The Leverage Effect without Leverage: An Experimental Study

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The Leverage Effect without Leverage: An Experimental Study*

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Abstract

Experimental stock markets are used to add some more evidence that Black's (1976) leverage effect in financial markets does not necessarily stem from the financial leverage of the firm. We surprisingly find a large number of markets in which the leverage effect is observed although the underlying asset does not exhibit a financial leverage at all.

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1 Introduction

Financial time series exhibit several so-called "stylized facts" that are present in most markets. Uncorrelated returns, non-constant volatility through time and fat-tailed return distributions are probably the most prominent, listed, for example, in Cont (2004) and Granger (2005). In addition, there are several asymmetry properties, for example, the skewness of the return distribution and the asymmetric impact of good and bad news to future volatility. With regards to the latter property, the so-called leverage effect, Black (1976) and Christie (1982) found that volatility seems to rise when stocks prices go down and that volatility decreases when stock prices go up. One economic rational behind this stylized fact links the stock's volatility to the firm's capital structure and goes back to Modigliani and Miller’s (1958) classic work. Briefly, for a firm issuing stocks and bonds, its debt to equity ratio changes when, ceteris paribus, the stock price moves. Its leverage changes because the claims of the debt holders are limited so that (almost) all the variation in total firm value is transmitted to equity. Thus, when the stock price increases the value of equity increases more than the value of debt and thus its debt to equity ratio decreases and the firm is less risky, which results in an drop in volatility. The same logic applies to falling stock prices which should lead to an increase in future volatility.

However, there is also evidence that the leverage effect observed in financial time series is not fully explained by the firm's leverage. Figlewski and Wang (2000) find a strong leverage effect for falling stock prices but for positive returns they found a very weak or even nonexistent leverage effect. They argue further that the firm's leverage is a level rather than a change. When the stock price changes and so its financial leverage, volatility should change permanently, too. However, volatility changes stemming from stock returns are not permanently but die out quickly. That is why they claim it would be more appropriate to call the leverage effect a "down market effect". Aydemir, Gallmeyer and Hollified (2005) quantify the leverage effect by using an equilibrium asset pricing model and find that financial leverage is economically not significant at market level and at firm level it just partially explains variations in volatility.

In this paper we will provide clear evidence that indeed the leverage effect is not fully explained by the capital structure of the firm. We do so by using experimental stock markets with no financial leverage in the underlying asset. While in real stock markets changes in volatility could result from many unobservable characteristics (for example, changes in expectation and changes in market liquidity) in experimental stock markets one has more control on the exogenous determinants. Experiments are by now a well-established method in finance, as, for example, the award of the Nobel price in economics to Vernon Smith has documented. In particular in an experiment one can control the degree of leverage while in real settings the leverage is subject to mistakes in accounting for example.

As is common in laboratory stock markets our experiment is such that eight to 24 traders interact with each other using an electronic trading system. Trading takes place in from of a double auction and the traded asset is a single stock that pays a dividend at the end of each period. The dividend process is stochastic but its true data generating process is unknown to the traders. In the beginning of the experiment traders start with an initial endowment of some experimental currency and some stocks and are rewarded with real money at the end of the experiment depending on their actual trading performance. To prevent falling market prices towards the end of the experiment, we use
a new design. Instead of being informed about the exact amount of periods to be run, investors were only informed about the likelihood that the experiment would continue after each period.

With this basic set up a stock price change does not affect the capital structure of the firm. So if the stock price decreases there is no increase in the firm’s debt/equity ratio neither does the firm become more highly leveraged. Its uncertainty stays exactly the same so we expect no leverage effect based on the firm’s capital structure. However, we find a strong and significant leverage effect in all our markets.

The remainder of the paper is organized as follows. Section 2 describes the basic design of the experimental markets and the experiment setup. In Section 3 we show the results concerning the leverage effect for the generated time series and Section 4 concludes. The Appendix contains an English translation of the instructions.

2 The Design of the Experiment

In the beginning of the experiment each participant received 10,000 Gulden (an imaginary currency) and five shares of a single risky asset as an initial endowment. The subjects were instructed to act as participants in the real stock markets and to use their initial endowment as well as their potential gains to participate in the one-asset stock market. The subjects were free to buy or sell shares, and could transfer gains to a special account which served as the final disbursement at the end of the experiment. The trading orders, which were entered into a computer terminal, were carried out in real time, and credited and debited directly to the individuals’ trading accounts.

The experiment was constructed such that the traded shares yielded a return paid out entirely as a dividend at the end of each period. The dividends were generated by an iid process with more probability on raising dividends. Both the iid characteristic of the dividend process as well as the probabilities of an increase or decrease were unknown to the subjects. However, the possible realizations of the randomly chosen dividends were common knowledge. In addition to the dividend information the subjects had a chart on the trading screen which showed the development of the dividends and mean traded prices for all past periods.

The subjects were students of the University of Zurich and ETH Zurich and were recruited from the database of interested students maintained by the Institute for Empirical Research in Economics (IEW).1 Participants were invited for a two to three hour interactive decision-making experiment in which they could earn real money. To allow reserves for no-shows 26 subjects were invited for each session although just 24 subjects were needed per session. In the event more than 24 participants showed up volunteers were invited to leave the experiment and were offered a show-up fee of SFR 10. At the beginning of each session the subjects were reminded on the importance of absolute silence and individual decision-making during the entire experiment. We ensured that subjects had enough time to study the instructions at their own pace and to answer the questions at the end of the instructions. These questions served solely the purpose of making sure that everybody understood the procedure and the rules of the experiment. After all the subjects had read the instructions and answered the questions, the experimenter read a summary of the experiment. Several possible random dividend paths were

\footnote{The database is created and increased annually by recruiting students in “freshman classrooms” as well as via e-mails.}
simulated for 5 minutes before the experiment started in order to give the participants an idea of the random characteristics.

Each experiment had the following two stages. First investors had to decide how much money they wanted to save for "consumption" and second they had to decide how many assets the wanted to buy or sell. Concerning this consumption decision the investor was asked to decide how much money he or she wanted to transfer to the disbursement account, and how much to keep available for trading shares. It is important to mention that the final disbursement was such that the money transferred to it could not be used for trading shares in the future. In other words the final disbursement account was a "one way account": the money remained in this account until the end of the session and constituted the sole payoff to the investor.

Trading took place in the form of a double auction that lasted 120 seconds. Each trader could make offers and close agreements according to their own wishes, although each new bid must have been higher than the previous bid, and each new ask must have been lower than the previous ask. Throughout the whole experiment short selling was not allowed.

Individual account statements were shown at the end of each period showing the amount of Gulden in the trading account, the amount of Gulden in the final disbursement account, and the amount of shares belonging to the investor.

The experiment was run in 2 sessions each with 24 subjects. In one of the sessions the 24 participants were divided into three groups of eight participants and in the other session all 24 participants acted in one market, so we obtained 4 independent time series. Furthermore, when constructing the experiment, we had to choose values for the termination probability of the sessions and the volatility of the dividend process. As already mentioned the experiment ended at random. With the termination probability of .03 for each period we obtained time series with 85 periods for the first session and with 61 periods for the second session. The dividend process we applied started with a dividend \( d_t = 0 \) of 100 Gulden. It was constructed such that in the periods \( t = 1, 2, \ldots, T \), the dividend \( d_t \) increased by five Gulden with probability .6 and decreased by five Gulden with probability .4, i.e. \( d_t \) followed a discrete Bernoulli process with drift that results from the higher probability of rising dividends.

3 Data and Empirical Results

In order to give a general overview of the data of the experiment Figures 1 to 4 illustrate the time series of the dividend process and the traded stock prices. For illustrative purpose the figures also contain the plots of the log returns and the liquidity for all markets. Turning to the log–returns, we plotted them in order to spot some high volatility periods in the series, e.g. volatility clusters can be better seen when plotting the returns. As additional information about the data we plotted the liquidity of the market. We observe that it is quite stable after some "adjustment" periods at the beginning, which takes about 5-10 periods. So we are free of any misinterpretation because of low liquidity in our markets.

Naturally, one can not see the leverage effect in these raw series just by eyeballing. We have to calculate it for each market. To do so, we calculate the correlation of lagged returns and a measure of future volatility; see, for example, Cont (2001), who defines the leverage effect of lag \( \tau \) as \( L(\tau) = \text{Corr}(r_{t-\tau}, r_t^2) \), where \( \text{Corr}(a, b) \) is the (linear)
correlation between $a$ and $b$, and $r_t^2$ is used as a measure of volatility at time $t$. The leverage is present when $L$ is significantly negative, so that past returns and future volatility are negatively correlated.

For all four markets we observe a leverage effect at a significance level of 5%. For the four markets the correlations of lag one, $L(1)$, are: -0.26 (0.0158), -0.44 (0.0000), -0.52 (0.0000), and -0.39 (0.0026). The associated p-values are given in parentheses. As you can see correlations for all four markets are negative and they are statistically significant at the 5% level. Three out of four markets exhibit correlations that are even significant at the 1% level, the underlying asset does not exhibit a financial leverage. It is just a financial security with a dividend process given by a random walk with drift, so there is no increase in leverage nor risk when the stock goes down, nor is there a decrease in leverage or risk when the stock price goes up, so it is surprising that we observe such a significant leverage effect in all four markets.

The observation of the leverage effect in these market with an asset that is free of any financial leverage is not even restricted to a particular time series pattern. No matter that some price series go up and others go down in the experiment, the leverage effect we observe is present.

4 Conclusion

We use experimental stock markets to give evidence under a controlled setting that the leverage effect in financial markets does not necessary stem from the financial leverage of the firm. In all four experimental markets we explore, we find a significant leverage effect although the underlying asset does not exhibit a leverage at all. So although the capital structure of the underlying firm never changes, we observe a leverage effect in traded asset prices. It would be interesting to see if the magnitude of the leverage effect changes when we introduce an asset which exhibits different degrees of financial leverage. We will leave this for future research.

![Figure 1: Price series together with the dividend, return and liquidity series of market 1.](image)
Figure 2: Same as Figure 1 but for market 2.

Figure 3: Same as Figure 1 but for market 3.
Figure 4: Same as Figure 1 but for market 4.
Appendix

Experiment Instructions

Overview

You are now participating in an economic experiment. Please read the following instructions carefully. You will find every information you need to take part in this experiment. If you do have further questions feel free to show hands so that we can answer your questions at you place.

Contingent on your decisions in this experiment, you can earn real money by collecting Gulden. The experiment takes place in several periods and in every period you can earn Gulden. The amount of Gulden you will earn depends on your decisions as well as on the decisions of the other participants. It is thus important that you read these instructions carefully. We will exchange your Gulden to Franken\(^2\) at the end of the experiment at a rate of:

100 Gulden to 15 Rappen.

Please refrain form talking for the duration of the experiment. Furthermore, you are only allowed to use the functions of the computer that are designed for the experiment. If you do not observe these rules, we will have to exclude you from the experiment and all payments, and ask you to leave. If you have questions please feel free to ask us.

At the end of these instructions you will find some control questions. Please answer them all and let us know that you are finished.

Basic Structure of the experiment

The experiment deals with consumption decisions and trading in financial markets in which you can invest your money in a single stock or transfer it to a final disbursement account. The stock pays a dividend which amount is determined by chance. Be aware that the experiment ends at random. At the beginning of the experiment, i.e. at the beginning of the first period, you receive an endowment in money and stocks of:

5 stocks and 100000 Gulden.

\(^{2}\)One dollar was about 1.8 Franken at the time the experiment took place. And one Franken is 100 Rappen
All following periods are structured in the same way. You first decide how much money you want to transfer to your final disbursement account and how much money you want to put into stocks. Please note the following two important points. First: The money transferred to the final disbursement account can not be transferred back to the trading account during the remainder of the experiment, so it can not be used for trading stocks again. Second: Only the money on the final disbursement account will be disbursed, that means, if the experiment ends the money in the trading account and the stocks are worthless.

After you chose how much money to transfer to your final disbursement account you can start trading the stock. We will describe how the actual trading takes place further below. Keep in mind that for trading you just have the money on your trading account. For all stocks you bought you receive a dividend. This dividend payment and the money that is left on your trading account can be used to trade in the next period or can be transferred to your final disbursement account.

At the end of each period the computer decides randomly if the experiment ends or continues. The probability of ending is 3%.

Some details

Trading
Trading takes place in form of double auction lasting 120 Seconds. During this time you can make offers and close agreements according to your own wishes. The rules for trading are easy, each new bid must be higher than the previous bid, and each new ask must be lower than the previous ask. The contracts are closed via pressing the button. Gains or losses will be immediately credited or debited to your account.

Shares
All shares are based on one company and every share pays a dividend which is paid out at the end of each period. The dividend payment is 100 Gulden in the first period and after that the dividend payment changes at random in every period. The dividend can rise or fall and the changes are such that the dividend from the previous period is multiplied by 1.20, 1.05, 0.95 or 0.80. However, none of the participants know the exact underlying dividend process. That means, you do not know with what probability the dividend will rise or fall in the next period.

Before we start the experiment, several possible random examples will be shown to you in a test run. Attention! None of the shown dividend paths will be the ”right” one in the actual experiment, they are just examples. During the experiment the computer will determine totally new random dividend paths.

In summary:

- The shares pay a dividend at the end of each period.
- The dividend is 100 Gulden in the first period but changes randomly for all other periods. The dividend can change +20%, +5%, -5% or -20%.
- The dividend payment will be announced at the end of each period.
- The experiment ends at the end of the period with a probability of 3%.
Accounts

Trading account: With the money on this account you can buy shares in each trading period (see below). Dividend payments will be transferred to this account, too.

Final disbursement account: At the beginning of every period you can transfer money to this account but please notice, you can not transfer it back to the trading account. However, just the money on this account will be paid to you as Swiss Francs when the experiment ends.

Experiment duration

The experiment lasts several periods but ends randomly. At the end of every period it will be determined whether the experiment ends or if there is another period. To give you a better feeling about the experiment duration, we will show you several examples with possible durations and dividend evolutions before the experiment starts. Attention! None of the durations and dividend paths will be the actual ones in the experiment. They are really just examples.

Gains

Your gain will be the actual amount on your final disbursement account at the end of the experiment.

Sequence of a period

In every period you have to decide how much money you want to save for "consumption" and how many shares you want to buy or sell.

Now we look at each of the steps in more detail:

- Allocation of money
  You decide how much money you want to transfer from your trading account to your final disbursement account.

- Trading
  In every period you have 2 Minutes to trade. You can see the remaining time and the period on the upper part of the screen. In the middle part you can see the actual number of stocks and the amount of money in your trading account. You can also see the dividend payments for the previous and current period.

  In the lower part you can trade:
  
  a) In the window on the left hand side you can make your offer for sale to the other participants. You enter the price for which you want to sell one single share and then press "Offer for sale". This price will then be shown to the other participants. You can only enter whole numbers that have to be positive. Your selling order has to be lower the current lowest one.

  b) In the next window you can view the selling orders of all other participants. You can buy one share for the depicted price. The best offer is highlighted. If you press "Buy" you will automatically buy from the person with the best offer. The price will be subtracted from your trading account.

  c) All actually traded prices of the current period are listed in the middle window.

  d) In the fourth window you can see the bids of all other participants. You can sell one of your shares for that price. The best offer is highlighted here, too. If you press
"Sell" you will automatically get the best price and the amount will be credited to your trading account.

e) In the window on the right hand side you can make you bids. Enter the price at which you want to buy one more share and press "Bid". This price will be shown to all other participants in the file "Bids". As for selling, you can just enter whole numbers that are positive and your bid must be higher than the current highest bid.

Some trading rules for stocks
You are not allowed to sell shares that you do not own. You are not allowed to sell shares to yourself. You are not allowed to buy shares with borrowed money, e.g. you are not allowed to bid for a share for more money you actually have on your trading account.

The computer will constrain your trading behavior and will automatically enforce these rules. In case you are surprised from a refuse of execution of one of your orders, please check if one of the above rules are violated.

Do you have any questions? If not please turn the page and answer the following control questions.

Control Questions

Please answer all of the following questions. We will not start before we have not checked your answers. False answers to not have any effect on your potential gains (nor do right ones). The questionnaire serves just to make sure that everybody has understood the experiment correctly. The prices and money on the accounts are chosen so that you do not have a hard time to do the math. In case there are any obscurities, please show hands and we will try to solve you problem.

1. Imagine a situation for participant A at the beginning of the trading. She owns 5000 Gulden on her trading account and 8 shares. Which of the following trans- action plans are valid given the following chronology?

   (a) Buying one share at a price of 2500 Gulden and after that buying one more for 3000 Gulden. Then selling one share for 3050 Gulden.

   (b) Selling one share for 2400 Gulden. Later cancellation through buying for her own.

   (c) On the screen are already depicted the following selling orders: 3700, 3600, 3500, 3400 Gulden. You enter your selling order of 3400 Gulden.

2. Another situation for participant A. Before the trading starts A transfers 500 Gulden to her final disbursement account. Until now, she has 4500 Gulden on this account. At the beginning of the trading she has 6500 Gulden on her trading account and 5 shares. She buys one share from participant B for a price of 3100 Gulden and one from participant C for 3300 Gulden. She then sells one for 3500 Gulden. In the end of the period the dividend increases 20% from a level of 110. How do the individual accounts of participant A, B and C look like?

3. Given the dividend is fixed at 200 Gulden for the whole experiment. How much is the sum of all dividends that you expect when you hold one share for the whole experiment and when you know the termination probability is 3%?
a) 10000 Gulden b) 6666 Gulden c) 1000 Gulden

d) Own estimate:

4. What is the average price of the share you expect in the first trading period? (This question can not be answered right or wrong, meaning there is no right answer from the instructions given so far. We are just keen on hearing your opinion.)

Ready? Please show hands. We will come to you!
References


