The conundrum of stock versus bond prices

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Abstract In a general way, stock and bond prices do not display any significant correlation. Yet, if we concentrate our attention on specific episodes marked by a crash followed by a rebound, then we observe that stock prices have a strong connection with interest rates on the one hand, and with bond yield spreads on the other hand. That second relationship is particularly stable in the course of time having been observed for over 140 years. Throughout the paper we use a quasi-experimental approach. By observing how markets respond to well-defined exogenous shocks (such as the shock of September 11, 2001) we are able to determine how investors organize their “flight to safety”: which safe haven they select, how long their collective panic lasts, and so on. As rebounds come to an end the correlation of stock and bond prices fades away, a clear sign that the collective behavior of investors loses some of its coherence; this observation can be used as an objective criterion for assessing the end of a market rebound. Based on the behavior of investors, we introduce a distinction between “genuine stock market rallies”, as opposed to spurious rallies such as those brought about by the buyback programs implemented by large companies. The paper ends with a discussion of testable predictions.

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1 Introduction

Stocks and bonds constitute the two main securities traded on stock exchanges. It is true that over the last two decades other products such as futures and options have acquired an ever increased importance; in a sense, however, one can consider that their main purpose is to provide hedging tools for those “primary products” such as stocks, bonds, commodities, exchange rates and so on. It is therefore a natural question, to ask whether there is a relationship between the prices of stocks and bonds. The reason why we call this issue a conundrum will be readily understood by taking a look at Fig.1 and 2. Let us comment them briefly (we will come back to them later on).

For bonds it is their yields rather than their prices which is usually recorded. The yield is the real (as opposed to the coupon rate) interest rate brought by the bond; it is defined as the ratio of the coupon rate to the bond’s price (for more detail see Appendix A). This means that over short time intervals of the order of a few months during which the average coupon rate of a sample of bonds remains approximately constant, the yield basically represents the inverse of the price. Figure 1 shows that for three episodes marked by a stock price dip followed by a rebound, the yield of US Treasury bonds closely follows the stock index; in each case the correlation is highly significant. In other words, prices of stocks and bonds move in opposite directions. How can we account for that observation? A first explanation, one which may sound particularly appealing to physicists, is to say: let us assume that the stock exchange is a closed system (which is not altogether absurd over short time spans) and for the sake of simplicity let us discard all other products except stocks and bonds, then the stock exchange would be fairly well described by a communicating vessel model in which the amount of liquid represents the total amount of capital while the levels of the liquid would represent price levels. In such a model if the level in vessel $S$ goes up, the level in vessel $B$ must go down, which is what we observe. This argument can be fleshed out by remarking that investors usually respond to a sharp drop in stock prices by a collective flight to safety, by which one means that investors are tempted to sell all their risky assets and to seek refuge into non risky assets such as Treasury bills and bonds. Subsequently, when the panic abates they will transfer back capital from bonds to stocks.

But these nice explanations, and especially the first one, do not hold very long if we bring in additional evidence. If we focus our attention on the time interval from 1 June 1999 to 11 October 1999, instead of obtaining a positive correlation between stock prices and bond yields we get instead a negative correlation equal to -0.56. Thus, the communication vessel model crumbles down. But we can still hope to save the flight to safety model. Indeed, as the above time interval does not contain any crash-rebound episode, the flight to safety mechanism simply does not apply. The main problem when trying to check this effect is to make sure that the evolution in yield indeed reflects the one in price, in other words we ought to make sure that the average coupon rate of the set of bonds that one considers remains constant. If one relaxes this constraint, then the connection between stock prices and bond yields disappears completely. This is what happens if one considers a broad time interval, as illustrated in Fig.2. The thin line gives the correlation of the Standard and Poor’s 500 stock index and the Treasury yields. The average correlation is -0.25 but this figure has in fact little meaning since the correlation fluctuates wildly. If we focus at the period 1969-1980 which was marked by several stock price slides, we see that instead of being positive the correlation in fact is consistently negative.

Figure 2 also displays the correlation between stock prices and bond yield spreads. The spread can be defined in several ways (see Appendix A); one of the most frequently used is the difference between

\[ The \text{ three correlations in Fig.1 are equal to } 0.51, 0.68 \text{ and } 0.75 \text{ respectively, which for } n > 50 \text{ are of course highly significant; subsequently, for the sake of simplicity, confidence intervals will be omitted except in those cases where they matter that is to say for fairly weak correlations. We computed the correlations for the prices themselves; as no trend has to be removed using price changes instead, would present no real advantage here; the main effect would be to increase the noise component. } \]
Fig.1 Comparison of share prices and Treasury yields during three crashes on the New York stock market. The three price falls occurred in the wake of the bull market of the 1990s. In order to facilitate the comparison the stock index was normalized to 100 at the beginning of the crashes (left-hand scale); the right-hand scale represents the yield of 10-year Treasury bonds in percent. All curves have been smoothed through a 3-point moving window average. The data are weekly in case 1 and daily in cases 2 and 3. The correlations for the three cases are 0.51, 0.68, 0.75 respectively which are highly significant as confirmed by the following confidence intervals (0.27,0.69),(0.63,0.83),(0.44,0.73). Source: [http://finance.yahoo.com](http://finance.yahoo.com)
**Fig.2: Correlation between stock prices and bond yields/spreads.** The correlations were computed using a moving window technique (width of the window was 41 months). The fact that they fluctuate wildly shows that there is no stable relationship between stock prices and bond yields. Thin line: correlation with 10-year Treasury yields; thick line: opposite of the correlation of stock prices and the difference between the yield of corporate bonds of Baa rating and 10-year Treasury yields. Dashed line: same as thick line except that the 10-year Treasury yield is replaced by the yield of Aaa bonds, the highest quality in the range of corporate bonds. Over the whole 1954-2003 time interval the correlations are -0.25, 0.29 and -0.26 respectively. Source: [http://economagic.com](http://economagic.com); [http://finance.yahoo.com](http://finance.yahoo.com).

Baa rated bonds (a medium quality bond) and Treasury bonds. The more troubled the economic situation, the less one would expect investors to invest in risky bonds, and therefore the higher the gap between the yields of risky and non-risky bonds. In other words, the spread can be seen as a measure of economic uncertainty perceived by investors, as was proposed in an earlier paper (Roehner 2000). Naturally, one would expect economic uncertainty to increase dramatically in the wake of major stock market crashes, in other words one would expect the spread to expand in times of falling stock prices. A confirmation of this interpretation can be found in Fig.3: we see that the spread widens during stock market crashes and narrows during the rebound; over this 7-month interval the correlation of stock prices and spread is $-0.85$. One could expect that because it is a difference of yields the spread would be less sensitive to variations in interest rates than the Treasury yield itself. Yet, Fig.2 shows that it nevertheless has no stable relationship with stock prices as shown by the wild fluctuations of the correlation. However the spread does a better job in that respect than the Treasury yield. For instance even a short lived crash such as the one in October 1987 brings about a positive correlation (note that in order to facilitate the comparison, the graph displays the opposite of the correlation). However the fact that the overall correlation for the whole time interval does not have the right sign (it is equal
to 0.29) shows that it only makes sense to study it if one restrict oneselfs to selected crash-rebound episodes.
This is something economists are reluctant to do. One reason for their unwillingness to focus on specific episodes is probably due to the fact that if one accepts the assumption of a “rational homo economicus” whose way of reasoning would be independent of any social Zeitgeist, it is difficult to imagine that investors may react differently in an optimistic environment or in a time of panic. As a result the methodology commonly used in econometrics does not prove very pertinent for handling problems of the kind considered in this paper. In standard econometric procedure, time series are treated en bloc without any attempt to break them up into episodes corresponding to different mechanisms; once the “en bloc” option has been adopted it makes little difference whether one uses multivariate analysis or any other statistical tool for the data are spoiled from the start. A recent paper by Gabe de Bondt (2002) is typical of this procedure. The author considers (en bloc) the three-year time interval since the introduction of the euro in January 1999 and develops a multivariate analysis with no less than 25 variables among which the corporate debt, price earnings ratio, corporate bond spreads, industrial confidence indicator, etc. With such a catch-all set of variables one is not in the best conditions for identifying and isolating a specific mechanism. In contrast, in a very stimulating paper which is one of the few exceptions to the above procedure, Frederic Mishkin (1991) focuses on a set of sharply defined banking panics.

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2A more detailed analysis of this important point can be found in Roehner 2002 (chapter 3)
The approach that we use in this paper consists in observing the response of the system to different kind of shocks. In physics, the perturbations used in order to probe a system can be selected at will by the experimentalist. Here, we are more in the situation of an astrophysicist who has to wait for a new supernova to appear in order to use it as an observational probe. In the next section we study how the system responded to a series of historical crashes. Then, in section 3, we take a close look at how it reacted to the shock of September 11, 2001. In the next section we study the transition between the crash-rebound regime and the more “normal” regime characterized by the absence of collective panic reactions. Finally, in the last section we propose some testable predictions. We do not claim that our study altogether solves the problem, but it provides a series of robust regularities which should be of usefulness in future attempts to build mathematical models or simulations.

2  Response to historical stock market crashes

So far we have considered two variables: the interest rate of Treasury bonds and the spread of corporate bonds. By observing the response of the US market to a sequence of nine historical stock market crashes, we will be able to determine which one of these variables has the most robust relationship with stock prices. Fig.4 represents the correlation of stock prices and interest rates (triangles) or yield spreads (circles). Obviously it is the spread which has the most robust relationship. As a matter of fact, such a stable relationship over a time span of one century and a half is quite remarkable, especially on account of the major institutional and organizational transformations that occurred at the New York Stock Exchange during this time. Although less stable, the pattern displayed by the triangles is not without interest. First, we see that there is an overall upward trend. Back in the nineteenth century, interest rates experienced a jump during stock market crashes; in these times over-investment provoked a dearth of capital (usually referred to as a credit crunch) which naturally lead to higher borrowing prices. Apart from this trend the cases of 1929-1930 and 2001-2002 stand out as being characterized by high positive correlations. These crashes were both preceded by a decade-long period of speculative frenzy and in both cases interest rates were massively reduced by the Federal Reserve (which had been created in 1913) in order to check the fall in stock prices (more details about the case of 1929-1930 can be found in Roehner 2001, p.186-188). For the sake of illustration Fig.5 compares the evolution of stock prices, spread and interest rate for the episode that is currently under way. This figure extends to 2003 the graphs displayed in Roehner (2000) for the eight earlier episodes. Table 1a provides regression results for the nine episodes.

The fact that the average value of the coefficient \(a\) is approximately equal to minus one means that a \(x\) percent drop in the spread would be accompanied by a \(x\) percent increase \((x > 20)\) in stock prices and vice versa. This is indeed what has been observed during the past nine months: between October 2002 and June 2003 (time of writing) the spread fell by 26 percent while the SP500 gained 22 percent.

Before we leave this section an observation is in order about the way we measure the interest rate spread. As explained in Appendix A, it mainly depends upon the data that we have at our disposal; certainly the best procedure is to calculate the coefficient of variation of the yields of a sufficiently large set of individual bonds. This is the procedure used by Mishkin (1991) for the pre-1935 episodes for which he could used Macaulay’s data (1938). The other option is to take the difference between the yield of Baa bonds and of Treasury bonds. This procedure is used by Mishkin (1991) for the episodes which occurred after 1950 and is the one that we used throughout this paper. However, it is clearly less satisfactory than the estimate derived from individual bonds for at least two reasons.

- The decision to grade a bond as Baa is made by rating agencies. But these agencies can make mistakes. An example was provided in December 2001 by the bankruptcy of Enron Corporation. Both Moody’s and Standard&Poor’s kept Enron’s bonds at investment grade until just 5 days before it filed
for bankruptcy (Wall Street Journal, 28 March 2002); a similar episode happened on 19 September 2002 when the company Electronic Data System announced a drastic reduction in profits (which provoked a fall of 53 percent of its share price) which took rating agencies completely by surprise; after the announcement, they downgraded the company’s debt.

By using the Baa-Treasury difference in fact, we discard the whole spectrum of low quality bonds between Caa and Baa. These bonds are issued by companies which are usually smaller and in a more difficult position; but precisely for these reasons, they would constitute a more sensible barometer of the business climate. Using this more sensible indicator would perhaps permit to explain away some of the outliers. Unfortunately, so far we were not able to find a comprehensive data set of individual US corporate bonds.

3 The response of investors to greater uncertainty

The historical evidence reviewed in the previous section highlights a number of interesting facts. (i) During crash-rebound episodes stock prices and spreads move in opposite directions; in percentage terms each change of one variable is mirrored by an identical change of the other (ii) During the two episodes of 1929 and 2001 the flight to security of investors was masked by the policy of the central bank. Indeed such a flight would have resulted in an increase in treasury prices and thus a decrease in their yields; but the Fed’s policy of lowering interest rates had of course essentially the same effect;
at this point we have no means which would enable us to disentangle these two effects\(^3\).

By observing the day-by-day response of investors to a shock we will be able to get a better understanding of how they react. More specifically, we will address two questions (i) Are the shift affecting bonds always a consequence of what happens on the share market? (ii) What forms take the flight to security?

Most often, in business news, moves affecting the bond market are seen as a result of changes in stock prices; one would for instance find statements such as “Today Treasury forfeit previous gains in wake of Dow’s advance”. Can we really take for granted this direction of causality? The shock of September 11 gives us an opportunity to test this assumption. Because the stock market was closed during a longer time interval than the bond market we can observe how bonds behave in the absence of stock quotations (Fig.6). We observe that: (i) The 5.6 percent increase in the price of 10-year Treasury bonds takes place on September 13-14 that is to say when the stock market was still closed. (ii) The main part (11 percent out of a total shift of 18 percent) of the price fall of Baa corporate bonds also occurred before the stock market reopened. In short we see that bond prices can make rapid and

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\(^3\)One might think that by focusing on a time interval during which there has been no reduction in the fed funds rate one would be able to observe the other effect alone, but this is not completely right because the fed funds rate is a short-term rate; the fact that it does not change does not necessarily mean that medium- and long-term rates remain unchanged as well.
### Table 1a Relationship between interest rate spread and stock prices in historical crash episodes in the United States over the time interval 1857-2003:

\[
\Delta \text{Spread}/\text{Spread} = a (\Delta \text{Stock price}/\text{Stock price}) + b
\]

| Year | Duration [month] | Amplitude of fall | a    | b    | Correlation of fall |
|------|-----------------|------------------|------|------|---------------------|
| 1    | 1857            | 0.60             | -0.94 ± 0.4 | -0.8 ± 3 | -0.82 ± 0.94      |
| 2    | 1873            | 0.80             | -2.00 ± 1   | 0.2 ± 4   | -0.78 ± 0.37      |
| 3    | 1890            | 0.80             | -0.82 ± 0.4 | -0.8 ± 1  | -0.74 ± 0.43      |
| 4    | 1893            | 0.73             | -1.70 ± 0.7 | -3.7 ± 3  | -0.84 ± 0.87      |
| 5    | 1907            | 0.62             | -1.00 ± 0.6 | 0.1 ± 3   | -0.57 ± 0.85      |
| 6    | 1931            | 0.18             | -0.51 ± 0.3 | 3.0 ± 6   | -0.62 ± 0.75      |
| 7    | 1938            | 0.55             | -0.75 ± 0.4 | 1.5 ± 4   | -0.78 ± 0.87      |
| 8    | 1987            | 0.70             | -0.63 ± 0.6 | -0.9 ± 5  | -0.63 ± 0.75      |
| 9    | 2002?           | 0.55?            | -0.42 ± 0.3 | -0.2 ± 2  | -0.43 ± 0.35      |

**Average**  
-0.98 ± 0.2  -0.20 ± 1  -0.69

Notes: The year refers to the trough of the stock price index. The amplitude of the fall is defined as the ratio of the stock price index at the trough to its level at the peak. The cases considered for the period before 1990 are essentially those identified and enumerated in Mishkin (1991). All data are monthly. The variation ratios \( \Delta \text{Spread}/\text{Spread} \) and \( \Delta \text{Stock price}/\text{Stock price} \) are defined in percent. The fact that the average of \( a \) is approximately equal to -1 means that when the spread decreases by 26 percent (as was the case between the end of 2002 and mid-2003) one may expect the SP500 to increase by 26 percent (in fact it increased by 22 percent). Sources: Mishkin (1991); [http://economagic.com](http://economagic.com), [http://finance.yahoo.com](http://finance.yahoo.com)

### Table 1b Relationship between Treasury yields and stock prices in three crashes in the United States over the time interval 1998-2003:

\[
\Delta \text{Stock price}/\text{Stock price} = a (\Delta \text{Yield}/\text{Yield}) + b
\]

| Year | Duration [month] | Amplitude of fall | a    | b    | Correlation |
|------|-----------------|------------------|------|------|-------------|
| 1    | 1998            | 0.84             | 0.19 ± 0.2 | 0.40 ± 0.7 | 0.25         |
| 2    | 2001            | 0.80             | 0.22 ± 0.3 | -0.12 ± 1  | 0.25         |
| 3    | 2002            | 0.80             | 0.72 ± 0.5 | 0.04 ± 2   | 0.61         |

**Average**  
0.38 ± 0.2  0.11 ± 0.7  0.37

Notes: The table focuses on the recurrent crashes (displayed in Fig.1) which occurred in the wake of the bull market of the 1990s. For some reason (not well understood yet) these crashes differed from the other ones (except 1929) listed in Table 1a by the fact that there was a significant positive correlation between the level of stock prices and the yield of Treasury bonds. All data are weekly. The relative variations of stock prices and yields are expressed in percent. Source: [http://finance.yahoo.com](http://finance.yahoo.com)

Moreover we see that the flight into long-term Treasury is about two times smaller than the withdrawal from moderately risky Baa bonds. This conclusion is confirmed by the results given in Table 2 for substantial moves without being pulled by stock prices.
bonds quoted in Frankfurt.
While the withdrawal from Moody’s Baa2 (BBB in Standard and Poor’s notation) results in a modest one percent price decrease, for the B1 to B3 range (Standard and Poor’s B+ to B-) the fall is about 6 percent.
If one looks at the change in constant maturity short-term Treasury bills (3 months to two years) which are not represented on Fig.6 for the sake of clarity, we see that their prices jump by about 14 percent.
To sum up, two major conclusions emerge.
- Bond yields can move quickly and substantially without such moves having necessarily to be triggered by shifts in share prices.
- What is usually referred to as a flight to safety in fact is more a flight away from risk. Investors pull back from what they perceive as risky assets and transfer the money into secure short-term assets such as Treasury bills where it will sit until eventually being retransferred to stocks in the rebound phase.

The second point is confirmed by the observation of another shock. In the afternoon of Tuesday 25 June 2002, the direction of WorldCom, a major telecommunication company, announced that due to a multibillion accounting fraud the company had to fill for bankruptcy. In the following week the SP500 index fell by about 4 percent; however, for companies in the telecommunication sector the fall in share prices was much more substantial. For Qwest it was 50 percent; for Lucent, 33 percent; for Nortel, 23 percent; for IBM it was only 3 percent; for McDonald’s it was less than 2 percent. The magnitude of the drop in fact provides an estimate of how distant the respective companies are from

Fig.6: Response of investors to the shock of September 11, 2001. From Sep.10 to its local maximum around Sep.21, the spread increased by 18 percent, of which 11 percent occurred before the reopening of stock quotations. Source: [http://economagic.com](http://economagic.com) [http://finance.yahoo.com](http://finance.yahoo.com).
Table 2 Response of bonds quoted in Germany to the shock of September 11, 2001

| Baa2 bonds |   | B1 to B3 bonds |   |
|------------|---|---------------|---|
| WKN code   | Price change | WKN code      | Price change |
| 610042     | −1.1         | 352445        | −3.9         |
| 308960     | −1.0         | 353764        | −3.1         |
| 352942     | −1.3         | 230637        | −9.6         |
| 610260     | −1.0         | 108565        | −5.3         |
| 677682     | −0.8         | 614414        | −9.1         |

Average -1.0 -6.0

Notes: Baa2 bonds are the lower end of the so-called investment-grade bonds; B1 to B3 bonds belong to the high-risk spectrum; these grades are just one notch above the Caa grade which designates bonds which are close to default. It is known that the reaction of bond prices to changes in interest rates depends upon the times left to maturity. Here, however, the shock was not primarily a change in interest rates; nevertheless, we tried to control for a possible effect of this kind by selecting (as far as available) two sets of bonds with similar average maturity dates.

Sources: http://www.finanztreff.de; http://www.bondboard.de (bond finder).

The telecommunication sector. What happened to bonds? The price of Baa bonds dropped by 1.8 percent while the price of Treasury bonds increased by 0.4 percent.

At this point the reader may wonder whether it is possible to determine the direction of causality between spread and stock prices by using statistical methods in the spirit of Granger’s causality tests. To this aim, we compute the correlation function of the spread and stock prices by introducing a varying time lag between the two series. The rationale of such a procedure is as follows: if the correlation is found to be maximum for the bond series lagging behind the stock prices, one would have good reason to think that the movements of the stock are the “cause” from which changes in bonds derive. We performed this test on the daily yield series from 1 July 2001 to 28 February 2002. The results are summarized in table 3.

We see that the maximum of the correlation occurs for \( d = -2 \) which corresponds to the spread lagging two days behind stock prices. However this test is not completely satisfactory for two reasons: (i) the maximum is fairly soft (ii) the position of the maximum is not robust with respect to a reduction in the length of the time interval (column 3 of table 3). In conclusion we can say that the test is consistent with changes in the two series occurring almost on the same day. Furthermore one cannot exclude that under a given set of circumstances the bonds drive the stocks while under different conditions the stocks drive the bonds. As an image consider the case of a person who walks his dog; in normal circumstances the dog follows its master, but if it spots another dog nearby, the situation may well get reversed!

4 When the connection between stocks and bonds fades away

The conundrum evoked in the title of the paper refers to the startling difference between crash-rebound episodes and long-term behavior. The former is marked by a strong connection between stock and bond prices whereas over the long-term there seems to be no connection at all. In this section we study more closely the transition between these two regimes. To this aim we use again the moving window
### Table 3 Correlation (with time lag \(d\)) of spread and stock prices: Cor[Spread(i),SP500(i+d)]

| Time lag [days] | Correlation (160-day interval) | Correlation (70-day interval) |
|-----------------|--------------------------------|------------------------------|
| −6              | −0.800                         | −0.881                       |
| −4              | −0.828                         | −0.923                       |
| −2              | −0.852*                        | −0.949                       |
| 0               | −0.847                         | −0.954*                      |
| 2               | −0.783                         | −0.906                       |
| 4               | −0.697                         | −0.826                       |
| 6               | −0.610                         | −0.734                       |

Notes: The series in the second column covers the interval from 1 July 2001 to 28 February 2002; the series in the third column covers the time interval from 1 July 2001 to 12 October 2001. Both time intervals were marked first by a drop in stock prices in the weeks preceding and following September 11, and then by a rebound. The asterisks denote the time lags for which the absolute value of the correlation is largest.

...technique already used in Fig.2 but in a slightly different form. We start with a time interval marked by a strong connection between stock and bond prices and we then progressively expand this interval by allowing its right-hand boundary to shift toward 24 May 1999. The result is summarized in Fig.7. The time interval is centered around the crash of August-September 1998; we selected this crash because in this case the rebound was followed by a long period of stock price increase (in contrast, after 2000, crashes occurred in short succession). As the time interval is progressively widened the two correlations first remain constant, then began to fall about 30 business days (i.e. 40 calendar days) after the trough of the crash; at about 60 days (i.e. 2.6 calendar months) the correlations are reduced to the point of being no longer significant. Yet, if we look at Fig.1a it is difficult to see any difference in the way stock prices progressed. The fact that until the end of November 1998 the increase was in fact a rebound and after that date gave way to the continuation of the bull market is by no means apparent on the graph of the SP500; nonetheless there was a drastic, hidden change in the behavior of investors.

### 5 Concluding comments

There are much closer ties between the stock and bond markets than for instance between the stock and housing markets if only because there are securities which provide links between them: for instance preferred stocks (see Appendix A), despite their name, share many attributes of bonds, and convertible bonds (see Appendix A) can be transformed into stocks under pre-determined conditions. Therefore the question of the connection between stock and bond prices is both a natural and important one. We have shown that there is a strong connection between stocks and bonds during crash-rebound episodes. Immediately after the crash, investors sell their risky bonds; the more risky, the more they sell them (Table 2); after the rebound they sell some of their Treasuries and buy back stocks as well and some of the more risky bonds (Fig.1 and 3). Subsequently, the collective behavior of investors becomes less coherent and as other factors (such as for instance changes in interest rates) take over, the strong connection between stocks and bonds fades away (Fig.7).

We would like to address three additional points which may be of interest in the perspective of future work on this issue.

- First, why did we restrict this study to US data? Two other possible candidates would be...
Fig. 7: The correlation between either yield or spread fades away in the course of time after the crash. The decreasing correlation clearly points to a drastic change in the behavior of investors; it can be interpreted as a shift away from the collective flight to safety reaction that prevailed during and shortly after the crash. The graph refers to the crash of August 1998 (Fig. 1a).

Europe and Japan. Europe has an important and fairly liquid Eurobond market, however European stock markets very much move in the shadow of Wall Street, a circumstance which is likely to bias the analysis. The Tokyo stock market is more independent from New York, but the domestic Japanese bond market lacks liquidity, especially in the range of medium and low grade bonds. As a matter of fact, it is because of this lack of liquidity that spread data were not published until 1997. Even after this date, daily spread data have fairly large error bars due to the small number of transactions in low grade bonds; whereas in 2000 the turn over (i.e. the ratio of trading volume to capitalization) of the corporate bond market reached 0.81 in the United States, it was equal to 0.16 in Japan (Hattori et al. 2001). Incidentally, the relative under-development of the Japanese bond market has had important consequences during the banking crisis of 1991-2003; their main assets were stocks and debt of companies, but after stocks had crashed and the financial situation of the companies had deteriorated, there was no junkbond market on which this bad debt could be sold; as a result it remained as a millstone around their necks for over a decade.

- Common opinion holds that by lowering short term interest rates the central bank is able to boost stock prices. However, from the regularities found in this paper, one could as well made a case for the opposite to be true. The argument would go as follows. When the Federal Open Market Committee lowers the fed funds rate, all existing bonds (which were issued in an environment of higher rates) become more attractive to investors. Consequently their price will climb while their yield will fall. If this happens in the context of a crash-rebound episode, we know (Fig. 1) that it should be accompanied by a concomitant fall in stock prices. Thus, we arrive at the conclusion that
cuts in the fed funds rate in fact depress stock prices. What makes this reasoning shaky is the fact that it ignores time lags. As Fig.8 shows, the decisions of the Fed follow the fluctuations of short-term interest rates rather than they provoke them. Seen in this light, the argument sounds more reasonable. As a matter of fact, a “true” stock market rally should be characterized by a transfer of capital from secure assets such as Treasuries to stocks. In contrast, a rally which occurs amidst increasing Treasury prices is an anomaly. This was the situation between March and June 2003 (time of writing); in such a case it seems safe to predict that either Treasury prices will stop increasing or stock will resume their slide.

Predictions

Ultimately the best way to test models or to check the validity of new regularities is to propose testable predictions. It is probably no coincidence that this “experimental” procedure has been pioneered by econophysicists. MarcelAusloos, Anders Johansen, DidierSornette and NicolasVandewalle were among the first to test their models through predictions (seeVandewalle et al. 1998, Johansen et al. 1999, Sornette 2002). Naturally, the difficulty of the task strongly depends on whether one considers short-, medium- or long-term predictions. For stock price predictions on very short time scales (of the order of one minute or less) the order book constitute a good guide (see Maslov 2001). The main difficulty when making predictions over very long time scales of the order of fifty years or more (seeSornette 2002, p.373) is that its horizon may extend beyond the life time of the model.

As we already noticed the spread can hardly provide a predictor for stock prices. As a matter of fact, short-term prediction of stock prices is probably impossible anyway for at least two reasons. Firstly because the market is efficient, a somewhat fuzzy notion which one can understand in the sense that a multitude of financial analysts track down any short-term predictor in order to exploit it. The second reason is quite different. As is well known, big companies run massive buyback programs of their own shares. As an estimate of their magnitude it is sufficient to recall that between 1996 and mid-2003 buyback programs represented $ 1.3 trillion, that is to say about 13 percent of the capitalization of the NYSE market at its peak in 2000. Although these programs are announced in advance, their timing and the way they are going to be implemented are not; as a matter of fact, some are never implemented and are announced merely to reassure stock holders. Because they are so massive these buybacks may generate “spurious” rallies which of course are impossible to predict. As another fairly exogenous source of spurious rallies, one can mention the merger and acquisitions which strongly increase the demand for stocks but are the result of strategic decisions made by big companies rather than the consequence of the moves made by individual investors. The Toronto stock market offered a spectacular illustration of this effect over the decade 1991-2000 when merger and acquisitions were multiplied by a factor 10, before abruptly declining in 2001 and 2002 (Security Industry 2002). 5

However, a buyback rally is unlikely to deeply change the behavior of investors which means that one can distinguish between genuine and spurious rally by looking at the changes in bond prices and bond spreads. If both prices and spreads drop the rally may be genuine. This was for instance the case of the rally that followed the crash of mid-September 2001; unfortunately it did not last very long; basically it began to fizzle out when stocks had regained their

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4The same scenario occurred in August 2002: the SP500 gained 20 percent while the yield of the 10-year Treasury dropped by 13 percent. This rally proved short-lived and was followed by a 20 percent slide between late August and mid-October 2002. Then in the last two weeks of October there was a new rally, this time accompanied by a drop in Treasury prices (a good omen), but also by an increase in the spread (see Fig.5) which was a less favorable portent.

5When it comes to short-term predictions about individual stocks the behavior of the chairman may become a crucial factor. For instance, Sanford I. Weill, the chairman of Citigroup, exercised the right to sell stock options (for more than half a million shares in each case) on 4 November 2001, 4 November 2002 and 17 June 2003. Citigroup’s stock price peaked on the first two of these dates, it will be interesting to see whether 17 June 2003 will also represent a local maximum. In this connection it should be remembered that Citigroup owns 10 percent at least of its stock and has run massive buyback programs over the recent years.
pre-September 11 level. Looking further into the past, the rally which followed the crash of late August 1998 was accompanied by a drop in the spread and an increase in Treasury yields in spite of a cut in the fed funds rate. Thus, it clearly qualified as genuine. After February 2000 the spread began to widen very quickly bringing the genuine rally to an end. However the market stayed on its stride for a while and the downturn of the S&P500 occurred only in August 2000.

Finally, it must be emphasized that one can of course hardly expect completely deterministic connections in such a complex system; it is virtually impossible to control for all the variables that we did not consider directly but which may nevertheless play a role in specific circumstances. Fig.2 conveys a feeling of this complexity. Whereas the stock market is only mildly dependent upon interest rates, the bond market has a very strong connection with them, and through these rates it is closely connected to the “real economy” (probably to a greater degree than the stock market itself). Our main objective in this paper was to scrutinize the behavior of investors during episodes marked by a sharp increase in overall uncertainty and to find regularities in their reactions. Further progress will become possible if we can find a comprehensive data set of individual US corporate bonds.

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A Appendix A: Some basic facts about bond markets

This appendix has three purposes. First we recall a few salient facts about the bond market, then we highlight its similitudes with the stock market and finally we describe some recent developments.

First of all one should recall the basic mechanism which governs the price of bonds. Suppose for instance that a 10-year government bond was issued by the US Treasury in 1998 with a (fixed) interest rate of 5 percent which in bond parlance is also called its coupon rate. Suppose further that, because there has been a general decline in interest rates, the coupon rate of this type of bond is 4 percent in 2003; then, at least theoretically, there will be an extra demand for this older bond with a 5 percent coupon rate that would cause its price to rise until the ratio of the coupon rate to the current price (this ratio is called the current yield, see more details below) would be the same 4 percent. In the present case this means that the price would increase from its initial level of 100 to 100 times $5/4$ that is to say 125.

As another example, consider a company that issues two different bonds at the same moment. If their durations are not the same their coupon rates are also likely to be different. Once they are on the market, their prices will adjust in the course of time so that their yields become fairly equal to those of other bonds of same duration and same quality (see more about quality below) that are already on the market.

Having explained the basic mechanism, let us now state some of the definitions which are used throughout this paper.

- The current yield of a bond is defined as the ratio of coupon rate to bond price. By the way, it can be observed that bond prices are always close to the coupon price which by convention is taken as equal to 1 or 100 (depending on the convention), except for bonds which are close to default. The yield to maturity\(^6\) refers to the total revenue gained from the bond; its computation is more involved because one has to take into account the present value of all subsequent coupons. Usually, however, the current yield and the yield to maturity vary in the same direction; at a qualitative level the two notions can be used without further distinction.

- Bonds are rated by rating agencies on a scale which comprises two main classes: the investment grade class which goes from Aaa to Baa in Moody’s notation and the high-yield (also called junk bond) class which goes from Baa to Caa (a Caa grade means that the bond is close to default)\(^7\). The high-yield market first came into existence as a fairly liquid market in the United States in the early 1980s; in some other developed countries such as for instance Japan this market is still fairly narrow and illiquid.

Because there is a broad spectrum of grades, a natural question is to ask how yields depend upon grades. Basically, the lower the grade, the higher the yield. This leads to the notion of spread. Depending on the data that are available the spread can be defined in various ways. If data for a large sample of individual bonds are available the spread can be defined as the (ensemble) standard deviation of the yields. If only average yield data are available the spread can be defined as the difference between the yield of Baa bonds and the yield of Treasury bonds. Note that although the Aaa grade designates the highest quality of bonds, Treasury bonds usually are priced higher than Aaa corporate bonds (for a same coupon rate). This premium is due to several factors which make Treasuries more attractive to investors. For instance, if advantageous to the company, an Aaa bond may be reimbursed before maturity date, a feature which introduces additional uncertainty for its

\(^6\)Note that in Japan this notion is used with a slightly different meaning. Whereas in the West, the calculation assumes that the coupon payments are reinvested, in Japan interest is not compounded; this slightly different notion is referred to as the simple yield (Padua 1998).

\(^7\)Here is the whole list of Moody’s grades: Aaa, Aa1-Aa2-Aa3, A1-A2-A3, Baa1-Baa2-Baa3, Ba1-Ba2-Ba3, B1-B2-B3, Caa.
owners.

When a publicly traded company wants to get financing it has three options: (i) apply for a bank loan (ii) issue and sell a bond (iii) issue and sell new stock. Once issued and sold to investors, bonds become fairly similar to shares in the sense that they can be sold and bought and that their price will fluctuate in the course of time. There are however three major differences (i) Year after year, the bond owner is assured to get a fixed interest rate, the so-called coupon rate. This is why bonds are called fixed income securities. (ii) At a predetermined date (the so-called maturity date) the bond owner will be reimbursed the face value of the bond. (iii) When the company fills for bankruptcy, usually holders of common stocks lose everything, while bond holders may be able to get at least part of their money back. In short, bonds provide predetermined, regular and secure flows of income a factor which probably explains that bond prices are much less volatile than stock prices. When a bond is close to its maturity its volatility almost drops to zero as the actual price of the bonds tends toward its face value.

The factor considered as the major determinant of bond prices is the interest rate. However, as we have seen in this paper, bond prices are also affected by many other factors and in particular by the situation of the stock market.

Interest rates which so to say represent the price of money, are crucial (albeit intricate) economic variables which like any other prices are ultimately determined by supply and demand. This observation is of little practical interest however for both the supply and the demand are in fact largely unknown (and probably are not even well defined). At the short-term end of the spectrum one important factor is the policy of the central bank. For instance in the United States, the Federal Open Market Committee meets eight times a year in order to set the level of the target for the federal funds rate, a rate which is used for overnight loans to financial institutions. Since in this paper we mostly used the benchmark of the 10-year Treasury bonds it is natural to wonder how this rate is related to the fed funds rate. Fig. 8 provides a comparison. Although there is a close relationship at the overall level of yearly rates, on shorter time scales it is not obvious how long term rates derive from short-term rates. Fig. 8 also emphasizes that the decision of the FOMC follow the changes in short-term yields brought about by the market rather than determining them, a feature often overlooked in financial commentaries.

There is no rigid separation between bonds and stocks. On the one hand, preferred stocks are similar to bonds in the sense that they carry no right to vote and in the event of a default their standing is closer to that of bonds; on the other hand, convertible bonds can be transformed into stocks under pre-defined conditions. Convertible bonds are in fact very similar to common stocks in the event of a default. They are usually issued by companies who would be unable to sell normal bonds; the convertibility provides a kind of bonus which may attract investors especially during stock market rallies. In May 2003 convertible bond issues represented $14 billion, an amount which is of the same order of magnitude as monthly buybacks. That the linkage between stocks and bonds is much stronger than for instance the one between stocks and real estate is shown by the fact that one cannot buy a property which would be convertible into stocks (of course there are real estate investment stocks, the so-called REIT, but that is purely a stock market affair).
Fig. 8: Short-term and long-term interest rates in the United States. The fed funds rate is a short-term rate that is set periodically during the meetings of the Federal Open Market Committee. It can be seen that these decisions in fact follow the changes in the yield of 3-month Treasury bills. Source: [http://www.dallasfed.org](http://www.dallasfed.org); [http://economagic.com](http://economagic.com).

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