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INVESTMENT BANKING CONTRACTS IN A SPECULATIVE ATTACK ENVIRONMENT: EVIDENCE FROM THE 1890'S*

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1. Introduction

In a previous paper[1] we focussed the attention on the activities of the U.S. Treasury in response to the numerous crises that the gold standard suffered during the period from 1885 to 1895. In particular, most of the paper was devoted to the analysis of what I consider to be one of the crucial episodes of the time, the contract signed in February of 1895 between a syndicate of bankers led by J.P.Morgan, August Belmont representing the Rothschild's and the U.S. Treasury.

The purpose of that paper was two-fold. First, it tried to provide a different, yet reasonable, way of reading the economic history of those years. Second, but of primary interest, it intended to demonstrate how, by using only speculative attack theory and optimal contracting theory, a simple theoretical model, capable of reproducing the characteristics of the Belmont-Morgan contract, could be constructed. More specifically, the paper developed a particular variant of investment banking contract theories in order to rationalize the behavior of the monetary authorities, when facing an impending collapse of the gold standard. The present paper intends to investigate whether the Treasury actually behaved according to this theory.

Several papers[2] have recently been proposed in order to explain the way in which investment banking contracts are formed. These papers describe the nature of the problem and derive the general characteristics of an optimal investment banking contract. However, as far as I know, no empirical application of these theories actually exists. This is because the form of the objective functions of the issuer and of the investment banker, as well as the constraints that bind thier actions, are usually unknown. In this paper it will be claimed that all the parameters, which define the Belmont-Morgan contracting problem, can be properly

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[1] Garber and Grilli (1985)

[2] Mandelker and Raviv (1977), Baron (1979), Baron and Holmstrom (1980).

estimated, so that it is possible to derive the specific features of the contract under investigation.

This paper, therefore, represents an empirical application of these theories. However, given the nature of the problem, traditional testing procedures cannot be applied. The main obstacle is that only one observation, the Belmont-Morgan contract, is available. Apparently, in this situation, it is impossible to use standard statistical methods to test potential restrictions implied by the theory. Nonetheless, in my opinion, a different, although unorthodox, methodology can be successfully used to examine the explanatory power of the model. First, I summarize the essential economic environment in which the contract took place, using a time series of probabilities of a speculative attack on the gold standard. Second, I provide estimates of the crucial institutional constraints that were binding the monetary authorities and the investment bank syndicate at the time that they entered the contract. Finally, given the simulated environment and constraints, I solve the optimization problem that the Treasury and the Belmont-Morgan syndicate were conceivably facing, and compare the solution to the actual contract. My conclusion is that the hypothesis, that the Treasury and the Syndicate behaved according to the proposed theory, receive empirical support, because there exist reasonable scenarios which imply the Belmont-Morgan contract as the optimal outcome.

The structure of the paper is as follows. In Section 2 the essential institutional environment of the period is reviewed. In Section 3 a speculative attack model is estimated in the period between January 1885 and December 1895. Section 4 is dedicated to the reproduction of the parameters and constraints of the contracting problem. In Section 5 the simulated contracts are presented. Some final remarks conclude the paper.

2. The Essential Institutional and Economic Environment of the Period and a Description of the Contract [3]

After January 1,1879, as prescribed by the Resumption Act of June 14,1875 , legal tender paper money had to be redeemable in coins. Even if "coin" meant, at the time, either gold or silver, the Treasury always redeemed in gold, de facto supporting a gold standard system.

In order to guarantee the redemption of the notes, the Treasury had two alternatives: (i) to use the surplus revenue or (ii) issue bonds of the kind authorized by the Refunding Act (July 14, 1870).[4]

The viability of the gold standard did not present any problems during the 80's. In particular, between 1885 and 1890, a constant government surplus guaranteed a large amount of gold reserves, well above the required minimum of $100 million.[5]

The period of monetary instability started early in the 90's. The underlying cause of the precariousness of the period was excess money supply that was generated by two different sources:

(a) Between 1890 and 1893 the Sherman Act, by forcing the Treasury to make huge monthly purchases of silver in exchange for a new kind of paper money (the Treasury Notes of the 1890), caused a steep increase in the paper component of the money supply[6].

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[3] For a more detailed analysis of the period, see Garber and Grilli (1985), and Simons (1968)

[4] The Refunding Act authorized the Treasury to issue three different kinds of bonds: (1) 10 year @ 5% (2) 15 year @ 4.5% (3) 30 year @ 4 %.

[5] The lower bound for the gold reserves originated in the Act of July 12, 1882 which established that any time the gold reserves of the Treasury fell below $100 million, the Treasury had to suspend the issuing of gold certificates. Since then, $100 million was considered to be the minimum level of the gold reserves in the Treasury, as set down by the Judiciary Committee of the House of Representatives in a report submitted on July 6, 1892. The report stated: "That it was the intention of the Congress to fix the minimum amount of this reserve fund at $100 million gold and gold bullion, and that it should be mantained at that sum, seems clear from the language of the Act [of 1882]".

[6] The Sherman Silver Purchase Act was passed in July 14, 1890.

(b) During the years between 1893 and 1896 the Congress did not allow any form of borrowing to finance the large and continuous deficit that originated in the period. The Treasury had the option of either monetizing the deficit by using previously accumulated legal tender, or issuing the kind of bonds authorized by the Resumption Act, once the gold reserves had fallen below the minimum[7].

During those years the viability of the gold standard became more and more uncertain; the Congress and the Treasury had to take various actions in order to avoid its collapse: the Sherman Act was repealed November 1, 1893 and the Treasury undertook four bond issues, in February 1894, in November 1894, in February 1895 (the Belmont-Morgan contract), and in January 1896.

The Belmont-Morgan contract stipulated the purchase of gold coins by the Treasury, in exchange for 30 year @ 4% bonds. The par value of the issue was $62.3 million. It was purchased by the syndicate at a price equivalent to 3.75% at par. In addition, and of most importance, the syndicate agreed that, "... so far as it lies within their power, will exert all financial influences and will make all legitimate efforts to protect the Treasury of the United States against withdrawls of gold, pending the complete performance of the contract".

With this provision the syndicate granted the Treasury a zero-interest line of credit in gold for the duration of the contract.[8] Throughout the duration of the contract, in fact, the syndicate delivered between $20 and $25 million in gold to the Treasury, in exchange for legal tender. This operation, therefore, guaranteed the Treasury both a long term financing, i.e. the 30 year bonds, and a short term financiing, i.e. the line of credit.

Note that the contract has the characteristic of a "firm commitment" contract, one by which the investment banker underwrites the entire issue, guaranteeing to the issuer a fixed

[7] Note that, by the Act of May 31, 1878, the Treasury was forbidden to cancel or retire any of the U.S. notes then outstanding.

[8] The duration of the contract was implicitly fixed at six months. The use of the term "line of credit" is perhaps inaccurate in this context. The real nature of the deal was an on-call exchange of gold for paper money. The contract had additional minor provisions that will not be expressely considered in the present paper. For a discussion, see Garber and Grilli (1985).

amount of funds. However, the choice of this contract, instead of other alternative forms like "best effort", was made for other reasons in addition to the insurance advantage. It is quite possible that the Treasury expected to be able to market the issue directly, at a price higher than the one agreed upon with the syndicate. The spread not only compensated the syndicate for undertaking the risk and for the distribution efforts, but was also a way to pay for the line of credit. This form of contract enabled the Treasury to secure short term financing without obtaining an explicit approval, that the Congress was not willing to concede.

The next section is dedicated to the construction of a model which reproduces the essential features of the environment in which the contract took place. Such a model is an application of speculative attack theories to fixed exchange rate regimes. The estimation of this model will produce a time series of probability of a speculative attack to the gold standard. This probability series will prove to be a sufficient summary of the environment as far as concerns the contracting process between the Treasury and the Belmont-Morgan syndicate.

3. Modelling the 1885-1895 period by Speculative Attack Models

a. The Theoretical Model

Our approach is to consider the gold standard as a fixed exchange rate system between the dollar and the English pound, where the fixed parity is given by the ratio of the gold content of the two currencies. This allows us to apply the speculative attack models to fixed exchange rate systems in order to explain the runs on the Treasury's gold reserves, interpreted, in this framework, as foreign currency reserves.

The intent of this section is to reproduce the evolution of the probability of the viability of the gold standard, in order to identify the periods of major strain on the system.

The basic idea underlying the speculative attack literature is that the fixed parity will be viable until it becomes profitable to attack it. This will happen as soon as the exchange rate expected to prevail right after the attack (shadow exchange rate) exceeds the given parity.[9] The level of the shadow exchange rate depends critically on what kind of regime is expected to prevail once the gold standard collapses. I assume that, in this circumtance, a paper money convertible in silver will be established.

We model this post-attack flexible system with the following monetary model of the exchange rate for a small economy:[10]

$$m_t - p_t = \beta + \gamma y_t - \alpha i_t + w_t \tag{1}$$

$$i_t - i_t^* = E_t\, e_{t+1} - e_t \tag{2}$$

$$p_t - p_t^* = e_t + u_t \tag{3}$$

Here m, p, e, and y are the logarithms of money stock, price level, exchange rate in dollars per pound and a measure of real activity; i is the nominal interest rate and w and u are uncorrelated stochastic disturbances. The parameters α, β, γ are all positive, and E_t is the expectation operator conditional on information at time t. British variables are marked with asterisks, and all variables are assumed to be exogenous to the exchange rate.[11]

[9] We are referring to a buying attack, i.e. when speculators buy foreign reserves (gold) from the monetary authorities, expecting to profit from a devaluation of the domestic currency. For a model in which selling attacks, i.e. attacks aiming to profit from a revaluation of the currency, are also considered, see Grilli (1985).

[10] This model has been widely use in speculative attack literature. For a more detailed explanation of solutions to these types of models, see Flood and Garber (1984a), Blanco and Garber (1983) and Grilli (1985).

[11] The actual form of equation (3) that we used in the empirical section is:

$$p_t - p_t^* + k = e_t + u_t$$

where k is constant such that mean(e)=mean (p-p*+k). This is to make the price levels, which are index numbers, compatible with the exchange rate which is in $ /£.

The model can be solved for the (shadow) exchange rate:

$$e_t = (1/1+\alpha) \sum_{j=0}^{\infty} (\alpha/1+\alpha)^j E_t h_{t+j} \tag{4}$$

where:

$$h_{t+j} = m_{t+j} - \beta - \gamma y_{t+j} + \alpha i^*_{t+j} - w_{t+j} - p^*_{t+j} - u_{t+j} \tag{5}$$

The money stock in a gold standard can be defined as the sum of two components: (i) the gold in circulation plus the part of the paper money backed by gold reserves in the Treasury and (ii) the silver in circulation plus the paper money not backed by gold reserves, which I defined as the domestic component of the money supply (DC_t).

In the post-attack regime, to which equations (1)-(5) refer, gold goes out of circulation. The money stock is given by the sum of the domestic component and the amount of reserves (G^m) still in the Treasury after the collapse of the gold standard. In the rest of the paper I assume that $G^m=0$[12], i.e. the Treasury abandons the defence of the gold standard when the level of gold reserves drops to zero, so that (5) can be rewritten as:

$$h_{t+j} = dc_{t+j} - \beta - \gamma y_{t+j} + \alpha i^*_{t+j} - w_{t+j} - p^*_{t+j} - u_{t+j} \tag{6}$$

where dc is the logarithm of DC. In order to express the equilibrium flexible exchange rate as a function of the variables in the information set, we have to make an assumption about the process driving h_t. I will assume that such a process is AR(1)[13], which provides an easy way to compute expectations. Under this hypothesis (4) can be rewritten as:

$$e_t = \alpha\mu a_1 + \mu h_t \,, \tag{7}$$

[12] For a discussion of this assumption see Garber and Grilli (1986)

[13] As we will show later, this assumption seems to fit the data reasonably well.

where

$$\mu = [(1+\alpha) - \alpha a_2]^{-1} \tag{8}$$

and a_1 and a_2 are given by

$$h_t = a_1 + a_2 h_{t-1} + \varepsilon_t \tag{9}$$

I assume that $\varepsilon_t \sim N(0,\sigma^2)$. An attack will occur if and only if

$$e_t \geq e \quad , \tag{10}$$

where e is the fixed parity. Given the AR(1) assumption and the normality of the ε_t, the probability that an attack will occur in the next period is[14]

$$\Pr(e_{t+1} \geq e) = 1 - \Phi(k_t/\sigma) \tag{11}$$

where Φ is the cumulative distribution function of the standard normal and

$$k_t = (e/\mu) - \alpha a_1 - (a_1 + a_2 h_t) \tag{12}$$

The theory also provides a formula for the expected future exchange rate, which is given by a weighted average of the expected exchange rate conditional on the occurence of an attack ($E_t(e_{t+1}|A)$), and the expected exchange rate conditional on the viability of the

[14] For a complete derivation of the probability of attack, see Flood and Garber (1984a) and Grilli (1985)

system ($E_t(e_{t+1}|V)$). The weights are given by the probability of an attack and the probability of viability of the system, respectively. The unconditional expected exchange rate is

$$E_t e_{t+1} = (1-\Phi(k_t/\sigma))E_t(e_{t+1}|A) + \Phi(k_t/\sigma)E_t(e_{t+1}|V) \tag{13}$$

where

$$E_t(e_{t+1}|A) = \mu[\alpha a_1 + (a_1 + a_2 h_t)] + [\mu\sigma/\sqrt{2\pi}(1-\Phi(k_t/\sigma))][\exp(-.5(k_t/\sigma)^2] \tag{14}$$

and $E_t(e_{t+1}|V)$ is the fixed parity e. This concludes the presentation of the theoretical attack model. The next sections will be dedicated to its estimation.

b. The Econometric Strategy and the Data

The first step of my analysis is to estimate the above model in the period 1885-95, in order to derive the movement over time of the probability of a speculative attack on the gold standard.

The domestic component of the money supply has been computed by subtracting the gold, gold certificates in circulation, and the gold reserves in the Treasury from the total money stock in circulation.[15] The U.S. price index is the Warren & Pearson price index,[16]

[15] The money stock is given by the sum of: (i) gold coins and gold certificates in circulation (ii) silver dollars, subsidiary silver coins and silver certificates in circulation (iii) Treasury Notes, U.S. Notes (greenbacks), National Bank Notes and Currency Certificates in circulation. All monetary aggregates are taken from the National Monetary Commission (1910)

[16] "Index Number of the Wholesale Prices of All Commodities, 1720 to 1932", in Warren and Pearson (1933), Table 1 pg.10.

the U.K. price index is the Sauerbeck price index.[17] As a measure of the level of activity, I used bank clearings outside New York City. Bank clearings represent dollar totals of checks and drafts drawn on individual banks and credited to the accounts of other banks through the city clearing house association to which the individual bank belonged. New York City's large volume of bank clearings are attributable to financial transactions that largely reflect stock and bond transactions[18], as a result, bank clearings outside New York City are a more reliable indicator of the movement in output and trade, then total clearings.

The U.S. nominal interest rate is the interest rate on call loans; the U.K. interest rate is the interest rate allowed for deposits at call by Discount Houses.[19]

We first estimate the money demand in the form of equation (1), to get estimates of the α, β, and γ parameters. Given these estimates, I compute the h_t variable, and I fit the AR(1) process for h_t. This will provide us with estimates for a_1, a_2 and σ that, together with the estimates for α, β, and γ, allow us to compute the time series of the probability of a speculative attack.

TABLE 1

MONEY DEMAND ESTIMATE: JANUARY 1885- DECEMBER 1895

Parameter	Estimate	Standard Error	Adj.R^2
β	4.92	0.156	0.69
γ	0.60	0.035	
α	0.009	0.0019	

17 "Monthly Fluctuations of the Index Number of Forty-five Commodities", in Sauerbeck (1895) and (1897).

18 Bank clearings are from F.R. Macaulay (1938), Table 27. The series is estimated by chaining monthly totals, making the percentage movement each December to the succeeding January the same as the percentage movement of the total of the largest number of cities whose clearings were available for the December and January. This adjustment is made in order to take into account changes in the number of cities reporting.

19 Interest rate series are taken from the Commercial and Financial Chronicle and the National Monetary Commission (1910).

c. Money Demand Estimates

The estimates of the money demand parameters in the period between January 1885 and December 1895 are presented in Table 1.[20] All coefficients are significant and have the expected signs (remember that α is the negative of the interest rate semi-elasicity).

d. Estimate of the AR(1) Process

Given the above estimates, I can now compute the h_t variable. This variable can be viewed as the excess money supply for given domestic and foreign price levels, and it determines, together with the monetary equilibrium condition, the dynamics of the exchange rate. Therefore, the process generating the money supply plays a crucial role in the determination of h_t. During the period under examination, two major shocks occurred in the rate of growth of the paper component of the money supply, the approval and the subsequent repeal of the Sherman Act. The issue is whether these two events are to be considered switches in the monetary regime or just temporary disturbances in an underlying stable process. Put in different terms, the problem is whether to approximate h_t with a unique autoregressive process for the entire period or, instead, to break the sample into three different periods in order to take into account the two regime switches. In order to answer this question, both experiments were conducted, and then an F-test was performed to verify the stability of the autoregressive coefficients. The three sub-periods are: (i) from January 1885 to August 1890 (ii) from September 1890 to October 1893 and (iii) from November 1893 to December 1895.

Table 2 presents the estimates of the four AR(1) processes. The value of F(4,126) is 3.1253, therefore we can reject the hypothesis that the coefficients are stable at the 5%

[20] In estimating the money demand equation we introduced monthly dummies in order to account for possible seasonal fluctuations

significance level. Consequently, the results presented in the next section are computed using the three different AR(1) processes for the subperiods. In any case, the probability series implied by the two assumptions, as shown in Figure 3a and Figure 4a in the Appendix, are very similar, suggesting that, from the empirical perspective, this is not a crucial problem.[21]

It is interesting to observe the way in which the process driving h_t changes over the period. The approval of the Sherman Act caused a definite increase in the autocorrelation coefficient, which jumps from 0.88 to 0.99. This suggests that the process was strongly tending toward non-stationarity. The repeal of the Act produced a considerable decrease in a_2, which fell to 0.82. In Tables A1 through A3, the autocorrelation and partial correlation coefficients for the three different samples are presented. The fact that the autocorrelation functions tail off and the partial autocorrelation functions cut off after lag one, suggests that the AR(1) assumption is a good approximation of the processes under investigation.

TABLE 2

ESTIMATES OF THE FIRST ORDER AUTOREGRESIVE PROCESSES

	Jan85-Aug90	Sept90-Oct93	Nov93-Dec95	Jan85-Dec95
a_1	0.13 (0.057)	0.025 (0.081)	0.27 (0.177)	0.046 (0.029)
a_2	0.88 (0.048)	0.99 (0.060)	0.82 (0.121)	0.96 (0.023)
σ	0.035	0.035	0.034	0.036
R^2	0.84	0.87	0.65	0.93

Note: standard errors are in parenthesis

[21] In addition to the problem of whether the Sherman Act and its repeal were switches in regimes or not, there is the question of whether they were anticipated. In general, in any given period there exists a probability attached to the occurrence of those events. However, given the complexity involved in the estimation of such probabilities, the assumption that they were constant at zero has been made. Therefore, we are treating these shocks as completely unexpected.

e. The Probability of a Speculative Attack on the Gold Standard

We now have everything necessary to compute the time series of the probability of attack, which is presented in Table 3 and in Figure 1. In Table 3, Figure 2, and Figure 3, I also present the expected exchange rate conditional on the occurrence of an attack, the exchange rate that would have prevailed if an attack had actually occurred (i.e. the realized shadow exchange rate), and the gold point, which in this context is the relevant fixed parity.

The viablity of the gold standard had never been a problem until the first half of 1893, as shown by the behavior of the probability of an attack, which steadily remains around zero.

The period of maximum strain on the system was between August and November of 1893, which overlaps with the Panic of 1893 (May to September 1893).

The probability of an attack drops after the repeal of the Sherman Act and after each of the bond issues.[22] This is in accord with the theory that was presented in the cited paper. The repeal of the Sherman Act produced a downward revision of the future expected domestic component of the money stock, which implies a lower expected post-attack exchange rate. Similarly, an issue of bonds has two possible effects. Either it produces a reduction in the present and expected future DC (if subscribed in paper money), or it reduces the perceived minimum reserves (if subscribed in gold). In both cases, this will lead to a decrease in the expected post-attack exchange rate and thus in the probability of an attack.

The above result seems to confirm that the trigger mechanism of the distress of the period was the rapid increase of the paper money supply induced by the Sherman Act. Its repeal, however, was not sufficient to restore the complete viability of the system. With

[22] Note that the probability of attack is overestimated after February 1895, since we did not take into account, in the computation, the line of credit that the Syndicate provided to the Treasury.

money stock at such a high level, any movement in the money demand could, and in fact did, cause instability of the system.

The fact that the realized shadow exchange rate has always been below the fixed parity, as shown by Figure 3, reveals how a speculative attack, even if it was a possible event ex-ante, never actually occurred because it was never profitable to engage in it. At this point it is legitimate to ask what the role of the Treasury was in guaranteeing the viability of the gold standard. I dedicate the next section to this problem.

f. What Would Had Happened if Treasury Had Not Taken Action?

The experiment conducted here is to see how essential the actions taken by the Treasury were for the viability of the system, i.e. investigate what would have happened if the bonds had never been issued. In order to do this, the effects of bond issues are annulled by adding the decrease in the domestic credit, implied by the issues, back to the post-attack money supply.

In Figure 4a I present the actual probability, together with the hypothetical probability, of an attack , given that none of the bond issues had ever been made. The simulated probability reaches 47% in March 1895 while the actual probability was just 6% in the same period. This emphasize the bond issues' essential role in preventing the collapse of the system. The same conclusion is suggested by Figure 4b where I present the actual realized shadow exchange rate and the hypothetical one. Without the bond issues an attack would have occurred between January and February 1895, i.e. the time period where the shadow rate would have exceeded the parity for the first time.

Figures 5a and 5b show the result of the same kind of experiment as the above, under the assumption that only the third issue, i.e. the Belmont-Morgan contract, never occurred. Even if the probability of attack would have increased, peaking in March 1895 at 17%

instead of 6%, the realized shadow exchange rate would have always been below the gold point, preventing an attack from ever occurring.

This analysis suggests that even if the bond issue strategy followed by the Treasury was essential in preventing the breakdown of the gold standard, the Belmont-Morgan contract itself, was not. However, it would be incorrect to claim that the Treasury made a mistake in issuing the third bond, since this analysis provides ex-post conclusions, while the Treasury had to make ex-ante decisions.

4. Reproducing the Belmont-Morgan Contract

The approach taken is to consider the Belmont-Morgan contract as the result of an optimization problem that the Treasury had to solve in order to assure the practicability of the gold standard.

We assume that the goal of the Treasury was to avoid the collapse of the gold standard which, when interpreted in this framework, is equivalent to minimizing the probability of a speculative attack. In order to achieve this target the Treasury had two possible instruments, and it was subject to a set of constraints. The instruments were (i) a bond issue and (ii) a short term line of credit provided by the syndicate. In addition, the Treasury was facing three different kinds of constraints: (i) it was bound by a maximum cost of the operation in terms of the interest rate paid on the bond issued (ii) it had to fulfill the $100 million gold reserves minimum and (iii) it had to guarantee a minimum level of profit to the syndicate, in order to compensate it for underwriting the bond issue and for providing the line of credit.

Formally, the maximization problem can be expressed as:

$$\min_{N,G^c} \; Pr(p'N+G^c)$$

$$\text{s.t.} \quad \Pi = [p(N) - p']N - I(G^c) \geq K$$

$$G^T = G_0^T + G \geq 100$$

$$r \leq r_{max} \quad (\text{or } p' \geq p'_{min})$$

Pr(•) is the probability of a speculative attack, a function of N and G^c, representing the number of one dollar bonds in the issue and the dollar amount of line of credit respectively. Π is the profit of the syndicate; p, a function of N, is the price at which the bond is purchased by the public and p' is the price at which it is underwritten by the syndicate; I(•), a function of G^c, is the cost of providing the line of credit; K is the minimum level of profit required by the syndicate in order to perform the services; G_0^T and G^T are the level of gold reserves in the Treasury, before and after the contract; r is the interest rate at which the bond issue is underwritten and r_{max} is its maximum possible level.

Note that, given the characteristics of the bond (i.e. 30 years @ 4%) and assuming that the last constraint holds with equality, the knowledge of r_{max} implies the knowledge of p'_{min}, and vice versa. The maximum allowed cost of the operation has been implicitly revealed by the contract itself to be r_{max}=3.75, and we take it as a given parameter.

The next sections are dedicated to the estimation of the additional elements of the optimization problem which are necessary to explicitly derive its solution. In particular, I will propose a way to derive the objective function of the Treasury, the profit function of the syndicate, and the minimum level of profit required by the syndicate, in order to perform the services prescribed by the contract.

a. Estimating the Treasury Objective Function

The following is the methodology used to derive the probability function faced by the Treasury. I computed the probability of an attack, at different levels of post-attack money supply, in the month of February 1895. In this way I could trace the relationship between the probability of an attack and the sum of the bond issue and the line of credit, which is presented in Figure 6.

In order to get a functional form representation of the relationship obtained with the above procedure I approximated it with a polynomial of the form:

$$Pr = b_0 + b_1*(N+G^c) + b_2*(N+G^c)^2 + ... + b_n*(N+G^c)^n \quad (16)$$

In Figure 7 the actual relationship and its polynomial approximation, where n=4, are presented. Note that, since the probability function is monotonically decreasing in N and G^c, the minimization of Pr(•) is equivalent to the maximization of $N+G^c$.

b. Estimating the Syndicate Profit Function

The estimation of the syndicate profit function requires information about the demand for Treasury bonds, p(G), about the costs of providing the line of credit, $I(G^c)$, and about the amount of profits, K, that the syndicate intended to make.

b.1 The Demand for Treasury Bonds

In order to derive the relationship between the size of the bond issue and the price at which it could have been allocated by the syndicate, the following strategy was used. As mentioned in section 2, in November 1894 the Treasury issued a $50 million, 10 year bond @ 5%, in order to replenish the gold reserves that had fallen below the required minimum of $100 million. All the bids made for the bond are recorded in the report of the investigation conducted by the Committee on Finance in 1896.[23] Making use of this data, the demand function faced by the Treasury can be traced out, and it is presented in Figure 8.

In addition to this function, the report provides an additional piece of information. In particular, it reveals that a syndicate of bankers, J.P. Morgan among them[24], made two separate bids for that bond issue. They offered to purchase the whole issue at a price of 1.17077 or to purchase any part of it at 1.168898. Note, however, that if the syndicate expected to face the same demand function that the Treasury was facing, it would have incurred a loss by acquiring the whole issue at 1.17077, since the equilibrium price along the Treasury demand curve was 1.16306. If we assume that the syndicate was behaving rationally, we have to conclude that it expected a larger demand for the bond than the one faced by the Treasury.

The reason for this difference is that the individuals may have had an incentive to report a price that was lower than their true reservation price. This is because of the particular structure of the auction used to allocate the issue. The Treasury, in fact, was adopting a discriminating auction, in which the bonds were assigned at the price bid, starting from the highest bid and working downward until the whole issue was allocated. In the auction literature it is known that, under a discriminating auction, the mean and the variance of the bids are lower than they would be a under competitive auction-- which would force the agent to reveal his true reservation price.[25] This implies that the demand curve derived from the bids has to be flatter and have a lower intercept than the true demand curve. It is the latter one that the syndicate expected to face. Despite the fact that the actual

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[23] The Committee was appointed in order to investigate the Treasury bond sales thatoccurred during the years 1894-96.

[24] Contrary to the Belmont-Morgan syndicate, the composition of this syndicate is known. Even if we cannot be certain about it, it is very likely that most of the members of the syndicate of November 1894, were also members of the February 1895 syndicate.

[25] These results can be found in Vickrey (1966), Smith (1966), and Harris and Raviv (1981), among others.

allocation mechanism used by the syndicate is not known, a close examination and review of the journals of the time suggests that competitive auction was utilized.

We must recover the actual demand faced by the syndicate-- a demand different from the one faced by the Treasury. Knowledge of this syndicate's function will be used to construct an estimate of the demand faced by the syndicate in February 1895. Since the two issues occurred within 10 weeks from each other, we can make the reasonable assumption that the demand did not change in such a short period of time. As a result, after accounting for the fact that part of this demand was satisfied by the November issue ($50 million), we can consider it to be the demand for the February 1895 bond as well.

The demand function has to pass through the price at which the syndicate sold the issue (1.19).[26] This condition, with an assumption of linearity, identifies a set of possible demand curves. This set can be further narrowed by recognizing the existence of a maximum price that any individual would be willing to pay for the bond. The maximum price has to be less or equal to 1.24; this corresponds to a yield of 2.3%, the interest rate on British consols of comparable maturity, which were expressly payable in gold. Moreover, the maximum price has to be greater or equal to 1.21, otherwise the function would be flatter than the demand faced by the Treasury. In the next section, the contracts corresponding to different demand curves in this family will be computed in order to see if any of them support the Belmont-Morgan contract as an optimal outcome.

b.2 The Syndicate's Expected Profit

The report on the November 1894 issue also contains information that can be used to identify the level of profit that the syndicate intended to make, as a return on the underwriting services. If the Treasury had accepted the "all or nothing" bid the syndicate's expected profit would have been:

[26] Commercial and Financial Chronicle, December 1, 1894.

$$K_1 = (p(N_1) - p_1)N_1 \quad \text{(I)}$$

where p(•) is the demand funtion faced by the syndicate, N_1 is the size of the issue ($50 million) and p_1 is the price offered by the syndicate for the "all or nothing" arrangement. If the Treasury, instead, had accepted the "all or any part" offer, the syndicate profit would have been:

$$K_2 = (p(N_2) - p_2)N_2 \quad \text{(II)}$$

where N_2 is the number of one dollar bonds that the Treasury would allocate to the syndicate, and p_2 is the price offered by the syndicate under the "all or any part" arrangement.[27] Note that, as described by Figure 9, the price at which the syndicate is able to sell the bonds it underwrites, is the same under the two arragements, that is $p(N_1)=p(N_2)=1.19$. If we assume that the syndicate profit is a linear function of the underwritten securities[28]

$$K = k_0 + k_1 N$$

equations I and II can be solved to obtain $k_0 = 0.19$ and $k_1 = 0.015$.

b.3 <u>The Cost of Providing the Line of Credit</u>

The last piece of information needed to solve the maximizaton problem is an estimate of the cost of providing the line of credit. By providing the line of credit, the syndicate lost

[27] The value of N_2=50-16.5=33.5, where 16.5 is the quantity of bonds on the Treasury demand function, corresponding to p_2.

[28] This linear form is often used in actual contracts. See Mandelker and Raviv (1977).

the opportunity to earn the interest that is obtainable by lending the gold on the London market. The cost of the operation in terms of the interest loss is $i_6^* G^c$, where i_6^* is the six month interest rate in London.[29]

The syndicate, in addition to the interest loss, was also bearing a second cost component, i.e. the capital loss that it expected in case the gold standard collapsed. If the Treasury were forced, by a speculative attack, to abandon the defence of the parity, the dollar would have been devaluated vis-a-vis the pound, thus increasing the price of gold. Since the syndicate was exchanging gold for dollars, it would have suffered a loss proportional to the size of the devaluation. This expected capital loss is given by the spread between the domestic and foreign interest rates, and it is represented by the interest parity condition. Therefore, the total cost of providing the line of credit can be approximated by $i_6 G^c$, where i_6 is the domestic six month interest rate.

5. Solving the Maximization Problem: the Belmont-Morgan Contract

We finally have all of the elements to solve the maximization problem. As we mentioned above, we will compute the optimal contract supported by different demand curves in the permissible set desribed in the previous section. The results of this grid procedure are reported in Table 4.

In Table 4, a and b are the parameters of the linear demand functions, N and G^c are in millions of dollars, and p(62.3) is the price implied by each demand curve, given that N=62.3. Since the syndicate actually sold the issue at a price around 1.125,[30] we can confidently restrict the set of feasible demand curves to the ones for which $1.23 \leq a \leq 1.24$. Recall that in the actual contract N was \$62.3 million and G^c was at least \$20 million. Therefore, our analysis produces a set of simulated contracts which is quite similar to the

[29] Remember that six-months was the duration of the contract, i.e. the period during which the syndicate had to provide the line of credit.

[30] Commercial and Financial Chronicle, February 1895.

Belmont-Morgan contract. Using the estimate of the Treasury objective function, that we derived in Section 4.a, and the contract produced by a=1.235, we conclude that the probability of a speculative attack was reduced to 0.025, as a result of the contract.

TABLE 4

OPTIMAL CONTRACTS

a	b	N	G^c	p(62.3)
1.21	0.0004	140.39	55.17	1.16508
1.215	0.0005	112.31	43.10	1.15885
1.22	0.0006	93.60	35.05	1.15262
1.225	0.0007	80.22	29.30	1.14639
1.23	0.0008	70.20	24.99	1.14016
1.235	0.0009	62.40	21.64	1.13393
1.24	0.001	56.15	18.96	1.12770

7. Summary and Conclusions

The objective of this paper was to examine the empirical relevance of theories of investment banking contracts in a speculative attack environment. Given the impossibility of applying standard regression analysis, I propose a different approach to tackle the problem.

To begin with, this unconventional procedure involved the reproduction of the environment in which the Belmont-Morgan contract took place. During this first phase, we obtain results which are interesting per-se. A speculative attack model was estimated from January 1885 to December 1895. This allowed us to identify the periods of the greatest stress on the system; here the discriminating criteria is the probability of an attack on the gold standard. Moreover, we were able to determine the effects of the Treasury's fiscal policy on the viability of the gold standard regimes.

Next, we provide estimates of the additional parameters and constraints involved in the contracting problem, facing the Treasury and the Belmont-Morgan syndicate.

Finally, by using the elements estimated in the first two steps of the procedure, we solve the optimization problem that the Treasury was facing, according to the theory under investigation. We find that there exists a reasonable set of parameters which supports the Belmont-Morgan contract as an optimal outcome. We therefore conclude that the hypothesis-- that the Treasury and the syndicate behaved following the proposed theory-- receive some support.

References

Baron, David P., 1979, The Incentive Problem and the Design of Investment Banking Contracts, Journal of Banking and Finance 3, 157-175.

Baron, David P. and Bengt Holmstrom, 1980, The Investment Banking Contract for New Issues under Asymmetric Information: Delegation and the Incentive Problem, Journal of Finance, Vol. XXXV No.5, 1115-1137.

Blanco, Herminio and Peter Garber, 1983, Recurrent Devaluation and Speculative Attacks on the Mexican Peso, Journal of Political Economy, February 1986.

Commercial and Financial Chronicle, 1885-1895.

Committee on Finance, 1896, Investigation of the Sale of Bonds during the Years 1894, 1895 and 1896, Washington D.C., Government Printing Office.

Dunbar, Charles F., 1893, Laws of the United States Relative to Currency, Finance and Banking, from 1789 1891, Ginn & Company, Boston.

Flood, Robert and Peter M. Garber, 1983, A Model of Stochastic Process Switching, Econometrica 51, 537-551.

Flood, Robert and Peter M. Garber, 1984, Collapsing Exchange Rate Regimes: Some Linear Examples, Journal of International Economics 17, 1-13.

Garber, Peter M. and Vittorio U. Grilli, 1986, The Belmont-Morgan Syndicate as an Optimal Investment Banking Contract, European Economic Review, forthcoming.

Grilli, Vittorio U., 1986, Buying and Selling Attacks on Fixed Exchange Rate Systems, Journal of International Economics, forthcoming.

Harris, Milton and Artur Raviv, 1981, Allocation Mechanisms and the Design of Auctions, Econometrica, 1477-99.

Hoffman, Charles, 1979, The Depression of the Nineties, An Economic History, Greenwood Publishing Corporation, Westport, Connecticut.

Laughlin, Laurence J., 1968, The History of Bimetallism in the United States, Greenwood Press, New York.

Macaulay, Fredrick R, 1938, The Movements of the Interest Rates, Bond Yields and Stock Prices in the United States since 1856, NBER, New York.

Mandelker, Gershon and Artur Raviv, 1977, Investment Banking: an Economic Analysis of Optimal Underwriting Contracts, Journal of Finance, 683-694.

Noyes, Alexander D., 1909, Forty Years of American Finance, Putnam's Sons, The Knickerbocker Press, New York

Sauerbeck, A., 1895, Prices of Commodities in 1894, Journal of the Royal Statistical Society.

Sauerbeck, A., 1897, Prices of Commodities in 1896, Journal of the Royal Statistical Society.

Simons, Matthew, 1968, The Belmont-Morgan Syndicate of 1895 and the Intervention in the Foreign Exchange Rate Market, Business History Review, 385-417.

Smith, V. L., 1966, Bidding Theory and the Treasury Bill Auction: Does Price Discrimination Increase Bill Prices?, Review of Economics and Statistics, 141-146.

U.S. Treasury, Annual Reports, 1885-1895.

U.S. National Monetary Commission, 1910, Statistics for the United States 1867-1909, Government Printing Office, Washington.

Vickrey, W., 1966, Counterspeculation, Auctions, and Competitive Sealed Tenders, Journal of Finance, 8-37.

Warren, George F. and Frank A. Pearson, 1933, The Price Series, John Wiley & Sons, New York.

TABLE 3

OBS	TIME	PROBABILITY OF AN ATTACK	EXPECTED RATE CONDITIONAL ON AN ATTACK	REALIZED SHADOW EXCHANGE RATE	GOLD POINT
1	JAN85	0.000	4.932	4.071	4.905
2	FEB85	0.004	5.039	4.027	4.905
3	MAR85	0.007	5.045	4.091	4.905
4	APR85	0.007	5.044	4.084	4.905
5	MAY85	0.001	5.022	3.832	4.905
6	JUN85	0.002	5.031	3.937	4.905
7	JUL85	0.000	5.017	3.765	4.905
8	AUG85	0.000	5.011	3.667	4.905
9	SEP85	0.000	5.013	3.705	4.905
10	OCT85	0.000	5.008	3.634	4.905
11	NOV85	0.000	5.002	3.531	4.905
12	DEC85	0.000	5.001	3.515	4.905
13	JAN86	0.000	4.999	3.470	4.905
14	FEB86	0.000	5.002	3.524	4.905
15	MAR86	0.000	4.995	3.400	4.905
16	APR86	0.000	4.991	3.333	4.905
17	MAY86	0.000	4.998	3.467	4.905
18	JUN86	0.000	4.998	3.466	4.905
19	JUL86	0.000	4.989	3.289	4.905
20	AUG86	0.000	4.987	3.251	4.905
21	SEP86	0.000	4.987	3.246	4.905
22	OCT86	0.000	4.988	3.269	4.905
23	NOV86	0.000	4.990	3.304	4.905
24	DEC86	0.000	4.988	3.259	4.905
25	JAN87	0.000	4.989	3.282	4.905
26	FEB87	0.000	5.011	3.679	4.905
27	MAR87	0.000	4.992	3.353	4.905
28	APR87	0.000	4.981	3.116	4.905
29	MAY87	0.000	4.984	3.184	4.905
30	JUN87	0.000	4.985	3.198	4.905
31	JUL87	0.000	4.978	3.032	4.905
32	AUG87	0.000	4.988	3.266	4.905
33	SEP87	0.000	4.985	3.195	4.905
34	OCT87	0.000	4.986	3.219	4.905
35	NOV87	0.000	4.990	3.300	4.905
36	DEC87	0.000	4.979	3.056	4.905
37	JAN88	0.000	4.989	3.284	4.905
38	FEB88	0.000	4.988	3.271	4.905
39	MAR88	0.000	4.984	3.181	4.905
40	APR88	0.000	4.985	3.202	4.905
41	MAY88	0.000	4.990	3.317	4.905
42	JUN88	0.000	4.986	3.223	4.905
43	JUL88	0.000	4.983	3.166	4.905
44	AUG88	0.000	4.982	3.124	4.905
45	SEP88	0.000	4.977	3.012	4.905
46	OCT88	0.000	4.982	3.131	4.905
47	NOV88	0.000	4.978	3.046	4.905
48	DEC88	0.000	4.982	3.134	4.905
49	JAN89	0.000	4.981	3.101	4.905
50	FEB89	0.000	4.976	2.989	4.905
51	MAR89	0.000	4.977	3.008	4.905
52	APR89	0.000	4.976	2.996	4.905
53	MAY89	0.000	4.978	3.029	4.905
54	JUN89	0.000	4.975	2.960	4.905
55	JUL89	0.000	4.974	2.924	4.905

TABLE 3

OBS	TIME	PROBABILITY OF AN ATTACK	EXPECTED RATE CONDITIONAL ON AN ATTACK	REALIZED SHADOW EXCHANGE RATE	GOLD POINT
56	AUG89	0.000	4.975	2.968	4.905
57	SEP89	0.000	4.977	3.024	4.905
58	OCT89	0.000	4.980	3.088	4.905
59	NOV89	0.000	4.973	2.918	4.905
60	DEC89	0.000	4.977	3.024	4.905
61	JAN90	0.000	4.982	3.146	4.905
62	FEB90	0.000	4.974	2.933	4.905
63	MAR90	0.000	4.977	3.016	4.905
64	APR90	0.000	4.975	2.949	4.905
65	MAY90	0.000	4.974	2.931	4.905
66	JUN90	0.000	4.972	2.882	4.905
67	JUL90	0.000	4.977	3.004	4.905
68	AUG90	0.000	4.974	2.945	4.905
69	SEP90	0.000	4.988	3.198	4.905
70	OCT90	0.000	4.984	3.132	4.905
71	NOV90	0.000	4.985	3.142	4.905
72	DEC90	0.000	4.991	3.269	4.905
73	JAN91	0.000	4.997	3.352	4.905
74	FEB91	0.000	4.995	3.331	4.905
75	MAR91	0.000	5.001	3.417	4.905
76	APR91	0.000	5.009	3.533	4.905
77	MAY91	0.000	5.000	3.401	4.905
78	JUN91	0.000	5.003	3.445	4.905
79	JUL91	0.000	5.002	3.439	4.905
80	AUG91	0.000	4.999	3.386	4.905
81	SEP91	0.000	4.997	3.366	4.905
82	OCT91	0.000	4.995	3.325	4.905
83	NOV91	0.000	5.001	3.416	4.905
84	DEC91	0.000	5.002	3.440	4.905
85	JAN92	0.000	5.008	3.518	4.905
86	FEB92	0.000	5.011	3.567	4.905
87	MAR92	0.000	4.999	3.390	4.905
88	APR92	0.000	4.999	3.397	4.905
89	MAY92	0.000	5.010	3.553	4.905
90	JUN92	0.000	5.015	3.617	4.905
91	JUL92	0.000	5.009	3.534	4.905
92	AUG92	0.001	5.022	3.695	4.905
93	SEP92	0.000	5.007	3.504	4.905
94	OCT92	0.000	5.011	3.559	4.905
95	NOV92	0.001	5.022	3.696	4.905
96	DEC92	0.000	5.013	3.588	4.905
97	JAN93	0.001	5.023	3.705	4.905
98	FEB93	0.002	5.031	3.788	4.905
99	MAR93	0.001	5.022	3.698	4.905
100	APR93	0.003	5.033	3.808	4.905
101	MAY93	0.009	5.048	3.948	4.905
102	JUN93	0.003	5.034	3.818	4.905
103	JUL93	0.017	5.060	4.044	4.905
104	AUG93	0.164	5.135	4.465	4.905
105	SEP93	0.360	5.202	4.713	4.905
106	OCT93	0.326	5.190	4.675	4.905
107	NOV93	0.224	5.155	4.694	4.905
108	DEC93	0.098	5.108	4.434	4.905
109	JAN94	0.190	5.144	4.636	4.905
110	FEB94	0.070	5.096	4.351	4.905

TABLE 3

OBS	TIME	PROBABILITY OF AN ATTACK	EXPECTED RATE CONDITIONAL ON AN ATTACK	REALIZED SHADOW EXCHANGE RATE	GOLD POINT
111	MAR94	0.100	5.109	4.439	4.905
112	APR94	0.071	5.096	4.353	4.905
113	MAY94	0.138	5.125	4.532	4.905
114	JUN94	0.105	5.112	4.454	4.905
115	JUL94	0.151	5.129	4.558	4.905
116	AUG94	0.204	5.148	4.660	4.905
117	SEP94	0.068	5.095	4.343	4.905
118	OCT94	0.143	5.126	4.542	4.905
119	NOV94	0.087	5.104	4.405	4.905
120	DEC94	0.063	5.092	4.324	4.905
121	JAN95	0.110	5.114	4.467	4.905
122	FEB95	0.038	5.078	4.216	4.905
123	MAR95	0.060	5.091	4.314	4.905
124	APR95	0.045	5.082	4.250	4.905
125	MAY95	0.036	5.076	4.203	4.905
126	JUN95	0.019	5.062	4.085	4.905
127	JUL95	0.021	5.064	4.102	4.905
128	AUG95	0.008	5.047	3.938	4.905
129	SEP95	0.005	5.040	3.866	4.905
130	OCT95	0.012	5.054	4.007	4.905
131	NOV95	0.008	5.047	3.935	4.905
132	DEC95	0.010	5.050	3.973	4.905

FIGURE 1

PROBABILITY OF A SPECULATIVE ATTACK

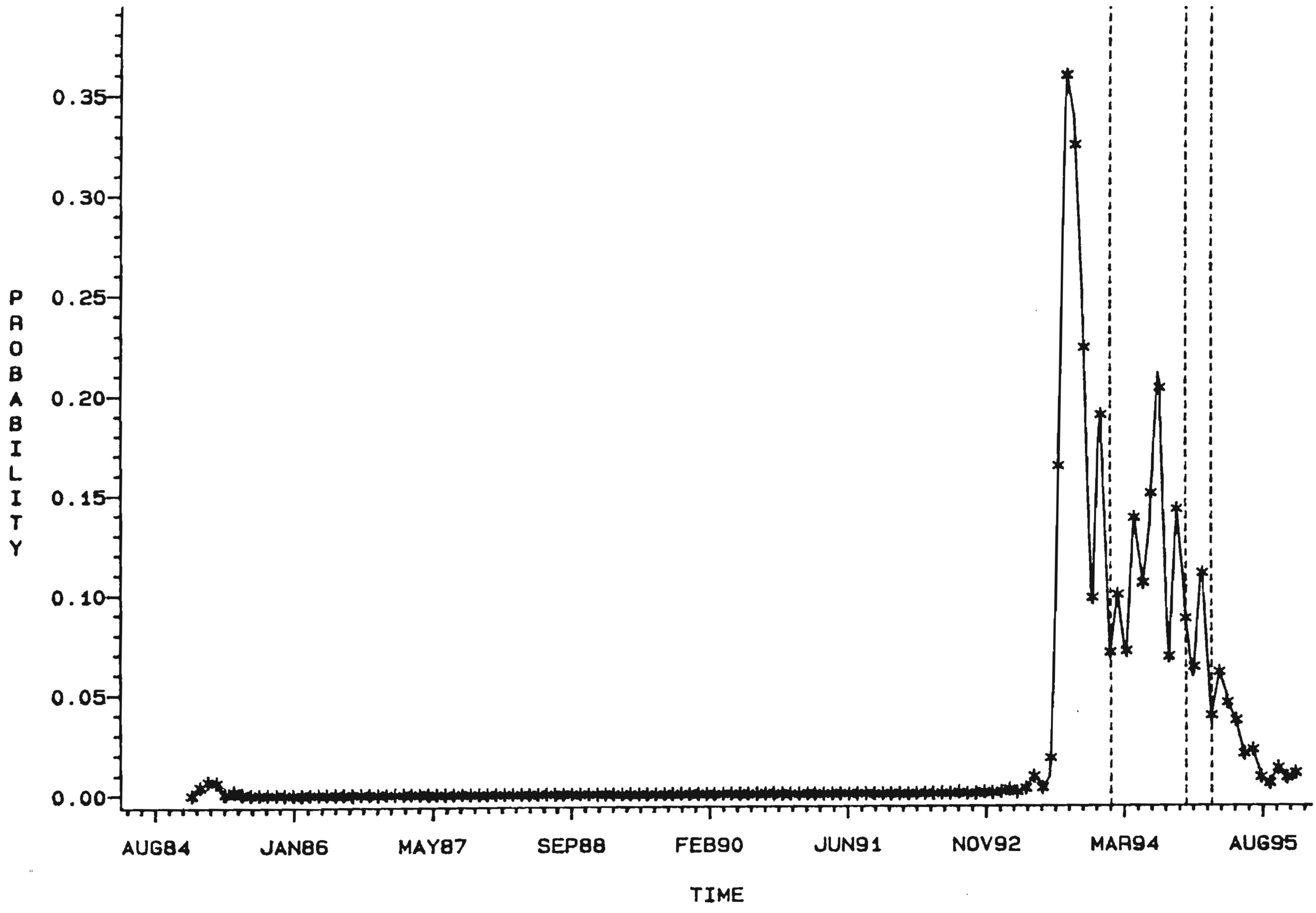


FIGURE 2
EXPECTED EXCHANGE RATE CONDITIONAL ON AN ATTACK

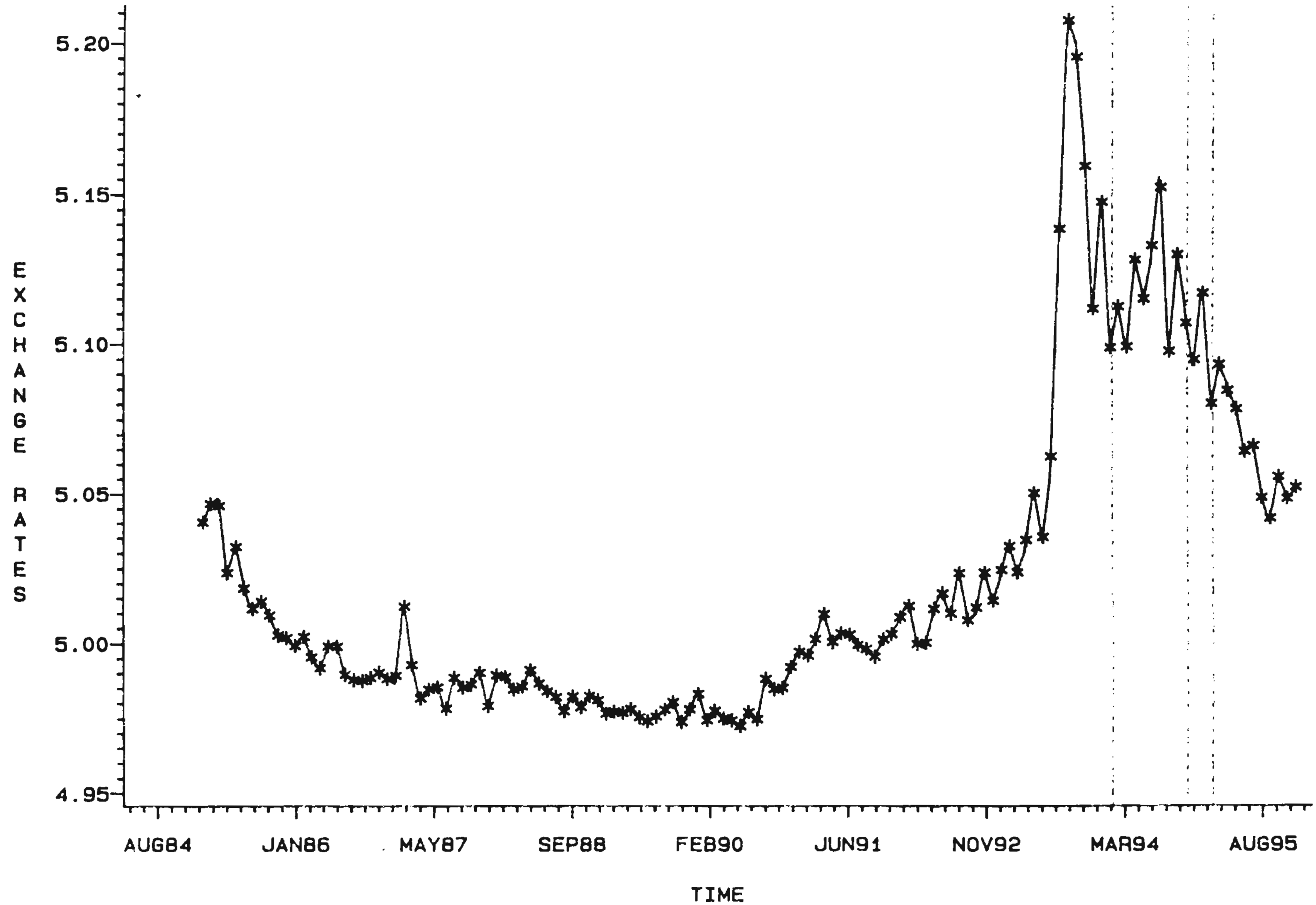


FIGURE 3
REALIZED SHADOW EXCHANGE RATE

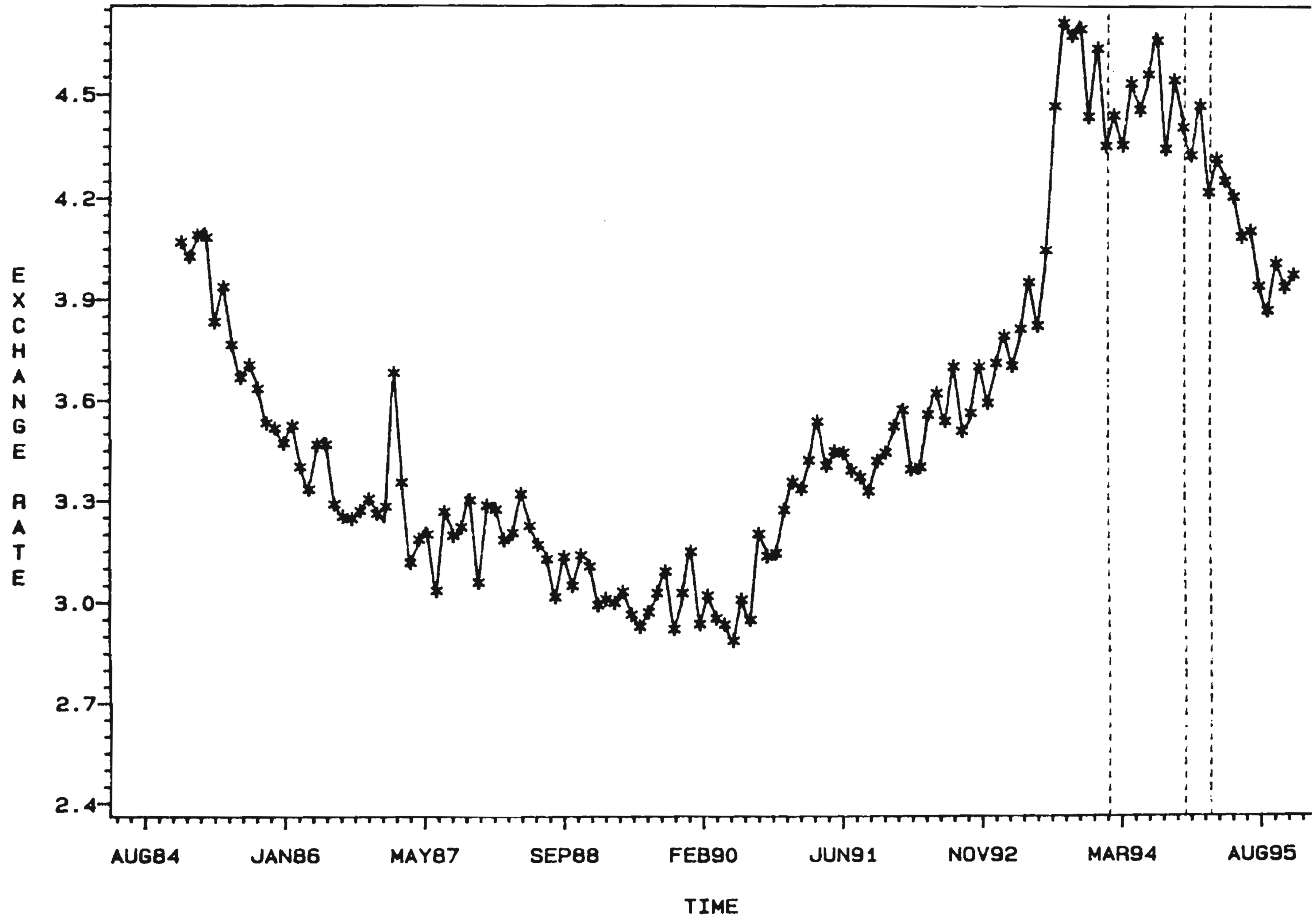


FIGURE 4A

PROBABILITY OF A SPECULATIVE ATTACK (+)
& HYPOTHETICAL PROBABILITY OF A SPECULATIVE ATTACK (*)
IF NONE OF THE THREE BOND ISSUES HAD EVER OCCURRED

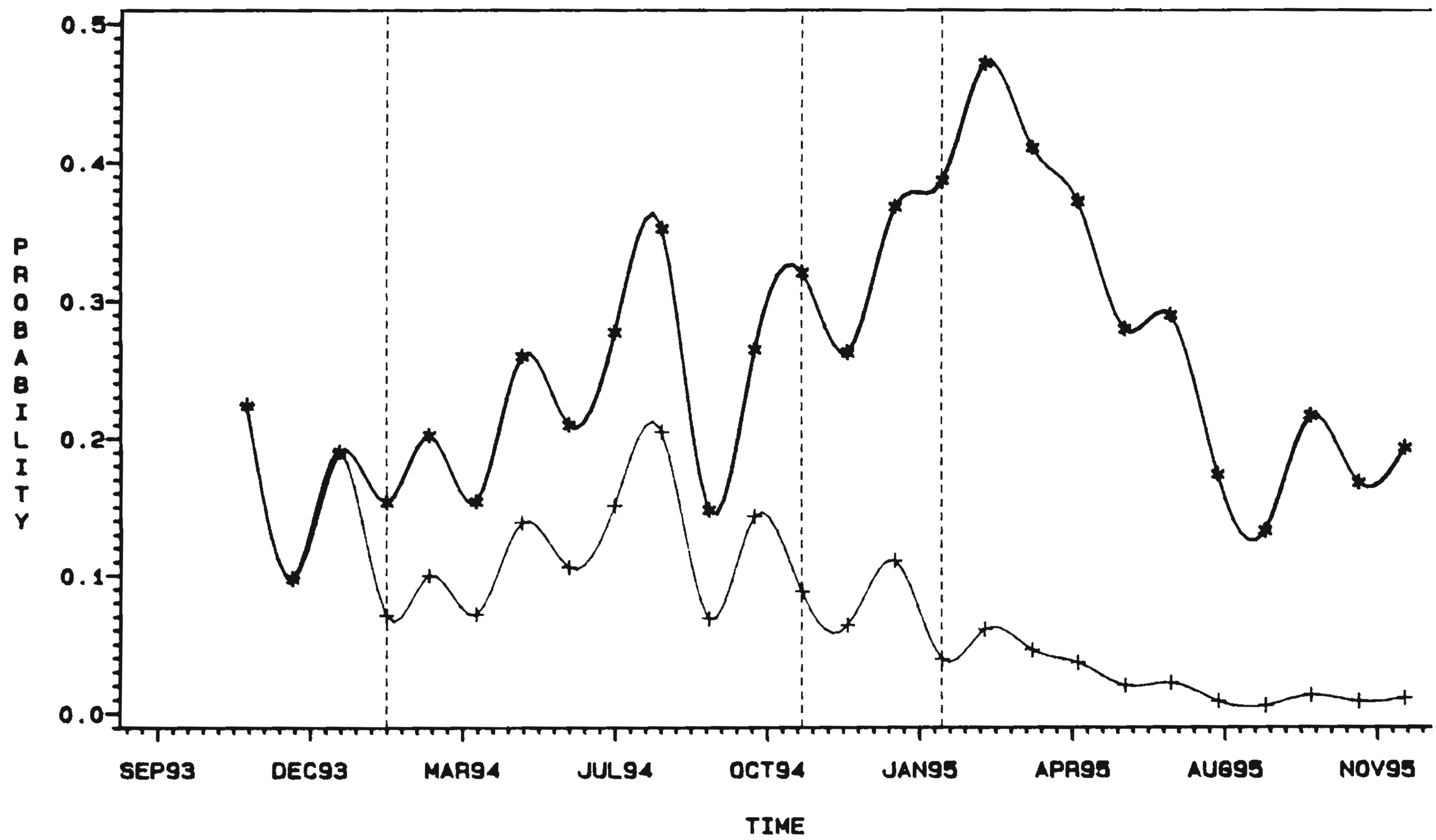


FIGURE 4B

REALIZED SHADOW (+) & HYPOTHETICAL REALIZED SHADOW (*) IF NONE OF THE THREE BOND ISSUES HAD EVER OCCURRED

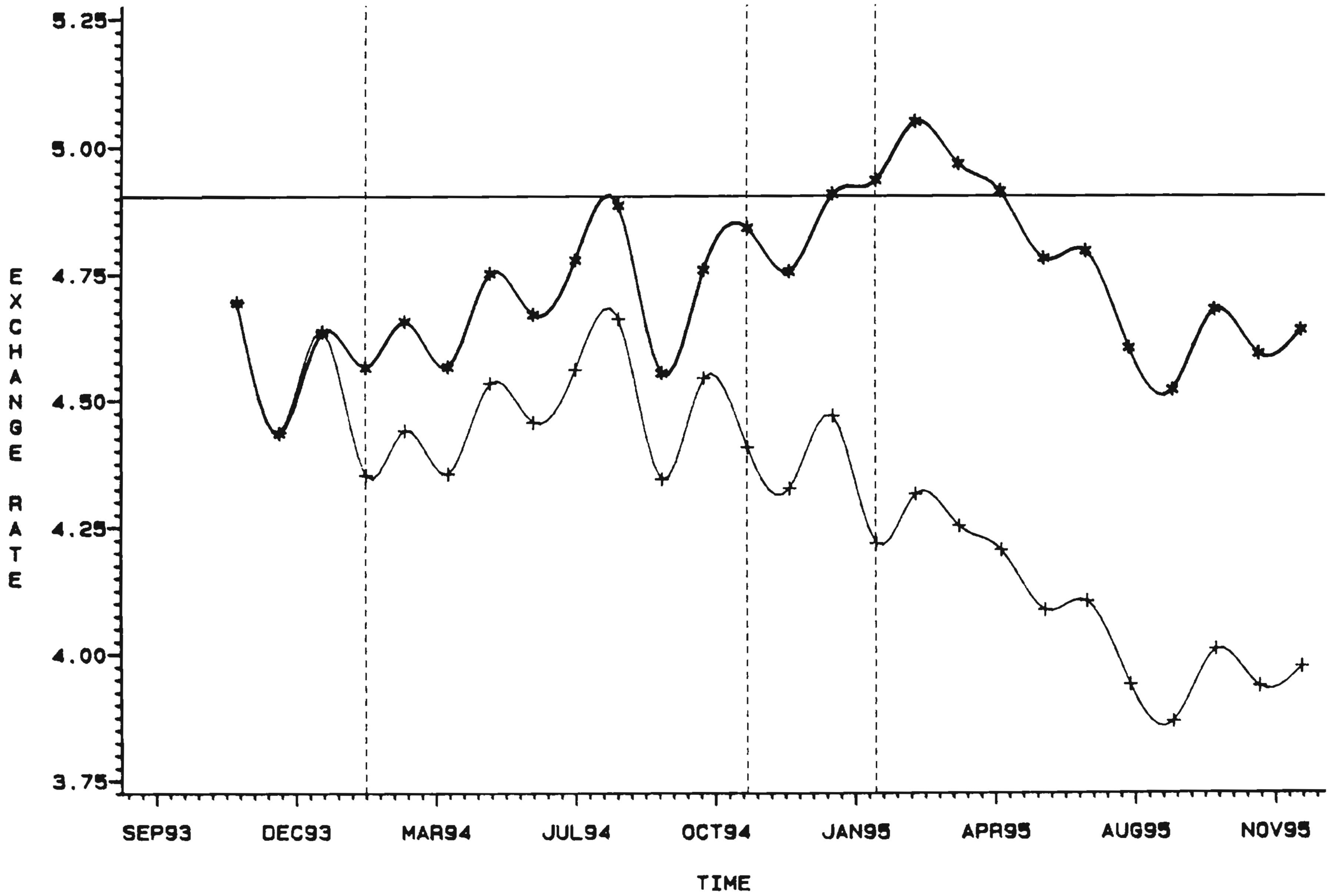


FIGURE 5A
PROBABILITY OF A SPECULATIVE ATTACK (+)
& HYPOTHETICAL PROBABILITY OF A SPECULATIVE ATTACK (*)
IF BELMONT-MORGAN CONTRACT HAD NEVER OCCURRED

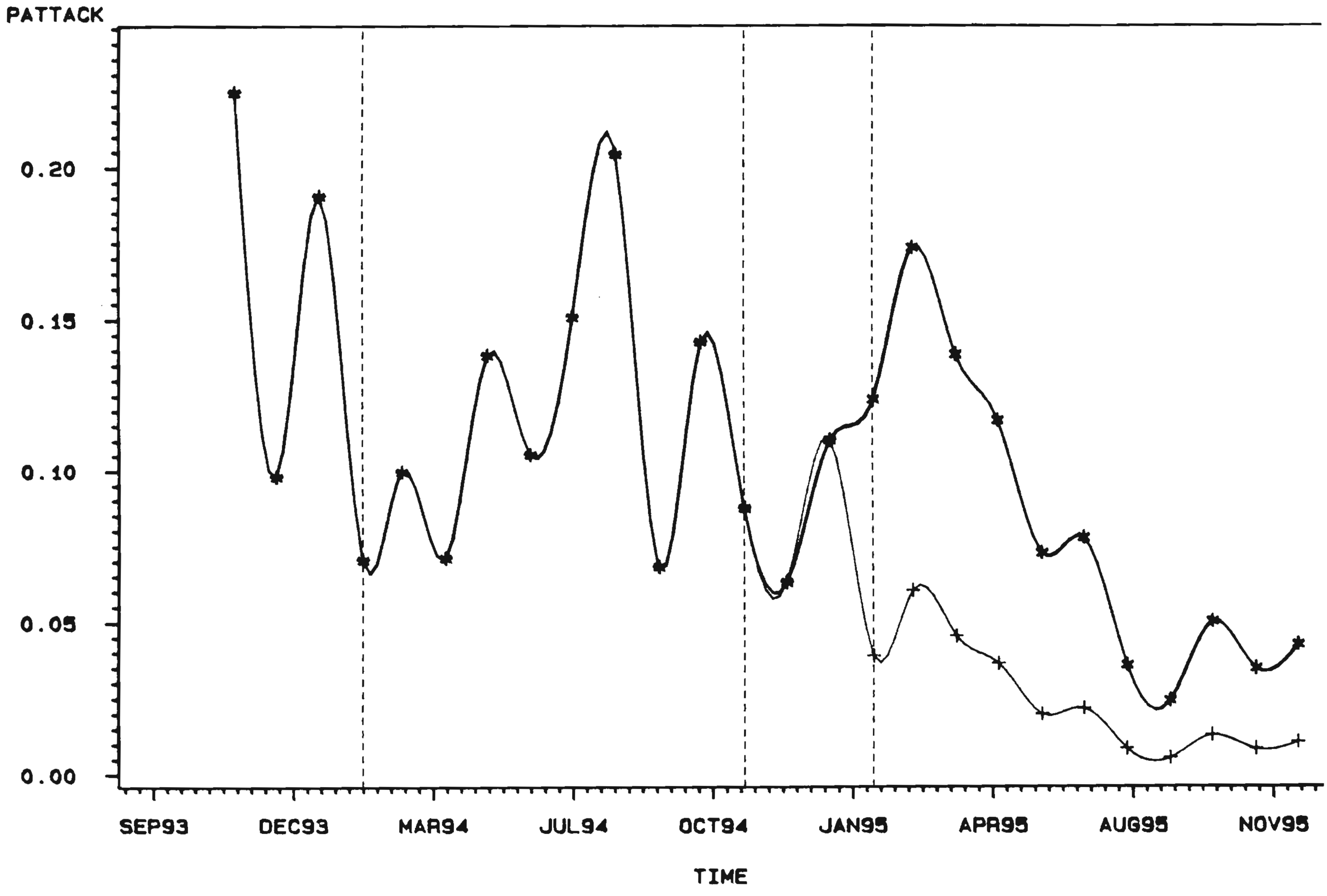


FIGURE 5B

REALIZED SHADOW (+) & HYPOTHETICAL REALIZED SHADOW (*)
IF BELMONT-MORGAN CONTRACT HAD NEVER OCCURRED

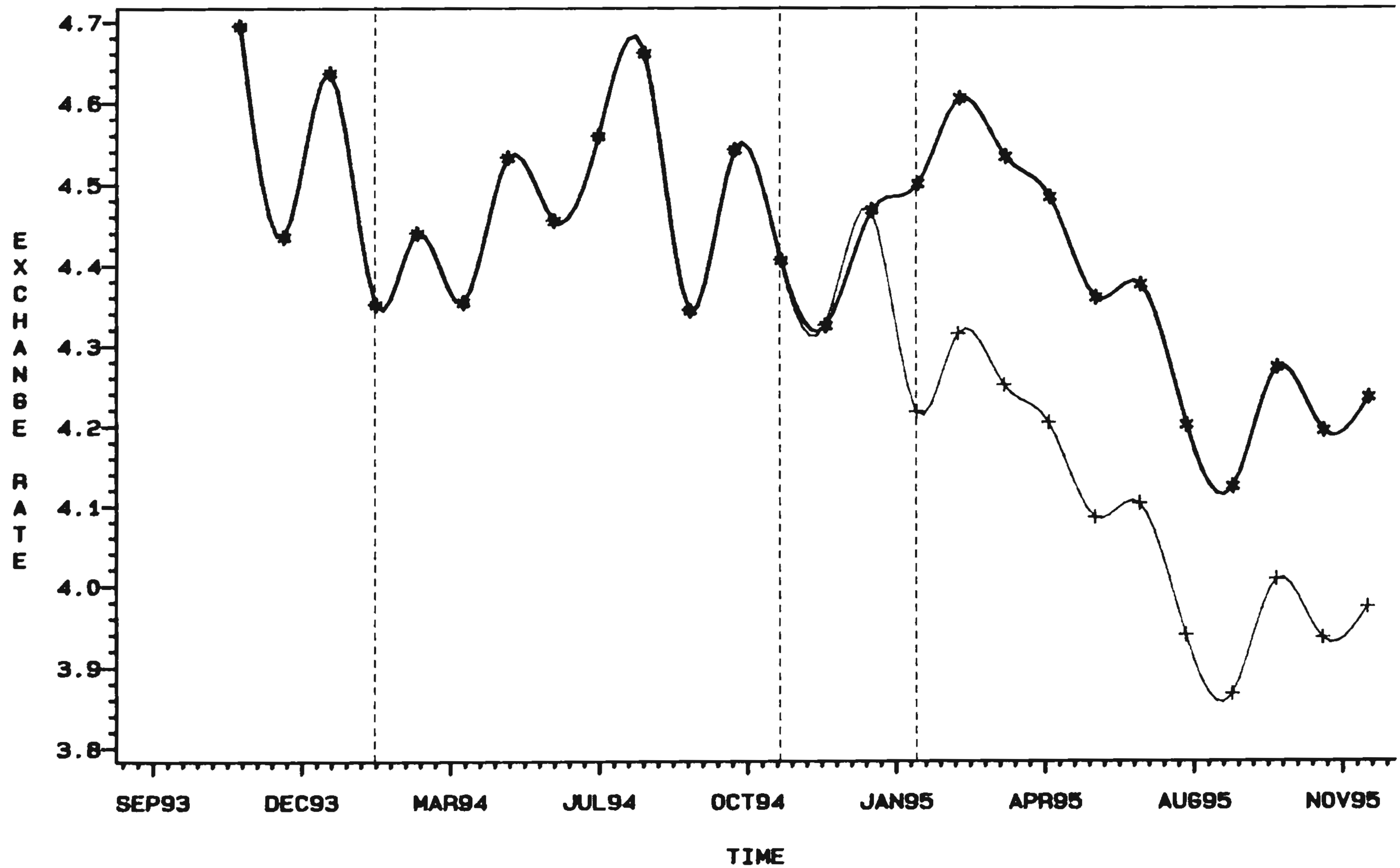


FIGURE 6

RELATIONSHIP BETWEEN SIZE OF BOND ISSUE & LINE OF CREDIT AND THE PROBABILITY OF A SPECULATIVE ATTACK

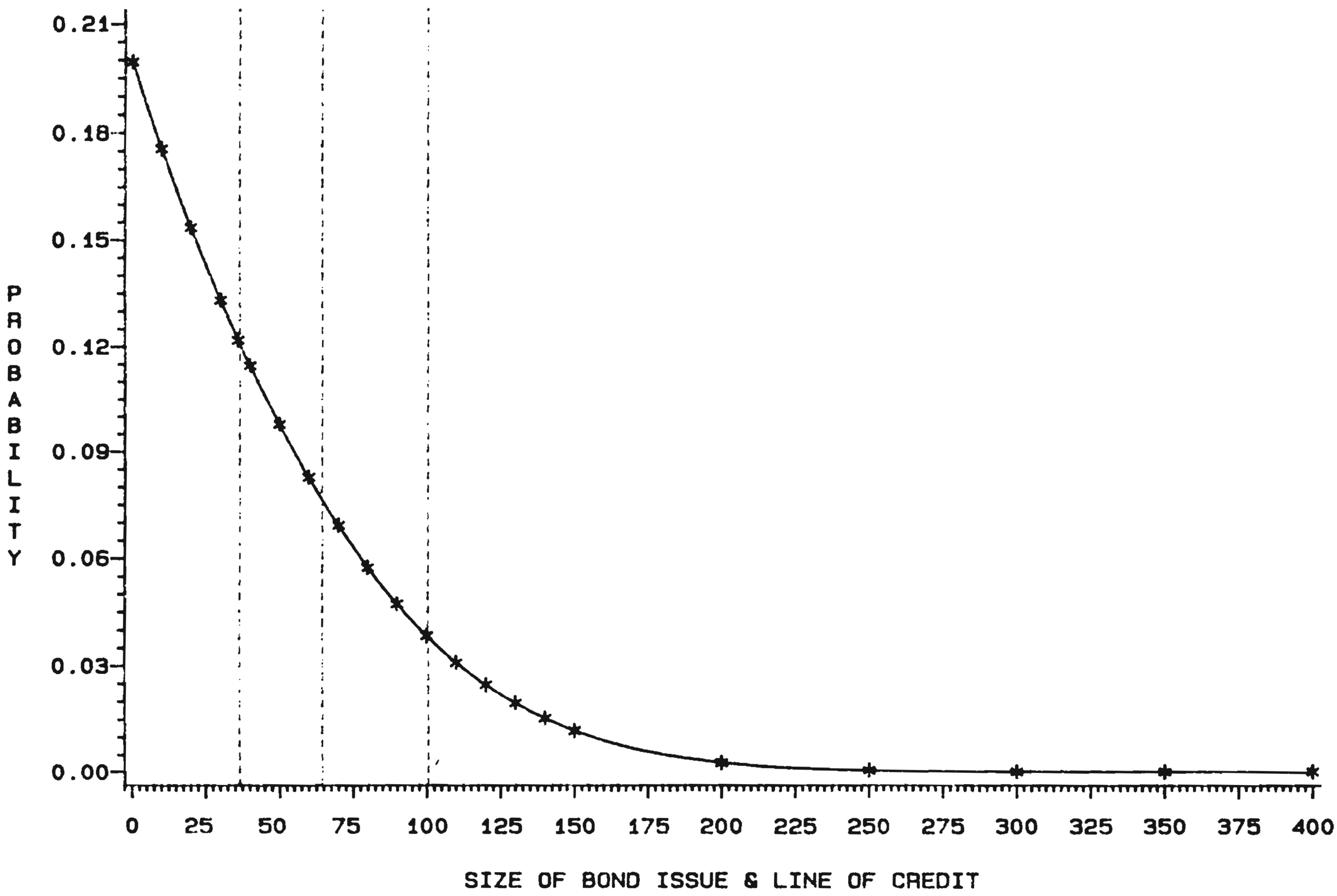


FIGURE 7

ACTUAL & **4 APPROXIMATED RELATIONSHIP BETWEEN SIZE OF ISSUE & LINE OF CREDIT AND THE PROBABILITY OF A SPECULATIVE ATTACK

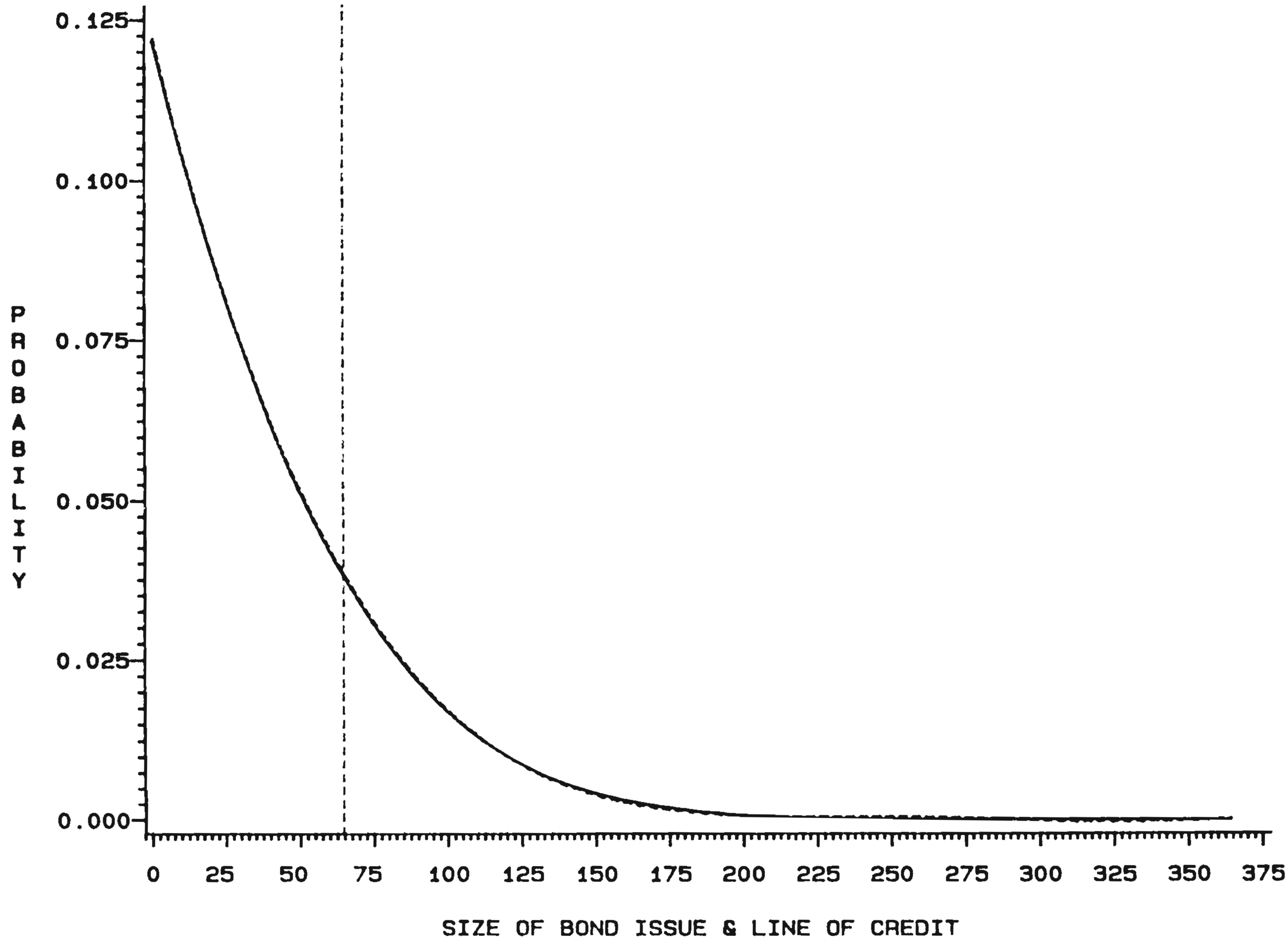


FIGURE 8
DEMAND FACED BY THE TREASURY

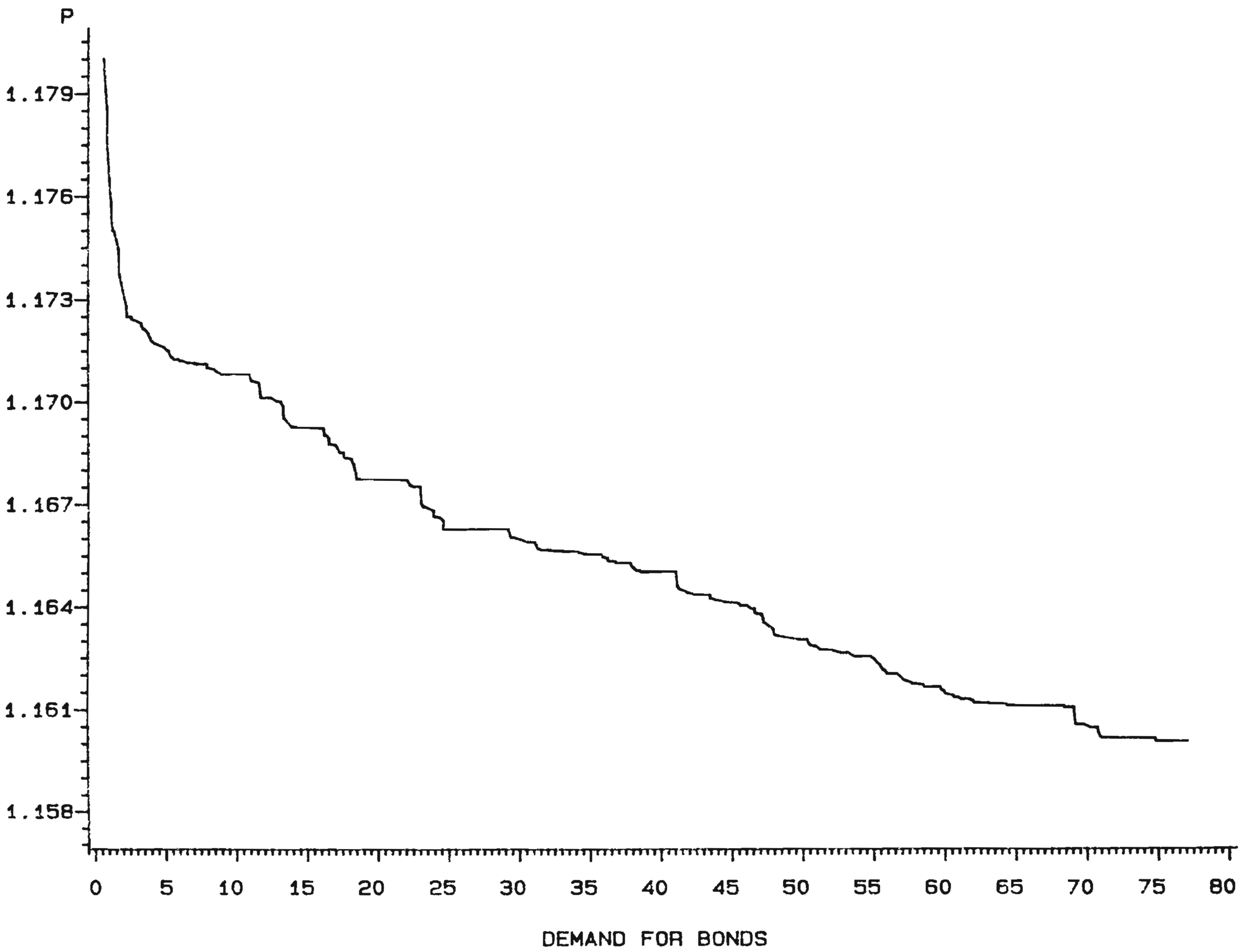


FIGURE 9

DEMAND FACED BY THE TREASURY
AND ESTIMATES OF THE DEMAND FACED BY THE SYNDACATE

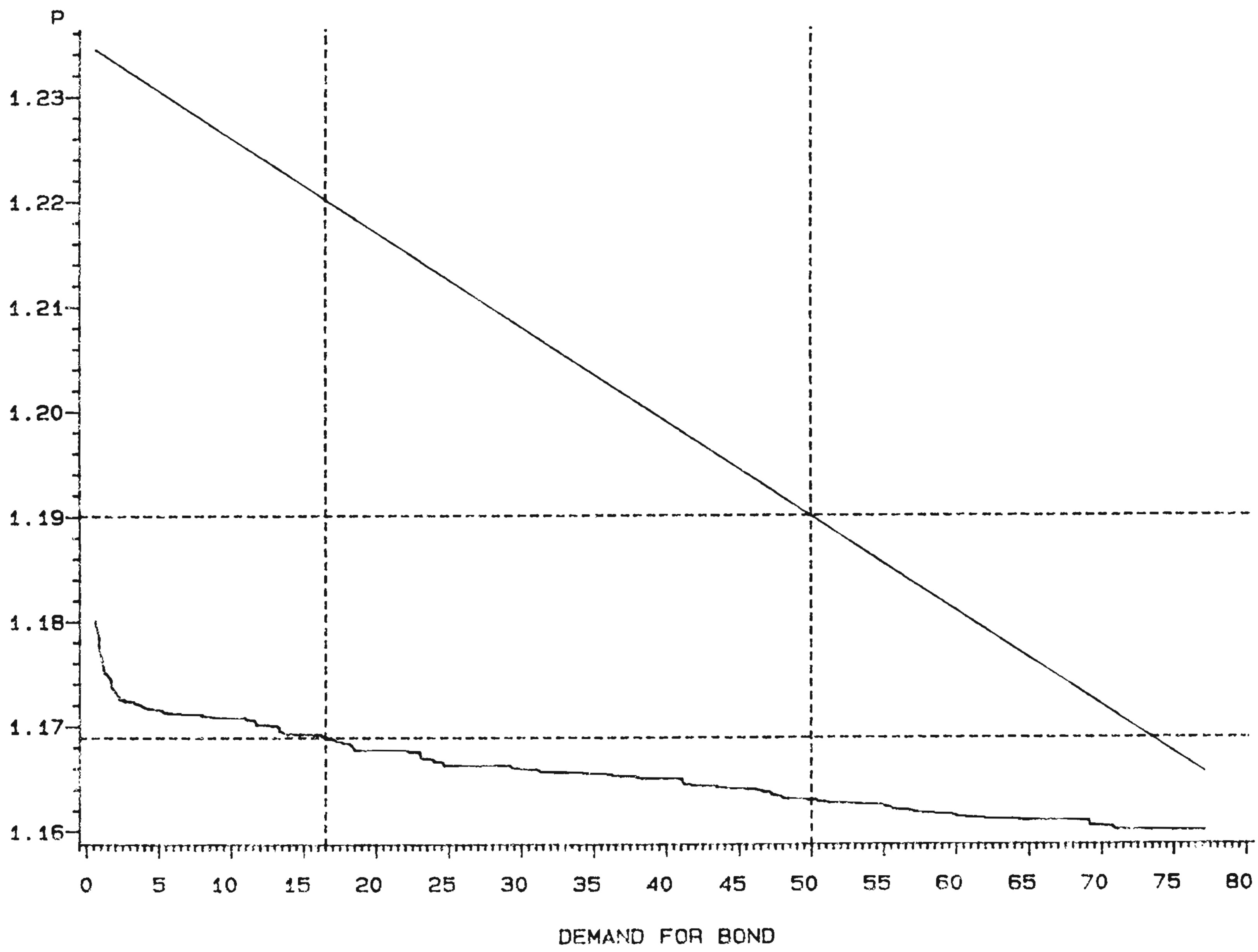


FIGURE 1A

NET GOLD RESERVES IN THE TREASURY

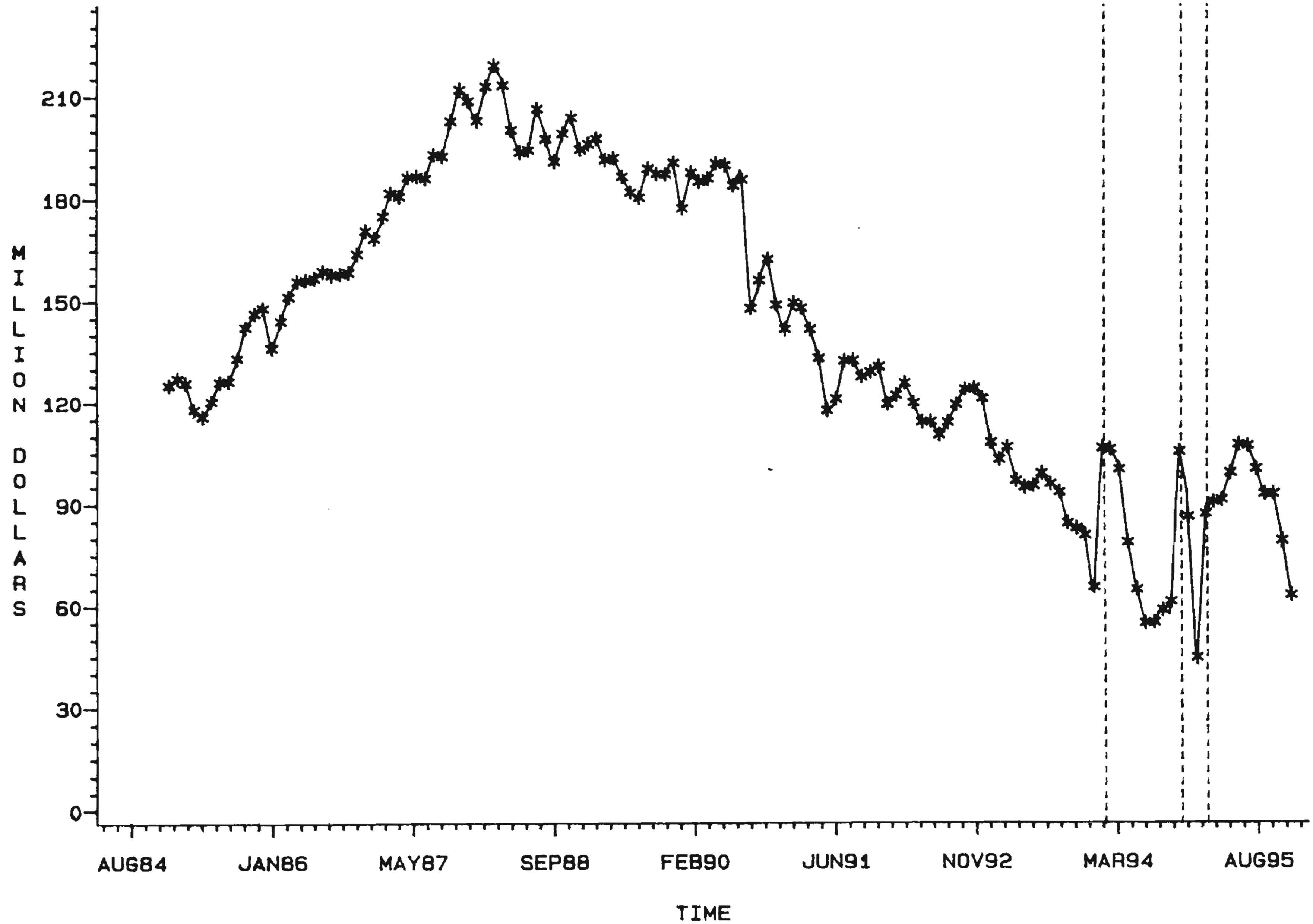


FIGURE 2A

DOMESTIC COMPONENT OF MONEY SUPPLY

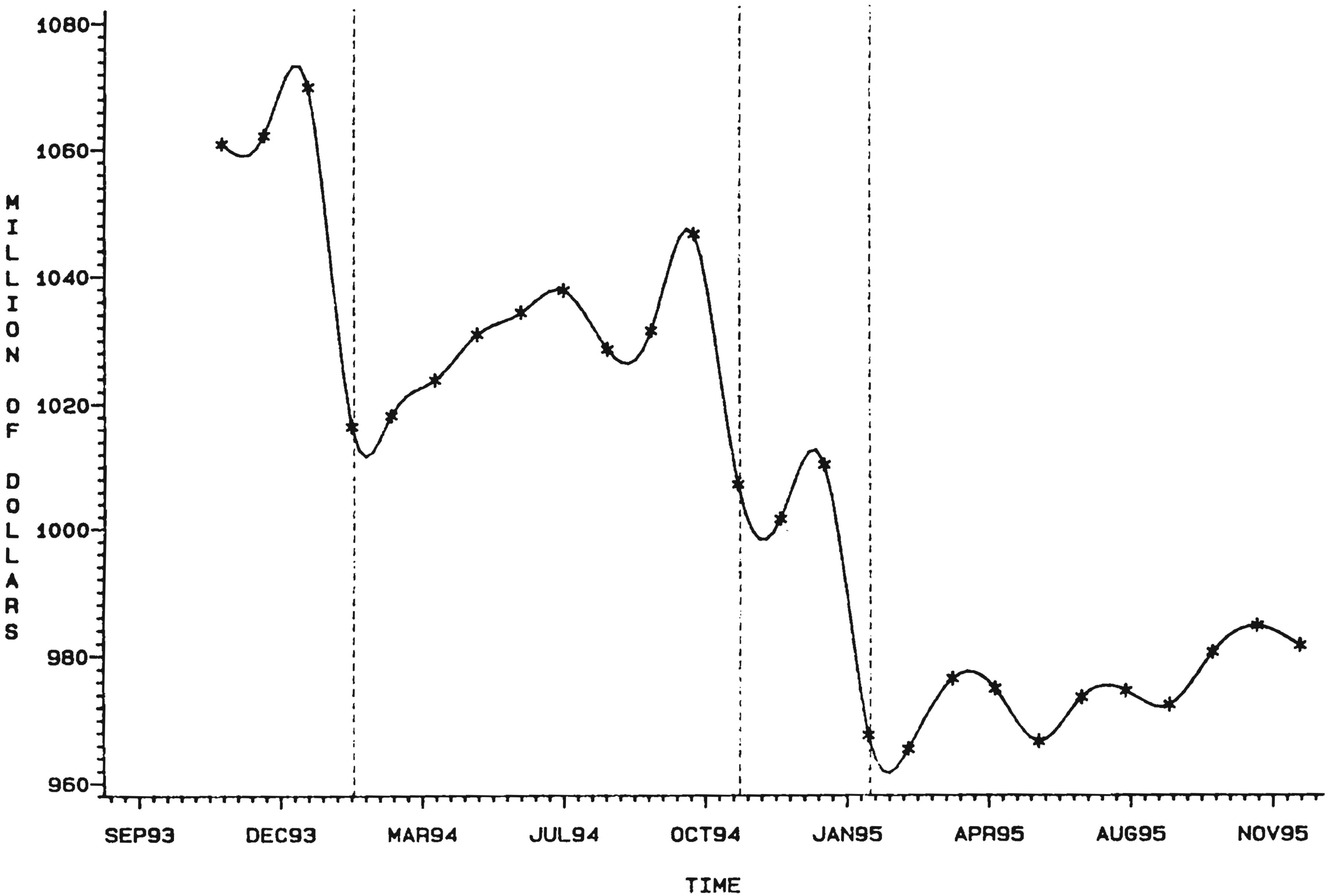


FIGURE 3A
PROBABILITY OF A SPECULATIVE ATTACK
IF SHERMAN ACT WAS VIEWED AS PERMANENT OR TEMPORARY

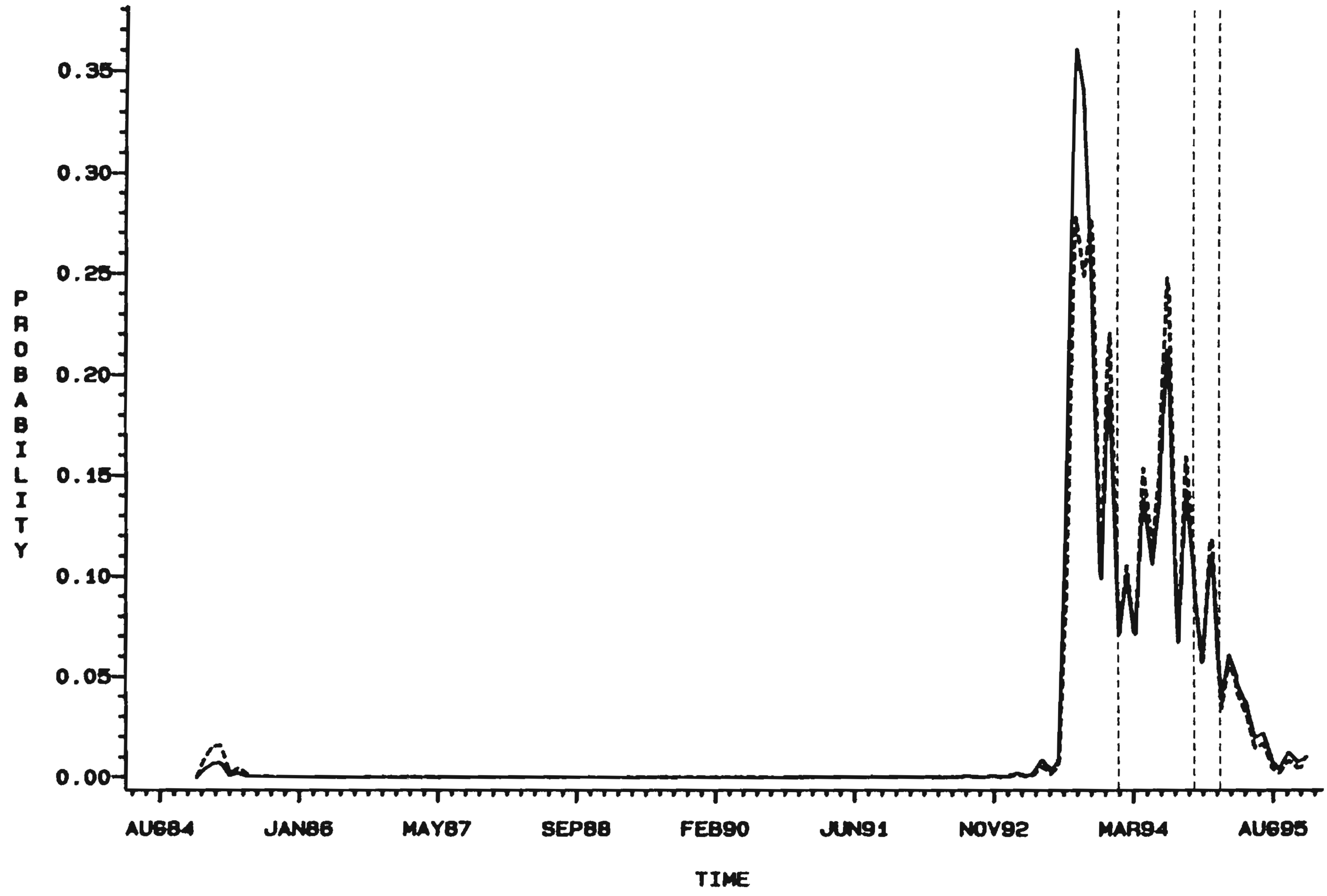
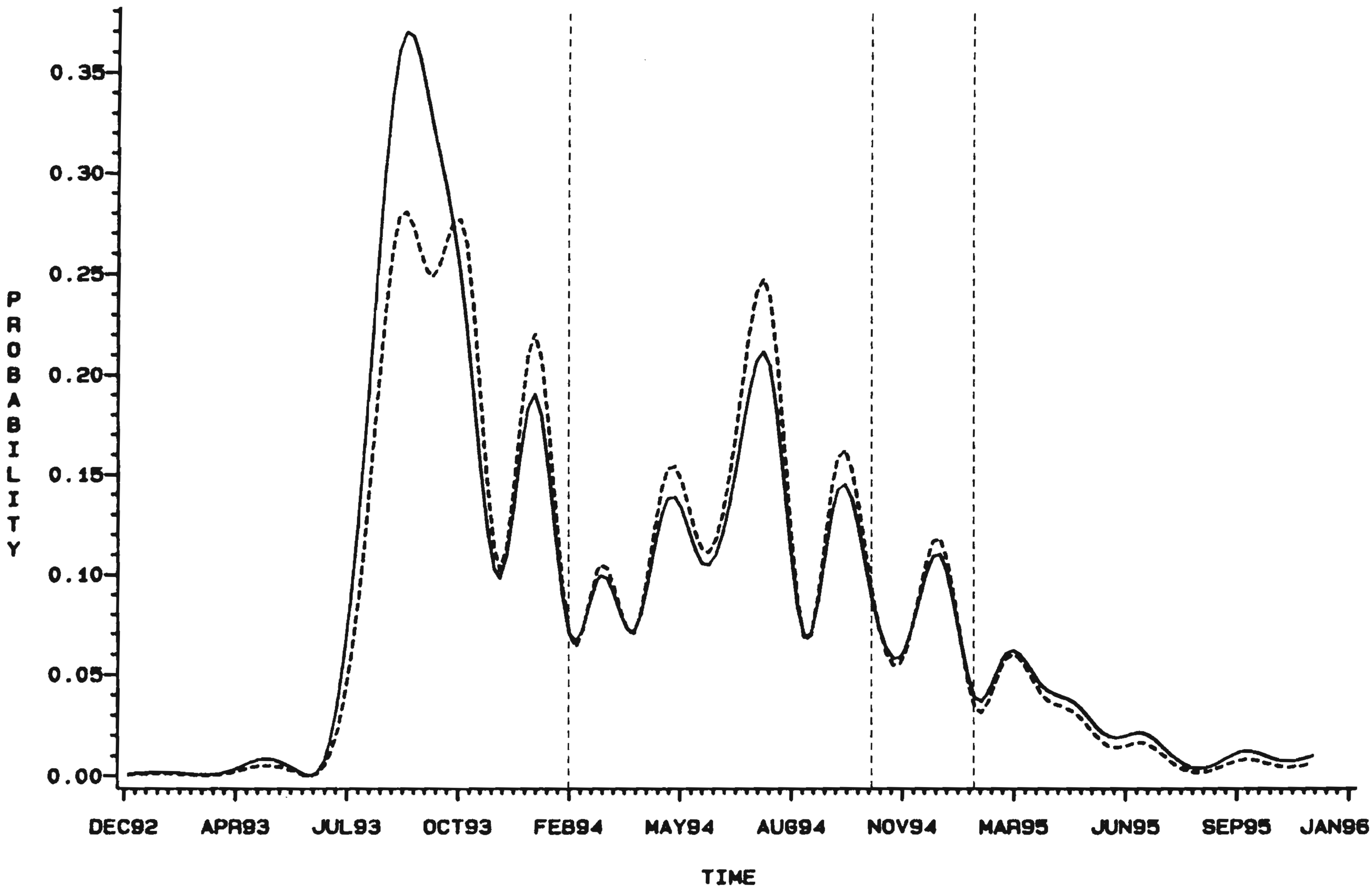


FIGURE 4A

PROBABILITY OF A SPECULATIVE ATTACK
IF SHERMAN ACT WAS VIEWED AS PERMANENT OR TEMPORARY



ARIMA PROCEDURE

NAME OF VARIABLE = H

MEAN OF WORKING SERIES= 1.18322
STANDARD DEVIATION = 0.0905925
NUMBER OF OBSERVATIONS= 68

SAMPLE: JANUARY 1885 - AUGUST 1890

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	STD
0	0.008207	1.00000	0
1	0.00710664	0.86592	0.121268
2	0.00652737	0.79534	0.191728
3	0.00609003	0.74205	0.235297
4	0.00531819	0.64801	0.267507
5	0.00487794	0.59436	0.289673
6	0.00442715	0.53944	0.307084
7	0.00397903	0.48483	0.320716
8	0.00387969	0.47273	0.33132
9	0.00352006	0.42891	0.341094
10	0.00284591	0.34677	0.348936
11	0.00280558	0.34185	0.353967
12	0.00257406	0.31364	0.358789
13	0.00212634	0.25909	0.362799
14	0.00194155	0.23657	0.36551
15	0.00175336	0.21364	0.367755
16	0.00156163	0.19028	0.369575
17	0.00124109	0.15122	0.371013
18	.000818069	0.09968	0.371919
19	.000730256	0.08898	0.372311
20	.000820715	0.10000	0.372624
21	.000621704	0.07575	0.373018
22	.000528327	0.06438	0.373245
23	.000564778	0.06882	0.373408
24	.000204847	0.02496	0.373594

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION
1	0.86592
2	0.18194
3	0.08725
4	-0.15399
5	0.05621
6	-0.00341
7	0.01036
8	0.12553
9	-0.06271
10	-0.21346
11	0.16838
12	0.03821
13	-0.09796
14	-0.02371
15	0.06550
16	-0.01470
17	-0.13888
18	-0.02889
19	0.11839
20	0.07228
21	-0.04209
22	-0.01012
23	-0.00161
24	[illegible]

ARIMA PROCEDURE

NAME OF VARIABLE = H

MEAN OF WORKING SERIES= 1.27678
STANDARD DEVIATION = 0.0934519
NUMBER OF OBSERVATIONS= 38

SAMPLE: SEPTEMBER 1890 - OCTOBER 1893

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1	STD
0	0.00873326	1.00000	********************	0
1	0.00707908	0.81059	****************	0.162221
2	0.00524609	0.60070	************	0.246774
3	0.0039337	0.45043	*********	0.282647
4	0.00309225	0.35408	*******	0.300944
5	0.00279569	0.32012	******	0.311715
6	0.00229955	0.26331	*****	0.320249
7	0.00185599	0.21252	****	0.325897
8	0.00173719	0.19892	****	0.329523
9	0.00139707	0.15997	***	0.332668
10	0.00104374	0.11951	**	0.334686
11	0.00096122	0.11006	**	0.335808
12	.000599068	0.06860	*	0.336756
13	.000427278	0.04893	*	0.337123
14	.000326542	0.03739	*	0.33731
15	-.00016974	-0.01944	*	0.337419
16	-.00040563	-0.04645	**	0.337448
17	-.00082044	-0.09394	**	0.337617
18	-.00102366	-0.11721	**	0.338304
19	-.00099477	-0.11391	**	0.339371
20	-.00108916	-0.12471	**	0.340376
21	-.00145667	-0.16680	***	0.341576
22	-0.0016642	-0.19056	****	0.343713
23	-.00188617	-0.21598	****	0.346482
24	-.00188311	-0.21562	****	0.350007

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	0.81059	****************
2	-0.16432	***
3	0.05001	*
4	0.03542	*
5	0.11150	**
6	-0.09847	**
7	0.03434	*
8	0.08057	**
9	-0.08854	**
10	-0.01183	
11	0.08128	**
12	-0.11544	**
13	0.03705	*
14	0.00677	
15	0.13832	***
16	0.03076	*
17	-0.09527	**
18	0.03697	*
19	-0.03352	*
20	-0.01171	
21	-0.13636	***
22	0.02213	
23	-0.04563	*
24	-0.00119	

ARIMA PROCEDURE

NAME OF VARIABLE = H

MEAN OF WORKING SERIES= 1 45966
STANDARD DEVIATION = 0 0550882
NUMBER OF OBSERVATIONS= 26

SAMPLE: NOVEMBER 1893 - DECEMBER 1895

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0	0 1 2 3 4 5 6 7 8 9 1	STD
0	0 00303471	1.00000		••••••••••••••••••••	0
1	0 00216785	0 71435		••••••••••••••	0 196116
2	0 002178	0 71770		••••••••••••••	0 278775
3	0 00170138	0 56064		•••••••••••	0.342546
4	0 00123536	0.40708		••••••••	0.376186
5	.000964141	0 31770		••••••	0 392763
6	.000729415	0 24036		•••••	0 402526
7	000465461	0 15338		•••	0.408009
8	.000132076	0 04352		•	0 41022
9	000067954	0.02239			0 410398
10	-.00040471	-0.13336	•••		0 410445
11	-.00055634	-0 18332	••••		0.412108
12	- 00059733	-0 19683	••••		0.415233
13	-.00100109	-0 32988	•••••••		0 418806
14	-0.0008165	-0 26905	•••••		0 428683
15	- 00097547	0 32144	••••••		0 43513
16	- 00094511	-0 31143	••••••		0 444169
17	-.00082993	-0 27348	•••••		0.452489
18	-0 0007576	-0 24965	•••••		0.458802
19	- 00081234	-0 26768	•••••		0.463998
20	-.00074188	-0 24447	•••••		0 4699
21	- 00075757	-0 24963	•••••		0 474766
22	- 00073187	-0 24117	•••••		0.479788
23	-.00057125	-0 18824	••••		0 484428
24	- 00039233	-0 12928	•••		0.487233

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0	0 1 2 3 4 5 6 7 8 9 1
1	0 71435		••••••••••••••
2	0 42352		••••••••
3	-0.09321	••	
4	-0 27827	••••••	
5	-0 02970	•	
6	0 13886		•••
7	-0 01752		
8	-0.25568	•••••	
9	0.02842		•
10	-0 13228	•••	
11	-0 12009	••	
12	0 14107		•••
13	-0 19546	••••	
14	0 03472		•
15	0 00223		
16	-0 02652	•	
17	0 07203		•
18	-0 03364	•	
19	-0 15318	•••	
20	-0 06503	•	
21	-0 08865	••	
22	0.12895		•••
23	0 00253		
24	0 01684		

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