1100.27
23.	Banque Paris et des Pays-Bas	25	1084.96
24.	Kredietbank Interni. Grp	23	1067.73
25.	Orion Bank	35	987.02
26.	Barclays	43	937.73
27.	Bankers Trust Company	23	886.17
28.	Wells Fargo	22	862.13
29.	Deutsche Bank	26	861.04
30.	Toronto Dominion Bank	28	852.43

JANUARY-DECEMBER 1979, loans signed

Position	Lead Managers	No. of loans	Amount ($m)
1.	Citicorp	78	5077.8
2.	Bank of Tokyo	44	4407.5
3.	Chase Manhattan	71	4001.3
4.	Bank of America	69	3856.7
5.	Bank of Montreal	57	3679.8
6.	Lloyds	39	2623.9
7.	Deutsche Bank	29	2550.1
8.	Morgan Guaranty	33	2512.4
9.	Manufacturers Hanover	31	2237.6
10.	Chemical Bank	34	1989.5
11.	Credit Lyonnais	34	1989.5
12.	Bankers Trust	31	1730.0
13.	WestLB	29	1623.8
14.	National Westminster	33	1574.0
15.	Wells Fargo	14	1350.2
16.	Industrial Bank of Japan	25	1316.8
17.	Orion	29	1274.4
18.	Grindlays	19	1117.9
19.	Midland	31	1113.5
20.	Long-Term Credit Bank	36	1106.6
21.	Societe Generale	12	1069.0
22.	Barclays	18	992.0
23.	Dresdner Bank	14	915.2
24.	Royal Bank of Canada	31	903.5
25.	Societe Generale Banque Grp	21	884.9
26.	First Chicago	18	863.3
27.	Commerzbank	17	862.7
28.	Shearson Loeb Rhoades Int	7	860.0
29.	Credit Commercial France	13	827.9
30.	CIBC	13	718.9

TABLE V (Cont'd)

JANUARY-DECEMBER 1980, loans signed				JANUARY-DECEMBER 1979, loans signed			
Position	Lead Managers	No. of loans	Amount ($m)	Position	Lead Managers	No. of loans	Amount ($m)
31.	Credit Commercial de France	27	806.37	31.	Sanwa Bank	15	673.2
32.	Chemical Bank	26	793.27	32.	Amsterdam-Rotterdam Bank	17	662.8
33.	National Bank of Canada	17	742.41	33.	Hill Samuel	6	656.6
34.	Gulf International Bank	33	696.77	34.	Sumitomo Bank	23	625.6
35.	Schroder Wagg	11	671.88	35.	Kredietbank Interni. Grp.	10	622.1
36.	Banque Bruxelles Lambert	6	654.91	36.	Continental Illinois	16	612.2
37.	DG Bank	21	590.79	37.	Credit Suisse First Boston	14	581.8
38.	Continental Illinois	26	555.49	38.	DG Bank	12	579.4
39.	Bank Bumiputra Malaysia	3	555.00	39.	Merill Lynch Int Bnkg Grp	7	572.5
40.	Commerzbank	19	550.00	40.	Swiss Bank Corporation	12	570.3
41.	Swiss Bank Corporation	19	510.29	41.	Banque Europeene de Credit	24	556.0
42.	Libra Bank	20	499.43	42.	American Express	17	545.8
43.	International Mexican Bank	8	487.83	43.	Bank of Nova Scotia	10	528.2
44.	Banca Commerciale Italiana	9	475.14	44.	Morgan Grenfell	15	510.2
45.	Dai-Ichi Kangyo Bank	15	471.21	45.	Mitsui Trust & Banking	9	489.7
46.	Credit Agricole	13	468.12	46.	SG Warburg	6	477.6
47.	First National Bank Chicago	20	467.96	47.	Mitsubishi Bank	16	470.3
48.	SG Warburg	12	467.74	48.	Toronto Dominion Bank	10	467.3
49.	Fuji Bank	18	466.11	49.	Hambros	18	465.2
50.	Hambros Bank	11	457.70	50.	Standard Chartered Bank	13	445.9

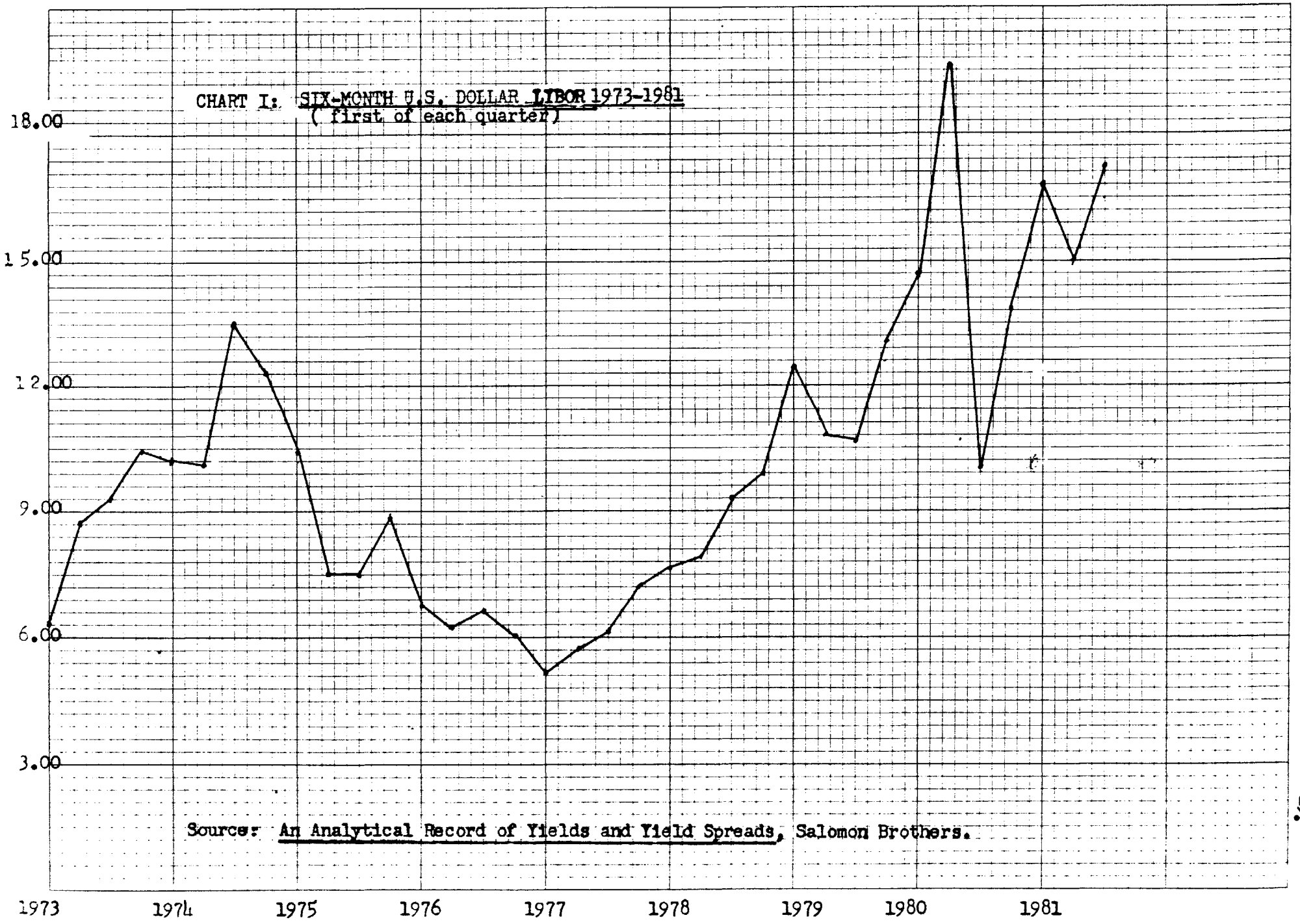
Source: Euromoney, March 1981.

and, since there is no intrinsic difference between these and floating rate private placements, may create an opportunity for arbitrage profits open to all large-scale investors.

Defined simply, a Eurocurrency Credit, sometimes termed a syndicated loan, is a contract to provide funds of major importance, from fifty millions to billions of dollars, for maturities that range from one to fifteen years but concentrate in the 7-10 year medium term. Borrowers are most often sovereign states; lenders are a small group of big international banks who, in turn, offer participations to smaller banks world-wide.

In a decade of violently fluctuating costs of money, the principal appeal to lenders of this source of funds has been its variable interest rate. Yields on loans are set at a "spread" or intermediation premium above the London Interbank Offered Rate (LIBOR), the short term rate at which major Eurocurrency banks lend funds to each other. Although the spread is fixed at the syndication date, the actual yield floats above LIBOR. More than ninety percent of all such loans depend upon the six-month LIBOR as the base rate, although some contracts do carry an option which permits the borrower to choose between the one, three or six month rate as an index, at each interest determination date. (See Chart I.) To lenders, the spread represents the profit above opportunity cost, for positions in loans can be funded without interest rate risk in the interbank

CHART I: SIX-MONTH U.S. DOLLAR LIBOR 1973-1981
(first of each quarter)



Source: An Analytical Record of Yields and Yield Spreads, Salomon Brothers.

market. It should not be construed, however, that intermediaries have infinite access to funds at LIBOR. Only the ten or fifteen largest banks can borrow without a premium and even these would find cost of funds higher and access limited should a dramatic increase in portfolio loans, and hence exposure, be attempted.

Ninety-five percent of all loans in the market are denominated in U.S. dollars, a reason for this study to focus solely on such assets. Industry tradition has it that the relative spread denotes the relative risk, one reason why much research and soul searching is presently devoted to sovereign credit analysis. In a market dominated by strong international financial intermediaries with a substantial commitment in terms of information gathering and processing, an a priori assumption of full information seems plausible.

A somewhat surprising feature of the Eurocredit market where the massive volume of funds, the leading position of the lenders, and the crucial role in world development suggest sophistication, is the implicit premise that spreads will be constant over time or, equivalently, that changes in their level are impossible to forecast. Questioning the optimality of this simplistic strategy provides the subject of this paper:

Are the market maturity premia truly invariable? (Section I.)

Can a model be developed to provide a basis for testing the consequences for efficiency of such a constant maturity premium policy? (Section II.)

How does the accuracy of market forecasts change as the time horizon increases? Actual market spreads were regressed on forecasts generated for 1, 2, 3, 4, and 5 year time spans and a statistical comparison made of the mean squared error, mean absolute error, and the absolute value of the mean error of the forecasts. (Section III.)

What is the breakdown of the market's error between relative and general fluctuations? (Section IV.)

Has the accuracy of market predictions increased over time, as claimed by market participants? The sample was split into 1973-75 and 1976-79 sub-periods and actual market spreads were regressed on 1, 2 and 3 year forecasts. Accuracy of forecasts was further compared between sub-periods via the mean squared error, the mean absolute error and the absolute value of the mean error. (Section V.)

Again, what is the breakdown of market error between the general and the relative over time? (Section VI.)

Can forecasts superior to those of the market be created by adding information, available at the time the market's expectation was formed? The market's expectational error was regressed on projections of variables found to be significant in the determination of spreads. Next, projections for the 1978-80, 1979-80 and 1980 periods were created by the use of regression models similar to those above but derived from the 1974-77, 1974-78 and 1974-79 sub-periods respectively, and compared to those of the market via regressions of actual market spreads on the respective projections, and as reflected in mean squared error, mean absolute error and the absolute value of the mean error of forecasts. (Section VII.)

How do the model's maturity premia compare to their perfect foresight values? Spreads predicted by the model were used to generate yield curves at given points in time over the 1973-78 period. From these, model-predicted maturity premia were derived and compared to the ex post rational maturity differentials. (Section VIII.)

I. WHAT ARE THE MATURITY PREMIA OF THE MARKET?

Both casual empriricism and comments from syndication managers of four leading international banks seemed to reveal a common 1/8% differential between maturity categories of 1, 3, 5, 7, 10, 12, and 15 years which was invariant both through time and across borrowers. Implicit in this constant maturity premium is the assumption that future changes in spreads are impossible to predict. At any moment in time:

$$S^{x}_{t} = S^{x-i}_{t} + P^{i}$$

S^{x}_{t} is the spot spread at time t for an x period loan

P^{i} is the i period maturity premium

The syndicated loan market seems to exhibit the unique characteristic that for all t in the 1973-80 period:

$$S^{15}_{t} - S^{12}_{t} = S^{12}_{t} - S^{10}_{t} = S^{10}_{t} - S^{7}_{t} = S^{7}_{t} - S^{5}_{t} = S^{5}_{t} - S^{3}_{t} = S^{3}_{t} - S^{1}_{t} = .125\%$$

To verify this hypothesis, a formal analysis of all loans to

twenty-five sovereign borrowers over the 1973-80 period was undertaken. These proffered a representative cross-section of industrialized nations, oil-exporting idc's, oil-importing idc's, and Eurpoean issuers in the idc category.

Denmark	Iran	Argentina	Greece
Finland	Indonesia	Brazil	Spain
France	Mexico	Peru	
Italy	Venezuela	Panama	
Norway	Gabon	Tunisia	
Sweden	Malaysia	Turkey	
U.K.	Algeria	Korea	
		Phillipines	
		Ivory Coast	

By noting spreads on loans of varying maturities to the same entity, at a given moment in time, the premia between maturity classes at that moment can be derived. In this manner, a sample population of 243 observations was obtained. Average market maturity differentials were then compiled by combining observations across borrowers at a given moment in time and between given maturity classes. These were found to be remarkably consistent with the hypothesis of an invariant premium, again through time and across maturity categories. The average for all maturity differences over the entire 1973-1980 period was .129% or within 3% of the hypothesized 1/8% value.

Further corroboration was provided by the limitation in the variation of this value over the sample period to a two basis point interval, while scrutiny of the average of specific maturity

differentials revealed a total variation of only 2.5 basis points. (See Table VI.) Conversely, if attempts at forecasting had been made, and the expectations theory of the term structure is valid, the maturity premia would have been highly unstable, given the 100 basis point variation in spread levels. Additional verification was offered by a second approach which focused on the frequency of occurence of the 1/8% rule in the sample population. In 54% of the cases, this rule was followed exactly. (See Table VII.)

Still another aspect of evidence that the market does not attempt to forecast future changes in the average level of spreads is found in the absence of any relationship between the future path of spreads and the maturity premia. For example, the forward premium in a period such as 1973-74, after which spreads rose, was .131%--- virtually identical to the .130% of the 1975-76 time span which was followed by a period of falling spreads. (See Chart II.)

This invariance can only be rationally consistent with the hypothesis that changes in the general level of spreads are impossible to forecast. The suboptimality of this present industry working premise will be demonstrated in Section VII.

TABLE VI

AVERAGE MATURITY PREMIA OF THE SYNDICATED LOAN MARKET: 1973-1980

	MATURITY CLASS DIFFERENTIAL (YEARS)						
	1-3	3-5	5-7	7-10	10-12	12-15	Average*
1973	-	-	.160%	.120%	.119%	.160%	.131%
1974	.125%	.125%	-	.138	.121	-	.132
1975	.125	.125	.125	-	-	-	.125
1976	.125	.125	.162	.125	-	-	.134
1977	-	.125	.138	.125	-	-	.135
1978	.149	.141	.127	.148	.179	.167	.143
1979	.146	.127	.127	.115	.122	.199	.127
1980	.126	.119	.111	.133	.112	.096	.123
Average*	.133	.126	.130	.129	.131	.151	.129

* Weighted by number of observations.

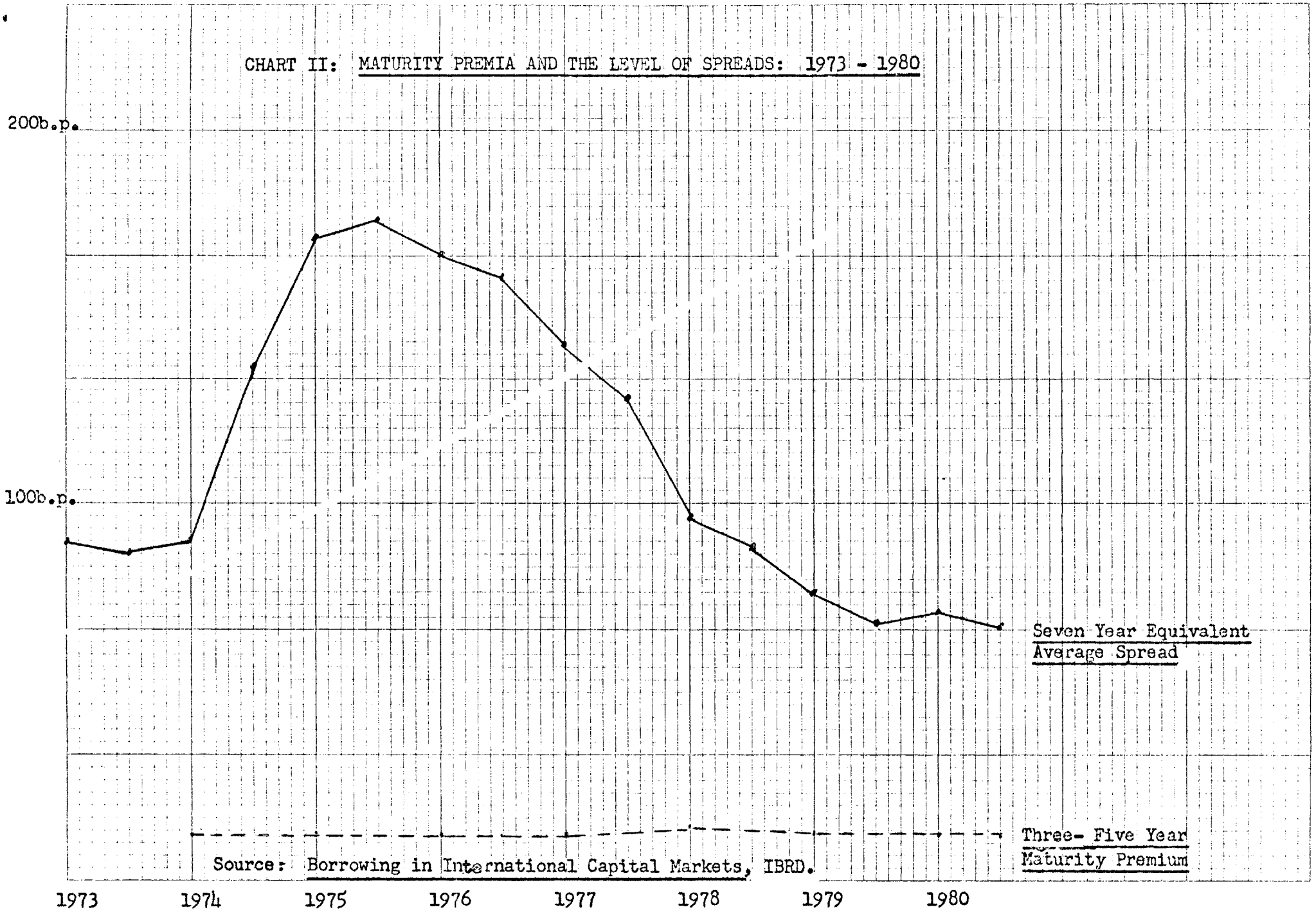
TABLE VII

FREQUENCY OF OCCURENCE* OF THE 1/8% MATURITY PREMIUM IN THE SYNDICATED LOAN MARKET: 1973-1980

	MATURITY CLASS DIFFERENTIAL (YEARS)						
	1-3	3-5	5-7	7-10	10-12	12-15	Average**
1973	-	-	-	50%	67%	33%	54%
1974	100%	100%	-	20	50	-	40
1975	100	100	100%	-	-	-	100
1976	100	100	56	100	-	-	69
1977	-	100	33	50	-	-	46
1978	-	60	59	40	50	67	50
1979	67	56	71	69	67	50	66
1980	100	78	42	20	17	0	35
Average**	82	76	58	38	54	38	54

* Minimum of two observations.

** Weighted by number of observations.


CHART II: MATURITY PREMIA AND THE LEVEL OF SPREADS: 1973 - 1980
200b.p.
100b.p.
Seven Year Equivalent Average Spread
Three- Five Year Maturity Premium
Source: Borrowing in International Capital Markets, IBRD.
1973
1974
1975
1976
1977
1978
1979
1980

II. A MODEL OF EXPECTATIONS FORMATION

Since the spread is the only portion of the asset's yield determined at syndication, a study of rationality requires a model which will generate an estimate of the market's expectation of the spread on a specific asset at a specific moment in time. This will be created by using the yield curve of the industry. The floating interest rate, by eliminating any risk due to movements in general interest levels, leaves only differences in liquidity and default risk* premia between maturities. Spreads must consequently be adjusted for varying maturities in order to achieve a more appropriate measure of relative attractiveness. The correction also compensates for shifts in maturity structures between countries and for all countries across time. Taking a seven year period as a bench mark, since the mean maturity over the 1973-80 time span tallied eighty-six months, all spreads have been homogenized to a seven-year-equivalent spread. The basis for recalculation is the time and cross-section invariant industry standard whereby the spread rises 1/8% between each maturity category.

---

* Here, default risk is used to cover all types of payments difficulties, ranging from exchange controls to debt repudiation.

The model of market expectations is based upon an expectations theory of the term structure of spreads. It assumes that the spot spread is equal to the expected forward spread plus a maturity premium for the additional risk of the longer exposure. A loan with an original maturity of ten years in 1974 is considered a perfect portfolio substitute, up to a standardization factor for the increased illiquidity and default risk, for a seven year loan newly-issued in 1977. It must therefore be anticipated to yield the same return plus a maturity premium.

The formation of market expectations is described in equations (1)--(6).

$$S^{x}_{t} = F^{x-1}_{t\ t+1} + P^{1} \qquad (1)$$

S^{x}_{t} is the spot spread at time t for an x period loan.

$F^{x-1}_{t\ t+1}$ is the expectation as of time t of the spot spread to prevail at time t+1 on an x-1 period loan.

P^{1} is the premium for the increased illiquidity and default risk of the additional 1 period commitment.

Using the market's maturity adjustment rule:

$$S_t^x = S_t^7 + P^{x-7} \qquad (2)$$

$$F_{t\,t+1}^{x-1} = F_{t\,t+1}^{7} + P^{x-1-7} \qquad (3)$$

Substituting equations (2) and (3) into equation (1):

$$S_t^7 + P^{x-7} = F_{t\,t+1}^{7} + P^{x-1-7} + P^{1} \qquad (4)$$

The market's adjustment rule which utilizes a constant differential between maturity classes implies that:

$$P^{x-7} = P^{x-1-7} + P^{1} \qquad (5)$$

Substituting equation (5) into equation (4):

$$S_t^7 = F_{t\,t+1}^{7} \qquad (6)$$

The equivalence of the spot <u>maturity-adjusted</u> spread to the

market's expectation of the future maturity-adjusted spread is now evident. Admittedly, this study focuses on risky assets, each with a positive probability of default, but which have not yet defaulted. The liquidity and default risk premia between maturity classes utilized by the market explicitly compensates for these risks and thereby eliminates the survivorship problem. The validity of the hypothesis that the current maturity-adjusted spread should be the optimal forecast of future maturity-adjusted spreads is thus reaffirmed. There remains the difficult problem of determining whether this rule whereby spreads rise by 1/8% for each maturity class and that the risk premium should be a linear function of maturity class is roughly optimal. Equivalently, is the probability distribution of default and liquidity difficulties implied by the market's rule, which implicitly specifies that the probability of loss of principal and/or funding problems rises by 1/8% every two-three years, plausible? Though an explicit analysis of the variance of spreads through time is not undertaken in this essay, studies of the U.S. bond market show that maturity premia for specific borrowers vary substantially through time. Why therefore should it be deemed reasonable that risk in the syndicated loan market be distributed in such a manner as to validate the constant maturity premium?

The model's approach provides estimates of the path of the market's expectations through time, since the spread on a loan with an

original maturity of ten years in 1974 would yield expectations, as of 1974, of the spread in any year up to 1983, and for any maturity, given proper adjustment.

In this manner, entire sequences of anticipated spreads can be generated for various borrowers, through time. The changes in these values should exhibit random fluctuations and be uncorrelated with any information publicly available at the time the expectations are dated. In short, does the seven year equivalent spread follow a random walk?

The obligations of issuers from twenty five countries, who were collectively responsible for about 66% of Eurocredit market volume and forty percent of all international borrowings over the 1973-80 period, provide the data base for this study. For a representative balance, these were drawn from four basic groups: developed industrialized nations; oil-exporting ldc's; oil-importing ldc's; and European issuers in the ldc category. To concentrate on the question of sovereign credit evaluation, only borrowings guaranteed by a public sector entity are included. The magnitude and distribution of these loans, over time, can be found in Table VIII.

Appropriate reference points for all spreads were established as June and December, since economic data for the previous year and for the first half of the current year are published in April and October, respectively.

TABLE VIII

BORROWINGS IN THE EUROCURRENCY CREDIT MARKET FOR TWENTY FIVE SOVEREIGN ISSUERS: 1973-80

	1973	1974	1975	1976	1977
	(US $ millions)				
Denmark	207	401	341	803	873
Finland	421	319	399	300	314
France	50	3,331	506	734	1,865
Italy	4,713	2,390	120	20	779
Norway	785	627	242	470	623
Sweden	114	189	282	440	1,376
U.K.	3,398	5,723	603	2,179	2,476
Iran	727	115	245	932	1,761
Indonesia	192	368	1,608	510	88
Mexico	1,178	1,478	2,158	2,140	2,895
Venezuela	129	50	200	1,129	1,650
Argentina	87	476	34	896	828
Brazil	822	1,605	2,120	3,288	2,341
Gabon	64	67	30	119	56
Ivory Coast	74	63	50	148	273
Korea	48	300	326	980	796
Panama	191	58	115	152	147
Philippines	179	883	253	873	705
Malaysia	-	140	425	200	130
Turkey	20	-	170	170	170
Peru	628	362	433	350	144
Greece	510	438	239	324	222
Spain	486	1,109	1,015	2,024	1,880
Algeria	1,302	-	500	663	427
Tunisia	-	-	-	-	145
Total of Sample	16,325	20,492	12,414	19,844	22,964
Total of Market	20,801	28,508	20,554	28,703	34,185
Sample % of Market	78%	72%	60%	69%	67%
Sample as % Total International Borrowing	52%	50%	28%	32%	33%

TABLE VIII (Cont'd)

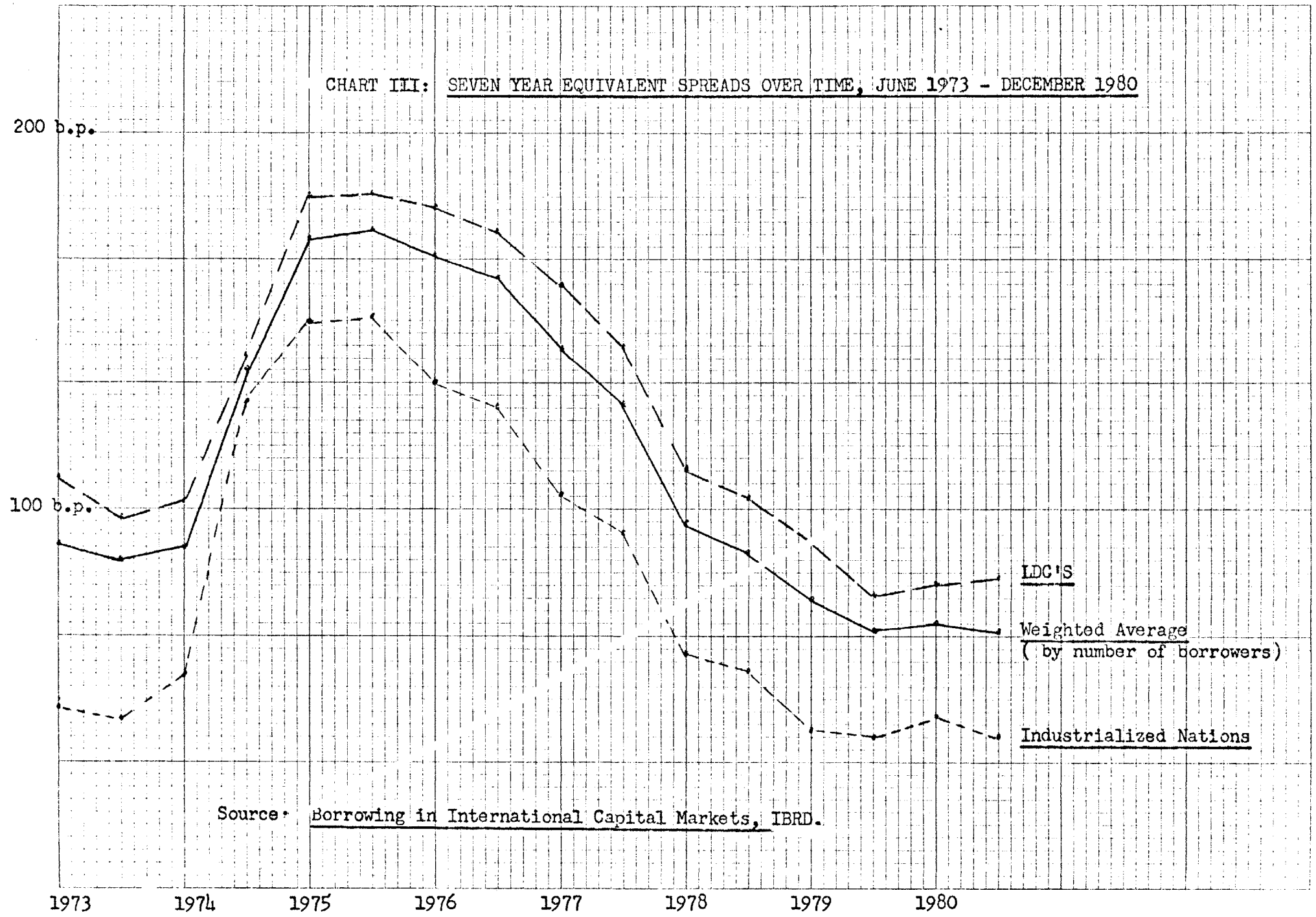
	1978	1979	1980
Denmark	2,335	1,211	1,325
Finland	551	42	1,090
France	2,475	2,735	1,960
Italy	2,808	3,415	6,177
Norway	1,175	1,175	853
Sweden	1,861	1,319	1,299
U.K.	4,722	1,377	954
Iran	1,132	-	-
Indonesia	1,623	670	1,080
Mexico	6,554	7,655	5,017
Venezuela	2,051	3,238	2,898
Argentina	1,273	2,122	2,290
Brazil	5,111	5,834	4,415
Gabon	86	100	100
Ivory Coast	159	137	350
Korea	1,699	2,590	1,903
Panama	554	155	225
Philippines	1,872	1,673	1,121
Malaysia	1,077	197	1,050
Turkey	350	532	-
Peru	-	525	210
Greece	570	1,034	1,174
Spain	2,200	3,632	4,349
Algeria	2,068	1,708	303
Tunisia	195	154	12
Total of Sample	44,501	43,230	40,155
Total Market	73,695	70,249	70,386
Sample % of Market	60%	62%	57%
Sample as % Total International Borrowing	40%	40%	37%

Source: Borrowing in International Capital Markets, 1973-80 IBRD.

Over the 1973-80 period, the average seven-year-equivalent spread of the sample varied between 68 and 175 basis points, with a mean of 114 basis points. By sub-groups, the variation was found to be between 40 and 151 basis points, or an average of 83 basis points for industrialized nations, and 78 to 184 basis points, or a mean of 126 basis points for less developed issuers. The paths of seven-year-equivalent spreads, by total sample and sub-groups, are plotted in Chart III. To indicate the market's evaluation of relative attractiveness, the spread for each country, in June of each year is shown in Table IX.

Corroborating the claims of market participants, the floating rate nature of the syndicated loan market permits spreads to lead a life independent of the general level of interest rates. LIBOR tracks the U.S. Treasury Bill rate, reflecting a high degree of substitutability between investment in treasury bills and lending in the interbank market. (See Chart IV.) An increased supply of funds to lenders in the syndicated credit market would simply force down spreads through competitive pressure, without causing LIBOR to fall, if the treasury bill rate remained constant. Conversely, a reduced volume of funds allows lenders to increase their intermediation premium. Changes in generalized risk, rather than shifts in market liquidity, could also be the major causal factor in changes in the general level of spreads. However, if this were the case,

CHART III: SEVEN YEAR EQUIVALENT SPREADS OVER TIME, JUNE 1973 - DECEMBER 1980



Source: Borrowing in International Capital Markets, IBRD.

TABLE IX

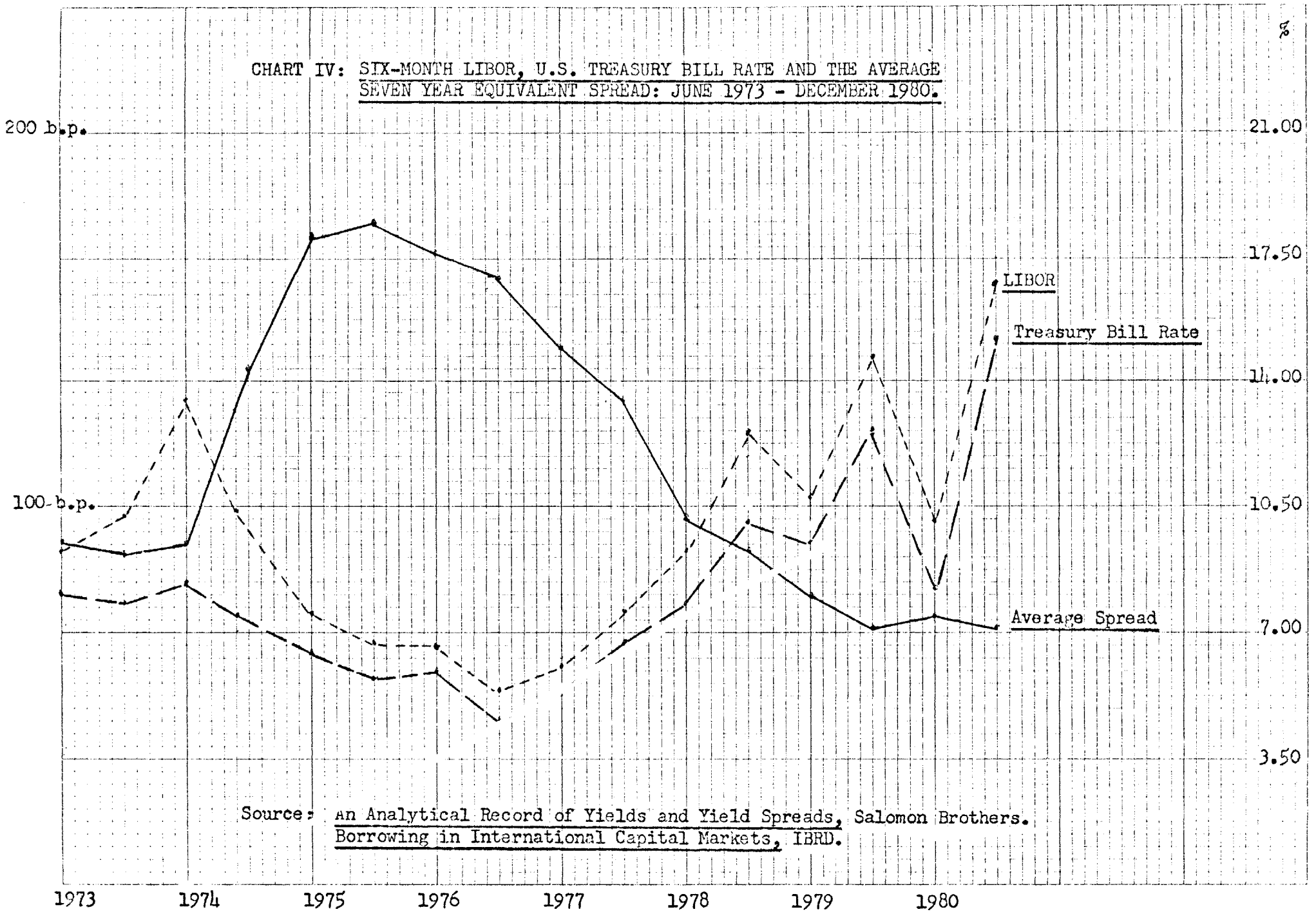
ACTUAL MARKET SPREADS ON SEVEN YEAR
EQUIVALENT BASIS
PREVAILING IN JUNE

	1973	1974	1975	1976
Denmark	.353%	.536%	1.500%	1.446%
Finland	.575	.525	1.500	1.464
France	-	.413	1.375	1.035
Italy	.456	.625	1.750	-
Norway	.625	.875	1.500	1.250
Sweden	-	-	1.375	1.375
U.K.	.375	.450	1.427	1.375
Iran	.500	.750	1.625	1.375
Indonesia	-	1.290	2.000	2.000
Mexico	.406	.625	1.625	1.625
Venezuela	-	1.062	-	1.125
Argentina	1.208	1.458	2.125	2.125
Brazil	.875	.500	1.875	2.000
Gabon	1.625	1.625	2.050	2.075
Ivory Coast	1.375	1.125	2.000	2.000
Korea	1.018	1.208	2.125	2.000
Panama	1.188	.938	1.875	1.875
Philippines	2.125	1.500	1.750	1.875
Malaysia	-	1.125	1.750	1.429
Turkey	-	-	1.625	1.875
Peru	1.750	1.063	2.000	2.375
Greece	.500	.688	1,875	1.604
Spain	.625	.438	1.625	1.625
Algeria	.813	-	1.375	1.750
Tunisia	-	-	-	-
Average	.911	.896	1.727	1.682

TABLE IX (Cont'd)

	1977	1978	1979	1980	Average
Denmark	1.195%	.750%	.375%	.458%	.827%
Finland	1.098	.646	.463	.500	.846
France	.905	.438	.338	.313	.688
Italy	1.437	.958	.450	.525	.886
Norway	.719	.550	.413	.333	.783
Sweden	.938	.500	.500	.625	.886
U.K.	.973	.500	.375	-	.782
Iran	1.125	.563	-	-	.990
Indonesia	1.750	1.375	.550	.550	1.359
Mexico	1.425	1.125	.750	.500	1.010
Venezuela	.875	.588	1.125	.625	.900
Argentina	1.875	1.536	.688	.646	1.458
Brazil	2.000	1.375	.625	.938	1.274
Gabon	2.010	2.071	1.821	1.458	1.842
Ivory Coast	2.125	1.750	1.500	1.500	1.672
Korea	1.750	.750	.750	.771	1.297
Panama	2.000	1.313	.750	1.208	1.393
Philippines	1.750	.875	.625	.625	1.391
Malaysia	1.125	.563	.438	.271	.957
Turkey	-	1.500	1.750	-	1.688
Peru	-	-	1.500	1.255	1.657
Greece	1.500	.588	.375	.583	.964
Spain	1.420	.625	.475	.583	.927
Algeria	1.625	1.375	1.125	.750	1.259
Tunisia	1.125	.833	.750	.625	.833
Average	1.424	.964	.771	.711	1.136

CHART IV: SIX-MONTH LIBOR, U.S. TREASURY BILL RATE AND THE AVERAGE SEVEN YEAR EQUIVALENT SPREAD: JUNE 1973 - DECEMBER 1980.



Source: An Analytical Record of Yields and Yield Spreads, Salomon Brothers.
Borrowing in International Capital Markets, IBRD.

differentials between borrowers would be expected to rise with the general level of spreads and not remain constant, as has been the fact. The risk associated with weaker issuers, in particular LDC's, should rise more than that of stronger industrialized credits during periods of increased generalized difficulties. (Again, see Chart III.)

III. DOES MARKET ACCURACY CHANGE AS THE TIME HORIZON INCREASES?

As might be anticipated, market accuracy declines as the time horizon becomes more distant-- a reflection of the incidence of the unforseen events of political upheaval, acts of nature and economic fluctuation. Uncertainties multiply with time; it becomes harder to predict since there is more to predict.

The change in accuracy of the market's forecasts, as the time horizon increased, was measured by regressions of actual market spreads on forecasts made one, two, three, four and five years in advance; each observation is a country for which spreads were available for two years.

$$S^{7}_{t} = a + b \times F^{7}_{t-1\ t}$$

S^7_t is the spot seven-year-equivalent spread at time t.

$F^7_{t-i\ t}$ is the expectation of the spot seven-year-equivalent spread to prevail at time t taken at an i period time horizon.

As the time periods of forecasting grew, the explanatory power, statistical significance and value of the coefficients deteriorated rapidly. Only one and two year forecasts proved to be statistically significant, with slope coefficients of .69 and .22 and t statistics of 14.72 and 2.93, accompanied by explanatory powers of 44% and 4% as measured by the R-squared statistics. Forecasts for all remaining time horizons were statistically insignificant, and even of the wrong sign for the three and four year time spans. (See Table X.)

Inefficiency seems to be revealed by the finding that <u>all coefficients of market forecasts are statistically different and less than one</u>. Even for the best performer of the group, one year forecasts, the coefficient of .69 is approximately six standard deviations away from its efficiency value. This implies:

$$S^7_{t+1} = .69S^7_t + \text{constant}$$

and

$$\Delta S^7 = .31S^7$$

TABLE X

REGRESSIONS OF ACTUAL SPREADS ON MARKET EXPECTATIONS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Regression Coefficient	.690	.218	-.102	-.111	.098
t statistic	14.72	2.93	-1.25	-1.41	1.29
R-squared	.44	.04	.01	.01	.02
Constant Term	.334	.880	1.215	1.083	.639
t Statistic	5.40	8.55	10.02	9.28	6.23
Standard Error of Regression	.421	.578	.568	.510	.410
Mean of Dependent Variable	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

* The number of observations is derived by taking the spreads for the twenty-five countries in Table IX prevailing in June and December of each year. Of a maximum of twenty-five observations per date, an average of nineteen were available.

It follows that the change in market spreads is negatively related to their levels, or that spreads tend to return to previous values. Efficiency is not absolutely refuted unless there is a certainty that market expectations have been exactly captured; a downward bias in the estimated coefficient may have been introduced from possible errors in variables problems.

When actual and predicted values were compared, precision of forecasts again fell as the time horizon rose. The paths of root-mean-squared error, mean absolute error, and the absolute value of the mean error, all confirmed the trend. The mean absolute error began at 35 basis points for one year forecasts, rose to 60 basis points for two year forecasts, 77 basis points for three year forecasts, and 81 basis points for four year forecasts, then dropped to 66 basis points for five year forecasts. (See Table XI.) It should be noted that the errors are large in relation to the returns. The mean absolute error averaged 63% of the mean spread across time horizons.

IV. GENERAL VERSUS RELATIVE ERROR AS THE TIME HORIZON INCREASES.

Forecasts in the syndicated loan market have two components--prediction of the general level of spreads and the foreseeing of the relative desirability of individual borrowers.

TABLE XI

COMPARISON OF ACTUAL AND MARKET-PREDICTED SPREADS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Root-Mean-Squared Error	.454%	.711%	.854%	.903%	.792%
Mean Absolute Error	.346%	.604%	.770%	.806%	.658%
Absolute Value of Mean Error	.040%	.129%	.324%	.454%	.481%
Correlation Coefficient	.665	.189	-.090	-.116	.128
Mean Actual Spread	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

Date dummy variables were used to eliminate the error introduced by the market's inability to forecast the general level of spreads. The market's expectational errors:

$$\text{Actual} - \text{Forecast} = \text{Error of Market}$$

were regressed on the date dummy variables.

$$\text{Error of Market}_i = a \times \text{Date Dummy Variable}_i$$

where i denotes a date from June 1974 to December 1980. Values and dates of coefficients are shown in Table XII. Fluctuation in the general level of spreads was found to be the preponderant contributor to the total variation in spreads -- on average, 75% of such variation in the expectational error could be explained by such generalized shifts. (See Table XII.)

Forecasts of spreads which incorporated perfect foresight as to fluctuations in the general level of spreads were next created by taking the forecasts of the market and adjusting them for the general error:

General Level Perfect Foresight Forecast (GLPF) = Forecast of Market + estimated coefficient x date dummy variable

TABLE XII

SEPARATION OF GENERAL AND RELATIVE MARKET ERROR: REGRESSIONS OF MARKET EXPECTATIONAL ERROR ON DATE-DUMMY VARIABLES

	TIME HORIZON (YEARS)				
Dummy Variable	1	2	3	4	5
June 1974	-.043	-	-	-	-
t statistic	(-.66)	-	-	-	-
December 1974	.609	-	-	-	-
t statistic	(6.21)	-	-	-	-
June 1975	.918	.834	-	-	-
t statistic	(10.25)	(10.63)	-	-	-
December 1975	.428	.096	-	-	-
t statistic	(4.52)	(.89)	-	-	-
June 1976	.022	-.071	.803	-	-
t statistic	(.25)	(-.66)	(8.87)	-	-
December 1976	-.052	-.559	.013	-	-
t statistic	(-.59)	(-4.89)	(.10)	-	-
June 1977	-.162	-1.104	-.212	.647	-
t statistic	(-1.83)	(-10.33)	(-1.70)	(7.02)	-
December 1977	-.238	-1.258	-.913	-.048	-
t statistic	(-2.62)	(-11.49)	(-6.77)	(-.37)	-
June 1978	-.446	-1.520	-1.538	-.579	.217
t statistic	(-5.13)	(-14.37)	(-12.75)	(-4.56)	(2.58)
December 1978	-.419	-1.526	-1.617	-1.271	-.124
t statistic	(-4.62)	(-14.18)	(-13.12)	(-9.26)	(-1.07)
June 1979	-.148	-1.592	-1.721	-1.642	-.416
t statistic	(-1.70)	(-15.05)	(-14.27)	(-13.38)	(-3.60)
December 1979	-.259	-1.588	-1.767	-1.718	-1.098
t statistic	(-2.89)	(-14.69)	(-14.50)	(-13.86)	(-9.08)
June 1980	- .006	-1.137	-1.600	-1.639	- 1.271
t statistic	(- .07)	(-10.64)	(-13.13)	(-13.07)	(-10.99)
December 1980	.142	-1.001	-1.478	-1.597	-1.300
t statistic	(1.51)	(- 8.76)	(-11.54)	(-12.25)	(-11.09)
R-squared	.67	.78	.79	.78	.73
Standard Error of Regression	.275	.333	.373	.380	.337
Mean of Dependent Variable	-.045%	-.129%	-.324%	-.454%	-.480%
Number of Observations	276	235	192	147	102

For example, the market's expectation as of June 1973 of the seven-year-equivalent spread for Finland anticipated to prevail in June 1974 was .575%. The date dummy variable for June 1974 for one year forecasts, and therefore the general error in market one year forecasts from June 1973 to June 1974, was -.043%. The one year June 1973 GLPF forecast for Finland was thereby .532%, compared to the actual value of .525%.

Actual market spreads were then regressed on these GLPF forecasts which are adjusted for errors in the forecast of the general level of spreads. These were compared to the regressions using the market's unadjusted expectations earlier performed.

$$S^{7}_{t} = a + b \times \left(F^{7}_{t-1\,t} + GE_{1t} \right)$$

GE_{1t} is the general error in market forecasts of spreads to prevail at time t over an 1 period time horizon.

The dramatic improvement in forecasting ability achieved by removing the general component of the market's expectational error is demonstrated in a comparison of Tables X and XIII. All regression coefficients and their statistical significance climbed substantially, while those of the constant term fell drastically. The average regression coefficient rose from .159 to .809 while the average statistical significance of the forecast jumped from a t statistic of

TABLE XIII

FORECASTS INCORPORATING PERFECT FORESIGHT OF GENERAL MARKET LEVELS

REGRESSIONS OF ACTUAL SPREADS ON GENERAL LEVEL PERFECT FORESIGHT FORECASTS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Regression Coefficient	.871	.842	.816	.780	.738
t Statistic	32.26	24.42	17.62	12.43	8.45
R-squared	.79	.72	.62	.52	.42
Constant Term	.149	.183	.197	.204	.200
t Statistic	4.26	4.07	3.54	3.12	2.72
Standard Error of Regression	.257	.312	.351	.357	.316
Mean of Dependent Variable	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

3.26 to 19.04. Similarly, the explanatory power of the equation rose from an average of 10% to 61%. The excess volatility revealed by the previous section's findings of regression coefficients of market forecasts statistically different and less than one was reaffirmed. Even when compensation was made for fluctuations in the general level of spreads, the coefficients remained at least two standard deviations below their efficiency values.

Lastly, a comparison of actual and General Level Perfect Foresight Forecasts was made. As before, the accuracy of market forecasting fell with increases in the time horizon, though not as significantly as when compensation for movements in the general level of spreads is not made. The mean absolute error rose from 20 basis points for one year forecasts, to 26 basis points for two year forecasts, to 29 basis points for three year forecasts, before leveling off and dropping to 28 and 25 basis points for four and five year time horizons. (See Table XIV.) A comparison of this table with Table XI again demonstrates that compensation for general fluctuations greatly reduces the market's error, for the average value of the Mean Absolute Error fell 60%-- from 64 to 26 basis points.

It can therefore be concluded that <u>the greatest source of market error is found to lie in its inability to predict changes in the general level</u> rather than the relative terms an individual borrower may merit.

TABLE XIV

COMPARISON OF ACTUAL SPREADS AND GENERAL LEVEL PERFECT FORESIGHT FORECASTS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Root-Mean-Squared Error	.267%	.324%	.364%	.370%	.327%
Mean Absolute Error	.202%	.261%	.290%	.284%	.254%
Absolute Value of Mean Error	.000%	.000%	.000%	.000%	.000%
Correlation Coefficient	.890	.848	.788	.718	.645
Mean Actual Spread	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

V. HAS MARKET ACCURACY IMPROVED OVER TIME?

Big players in the Eurocredit market like to affirm that skills in setting spreads have grown, along with capabilities for stockpiling information and analyzing sovereign credits. In the light of the persistence of the constant maturity premium throughout the market's history, this improvement must be seen as limited to relative spread determination. To verify the claim of progress in prognostication, the sample period was segmented and market forecasts generated in the 1973-75 and 1976-79 intervals were compared. However, a finding that market forecasts have improved need not reflect efficiency gains; predictions may be better simply because there has been less to predict.

Following the methodology of the previous section, accuracy was first gauged by regressions of actual spreads on one, two and three year forecasts, and an analysis of coefficient value, statistical significance, explanatory power, and standard error of the regression.

$$S_t^7 = a + b \times F_{t-i\ t}^7$$

For all three time horizons, predictions showed substantial improvement from the 1973-75 to the 1976-79 period. The longer the forecast, the greater was the amelioration. Although coefficient values for the regressions rose over time, pointing to increased efficiency, they always measured less than one, at a statistically significant level, an indication of excess volatility.

for one year forecasts: the coefficient rose from .45 to .73 while its statistical significance, as measured by its t statistic, climbed from 6.86 to 18.24 and the explanatory power, as measured by the R-squared statistic, rose from 30% to 67%. Furthermore, the standard error of the regression fell by 25% (from 37 basis points to 28 basis points) while the value and statistical significance of the constant term declined dramatically from .963 (t statistic 10.44) to .068 (t statistic 1.35).

for two year forecasts: the coefficient rose from .04 to .52 with a change in t statistic from .54 to 8.88 and R-squared statistic from 0% to 40%. The standard error of the regression fell by 20% (from 39 to 31 basis points) and the constant term and its statistical significance plummeted from 1.559 (t statistic 16.36) to .056 (t statistic .68).

for three year forecasts: the coefficient rose from -.19 to .60 the t statistic from -1.98 to 7.25 and the R-squared statistic from 3% to 40%, while the standard error of the regression fell 39% (from 52 to 32 basis points) and the constant term and its statistical significance fell from 1.577 (t statistic 12.13) to -.219 (t statistic -1.65).

(See Table XV.)

TABLE XV

MARKET ACCURACY OVER TIME:
COMPARISON OF 1973-75 AND 1976-79
PERIODS

REGRESSIONS OF ACTUAL SPREADS ON MARKET EXPECTATIONS

	TIME HORIZON (YEARS)			
	1		2	
	1973-75	1976-79	1973-75	1976-79
Regression Coefficient	.452	.732	.038	.520
t Statistic	6.86	18.24	.54	8.88
R-squared	.30	.67	.00	.40
Constant Term	.963	.068	1.559	.056
t Statistic	10.44	1.35	16.36	.68
Standard Error of Regression	.370	.278	.392	.314
Mean of Dependent Variable	1.548%	.903%	1.606%	.742%
Number of Observations	111	165	114	121

	3	
	1973-75	1976-79
Regression Coefficient	-.186	.596
t Statistic	-1.98	7.25
R-squared	.03	.40
Constant Term	1.577	-.219
t Statistic	12.13	-1.65
Standard Error of Regression	.516	.315
Mean of Dependent Variable	1.338%	.707%
Number of Observations	111	81

To differentiate the same data, from another vantage point, a statistical comparison of actual and forecast values was undertaken for the pair of sub-periods. Accuracy, as measured by the root-mean-squared error and mean absolute error of the forecasts, rose for both one and two year time horizons from the 1973-75 to the 1976-79 periods; for the three year time horizon, however, skill at forecasting fell slightly. (See Table XVI).

VI. GENERAL VERSUS RELATIVE ERROR OVER TIME.

Whether the market's sophistication is indeed largely concentrated in the ability to distinguish the future relative desirability of borrowers can be examined by once more isolating the general error component and contrasting the sub-periods 1973-75 and 1976-79.

When the market's expectational errors were regressed upon date dummy variables, the values of the coefficients and their statistical significance for the sub-periods were identical to those in Table XII which analysed the entire 1974-80 span. GLPF forecasts were next generated and their accuracy between sub-periods compared via regression analysis.

$$S_t = a + b \times (F_{t-1,t} + GE_{1t})$$

TABLE XVI

MARKET ACCURACY OVER TIME
COMPARISON OF 1973-75 AND 1976-79 PERIODS

COMPARISON OF ACTUAL AND MARKET PREDICTED SPREADS

TIME HORIZON
(YEARS)

	1		2	
	1973-75	1976-79	1973-75	1976-79
Root-Mean-Squared Error	.533%	.398%	.726%	.696%
Mean Absolute Error	.398%	.311%	.616%	.592%
Absolute Value of Mean Error	.255%	.238%	.347%	.576%
Correlation Coefficient	.549	.819	.051	.632
Mean Actual Spread	1.548%	.903%	1.606%	.742%
Number of Observations	111	165	114	121

	3	
	1973-75	1976-79
Root-Mean-Squared Error	.803%	.919%
Mean Absolute Error	.714%	.847%
Absolute Value of Mean Error	.058%	.847%
Correlation Coefficient	-.186	.632
Mean Actual Spread	1.338%	.707%
Number of Observations	111	81

Evidence in favor of improved precision in predicting over time was mixed. While accuracy (as measured by the value of the coefficient, its statistical significance, the explanatory power of the equation, the value and statistical significance of the constant, and the standard error of the regression rose for one and two year time horizons, three year forecasts showed a market deterioration from the earlier to the later period. (See Table XVII.)

Finally, a statistical comparison of actual spreads and GLPF forecasts was made. For all time horizons, an improvement between the 1973-75 and 1976-79 periods supported, in part, the market's claim of growing forecasting skills. (See Table XVIII.)

VII. IS THE MARKET OPERATING AT OPTIMUM?

The thrust of this investigation centers on whether forecasts superior to those of the market can be created by the addition of information which was widely available at the time expectations were formed. Because it was observed that there existed relatively consistent differentials between spreads of sovereign borrowers at any moment in time and a substantial variation in the spreads of all individual nations across time, it has been hypothesized and then confirmed that a general influence might be the major causal factor in

TABLE XVII

MARKET ACCURACY OVER TIME:
COMPARISON OF 1973-75 AND 1976-79
PERIODS

REGRESSIONS OF ACTUAL SPREADS ON GENERAL LEVEL
PERFECT FORESIGHT FORECASTS

TIME HORIZON
(YEARS)

	1		2	
	1973-75	1976-79	1973-75	1976-79
Regression Coefficient	.750	.857	.637	.679
t Statistic	13.99	21.90	8.87	10.50
R-squared	.64	.75	.41	.48
Constant Term	.387	.129	.583	.238
t Statistic	4.47	3.22	4.91	4.33
Standard Error of Regression	.265	.244	.301	.292
Mean of Dependent Variable	1.548%	.903%	1.606%	.742%
Number of Observations	111	165	114	121

	3	
	1973-75	1976-79
Regression Coefficient	.772	.643
t Statistic	10.62	7.53
R-squared	.51	.42
Constant Term	.306	.253
t Statistic	2.96	3.63
Standard Error of Regression	.368	.310
Mean of Dependent Variable	1.338%	.707%
Number of Observations	111	81

TABLE XVIII

MARKET ACCURACY OVER TIME:
COMPARISON OF 1973-75 AND 1976-79
PERIODS

COMPARISON OF ACTUAL SPREADS AND GENERAL LEVEL
PERFECT FORESIGHT FORECASTS

TIME HORIZON
(YEARS)

	1		2	
	1973-75	1976-79	1973-75	1976-79
Root-Mean-Squared Error	.287%	.252%	.330%	.318%
Mean Absolute Error	.222%	.188%	.266%	.255%
Absolute Value of Mean Error	.000%	.000%	.000%	.000%
Correlation Coefficient	.802	.864	.642	.693
Mean Actual Spread	1.548%	.903%	1.606%	.742%
Number of Observations	111	165	114	121

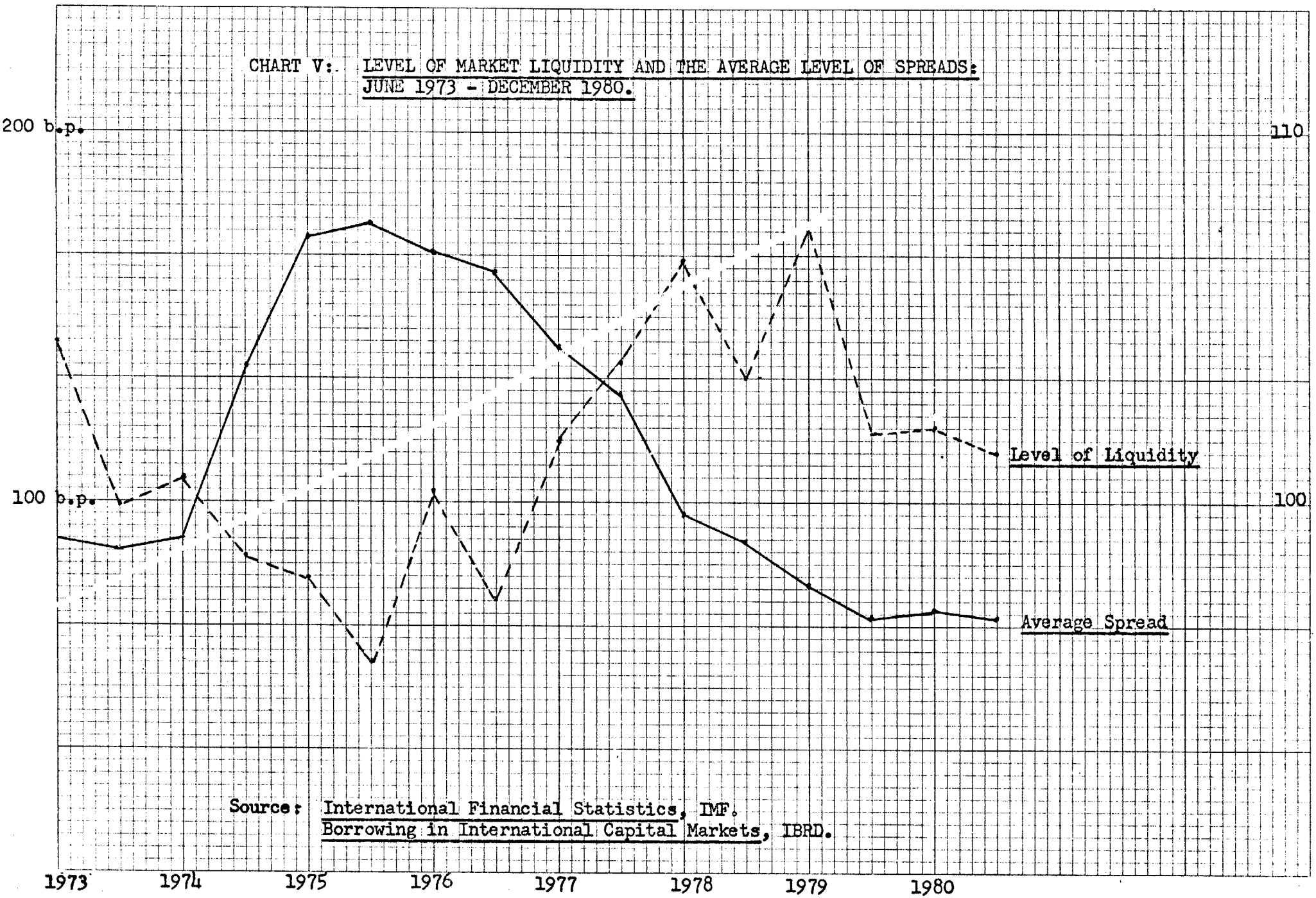
	3	
	1973-75	1976-79
Root-Mean-Squared Error	.381%	.339%
Mean Absolute Error	.301%	.274%
Absolute Value of Mean Error	.000%	.000%
Correlation Coefficient	.713	.647
Mean Actual Spread	1.338%	.707%
Number of Observations	111	81

the divergence between fact and forecast. The level of market liquidity, a direct measure of competitive pressure on lenders, was postulated as a candidate for the moving force.

The level of the real world money supply seemed to capture this important influence and was derived by taking the level of world nominal money, weighted by shares in the world GNP, and deflating by the level of the world consumer price index, again weighted by shares in world GNP, both using 1972 as the base year. The path of this variable can be seen to relate negatively to the path of the average level of spreads, with a moderate lead. (See Chart V.) Common industry belief which equates the real global money supply with a proxy for the liquidity factor was recently illustrated in a 1980 Euromoney paper by Dr. Monroe J. Haegele of the First Pennsylvania Corporation which singles out the change in the real world money supply as the determinant of changes in the general level of spreads.

When a regression of the average seven-year-equivalent spread of the sample population was performed on this measure of the level of market liquidity, lagged six months to permit transmission of effects, the estimated coefficient was negative, as hypothesized, and statistically significant at the 1% level. As suggested earlier, a rise in market liquidity exerts a downward force on spreads. In this exploration of the syndicated loan market, 58% of the variation in the average level of spreads over the 1973-80 period could be explained by the real money supply measure.

CHART V:. LEVEL OF MARKET LIQUIDITY AND THE AVERAGE LEVEL OF SPREADS: JUNE 1973 - DECEMBER 1980.



Source: International Financial Statistics, IMF.
Borrowing in International Capital Markets, IBRD.

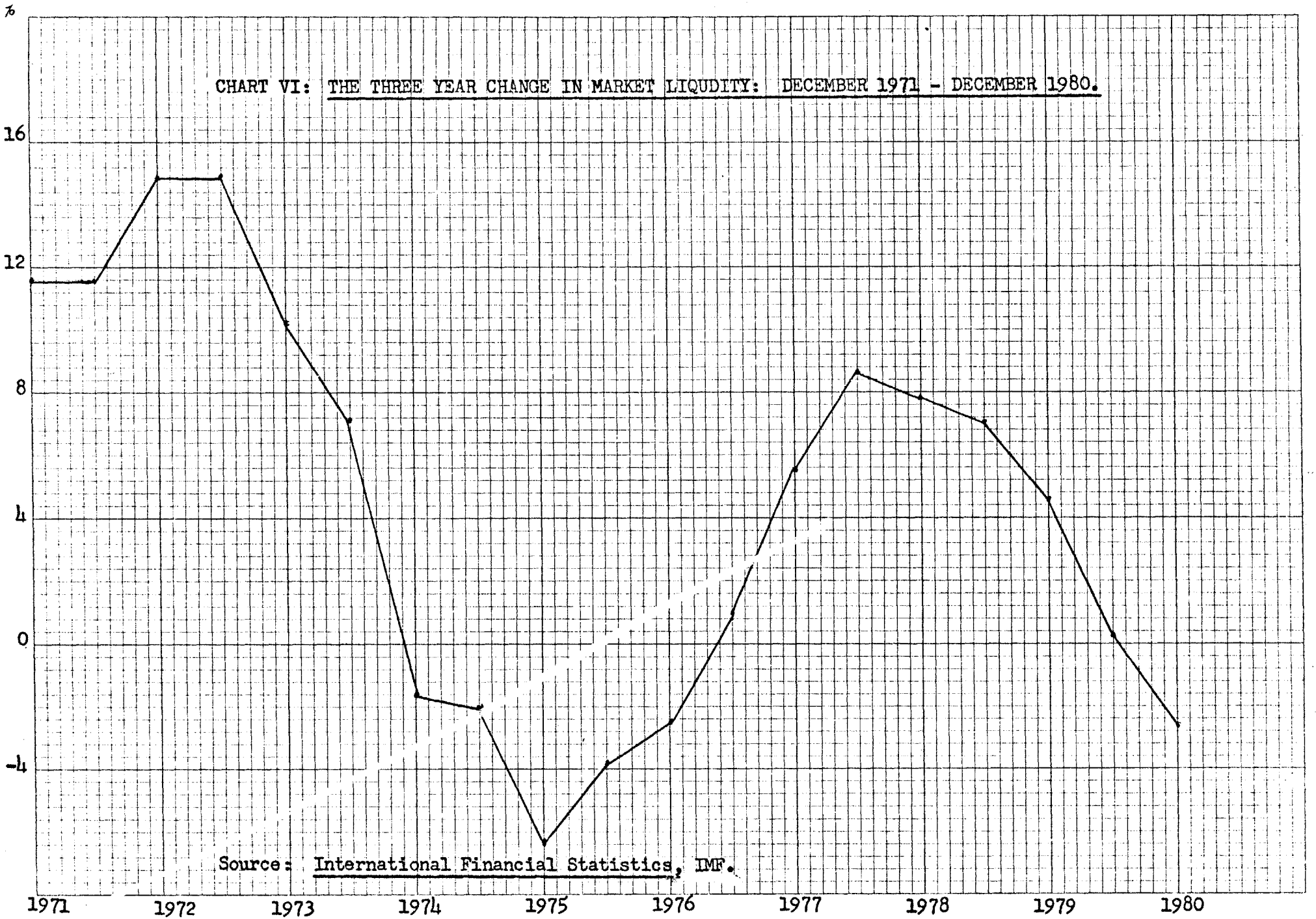
Average Spread = 10.74 - .097 x Level of Real World Money Supply

(4.93)* (-4.40)*

R-squared = .58
Standard Error of Regression = .270
Mean of Dependent Variable = 1.142%
Number of Observations = 16

* t statistics in parentheses

Just as the level of the real world money supply is related to the level of spreads, so will changes in the level of the real world money supply be shown to be related to changes in the level of spreads and, thereby, to the divergence between market forecasts and actual spreads. A three year change in this determinant seemed preferable to the annual growth rate from two vantage points. First, portfolio adjustment is not assumed to be instantaneous and the liquidity of the market may be assumed to exert a cumulative pressure on lenders. Second, the independent variable must denote a force which can exert its effects far into the future, providing information content as the time horizon is extended beyond one or two years. This three-year change in the real world money supply (change in market liquidity) did not exhibit any serial correlation and fluctuated substantially over the sample period. (See Chart VI.)


%
CHART VI: THE THREE YEAR CHANGE IN MARKET LIQUDITY: DECEMBER 1971 - DECEMBER 1980.
16
12
8
4
0
-4
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
Source: International Financial Statistics, IMF.

To demonstrate that the difference between the actual market spread and the expectation generated at a previous date is due to changes in market liquidity, regressions of the average expectational errors of the market, for different time horizons, on the change in market liquidity between the date of the forecast and the date of the actual market spread were run:

$$\text{Average (Actual - Expected Spread)} = a + b \times \text{Current Changes in Market Liquidity}$$

In all cases, the coefficient on the change in market liquidity was negative and statistically significant at the 1% level. As hypothesized, a rise in market liquidity <u>after</u> the date of the forecast will induce a negative expectational error. (See Table XIX.)

There remains the question of whether changes in market liquidity, <u>whose values were available as of the date of expectation formation</u>, would have been useful in the generation of improved forecasts. Average expectational errors were regressed on the most recently available change in market liquidity, as of the date the expectation was formed.

$$\text{Average (Actual - Expected Spread)}_{it} = a + b \times \text{Change in Market Liquidity from } t-i-3 \text{ to } t-i$$

TABLE XIX

AVERAGE EXPECTATIONAL ERRORS AND CURRRENT CHANGES IN MARKET LIQUIDITY

TIME HORIZON
(YEARS)

	1	2	3	4	5
Regression Coefficient	-.047	-.108	-.127	-.133	-.094
t Statistic	-2.97	-6.02	-7.84	-8.41	-9.57
R-squared	.42	.78	.88	.92	.96
Constant Term	.051	.061	.003	.047	-.206
t Statistic	.63	.67	.03	.52	-3.72
Standard Error of Regression	.288	.303	.256	.201	.118
Mean of Dependent Variable	-.028%	-.100%	-.282%	-.428%	-.471%
Number of Observations	14	12	10	8	6

$(\text{Actual} - \text{Expected Spread})_{it}$ is the market's expectational error on a spread prevailing at t made over an i period time horizon.

For example, is the average expectational error of two year forecasts, made in June 1975 for a spread expected to prevail in June 1977, correlated with the three year percentage change in the <u>real</u> world money supply from December 1971 to December 1974.

It was found that the independent variable provided a large information content for all time horizons. This content rose substantially for two, three, four and five year forecasts, in contrast to the shortest time period, suggesting that the effects of changes in liquidity do not reach the market before a two or three year lag. Taking lagged values of the independent variable for one and two year forecasts, which provided an overall waiting period of between 2.5 and 3.0 years, confirmed this suppositon. For example, when examining the market's three year forecasts as of June 1975 for June 1978, the most recently available three year change in the real world money supply (from December 1971 to December 1974) is used as the value of the independent variable. In contrast, for one year forecasts, made as of June 1975, it is a lagged change in the real world money supply (from December 1970 to December 1973) that is taken as the value of the independent variable. The statistical significance of the coefficients and the explanatory power of the

equations rose substantially when an eighteen month lag was introduced in the case of one year forecasts and a one year lag in the case of two year forecasts. (See Table XX.)

The positive sign of the coefficient on expectation-dated values of the independent variable is as would be hypothesized. (It has previously been shown that the expectational error of the market is negatively related to the change in market liquidity over the period between the date of the expectation and the date of the actual market spread.) If the nominal money supply has been rising faster than prices over a given period, it is to be anticipated that the rise in prices in the future will surpass that of nominal money. Thus growth (decline) in the real world money supply would presage a subsequent contraction (expansion) of market liquidity and a rise (fall) in spreads.

However, only the properties of the individual expectational errors can provide a true test of market rationality.

$$S_{tj} - F_{t-1\,tj} = E_{t-1\,tj}$$

S_{tj} is the actual spread of country j at time t.

$F_{t-1\,tj}$ is the market expectation as of time t-1 of the spread to prevail at time t for country j.

TABLE XX

AVERAGE EXPECTATIONAL ERRORS AND EXPECTATION-DATED CHANGES IN MARKET LIQUIDITY

TIME HORIZON
(YEARS)

	1		2		3	4	5
Regression Coefficient	.034	.042*	.078	.077**	.088	.074	.066
t Statistic	2.89	5.66	7.49	9.24	16.31	9.29	9.06
R-squared	.41	.73	.85	.90	.97	.94	.95
Constant Term	-.176	-.238	-.400	-.419	-.566	-.740	-.952
t Statistic	-1.89	-3.69	-4.79	-5.98	-12.77	-10.16	-12.96
Standard Error of Regression	.291	.198	.254	.211	.129	.183	.124
Mean of Dependent Variable	-.028%		-.100%		-.282%	-.428%	-.471%
Number of Observations	14		12		10	8	6

* Eighteen month lag in value of independent variable.

** One year lag in value of independent variable.

This is equivalent to constraining the value of the regression coefficient of actual spread on forecasted spread to unity. Efficiency would require that the error term fluctuate randomly and be uncorrelated with any information available at the time the forecast was generated. The relationship of this expectational error to the three year change in the real world money supply, available as of a date before the expectation was formed, was next documented.

Regression Models for the Entire 1974-80 Period.

For the entire sample period, 1974-80, regressions of the market's expectational error on the measure of the change in market liquidity, which took on the same value for all observations at a given date, were run for one, two, three, four and five year time horizons, using the lag structure previously detailed.

Expectational Error = a + b x Change in Market Liquidity
(previously known)

The proportion of the total variation in the expectational error explained by variation in the change in the liquidity level averaged 66%, as measured by the R-squared statistic. The coefficient was at all times positive and highly statistically significant with a t statistic which averaged 19.33.

As the time horizon is extended from one to five years, the mean of the dependent variable (the market's expectational error) rises in absolute value from four basis points to forty-eight basis points. The influence of the change in market liquidity on the expectational error of the market was virtually identical for two, three, four and five year forecasts, with the range of the variation contained within a .073 and .091 interval or less than two standard deviations. The explanatory power of the equation for one year expectational errors was, as expected, less than for longer time horizons, a corollary to previous findings where only one year market forecasts proved to be statistically significant and with a substantial value of the estimated coefficient in regressions of actual on forecasted spreads. (See Table XXI.)

A dominant proportion of the ex post total variation in spreads and virtually all of the variation due to changes in their general level is seen to be captured by the change in market liquidity over a period preceding the formation of expectations and known at the time they were formed. A comparison of the Market Liquidity and the General Level Perfect Foresight models, as documented in Tables XXI and XII, shows the extent to which ex ante information provides an explanation for ex post error. The R-squared of the market liquidity expectational error regression models averaged 88% of that of the year dummy expectational error regression models while, on average, the

TABLE XXI

THE EXPECTATIONAL ERROR OF THE MARKET: 1974-80

REGRESSION MODELS

TIME HORIZON
(YEARS)

	1*	2**	3	4	5
Regression Coefficient	.044	.080	.091	.081	.073
t Statistic	15.57	23.79	24.64	18.65	14.00
R-squared	.47	.71	.76	.71	.66
Constant Term	-.237	-.436	-.565	-.751	-1.009
t Statistic	-10.04	-15.63	-19.06	-19.46	-19.19
Standard Error of Regression	.331	.379	.388	.426	.370
Mean of Dependent Variable	-.040%	-.129%	-.324%	-.454%	-.480%
Number of Observations	276	235	192	147	102

* Eighteen month lag in value of independent variable.

** One year lag in value of independent variable.

standard error of the regression was only 12% greater, thereby corroborating this variable's identity with changes in the general level of spreads.

In another comparison of the two models, forecasts were generated using the information provided by the Market Liquidity regression models and contrasted to the GLPF forecasts of Section IV.

$$LMF_{t-1\ tj} = F_{t-1\ tj} + \text{Est. Coeff.} \times \text{Change In Market Liquidity}$$

$LMF_{t-1\ tj}$ is the liquidity model forecast of the spread to prevail at time t for country j taken from an i period time horizon.

Regressions of actual spreads on forecasts were run:

$$S_{tj} = a + b \times LMF_{t-1\ tj}$$

The excellent performance of the liquidity model can be seen in the average value of the estimated coefficient which was 92% of its perfect foresight counterpart, as well as in the statistical significance and explanatory power which measured 81% and 84%

respectively of their corresponding average omniscient values. (See Tables XXII and XIII.) A further statistical comparison revealed that the mean absolute error of the liquidity model forecasts measured only 16% more than that of the GLPF model while the root-mean-squared error exceeeded its corrresponding value by only 14%, on average. (See Tables XXIII and XIV.)

In sum, while an ex post foundation invalidates the GLPF models as forecasting tools, the liquidity models, which are based upon information readily available at the time forecasts are generated, should prove invaluable. From a profitability standpoint, although financial institutions presently devote ever-increasing resources to sovereign credit analysis as a means to establish differentials between spreads at a given moment in time, three-quarters of the error in market predictions results from general market conditions. Of this, a massive 88% is ascertainable with minimal effort and expense.

Generating Projections Beyond the Sample Period.

Since the issue of market efficiency can be decided only by the formulation of a superior forecasting technique, projections beyond the sample period were created via regression models similar to those employed previously, but restricting the sample to the 1974-77, 1974-78, and 1974-79 periods. Forecasts of the expectational error were generated and, with these, improved forecasts of actual market

TABLE XXII

REGRESSIONS OF ACTUAL SPREADS ON LIQUIDITY MODEL FORECASTS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Regression Coefficient	.809	.788	.794	.692	.638
t Statistic	24.98	19.96	16.06	9.58	6.46
R-squared	.69	.63	.58	.39	.29
Constant Term	.221	.247	.222	.287	.275
t Statistic	5.27	4.82	.374	3.83	3.33
Standard Error of Regression	.311	.357	.371	.402	.347
Mean of Dependent Variable	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

TABLE XXIII

COMPARISON OF ACTUAL SPREADS AND LIQUIDITY MODEL FORECASTS: 1974-1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Root-Mean-Squared Error	.329%	.377%	.386%	.423%	.366%
Mean Absolute Error	.253%	.307%	.298%	.348%	.294%
Absolute Value of Mean Error	.000%	.000%	.001%	.001%	.000%
Correlation Coefficient	.833	.794	.759	.623	.543
Mean Actual Spread	1.162%	1.161%	1.072%	.930%	.761%
Number of Observations	276	235	192	147	102

spreads for the 1978-80 period as of 1977, for the 1979-80 period as of 1978, and for 1980 as of 1979.* Only information generally available at the time the market forecast was dated was employed--specifically, the change in market liquidity. Values of the estimated coefficients on the change in liquidity were stable for all time horizons, both within each of the three sub-periods and for the entire 1974-80 term. (See Tables XXIV - XXVI.)

To incorporate the information added by the previously-known change in liquidity, improved 1 period forecasts of actual market spreads were derived as the market forecast plus the 1 period expectational error:

$$FORA_{t-1\ tj} = F_{t-1\ tj} + FERRM_{t-1\ 1}$$

(This process constrains the value of the coefficient of the forecast of the market's expectational error to one.) Actual market spreads were then regressed on these improved forecasts for one and two year time horizons and compared with the performance of the market's expectations.

$$S_{tj} = a + b \times FORA_{t-1\ tj}$$

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* Due to sample limitations, five year expectational error forecasts and improved spread forecasts can be obtained only for the 1980 period, while four year forecasts are available only for the 1979-80 and 1980 periods.

TABLE XXIV

THE EXPECTATIONAL ERROR OF THE MARKET: 1974-77

REGRESSION MODELS FOR THE GENERATION OF FORECASTS OF MARKET ERROR FOR 1978-80

	TIME HORIZON (YEARS)		
	1	2	3
Regression Coefficient	.046	.086	.104
t Statistic	9.99	12.78	6.76
R-squared	.40	.59	.41
Constant Term	-.250	-.477	-.701
t Statistic	-5.25	-6.36	-3.63
Standard Error of Regression	.363	.410	.403
Mean of Dependent Variable	.123%	.347%	.563%
Number of Observations	151	114	69

TABLE XXV

THE EXPECTATIONAL ERROR OF THE MARKET: 1974-78

REGRESSION MODELS FOR THE GENERATION OF FORECASTS OF MARKET ERROR FOR 1979-80

	TIME HORIZON (YEARS)			
	1	2	3	4
Regression Coefficient	.046	.078	.097	.153
t statistic	14.26	19.29	18.46	10.07
R-squared	.52	.71	.76	.61
Constant Term	-.244	-.396	-.607	-1.639
t Statistic	-8.09	-9.91	-11.63	-8.66
Standard Error of Regression	.350	.398	.398	.393
Mean of Dependent Variable	-.008%	.068%	.058%	.205%
Number of Observations	193	156	111	67

TABLE XXVI

THE EXPECTATIONAL ERROR OF THE MARKET: 1974-79

REGRESSION MODELS FOR THE GENERATION OF FORECASTS OF MARKET ERROR FOR 1980

	TIME HORIZON (YEARS)				
	1	2	3	4	5
Regression Coefficient	.044	.081	.091	.097	.123
t Statistic	15.02	22.81	22.82	17.02	8.89
R-squared	.49	.73	.77	.73	.55
Constant Term	-.231	-.430	-.539	-.922	-1.651
t Statistic	-9.15	-13.68	-15.33	-16.55	-9.59
Standard Error of Regression	.341	.395	.401	.429	.364
Mean of Dependent Variable	-.050%	-.107%	-.221%	-.279%	-.174%
Number of Observations	236	198	154	110	67

The model outperformed the market at all times. The value of the regression coefficient was closer to its hypothesized value of unity, while its statistical significance and the explanatory power of the equations were greater. Correspondingly, the standard error of the regression was lower. (See Tables XXVII and XXVIII.)

The errors and, hence, the income streams associated with each forecasting process are revealed by a statistical comparison of actual spreads with forecasts. Again, the model's forecasts substantially outperformed the market, for all time periods and all time horizons.*

The root-mean-squared error of the model's one year forecasts averaged 84% that of the market, while the mean absolute error and absolute value of the mean error measured only 84% and 71% of their market counterparts. For two year time hoirzons, they reached only 60%, 62% and 16% of corresponding values. For three year time

---

* As the period of projection and the time horizon were extended, the independent variable took on values outside those encountered in the sample period of the regression models and forecasts of negative spreads appeared. Because the option always exists of lending very short term (1-6 months) at LIBOR in the interbank market, in real fact any spread below a minimal level would be refused. A zero value, therefore, was substituted in such cases. This occurred only for 3, 4, and 5 year forecasts and the number of such instances fell as the regression period was extended from 1974-77 to 1974-78 to 1974-79.

TABLE XXVII

REGRESSIONS OF ACTUAL SPREADS ON MARKET EXPECTATIONS AND MODEL FORECASTS: 1978-80 PERIOD

	TIME HORIZON (YEARS)			
	1		2	
	Market	Model	Market	Model
Regression Coefficient	.561	.691	.520	.617
t Statistic	11.98	12.96	8.88	8.84
R-squared	.54	.58	.39	.40
Constant Term	.199	.236	.056	.307
t Statistic	3.82	5.13	.68	5.40
Standard Error of Regression	.264	.253	.314	.315
Mean of Dependent Variable	.756%		.742%	
Number of Observations	125		121	

TABLE XXVIII

REGRESSION OF ACTUAL SPREADS ON MARKET EXPECTATIONS AND MODEL FORECASTS: 1979-80 PERIOD

	TIME HORIZON (YEARS)			
	1		2	
	Market	Model	Market	Model
Regression Coefficient	.639	.692	.370	.500
t Statistic	9.87	10.63	5.62	7.02
R-squared	.55	.58	.29	.39
Constant Term	.177	.210	.212	.272
t Statistic	2.99	3.97	2.58	4.52
Standard Error of Regression	.256	.246	.281	.261
Mean of Dependent Variable	.692%		.640%	
Number of Observations	83		79	

horizons, those of the model tallied only 43%, 35% and 14% of their market equivalents. Four year forecasts by the model were conspicuously better than the market's with a root-mean-squared error of 61%, a mean absolute error of 56%, and an absolute value of the mean error of 55% those of the market. For five year forecasts, the relationship was similar: the model's root-mean-squared error amounted to 65% of the market's, the mean absolute error to 60% and the absolute value of the mean error to 60%. (See Tables XXIX - XXXI.)

Because the youth of the market creates data limitations, an entirely pure test of market efficiency must restrict itself to one and two year time horizons where the inefficiency demonstrated, while substantial, is not as dramatic as for longer time spans. The explanation is that although the values of the independent variable, used in the generation of all projections and improved forecasts, are known at the date of expectation formation, the estimated coefficients for three, four and five year time horizons could not have been ascertained at that date. For example, to generate an improved four year forecast for spreads prevailing in December 1980, the appropriate value of the independent variable is the change in market liquidity from June 1973 to June 1976 and is known as of October 1976, before the forecast is made. In contrast, the value of the coefficient to be applied to the independent variable was not ascertainable until June

TABLE XXIX

COMPARISON OF MARKET EXPECTATIONS AND MODEL FORECASTS:
1978-80 PERIOD

TIME HORIZON
(YEARS)

	1			2		
	Market	Model	Model as % of Market	Market	Model	Model as % of Market
Root-Mean-Squared Error	.417%	.283%	68	.700%	.352%	50
Mean Absolute Error	.330%	.218%	66	.592%	.282	48
Absolute Value of Mean Error	.236%	.004%	2	.576%	.037	6
Mean Actual Spread	.756%			.742%		
Number of Observations	125			121		

	3		
	Market	Model	Model as % of Market
Root-Mean-Squared Error	.901%	.403%	45
Mean Absolute Error	.824%	.303%	37
Absolute Value of Mean Error	.822%	149%	18
Mean Actual Spread	.792%		
Number of Observations	123		

TABLE XXX

COMPARISON OF MARKET EXPECTATIONS AND MODEL FORECASTS:
1979-80 PERIOD

TIME HORIZON
(YEARS)

	1			2		
	Market	Model	Model as % of Market	Market	Model	Model as % of Market
Root-Mean-Squared Error	.319%	.274%	86	.660%	.344%	52
Mean Absolute Error	.246%	.207%	84	.539%	.275%	51
Absolute Value of Mean Error	.114%	.005%	4	.517%	.096%	19
Mean Actual Spread	.692%			.640%		
Number of Observations	83			79		

	3			4		
	Market	Model	Model as % of Market	Market	Model	Model as % of Market
Root-Mean-Squared Error	.919%	.373%	41	1.068%	.801%	75
Mean Absolute Error	.847%	.280%	33	1.011%	.697%	69
Absolute Value of Mean Error	.847%	.059%	7	1.005%	.697%	69
Mean Actual Spread	.707%			.721%		
Number of Observations	81			80		

TABLE XXXI

COMPARISON OF MARKET EXPECTATIONS AND MODEL FORECASTS: 1980

TIME HORIZON
(YEARS)

	1			2		
	Market	Model	Model as % of Market	Market	Model	Model as % of Market
Root-Mean-Squared Error	.267%	.263%	98	.358%	.282%	79
Mean Absolute Error	.190%	.193%	102	.278%	.239%	86
Absolute Value of Mean Error	.024%	.050%	208	.245%	.053%	22
Mean Actual Spread	.700%			.657%		
Number of Observations	40			37		

	3			4		
	Market	Model	Model as % of Market	Market	Model	Model as % of Market
Root-Mean-Squared Error	.803%	.336%	42	1.012%	.468%	46
Mean Absolute Error	.742%	.263%	35	.973%	.405%	42
Absolute Value of Mean Error	.742%	.119%	16	.973%	.392%	40
Mean Actual Spread	.670%			.711%		
Number of Observations	38			37		

	5		
	Market	Model	Model as % of Market
Root-Mean-Squared Error	1.108%	.718%	65
Mean Absolute Error	1.068%	.641%	60
Absolute Value of Mean Error	1.068%	.641%	60
Mean Actual Spread	.696%		
Number of Observations	35		

or December 1978. However, the stability of the coefficients, both on the averages and the individual observations between two, three, four and five year time horizons, suggest the validity of short term coefficients for longer term forecasting. (See Tables XX, XXI, and XXIV - XXVI.)

Division of the sample into three sub-periods documents that inefficiency in the syndicated Eurocredit market has persisted through time. Financial institutions and borrowers had the capability to develop forecasting models as early as 1977, from regressions using data from the 1973-77 period, which would have increased market accuracy over the 1978-80 time span. As early as 1978, these would have been proven superior forecasting tools. Yet the market continued to operate suboptimally -- forecasting procedures were neither updated nor improved; publicly available information was not utilized; excess profit-taking persisted. Evidence that the market is ameliorating its performance, over time, is mixed. While the model's error as a percentage of that of the market rises through time for one and two year forecasts, no such trend is discernible for three and four year time horizons. (Again, see Tables XXIX - XXXI.)

Statistical significance, here, translates into economic significance of major proportions. The relative importance of the improvement in prediction in terms of total asset yield was next explored. Since financial intermediaries fund their positions in the

syndicated loan market by borrowing from depositors or in the interbank market, at the bid rate, the spread constitutes the only net return on the asset to the lender. Thus, the contribution of the improved forecasting model can be ascertained by comparing the increase in accuracy offered by the model to the actual mean spread. The economic value of the increased precision generated by the model proved to be sizable. For one year time horizons, the augmented accuracy, as measured by the improvement in mean absolute error as a percentage of mean actual spread, averaged 7% for the three projection periods, while for two, three, four and five year forecasts, the yield was even greater, averaging 30%, 72%, 62% and 61% respectively. From another vantage point, when increased accuracy was viewed as the reduction in the absolute value of the mean error as a percentage of mean actual spread, the model generated improvements averaging 14%, 56%, 96%, 63% and 61% over the three projection periods, again for one, two, three, four and five year forecasts. (See Table XXXII.)

Looking beyond the period under study, projections of the liquidity model covered the 1981-85 span: these show a rise in the average seven-year-equivalent spread from .686% in December 1980 to .822% in June 1981, before a slight decline to .761% in December 1981. Two year forecasts envisage average spreads of .843% in June 1982 and .618% in December 1982, while three year predictions indicate a fall in the average seven-year-equivalent spread to .565% in June 1983 and

TABLE XXXII

THE ECONOMIC IMPORTANCE OF IMPROVED FORECASTING

Projection Period	TIME HORIZON (YEARS) 1	2	3	4	5
1978-80					
Mean Actual Spread	.756%	.742%	.792%	-	-
Improvement in Mean Absolute Error as % Mean Actual Spread	15%	42%	66%	-	-
Improvement in Absolute Value of Mean Error as % of Mean Actual Spread	31%	73%	85%	-	-
Improvement in Root-Mean-Squared Errror as % Mean Actual Spread	18%	47%	63%	-	-
1979-80					
Mean Actual Spread	.692%	.640%	.707%	.721%	-
Improvement in Mean Absolute Error as % Mean Actual Spread	6%	41%	80%	44%	-
Improvement in Absolute Value of Mean Error as % Mean Actual Spread	16%	66%	111%	43%	-
Improvement in Root-Mean-Squared Error as % Mean Actual Spread	7%	49%	77%	37%	-
1980					
Mean Actual Spread	.700%	.657%	.670%	.711%	.696%
Improvement in Mean Absolute Error as % Mean Actual Spread	0%	6%	71%	80%	61%
Improvement in Absolute Value of Mean Error as % Mean Actual Spread	-4%	29%	93%	82%	61%
Improvement in Root-Mean Squared Error as % Mean Actual Spread	1%	12%	70%	77%	56%

a further substantial drop to .150% in December 1983, a minimal level which is seen to continue until December 1985. (The market's 1980 forecasts measured .711% and .686% for June and December spreads, respectively.)

VIII. TOWARD OPTIMAL MATURITY DIFFERENTIALS.

Maturity premia have two components, according to the expectations theory of the term structure. The first comprises the issuer-specific risk associated with longer commitments of funds and corresponds to the Eurocredit market's 1/8% increment in spread per maturity category. Far more important, quantitatively, are expected forward changes in the general level of spreads. Given that movements in this level are predictable, as evidenced by the model's significantly superior performance, the market's constant maturity premium rule must be seen as suboptimal. This is underscored by a comparison of model-predicted maturity differentials with their perfect foresight values, derived from pairs of yield curves at given points in time over the 1973-78 period.

To generate predicted values of seven-year equivalent spreads over the 1974-80 period:

$$FOR^{7}_{t\ t+1} = S^{7}_{t} + a_{1} + b_{1} \times \text{Change in Market Liquidity} \quad (1)$$

$FOR^{7}_{t\ t+i}$ is the model's seven-year-equivalent spread expected at time t to prevail i years into the future.

S^{7}_{t} is the spot seven-year-equivalent spread.

a_i is the constant term from Table XXI appropriate for an i year time horizon.

b_i is the regression coefficient applied to the previously known change in market liquidity from Table XXI for an i year time horizon.

These values were then transformed into one-year-equivalent spreads, using the 1/8% per maturity class rule of the market:

$$FOR^{7}_{t\ t+i} = FOR^{1}_{t\ t+i} + .375 \qquad (2)$$

From these values, the expectations theory of the term structure can be used to generate model-predicted yield curves at given points in time, during the 1973-1978 period:

$$M^{j}_{t} = \frac{S^{1}_{t} + FOR^{1}_{t\ t+1} + FOR^{1}_{t\ t+2} + \ldots + FOR^{1}_{t\ t+j-1} + r_{j}}{j} \qquad (3)$$

M^{j}_{t} is the model-predicted spread for a j period loan starting at time t.

r_j is the j period issuer-specific risk premium.

The model-predicted maturity premia can then be derived:

$$P^{ij}_t = M^j_t - M^i_t \qquad (4)$$

P^{ij}_t is the model's prediction of the correct premium between i and j period loans at time t.

In a similar fashion, perfect foresight spreads can be constructed, using the actual spot one-year-equivalent spreads:

$$Z^i_t = \frac{1}{i}\left(S^1_t + S^1_{t+1} + \ldots + S^1_{t+i-1}\right) + r_i \qquad (5)$$

Z^i_t is the ex post rational i period spread at time t.

From these, the ex post rational maturity differentials are obtained:

$$N^{ij}_t = Z^j_t - Z^i_t \qquad (6)$$

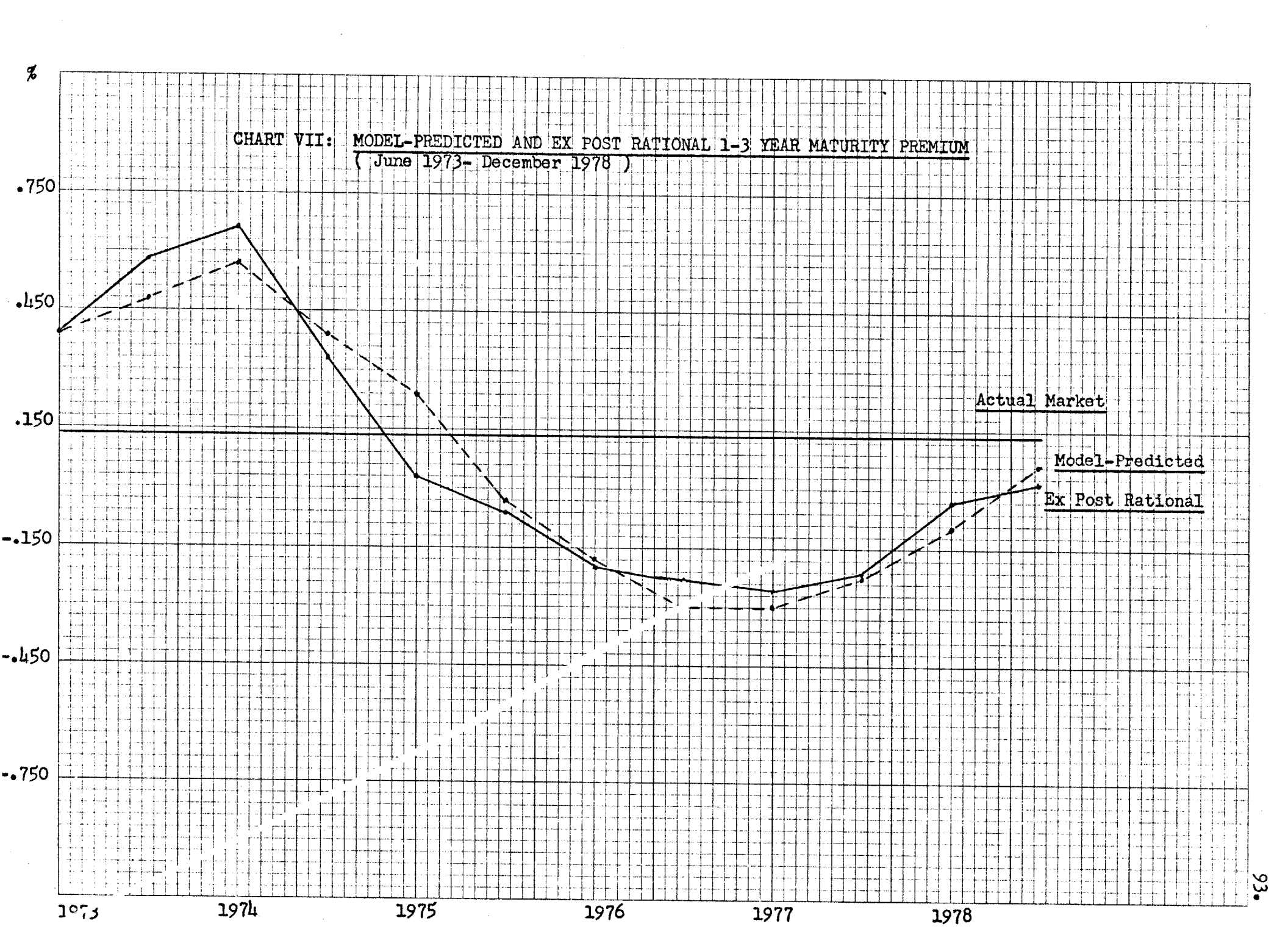
N_t^{ij} is the ex post rational maturity premium between i and j period loans at time t.

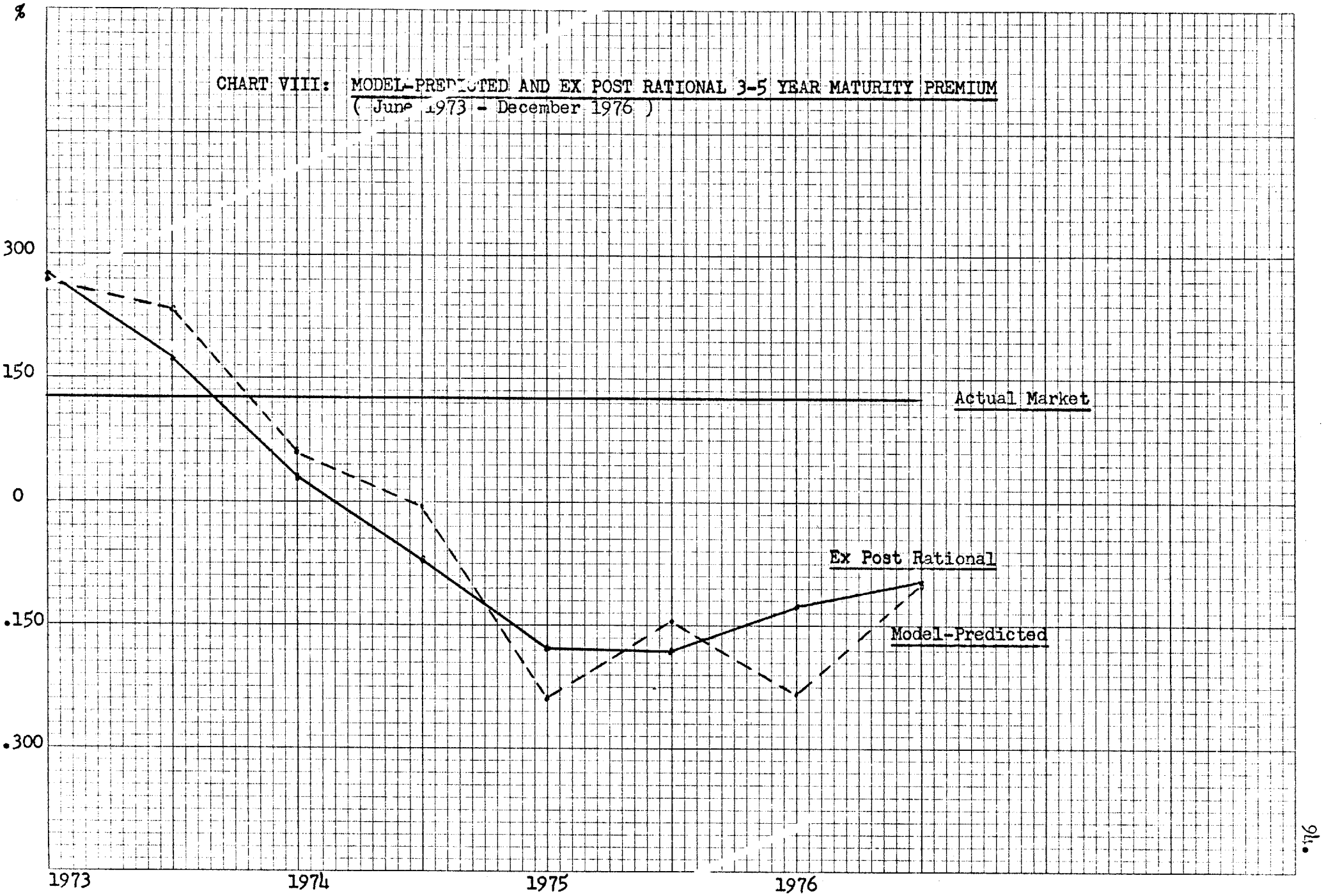
The model's predicted values of appropriate maturity premia can then be compared with the perfect foresight series and both, in turn, contrasted with the market's suboptimal constant value rule. The model-predicted series track the ex post rational paths of the 1-3 and 3-5 year differentials exceptionally well, outperforming the market's constant maturity premium rule at every point in time over the 1973-80 period. (See Charts VII and VIII.) Access to the information which forms the basis for the model was open as early as 1977, yet the latest audited year, that of 1980, revealed no evidence of policy change.

IX. MONOPOLY POWER OR MARKET IGNORANCE?

The acid test of market inefficiency and the validity of superior forecasting tools is a profitable income stream. In the Eurocredit market, this stream would not have accrued to the big banks who are currently the major lenders and profit-takers, but to borrowers and to new market entrants attracted by the opportunities afforded by present inefficiencies.

The totality of findings confirms that lending institutions have been consistently earning excess profits, possibly as a result of the monopoly power they exert as the sole source of funds on such a regular and massive scale. For all time horizons, during the projection period, the market has consistently overestimated spreads.


%
CHART VII: MODEL-PREDICTED AND EX POST RATIONAL 1-3 YEAR MATURITY PREMIUM
(June 1973- December 1978)
.750
.450
.150
-.150
-.450
-.750
Actual Market
Model-Predicted
Ex Post Rational
1973
1974
1975
1976
1977
1978


%
CHART VIII: MODEL-PREDICTED AND EX POST RATIONAL 3-5 YEAR MATURITY PREMIUM
(June 1973 - December 1976)
300
150
0
.150
.300
Actual Market
Ex Post Rational
Model-Predicted
1973
1974
1975
1976
.176

Its mean expectational errors are uniformly positive and greater than those derived from the forecasting model.* An important divergence from perfect competition and rationality is seen to exist when the excess profits derived by lenders are calculated and measured as a percentage of the mean actual spread (net return) during the projection period.

$$\text{Excess Profits} = \frac{\text{Mean (Market Forecast - Actual Spread)}}{\text{Mean (Improved Forecast - Actual Spread)}}$$

For one year horizons, the excess return averaged 12%, while for two, three, four and five year forecasts, the yield was massive, averaging 59%, 115%, 214% and 246% respectively. As the projection period moves ahead from 1978-80 to 1980, the excess return falls consistently for one and two year time horizons. For three and four year horizons, this trend is visible only in the shift between the 1979-80 and 1980 sub-spans. This pattern would suggest that 1978 marks the beginnings of a decline in excess returns. (See Table XXXIII.) Decline in "Excess" is seen as an appropriate label, rather than that of a fall to subnormal profitability, for new institutions entered the market, even as the reduction in yields continued.

---

* A single exception is found in the most recent 1980 period, for one year forecasts alone.

TABLE XXXIII

EXCESS PROFITS TO LENDERS

TIME HORIZON
(YEARS)

	1		2		3		4		5	
	Market	Model	Market	Model	Market	Model	Market	Model	Market	Model
Projection Period										
1978-80										
Mean Error	.236%	-.004%	.576%	-.038%	.822%	-.149%	-	-	-	-
Mean Actual Spread	.756%		.742%		.792%		-		-	
Absolute Excess Profits	.240%		.614%		.971%		-		-	
Relative to Total Return	32%		83%		123%		-		-	
1979-80										
Mean Error	.114%	.005%	.517%	.096%	.847%	-.059%	1.005%	-.697%	-	-
Mean Actual Spread	.692%		.640%		.707%		.721%		-	
Absolute Excess Profits	.109%		.421%		.906%		1.702%		-	
Relative to Total Return	16%		66%		128%		236%		-	
1980										
Mean Error	-.024%	.052%	.245%	.053%	.742%	.119%	.973%	-.392%	1.068%	-.641%
Mean Actual Spread	.700%		.657%		.670%		.711%		.696%	
Absolute Excess Profits	-.076%		.192%		.623%		1.365%		1.709%	
Relative to Total Return	-11%		29%		93%		192%		246%	

It is not farfetched to conjecture that if the monopoly power of lenders is the cause of the deviation from efficiency, it is closely related to the current proscription against trading in syndicated loan participations. The ostensible rationale, most often proffered by banks, is that, since spreads vary over time, borrowers fear that loans carrying a high spread (issued during a previous period of tighter market conditions) will interfere with the successful syndication of a new loan carrying a lower spread (again possibly the result of generalized changes in demand.) This excuse runs contrary to the everyday operaton of analagous marketplaces. Yields on securities traditionally vary over time, causing outstanding issues to be valued at a premium or discount from par value and equalizing the returns on newly-issued and seasoned paper. For a floating rate security, since the spread is the only portion of the yield fixed at issue date, participations should be valued at a premium (discount) from par value related to how much the current spread is below (above) that carried by the outstanding loan.

In short, there is no substantive difference between a participation in a syndicated loan and a large-denomination floating rate note. Regulation, namely disclosure provisions which differentiate private placements from public offerings, does not pertain since securities issued in the Eurodollar market are not subject to U.S. or any other true registration process. If lenders really wished to promote a secondary market, a lower spread could be

offered to borrowers if an option was written into the contract which permitted trading in participations.

Given the lack of valid economic backing for the ban on trading, which now constitutes a barrier to entry into the industry, it would seem that a significant secondary market in these securities will emerge as pressure continues to be exerted on behalf of smaller commercial banks, insurance companies and other institutional investors. Opportunities for arbitrage will then be widespread as such large-scale buyers trade and take positions in the market. The passing of excess profits from the scene will result and borrowers will be the ultimate beneficiaries.

Even before an active secondary market in loan participations becomes a reality, lenders and borrowers alike can benefit from what would seem to be a higly lucrative forecasting tool whose use will drive maturity differentials toward their perfect foresight values.

Whenever the model predicts rises in spreads, a lender can heighten profitability by contracting only short term commitments and, at the limit, temporarily eschewing new lonas, while placing funds, extremely short term with other banks at LIBOR. (This maintains a constant proportion of the portfolio based on the Eurodollar market interest rate, and hence a constant exposure to risk.) Postponement of the long term commitment of funds would entail the foregoing of a small interest spread over the short term, in anticipation of a larger one of longer duration in the near future. An auspicious moment for

borrowers is provided by the same circumstances. These might attempt to lengthen the maturity structure of their debt in the syndicated loan market, to switch to this source of financing, or merely adapt their scheduling to profit from prevailing market conditions.

Movement from both sides of the marketplace creates forces that work to eliminate inefficiency. As the number of net lenders falls long term and rises short term, the consequent excess supply of short term funds and excess demand for long term funds will drive short term spreads downward and long term spreads upward. This process will continue until maturity differentials reach the values implied by the expectations theory of the term structure. Conversely, when the model predicts spreads below those inherent in the market's current level, the reverse process would apply, thereby reducing maturity premia. In short, competitive pressures that serve to drive the yield curve toward its ex post rational value, and away from its rigid 1/8% rule, would be the outcome of the model's use.

But far and away the greatest force toward the elimination of monopoly excess profits resides in their intrinsic appeal to other financial intermediaries who have been kept one step removed from the field of action. Lending giants, such as insurance companies, who have thus far placed their funds with big international banks in the form of CD's or Eurodollar deposits, are entering the syndicated Eurocredit market to contract directly with borrowers. Vis a vis commercial banks their competitive position benefits by a supply of

long term money which obviates the need for intermediation compensation. Merchant and investment banks, backed by coalitions of small regional commercial banks, are establishing a spearhead in the marketplace, with an eye to a role as market-makers in later secondary trading. That this disintermediation process has already begun can be seen in the new names on the tombstones of recent loans and in the pattern of the decline of profitability, both of which made their first appearance in 1978. Since that date, the percentage of Eurocredits controlled by the same four leading banks has declined from thirty percent to nineteen percent, again signalling the end of an era.(2)

When spreads decline, as they have during the 1978-80 forecast interval, it is impossible to determine whether simple market ignorance or an erosion of monopoly power is the causal factor in a drop in excess returns. In a period of decline, the superior performance of the liquidity model demonstrates that its use would have generated a supranormal income stream to borrowers or, equivalently, that during this kind of period, lenders have earned unusually high returns. Only in a time of rising spreads, when bank profits would be far below levels attainable with the model's use, is there the opportunity to distinguish between the two hypotheses.

A rise in the level of spreads between 1980 and 1981, predicted by the model, has been corroborated. The average seven-year-equivalent spread climbed from .711% in June 1980 to .828% in June

1981. This level was virtually identical to the model's forecast of .822%. Similarly, the average December 1981 seven-year-equivalent spread was .806%, as compared to the market's one-year forecast of .686%, far below the model's .761% estimate. The continued strong showing of the liquidity model in a time of rising spreads points to market ignorance and excess volatility in the returns of lenders (supranormal during intervals of falling spreads, subnormal when spreads rise) rather than the extraction of monopoly rents as the probable source of the deviation from competitive rationality.

There remains the quasi-philosophical question of whether monopoly power, of itself, can be a source of ignorance and inertia. The 1/8% constant maturity premium rule may be an example of the arbitrary practices that a protected environment fosters.

FOOTNOTES

(1) International Monetary Fund, International Financial Statistics, 1973--1980.

(2) Euromoney, March 1978, March 1979, March 1981.

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THE EURODOLLAR AND YANKEE BOND MARKETS:

UNEXPLOITED ARBITRAGE OPPORTUNITIES

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The transformation of the Eurobond market into a major funding force has been one of the significant international financing developments of the '70's. From a minor private placement market in Switzerland, of some U.S. $ 30 billions in relatively small offerings, it has grown during the past decade to the world's fifth largest capital market by value of U.S. $ 113.2 billions in outstandings and third largest, ranked by secondary trading activity.(1) Dollars now dominate the offerings, accounting for more than half of outstandings, a market share that has increased from one-third in 1970.(2)

Lack of regulation explains the Eurobond vehicle's appeal. For European universal banks, it provides the only dollar market in which they can play a leading role. For Iron Curtain countries, reluctant to place funds in U.S. custody, it offers a safe haven for surplus dollars. For all non-U.S. investors, both corporate and individual, it presents an investment opportunity, in dollars, free of the requirements of witholding tax on interest payments.

The same expansion has been experienced by Yankee Bonds, or dollar-denominated securities proffered in the U.S. marketplace by

foreign issuers. Present on a small scale since the early 1960's, they have doubled in volume during the past five years to total U.S. $47.6 billions at latest count.(3)

Sophisticated investors with large portfolios, notably institutions, have heavy committments and continuing contact with both the Eurodollar and Yankee bond markets. Yet surprisingly, substantial yield differentials on quasi-identical traded securities occur and persist--not just for minutes and hours, but for days and even weeks!

Explanations of this phenomenon are various, from investor inertia to lack of Eurodollar market liquidity, all of which might account for random deviations. But those closest to the investor, bond traders and salesmen, offer a rationale for a systematic relationship between movements in the general level of interest rates and yield differentials. Since purchase price rather than actual market value is used as accounting procedure by most institutional investors, managers are reluctant to execute a transaction which would reflect a book loss, even if this entails a real profit.* As one bond trader put it, "When bond

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* This has sometimes been circumvented by an illegal practice known as "overtrading" whereby two transactions (a purchase and a sale) are executed simultaneously at inflated prices, thus satisfying the investor's concern for a book as well as a real profit, while leaving the market maker indifferent. In this manner, the portfolio manager can record the sale of his previous holdings at an artificially high price and thus generate his desired book profit. Since the transaction involves only the exchange of securities (whose price differential is kept constant) and no exchange of cash, the market-maker has no cost associated with this practice.

values fall, there is nobody to play with". If this "lock-in" effect prevents arbitrage between markets, then yields should diverge as the general level of interest rates rises. With an eye to the discovery of profitable trading opportunities, the pattern of such differentials will be examined to determine whether they are of a systematic or random nature.

The study concentrates on the obligations of sovereign governments and supranational agencies to avoid possible influences from differential tax legislation to which the borrowings of corporate entities would be subject. Foreign investors, both corporate and individual, are exempt from U.S. federal income tax or witholding taxes on Yankee bonds issued by governmental entities in contrast to that levied on domestic issues by U.S. non-federal issuers; U.S. investors are subject to identical tax treatment, whether income is derived from Eurobond or Yankee bond sources.

Sixteen pairs of widely-traded securities of the same issuers, in the same currency (U.S. dollars) and with similar maturities and coupons, were selected. A single feature distinguishes the bonds within each pair: one is listed on the New York Stock Exchange (Yankee Bond), while the other is listed on one of the European exchanges, either London or Luxembourg (Eurobond).

End-of-week bid yield quotes were documented from the archives of the largest U.S. market maker in Eurodollar and Yankee bonds, thought to

be a highly accurate indication of true market conditions. These were recorded from December 1978* to August 1981 and then grouped by maturity classes:

> money market substitutes: with maturities between two and four years, as of December 1978.**
>
> short term notes: with maturities between four and five years, as of December 1978.
>
> medium term notes: with maturities between seven and nine years, as of start date.
>
> long term bonds: with maturities between twelve and eighteen years, as of first observation.

Although the characteristics of each pair of issues were not identical, the obligations are, as can be seen, close to perfect substitutes. The variation in maturities between the issues within any given pair averaged only 2.5 months for money market substitutes, 1.75 months for the short term notes, 4.75 months for the medium notes, and 8.0 months for the long term bonds. The total variation in coupons was contained within the 200 basis point range (7.50% - 9.50%), while within any pair of comparable securities, it was not significant, averaging 34 basis points*. (See Table I.)

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* earliest data available

** the time series were truncated when observations arrived near enough to the maturity of the instruments to cause the difference in maturity within the pair to be significant.

TABLE I

PAIRS OF INTERNATIONAL BOND ISSUES, BY MATURITY CLASS

	Issuer	Coupon	Maturity	Market
Money Market				
	European Econ. Comm.	8.25%	4/1/82	Euro
		7.625%	7/1/82	Yankee
	BFCE (France)	8.75%	2/15/83	Euro
		8.95%	7/15/83	Yankee
	Norway	8.50%	2/15/81	Euro
		8.25%	3/15/81	Yankee
	Norway	7.25%	5/15/82	Euro
		7.50%	6/15/82	Yankee
Short Term				
	Australia	8.25%	10/1/83	Euro
		8.125%	11/15/83	Yankee
	Australia	7.50%	9/1/84	Euro
		8.25%	12/1/84	Yankee
	Euro Investment Bnk	8.00%	4/1/84	Euro
		8.625%	4/1/84	Yankee
	Norway	8.25%	4/1/83	Euro
		8.75%	7/1/83	Yankee
Medium Term				
	Australia	8.50%	10/1/86	Euro
		8.75%	6/1/86	Yankee
	CNA (France)	9.00%	5/7/86	Euro
	EDF (France)	8.90%	9/15/86	Yankee
	CRN (France)	8.50%	12/15/86	Euro
	EDF (France)	8.50%	6/1//87	Yankee
	Sweden	8.25%	6/15/87	Euro
		8.50%	11/15/87	Yankee

TABLE I (Cont'd)

	Issuer	Coupon	Maturity	Market
Long Term				
	Australia	8.25%	9/1/92	Euro
		9.125%	6/1/93	Yankee
	Euro Coal & Steel	8.75%	10/1/97	Euro
		9.125%	4/1/97	Yankee
	Euro Investment Bnk	8.75%	2/1/93	Euro
		8.375%	10/1/92	Yankee
	CNA (France)	9.25%	9/9/91	Euro
	SNCF (France)	9.00%	12/1/92	Yankee

Source: International Yield Data Base, Salomon Brothers.

Securities within each pair were revealed to be almost perfect substitutes, confirming the validity of the sample selection. The absolute value of the mean yield differential for all maturity classes, for the entire sample period, was only fourteen basis points, varying between three basis points and twenty-eight basis points, depending on the maturity class, a level well within the interval defined by the ideal value of zero $\pm$ transactions costs. (See following for a discussion of trading expenses.) An analysis of the absolute value of the yield differential, which averaged twenty-six basis points, varying between nineteen and thirty-two basis points depending on the maturity class, revealed it to be again within the efficient markets range.

Although, on average, the pairs of securities proved almost interchangeable, the absolute value of the yield differential fluctuated widely, reaching a maximum of 171 basis points for money market substitutes, 111 basis points for short term maturities and 187 and 162 basis points for medium and long term maturities. What is even more remarkable, these substantial deviations often persisted for weeks!

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* For comparability, Eurobond yields and coupons have been adjusted to a semi-annual equivalent, since interest, there, is paid annually rather than semi-annually as in the United States.

I. DO UNEXPLOITED ARBITRAGE OPPORTUNITIES EXIST AND PERSIST?

Unexploited profitable trading opportunities were clearly revealed by the frequent appearance of yield differentials substantial enough to outweigh transactions costs (equal to customary charges of the 1/4 point spread between bid and offer prices of market-makers and a fee of $2.50 per bond, plus a flat $25.00 per transaction to cover the investor's internal administration costs). A $10,000 trade was taken as standard, since this constitutes the legally-binding maximum of any bid-offer quote by a market-maker, although transactions far in excess of this amount are often possible at the same prices. Yield differentials required to justify such a transaction were calculated for each maturity class and were found to total sixty basis points for money market substitutes, thirty-five basis points for short term instruments, twenty basis points for medium term notes and fifteen basis points for long term bonds.

The arbitrage cycle begins when yields are identical in both markets and investors desiring to hold twenty thousand dollars, nominal value, in the securities of a specific issuer and maturity, execute a pair of ten thousand dollar purchases in the Eurobond and Yankee bond markets. Whenever returns diverge sufficiently to justify a transaction, all funds are switched to the undervalued security, that is, ten thousand dollars moves from the temporarily overrvalued of the

pair. Whenever differentials return to their trend level of zero, the portfolio is re-equilibrated to its original proportions beween the two markets. Each arbitrage opportunity, therefore, requires a yield differential that justifies two transactions, hereinafter defined as arbitrage execution costs.

Opportunities for profitable trading were found to be concentrated in medium and long term maturities. Although only 2% of the observations in the money market substitute and short term maturity classes offered yield differentials exceeding arbitrage execution costs, 26% of the medium term and 32% of the long term yield differentials afforded excess returns. More amazing was the finding that 12% of the medium and 10% of the long term samples proffered differentials exceeding twice the level of execution costs, while 4% and 3% exceeded those costs by a three-time multiple. (See Table II.)

Taking advantage of opportunities was not a matter of split-second timing. For medium term maturities, yield differentials in excess of execution costs persisted for two weeks or more 20% of the time, those double execution costs for 9% of the time, and those triple the costs, for 3% of the time. For long term maturities, these two-week options occurred 24%, 7% and 2% of the time respectively. (See Table III.) The persistence of unexploited opportunities was shown to be significant, even for the unlikely period of one month. For medium term notes, differentials high enough to justify execution remained for four

TABLE II

FREQUENCY OF UNEXPLOITED ARBITRAGE OPPORTUNITIES

Maturity Class

	Money Market		Short Term		Medium Term		Long Term	
	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample
> Execution costs	10	2%	13	2%	140	26%	170	32%
> 2x Execution costs	0	0%	0	0%	65	12%	55	10%
> 3x Execution costs	0	0%	0	0%	21	4%	18	3%

TABLE III

PERSISTENCE OF UNEXPLOITED ARBITRAGE OPPORTUNITIES

(IN EXCESS OF TWO WEEKS)

Maturity Class

	Money Market		Short Term		Medium Term		Long Term	
	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample
> Execution costs	2	0%	4	1%	110	20%	129	24%
> 2x Execution costs	0	0%	0	0%	49	9%	36	7%
> 3x Execution costs	0	0%	0	0%	17	3%	13	2%

weeks 15% of the time; 6% of the four-week periods offered a possible gain of twice execution costs and 2% of three times the figure. A similar pattern of 17%, 5% and 2% was obtained for long term bonds. (See Table IV).

Market inefficiencies are, traditionally, the source of profitable income streams. To translate the profit-taking potential of yield divergences into a return on investment, the results of two possible trading strategies were calculated. The first executed transactions when the yield differential initially exceeded execution costs, held the undervalued bonds until the differential was wiped out, and then returned the portfolio to its original fifty-fifty composition. The second restricted trades to times when the yield differential exceeded twice the level of execution costs.

Both trading rules proved lucrative. In medium and long term securities where arbitrage opportunities are greatest, the first system yielded a 33.25 point trading profit, while the second strategy generated a 36.7 point gain, both over a thirty-two month period. When these profits were reinvested in one-month U.S. Treasury Bills, the total rewards rose to 49.3 and 54.4 points respectively.

Predicated on a portfolio of $160,000 nominal value, divided into $20,000 in each of the eight pairs of bonds in the medium and long term maturity classes, pure profits generated in excess of the regular holding yield, amounted to $4940 and $5540, again over thirty-two

TABLE IV

PERSISTANCE OF UNEXPLOITED ARBITRAGE OPPORTUNITIES

(IN EXCESS OF FOUR WEEKS)

Maturity Class

	Money Market		Short Term		Medium Term		Long Term	
	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample	Number of Occurences	% of Sample
> Execution costs	0	0%	0	0%	83	15%	91	17%
> 2x Execution costs	0	0%	0	0%	32	6%	25	5%
> 3x Execution costs	0	0%	0	0%	11	2%	11	2%

months. This is equivalent to an average percentage excess return of 3.7% and 4.0%, given that the average market values of the bonds were 86.40 and 82.25. In the frame of reference of average yields to maturity for medium and long term bonds of 11.65% and 11.85% respectively, over the 32-month span, arbitrage streams can be seen to make a significant contribution to profitability. They would have riskiessly increased the portfolio yield by 12.8%. It is probable that a daily scrutiny of yields would reveal an even higher incidence of opportunity, with concommitant increased trading return, since observations for the study were taken on a weekly basis only. Fixed costs occasioned by arbitrage operations would be more than covered by maintaining six such accounts, each at a different market maker, and trading in other pairs of securities as well.

II. MOVEMENTS IN THE GENERAL LEVEL OF INTEREST RATES AND THE LOCK-IN EFFECT.

The causal role of the path of the general level of interest rates, and the consequent "lock-in" effect, on unwillingness to exploit arbitrage possibilities which have been shown to exist and persist through time, was next examined. Precedent for the "lock-in" effect can be found in the economics literature of the 1950's which identified this phenomenon as one of the channels of restrictive U.S. monetary policy. (See Riefler.) It was argued that a tightening of monetary aggregates,

with the resultant rise in interest rates, would lock commercial banks, who were the major holders of U.S. Treasury obligations, into existing portfolios, in order to avoid a recorded book capital loss. The result would be a heightening of the contractionary effects of the original policy. In the light of current interest in the overall issue of the effectiveness of monetary policy, the lock-in effect merits further study.

As a proxy for this influence in portfolio decision making, the discount from issue price of the New York-listed member of each pair was calculated. Implicit in the choice of this independant variable is the assumption that the majority of investors had purchased the bond at the initial offering price. An alternate measure, that of the capital gain or loss over the most recent fifty-two or twenty-six week period seemed less desirable, since data limitations would have halved the observation period. To test the "lock-in" hypothesis, regressions were run of the form:

Absolute Yield Differential = a + b x Discount from Issue Price

When ordinary least squares estimation was performed, evidence of substantial first order serial correlation within each time series appeared; this was corrected by the use of the Cochrane-Orcutt iterative technique. For the three longer maturity classes, the coefficient on the discount from issue price was positive and highly statistically

significant, with a t statistic averaging 7.88. The percentage of the variation in the absolute value of the yield differential accounted for by variation in the independent variable averaged 10.3%. Support for the causal role of the lock-in effect in the substantial divergence of yields was found in the fact that the value of the coefficient, its statistical significance and the explanatory power of the equation were much higher in medium and long term maturities where unexploited arbitrage opportunities have already been shown to be greatest while in the shortest maturity class where unexploited opportunities are virtually non-existent, such figures approached insignificance. (See Table V).

Here is clear evidence in support of the lock-in hypothesis. As the curent market value of a security falls from its initial purchase price, the discount, and the consequent book loss entailed by any transaction, rises. Portfolio managers have a disincentive to execute trades, and permit yields on substitutable securities to diverge and yield differentials to arise.

Arbitrage between the Eurobond and Yankee Bond capital markets is more subtle than the norm, for the commodities are intrinsically the same but not exchangable, and cannot flow between the segmented New York and European markets. It is not merely a question of buying a bond in

TABLE V

A TEST OF THE "LOCK-IN" HYPOTHESIS: REGRESSION ANALYSIS

MATURITY CLASS

	Money Market	Short Term	Medium Term	Long Term
Estimated Coefficient	.0155	.0175	.0392	.0286
t Statistic	2.05	6.11	8.94	8.58
R-squared	.01	.06	.13	.12
Mean of Dependent Variable	.283	.195	.324	.259
Number of Observations	514	548	548	537

London and reselling it instantaneously in New York; rather, participants must move from one marketplace to another and, by their transactions, reequilibrate prices. The bonds, at all times, remain on the appropriate side of the Atlantic, but investors who switch between European-registered and U.S.-registered issues, can increase portfolio yields, while leaving risk exposure unchanged.

In sum, an investor commited to the securities of a specific issuer, and of a specific maturity and coupon, as part of his portfolio plan, would balance his obligations between the U.S. and Eurodollar bond markets, follow the yields of both issues, and shift his holdings from the temporarily-overvalued version to its temporarily-undervalued counterpart whenever the yield differential exceeds execution costs. Risk remains constant (in terms of proportion of portfolio devoted to issuer and maturity) while excess profits are garnered as, over time, the yields of the two securities are driven toward equalization, generating a <u>real</u> capital gain from positions in the initially-undervalued bonds.

Why such opportunities for profit-taking are almost uniformly eschewed remains in the area of speculation. If trade gossip is informed, <u>real profits</u> are of no value to the portfolio manager unless they are partnered with a book gain to add lustre to the manager's track record; promotion and financial reward will be in direct proportion to <u>book profits</u> rather than real and, whenever the two diverge, the incentive points in a direction opposite to efficiency. Such a

hypothesis is confirmed by the relationship of yield differentials to movements in the general level of interest rates and may be classified as but another instance of the economic consequences of the principal-agent problem, as entrepreneurs are increasingly displaced by professional managers.

When and if the mass of major financial institutions substitute market value for book value in accounting procedures for investments, as has recently occurred in West Germany, all yield differentials resulting from this "lock-in" effect, will be wiped out, along with the incentive to overlook the opportunity for real profits offered by international arbitrage between Yankee and Eurodollar bonds. This day may be here, for the West German financial intermediaries are sufficiently powerful, in themselves, to eliminate all excess profits in the marketplace and are almost certain to do so.

FOOTNOTES

(1) Hanna, Jeffrey D. and Johnson, David, How Big Is the World Bond Market?, Salomon Brothers Inc., 1981.

(2) Ibid.

(3) Ibid.

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THOROUGHBRED HORSES:

A SPECULATIVE RACE

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"It is the best international exchange in the world today. It is better than gold!"

John A. Nerud of Tartan Farms, defending the thoroughbred industry, in Washington, at 1976 congressional hearings.

"The horse market is the most solid investment in the country today. Where else can you go-- gold, stocks, oil? Horses are a lot less risky than any of those avenues."

Tom Gentry, leading breeder, at the 1980 Keeneland fall sales, after purchasing an aged broodmare for a record $2 million tag.

The past decade has seen thoroughbred racing transformed from a leisure pursuit to a bona fide international investment market in real but highly volatile assets. The pattern of the growth seems to repeat that of historic crazes like the Tulip Mania and the South Sea bubble.

Market size has increased from $24 million for all auction yearling sales in 1970 to $210 million in 1980. Prices, notably, at the two select sales which are restricted to top offerings, exhibit a comparable rise; in real terms, these doubled from 1960 to 1970, and then almost tripled again during the 1970's. (See Table I.) Breeders with an

TABLE I

AVERAGE REAL PRICES: THE 1960-1980 SELECT SALES

(Constant 1967 Dollars)

	Keeneland		Saratoga		Combined
	Colts	Fillies	Colts	Fillies	
1960	$15,042	$10,773	$13,935	$10,081	$12,968
1961	18,704	12,393	12,738	15,462	13,989
1962	15,717	12,862	15,339	11,298	14,052
1963	18,131	12,095	16,654	10,411	14,559
1964	20,671	15,285	19,427	18,688	18,964
1965	18,407	19,884	19,999	16,821	18,794
1966	21,049	15,880	20,001	20,233	19,343
1967	21,040	20,455	22,571	21,625	21,442
1968	29,655	29,145	21,242	26,547	26,350
1969	25,318	20,630	17,739	15,466	20,708
1970	28,915	21,987	21,400	25,131	24,618
1971	27,419	24,824	28,902	20,476	25,786
1972	32,898	25,795	22,497	23,791	27,045
1973	44,678	40,236	33,600	23,677	38,530
1974	36,349	36,039	27,414	23,137	31,679
1975	35,086	31,009	22,837	23,177	29,141
1976	41,949	35,777	26,191	25,760	33,786
1977	50,154	44,767	31,197	31,961	41,194
1978	70,967	56,127	44,709	36,409	55,117
1979	76,197	69,297	45,327	44,812	61,628
1980	86,957	74,070	38,273	53,434	65,003

Source: Auction Yearlings of 1960-80, The Blood-Horse.

established productive capacity are benefiting from what appears to be an open-end potential for yearlings at the top end of the spectrum. Again, viewed in real terms, the record price of $250,000 set in 1967 rose 73% by 1970 and then tripled by 1981 to $3.5 million or $1.3 million in constant 1967 dollars.

Values for proven performers on the race track, when they are retired to breeding stock, show an equivalent transformation. A $5.4 million record set in 1970, when Nijinsky II was syndicated, more than doubled in real terms by 1981 with the $28 million paid for shares in Storm Bird. Established broodmares, too, have become highly valued production machinery, in response to the spiral of yearling prices. Here, auction bids at levels as high as $2 million reflect the concerted confidence of the breeding establishment in continued market strength for the next two years and longer, the time lag before a return can begin to be realized.

Final evidence of the transformation of the thoroughbred to the asset category can be found in the increasing sophistication of the market which now abounds with financing instruments, risk-diversifying techniques and advisory services. Debt financing, leveraged leasing, and centralized trading in stallion shares, have made their appearance during the past two years, while buying syndicates designed to overcome market indivisibilities, have expanded their concept to cover the sharing of risk, not only between a group of investors, but also over a group of horses. Now the authoritative buying force at the upper

levels, such syndicates purchased five of the top seven colts sold in 1980; price range $700,000 to $1,700,000.

> "Bidding on the highest-priced yearlings at both Saratoga and Keeneland was between representatives of syndicates comprised of an indeterminate number of individuals who in sum have an apparently unlimited supply of investment capital."
>
> The Blood-Horse, August 1978 in a review of the Saratoga Sale.

I. THE INSTITUTIONAL ENVIRONMENT

The favored medium of the thoroughbred marketplace is the auction--an interaction that provides not only a means of exchange of goods, but of the pooling of information and the public setting of what will be established guidelines for future purchases of similar merchandise. In 1980, 7100 yearlings were offered for sale at 46 public auctions in the United States and Canada.(2) But the market is dominated by a once-a-year summer event which joins two Select Sales -- Keeneland in July in Kentucky and Fasig-Tipton in August at Saratoga. For their collective offering (520 yearlings or just 7.3% of all auction prospects in 1980), there is an international marketplace, analagous to that of other rare, high unit value and one-of-a-kind commodities, such as paintings, antiques and precious gems. The health of the US economy does not influence the levels of these sales, for the top thoroughbred auctions are frequented by the same multilingual group. Mirroring a pattern consistent since the 1970's, 33% of the 287 Keeneland yearlings

presented in 1980 went to foreign owners, at an average price of $248,245 or 43% of the auction gross. At Saratoga, 25% of the total number, equivalent to 31% of the intake, was purchased by bloodstock agents from abroad. More telling, almost every yearling with a top pricetag was acquired by non-U.S. stables; in 1980, this held true for eight of the top ten colts, with final bids in excess of $500,000.(3)

Inclusion in a select summer sale is somewhat like being rated in the bond market by Moody's or Standard and Poor. The merchandise has been carefully screened by the sales companies, acting as intermediaries to bring buyers and sellers together for a 5% fee. Pedigrees have been graded by experts; conformation and soundness have been noted by a leading veterinarian; only 30% of the top prospects submitted by top breeders reach the sales ring.(4) Successful colts from these sales can count on a far higher syndication value than a similar achiever from a more commonplace source.

Just a few statistics will serve to underscore the significance of the two Select Sales. The average price was $160,427 in 1980 or 8.3 times the $19,318 mean for all yearling sales in the same year. That this dominance continues to grow with each decade is demonstrated by the ratio between the percentage of total purchase price and the percentage of total yearlings sold, represented by the top two auctions, which has jumped from 2.13 to 5.42 or 154% between 1960 and 1980. (See Table II.) One precise measure of the quality of performance expected of select sale yearlings is that of the Standard Starts Index (a deflated index of

TABLE II

THE RISE OF THE SELECT YEARLING SALES:
MORE $ SPENT IN THE SEARCH FOR THE TOP HORSE

	Total Auction Yearlings Sold	Total Yearlings Sold at the Two Select Sales	% of Total Sold at the Two Select Sales	Total Purchase Price of all Auction Yearlings
1960	1857	548	29.5%	$ 9,996,975
1961	1962	553	28.2%	11,114,840
1962	2244	523	23.3%	12,544,300
1963	2460	529	21.5%	13,319,635
1964	2644	483	18.3%	15,959,775
1965	2863	519	18.1%	17,814,975
1966	3100	529	17.1%	19,544,145
1967	3167	540	17.1%	21,199,800
1968	3411	510	15.0%	26,162,660
1969	3242	590	18.2%	24,502,095
1970	3229	480	14.9%	24,786,075
1971	3510	580	16.5%	30,875,750
1972	4108	534	13.0%	37,880,275
1973	4251	576	13.5%	52,097,520
1974	4603	544	11.8%	49,201,580
1975	4905	572	11.7%	53,673,050
1976	5001	558	11.2%	65,116,425
1977	5106	519	10.2%	83,418,950
1978	5777	531	9.2%	114,648,450
1979	6326	496	7.8%	156,683,500
1980	7079	420	7.3%	210,128,000

Calculated from data: The Jockey Club Statistical Bureau
The Keeneland Association
Auction Yearlings of 1960-80, The Blood-Horse.

TABLE II (cont'd)

Total Purchase Price of Yearlings Sold at the Two Select Sales	% of Total Purchase Price of Auction Yearlings Made at the Two Select Sales	Ratio: % of Total Purchase Price Made at the Two Select Sales to % of Total Number Sold at the Two Select Sales
$ 6,285,900	62.9%	2.13
6,931,100	62.4%	2.21
6,618,800	49.3%	2.12
7,120,900	53.5%	2.49
8,509,600	53.3%	2.91
9,226,400	51.8%	2.86
9,945,800	50.9%	2.98
11,557,700	54.5%	3.19
14,021,300	53.6%	3.57
12,514,400	51.1%	2.81
13,743,000	55.4%	3.72
18,124,627	58.7%	3.56
18,096,000	47.8%	3.68
29,539,200	56.7%	4.20
25,453,600	51.7%	4.38
26,869,700	50.1%	4.28
32,143,700	49.4%	4.41
38,804,000	46.5%	4.56
57,187,500	49.9%	5.42
66,454,000	42.4%	5.44
83,422,000	39.7%	5.44

earnings) which averaged 2.24 for graduates of the 1970 Keeneland Sale, placing them in the top 6.5% of all starters.(5) Select sales were proven the principal source for the purchase of top-performance horses in a previous study which focused on auction yearlings sold during the 1960-70 period; the two select sales, which represented just 19% of the auction population, accounted for 85% of all top stakes winners, 82% of champions, and 75% of seven-figure syndicated stallions. In every price class but the lowest, they were a high majority (62%, 81%, 90% and 100%) and even at the lowest level, where they represented only 16.2% of the horses, they were the source of 44% of top stakes winners and 33.3% of champions, or multiples of 2.74 and 2.05 times their share.(6)

The market, once confined to a small, select circle, has broadened its base. Today, "the sport of kings" is a business like any other, populated by professional hardboots who quip that "for each new crop of foals there is a new crop of suckers", and increasingly by successful businessmen who find in racing a challenge to their entrepreneurial skills and the opportunity to make and keep more money than in most conventional forms of investment. To many newcomers, the horses might just as well be a stand of lumber, a herd of cattle, or a safe-deposit box of bond certificates. They are simply the hottest new asset in a diversified portfolio:

> "Five, ten years ago, commercial breeders could not think of more than fifteen possible contending bidders for a $100,000 yearling. Today, the number and location of persons prepared to invest $100,000 in a yearling with a chance of being worth $1 million in two years is indeterminable."
>
> Kent Hollingsworth, editor The Blood Horse after the 1977 Saratoga Select Sale.

Like other high-risk activities, racing is a highly volatile sector where the overwhelming frequency of loss is partnered with an enormous potential for gain. Rising prices for yearlings are all the more remarkable in the face of racing facts. Even at the top level of the 1970 Keeneland Select Sale:

> 24% of all yearlings earned 0
>
> 79% earned less than the $10,000 a year which represented annual training outlay
>
> 7% had career earnings of $100,000 over a five-year period, the cut-off point for a break-even investment
>
> 3% could be classified as "top horses", winners of major races. (A probability more than 15 times that of the .19% of the breed.)
>
> (7)

A comparison of the investment in top sale yearlings and the returns on this investment reveals an overall loss for buyers. The collective earnings of the 1970 select sale yearlings, through a three-year-old season, amounted to approximately $10 millions, contrasted to an initial purchase price of $13.74 millions. Residual value totaled $16 millions and the present discounted value of th e costs of training and racing through the three-year-old season amounted to $11.41 millions*. Taking maximum advantage of tax benefits and assuming an after-tax nominal discount rate of 2%, the present discounted value of the investment stream involved a collective loss of $2.2 millions or an average loss of $4400 for every horse in the sales. This can be translated as an after-tax internal rate of return of minus

4%. However, some investors realized major returns. There were 28 winners in the 1970 sales who earned $5.6 millions and had an estimated residual value of $10.26 millions. Of these, just eight "top horses" accounted for $10.65 millions of the total, or ten times an overall investment of $1.05 million.(8)

Here is evidence of market irrationality and a classic example of the fallacy of composition. Although racing is a loss industry, each buyer at the select sales is convinced that his skill in choosing promises success. What is believed by every individual is clearly untrue for the whole.**

The ultimate value of the top runner, represented as syndication price, stud fee, or broodmare ovary value, is the new goal, a vast sum which under current assymetrical taxation conditions of deductions, depreciation, and capital gains, allows the transformation of what would be highly-taxed income into accumulated wealth.*** In 1960, Bald Eagle set a syndication benchmark for an unproven sire at $1.4 millions. In 1980, Spectacular Bid obtained a syndication of over $22 millions. It is this extraordinary multiple which explains the market explosion and the broadening base of participants. (See Table III.)

---

* Based on the three year U.S. Treasury note yield prevailing in 1970 as a conservative pre-tax nominal discount rate.

** Extreme risk-prone attitudes offer an altenate hypothesis

*** The government absorbs 70% of annual expenses, including accelerated depreciation, but witholds only 35% of the "profits" which qualify as capital gains.

TABLE III

A HISTORY OF TOP COLT SYNDICATION

1955	Nashua	$ 1,251,200
1957	Swaps	2,000,000
1958	Gallant Man	1,333,333
1959	Swoon's Son	1,000,000
1960	Bally Ache	1,250,000
1961	Bald Eagle	1,400,000
	Hail to Reason	1,085,000
1964	Gun Bow	1,000,000
1965	Hail To All	1,650,000
	Tom Rolfe	1,600,000
	Candy Spots	1,600,000
	Sea Bird (5 year lease)	1,500,000
	Meadow Court	1,120,000
	Father's Image	1,000,000
	Prove It	1,000,000
	Olden Times	1,000,000
1966	Graustark	2,400,000
	Kauai King	2,160,000
	Royal Gunner	1,260,000
	Creme de la Creme	1,200,000
1967	Buckpasser	4,800,000
1968	Vaguely Noble	5,000,000
	Dr. Fager	3,200,000
	Dancer's Image	2,000,000
	Ribocco	2,000,000
	Stage Door Johnny	1,920,000
	Successor	1,050,000
1969	Hawaii	1,120,000

TABLE III (cont'd)

1970	Nijinsky II	5,440,000
	Arts and Letters	3,000,000
	Sir Ivor	2,080,000
	Majestic Prince	1,800,000
	Silent Screen	1,650,000
	Indian Chief	1,400,000
1971	Bold Reason	3,200,000
	Damascus	2,550,000
	Personality	2,550,000
1972	Unconscious	1,800,000
	Executioner	1,680,000
	Run the Gauntlet	1,600,000
	Crowned Prince	1,200,000
1973	Secretariat	6,080,000
	Riva Ridge	5,120,000
	Mill Reef	5,000,000
	Key to the Mint	4,800,000
	Roberto	4,000,000
	Sham	2,880,000
	Tentam	2,400,000
	His Majesty	2,000,000
	Royal and Regal	1,800,000
	Kennedy Road	1,440,000
1974	Little Current	4,000,000
	Our Native	1,860,000
	L'Enjoleur	1,280,000
	True Knight	1,200,000
	Halo	1,200,000
1975	Wajima	7,200,000
	Foolish Pleasure	4,500,000
	Grundy	2,000,000
	Cougar II	1,080,000
	Singh	1,080,000
	Gold and Myrrh	1,000,000

TABLE III (cont'd)

1976	Empery/Youth	12,000,000
	Honest Pleasure	5,120,000
	Bold Forbes	4,160,000
	Intrepid Hero	2,160,000
	Avatar	1,920,000
	Elocutionist	1,080,000
1977	The Minstrel	9,000,000
	Artaius	3,982,000
	Caucasus	2,880,000
	Val de l'Orne	2,160,000
	Soy Numero Uno	1,929,000
	On the Sly	1,080,000
1978	Affirmed	14,400,000
	Alleged	13,000,000
	Seattle Slew	12,000,000
	J. O. Tobin	7,200,000
	Dactylographer	1,000,000
1979	Troy	16,500,000
	Exceller	15,000,000
	Coastal	5,400,000
	Majestic Light	5,400,000
	Star de Naskra	2,700,000
	Smarten	2,700,000
	Hawaiian Sound	2,400,000
	Medaille d'Or	1,020,000
1980	Spectacular Bid	22,000,000
	Valdez	8,000,000
	State Dinner	8,000,000
	Codex	6,200,000
	Hello Gorgeous	5,000,000
	Policeman	4,400,000

Source: American Racing Manual 1980, Daily Racing Form.

In attempts to explain the attraction of racehorses, the question of psychic income cannot be entirely ignored. Racing has always been a traditional avenue for the nouveau riche to enter a social elite closed to him on other levels. For those whose needs are met by an owner's identification badge, entry to the backstretch, and a seat in the clubhouse to entertain friends and neighbors, there are vastly cheaper, easier, and swifter means of access to racing than bidding from a chair at the select sales. Most new entrants do begin via non-select yearling sales, the purchase of horses of racing age, or claiming horses at a nearby track, where they can write a check today and race tomorrow. All of these are non-avenues to a top horse. For others, like Stavros Niarchos, whose psychic income is derived from being in the winner's circle at the big races, rather than simply owning a horse, appropriate identification of top-performance prospects is as crucial as it is for the bottom line of profit-minded investment. Both psychic income and monetary income meet with a wreath of roses at the Kentucky Derby.

As large numbers which denote major investment become commonplace in the thoroughbred industry, it seemed worthwhile to examine the workings of the auction market for yearlings, at the top level, where the objective is to breed and to buy the top horse and to make the top dollar. Is the market functioning efficiently? Are the prices paid,

which should indicate the collective view of an informed and professional public, a correct assessment of the value or future performance of the individual? Are the correct signals, readily available in statistical and other form, being optimally used? Is there other data which can be developed to predict future success? Whatever the efficiency within the market, a final question remains -- is the price spiral moving rationally in response to potential reward and is that reward a logical return or an unsound speculative gain? In short, should the sign over the entry to the auction ring read, as many oldtimers believe:

"Check Your Brains At The Gate!"

II. INVESTMENT AS AN INDICATOR OF PERFORMANCE.

After the select summer sales for 1960, 1965 and 1970 (six in all) were grouped as a single sample of 1568 individuals, prices of each yearling were located in contemporary reports of sales results and career earnings were traced through the American Produce Records, 1930-78 which accumulates statistics on each foal born or raced in the United States. To correct for upward trends in demand and inflation during the decade in question, it was necessary to reorganize the observations into price classes. Drawing upon the experience of John Finney, President of Fasig-Tipton, Inc., thoroughbred auctioneers, five

classes were established: 0-1/2 times the mean; 1/2 the mean to the mean; the mean to 2 times the mean; 2 times the mean to 5 times the mean; and over 5 times the mean. Each individual was classified according to the mean of the year's combined sales and, due to the differential between average prices of fillies and colts, according to its respective sex.

To obtain an appropriate relationship between price categories, two approaches were taken and tested. The first considered only original purchase price as investment. Means were calculated within each price category and within each sex and consolidated, weighted by the percentage of total numbers within each group. Using the mean of the lowest category as the norm, a "price" scale was established where the average of each class was measured as a multiple of the average of class I:

I (0-1/2 the mean) = 1
II (1/2 the mean to the mean) = 2.04
III (the mean to 2 times the mean) = 3.92
IV (2 times the mean to 5 times the mean) = 7.92
V (greater than 5 times the mean) = 20.09

A second approach took into account total investment, adding to the purchase price the present discounted value of the future stream of training and racing costs. While the addition of a constant has no effect upon the power of the regressions, it provides a more

appropriate measure of the slope parameter, since rational calculations must include these costs as an integral part of the price of the option. Although many horses race for four years or more, it was decided to take costs through a three-year-old campaign as the average for all horses. Training costs were researched for the periods in question and annual expenses for the 1960 period were found to be $4000; for the 1965 period, $6400; and for the 1970 period, $9400. Accordingly a second "investment" scale was established, again using the mean of the lowest price category as the norm.

I (0-1/2 the mean) = 1
II (1/2 the mean to the mean) = 1.30
III (the mean to 2 times the mean) = 1.83
IV (2 times the mean to 5 times the mean) = 2.98
V (greater than 5 times the mean) = 6.45

The distribution of individuals by price categories was:

I: 515 yearlings or 32.8%
II: 554 yearlings or 35.3%
III: 335 yearlings or 21.4%
IV: 146 yearlings or 9.3%
V: 18 yearlings or 1.2%

(See Table IV for detailed population distribution.)

TABLE IV

POPULATION DISTRIBUTION: BY INVESTMENT CLASS

	I	II	III	IV	V
1960	32%	36%	20%	11%	1%
1965	34%	32%	23%	10%	1%
1970	32%	38%	21%	8%	1%
1973	28%	38%	24%	9%	1%
1975	28%	42%	21%	8%	1%
1977	31%	35%	24%	9%	1%
1978	38%	30%	20%	10%	2%
1979	35%	35%	19%	10%	1%
1980	35%	35%	21%	8%	1%

Next, "Performance" was scrutinized via three increasingly stringent measures, each one highly correlated with the ultimate goal of market participants-- that of obtaining a top horse with large residual value:

> simple dollar earnings. The dollar earnings of the top syndicated colts of the 1968, 1969 and 1970 foal crops averaged $528,504 or 17.6 times the average earnings of the graduates of the corresponding Keeneland Select Sales. ($29,980)
>
> classification into three qualitative categories of "Success" which were weighted on a scale of 1, 100 and 5000. These were: "failures"; "successful horses", those who earned at least $100,000* in all (averaging at least $20,000 per year, the profitability break-even point) or a minimum of $40,000 per year; and "top horses", those winning Grade I stakes races, with high earnings and residual value in the millions.
>
> A measurement of racing success for all the top syndicated colts in Table III would have averaged 5000 on the scale or 41.3 times the average of all 1969, 1970 and 1971 Keeneland Select Sale graduates. (121)
>
> the Standard Starts Index (SSI) of the yearling which is calculated as:
>
> $$\frac{\text{the average earnings per start of the runner}}{\text{a.e.s. of all runners of the same sex in the same year}}$$

---

* Although the cut-off point of $100,000 is an industry standard, a variation of 25% on either side, $75,000-$125,000 showed no change in the relationship, nor did the same test applied to the annual $40,000 earnings criterion.

> The average SSI of the top syndicated colts from 1955-1978 (Table III) was 61.2 or 28.7 times the average of the 1969, 1970 and 1971 Keeneland Select Sales graduates. (2.13)
>
> A high Standard Starts Index consistently distinguishes the top horse which will later have a large residual value, for large purses denote the winning of top races against top competition. From a profitability standpoint, a shorter racing career increases the net return from a given earnings total. Among major syndicated stallions: Nashua scored 116.74; Buckpasser, 113.28; Secretariat, 118.50; and Seattle Slew, 104.98. (Again, see Table III for syndication values.) The SSI adjusts an absolute measure of performance by eliminating distortions created by inflation, changes in purse structure, and sex discrimination (purses for fillies are always lower than those for colts).

Six ordinary least-squares regressions were then run, using the pair of scales developed from initial price and total investment constructs: two related these to dollar earnings; two to "success"; two to SSI. The regressions yielded, in all cases, positive and highly statistically significant estimated coefficients between both price as initial investment and price as total investment, as related to all three measures of performance. Further, the statistical significance of the estimated coefficient and the explanatory power of the equation increased with the stringency of the test. (See Table V.) It is important to note that the degree of correlation between the three measures of performance is, though significant, far from perfect. In regressions of one measure upon the other, the t statistics on the coefficients were: 41.62, 43.51, and 55.63, while the R-squared statistics measured .53, .55, and .66.

TABLE V

INVESTMENT AS PREDICTOR OF PERFORMANCE:

THE 1960, 1965 AND 1970 SELECT SUMMER SALES

INVESTMENT AND DOLLAR EARNINGS:

Investment = Initial Purchase Price

Earnings = 16,147 + 1,408 x Price
(9.10)* (3.16)

R-squared = .006 Number of Observations = 1568

Investment = Purchase Price plus Training Costs
(through the three-year old season)

Earnings = 12,669 + 4,898 x Investment
(4.71) (3.14)

R-squared = .006 Number of Observations = 1568

* (t statistics in parentheses)

TABLE V (cont'd)

INVESTMENT AND SUCCESS:

Investment = Initial Purchase Price

Success = -3.68 + 26.83 x Price
(-.17) (5.02)

R-squared = .016 Number of Observations = 1568

Investment = Purchase Price plus Training Costs
(through the three-year old season)

Success = -70.2 + 93.45 x Investment
(-2.18) (5.01)

R-squared = .016 Number of Observations = 1568

INVESTMENT AND THE STANDARD STARTS INDEX (SSI):

Investment = Initial Purchase Price

SSI = .890 + .243 x Price
(6.86) (7.44)

R-squared = .034 Number of Observations = 1568

Investment = Purchase Price plus Training Costs
(through the three-year old season)

SSI = .288 + .845 x Investment
(1.46) (7.42)

R-squared = .034 Number of Observations = 1568

The finding of statistically significant coefficients with but low explanatory power of the equations is in no way inconsistent with market efficiency. Racehorses may be such volatile assets that there is no means of obtaining a superior forecast of ex post performance with available information. However, the sections that follow will provide evidence that this is not the case.

III. A TEST OF THE MARKET'S EFFICIENCY IN ITS SEARCH FOR THE TOP HORSE.

The probability of obtaining equine superstars as a function of the magnitude of investment was next examined, using the price classes of the six summer select sales of 1960, 1965 and 1970. Six objective measures were established:

(1) a "successful horse" ($100,000 career earnings, as before)

(2) a "top horse" (Grade I stakes winners)

(3) SSI > 7.5 (or the top 1% of all starters)

(4) SSI > 12 (or the top .5% of all starters)

(5) SSI > 20 (or the top .2% of all starters)

(6) SSI > 30 (or the top .1% of all starters)

Relative investment scales, analagous to those derived in the previous section for the combined 1960-1965-1970 Select Sales, were also calculated, using three possible gestation periods-- the end of the three-year old season, the middle of the three-year-old campaign, and the end of the two-year-old season. (See Table VI.)

TABLE VI

INVESTMENT SCALE: BY INVESTMENT CLASS

2.5 YEAR GESTATION PERIOD

	I	II	III	IV	V
1960	1	1.31	1.91	3.17	5.75
1965	1	1.27	1.80	2.87	6.01
1970	1	1.34	1.90	3.14	7.80
1973	1	1.39	2.17	3.84	7.41
1975	1	1.32	1.94	3.30	8.99
1977	1	1.45	2.24	4.02	8.34
1978	1	1.47	2.40	4.10	9.88
1979	1	1.48	2.38	4.28	11.49
1980	1	1.53	2.41	4.50	11.11

TABLE VI (Cont'd)

INVESTMENT SCALE: BY INVESTMENT CLASS

2.0 YEAR GESTATION PERIOD

	I	II	III	IV	V
1960	1	1.36	2.05	3.52	6.52
1965	1	1.31	1.93	3.18	6.82
1970	1	1.39	2.05	3.49	8.93
1973	1	1.45	2.33	4.24	8.30
1975	1	1.36	2.07	3.64	10.17
1977	1	1.51	2.40	4.43	9.33
1978	1	1.53	2.58	4.50	11.02
1979	1	1.54	2.55	4.68	12.77
1980	1	1.59	2.58	4.91	12.30

TABLE VI (Cont'd)

INVESTMENT SCALE: BY INVESTMENT CLASS

1.5 YEAR GESTATION PERIOD

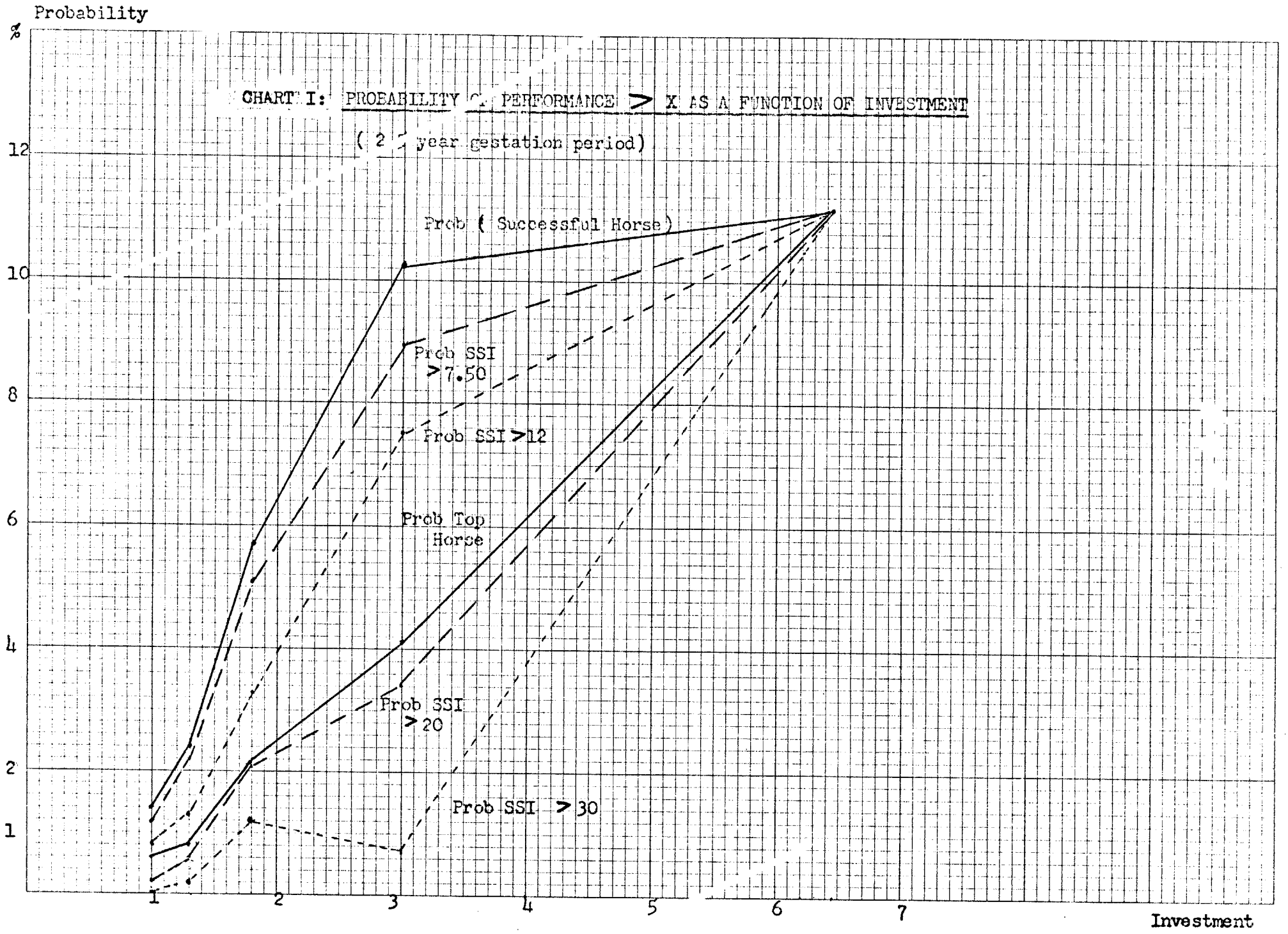
	I	II	III	IV	V
1960	1	1.43	2.25	4.00	7.56
1965	1	1.37	2.12	3.61	7.98
1970	1	1.47	2.26	3.99	10.50
1973	1	1.52	2.55	4.76	9.48
1975	1	1.43	2.26	4.10	11.75
1977	1	1.59	2.62	4.96	10.62
1978	1	1.60	2.81	4.99	12.44
1979	1	1.62	2.76	5.20	14.41
1980	1	1.68	2.81	5.46	13.90

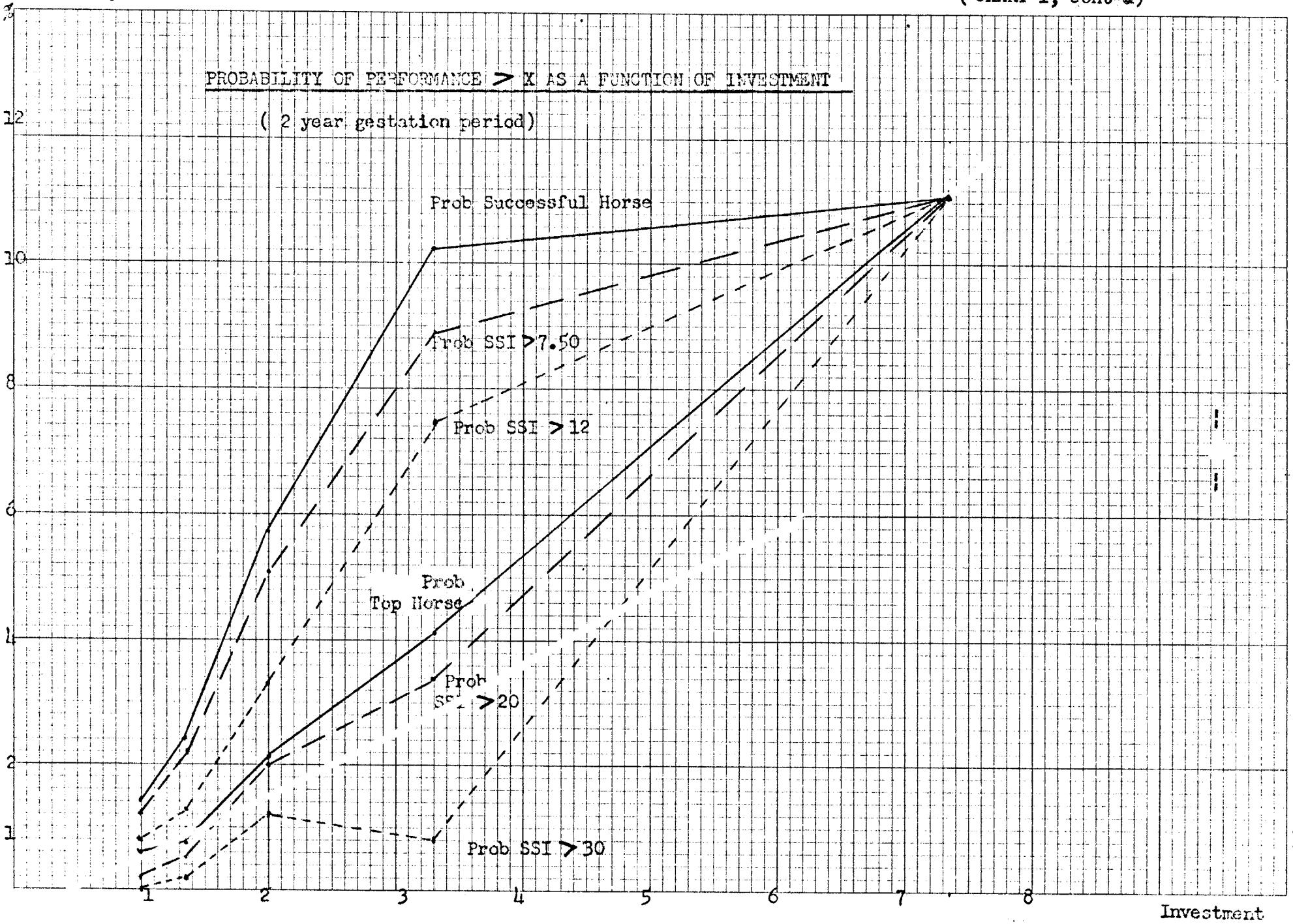
Probabilities of performance in excess of the given criteria were then calculated by taking the number of horses meeting the criteria, within each investment class, as a percentage of the total number of individuals in that class, and plotted versus investment. (See Chart I.) Probabilities of success are synonomous with expected gain. Each yearling should be considered as a lottery ticket with a given probability of winning a known extremely large reward and with an ex post value of zero, for failure. Regressions of the form:

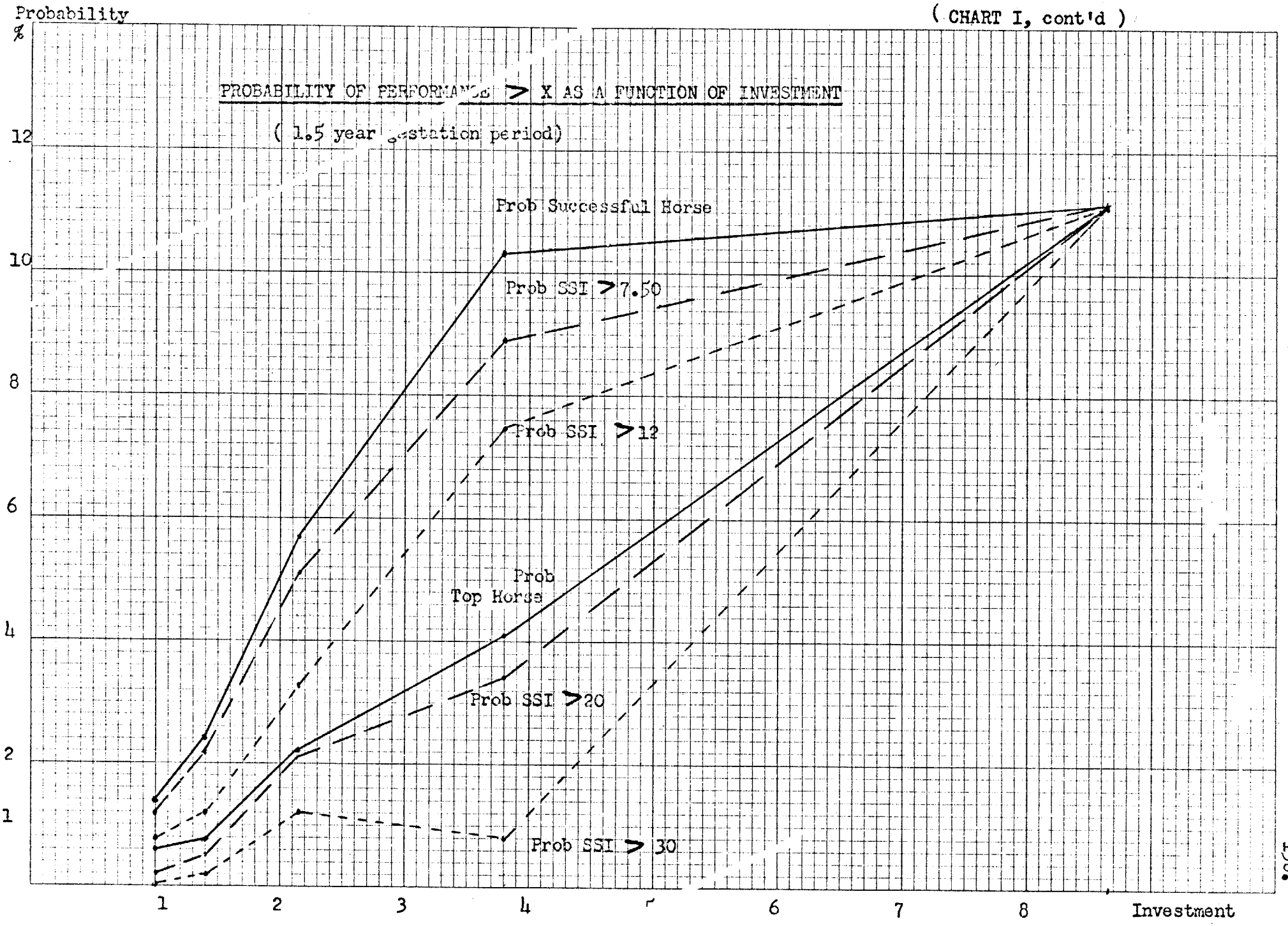
$$\text{Prob (performance} > X) = a + b \times \text{Investment}$$

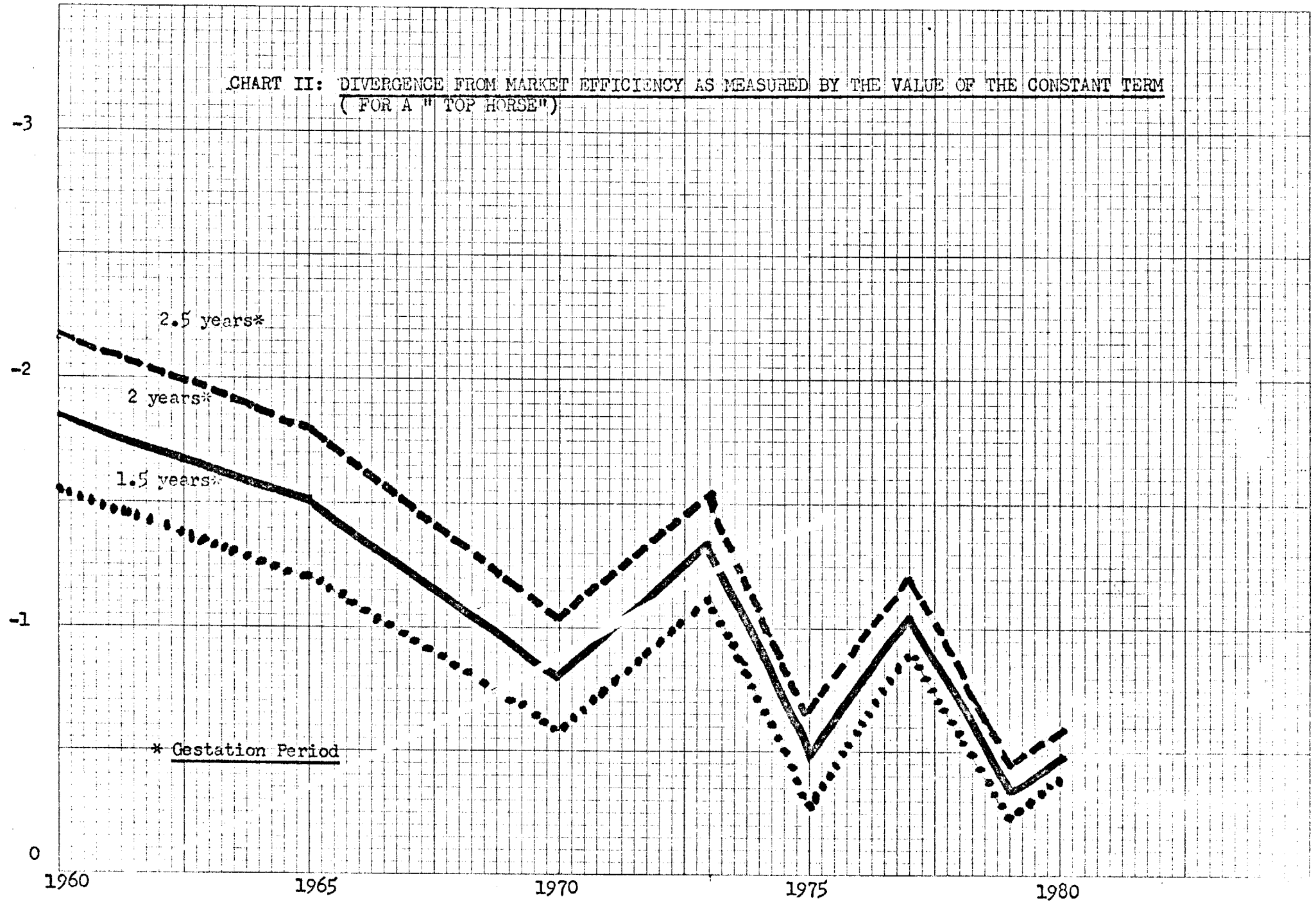
yielded a value of the constant term which was negative and statistically significant at the 95% level for the three most stringent performance criteria. (See Chart II.) For the remaining three measures, its value was at all times of extremely low statistical significance (t statistic < 1) and varying in sign. The coefficient b or slope parameter represents the increase in probability of success per unit investment and, when the constant term is zero, also the probability of success per unit investment. (To be discussed in Section V.)

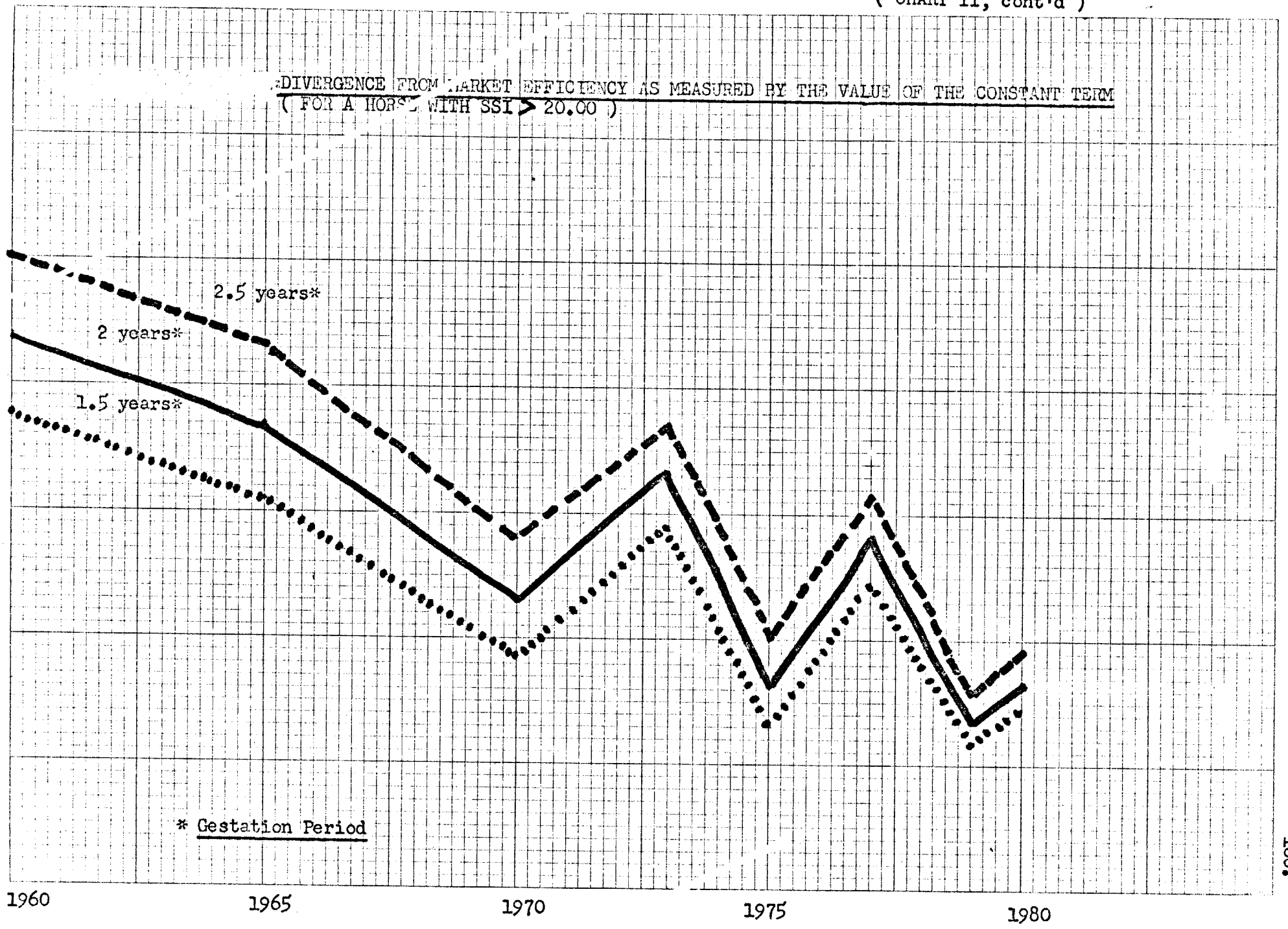
Market efficiency would require a constant probability of success per unit investment, irregardless of the scale of expenditure, so that one dollar, whether placed in a low-priced yearling or a high-priced


Probability
%
CHART I: PROBABILITY OF PERFORMANCE > X AS A FUNCTION OF INVESTMENT
(2 ½ year gestation period)
12
10
8
6
4
2
1
Prob (Successful Horse)
Prob SSI >7.50
Prob SSI >12
Prob Top Horse
Prob SSI >20
Prob SSI >30
1
2
3
4
5
6
7
Investment


Probability
PROBABILITY OF PERFORMANCE > X AS A FUNCTION OF INVESTMENT
(2 year gestation period)
Prob Successful Horse
Prob SSI >7.50
Prob SSI > 12
Prob Top Horse
Prob SSI > 20
Prob SSI > 30
12
10
8
6
4
2
1
1
2
3
4
5
6
7
8
Investment


Probability
%
PROBABILITY OF PERFORMANCE > X AS A FUNCTION OF INVESTMENT
(1.5 year gestation period)
12
10
8
6
4
2
1
Prob Successful Horse
Prob SSI >7.50
Prob SSI >12
Prob
Top Horse
Prob SSI >20
Prob SSI > 30
1
2
3
4
6
7
8
Investment


CHART II: DIVERGENCE FROM MARKET EFFICIENCY AS MEASURED BY THE VALUE OF THE CONSTANT TERM
(FOR A " TOP HORSE")
-3
-2
-1
0
2.5 years*
2 years*
1.5 years*
* Gestation Period
1960
1965
1970
1975
1980


DIVERGENCE FROM MARKET EFFICIENCY AS MEASURED BY THE VALUE OF THE CONSTANT TERM
(FOR A HORSE WITH SSI > 20.00)
-3
-2
-1
0
2.5 years*
2 years*
1.5 years*
* Gestation Period
1960
1965
1970
1975
1980

(CHART II, cont'd)



option, would yield the same expected return. Any negative value of the constant term in the equation, significantly different from zero, would imply that the probability per unit investment rises with investment, reflecting an under-valuation of high-priced, high-probability yearlings. It should be noted that a zero value on the constant term for the 1960-70 time span would require an implausibly short gestation period (less than a year) which would precede the racetrack debut of most of the summer sale yearlings. Although some feeling of ability can be perceived before real racing begins, many past three-year old champions and classic winners, and even some past two-year old champions, have given no indication of class this early in their careers.

Market ignorance of the true probability distribution, risk aversion and investment indivisibilities, proffer possible reasons for the "inefficiency" revealed. The argument that mere participation in the market is a source of substantial psychic income might also be advanced. If the first two explanations are valid, the inefficiency can be identified as a disequilibrium phenomenon which will be self-correcting over time. As the market continues to meet, and the outcomes of previous decisions become known, the market's estimate of the probability distribution should converge to its rationally expected value. It must be underscored that this is a market which meets virtually once a year and requires a gestation period of more than two years to establish results. If risk aversion and financial indivisibilities have led to an under-valuation of high-priced options,

then institutions should arise, permitting risk diversification at low investment levels. This institutional change has occurred. Since 1970, the syndicates of buyers which have become a major and now dominant force in the purchase of high priced yearlings, should have, and as will be seen, have, reduced their under-valuation. The final consideration--that mere participation in the select yearling market provides psychic income-- has limited validity. It is worth repeating that there are far less costly and more expeditious means of gaining access to thoroughbred racing in the form of non-select yearling sales, the purchase of horses of racing age, or claiming horses at the track, all avenues that almost vitiate the possibility of top-horse ownership. At the highest level, psychic income is virtually identical to success on the race track, which in turn is highly correlated with financial yield, another reason why the extreme under-valuation of high-priced, high-probability yearlings cannot be so easily explained away.

IV. HAS THE MARKET'S SEARCH FOR THE TOP HORSE BECOME MORE EFFICIENT OVER TIME?

Market response to the institutional changes introduced in the 1970's and improved information flows was next explored, with a plotting of performance over time. The means of each investment class were calculated and deflated by the mean of the lowest class to obtain a relative price scale for the 1973, 1975, 1977, 1978, 1979 and 1980 sales, independent of the absolute level. Since probabilities of

success from the previous 1960-70 study were utilized, a key assumption in this test is that the relative, not the absolute, probabilities of obtaining high-performance horses remain invariant from the 1960-70 sample population to that of the 1973-80 period. Once this is accepted as reasonable, the same six objective and increasingly stringent measures of racing performance can be regressed on three investment scales, as determined by holding periods of 1.5 years, 2.0 years and 2.5 years. As market efficiency improves, the time trend on the value of the constant term should converge to zero, equalizing probabilities per unit investment across investment classes. Though the number of observations is small (nine), limiting the significance of the extremely high R-squared statistics, the empirical results are remarkably consistent with market adjustment toward equilibrium for the three measures which had previously provided evidence against efficiency. The value of the constant term rose

> for a gestation period of 2.5 years: from - 3.34 to -2.17 in 1960 to -1.91 to -.62 in 1980.
>
> for a 2.0 year holding period: from -3.02 to -1.85 in 1960 to -1.79 to -.50 in 1980.
>
> for a 1.5 year holding period: from -2.71 to -1.55 in 1960 to -1.67 to -.39 in 1980.
>
> (Again, see Chart II.)

Results were statistically significant at the 90% level throughout. Values of Durbin-Watson statistics near 3.00 were obtained but only in less than 5% of the cases-- equal to that of random occurrence-- and did

not provide evidence of serial correlation in the error term. The credibility of the path of market adjustment toward equilibrium was substantiated by repeating the procedure with the three less stringent measures of success which had previously revealed consistency with market efficiency and which continued to do so over time.

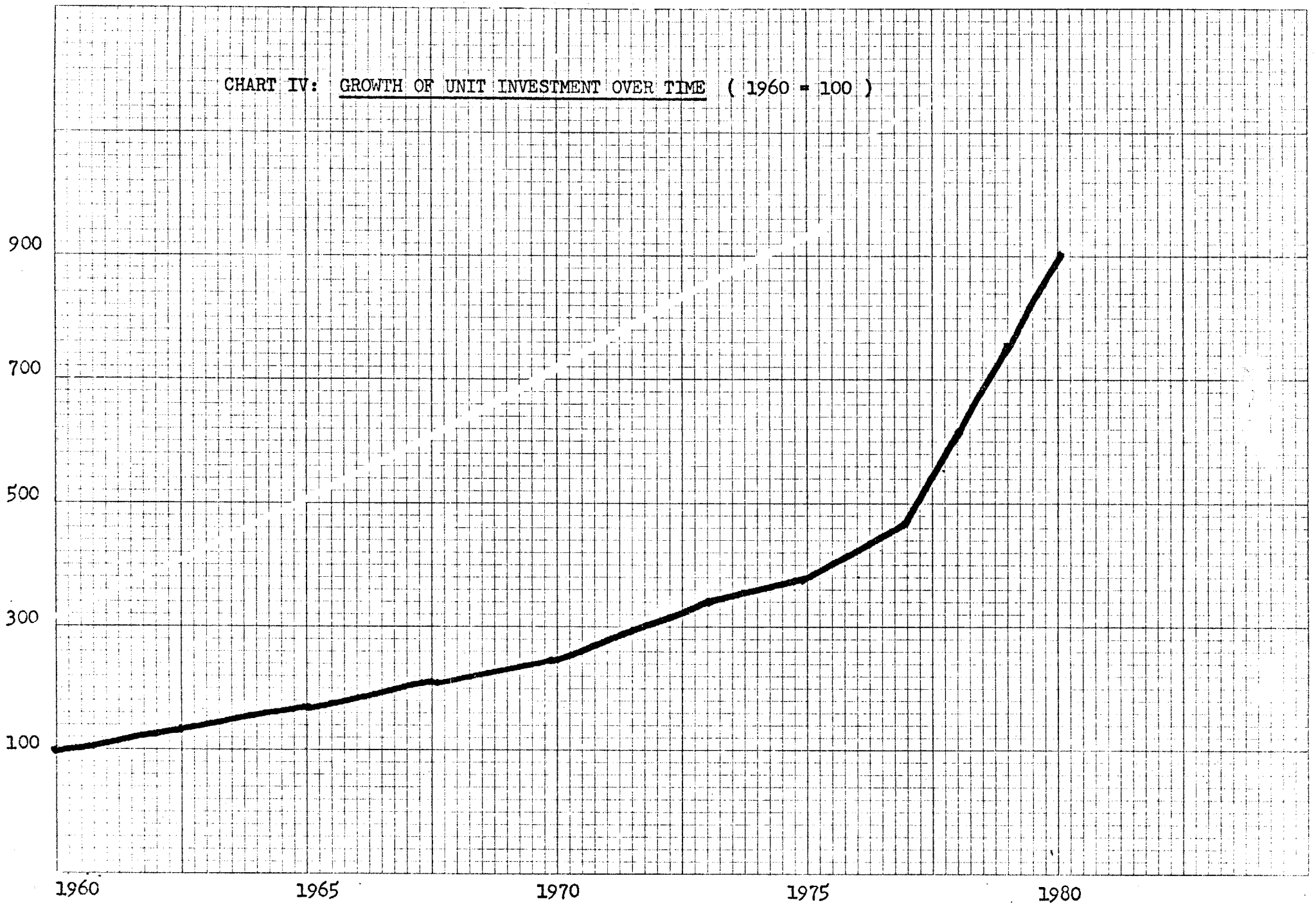
V. DOES THE RISE IN YEARLING PRICES OVER TIME ACCURATELY REFLECT CHANGING PROBABILITIES AND CHANGING REWARDS?

Focusing on the coefficient on investment, the same data and equations utilized in Section IV were re-examined. This was found to have virtually the same value for all six measures of performance, within each time period; however the common value exhibited a substantial 32.5% decline over the 1960-70 period. As the constant term approaches zero, as indicated in Section IV, the coefficient on investment can be equated with the probability of finding a top horse per unit investment. Following the methodology, used in Section IV, the coefficient on investment was derived for the 1973 through 1980 time span. Results illustrated the same sharply declining trend, dropping in 1980 to 46% of its 1960 value. (See Chart III.)

The time path of the size of the investment unit was also plotted, using appropriate purchase prices, training costs, and discount rates. This rose to nine times its initial value in two decades. (See Chart IV.)


CHART III: PROBABILITY / UNIT INVESTMENT OVER TIME (1960 = 100)
100
80
60
40
20
1960
1965
1970
1975
1980

CHART IV: GROWTH OF UNIT INVESTMENT OVER TIME (1960 = 100)



From these two, the trend of an implied reward index was derived, defined as the value of rewards which, given the probabilities of success, justifies the unit investment. (It corresponds to the index of residual value, within the craze, which bears out expectations and accurately forecasts aggregate movements. See Section VIII.) The derived index was then regressed against an actual reward path (an index of the average value of the six top colts, syndicated in the three-year period straddling the reference year). This moving average process seemed appropriate, since the end of a horse's racing career and the timing of the syndication date within this career are not uniformly fixed.

$$\text{Index of Implied Reward} = \frac{\text{Index of Unit Investment}}{\text{Index of Probability per Unit Investment}}$$

This index was found to be an excellent predictor of actual reward over the 1960-1980 period; results yielded a highly statistically significant coefficient on implied reward of 1.02 within .25 standard deviations of its theoretically hypothesized unit value, while the value of the constant term proved statistically insignificant, leading to acceptance of the assumption that its true value is zero.

$$\underset{\qquad\qquad (.44)^* \quad (12.41)^*}{\text{Actual Reward} = .37 + 1.02 \times \text{Implied Reward}}$$

R-squared = .96 Durbin-Watson Statistic = 2.27

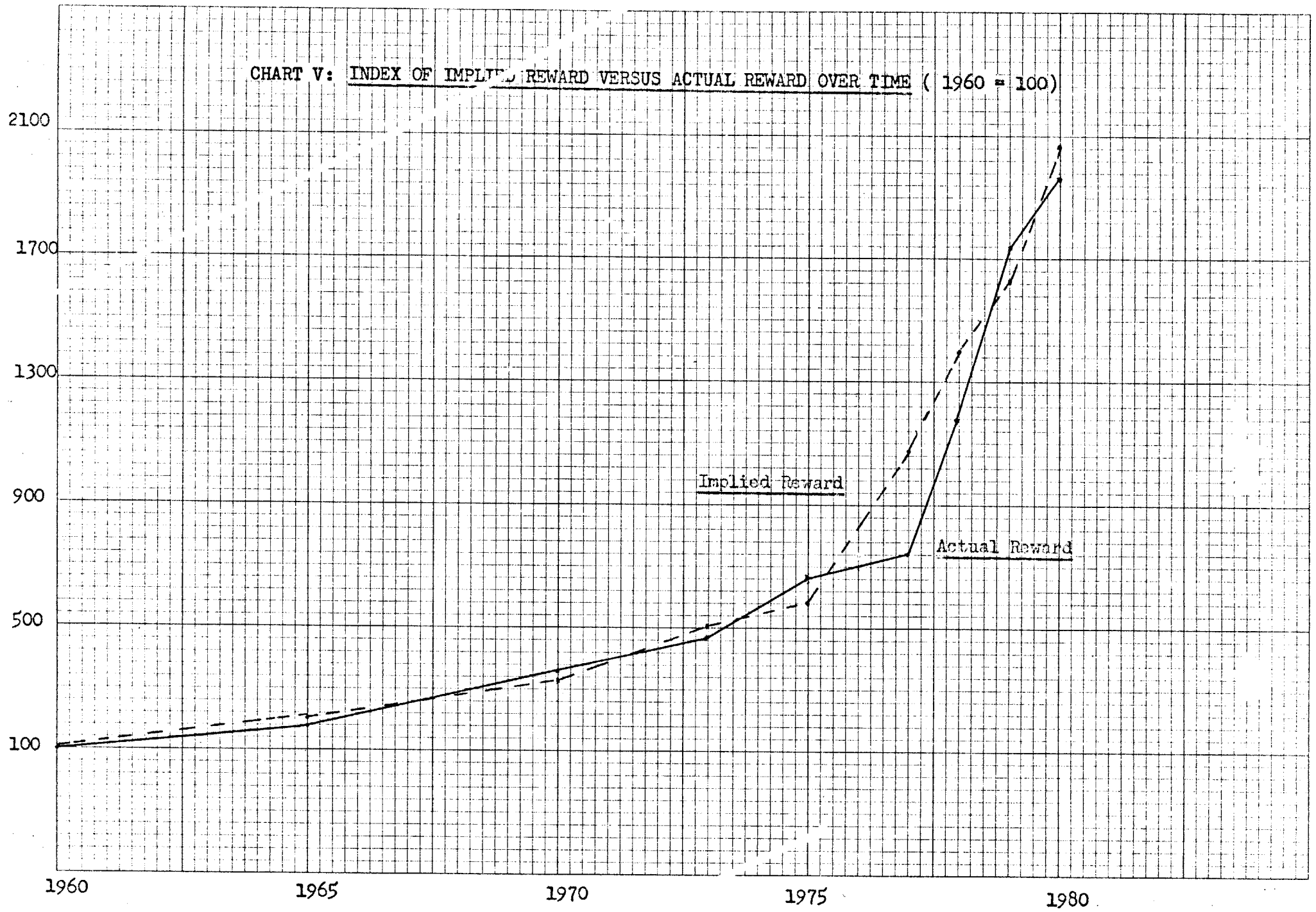
Number of Observations = 9

* t statistics in parentheses

Summing up, the market value of the options over time, as determined by the size of the unit of investment, reflected an accurate assessment of the probabilities and potential rewards and aggregate efficiency. (See Chart V.)

VI. FROM THE GENERAL TREND TO THE INDIVIDUAL OPTION: A MODEL TO IDENTIFY INFLUENCES ON PRICE AND A MODEL TO PREDICT PERFORMANCE.

Every thoroughbred has been bred to run; the difference between the best and the worst is a matter of split seconds. Humphrey Finney said it simply, "The single most important thing about a horse can't be seen: the heart spells a runner or it doesn't." Big breeder Leslie Combs II noted, "Six of the most important things about a champion race horse, you can't feed into it (the computer). That's class, intelligence, conformation, courage, soundness and the combination of bloodlines. Two of the factors, conformation and soundness are evident to the eye, but the other four are completely intangible." Therefore, it becomes a queston of establishing proxies and appropriate scales for these qualities. Adding to the unpredictables, the earnings of any runner in a given year are a function not just of his own ability but of that of the competition. Many a merely good horse has been a classic winner in a season of mediocre runners, while what might have been a great horse in another year ends up as just another also-ran, as was the case of the


CHART V: INDEX OF IMPLIED REWARD VERSUS ACTUAL REWARD OVER TIME (1960 = 100)
2100
1700
1300
900
500
100
1960
1965
1970
1975
1980
Implied Reward
Actual Reward

outstanding Sham who always stood in Secretariat's shadow or, in 1979, Alydar who finished "just a dirty nose" behind Affirmed in every major race for two years. What will happen after the yearling leaves the sales ring is another dark area. The skill of the trainer and the patience of the owner are critical, while the accidents of training and racing and the everyday hazards of handling what are delicate and excitable athletes compound the risk. (17 or 23% of the 75 most expensive yearlings of the past 15 years never even reached the track.)(9)

In an attempt to identify and refine the signals available to market participants at the date of sale, interviews were conducted with top agents, breeders and buyers. From these, a group of factors emerged which represented a concensus of expert opinion. Some were thought to be true indicators of racing potential; others were suggested a fashionability-- linked and possibly potent in the explanatory power of price. Purchasers have easy access to the facts, via catalogue pages, reference material, and the possibility for private physical inspection, with the counsel of trainers and veterinarians. Taking the 1970 Keeneland summer auction as a sample, thirteen different variables were compiled for the entire populaton of 261 yearlings. Since the group was homogenous in time period, actual dollar prices were used.

Factors relating to the individual:

(1) Price

(2) Conformation which describes overall physical excellence and covers both visual appeal and an indication of athletic ability and soundness. Bone structure, balance, defects in the way of going, and minor flaws that may develop into major disabilities under racing stress, should all be carefully evaluated. Yearlings were rated on a scale of 1-5 (low to high) based on the inspection records of Dr. Arthur Davidson, the veterinarian who passes all yearlings for inclusion in the sale.

(3) The Breeder, if his past record of continuing public relations effort has achieved product differentiation which induces consumers to pay a premium price. Three breeders qualified, who together accounted for 24% of the offerings; Spendthrift Farm, Gainesway Farm and Tom Gentry. A 0-1 dummy variable was used.

Factors relating to the sire:

(4) Stud Fee is an indicator of the value which the market places on the sire, one which fluctuates with the success of his progeny. The fee used was that for the 1971 season (set in mid-1970), not the one charged at the breeding of the yearling, three years earlier. Fees for the coming season reflect the same updated information that should influence buyers. Stud fees for the sale ranged from $1500 to $50,000, with a mean of $9700.

(5) Average Earnings Per Start reflects the importance of the purses and races won by progeny running in 1969, or about three crops on the track. Average for the sample was $1229, contrasted with a $355 nationwide average in 1969.

(6) Mystique or the inexplicable appeal of certain stallions is equivalent to star quality. Their yearlings command premium prices, above any visible or calculable value. Six sires in the sample answered this description, and were responsible for 20 yearlings: Graustark, Buckpasser, Bold Ruler, Ribot, Northern Dancer, and Sea Bird. A 0-1 dummy variable was used.

Tradition has it that "the family is far stronger than the individual" and not just the dam herself but the record of the second dam, both as runner and producer, is carefully screened. Since a great many of the mares with offspring at the top sales are untried at the track and have produced no foals of racing age, proxies must be relied upon. (It is not mere coincidence that such is the case; top broodmares are rare and sales companies prefer to let imagination guide the bids rather than what might be unpalatable fact.)

Factors relating to the bottom line:

(7) The Dam's Earnings at the track, as a quantitative dollar figure.

(8) Full-Sisters to championship runners or producers are in demand, under the assumption that a successful crossing of bloodlines will transmit the same characteristics, perhaps a generation later. There were 14 of these in the sample.*

(9) Half-Sisters to top runners or producers (related through the female line) are valued for the same reasons. There were 44 of these in the sample.*

(10) A yearling with Full Siblings which were big winners has a premium value. Again, there is the expectancy that the felicitous combination of the same sire and dam will be duplicated. There were 9 of these in the sample.*

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* The scales used in factors (8), (9), (10), and (11) reflect both earning potential and residual value and were cleared with three experts. All were 0, 1 and 10.

(11) A Yearling with Half Siblings with a high performance record (related through the female line) is also valued, but not as highly. This measure doubles as a qualitative overview of the dam's production record. There were 27 of these in the sample.*

Factors relating to the yearling's performance record:

(12) Dollar Earnings

(13) Standard Starts Index. (See Section II.)

First, in an effort to determine the signals used by the market in its valuation of yearling prospects, a model was set up which focused on price. (See Table VII.)

A second analysis tested semi-strong market efficiency for the 1969 Keeneland Summer Sale, according to the definition of Fama and others: was there any information, publicly available at the time of the sale, which predicted performance and was not fully reflected in market price.(10) To measure the market's skill in evaluating prospects, two simple ordinary least-squares regressions related the two measures of performance to price. These will be considered as the "efficient markets" or restricted models.

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* The scales used in factors (8), (9), (10), and (11) reflect both earning potential and residual value and were cleared with three experts. All were 0, 1 and 10.

TABLE VII

A MODEL TO EXPLAIN PRICE

	Estimated Coefficient	t Statistic
Conformation	4,377	3.89
Breeder	4,542	1.65
Stud Fee	.8794	3.63
Average Earnings per Start (of sire's progeny)	2,808	1.47
Mystique	16,875	3.67
Dam's Earnings	.05792	2.09
Dam, if Full Sister	13,042	2.53
Dam, if Half Sister	2,010	3.14
Yearling, if Full Sibling	43,029	23.64
Yearling, if Half Sibling	2,107	3.22

R-squared = .78 Number of Observations = 261

Price as Predictor of Dollar Earnings

Earnings = 15,449 + .5177 x Price
(3.65)* (4.36)*

R-squared = .06 Number of Observations = 299

Standard Error of the Regression = 50,975

Price as Predictor of Standard Starts Index (SSI):

SSI = .961 + .0000432 x Price
(2.36)* (3.79)*

R-squared = .05 Number of Observations = 299

Standard Error of the Regression = 4.87

* (t statistics in parentheses)

To test the rationality of the market, an a priori assumption was made that two important factors which influence a racehorse's performance are its conformation and the produce record of its dam. To discover whether this information, readily available to the buyers who determined the prices at the 1969 Keeneland Select Sale, was efficiently utilized, regressions of the following form were run:

Performance = a + b x conformation + c x Yearling, if half or full sibling

Coefficients were found to be positive, as hypothesized and highly statistically significant. The explanatory power and standard error of the regressions compared favorably with those relating performance to price. (See Table VIII.)

TABLE VIII

A MODEL TO EXPLAIN TWO MEASURES OF PERFORMANCE

TO EXPLAIN DOLLAR EARNINGS:

	Estimated Coefficient	t Statistic
Conformation	6930	2.67
Yearling, if Half or Full Sibling	7286	4.73

R-squared = .09 Standard Error of Regression = 50,171

Number of Observations = 299

TO EXPLAIN STANDARD STARTS INDEX (SSI):

	Estimated Coefficient	t Statistic
Conformation	.549	2.17
Yearling, if Half or Full Sibling	.478	3.19

R-squared = .05 Standard Error of Regression = 4.88

Number of Observations = 299

In contrast to the earlier efficient markets model of performance prediction, which would restrict itself to price as the only valuable information source, an unrestricted model was derived:

Performance = a + b x Conformation + c x Yearling, if half or full sibling
+ d x Price

In the performance regression involving dollar earnings, both conformation and the produce record of the dam remained significant at the 1% level while, although coefficients in the regression dealing with the Standard Starts Index remained significant at only the 10% level, a test of the joint hypothesis that both were zero can be rejected at the 5% significance level by use of an F test. (See Table IX.) These regressions were then used to test the efficiency of the market through the relative forecasting abilities of the efficient markets and unrestricted models.

VII. TESTING THE PERFORMANCE MODEL: A PROJECTION FOR ANOTHER POPULATION

Yearlings from the 1970 Keeneland Select Sale, a group closely related to that from which the performance models were derived, were used to test the validity of performance projections generated by the

TABLE IX

AN UNRESTRICTED MODEL TO PREDICT TWO MEASURES OF PERFORMANCE

TO PREDICT DOLLAR EARNINGS:

	Estimated Coefficient	t Statistic
Conformation	5974	2.30
Yearling, if Half or Full Sibling	.5544	3.27
Price	.311	2.40

R-squared = .10 Standard Error of Regression = 49,774

Number of Observations = 299

TO PREDICT STANDARD STARTS INDEX (SSI):

	Estimated Coefficient	t Statistic
Conformation	.452	1.79
Yearling, if Half or Full Sibling	.303	1.84
Price	.0000313	2.48

R-squared = .07 Standard Error of Regression = 4.84

Number of Observations = 299

restricted (efficient markets) and unrestricted models.*

$$\text{Actual Performance} = a + b \times \text{FORE}$$

$$\text{Actual Performance} = c + d \times \text{FORU}$$

FORE: Efficient markets forecast of performance.

FORU: Unrestricted forecast of performance.

Forecasts of performance for this new population were generated via both formulas and regressed against the realities of dollar earnings and SSI. For both measures of performance, the unrestricted models demonstrated marked superiority over the efficient markets models. The values of the coefficients on the unrestricted forecasts were closer to their optimal value of unity, while their statistical significance was substantially greater. The explanatory power of the equations using unrestricted forecasts averaged 248% that of the restricted models. Further, the value of the constant term in the equations using unrestricted forecasts was closer to its hypothesized value of zero than was its restricted counterpart, as was also its statistical significance. In addition, the correlation coefficient between the actual and the projected performance, from the unrestricted models, averaged 156% that of the efficient markets predictions. (See Table X.)

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* Since prices rose 20% from 1969 to 1970, the estimated coefficients on price were correspondingly adjusted downward in the forecast-generating equations.

TABLE X

COMPARISON OF RESTRICTED AND UNRESTRICTED PROJECTIONS

	Efficient Markets Model	Unrestricted Model
DOLLAR EARNINGS:		
Estimated Coefficient on Forecast	.755	1.034
t statistic	2.88	5.28
R-squared statistic	.03	.10
Standard Error of the Regression	68,795	66,407
Est. Coefficient on Constant Term	10,103	-2640
t statistic	1.17	- .34
Correlation Coefficient	.176	.312
Number of Observations	261	
STANDARD STARTS INDEX (SSI):		
Estimated Coefficient on Forecast	.839	.971
t statistic	4.18	5.81
R-squared statistic	.06	.12
Standard Error of the Regression	4.40	4.28
Est. coefficient on Constant Term	.503	-.085
t statistic	1.01	-.18
Correlation Coefficient	.251	.340
Number of Observations	261	

In sum, regression analysis and forecasting performance alike prove that the collective view of the marketplace, as equated with price, does not reflect all signals publicly available at the time of the sale. Two high profile factors, conformation which can be rated by examination of the yearling, with or without an expert opinion, and the dam's produce record which appears in bold type at the top of each catalogue page and is made much of during announcements at the very instant of sale, have been undervalued. The inexperience of buyers, often reinforced by the counsel of self-styled experts is the obvious source of such faulty decision-making, for the market's composition changes each year. The latest tally shows that one third of all investors exit from the industry while more than one-third enter annually as the market expands.

When the obvious is so suboptimally utilized, speculation suggests that other factors, perhaps more arcane, must exist and may be employed, either consciously or instinctively, by the small group of insiders who have devoted a lifetime of labor to the field and consistently obtain superior results.

VIII. RATIONAL INVESTMENT OR MANIA?

Trading in thoroughbreds exhibits many of the classic symptoms and the classic cast of characters of the speculative bubble. Prices are rising consistently, at an accelerated pace in relation to the economy, and are not based upon an outside earnings potential, such as racing

purses. Rather, the speculative spiral is self-nourished. The enthusiasm for syndication, and the publicity attendant upon multi-million dollar gains, has created a sequence of self-fulfilling expectations. Yearling prices rise because of the increase in anticipated residual (reproduction) value; stud fees and broodmare prices follow yearling prices; syndication prices continue the spiral. The brisk bidding at the 1980 breeding stock sales, where prices were double those of 1979, was basing estimates on an extrapolation of past growth trends to calculate the probable value of offspring.

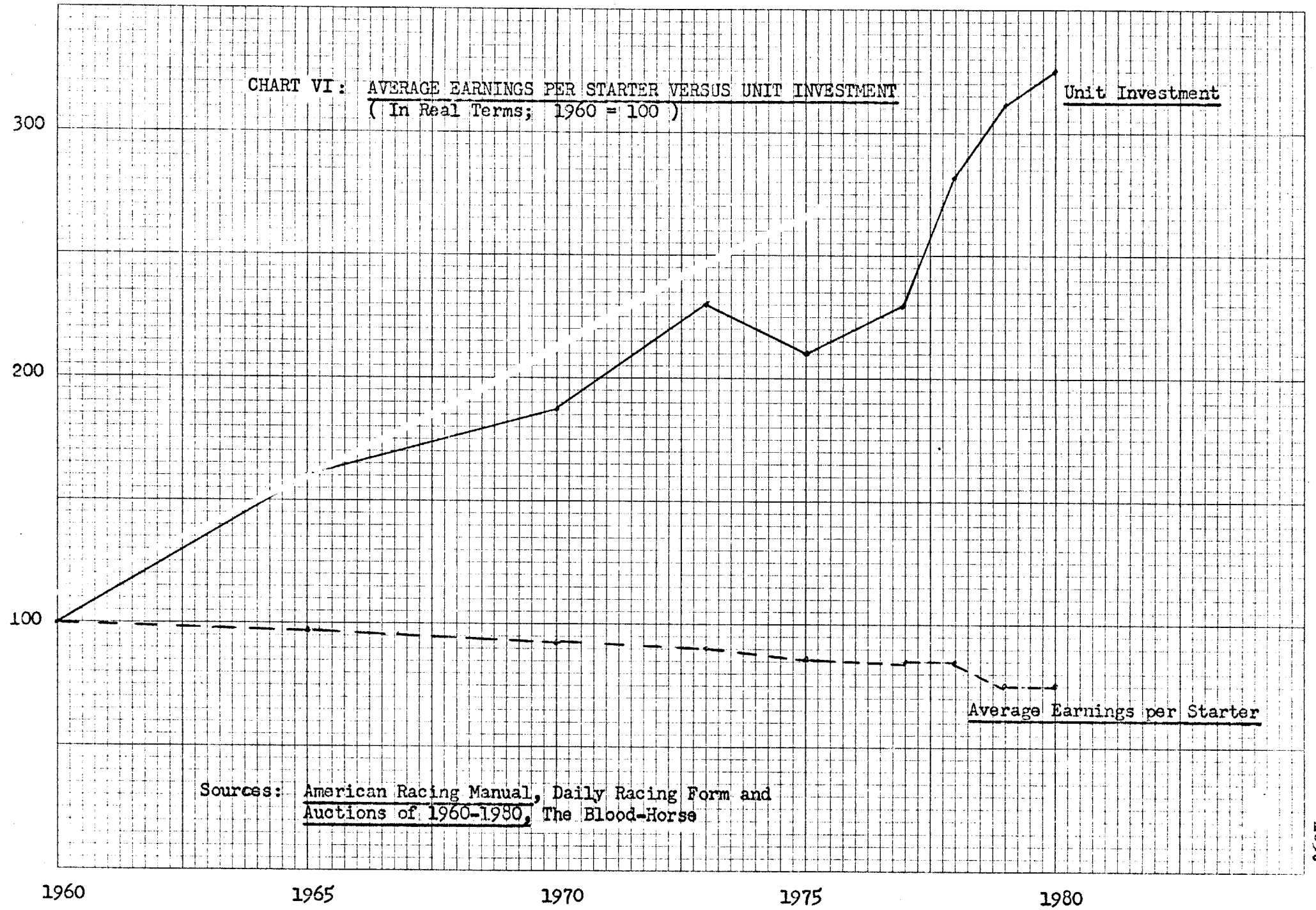
The market is divided between a group of knowledgeable insiders and a constant inflow of inexperienced investors who incorrectly utilize market information and signals, lose money on the average, often in vast amounts, and exit from the marketplace. There are signs of withdrawal by the oldtime thoroughbred community which is increasingly prone to offer top yearlings at auction rather than retain them for racing, as in the past, and to cash in prized broodmares and stallion shares for premium profits. However, new recruits to speculation have overbalanced the retreating insiders. In this can be found the source for the inefficiency which has been proven to exist <u>within the bubble</u> -- an inefficiency which, by its very nature, is closely related to the bubble itself. (See Sections VI and VII.)

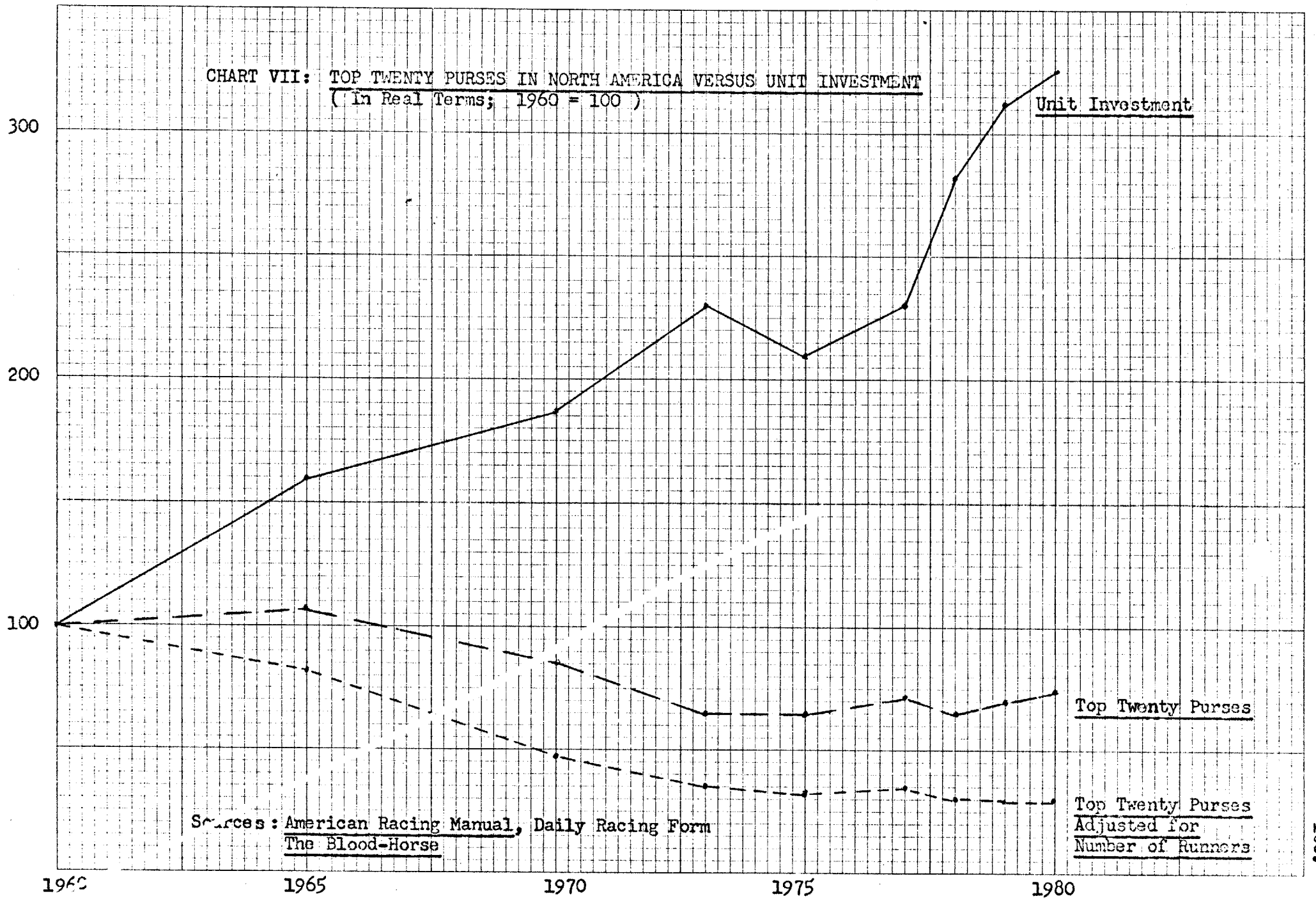
In an overview of price movements of the aggregate, the market has been shown to follow a rational expectations path. (See Section V.) Why this path is also <u>divergent</u> will be explored, to corroborate the

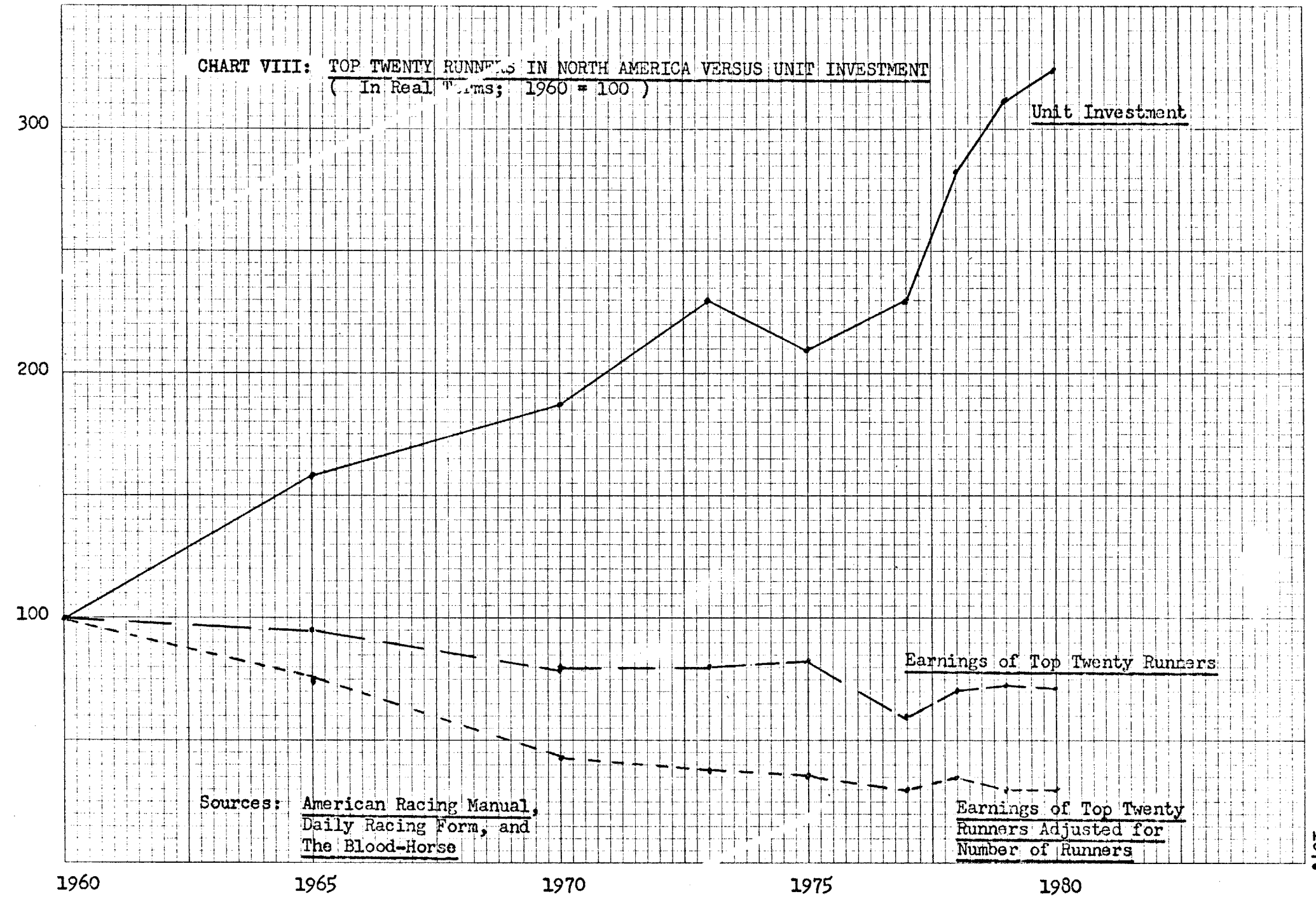
bubble hypothesis. If the ultimate purpose of a thoroughbred is reproduction machinery, then its value should logically be related to the earnings potential of the offspring, as measured by racetrack results. If, on the other hand, mania elements predominate, this value will relate to its role as producer of yearlings whose own rising prices are founded on reproductive value rather than racetrack potential.

To investigate the path of logical reward, four possible indices, based on racetrack earnings, were created and plotted versus the unit investment (smallest investment possible) of the select yearling sales over the 1960-1980 period. None could explain the rapid rise of yearling prices!

> average earnings per starter, during the 1960-1980 period fell 26% in real terms while the unit investment rose by 225%. (See Chart VI.)
>
> focusing on participants in the select sale market who are searching for the top horse rather than the average runner, were two further indices:
>
> the total value of the top twenty purses in North America which actually fell 27% in real terms between 1960 and 1980.
>
> the annual earnings of the top twenty runners in North America which fell 29% in real terms over the same interval.
>
> when these two measures are adjusted for the diminishing probability of winning such a purse or finding such a runner in the face of an ever-growing number of starters, the logical value of the unit investment fell 69% between 1960 and 1980, again in sharp contrast to the 225% real rise in investment. (See Charts VII and VIII.)


CHART VI: AVERAGE EARNINGS PER STARTER VERSUS UNIT INVESTMENT
(In Real Terms; 1960 = 100)
Unit Investment
Average Earnings per Starter
300
200
100
1960
1965
1970
1975
1980
Sources: American Racing Manual, Daily Racing Form and
Auctions of 1960-1980, The Blood-Horse


CHART VII: TOP TWENTY PURSES IN NORTH AMERICA VERSUS UNIT INVESTMENT
(In Real Terms; 1960 = 100)
300
200
100
1960
1965
1970
1975
1980
Unit Investment
Top Twenty Purses
Top Twenty Purses Adjusted for Number of Runners
Sources: American Racing Manual, Daily Racing Form
The Blood-Horse


CHART VIII: TOP TWENTY RUNNERS IN NORTH AMERICA VERSUS UNIT INVESTMENT
(In Real Terms; 1960 = 100)
300
200
100
Unit Investment
Earnings of Top Twenty Runners
Sources: American Racing Manual, Daily Racing Form, and The Blood-Horse
Earnings of Top Twenty Runners Adjusted for Number of Runners
1960
1965
1970
1975
1980

> the earnings of the top fifteen Keeneland Select Sale graduates which fell 13% over the period, contrasted once more with the rise of 225% in unit investment in real terms-- a test of the possibility that the quality of individuals offered in this sale has improved over time. A logical time path was obtained by calculating winnings for the most recent three years for which results were available and adjusting for the number of yearlings sold each year. (See Chart IX.)

Rather, it is the reproduction value of the yearling which provides the mobile behind rising prices. The path of unit investment, which diverges so widely from any logical earnings trend, conforms closely to a plot of the reproductive value of top stallion prospects. The syndication price of the top six colts, within a three year period straddling the reference year, was seen as appropriate measure, since the end of a horse's racing career and the timing of syndication within this career are not uniformly fixed. Adjustment was made for the number of starters in each year, again to take account of changing probabilities.

> this mania-linked measure followed the path of unit investment extremely well over time, rising 220% in real terms between 1960 and 1980, a growth virtually identical to the 225% rise in unit investment. (See Chart X.)

In this framework of a speculative market, any value for yearlings is rational as long as it rises at the correct rate.

In answer to the challenge that this apparently divergent path might be based on a rational earnings model, two possibilities should be examined and dismissed. The interaction of inflation and taxation has logically caused the real value of many assets to increase rapidly.

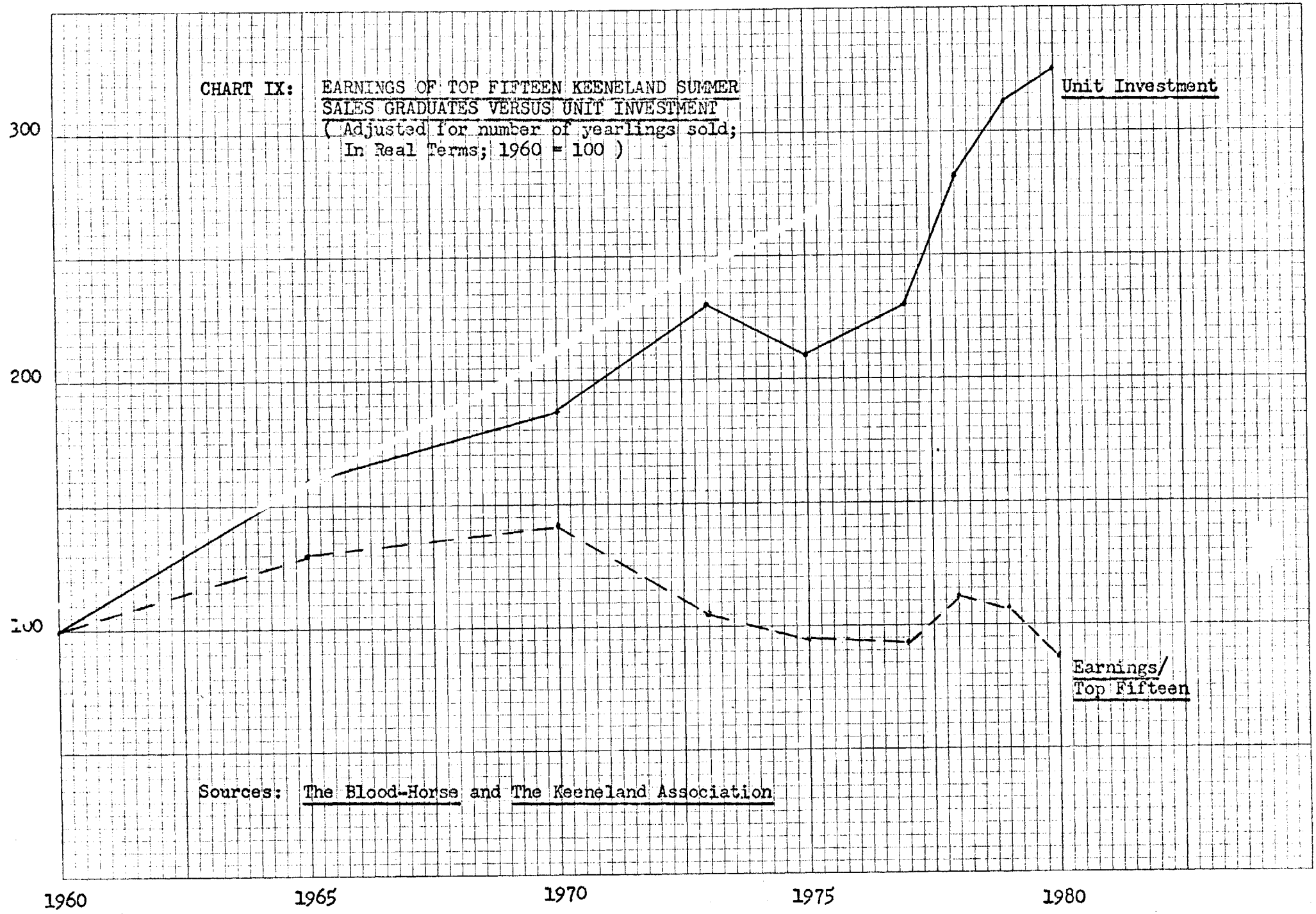
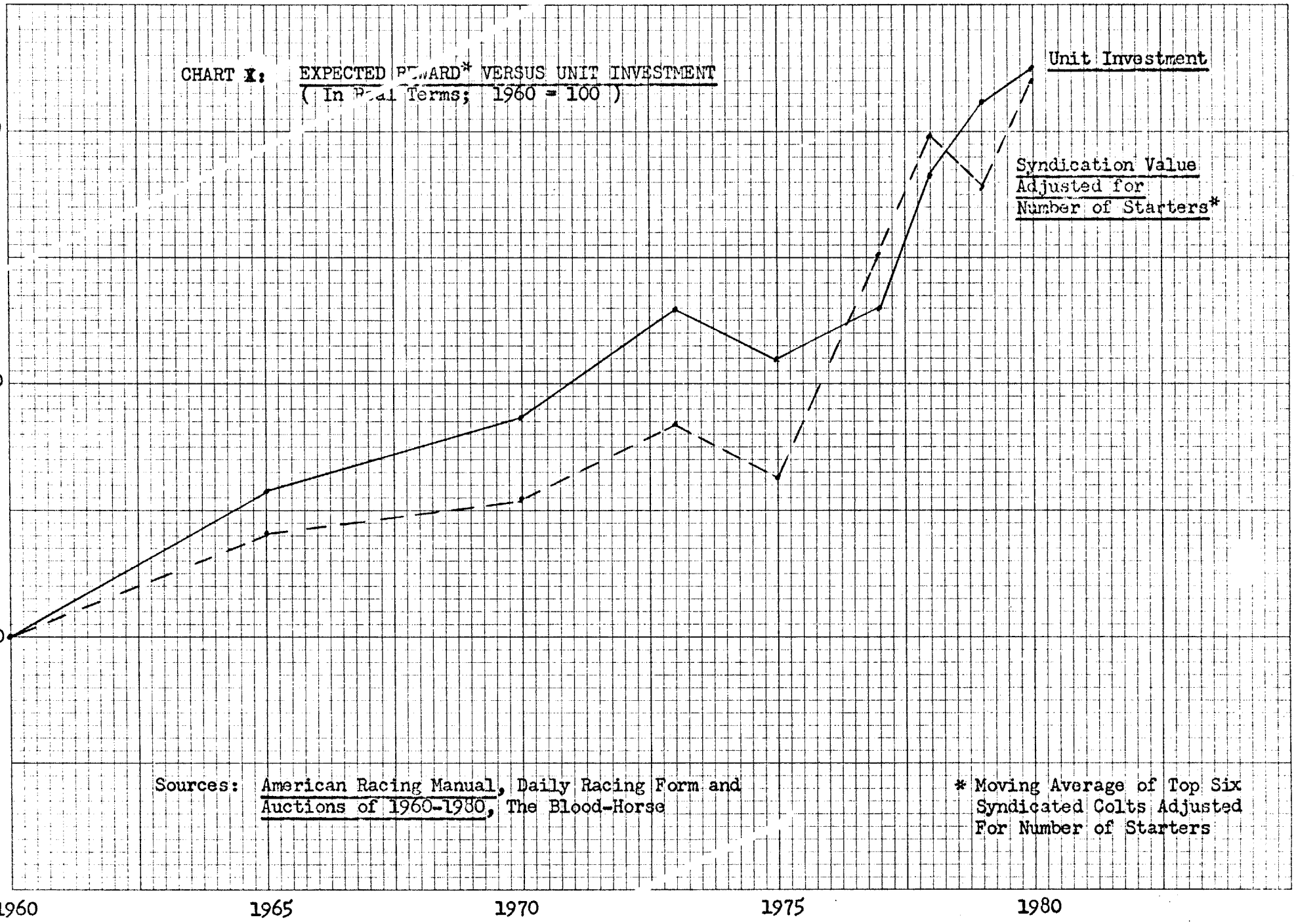

CHART IX: EARNINGS OF TOP FIFTEEN KEENELAND SUMMER SALES GRADUATES VERSUS UNIT INVESTMENT
(Adjusted for number of yearlings sold; In Real Terms; 1960 = 100)
Unit Investment
Earnings/ Top Fifteen
300
200
100
1960
1965
1970
1975
1980
Sources: The Blood-Horse and The Keeneland Association

CHART X: EXPECTED REWARD* VERSUS UNIT INVESTMENT
(In Real Terms; 1960 = 100)



Sources: American Racing Manual, Daily Racing Form and Auctions of 1960-1980, The Blood-Horse

* Moving Average of Top Six Syndicated Colts Adjusted For Number of Starters

However, racehorses cannot be included in this group, for inflation does not increase the size of the industry tax subsidy. Alternately, the accelerated expansion of the price/earnings ratio could be caused by a dramatic fall in the after-tax real discount rate used in evaluating progeny racetrack earnings. While the after-tax real interest rate has fallen over the 1960-80 time span, all of this decrease occurred in the 1970-80 sub-period. More important, during the 1960's, the real after-tax interest rate, as calculated by Summers, rose 64% (from 1.38% to 2.27%). Consequently, the 87% rise in thoroughbred real unit investment, in the face of a decline of between 8% and 58% in real earnings (depending on the measure chosen) over the 1960-70 interval, is clearly not related to discount rate movements. A deviant, though rational expectations, path remains the only valid explanation of the plummeting earnings/price ratio in the industry.

The preconditions of the speculative bubble are all distinguishing features of the select yearling marketplace--- simplicity of investment management, favorable tax treatment and non-reproducibility of assets.

An investor need not see his horse, not even from a table in the clubhouse bar, for syndicates of buyers have gradually come to dominate the top levels of the market, employing experts for the selection process and professional managers to govern the care, conditioning and career of the asset, while providing auxiliary legal and accounting services.

Tax treatment for investment in thoroughbreds continues to proffer an effective federal government subsidy to the industry because race-track proceeds are a source of major tax revenues to the states. For owners, racing itself has become an increasingly unprofitable venture. Average earnings per runner fell 26% between 1960 and 1980, in real terms, while purses for even the top races dropped 27% in the same interval. Because racing is classified as a "business" rather than a leisure pursuit (as it was considered before a historic 1923 decision), all operating costs from expenses to losses are deductible at marginal income tax rates while an operating profit is required in only two out of each seven years. On the other hand, profits on the sale of performers, for reproductive machinery at the end of their racing careers, are seen as capital gains. A highly-accelerated depreciation schedule which permits full amortization of race horse investment within four years adds to the attractiveness of the tax formula for investors with another significant source of income.

Industry practices in the stallion sphere conspire to limit the supply of select sale yearlings, thus making them non-reproducible assets. The energy level of the sire (each crop is limited to 35-50 foals), the prohibition by law of artificial insemination, and a strict screening by auction management for stallions whose offspring are seen to qualify for the select sales (a fairly constant number to which only a few new-comers are added each year, replacing those which are being phased out) all work toward this end. Although rising prices may cause

an increasing percentage of high quality yearlings to be offered in the marketplace, rather than retained by their breeders, they cannot effectively raise output. Increased production of other, non-select, yearlings which might act to lower the probability of success of select yearlings together with their value does not seem to pose a major threat. Currently, the value of non-select prospects is rising at a lower rate than is their cost of production, a declining profitability which will tend to bolster the speculative mania in select sale offerings.

Excess profits in the production of select yearlings may be falling, as the cost of reproductive machinery rises in response to the value of its output, and capital equipment of older vintage, purchased at earlier and lower prices, wears out. But there does not seem to be any process on the production side, except in the extremely long term, for a price-responsive variation in output, through which competition and high prices would cause the bubble to self-destruct.

There are straws in the wind. An occasional highly-desirable yearling is selling for extraordinary select sale prices at run-of-the-mill sales. The enormous present opportunity in the industry has led to the syndication of a secondary level of stallions which would have been rejected in a less-expansive market. These are standing at farms with the capital and acumen to develop their reputations, should there be among them horses whose ability to transmit talent exceeds their racing records. The broader spectrum of choice now afforded to

the breeder will ultimately expand the select sire list. But biology bolsters the mania. It takes four years from the mating to the Triple Crown, and another for the next group of yearlings to reach the select sales auction ring. This assumes instantaneous success in such new ventures; several decades is the more likely estimate for a notable change in production.

What would prick the bubble is government withdrawal from what is essentially an industry subsidy. State governments are moving into dog racing, jai alai, lotteries and legalized gambling, all superior sources of "voluntary taxes" which do not force the federal government to provide racing owners with a shelter from income tax demands. If racing should be reclassified back from "business" to "leisure", the market for thoroughbreds would surely crash.

FOOTNOTES

(1) The Blood-Horse, Auctions of 1960-80.

(2) The Blood-Horse, Auctions of 1980.

(3) Ibid.

(4) The Keeneland Association, unpublished data.

(5) Bloodstock Research and Statistical Bureau, American Produce Records 1930-1978 and The Keeneland Association, catalogue for the 1970 Selected Yearling Sale.

(6) Lerrick, Adam, What Does Make Horseraces?, unpublished thesis.

(7) Bloodstock Research and Statistical Bureau, American Produce Records 1930-1978, and The Keeneland Association, catalogue for the 1970 Selected Yearling Sale.

(8) Bloodstock Research and Statistical Bureau, American Produce Records 1930-1978, and The Fasig-Tipton Co, Inc., unpublished data, and The Keeneland Association, unpublished data.

(9) The Blood-Horse, August 9, 1980.

(10) Fama, Eugene, "Efficient Capital Markets: A Review of Theory and Empirical Work", Journal of Finance, 1970, pp. 383-417.

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