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INTEREST-ONLY/PRINCIPAL-ONLY MORTGAGE-BACKED STRIPS: A VALUATION AND RISK ANALYSIS

Alan J. Marcus

Arnold Kling

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ABSTRACT

We examine the risk characteristics of each portion of IO/PO mortgage strips, present results of a valuation model of these securities, and examine market prices of both the interest-only and principal-only portions of mortgage pools. We show that IO/PO securities are highly sensitive to the prepayment behavior of the underlying mortgage pool. Because that behavior varies systematically with the interest rate, and because prepayments affect the values of IO and PO components in opposite ways, the interest-rate risk of strip securities can differ substantially from that of the underlying mortgage pool. The PO component has much longer duration than the underlying mortgage pool. In contrast, the IO component typically will have a negative duration, at least in ranges for which interest-rate movements induce meaningful changes in mortgage prepayment behavior. We also show how market prices of partially-stripped MBSs that are actively traded on secondary markets can be used to infer market values of pure IO/PO strips. Recent market data is fully consistent with the theoretical insights offered by our valuation model. When interest rates spiked last April, PO values fell far more dramatically than those of the underlying mortgage pool while IO values actually rose.

Arnold Kling
Federal Home Loan Bank Board
1776 G Street, NW
Washington, DC 20013

Alan J. Marcus
School of Management
Boston University
704 Commonwealth Avenue
Boston, MA 02215

The huge trading losses of Merrill Lynch and other investment bankers recently focused considerable attention on interest-only/principal-only (IO/PO) mortgage-backed securities. These securities are formed by separating interest payments on mortgage pools from principal repayments and selling claims to each income stream separately. The IO security receives all the interest payments made on the mortgages in the pool. These payments cease when mortgages are prepaid. PO securityholders, in contrast, benefit from early payment of principal. Neither the risk characteristics nor the appropriate pricing of these new securities are yet well understood. Equally important, it is not widely recognized that in some cases market data is available that can be used by issuers to price these securities precisely. In this paper, we examine the risk characteristics of each portion of IO/PO strips, present results of a valuation model of these securities, and show how market prices of traded securities can be used to infer the values of both the interest-only and principal-only portions of mortgage pools.

1. Interest-Rate Risk in IO/PO Securities

The major difficulty in analyzing all mortgage-backed securities lies in the analysis of prepayments. A 30-year 10% conventional mortgage selling at par would have a duration of about 8.4 years if prepayments were disallowed.[1] In practice, of course, prepayments shorten durations of mortgage pools considerably. For example, a prepayment rate of 5 percent of outstanding mortgages per year would reduce duration to 6.2 years. The peculiarity of IO/PO securities is that the risk of interest-rate increases is borne overwhelmingly by the owner of the principal-only security. The duration of the PO portion greatly exceeds that of the underlying mortgage pool, while the duration of the IO portion is correspondingly smaller. In fact the IO portion is likely to have negative duration, and thus potentially may serve as a hedging asset for fixed-income portfolios.

This disparity in interest-rate exposure derives primarily from the interaction of prepayment behavior with interest-rate movements. When interest rates increase, the value of the PO security falls for two reasons. First, future repayments of principal are worth less as the discount factor for the time value of money increases. Second, mortgage prepayment rates fall when interest rates rise, thereby increasing the average time until repayment of principal. The increase in the time until receipt of principal payments in conjunction with the increase in the discount rate results in a substantial decrease in the present value of those payments. These factors lend the PO security a duration substantially longer than that of the underlying pool of mortgages.

In contrast, the IO portion of the mortgage is affected in offsetting ways by interest rate movements. A decline in interest rates increases the present value of scheduled interest payments, but simultaneously increases the incidence of prepayments of principal. Since these prepayments terminate the stream of interest payments made on the mortgage pool, they lower the value of the IO security. The net effect on the value of the IO security may be either positive or negative. However, for interest rates near the coupon rate of the mortgage pool, prepayments tend to increase enough in response to a fall in the interest rate that the IO security loses value. In this empirically relevant region, the termination of interest payments dominates the effect of lower discount rates, resulting in a negative duration for the IO security.

To illustrate these points, consider a 30-year $100,000 mortgage with a 10% coupon rate. If prepayments were disallowed, then 84.2% of the present value of the total cash flows on the loan would derive from the interest component of payments while only 15.8% would derive from principal repayments. At the other extreme, if the mortgage were prepaid immediately, an interest-only claim would become worthless while the value of the principal claim would jump from $15,800 to the principal balance of $100,000.

The effect of prepayment behavior is examined in Table 1 where prepayment per year is assumed to be a constant fraction of outstanding mortgages. The effect of prepayment experience is evident. An unanticipated increase in the prepayment rate from 5% to 7.5% would, even without coincident interest-rate movements, reduce the value of interest payments from $61 to $53.2 per $100 principal balance, inducing a capital loss to an IO security holder of 12.8%. The corresponding gain on the PO security would be from $39 to $46.8, for a capital gain of 20%. These calculations are incomplete, of course, because they ignore the interaction between prepayment behavior and changes in interest rates, but they do illustrate the wide swings in the relative shares of the mortgage value that accrue to interest versus principal claimants when prepayment rates change. Market values in practice should be even more volatile than suggested by Table 1 since prepayment rates in fact vary in response to interest-rate swings.

The weighted average of the durations of the IO and PO securities must equal the duration of the underlying pool of mortgages. Thus, the great disparity in durations of the component securities are necessary counterparts: the short or negative duration of the IO security must be matched by correspondingly long durations of the PO security.

Table 1: Components of Mortgage Values

Prepayment Rate (per year)	Percent of Value Due to Interest Payments	Percent of Value Due to Principal Repayments
0.0%	84.2%	15.8%
2.5	71.0	29.0
5.0	61.0	39.0
7.5	53.2	46.8
10.0	47.1	52.9
15.0	38.1	61.9
20.0	31.9	68.1
25.0	27.4	72.6

2. Contingent-Claims Analysis

The right to prepay a mortgage is in essence a call option that gives the homeowner the right to call back the loan from the lender at a price equal to the scheduled balance remaining on the loan. Thus, mortgage-backed securities may be valued using the same techniques that have been developed for other option-valuation problems. In fact, option-pricing techniques have been applied to GNMA mortgage-backed security valuation by Dunn and McConnell (1981a, 1981b), Brennan and Schwartz (1985), and others. Here, we apply similar techniques to the valuation of the IO and PO components of a mortgage-backed pool. Following their lead, we assume that there are two types of mortgage prepayments: economically-motivated prepayments (and refinancings) that exploit interest rate declines, and "autonomous" prepayments that arise when homeowners change their residences. We will assume that 5% of all outstanding mortgages prepay for autonomous reasons in each year. Such a simplistic specification is arbitrary, but does little harm to the analysis of the interest-rate dependence of these securities, which depends primarily on economically-motivated prepayment.[2]

Economically-motivated prepayment will occur when the interest rate reaches a critical point at which refinancing is optimal for the homeowner. This critical point will be determined by the process under which interest rates evolve over time. We will assume that the interest rate is expected to increase when it is below 10% and to fall when above 10%. Hence, 10% is the natural or long-run equilibrium value of the interest rate. The speed with which rates are impelled toward that long-run value is assumed to be proportional to the difference between the interest rate and its long run equilibrium value.[3]

In addition to the expected drift in the interest rate, there are continuous shocks to rates due to unanticipated economic events. We model interest rate uncertainty as increasing with the level of rates, specifically that the variance of the interest rate is proportional to the level of the rate.[4] In our numerical simulations, we set the proportionality constant equal to .25. At a 10 percent interest rate, this results in a standard deviation of the interest rate of 1.6 percent annually.

Using this particular set of assumptions, we can use a valuation model to examine the response of IO, PO, and mortgage-pool values to interest rate changes. Our mathematical approach is modelled after Brennan and Schwartz (1977), which provides a full discussion of the techniques used to value interest-rate-dependent option-like securities.

In brief, the valuation methodology uses the dynamics for interest rate movements given in footnotes 2 and 3 to derive the corresponding dynamics for the value of interest-rate dependent securities. These, together with "boundary conditions" for the values of the security at extreme values of the interest rate or at optimal prepayment dates, uniquely determine both the value of the security at all points and the optimal prepayment schedule. In our model, we employ a version of the liquidity preference theory, and assume that the expected risk premium earned by each security is proportional to the instantaneous standard deviation of that security's rate of return, with a proportionality constant of 0.1. Such a specification generates a liquidity premium of about 1.5% for an 8-year duration asset.

Figure 1 is a graph of the value of the 3 securities (IO, PO, and the mortgage pool itself) backed by a mortgage pool with a coupon rate equal to the long-run equilibrium interest rate, 10%, as a function of the current market interest rate. The mortgage pool is assumed to have been issued 10 years ago with an original life of 30 years. The current principal value is $90.78 per $100 original principal. Notice that, as anticipated, the value of the PO security falls most dramatically with interest rate increases, especially at interest rates near the optimal prepayment point of about 8 percent. As economically-motivated prepayment becomes more likely at lower interest rates, the value of the PO security rises dramatically. In contrast, the IO security falls in value with interest rate decreases, even at rates as high as 14%. Like the PO, the value of the IO security is most sensitive to the interest rate near the optimal economic-prepayment point.

These interest-rate sensitivities are even more evident in Figure 2, which depicts the durations of the securities as functions of the interest rate. The duration of the mortgage pool is nearly 3 years at high interest rates. Without prepayment, it would be about 6 years. The seemingly-large difference in duration is due both to the incidence of autonomous prepayments and to the threat of economic prepayment. Even at an interest rate of 14%, such a threat is not trivial since the interest rate at that point is drifting downward to its long-run equilibrium value of 10%. The duration of the mortgage is even shorter at lower interest rates since economic prepayment is that much more imminent.

The duration of the PO security is far larger. For larger values of the interest rate, it is roughly double that of the mortgage pool. At an interest rate of 10%, the duration of the PO is 13 years, roughly 5 times that of the mortgage. From there, duration rises dramatically to 60 years at an interest rate just above the prepayment point.

The duration of the IO security is, in contrast, negative and of quite large magnitude at interest rates below 10%. At an interest rate of 11 percent, duration is 52 years; at 10 percent it is 58 years. From there duration spikes downward even more dramatically. At the optimal economic prepayment point duration is essentially infinitely negative.[5]

These values are more extreme than one would expect to observe in reality since the valuation model assumes that all outstanding mortgages are prepaid at the optimal moment, when in practice some homeowners will defer prepayment for reasons not captured by the model. While the model allows for suboptimal (autonomous) prepayment, it does not allow for suboptimal non-prepayment. Nevertheless, the qualitative pattern of strip values illustrated in Figures 1 and 2 will be observed in practice, and IO/PO strips do empirically exhibit large durations. Indeed, Figure 5, which traces out estimates of actual IO and PO strip values during a period of rising interest rates is remarkably similar to Figure 1.

Other (nonreported) simulations replicate the analysis of Figures 1 and 2 for mortgage coupon rates of 8 and 12 percent, thus bracketing the long-run equilibrium interest rate. While the optimal economic-prepayment points differed from the analysis of Figures 1 and 2, the qualitative patterns that emerged were otherwise identical.

3. Investment Implications

The peculiar interest rate exposures of the IO/PO securities create both opportunities and risks for their investors. The interest-rate exposure of the PO security is apparent. Nevertheless, such securities may be useful portfolio tools for investors seeking very-high-duration assets. For example, pension funds with long-duration liabilities might find PO securities useful for immunization purposes.

IO securities offer hedging opportunities for investors holding more conventional fixed-income securities. For example, a thrift institution with holdings of conventional mortgages could offset some of its interest rate exposure by holding part of its portfolio in mortgage-backed IO securities with negative duration.

4. Empirical Evidence

While the valuation model presented above is useful for analyzing the properties of IO/PO securities, the particular values derived are dependent on assumed autonomous prepayment rates and on the posited process for the evolution of interest rates. One would like a valuation procedure that is consistent with market information as reflected in prices of other traded assets. Fortunately, such data do exist, and market assessments of the values of the IO/PO components of some mortgage pools can be computed directly from these data. Hence, the "proper" market prices for the IO/PO components of at least some mortgage pools can be inferred.

Completely stripped mortgage-backed securities tend to be privately placed, and to date have been traded only erratically on the secondary market. Consequently, investment bankers cannot easily rely on market values of outstanding strips to price newly issued securities. However, FNMA has issued partially stripped securities that are actively traded that can be used to infer the market values of IO/PO securities. This inference is made possible because the partial strips allocate principal and interest in different proportions to different-class securites.

To illustrate, consider the issues of "B" and "C" series securities by FNMA in the letter half of 1986, in which two 9 percent coupon mortgage-backed securities (MBSs) were divided up so that the premium classes received 2/3 of the interest and 1/2 of the principal payments, while the discount classes received 1/3 of the interest and 1/2 of the principal. The premium class, therefore effectively became a 12% security (= 9% x 2/3 ÷ 1/2) while the discount class was effectively a 6% security (= 9% x 1/3 ÷ 1/2). (However, these synthetic securities would not behave precisely like original-issue 12 or 6 percent coupon mortgage pools since the prepayment behavior of the "synthetic" securities would be tied to the 9% coupon rate of the underlying mortgage pools.

If one were to take a long position in the premium-class security and a short position in the discount-class security, the principal payments would net out to zero, and one would be left with a three percent IO strip on the underlying 9% coupon mortgage pools. Therefore, three times the value of the price difference between the premium and discount securities equals the value of a pure 9% IO strip. Substracting the value of that IO strip from the sum of the values of the discount and premium securities then gives the value of a "synthetic" PO position on the 9% mortgage pool. The key to this procedure is that the premium and discount securities are written on the same underlying MBS and so have identical prepayment exposure. Long and short positions on <u>different-coupon</u> passthroughs would create interest and principal-only securities only until the prepayment behavior of the two passthroughs diverged.

Goldman Sachs supplied us with price data for 3 types of partial strips:

the "B" and "C" series just discussed in which 9% pools were split into 6 and 12 percent securities, the "D" series, in which an 8.5% coupon MBS was split into 11% and 6% securities, and the "F", "G", "H", and "I" series, in which 9% coupon MBSs were split into 11.5% and 6.5% securities. Using these data we created three synthetic IO strips and three synthetic PO strips. The inferred prices of the IO and PO strips over time are presented in Figures 3 and 4. The three IO and PO prices all tended to move together over time, which is gratifying, given that the underlying mortgage coupons are similar and thus should have similar prepayment behavior.

The most dramatic price movements took place in April 1987, when the bond market fell sharply. Prices of mortgage passthroughs (obtained by adding together the prices of the premium and discount securities) fell as well. Figure 5 shows that the value of the PO component fell far more dramatically than the value of the overall MBS, confirming the extremely long duration of this asset predicted by the previous sections. In contrast, the value of the IO security actually rose, also confirming the theoretical prediction of a negative duration, and indicating that prepayment activity was expected to decline sufficiently to more than offset the increase in the discount factor applied to IO payments.

5. Summary

We have shown that IO/PO securities are highly sensitive to the prepayment behavior of the underlying mortgage pool. Because that behavior varies systematically with the interest rate, and because prepayments affect the values of IO and PO components in opposite ways, the interest-rate risk of strip securities can differ substantially from that of the underlying mortgage pool. The PO component has much longer duration than the underlying mortgage pool. In contrast, the IO component typically will have a negative duration, at least in ranges for which interest-rate movements induce meaningful changes in mortgage prepayment behavior. The distinct durations of these securities make them interesting candidates for immunization of long-term obligations or for hedging the value of fixed income portfolios.

We've shown how market prices of partially-stripped MBSs that are actively traded on secondary markets can be used to infer market values of pure IO/PO strips. This inference method is potentially of value to issuers and purchasers of such strips. Recent market data is fully consistent with the theoretical insights offered by our valuation model. When interest rates spiked last April, PO values fell far more dramatically than those of the underlying mortgage pool while IO values actually rose.

Footnotes

1. Duration is, strictly speaking, the weighted average of the times until receipt of each payment from a security, with weights proportional to the present value of each payment. For mortgages with possible prepayments, such a definition is problematic since the cash flow stream will vary with prepayment experience. Throughout this paper, I will use duration in a looser, but more common, context as the interest-rate elasticity of a security's value, that is, as the proportional change in the security's price due to a 1 percent change in its yield to maturity.

2. This simple rule is probably reasonably realistic. Although prepayment rates generally are lower in early years of mortgage lives, before they ultimately level off, mortgage defaults are generally higher in the early years. Because these mortgages are insured, a default is essentially equivalent to an autonomous prepayment from the perspective of the lender, and the sum of the two sources of autonomous prepayments might be relatively stable.

3. This specification can be written formally as,

   $$E(dr/dt) = k(.10-r),$$

   where dr/dt is the time derivative of the interest rate, E is the expectation operator, and k is the proportionality constant, which we set equal to .2 in our illustrative examples below.

FIGURE 1
SECURITY VALUES

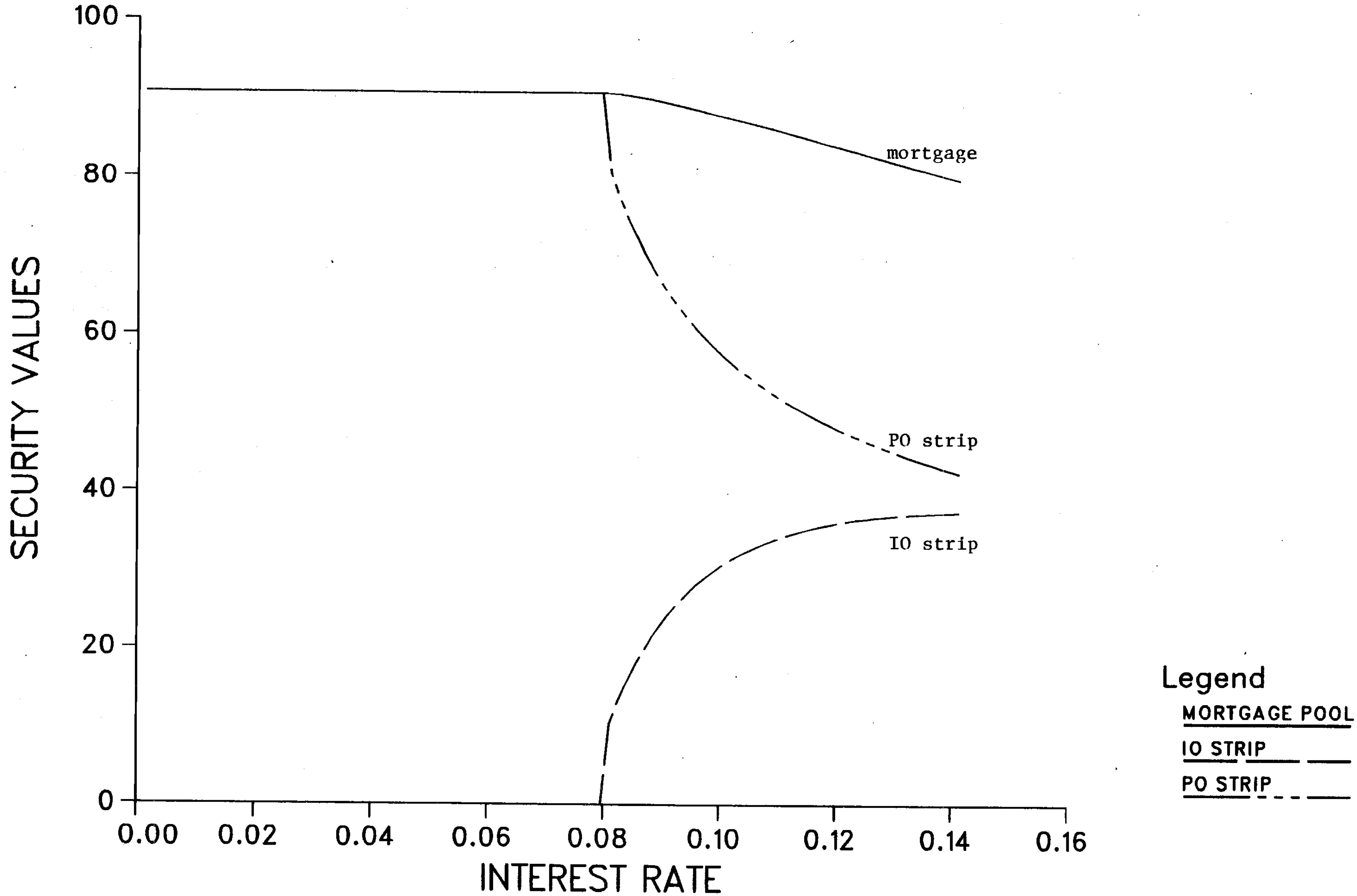


FIGURE 2
SECURITY DURATIONS

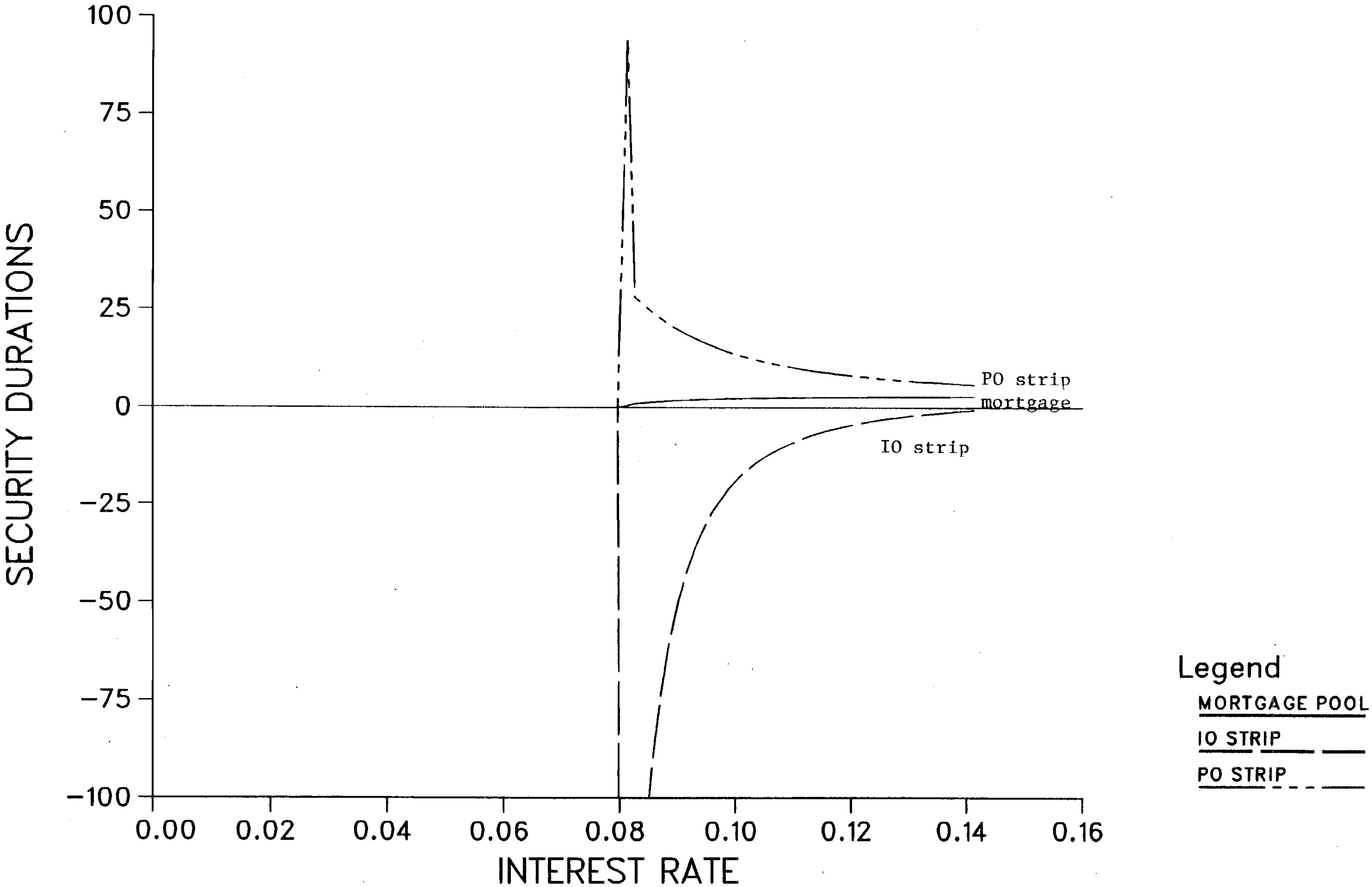


Figure 3

Synthetic IO Strip Prices

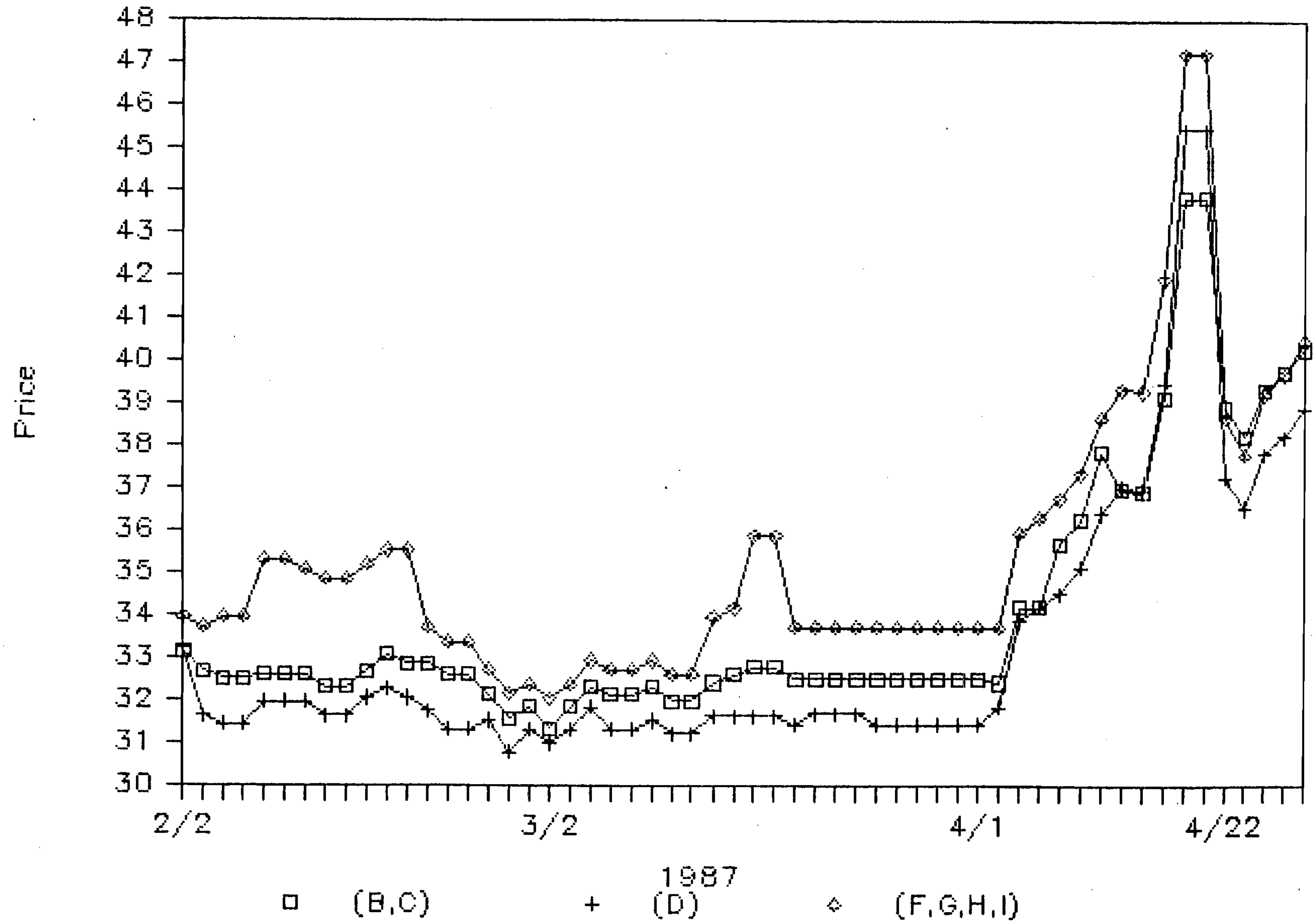


Figure 4

Synthetic PO Strip Prices

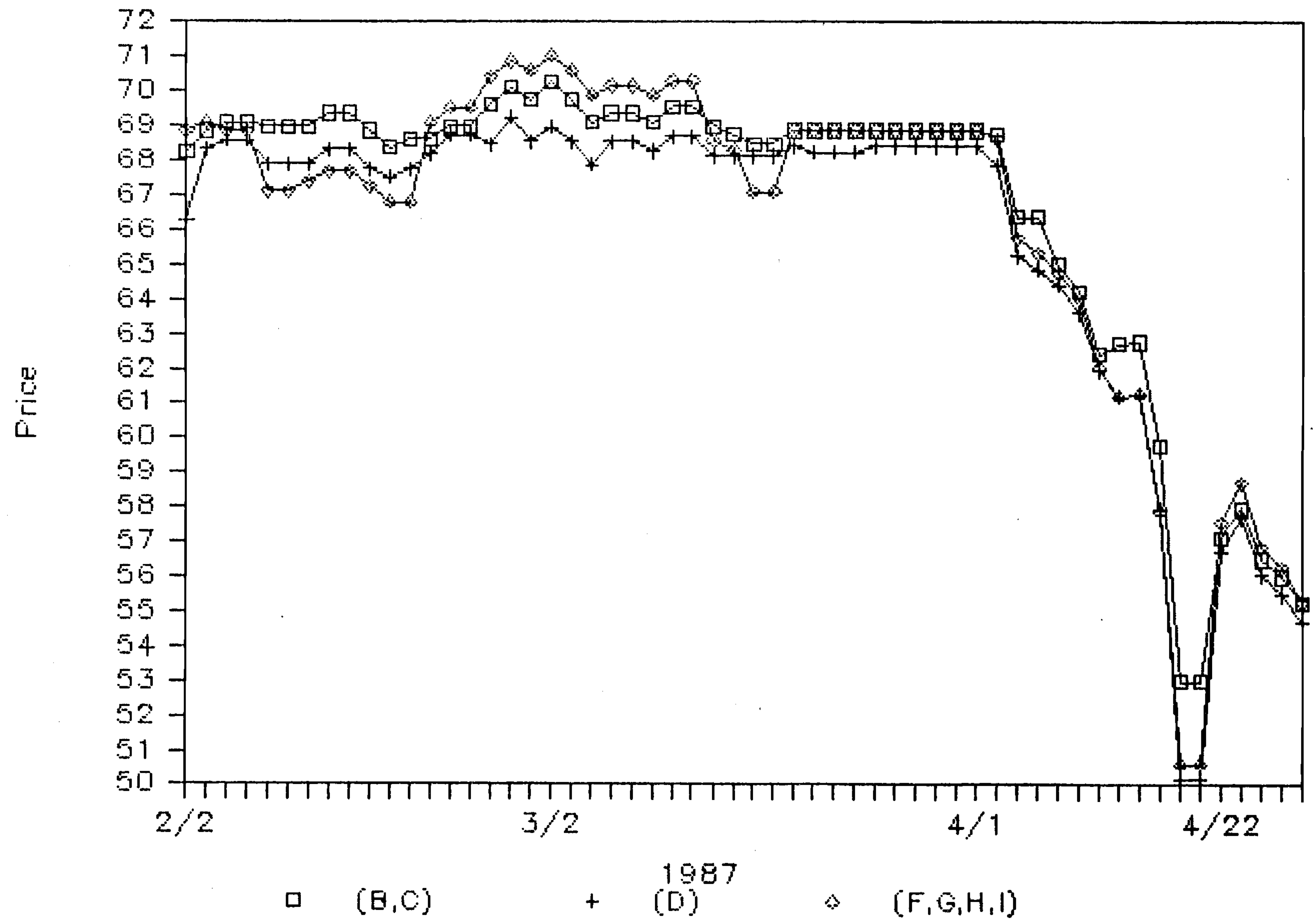
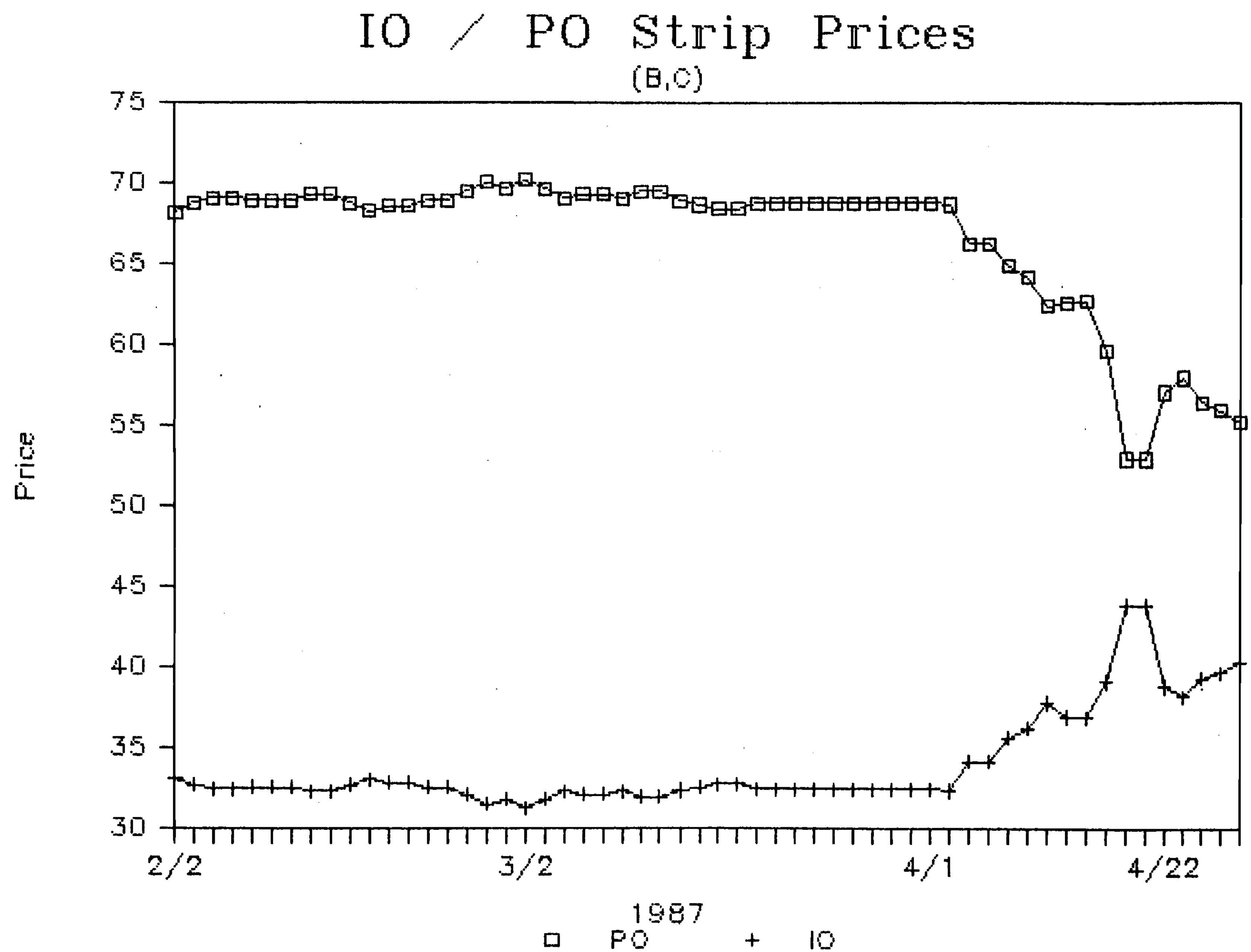


Figure 5


IO / PO Strip Prices
(B,C)
Price
75
70
65
60
55
50
45
40
35
30
2/2
3/2
4/1
4/22
1987
□ PO
+ IO

4. Formally, we specify that,

$$\text{Variance}(dr/dt) = s_o^2 r,$$

and set $s_o = .5$.

5. The value of the IO srip is zero if the pool is repaid. Hence, a small increase in the interest rate from the prepayment point to a value just above it, increases the value of the IO strip from zero to a positive value, which is an infinite percentage increase.

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