THE MONEY AND BOND MARKETS IN FRANCE: SEGMENTATION VS. INTEGRATION

by

Bernard Dumas
Bertrand Jacquillat

34-89

RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

First Draft: September 1986
Last revision: May 1989

THE MONEY AND BOND MARKETS IN FRANCE: SEGMENTATION VS. INTEGRATION

Bernard Dumas
The Wharton School
University of Pennsylvania
and Centre HEC-ISA
Bertrand Jacquillat
University of Paris Dauphine
and the Hoover Institution

The financial support of the French Ministry of Research and Technology, under grant # 82 E1177, is gratefully acknowledged. We also thank Mme Le Moing of the Bank of France who supplied data on the money market, and M. Bouteau, M. Kerneis and Melle Guillaumot of the Société Générale who supplied data on the bond market. Data on the bond market were purchased with the support of the Foundation Jouy-Entreprises. Sylvie de la Guiche was of great assistance at the data processing stage. This paper was presented at Université Laval where members of the audience made helpful comments. S. Schaefer made valuable comments and M. Gibbons made a useful suggestion. They do not bear responsibility for our errors.

5.7.0

ABSTRACT

When rates of return on bonds are computed over exremely short holding periods, the ex post cross-sectional relationship between realized return and risk is linear. It is therefore possible, at any time, to extrapolate the cross-sectional relationship to a zero risk level, and thus to determine the implied instantaneous riskless rate of interest. We apply this technique to French bond price data. Using this rather unique data set in which prices are sampled daily, we are able to compare the overnight rate implied in bond price data to the actual overnight money market rate. We conclude that the two rates are significantly different, which is evidence of segmentation between the two markets. The institutional set-up prevailing in France during the sample period explains the segmentation result.

1. Introduction

Until 1985, access to the money market in France was restricted to a limited number of financial institutions such as banks. Other financial institutions and economic agents only had an indirect access to the market. They had to deal with the banking system if they wanted to invest or borrow short-term funds. By contrast, markets for long-term funds, such as the bond or equity markets, were not restricted in that respect since all economic agents had direct access to them.

Since 1985, a series of reforms has been aimed at deregulating the short-term money markets. These reforms include the possibility, granted to firms, of issuing commercial paper and a direct access, for all financial institutions and some non-bank firms to the money market. As a consequence of this deregulation, one would expect a better integration of the various financial markets in France. The interventions of the Central Bank should have more repercussions on the whole financial system and the yield curve should be better arbitraged.

In order to appreciate the potential impact of these reforms, as far as the segmentation vs. integration issue is concerned, it is useful to determine whether or not and to what extent the money market was segmented vis-à-vis other financial markets, prior to 1985. Were the interventions of a selected group of banks on the money market sufficient to bring about a satisfactory integration of the whole financial system? Or did there exist a barrier between the money market, where monetary policy is implemented, and the other financial markets, where households and institutions invest and firms obtain their financing?

To answer that question, we look specifically at the links between the money market and the bond market, by comparing the random returns of bonds to the short-term rate prevailing on the money market.

Obviously, even in the case of perfect integration of both markets, these two series of numbers need not be the same, since the random returns on bonds cause one to bear a risk whereas the returns on the money market are riskless. The risk of a bond is primarily a function of its duration. Therefore we consider the short-term returns of bonds of various durations, extrapolate them to small durations, in order to obtain the implicit return of a very short-term bond, and compare this rate to the prevailing short-term rate on the money market.

This approach runs counter to the standard approach which has been used in the literature on bond pricing. Brennan and Schwartz (1982) and Brown and Dybvig (1986), for example, estimate the dynamic process of the short-term rate to infer the theoretical prices of bonds of various durations and compare them to market prices. In so doing, they rely on a particular model of bond pricing where bond prices are a function of one or two interest rates. An empirical analysis of this type is, therefore, a test of the joint hypothesis of accuracy of the model, and integration of the money and bond markets. Although one cannot abstract completely from a certain kind of joint hypothesis testing, our objective in this paper is to use an econometric procedure which is robust to the form of risk pricing in the financial markets, but still allows us to test the degree of integration.

The rest of the paper is organized as follows. Section 2 presents two theoretical models of interest rate behavior and bond pricing: the partial-equilibrium model of Vasicek (1977) and the general-equilibrium model derived by Dumas (forthcoming). Section 3 describes the econometric procedure we use; section 4 presents the data and section 5 discusses the results.

2. Bond valuation models

In this section we compare bond valuation models of two different types, in order to demonstrate that the procedure we are going to use is not very sensitive to the choice of a model. The two types are: partial-equilibrium models, exemplified by Vasicek (1977), and general-equilibrium models exemplified by Dumas (forthcoming).

2.1 The Vasicek model

This model relies on two assumptions. The first one pertains to the behavior of the short-term interest rate, which is assumed to follow an Ornstein-Uhlenbeck mean-reverting process, represented by the following equation:

(1) $$dr = \alpha(\gamma - r)dt + \sigma dz \ ,$$

where: dr is the instantaneous variation of the interest rate r during the infintesimal period of time dt;

γ is a constant which can be interpreted as the "normal" value of the interest rate towards which r reverts after a random shock;

α is a constant which can be interpreted as the speed with which the interest rate r returns to γ;

σ is a constant which determines the size of the shocks which affect the interest rate;

dz is an infintesimal white noise.

This equation reflects a very special behavior of the rate of interest. The rate is subjected to random shocks while an elastic force pulls it back, with greater or smaller speed, towards a constant value. This type of behavior has little economic content or justification.

The second assumption of the Vasicek model pertains to the attitude of agents towards risk. With an arbitrage argument, Vasicek shows that, at each instant in time, the relation which links expected bond returns and volatilities is linear. Vasicek assumes for this relationship a positive slope called "the market price of interest rate risk". This slope, denoted λ is also supposed to be constant, independently of time or the level of the interest rate.

One has then to search for the unknown functions P(r,t) which link the prices of bonds to the interest rate at a particular time. Given the stochastic differential equation (1) a pricing function P(r,t) determines the expected return and the volatility of a bond. When these two variables are tied together cross-sectionally by the linear risk-return relationship (of slope λ) imposed by the market, the following partial differential equation prevails:

$$\frac{1}{P}\frac{\partial P}{\partial t} + \frac{1}{P}\frac{\partial P}{\partial r}\mu(r) + \frac{1}{2}\frac{1}{P}\frac{\partial^2 P}{\partial r^2}\sigma^2 = r + \lambda\frac{1}{P}\frac{\partial P}{\partial r}\sigma \; ; \tag{2}$$

where:

$$\mu(r) \equiv \alpha(\gamma - r) \; .$$

The functions P are solutions of this equation, subject to boundary conditions describing the contractual features of a particular bond: coupons, repayment of principal etc...

The assumptions made by Vasicek allow one to find a closed-form solution, at least as far as the pricing of ordinary bonds is concerned.

2.2 The Dumas model

This model is not based on arbitrary assumptions concerning the behavior of variables such as the interest rate or the market price of risk. These are endogenous to the economic system.

The ingredients of the model are, on the one hand, a random production system with constant returns to scale and, on the other, two investors with constant but different relative risk aversions who can invest in the production process and lend or borrow, to and from one another, at the short-term riskfree rate.

As far as the current issue is concerned, the main result of the model is the following: the rate of interest follows a stochastic process with mean-reversion (as in the Vasicek model). The rate, however, is also confined to a tunnel, or corridor, formed by the two natural barriers corresponding to the extreme situations where one or the other of the two investors would have acquired all the wealth. Thus, the process which governs the interest rate is markedly different from the Ornstein-Uhlenbeck process postulated in the Vasicek model: the trend function $\mu(r)$ is non linear in r and the volatility of the rate of interest is not a constant but a function $\sigma(r)$.

Furthermore, the market price of risk λ fluctuates with the interest rate but in the opposite direction (when the interest rate is high, the market price of risk is low, and vice versa). This result illustrates that it may not be consistent, from the point of view of general equilibrium, to postulate, as Vasicek does, that the price per unit of risk is constant and, at the same time, that the rate of interest fluctuates randomly.

Obviously, the two models imply different relations $P(r,t)$ between the price of a bond and the interest rate. This is because the specifications of

$\mu(r)$, $\sigma(r)$ and $\lambda(r)$ are fundamentally different. But in both models the functions satisfy an arbitrage equation such as (2).

3. The econometric procedure

Our objective is to determine whether interest rates observed in the money market are consistent with prices observed in the bond market. We wish to do so by means of an econometric procedure which is robust and which does not force us to make a choice between the two above-mentioned theoretical models. This is possible because of the common element which we have identified: in both models an *ex ante* linear relationship such as (2) holds at all times between expected return and volatility.

As far as equation (2) is concerned, the two models exhibit two major differences. First, the slope of the relation -- the market price of risk λ -- is constant in Vasicek whereas it is not in Dumas, and would not be generally in a general-equilibrium model. In the econometric procedure to be used, the cross-sectional relationship between risk and return is estimated every day separately. The procedure thus allows the slope to fluctuate and neutralizes this difference between the two models.

Secondly, the measure of the risk of a bond differs between the two models. The semi-elasticity $-(1/P)(\partial P/\partial r)$ of the price of a bond with respect to the interest rate, standing for the source of risk, does not take the same form or the same value in the two models, since the pricing function $P(r,t)$, solution to the partial differential equation, is different.[1]

---

[1]The way to express and value the expected returns would also be different among the two models. This distinction will turn out to be irrelevant here since we shall proceed to replace *ex ante* return and with *ex post* return, which is directly observable.

From a practical point of view, this difference is probably negligible. Several authors, including Nelson and Schaefer (1983), Ingersoll (1983), Brennan and Schwartz (1983), Gultekin and Rogalski (1984),[2] have found that none of the several measures of bond risk which they have tested is superior to Macaulays' (1938) "duration". In fact, Brennan and Schwartz, using a two-factor model of the term structure, found that the elasticity of bond returns with respect to the long rate is also very close indeed to conventional duration. We, therefore, simply use duration as a measure of risk. This forgivable sleight of hand irons out the second distinction between the two models.

It remains that the ex ante linear relationship cannot be directly estimated. The only measurable returns are the ex post returns of the bonds. Given a particular valuation model $P(r_t,t)$ for a bond, the ex post returns are obtained in the following way:

$$\frac{P(r_{t+1},t+1) - P(r_t,t) + \text{any coupon paid}}{P(r_t,t)} .$$

If we neglect the coupon for the time being, and if we shift to continuous time (that is, considering very short holding periods) the ex post return is dP/P. For a pricing function $P(r,t)$, we have:

$$(4) \qquad \frac{1}{P}\, dP = \frac{1}{P}\frac{\partial P}{\partial t}\, dt + \frac{1}{P}\frac{\partial P}{\partial r}\, dr + \tfrac{1}{2}\frac{1}{P}\frac{\partial^2 P}{\partial r^2}\,\sigma^2\, dt .$$

By combining this equation with the equilibrium condition (2), we obtain the following relation between ex post return and risk:

$$(5) \qquad \frac{1}{P}\, dP = r\, dt - \left[dr - (\mu + \lambda\sigma)dt\right]\left(-\frac{1}{P}\frac{\partial P}{\partial r}\right) .$$

---

[2]See also the very pedagogical discussion in Schaefer (1984).

Hence, provided that we only consider very short holding periods (we use one day), there also exists a linear relationship between <u>ex post</u> return and risk. The slope of this relationship (within square brackets on the right-hand side of equation (5)) is now stochastic and is a function of the <u>ex post</u> variation of the interest rate between two instantaneous and successive moments in time.

In this study, we do not pay further attention to the slope, but concentrate on the measurement of the intercept of the line with the vertical axis, which should be equal to the short-term rate.

The adequacy of using this intercept as an estimate of the short-term bond market rate rests <u>on a single assumption</u> which is that the duration represents an adequate[3] proxy measure of the risk of a bond, in lieu of the exact measure $-(1/P)(\partial P/\partial r)$. In order to better appreciate the impact of this assumption on the measure of the intercept, we have simulated our procedure on data constructed to conform to the Vasicek and Dumas models. Results of these simulations appear on Figures 1 to 3.

Figures 1 and 2 pertain to the Vasicek model. They show <u>ex post</u> returns on zero coupon bonds,[4] in excess of the instantaneous riskless rate, on the vertical axis, and the duration on the horizontal axis, for several periods of simulation. For each period, and on average for all periods, the cross-sectional relationship between the <u>ex post</u> excess return and the duration is approximately linear and the intersection with the vertical axis is zero, as it should be. Figure 2, which represents a magnification of one of the graphs

---

[3]In the sense that it induces an approximately linear <u>ex post</u> relationship between risk and return.

[4]In the empirical application, we extend the use of duration as a measure of risk to standard multi-payment bonds. Pitfalls can conceivably arise from the use of duration in that context.

of figure 1, serves as a warning: the use of duration as a measure of risk brings with it a small amount of non linearity. However, one can verify that the error made on the intercept, when one wrongly presupposes a linear relationship, is negligible (it is of the order of magnitude of 0.0001 for a one-day holding period, that is 3.65% per annum, which, as we shall see later, is small compared with the uncertainty on bond returns in the Paris market).

Figure 3 reports results on a similar experiment based on the Dumas model. Here too, the relation between ex post excess return (indicated in percent per annum on the vertical axis) and duration is approximately linear and its intersection with the vertical axis is close to zero.

At any rate, the econometric tests, which we have conducted on real data in order to detect non linearities, have produced a significant result (at the 5% level of significance) for only 2 out of the 39 months of our sample.[5] Gultekin and Rogalski (1984) report significant non linearities on the U.S. market; however, their tests are based on monthly holding periods, much longer therefore than ours.

Equation (5), which represents the theoretical basis of our procedure, is valid strictly for short holding periods only. This is why we have decided to use daily data and to measure the returns over daily holding periods and then to compare them with the corresponding daily rates prevailing on the money market.

This procedure is open to some criticisms. Transactions costs arising from the daily arbitrage of short-term vs. long-term investments would be excessively onerous. Because some arbitrage is prevented by transaction costs, random discrepancies can appear between the money-market rates and the

---

[5]They are the last two months: July and August 1984.

short-term rates implicit in bond prices. In percentage terms, these discrepancies have to be lower than the cost of a round trip, which is of the order of magnitude of 0.4%. If these costs were to be expressed on an annual basis, the two rates could differ by an amount equal to .4% x 365 = 146%! Although this number represents an absolute upper bound, it is clear that it would be foolish to make daily measures and comparisons.

If we observe, however, that the random differences between the two rates can be of either sign and if we compare the monthly averages of these daily rates, instead of daily rates themselves, the maximum difference between the two should be greatly reduced. Our conjecture is that it would be reduced to: 0.4 x 12 = 4.8% (on a per annum basis). This is still a large margin of error and one could argue that a three-month average would be preferable.[6]

To sum up, our econometric procedure includes the following steps:

- computation of the daily returns of the various bonds;
- computation of the monthly means;
- cross-sectional regression of the monthly means on durations and estimation of the intercept of this regression;
- comparison of the intercept with the concomitant mean rate on the money market.

4. The data

The data set pertains to a variable collection of straight bonds which are heavily traded on the Paris Bourse. For each of them, we have the following information: the market price expressed as a percentage of the bond's par

---

[6]One has to recognize that one lacks a solid theory to completely justify this stage of the econometric procedure. It is clear that the bounds on the mean monthly differences depend very much on the behavior of the daily differences within a month, but one has no clear understanding nor much information on this phenomenon.

value, the accrued coupon (minus 10% of withholding tax for non Government bonds), the contractual terms (coupon rate, repayments of principal with their corresponding dates). From this information, we computed the duration of each bond on each day. Data were available from 6/16/81 to 8/27/84, that is for 789 working days and 39 months. For these same days, overnight money market rates[7] were collected.

The computation of the daily return between day t and day t+1 was made according to equation (3). Since the quoted price was expressed in percentage terms, we multiplied it with the par value of the bonds, and added the accrued coupon to obtain the effective price to be paid by the purchaser at time t and received on resale at t+1. Then the actual coupon, if any, paid effectively on day t+1 was incorporated into (3).

A number of technical difficulties, concerning mostly bonds other than Government bonds, had to be contended with:

- taxes can significantly alter the net return for the investor, depending on his/her fiscal status;[8]
- some bonds are partially redeemed during their life by random ballot. When t+1 in equation (3) is an "ex-ballot" date, the bond price in t+1 (but never the price in t) must be computed as the mean of two prices: the price computed normally for the fraction of the bonds still outstanding, and the present value of the imminent redemption for the fraction of the bonds which are redeemed;

---

[7]"taux au jour le jour sur effets prives."

[8]The withholding tax imposed on each coupon paid (on bonds other than Government bonds) may be refundable, depending on whether or not the investor is taxed (see Bito (1985), pages 33-35). In computing returns, we ignore the withholding tax, thus making the assumption that tax paying investors, who can get it back, dominate the market.

- in the rare event of no trading, only the returns corresponding to two consecutive days have been taken into consideration. The returns corresponding to two trading days which were separated by holidays or weekends have been divided by the number of intermediate days.

In the end, we had 26007 observations of returns, which represents an average of 26007/789 = 33 bonds in the sample per day.[9] However, it was not clear that all categories of bonds would contribute equally well to an estimation of the short-term rate. Government bonds may be quoted more "reliably" than other bonds because their market is characterized by a stronger volume of trading. While retaining the entire sample would mean many more data points, it may also mean more "noise." In order to make a determination on this issue, we compared the typical range of variation of daily returns, taken across all bonds over one sample month, to the similar range restricted to Government bonds. The most volatile Government bond during the last month of the sample exhibited a range of daily rates of return of -0.6% to +0.7%, whereas the range for all bonds extended from -2% to +2%.[10] In view of this inexplicably larger volatility of non Government bonds, we decided to exclude them from the sample, in the hope of improving the efficiency of the estimated intercept.[11] The first column of table 1 indicates the number of usable bonds during each one of the months of the sample period. Over the entire sample, the bond with the smallest average

---

[9]In fact, there were more than twice that many bonds in the sample at the end of the sample period.

[10]These are % per day.

[11]An earlier draft of this paper contained the results of a statistical analysis conducted on the entire sample of bonds. A comparison reveals that the restriction to Government bonds improves the efficiency of the estimate of the intercept towards the end of the sample period, leaves it unchanged towards the middle and worsens it during the first few months.

duration had a duration of 913.87 days and the longest average bond duration was 2298.28.

5. Results

Our analysis is a comparison of rates of return of bonds of various durations, month after month:

(6) $$ROR_{i,t} = a_t + b_t \, DUR_{i,t} + e_{i,t}, \text{ for every given } t \, .$$

where i indexes bonds and t indexes months. A straight OLS regression yields an estimate of the intercept a of the return-vs-duration relationship and a standard error for this estimate, so that a statistical test (a Student t test) can be performed against the average money rate of the corresponding month (the null hypothesis is: $a_t = MON_t$, and the alternative: $a_t \neq MON_t$). The results are shown in table 1 (panel A), columns 1, 2 and 3. Seven months (those whose t-test value is underlined in column 3), out of the 39 months of the sample, provide evidence of segmentation (at the 5% level of significance).

Figure 1 displays graphically the same information: the three unmarked lines represent the point estimate and the confidence interval for the implied short bond-market rate, while the line marked with + signs represents the short money-market rate. Significant segmentation is evident in the months of August and July 1984,[12] April and January 1984, November, June and May 1983. In almost all these instances, the bond market short rate was above the money rate. The figure displays another phenomenon as well: the confidence

---

[12]But recall that these are the two months where evidence of significant non linearity has been found in the ex post relationship. Nonetheless the specification test which we are about to describe leads to no rejection (see column (4)) during these months.

interval is much narrower during the later months than during the earlier ones, and the difference goes beyond what would be accounted for by the smaller number of bonds available in the earlier months.

In performing this analysis, one must be mindful of heteroscedasticity. This is true generally because the hypothesis of constant residual variance plays a role in any statistical test.[13] This is especially true here because we are interested in the intercept, corresponding to a security of duration zero (or one day), which is far outside the range of the regressor.

In order to test for the presence of heteroscedasticity, a White (1980) specification test of the monthly regressions was performed,[14] with results, in the form of pvalues, shown in column 4. This lead to a rejection of the specification (at the 5% level) for 9 of the 39 months, implying that OLS estimates of the standard error of the intercept may be inconsistent.

White (1980) designed a heteroscedasticity-consistent technique to obtain an estimate of standard errors. The value of the estimate computed according to this technique is shown in column 5: in most cases the White standard error is lower than the OLS standard error but one must remember that the White estimate, while consistent, may be biased in small samples. The corresponding chi^2 test of the hypothesis that the intercept is equal to the money rate is shown in column 6. It leads to a rejection of the hypothesis of integration for 10 of the 39 months: the same 7 months found earlier plus May 1984, April 1983 and January 1983.

---

[13]Under heteroscedasticity the estimated standard error of the regression coefficients is inconsistent.

[14]See also Cumby and Obstfeld (1984). The squared residuals from regression (7) were regressed against duration and squared duration. Then we ran a heteroscedasticity-consistent chi^2 test of the hypothesis that the two slope coefficients were equal to zero.

Other specifications we have tried for the cross-sectional analysis include:

- weighted regressions with weights inversely proportional to duration or squared duration. The results displayed in panels B and C of table 1 indicate that they lead to a negligible gain in efficiency;
- a dummy-variable analysis encompassing in one dataset the information from the bond and the money market:

(7) $$ROR_{i,t} = a_t + b_t\ DUR_{i,t} + c_t\ DUMMY_i + e_{i,t},\ \text{for every } t\ ;$$

where the index i now spans not only bonds but also the single overnight money-market instrument, and $DUMMY_i$ takes the value 1 for the money market and the value 0 for the bond market. Table 2 provides the results of an OLS estimation of (7). We have not displayed the estimates of a_t, which are identical to the ones found before (table 1, panel A). The estimate of c_t (table 2, column 1) give a measure of the discrepancy between the money and the bond market: as noted before, the money market rate is generally below the implied short-term bond rate. A two-sided t test of the significance of c provides a test of segmentation between the two markets (see table 2, column 3). Rejection of the null hypothesis that c = 0 occurs only for one month (January 1984). The difference between the test results obtained from (6) and (7) is puzzling at first,[15] but the explanation is provided by the two specifications tests (table 1, column 4 for (6); table 2, column 4 for (7)) which lead to a fair number of rejections. One must therefore resort to heteroscedasticity-consistent tests of the same hypothesis c = 0. When that is done (table 2, column 6), the chi^2 values obtained are practically

[15]The two tests are, in principle, equivalent since $a_t + c_t \equiv MON_t$.

identical to what they were under (6) (compare with table 1, column 6). When heteroscedasticity is accounted for, there is practically no difference between the test of a = MON under (6) and the test of c = 0 under (7).

It is probably not legitimate to attribute segmentation properties to specific months. In a test conducted at the 5% level of significance we should expect rejections to occur purely by chance for approximately 2 of the 39 months of the sample. This would be the result of chance and would not indicate that the specific two months have special properties. In point of fact, we found 10 rejections out of 39 months, whereas the probability of ten or more rejections occurring by chance in this test is less than 10^{-4}. A preferable interpretation of our test results is that segmentation is present all the time with significant differences appearing randomly in month x or y. In this interpretation only the frequency of rejections matters and our tests indicate clearly that segmentation exists globally.

A method for testing, and possibly rejecting, globally the null hypothesis of integration is a combined cross-section/time-series analysis. Specifically, calling $INTERCEPT_t$ the intercept of the month-t regression (denoted so far a_t in equations (6) and (7)), we can run the regression:

$$(8) \qquad INTERCEPT_t = a + b\ MON_t + e_t\ ,$$

and test the joint null hypothesis: $\{a = 0, b = 1\}$. $INTERCEPT_t$ is the OLS point estimate obtained from (6) or (7), which is unbiased and consistent (but, perhaps, not efficient) even in the presence of heteroscedasticity. This new procedure therefore has the advantage of being impervious to the presence of cross-sectional heteroscedasticity. But it is evidently subject to problems of time-series heteroscedasticity and serial dependence, which may have to be solved.

Table 3 contains the results of this procedure carried out in various ways. It also contains some preliminary information regarding the monthly time-series behavior of the dependent and the independent variables: the first-order serial regression coefficient of the monthly average money-market rate is positive (+0.89207) while the same coefficient for the monthly bond-market intercept is negative (-0.14863).[16] Both are significantly less than one, so that there is no unit-root problem to contend with.

OLS estimation of time-series equation (8) produces estimates which are displayed in panel A of table 3. The intercept a is found to be slightly negative while the estimated slope coefficient b is equal to 2.14. The separate hypotheses (a = 0), (b = 1) and the joint hypothesis {a = 0, b = 1} are tested in two ways. Although standard t tests conducted on the separate hypotheses lead to no rejection, a standard finite-sample F test rejects the joint hypothesis (pvalue = 0.0389). This test, however, is sensitive to heteroscedasticity. Heteroscedasticity-consistent asymptotic chi^2 tests are conducted; they lead to the same conclusions.

Panels B and C of table 3 present the results of estimating (8) by weighted time-series regression. In panel B, the weights are inversely proportional to the OLS standard error of the intercept found in the first pass (6),[17] while, in panel C, they are inversely propotional to the White (1980) heteroscedasticity-consistent standard error of the same intercept.[18] These weighting schemes -- meant to give more importance to observations of

---

[16]We shall explore later the sources of the negative correlation in the bond-market intercept. The negative serial correlation is apparent in the wavy pattern of the unmarked lines of figure 4.

[17]Table 1, column 2.

[18]Table 1, column 5.

$INTERCEPT_t$ which are more reliable -- have the effect of markedly increasing the weight of the second half of the sample period relative to the second half. In both cases, the intercept a of the time-series regression is found to be slightly positive and the slope coefficient is less than one. The F chi^2 tests reject the joint hypothesis {a = 0, b = 1} even more resoundly than before.

Although the Durbin-Watson test in panel A (the non weighted time-series regression) was quite acceptable, a correction for serial dependence of the residuals is conducted in panel D. The conclusion is unchanged.

Finally, the wavy pattern which characterized the bond-market intercept behavior in Figure 4 makes it tempting to run a joint test of market integration and efficiency of the bond market. Market efficiency was an implicit assumption when writing (8): it justified including no additional variables, belonging to the time-t information set, as regressors when testing for {a = 0, b = 1}. But we now include such a variable and test its significance. The pattern of Figure 4 suggests including the lagged bond-market intercept as a regressor:

$$(9) \qquad INTERCEPT_t = a + b\ MON_t + c\ INTERCEPT_{t-1} + e_t \ .$$

The results are shown in table 3, panel E. The intercept a is practically unchanged but the estimated value of the coefficient b is now remarkably close to 1, while the coefficient c, reflecting market inefficiency, is negative, but not significantly so. According to the F and chi^2 tests, the joint hypothesis of market integration and market efficiency {a = 0, b = 1, c = 0} becomes marginally acceptable, while the separate hypothesis of market integration {a = 0, b = 1} (accepting some degree of inefficiency) would clearly be acceptable.

Before we conclude, it may be appropriate to mention a potential critique of the linear-extrapolation procedure which has been used throughout. Figure 5 allows us to investigate the sources of the negative serial correlation (-0.14863) which has been found for the bond-market intercept. It displays the degree of serial dependence of rates of returns for the various bonds of the sample, in relation to their average duration. A bond of fixed maturity date, of necessity, must exhibit some degree of long-run negative serial correlation since its price must ultimately converge to the final redemption value. Moreover, the serial correlation, measured on a monthly basis, is likely to be more markedly negative for shorter-term bonds than for longer-term ones. This presupposition is confirmed by the diagram of Figure 5: most bonds have a negative serial correlation of ROR, except for the longer ones. But the serial correlation of the return on a rolling instrument of fixed time to maturity, such as the money-market overnight rate, can conceivably be of either sign.

Given that the money-market rate has been found to be positively serially correlated (significantly so), the extrapolation to zero duration obtained by means of (6), should have, under the null hypothesis of integration, produced an intercept which would also be positively serially correlated. This is true even though this intercept is generated from individual bond returns most of whom (particularly shorter-term ones) are negatively correlated (Figure 5). This is by no means an analytical impossibility since the volatility of long bonds is larger than that of shorter bonds. Nonetheless the suspicion remains that the linear extrapolation procedure combined with the correlation structure of Figure 5 may have mechanically produced the negative serial correlation of the intercept.

The suspicion that the serial correlation of the bond-market intercept may be unwarranted is somewhat reinforced by some results obtained above. Regression (9), which included the lagged intercept as a regressor, lead to the results of table 3, panel E. We have already observed that the b coefficient so obtained is remarkably close to 1 (while the a coefficient implies a small permanent spread equal to 0.029% per day between the two markets). Observe also that the c coefficient (-0.16892) is remarkably close to the serial correlation of the bond-market intercept (-0.14863). We have interpreted the c coefficient as a mark of inefficiency. But another interpretation, hostile to the linear-extrapolation procedure, is possible: when the perhaps spurious serial dependence in the bond-market intercept is corrected for, by means of the intercept's own lagged value, the b coefficient returns to its value of 1, postulated under market integration. The proper choice between the two interpretations will remain a conundrum, until further research.

6. Conclusion

In this paper we have addressed the issue of segmentation vs. integration of the money and bond markets in France during the period 1981-1984 which was characterized by severe limitations for all but a few selected financial institutions, as far as the access to the money market was concerned. Since then profound deregulation has taken place. Thus, it was interesting to verify to what extent the money market was disconnected from other markets, e.g. the bond market, during this pre-deregulation period. Based on numerous and robust econometric tests, we have found that 10 out of the 39 months in our sample provided evidence of segmentation between the two markets.

One last word is in order concerning the methodological choices which have been made. In theory, all variations in the prices of bonds should be related to the current and anticipated variations in the short-term interest rate. The theoretically correct approach would have been to estimate the stochastic process for the short rate and to integrate the partial differential equation (2) to obtain the price of a bond as a function of the rate of interest, and then to infer from bond prices the implied short rate. This is the approach adopted by Brennan and Schwartz (1982) and Brown and Dybvig (1986). Technically, its major weaknesses are that, lacking a credible general-equilibrium model, we do not know a priori the functional form for the interest-rate process and we do not know the behavior of the market price of risk.

But, more importantly, a glance at rates of return on the bond markets of the world (see also the indirect evidence of Figure 4) reveals a degree of volatility which is so many times larger than the volatility of the corresponding short-term money-market rates[19] that it is implausible that interest-rate fluctuations should account for fluctuations in bond prices, let alone bond rates of return.

Faced with this observation and apparent dead end, our approach has been a pragmatic one: we have treated most of the variance in bond returns, as yet unaccounted for, "noise." We wrote bond rates of returns as being equal to an intercept (which should be equal to the short rate of interest) plus a variable reward for risk, plus noise, where the reward for risk was based -- once again pragmatically -- on an all-encompassing measure: duration. Then we asked the question: can one discern behind the noise whether the intercept is indeed equal to the money-market rate or not? The answer, on this sample, is fairly clear-cut: they were not equal.

---

[19]See Campbell and Shiller (1984, 1987).

REFERENCES

Bito, C., Marché des obligations et gestion obligataire, Paris: Dalloz, 1985.

Brennan, M. and E. Schwartz, "An Equilibrium Model of Bond Pricing and a Test of Market Efficiency," Journal of Financial and Quantitative Analysis, 17 (1982), 301-329.

__________, "Duration, Bond Pricing, and Portfolio Management," in G. O. Bierwag, G. G. Kaufman and A. Toevs, eds, Innovations in Bond Portfolio Management: Duration Analysis and Immunization, Greenwich, CT: JAI Press, 1983, 3-36.

Brown, S. J. and P. H. Dybvig, "The Empirical Implications of the Cox-Ingersoll-Ross Model of the Term Structure," Journal of Finance, 41 (1986), July, 616-630.

Campbell, J. Y. and R. J. Shiller, "A Simple Account of the Behavior of Long-term Interest Rates," American Economic Review, 74 (1984), 2, 44-48.

__________, "Cointegration and Tests of Present Value Models," Journal of Political Economy, 95, 5 (October 1987), 1062-1088.

Cumby, R. E. and M. Obstfeld, "International Interest Rates and Price-level Linkages under Flexible Exchange Rates: a Review of Recent Evidence," in J. F. O. Bilson and R. C. Marston, eds, Exchange Rate Theory and Practice, University of Chicago Press, 1984, 121-151.

Dumas, B., "Two-person Dynamic Equilibrium in the Capital Market," Review of Financial Studies, forthcoming.

Gultekin, N. B. and R. J. Rogalski, "Alternative Duration Specifications and the Measurement of Basis Risk: Empirical Tests," Journal of Business (April, 1984).

Ingersoll, J., "Is Immunization Feasible: Evidence from the CRSP Data," in G. O. Bierwag, G. G. Kaufman and A. Toevs, eds, Innovations in Bond Portfolio Management: Duration Analysis and Immunization, Greenwich, CT: JAI Press, 1983.

Macaulay, F. R., "Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields, and Stock Prices in the U.S. since 1856," New York: NBER, 1938.

Nelson, J. and S. Shaefer, "The Dynamics of the Term Structure and Alternative Portfolio Immunization Strategies," in G. O. Bierwag, G. G. Kaufman and A. Toevs, eds, Innovations in Bond Portfolio Management: Duration Analysis and Immunization, Greenwich, CT: JAI Press, 1983, 61-101

Vasicek, O., "An Equilibrium Characterization of the Term Structure," Journal of Financial Economics, 5, 2 (November 1977).

White, H., "Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity," Econometrica, 48, 4 (May 1980), 817-838.

Table 1 Month-by-month cross-sectional analysis
of bonds' average daily rates of return
ROR = a + b DUR + e

Month		Money mkt avg rate (0)	Numb. of bonds	Panel A: non weighted regressions (1) Inter-cept a	(2) St. dev. of a	(3) t test vs money	(4) Specif p value	(5) St. dev. of a	(6) Chi2 vs money 1df	B: regressions weighted by 1/DUR (7) Inter-cept a	(8) St. dev. of a	C: regressions wt'd by 1/DUR^2 (9) Inter-cept a	(10) St. dev. of a
8	84	0.000315	16	0.000680	0.000132	2.769177	0.083800	0.000143	6.416762	0.000550	0.000105	0.000441	0.000086
7	84	0.000314	16	0.000575	0.000078	3.355019	0.198100	0.000063	17.093892	0.000512	0.000062	0.000475	0.000047
6	84	0.000331	16	0.000448	0.000146	0.795447	0.200600	0.000079	2.120366	0.000425	0.000125	0.000412	0.000105
5	84	0.000327	14	0.000552	0.000136	1.647057	0.242100	0.000096	5.455980	0.000578	0.000126	0.000615	0.000118
4	84	0.000330	16	0.000629	0.000099	3.010941	0.007100	0.000069	18.774488	0.000639	0.000095	0.000650	0.000090
3	84	0.000339	14	0.000463	0.000070	1.762567	0.046200	0.000086	2.056545	0.000396	0.000079	0.000308	0.000084
2	84	0.000336	14	0.000345	0.000142	0.058198	0.000100	0.000145	0.003217	0.000393	0.000130	0.000445	0.000121
1	84	0.000336	14	0.000866	0.000135	3.919757	0.383900	0.000137	14.960460	0.000919	0.000134	0.000994	0.000132
12	83	0.000334	12	0.000400	0.000120	0.546465	0.042600	0.000080	0.659787	0.000387	0.000101	0.000367	0.000086
11	83	0.000339	12	0.000689	0.000130	2.689340	0.275300	0.000088	15.688474	0.000705	0.000110	0.000726	0.000096
10	83	0.000338	12	0.000363	0.000276	0.085633	0.075300	0.000199	0.013963	0.000373	0.000237	0.000378	0.000208
9	83	0.000343	11	0.000363	0.000305	0.063838	0.228000	0.000236	0.006819	0.000322	0.000284	0.000288	0.000267
8	83	0.000341	12	0.000202	0.000285	-0.488366	0.507300	0.000254	0.300909	0.000251	0.000281	0.000312	0.000278
7	83	0.000339	11	0.000255	0.000505	-0.166672	0.396100	0.000433	0.037569	0.000295	0.000499	0.000328	0.000502
6	83	0.000344	11	-0.000255	0.000265	-2.267765	0.018600	0.000282	4.502909	-0.000161	0.000241	-0.000071	0.000221
5	83	0.000340	12	0.001240	0.000347	2.592996	0.202300	0.000258	12.048724	0.001178	0.000338	0.001118	0.000330
4	83	0.000343	12	0.001020	0.000363	1.863761	0.079700	0.000287	5.529252	0.001080	0.000348	0.001135	0.000336
3	83	0.000351	11	0.000425	0.000368	0.200557	0.097700	0.000368	0.040108	0.000367	0.000361	0.000315	0.000362
2	83	0.000349	12	0.000267	0.000233	-0.352073	0.351300	0.000166	0.244889	0.000283	0.000226	0.000298	0.000220
1	83	0.000347	12	0.001595	0.000661	1.887816	0.029600	0.000415	9.001043	0.001506	0.000606	0.001431	0.000558
12	82	0.000352	12	-0.000041	0.000393	-1.002169	0.063500	0.000221	3.176304	0.000054	0.000354	0.000133	0.000319
11	82	0.000360	11	0.000629	0.000686	0.391793	0.038200	0.000269	0.996848	0.000585	0.000633	0.000551	0.000585
10	82	0.000380	11	0.000870	0.000348	1.403816	0.400300	0.000272	3.217253	0.000808	0.000340	0.000753	0.000334
9	82	0.000386	9	-0.000441	0.000532	-1.556067	0.087200	0.000517	2.556021	-0.000522	0.000536	-0.000605	0.000544
8	82	0.000399	10	-0.000180	0.000842	-0.688317	0.184800	0.000580	0.997696	-0.000078	0.000808	0.000028	0.000776
7	82	0.000412	10	0.001026	0.001303	0.470902	0.306200	0.000661	0.861003	0.000918	0.001278	0.000797	0.001251
6	82	0.000437	10	0.000930	0.000596	0.825952	0.542200	0.000616	0.638343	0.000795	0.000612	0.000671	0.000630
5	82	0.000448	10	0.001035	0.000895	0.655284	0.776300	0.000828	0.500400	0.000922	0.000925	0.000838	0.000961
4	82	0.000459	9	0.001061	0.000847	0.708906	0.880600	0.000777	0.596043	0.001021	0.000835	0.000984	0.000829
3	82	0.000429	9	0.000675	0.000747	0.327282	0.331800	0.000500	0.238570	0.000751	0.000686	0.000821	0.000630
2	82	0.000399	9	0.000221	0.000488	-0.365050	0.386700	0.000330	0.290222	0.000154	0.000459	0.000091	0.000432
1	82	0.000417	9	0.001223	0.000729	1.105697	0.443600	0.000718	1.256060	0.001126	0.000704	0.001020	0.000687
12	81	0.000423	8	-0.000006	0.000774	-0.553522	0.005600	0.000699	0.375496	0.000023	0.000789	0.000056	0.000812
11	81	0.000429	8	0.001483	0.000982	1.072484	0.446800	0.000863	1.486689	0.001337	0.000990	0.001187	0.001006
10	81	0.000467	8	0.000509	0.000643	0.063720	0.004500	0.000402	0.010361	0.000461	0.000623	0.000425	0.000607
9	81	0.000487	8	0.000620	0.000516	0.256086	0.460800	0.000448	0.086883	0.000606	0.000523	0.000590	0.000534
8	81	0.000479	8	-0.000157	0.001052	-0.604684	0.250300	0.000718	0.784288	-0.000224	0.001019	-0.000283	0.000988
7	81	0.000505	8	0.000428	0.001780	-0.043380	0.365700	0.001685	0.002099	0.000596	0.001796	0.000747	0.001820
6	81	0.000542	8	0.001957	0.003831	0.369117	0.209600	0.003308	0.182694	0.001878	0.003886	0.001811	0.003966

Legend:
throughout, underlining denotes rejection of the null at the 5% level
(2) OLS standard error of estimated intercept
(3) = ((1)-(0))/(2)
(4) White (1980) or Cumby-Obstefld (1984) specification test
(reject the null if p value is less than 0.05)
(5) White (1980) heteroscedasticity consistent standard error
(6) Heteroscedasticity-consistent test of H0: a = MON [i.e., (1) = (0)]

Table 2 Month-by-month cross-sectional comparison
of rates of return on the bond and money market
ROR = a + b DUR + c DUMMY + e

non weighted regressions

Month	(1) Estimate of c	(2) St. dev. of c	(3) t test	(4) specif. value	(5) St. dev. of c	(6) Chi2 1df
8 84	-0.00036	0.000231	-1.571	0.2154	0.000143	6.433635
7 84	-0.00026	0.000135	-1.926	0.0749	0.000063	17.13173
6 84	-0.00011	0.000252	-0.461	0.2887	0.000079	2.126165
5 84	-0.00022	0.000223	-1.004	0.1102	0.000095	5.455947
4 84	-0.00029	0.000169	-1.765	0.0084	0.000068	18.80284
3 84	-0.00012	0.000108	-1.136	0.1750	0.000085	2.057789
2 84	-0.00000	0.000221	-0.037	0.0001	0.000145	0.003167
1 84	-0.00053	0.000209	-2.528	0.3896	0.000136	14.98765
12 83	-0.00006	0.000153	-0.43	0.0014	0.000080	0.666267
11 83	-0.00034	0.000165	-2.111	0.0872	0.000088	15.69920
10 83	-0.00002	0.000348	-0.069	0.0084	0.000199	0.014390
9 83	-0.00001	0.000381	-0.051	0.0040	0.000235	0.006845
8 83	0.000139	0.000352	0.395	0.0881	0.000253	0.300973
7 83	0.000083	0.000581	0.143	0.0001	0.000433	0.036945
6 83	0.000599	0.000313	1.911	0.0409	0.000282	4.499951
5 83	-0.00089	0.000404	-2.224	0.0516	0.000258	12.05644
4 83	-0.00067	0.000420	-1.607	0.0001	0.000287	5.528075
3 83	-0.00007	0.000426	-0.175	0.0001	0.000368	0.040919
2 83	0.000081	0.000271	0.302	0.0291	0.000165	0.243286
1 83	-0.00124	0.000767	-1.625	0.0088	0.000415	9.009903
12 82	0.000392	0.000457	0.859	0.0056	0.000220	3.164550
11 82	-0.00026	0.000783	-0.343	0.0567	0.000268	0.997411
10 82	-0.00048	0.000395	-1.238	0.0321	0.000272	3.227728
9 82	0.000826	0.000579	1.426	0.0048	0.000517	2.555516
8 82	0.000579	0.000911	0.635	0.0062	0.000579	0.997943
7 82	-0.00061	0.001399	-0.438	0.2115	0.000660	0.862006
6 82	-0.00049	0.000644	-0.764	0.0354	0.000615	0.639270
5 82	-0.00058	0.000973	-0.602	0.0090	0.000828	0.501092
4 82	-0.00060	0.000886	-0.677	0.0537	0.000777	0.596522
3 82	-0.00024	0.000793	-0.308	0.0192	0.000500	0.238629
2 82	0.000177	0.000516	0.344	0.0523	0.000330	0.290017
1 82	-0.00080	0.000777	-1.036	0.0038	0.000718	1.256919
12 81	0.000428	0.000833	0.514	0.0002	0.000698	0.375143
11 81	-0.00105	0.001051	-1.001	0.0095	0.000862	1.488687
10 81	-0.00004	0.000682	-0.061	0.0028	0.000402	0.010574
9 81	-0.00013	0.000543	-0.243	0.0045	0.000448	0.087122
8 81	0.000636	0.001091	0.583	0.1123	0.000717	0.785623
7 81	0.000076	0.001846	0.042	0.0001	0.001684	0.002080
6 81	-0.00141	0.003959	-0.357	0.0232	0.003305	0.182824

Legend:
throughout, underlining denotes rejection at the 5% level
(2) OLS estimate of standard deviation of c
(3) = (1)/(2); t test statistic of hypothesis c=0
(4) White (1980) specification test
(5) White (1980) h-consistent estimate of standard deviation
(6) h-consistent asymptotic test statistic of hypothesis c=0

Table 3 Comparison of time-series behavior
of money and bond markets

Descriptive statistics: First-order autocorrelations

Money market:	0.89207	Standard error:	0.034937
Bond market intercept:	-0.14863	Standard error:	0.147939

Serial correlation of individual bonds: see figure

Panel A:
non weighted regression (39 observations)
INTERCEPT(t) = a + b MON(t) + e(t)

a=	-0.00023297	b=	2.141124
st.error=	0.000534878	st.error=	1.377532
t (a=0)=	-0.43556409	t (b=1)=	0.828383
h-cons. st.e.=	0.000598931	h-cons. st.e.=	1.622617
chi2 (a=0)=	0.151307803	chi2 (b=1)=	0.494576

Durbin-Watson:	2.212	1st order autocorrelation:			-0.165
Joint test (a=0, b=1):*		F=	3.5498	pvalue=	0.0389
		chi2=	6.8223	pvalue=	0.033

Panel B:
regression weighted by first-pass standard error:

a=	0.000321146	b=	0.603717
st.error=	0.000500226	st.error=	1.422504
t (a=0)=	0.642001958	t (b=1)=	-0.27858
h-cons. st.e.=	0.000345509	h-cons. st.e.=	0.998747
chi2 (a=0)=	0.863942650	chi2 (b=1)=	0.157434

Durbin-Watson:	2.397	1st order autocorrelation:			-0.218
Joint test (a=0, b=1):*		F=	5.448	pvalue=	0.0084
		chi2=	15.8965	pvalue=	0.0004

Panel C:
regression weighted by first-pass h-consistent standard error:

a=	0.000386023	b=	0.423098
st.error=	0.000499629	st.error=	1.419913
t (a=0)=	0.772619219	t (b=1)=	-0.40629
h-cons. st.e.=	0.000334847	h-cons. st.e.=	0.969868
chi2 (a=0)=	1.329021796	chi2 (b=1)=	0.353816

Durbin-Watson:	2.182	1st order autocorrelation:			-0.135
Joint test (a=0, b=1):*		F=	13.5969	pvalue=	0.0001
		chi2=	81.9084	pvalue=	0.0001

Table 3 Panel D:
regression adjusted for serial correlation:
INTERCEPT(t)+0.165INTERCEPT(t-1) = 1.165a + b[MON(t)+0.165MON(t-1)] + e(t)

1.165a=	0.000298296	b=	0.792508
st.error=	0.000538671	st.error=	1.203215
t (a=0)=	0.553763163	t (b=1)=	-0.17244
h-cons. st.e.=	0.000452759	h-cons. st.e.=	1.049414
chi2 (a=0)=	0.434072040	chi2 (b=1)=	0.039093

Durbin-Watson: 2.069 1st order autocorrelation: -0.037

Joint test (a=0, b=1):*	F=	3.7296	pvalue=	0.0337
	chi2=	8.6743	pvalue=	0.0131

Panel E:
regression with lagged bond market as a regressor: 38 observations
INTERCEPT(t) = a + b MON(t) + c INTERCEPT(t-1) + e(t)

a=	0.000296426	b=	0.936325	c=
st.error=	0.000550996	st.error=	1.467819	st.error=
t (a=0)=	0.537981806	t (b=1)=	-0.04338	t (c=0)=
h-cons. st.e.=	0.000454343	h-cons. st.e.=	1.297349	h-cons. st.e.=
chi2 (a=0)=	0.425661693	chi2 (b=1)=	0.002408	chi2 (c=0)=

Durbin-Watson: 2.064 1st order autocorrelation: -0.034

Joint test (a=0, b=1, c=0):*	F=	2.1314	pvalue=	0.1138
	chi2=	6.6837	pvalue=	0.0827

* F test: finite sample but not heteroscedasticity consistent
chi2 test: heteroscedasticity consistent but asymptotic

Figure 1: Simul. of econometric proced.

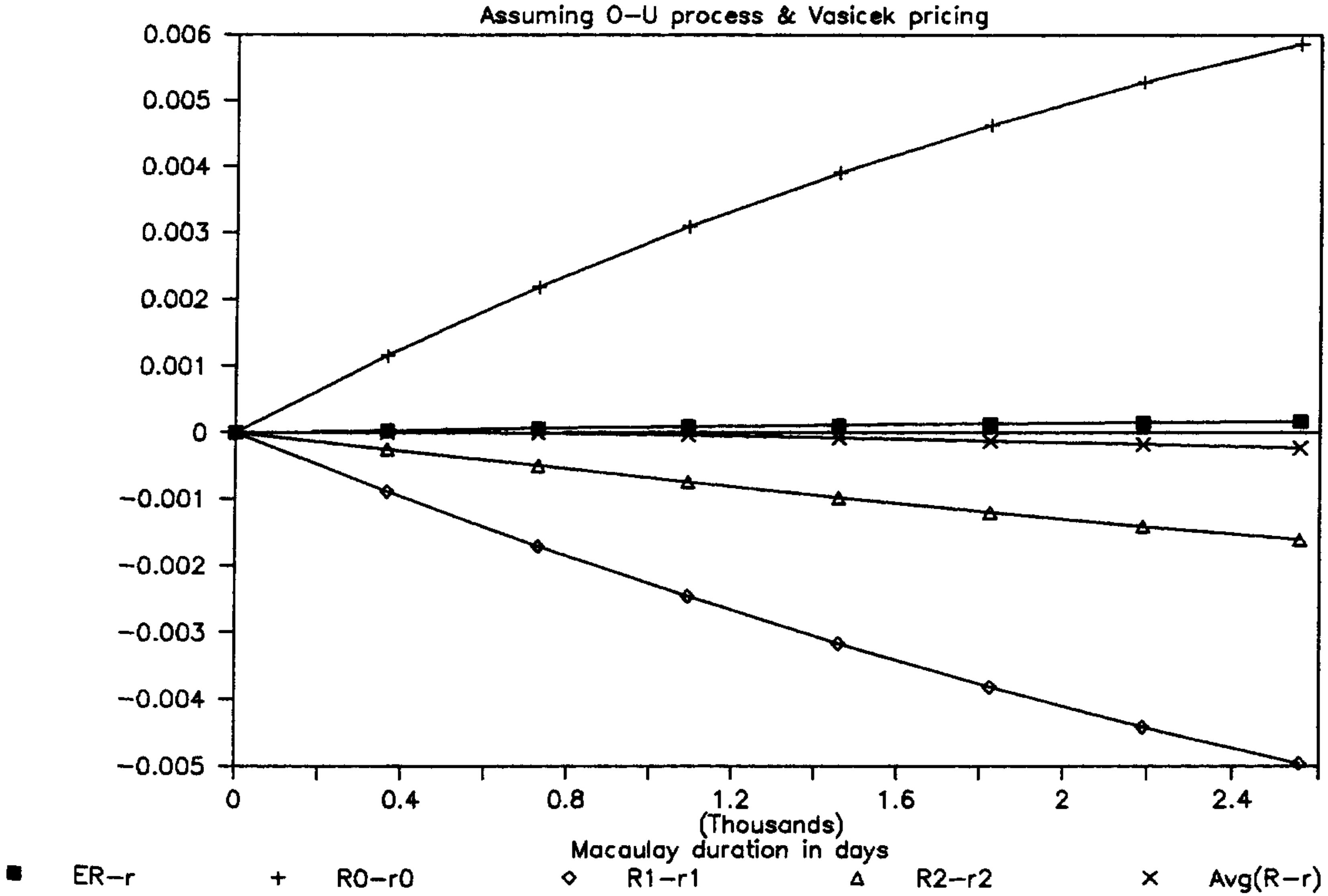

Figure 2: Simul. of econometric proced.

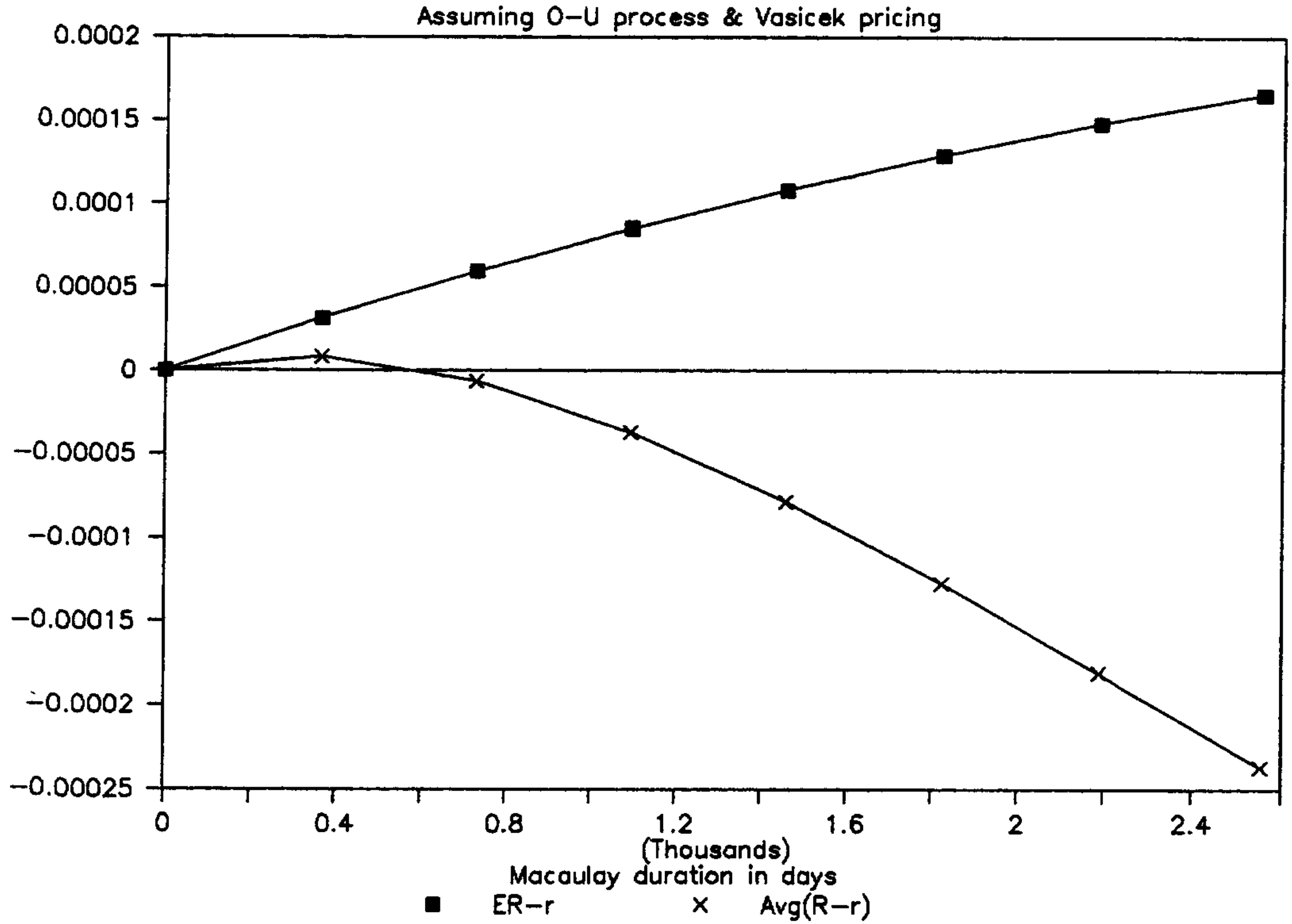

Figure 3: Simul. of econometric proced.

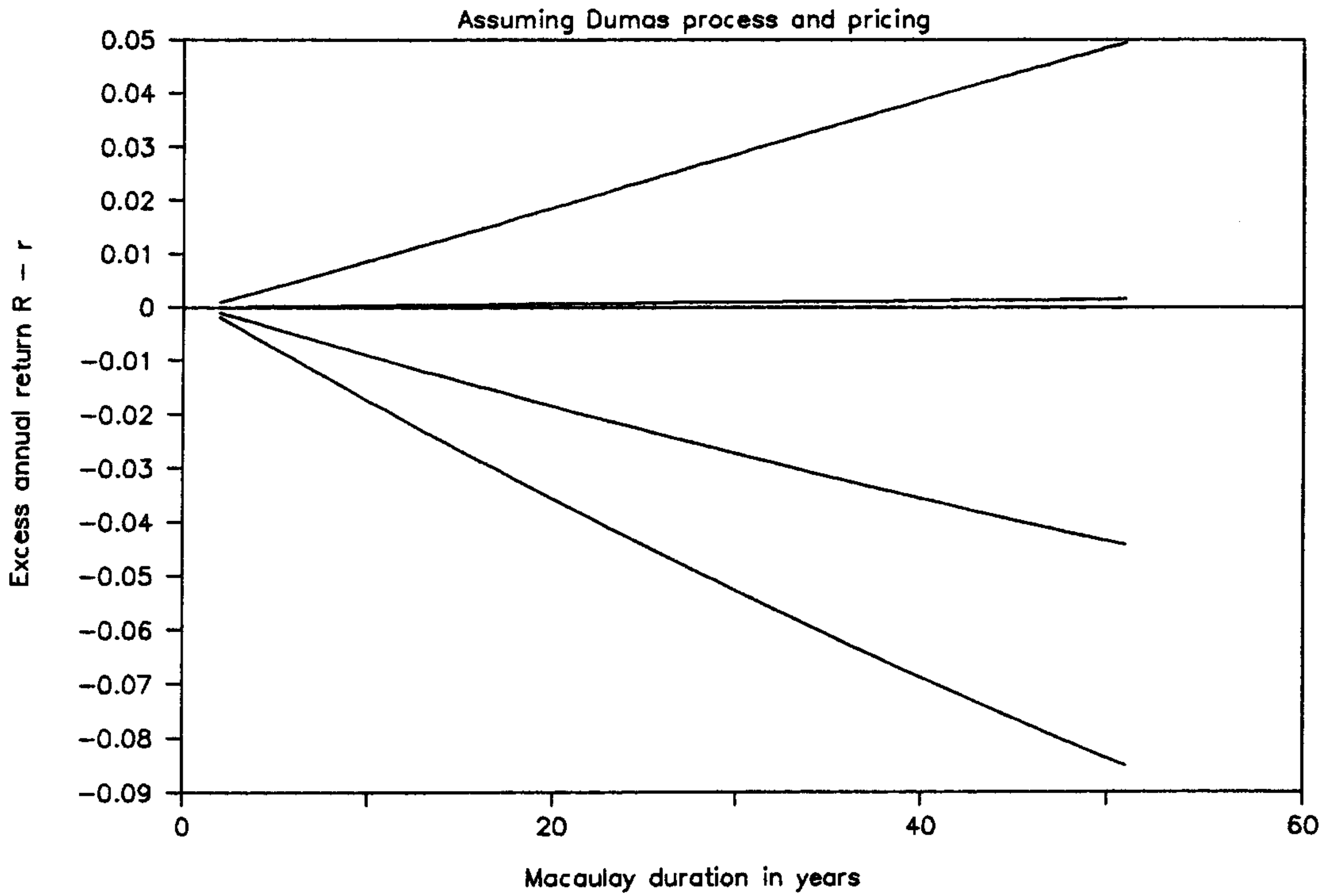

Figure 4: Link money/bond mkt

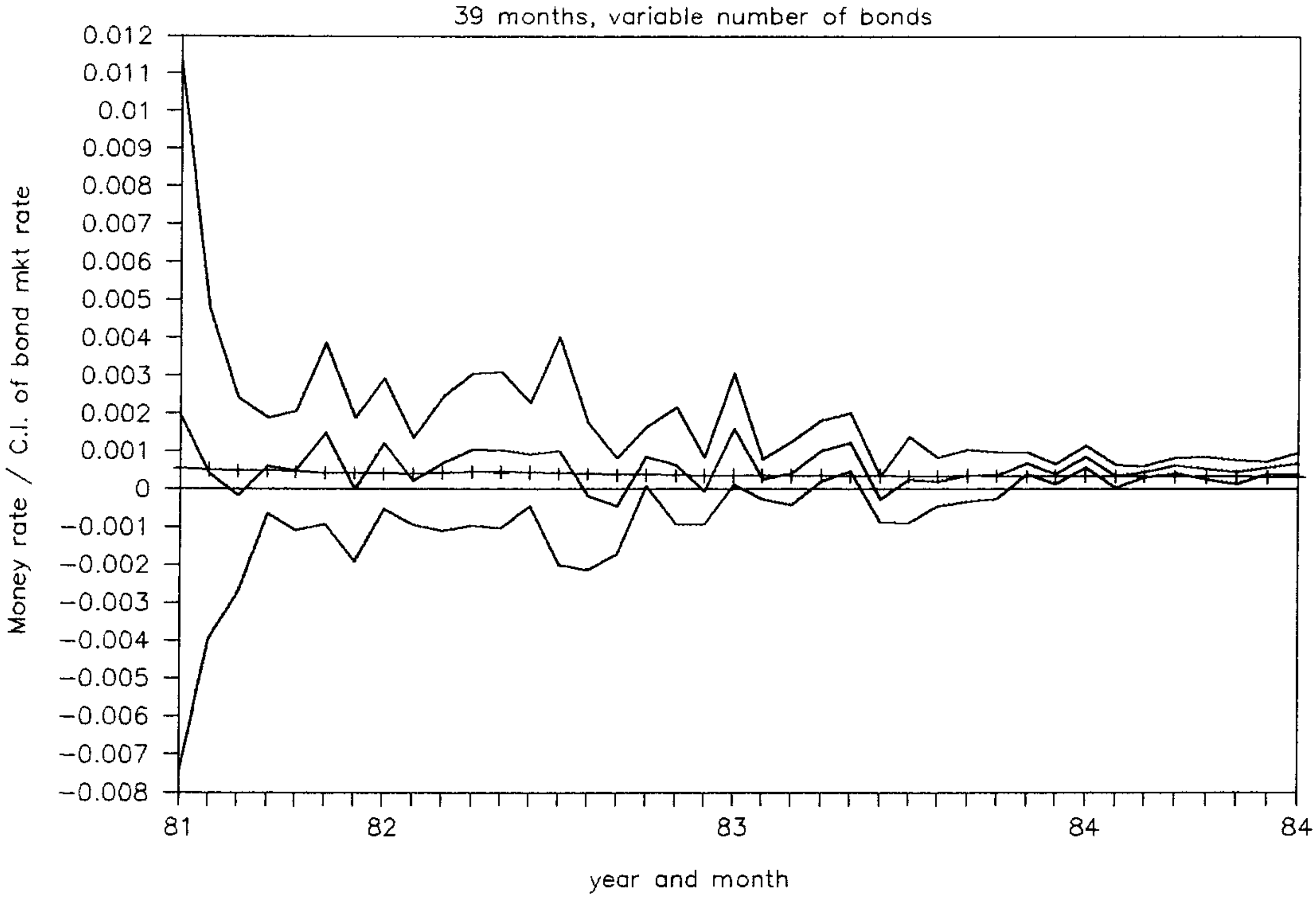

Figure 5: Serial corr. of individual bonds