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# What Is The Link Between Margin Loans And Stock Market Bubbles?

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## A Model to Show the Effectiveness of Margin Regulation

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# Abstract

This paper contributes to three important areas of research: Bubbles, the influence of margin loans on asset prices, and the effectiveness of margin regulation. Margin loans are suspected to cause bubbles through a pyramiding process. Therefore, in 1934 the Federal Reserve Bank was empowered to regulate security credit through an initial margin requirement which defines a minimum equity position on the date of a margin loan financed transaction. However, following a number of empirical studies which denied the effectiveness of margin regulation, active margin policy was given up in 1974. The stock market crash of 1987 revitalized interest in the topic and caused another intense discussion about the need for margin regulation. Lately, the stock market boom in the late 1990s led to calls for the return to an active margin policy.

In this paper we develop a model in which investors and a margin loan offering bank hold different beliefs about the future return of a risky asset and the non-observability of the investors' expectations under certain conditions leads to a risk shifting problem. Three results can be derived: First, it is shown that margin loans can cause bubbles. Second, the level of margin debt as well as the level of the initial margin requirement can have an impact on asset prices. Third, an appropriate initial margin requirement can prevent the development of a bubble.



*JEL classification:* D82, G12, G18, G21

*Key Words:* asset pricing, bubble, information asymmetry, heterogeneous expectations, margin loan, margin regulation.

# 1 Introduction

There has been a long and continuing debate on the existence of bubbles. While some economists believe that the price of a risky asset always reflects its economic fundamentals (efficient markets hypothesis),[1] others argue that asset prices sometimes deviate from their intrinsic value. The term bubble is commonly used to designate a situation in which the price of an asset is above its fundamental value (mostly measured by the discounted return of the asset).[2]

The question whether bubbles exist has first been raised by a number of extreme incidents. Famous manias which are often assumed as first examples for bubbles are the "Tulip Mania" (1634-1637), the "Mississippi Bubble" (1719-1720), and the "South Sea Bubble" (1720).[3] Especially the stock market crashes of October 1929 and October 1987 have led to an intense discussion whether there are bubbles and if so, why they emerge.[4] This discussion has been revitalized by the strong decline in stock prices since April 2000 which is widely believed to be the bursting of a massive bubble.[5]

Besides these extreme incidents, the findings of Shiller (1981), LeRoy and Porter (1981), and Grossman and Shiller (1981) that the volatility in American stock prices is too excessive to be explained just by changes in economic fundamentals were the starting point for an extensive empirical analysis whether stock prices always reflect the fundamental value of the underlying companies.[6] However, the methodology of these first tests was challenged by many authors.[7] Responding to this criticism, new tests were developed that mostly still find a non-fundamental component.[8]

Price paths that deviate from underlying fundamentals have also been observed in experimental settings by Smith et al. (1988), King et al. (1993), Lei et al. (2001), Ackert et al. (2002), and Camerer (2002).

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[1] See e.g. Fama (1970) and Fama (1991).

[2] See Allen et al. (1993) for a discussion of the definition of fundamental value and bubble.

[3] For a description of these manias see Posthumus (1929), Carswell (1960), Garber (1989), and Neal (1990). Garber (1990), however, denies that these incidents have been bubbles. For a good survey of financial manias in general see Kindleberger (2001).

[4] The question whether there have been bubbles in the stock market in 1929 or 1987 is still not answered. While e.g. White (1990) and Rappoport and White (1993) favor the view that there was a bubble in 1929 and Conrad and Stahl (2002) find indicators for speculative bubbles in both decades, Santoni (1987) provides evidence contrary to this theory.

[5] See for example Dreman (2002), Fisher and Statman (2002), Evans (2003), Ljungqvist and Wilhelm (2003), or Ofek and Richardson (2003).

[6] DeLong and Becht (1992) and Bruns (1994) find excess volatility in the German stock market as well as Bulkley and Tonks (1989) in the UK stock market, too.

[7] See for example Flavin (1983), Hamilton and Whiteman (1985), Hamilton (1986), Kleidon (1986a), Kleidon (1986b), and Marsh and Merton (1986).

[8] See for example Mankiw et al. (1985), Campbell and Shiller (1987), West (1987), Campbell and Shiller (1988a), Campbell and Shiller (1988b), West (1988a), and Anderson et al. (2003). For a survey of tests on excess volatility see West (1988b), Hodrick (1990), and Gilles and LeRoy (1991).

In order to theoretically explain the emergence of a bubble, an enormous number of models has been developed.[9] A factor which is often associated with extreme incidents that are assumed to have been (the emergence and bursting of) bubbles is margin lending. Galbraith (1954) for example emphasizes the great impact of margin loans on the extreme rising of stock prices in the late 1920s and the stock market crash of October 1929. The analyses of the U.S. Securities and Exchange Commission (1988) and of Brady (1988) find an important role of low margin requirements (in the futures markets) in the 1987 stock market crash. Shiller (2000) claims in a Wall Street Journal article that the Federal Reserve should in view of the combination of a dramatically booming stock market and sharply soaring margin debt increase the initial margin requirement, shortly before the three years lasting decrease of stock prices, which is widely believed to be the bursting of the so-called "internet bubble", starts.

A margin loan is a security credit, hence a loan that is secured by the pledge of stocks or bonds as collateral, for the acquisition of securities.[10] Under the impression of the 1929 stock market crash the Federal Reserve Board was given the authority to regulate margin loans with the Securities and Exchange Act (Regulation T which was later amended by Regulation U and X) of 1934 in order to reduce excessive credit used in stock speculation, to protect investors from going too deep in debt to invest in stocks, and to reduce stock market price volatility.[11] Especially the third objective, the prevention of excessive price volatility, has become the major justification for margin regulation over the following years. To achieve this goal, the Board of Governors of the Federal Reserve System established an initial margin requirement for margin loans.[12] This requirement sets a minimum equity position on the date of a credit-financed security transaction.[13] Proponents of an active margin policy argue that by changing the initial margin requirement the level and volatility of stock prices can be affected substantially.

Between 1934 and 1974 the initial margin requirement was changed 22 times. The required ratio has been as high as 100% and as low as 40%. Since 1974 it has been fixed at 50%, because of a number of empirical studies which have raised doubts on the supposed connection between the level of the initial margin requirement and stock prices.[14] Prior to 1987 there was a consensus that the initial margin requirement is not an ingenious tool to accomplish the goals behind the Federal Reserve Board's authorization to regulate margin loans in 1934.[15] It was the 1987 stock market crash that was the starting point

[9] See for example Blanchard (1979), Blanchard and Watson (1982), Flood and Garber (1982), Allen and Gorton (1993), Hong and Stein (1999), Allen and Gale (2000), Scheinkman and Xiong (2003), or Allen et al. (2003). For a survey of bubble models see Camerer (1989), Flood and Hodrick (1990), Santoni and Dwyer (1990), or Evans (2003).

[10] See e.g. Bogen and Krooss (1960) or Fortune (2000).

[11] See Climan (1978) for an extensive discussion of these objectives.

[12] See Sofianos (1988) or Fortune (2000) for an overview of the regulation of margin loans.

[13] Additionally, all registered exchanges have established a maintenance margin requirement for their member firms' customers. This requirement applies to open positions and thus sets a minimum equity position for existing holdings of securities, see e.g. Fortune (2000).

[14] See e.g. Cohen (1966), Moore (1966), Largay and West (1973), or Officer (1973).

[15] See for example Grube et al. (1979) or Federal Reserve Board (1984). Luckett (1982), however, found evidence for the effectiveness of the Federal Reserve's margin regulation.

for another debate on margin policy in which especially Hardouvelis argued for the return to an active margin policy to control stock market price volatility.[16] However, following the original Hardouvelis (1988) study, a number of empirical studies that reexamined his findings found no support for an inverse level of initial margin requirement-stock market price volatility relationship.[17]

Thus, from an empirical point of view it seems that the level of margin requirements has no significant impact on stock price volatility. Nevertheless, the idea that margin loans can cause or at least contribute to the emergence of a bubble remains popular. Margin loans are commonly believed to raise stock prices above their fundamental value through a pyramiding process. The initial credit-financed purchase of a security is assumed to lead to an increase in its price. As the price rises, the wealth of the owner also rises, allowing him to purchase still more of the security and hence drive its price still higher.[18]

The analytical literature on the effects of margin loans and an initial margin requirement on stock prices is far from extensive. Heal (1984) developed a model to analyze the effects of changes in the initial margin requirement using two different frameworks and concluded that the stock market's response to margin changes is unpredictable. Goldberg (1985) introduced margin trading into the model of Miller (1977b) to show that an increase in the initial margin requirement has the opposite effect to that originally intended and results in greater stock price volatility. Kupiec and Sharpe (1991) constructed a simple overlapping generations model to characterize the effects of the introduction of an initial margin requirement on security prices. Assuming investor heterogeneity concerning their preferences for risk-bearing, they concluded that imposing an initial margin requirement may either increase or decrease stock price volatility.

This paper seeks to contribute to the analytical literature on margin loans and their impact on asset prices. We develop a model in which there is a heterogeneity concerning the expectations about the future outcome of a risky asset and an information asymmetry in the form that the bank is not able to observe the investors' expectations leads to a risk shifting problem.

A vast number of models has been developed in which there are heterogeneous expectations about the future payoff of a risky asset among investors.[19] The impact of heterogeneous beliefs among investors on asset prices has particularly been shown by models

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[16] See Hardouvelis (1988), Hardouvelis (1989), Hardouvelis and Peristiani (1989), Hardouvelis (1990), Hardouvelis and Peristiani (1992), and Hardouvelis and Theodossiou (2002).

[17] See Ferris and Chance (1988), Kupiec (1989), Salinger (1989), Schwert (1989), and Hsieh and Miller (1990). Kofman and Moser (2001), however, at least found a positive relationship between the level of the initial margin requirement and the frequency of price reversals.

[18] When the pyramiding of the stock price ends, the start of a process of depyramiding is assumed where an initial decline in the stock price leads to forced sales of the stock to meet maintenance margin calls. These liquidating sales cause further reductions in the price of the stock and hence more maintenance margin calls and forced sales. For an extensive description of the pyramiding/depyramiding process see Bogen and Krooss (1960), Note (1966), Ulrey (1975), or Garbade (1982).

[19] See Odean (1998), Section I, for an excellent review or Kogan et al. (2003).

that analyze the phenomenons of noise traders[20], under- and overreaction[21], and overconfidence[22]. Furthermore, there is a considerable amount of literature that looks at the influence of short sales restrictions on stock prices when investors hold heterogeneous expectations.[23] An innovation of our model is that we assume a heterogeneity of beliefs about future payoffs not among investors but between lenders and borrowers.

The impact of a risk shifting problem arising from an information asymmetry between lenders and borrowers on stock prices has extensively been investigated by Allen and Gale.[24] But while in their model the bank offers a simple debt contract, in our model the investors are offered a margin loan.

The purpose of this paper is threefold:

- Our first aim is to show how margin loans can contribute to the emergence of a bubble.
- Our second aim is to theoretically establish a link between the level of the initial margin requirement as well as the level of margin debt outstanding and the level of stock prices, and to provide some new insights into the results of empirical studies on these relationships.
- Finally, our third aim is to show that, in spite of the conclusion of most of the empirical studies that changes of the initial margin requirement have no influence on stock price volatility, margin regulation is reasonable as it provides an effective tool to prevent stock market price bubbles caused by margin loans.

After defining the fundamental value of a risky asset in Section 2, we examine under which circumstances the introduction of a margin loan can induce investors to bid up the asset's price above its intrinsic value in Section 3. In Section 4, we employ our model to reconsider the results of some of the empirical studies on margin regulation. The efficacy of margin regulation to prevent bubbles caused by margin loans is eventually shown in Section 5.

[20] See e.g. DeLong et al. (1990) or Palomino (1996).
[21] See e.g. Hong and Stein (1999).
[22] See e.g. Daniel et al. (1998) or Odean (1998).
[23] See e.g. Miller (1977a), Jarrow (1981), Duffie et al. (2002), Jones and Lamont (2002), or Scheinkman and Xiong (2003).
[24] See Allen and Gale (2000, 2001, 2003).

## 2 The fundamental value of a risky asset

We define a bubble as a positive deviation of an asset's price from its fundamental value. Hence, to identify a bubble component in the price of an asset we first need to know its fundamental value as the benchmark price. As a first step, we therefore determine the intrinsic value of a risky asset in our model.

Standard asset pricing models assume that people invest with their own money. Therefore, the price an investor is maximally willing to pay when he invests his own wealth is defined as the benchmark price in our analysis.

The basic assumptions of our model are:[25]

- There are two dates $t_0$ and $t_1$.
- There are two sorts of assets, a safe one and a risky one:[26]
  - For each 1 $ invested in the safe asset in $t_0$ the return is $r_s > 1$ in $t_1$.
  - The return of the risky asset in $t_1$ is uncertain and binomially distributed.
- All investors are risk neutral and each has an initial wealth of 1 $ which he directly invests either in the risky or the safe asset. They expect a return of $r_u > 0$ with probability $w_u \in (0, 1)$ and a return of $r_d \in [0, r_u)$ with probability $w_d = 1 - w_u$ in $t_1$. Hence, the investors expect the return of the risky asset to be

$$E(r_r) = w_u \cdot r_u + w_d \cdot r_d. \tag{1}$$

  in $t_1$.

Since all investors are risk neutral the equilibrium price of the risky asset $P^f$ can easily be calculated, because the marginal returns from investing 1 $ will be equated for the two assets in the way that

$$\frac{1}{P^f} \cdot E(r_r) = r_s. \tag{2}$$

Therefore, the price of the risky asset in $t_0$ must be

[25] The following basic model to determine the fundamental value of a risky asset is inspired by Allen and Gale (2001, 2003). They design a simple example based on the model in Allen and Gale (2000) to illustrate how an expansion in credit can cause a bubble.

[26] The safe asset can be interpreted as debt issued by the public sector of a large country with a negligible default risk while the risky asset can be thought of as stocks.

$$P^f = \frac{E(r_r)}{r_s}. \tag{3}$$

This price $P^f$ we consider as the fundamental value of the risky asset. It is the present value of the return the investors expect where the discount rate is the investors' opportunity cost. Any price above this fundamental value, contains a bubble component.

# 3 The introduction of a margin loan into the model

Suppose all investors have invested their initial 1 \$ in the risky asset at the price $P^f$ in $t_0$. Then, each one owns $1/P^f$ units of the risky asset and expects a return of $r_u/P^f$ with a probability of $w_u$ and $r_d/P^f$ with a probability of $w_d$ in $t_1$.

Now, still in $t_0$, a risk neutral bank[27] that offers a margin loan, but also has access to the safe as well as to the risky asset is introduced into the model. Each investor is offered to borrow up to $r \in (0, 1]$, where $r$ is the loan-to-value ratio[28] of the security credit. He can invest the money in either the risky or the safe asset. If an investor borrows $q \in (0, r]$ in $t_0$, the bank demands a repayment of $q \cdot i$ in $t_1$ with $i \geq r_s$.[29] If he is unable to repay $q \cdot i$ in $t_1$ from the return on the additional investment, the bank can use the return on his initial units of the risky asset to fulfill its claim. So, the investor's initial portfolio, which he bought from his own wealth, functions as a security.

Moreover, we assume that there are heterogeneous beliefs about the expected return of the risky asset in $t_1$ in the form that the bank expects a return of $E^B(r_r) \neq E(r_r)$, and that there is an information asymmetry between the bank and the investors in the form that the bank is not able to observe $E(r_r)$.

## 3.1 Calculation of the new maximum price the investors are willing to pay for the risky asset

We will now calculate the new price $P^c$ an investor is maximally willing to pay for the risky asset if he invests not his own but the borrowed money from the margin loan.[30]

[27] Presuming the lender to be risk neutral is an usual assumption when problems arising from an information asymmetry between lenders and borrowers are modeled, see e.g. Stiglitz and Weiss (1981).

[28] This means that the investor gets up to $r$ \$ of security credit for each 1 \$ of value of his initial portfolio, e.g. if an investor owns a portfolio with a value of 50.000 \$ and $r$ is 0.1, he gets at most a margin loan of 5.000 \$.

[29] The bank will minimally demand a repayment of $q \cdot r_s$, because alternatively it is able to invest directly in the safe asset instead of lending to the investors.

[30] This price $P^c$ can be interpreted as the investors' reservation price of the risky asset.

We will show that it is possible that $P^c > P^f$ for certain cases and hence $P^c$ contains a (positive) bubble component.

The investor's expected additional net return from borrowing $q$ and investing it in the safe asset $ANR_s^E$ is

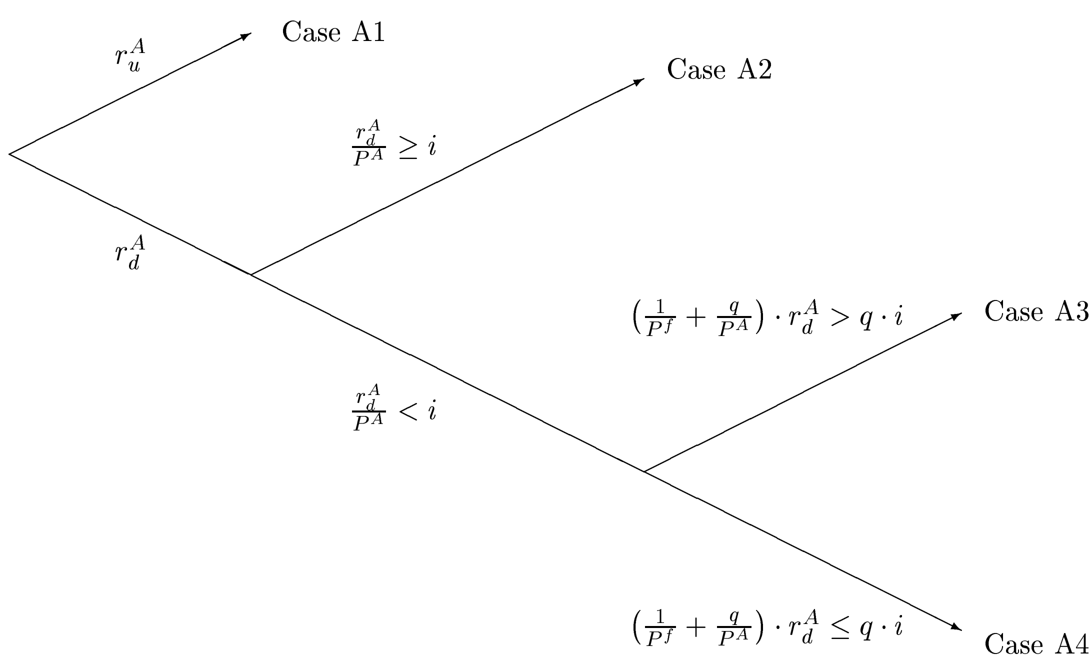
$$ANR_s^E = q \cdot (r_s - i) \leq 0$$

as $i \geq r_s$. Therefore, the investor will not make use of the margin loan to invest in the safe asset.

The additional net return that the investor expects from the margin loan if he invests the borrowed $q$ in the risky asset at the price $P^c$, $ANR_r^E$, can be calculated by comparing the investor's expected total return with and without the security credit.

As a first step to determine $ANR_r^E$, we distinguish between four different possible cases for the investor's *actual* additional net return in $t_1$, $ANR_r^A$, when he makes use of the bank's offer and buys $q/P^A$ units of the risky asset at the price $P^A > 0$ in $t_0$ (see Figure 1).

Figure 1: Possible cases for $ANR_r^A$



Case A1:
In case A1 the return of the risky asset in $t_1$ is $r_u^A$ with $r_u^A/P^A > i$.[31] As $r_u^A/P^A > i$, the investor is able to completely repay $q \cdot i$ from the return on the borrowed $q$ and gains an additional return from the margin loan as well. Thus, his actual total return in $t_1$ is

$$TR^A = \frac{r_u^A}{P^f} + q \cdot \left( \frac{r_u^A}{P^A} - i \right) > \frac{r_u^A}{P^f}.$$

The actual additional net return from investing the margin loan in the risky asset $ANR_r^A$ is

$$ANR_r^A = q \cdot \left( \frac{r_u^A}{P^A} - i \right) > 0.$$

In cases A2-A4 the actual return of the risky asset in $t_1$ is $r_d^A \in [0, r_u^A)$.

Case A2:
In case A2 the return of the risky asset is $r_d^A < r_u^A$, but as $r_d^A/P^A \geq i$, it is still high enough that the return on the initial portfolio must not be touched for the repayment of $q \cdot i$. Therefore, the margin loan again generates an additional net return that is not negative. The investor's actual total return $TR^A$ is

$$TR^A = \frac{r_d^A}{P^f} + q \cdot \left( \frac{r_d^A}{P^A} - i \right) \geq \frac{r_d^A}{P^f}.$$

The actual additional net return from the margin loan in this case is

$$ANR_r^A = q \cdot \left( \frac{r_d^A}{P^A} - i \right) \geq 0.$$

In cases A3 and A4 the investor is not able to repay $q \cdot i$ from the return of the credit financed purchase of the risky asset alone and hence the bank gets (a part of) the return of his initial portfolio. Therefore, the actual additional net return of the margin loan is negative.

Case A3:
If $r_d^A/P^A < i$, the investor cannot completely repay the credit from the return on the borrowed $q$ alone. So, the bank gets a part of the return of his initial $1/P^f$ units of the

[31] Assuming $r_u^A/P^A > i$ excludes some more possible cases from our analysis. In footnote 34 on page 10 it will become clear that these cases are not relevant for the determination of $ANR_r^E$.

risky asset. As $\left(1/P^f + q/P^A\right) \cdot r_d^A > q \cdot i$, in case A3 the total return of the investor is still positive as the bank gets only a part of the return of his initial portfolio. Therefore, his actual total return is

$$TR^A = \frac{r_d^A}{P^f} + q \cdot \left(\frac{r_d^A}{P^A} - i\right) > 0.$$

As in Case A2, the actual additional net return from from borrowing $q$ and investing it in the risky asset is

$$ANR_r^A = q \cdot \left(\frac{r_d^A}{P^A} - i\right) < 0,$$

but this time this term is negative.

Case A4:
If $\left(1/P^f + q/P^A\right) \cdot r_d^A \leq q \cdot i$, the bank gets all payments of the investor's $1/P^f + q/P^A$ units of the risky asset. Hence,

$$TR^A = 0.$$

The actual additional net return from the security credit in this case is

$$ANR_r^A = -\frac{r_d^A}{P^f} < 0.$$

So, while in case A3 the bank only gets a part of the return of the investor's initial portfolio, in case A4 the investor's return in $t_1$ is zero in the low payoff state.

It becomes obvious that although the margin loan is secured, there is a default risk for $\left(1/P^f + q/P^A\right) \cdot r_d^A < q \cdot i$ as the investor's liability is limited to the return of his initial portfolio.

The possible actual additional net returns from investing the margin loan in the risky asset are summed up in Table 1.

The condition $\left(1/P^f + q/P^A\right) \cdot r_d^A > q \cdot i$ can be transformed to

Table 1: Actual additional net return in $t_1$ from a margin loan financed investment in the risky asset $ANR_r^A$

| Case | Actual return of the risky asset in $t_1$ | Condition | $ANR_r^A$ | Sign |
|---|---|---|---|---|
| A1 | $r_u^A$ | | $q \cdot \left(\frac{r_u^A}{P^A} - i\right)$ | $> 0$ |
| A2 | $r_d^A$ | $\frac{r_d^A}{P^A} \geq i$ | $q \cdot \left(\frac{r_d^A}{P^A} - i\right)$ | $\geq 0$ |
| A3 | $r_d^A$ | $\frac{r_d^A}{P^A} < i$ and $\left(\frac{1}{P^f} + \frac{q}{P^A}\right) \cdot r_d^A > q \cdot i$ | $q \cdot \left(\frac{r_d^A}{P^A} - i\right)$ | $< 0$ |
| A4 | $r_d^A$ | $\left(\frac{1}{P^f} + \frac{q}{P^A}\right) \cdot r_d^A \leq q \cdot i$ | $-\frac{r_d^A}{P^f}$ | $< 0$ |

$$
\begin{aligned}
\left(\frac{1}{P^f} + \frac{q}{P^A}\right) \cdot r_d^A &> q \cdot i \\
\Leftrightarrow \frac{q \cdot r_d^A}{P^A} - q \cdot i &> -\frac{r_d^A}{P^f} \\
\Leftrightarrow q \cdot \left(\frac{r_d^A}{P^A} - i\right) &> -\frac{r_d^A}{P^f}.
\end{aligned}
$$

Table 1 reveals that for the determination of the additional net return that the investor *expects* from making use of the margin loan and investing the borrowed money in the risky asset, $ANR_r^E$, it has to be distinguished between two price intervals,[32] I1 and I2.[33]

Interval I1:
For prices $P^c$ for which $q \cdot (r_d/P^c - i) > -r_d/P^f$ holds, the investor's *expected* additional net return is[34]

[32] However, for the case that $r_d = 0$ there is only interval I2.
[33] While up to this point we have analyzed $ANR_r^A(r_u^A, r_d^A)$, we will now look at $ANR_r^E(P^c)$.
[34] We assume that $r_u/P^c > i \Leftrightarrow P^c < r_u/i$ as if the investor pays more than $q \cdot r_u/i$ for the risky asset, his expected additional net return from the margin loan is negative in both payoff states and hence a usage of the security credit would make no sense.

$$ANR_r^E = \underbrace{w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right)}_{>0} + \underbrace{w_d \cdot q \cdot \left(\frac{r_d}{P^c} - i\right)}_{>-w_d \cdot \frac{r_d}{P^f}}. \tag{4}$$

Interval I1 contains all $P^c$ for which the investor expects to not have to use the whole return of his $1/P^f + q/P^A$ units of the risky asset to repay $q \cdot i$ in $t_1$ and hence to gain a positive total return.

While the first summand of (4) is always positive, the second part of the sum is nonnegative for prices up to $r_d/i$ and negative for $P^c$ that are above $r_d/i$. This is due to the fact that for $P^c \leq r_d/i$ the investor expects to be able to completely repay $q \cdot i$ from the return of the security loan financed investment even in the low payoff state of the risky asset. For $P^c > r_d/i$ he expects to have to use (a part) of the return of his initial portfolio, $r_d/P^f$, for the repayment of the margin loan in the low payoff state so that his expected total return is lowered by the margin loan.

$r_d/P^f$ is the maximum amount the investor expects to be able to use to fulfill the bank's remaining claim for the case that the return of the margin loan financed investment in the risky asset is not sufficient to repay $q \cdot i$ and hence the maximum possible loss he expects from the margin loan.

<u>Interval I2:</u>
For $q \cdot (r_d/P^c - i) \leq -r_d/P^f$, the expected additional net return is

$$ANR_r^E = \underbrace{w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right)}_{>0} + \underbrace{w_d \cdot \left(-\frac{r_d}{P^f}\right)}_{\leq 0}. \tag{5}$$

Interval I2 contains all prices for which the investor expects to have to use all payments of his $1/P^f + q/P^c$ units of the risky asset to fulfill the bank's claim in the low payoff state.

While again the first addend of (5) is always positive, the second part of the sum is negative for $r_d > 0$ and zero for $r_d = 0$. This is due to the fact that for prices $P^c$ of the interval I2 the investor expects to always lose the whole return of his initial portfolio in the low payoff state of the risky asset no matter how high $P^c$ is. If he expects the return of his initial portfolio to be zero in the low payoff state anyway (hence $r_d = 0$), the margin loan can never lower his expected total return.

To sum it up, the investor's expected additional net return from borrowing $q$ and investing it in the risky asset is

$$ANR_r^E = w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right) + w_d \cdot \begin{cases} q \cdot \left(\frac{r_d}{P^c} - i\right) & \text{for} \quad q \cdot \left(\frac{r_d}{P^c} - i\right) > -\frac{r_d}{P^f} \\ -\frac{r_d}{P^f} & \text{for} \quad q \cdot \left(\frac{r_d}{P^c} - i\right) \leq -\frac{r_d}{P^f}. \end{cases} \tag{6}$$

For both price intervals the first derivative of $ANR_r^E$ with regard to $P^c$ is negative with

$$\begin{aligned} \frac{\partial ANR_r^E}{\partial P^c} &= -\frac{w_u \cdot q \cdot r_u}{P^{c2}} - \frac{w_d \cdot q \cdot r_d}{P^{c2}} \\ \Leftrightarrow \frac{\partial ANR_r^E}{\partial P^c} &= -\frac{q \cdot E(r_r)}{P^{c2}} \end{aligned} \tag{7}$$

for I1 and

$$\frac{\partial ANR_r^E}{\partial P^c} = -\frac{w_u \cdot q \cdot r_u}{P^{c2}} \tag{8}$$

for I2.

As it can be seen from (7) and (8) $|\partial ANR_r^E / \partial P^c|$ is higher for I1 than for I2 because the investor expects a total return of zero in the low payoff state for prices of the interval I2 anyway. Hence, he is only interested in the upper part of the distribution of the payoffs of the risky asset as no matter how much he pays for the risky asset, he expects to lose (only) $r_d/P^f$ in the low payoff state. So, the investor's expected additional net return from the margin loan is only underproportionally lowered the more he pays for the risky asset. A look at the repayment the investor expects the bank to get in $t_1$, $E(B)$, reveals that there is a risk shifting problem for prices of the interval I2. While for I1 $E(B)$ is $q \cdot i$, for I2 $E(B)$ is

$$E(B) = \left(\frac{1}{P^f} + \frac{q}{P^c}\right) \cdot r_d. \tag{9}$$

As

$$\frac{\partial E(B)}{\partial P^c} = -\frac{w_d \cdot q \cdot r_d}{P^{c2}} \tag{10}$$

it becomes obvious that for $P^c$ of the price interval I2 the investor shifts a part of the risk to the bank.[35]

The possible cases for the expected additional net return from the margin loan $ANR^E$ are summed up in Table 2.

Table 2: Expected additional net return from the margin loan

| Asset | Interval | Condition | $ANR^E$ |
|---|---|---|---|
| Safe | | | $q \cdot (r_s - i)$ |
| Risky | I1 | $q \cdot \left(\frac{r_d}{P^c} - i\right) > -\frac{r_d}{P^f}$ | $w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right)$ + $w_d \cdot q \cdot \left(\frac{r_d}{P^c} - i\right)$ |
| Risky | I2 | $q \cdot \left(\frac{r_d}{P^c} - i\right) \leq -\frac{r_d}{P^f}$ | $w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right)$ - $w_d \cdot \frac{r_d}{P^f}$ |

As for the calculation of the fundamental value of the risky asset in Section 2, the maximum price the investor is willing to pay for the risky asset when a margin loan is available can be calculated by equating the expected additional net returns from investing the margin loan in the risky asset and from the opportunity.

However, in contrast to Section 2, this time the opportunity is not to make use of the margin loan and hence to receive an additional net return of zero because the expected additional net return from borrowing $q$ and investing it in the *safe* asset, $ANR_s^E$, is $\leq 0$.

Therefore, the maximum $P^c$ the investor is willing to pay can be derived by

$$
\begin{aligned}
0 &\stackrel{!}{=} ANR_r^E \\
\Leftrightarrow 0 &\stackrel{!}{=} w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right) + w_d \cdot \begin{cases} q \cdot \left(\frac{r_d}{P^c} - i\right) & for \quad q \cdot \left(\frac{r_d}{P^c} - i\right) > -\frac{r_d}{P^f} \\ -\frac{r_d}{P^f} & for \quad q \cdot \left(\frac{r_d}{P^c} - i\right) \leq -\frac{r_d}{P^f} \end{cases}
\end{aligned}
$$

[35] The only chance for the bank to prevent this risk shifting problem is *not* to offer the margin loan at all as it cannot observe the investors' expectations.

### 3.1.1 The maximum price the investor is willing to pay for the risky asset when he expects a positive total return even in the low payoff state (Interval I1)

For prices $P^c$ for which $q \cdot (r_d/P^c - i) > -r_d/P^f$ holds, the investor expects a positive total return even in the low payoff state of the risky asset. The maximum price he is willing to pay for the risky asset can be calculated by

$$\begin{aligned} 0 &\stackrel{!}{=} w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right) + w_d \cdot q \cdot \left(\frac{r_d}{P^c} - i\right) \\ \Leftrightarrow 0 &= \frac{w_u \cdot r_u + w_d \cdot r_d}{P^c} - (w_u + w_d) \cdot i \\ \Leftrightarrow P^c &= \frac{E(r_r)}{i} \end{aligned} \tag{11}$$

which is not higher than $P^f$ as $i \geq r_s$.

It becomes obvious that again, as in Section 2, for the price interval I1 the price the investor is maximally willing to pay for the risky asset is the present value of the return the investor expects where the discount rate is his opportunity cost. However, in contrast to Section 2, this time the opportunity cost is $i$ instead of $r_s$ as the investor does not invest with his own wealth which he could alternatively invest in the safe asset, but with money borrowed from the bank at an interest rate of $i - 1$.

With this result, the condition for the case that $P^c$ is in the interval I1 can be transformed to

$$\begin{aligned} q \cdot \left(\frac{r_d}{P^c} - i\right) &> -\frac{r_d}{P^f} \\ \Leftrightarrow \frac{q \cdot r_d \cdot i}{E(r_r)} - q \cdot i &> -\frac{r_d \cdot r_s}{E(r_r)} \\ \Leftrightarrow q \cdot i \cdot (E(r_r) - r_d) &< r_d \cdot r_s \\ \Leftrightarrow q \cdot \frac{i}{r_s} &< \frac{r_d}{w_u \cdot (r_u - r_d)}. \end{aligned} \tag{12}$$

So, with (11) and (12) we have shown that for $q \cdot i/r_s < r_d/(w_u \cdot (r_u - r_d))$ the maximum price the investor is willing to pay for the risky asset is

- in I1 so that no risk shifting occurs and
- $P^c = E(r_r)/i \leq P^f$ so that no bubble can emerge.

An example for $ANR_r^E$ where (12) holds is displayed in Figure 2. The fundamental value of the risky asset in this example is $P^f = 1.25/1.1 \approx 1.136364$ and the price interval I1 contains all prices lower than $P^c = 1.2$.

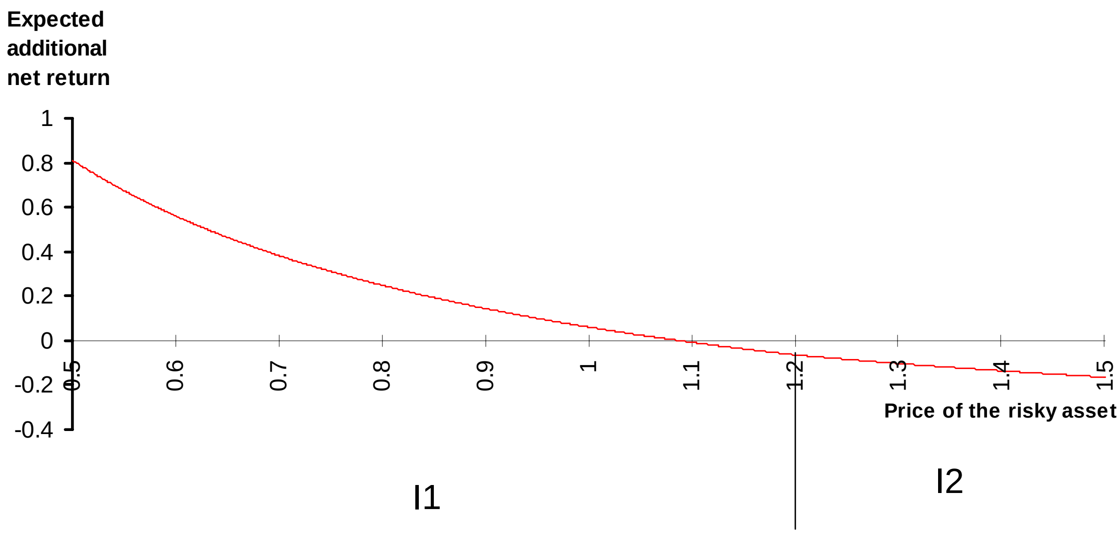



Figure 2: Example for $ANR_r^E$ with $r_s = 1.1$, $w_u = w_d = 0.5$, $r_u = 2$, $r_d = 0.5$, $q = 0.6$, and $i = 1.15$.

As $E(r_r)/i = 1.25/1.15 \approx 1.086957$ is in price interval I1, $P^c$ is not higher than $P^f$ and hence no bubble can emerge.

### 3.1.2 The maximum price the investor is willing to pay for the risky asset when he expects a total return of zero in the low payoff state (Interval I2)

For prices for which $q \cdot (r_d/P^c - i) \leq -r_d/P^f$ holds, the investor expects a total return of zero in the low payoff state of the risky asset. For this interval the new maximum price the investor is willing to pay for the risky asset can be calculated from

$$
\begin{aligned}
0 &\overset{!}{=} w_u \cdot q \cdot \left(\frac{r_u}{P^c} - i\right) - w_d \cdot \frac{r_d}{P^f} \\
\Leftrightarrow \frac{w_u \cdot q \cdot r_u}{P^c} &= w_u \cdot q \cdot i + \frac{w_d \cdot r_d}{P^f} \\
\Leftrightarrow \frac{P^f \cdot w_u \cdot q \cdot r_u}{P^c} &= P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d \\
P^c &= P^f \cdot \frac{w_u \cdot q \cdot r_u}{P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d}. \qquad (13)
\end{aligned}
$$

Inserting (13) into the condition for price interval I2 leads to:

$$\begin{aligned}
q \cdot \left(\frac{r_d}{P^c} - i\right) &\leq -\frac{r_d}{P^f} \\
\Leftrightarrow -q \cdot i &\leq -\frac{r_d}{P^f} - \frac{q \cdot r_d \cdot (P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d)}{w_u \cdot q \cdot r_u \cdot P^f} \\
\Leftrightarrow q \cdot i &\geq \left(\frac{1}{P^f} + \frac{q \cdot (P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d)}{w_u \cdot q \cdot r_u \cdot P^f}\right) \cdot r_d \\
\Leftrightarrow q \cdot i &\geq \frac{r_d \cdot r_s}{E(r_r)} + \frac{r_d \cdot (P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d)}{w_u \cdot r_u \cdot P^f} \\
\Leftrightarrow q \cdot i &\geq \frac{r_d \cdot r_s \cdot w_u \cdot r_u + r_d \cdot E(r_r) \cdot w_u \cdot q \cdot i + w_d \cdot {r_d}^2 \cdot r_s}{E(r_r) \cdot w_u \cdot r_u} \\
\Leftrightarrow E(r_r) \cdot w_u \cdot r_u \cdot q \cdot i &\geq r_d \cdot r_s \cdot w_u \cdot r_u + r_d \cdot E(r_r) \cdot w_u \cdot q \cdot i + w_d \cdot r_d^2 \cdot r_s \\
\Leftrightarrow w_u \cdot q \cdot i \cdot E(r_r) \cdot (r_u - r_d) &\geq r_d \cdot r_s \cdot E(r_r) \\
\Leftrightarrow q \cdot \frac{i}{r_s} &\geq \frac{r_d}{w_u \cdot (r_u - r_d)}. \qquad (14)
\end{aligned}$$

Therefore, if the investor expects that $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$, the new maximum price he is willing to pay for the risky asset $P^c$ is in the interval I2 (hence he assumes a total return of zero in the low payoff state in $t_1$) and there is a risk shifting problem.

From (13) it can also be seen that $P^c$ is bigger than $P^f$, and hence contains a bubble component, if

$$\begin{aligned}
w_u \cdot q \cdot r_u &> P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d \\
\Leftrightarrow \frac{w_u \cdot q \cdot r_u}{P^f} - w_u \cdot q \cdot i - \frac{w_d \cdot r_d}{P^f} &> 0 \\
\Leftrightarrow w_u \cdot q \cdot \left(\frac{r_u}{P^f} - i\right) - \frac{w_d \cdot r_d}{P^f} &> 0. \qquad (15)
\end{aligned}$$

$w_u \cdot q \cdot \big(r_u/P^f - i\big) - w_d \cdot r_d/P^f$ is the investor's additional net return from the margin loan if he pays a price of $P^f$ for the risky asset (see Table 2). $P^c$ is the maximum price he is willing to pay for the risky asset when a margin loan is available. As it can be seen from (8), $\partial ANR_r^E/\partial P^c < 0$ for prices of the interval I2. Therefore, the investor is only willing to pay a price of $P^c > P^f$, and hence a bubble can emerge, if at least his additional net return for $P^f$ is positive.[36]

In Figures 3 and 4 two examples for $ANR_r^E$ where (14) holds are displayed. The fundamental value of the risky asset in both examples again is $P^f = 1.25/1.1 \approx 1.136364$. The price interval I1 contains all prices lower than $P^c \approx 0.704225$ in Figure 3 and lower than $P^c \approx 1.056911$ in Figure 4.

[36] Therefore, while (14) is a necessary condition for $P^c > P^f$, (15) is a sufficient condition.

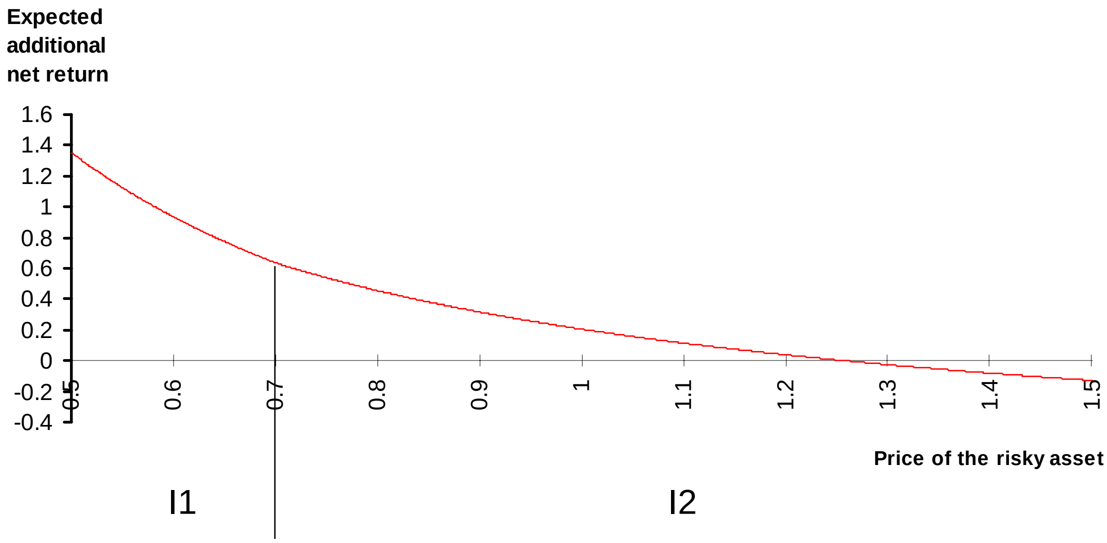



Figure 3: Example for $ANR_r^E$ with $r_s = 1.1$, $w_u = w_d = 0.5$, $r_u = 2$, $r_d = 0.5$, $q = 1$, and $i = 1.15$.

In both examples, $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$ holds. Hence, in both cases $P^c$ is in I2 and there is a risk shifting problem.

While in the example of Figure 3 (15) holds, in the example of Figure 4, $w_u \cdot q \cdot \big(r_u/P^f - i\big) - w_d \cdot r_d/P^f$ is lower than zero. Therefore, the maximum price the investor is willing to pay for the risky asset in Figure 3 is $P^c \approx 1.257862 > P^f$ so that it is possible that a bubble emerges whereas in Figure 4 the investor is maximally willing to pay a price of $P^c \approx 1.094737 < P^f$.

The results derived in Section 3.1 are summed up in Tables 3 and 4.

Table 3: Results of Section 3.1

| Condition | Risk shifting problem | New price of risky asset $P^c$ |
|---|---|---|
| $q \cdot \dfrac{i}{r_s} < \dfrac{r_d}{w_u \cdot (r_u - r_d)}$ | No | $\dfrac{E(r_r)}{i} \leq P^f$ |
| $q \cdot \dfrac{i}{r_s} \geq \dfrac{r_d}{w_u \cdot (r_u - r_d)}$ | Yes | $P^f \cdot \dfrac{w_u \cdot q \cdot r_u}{P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d}$ |

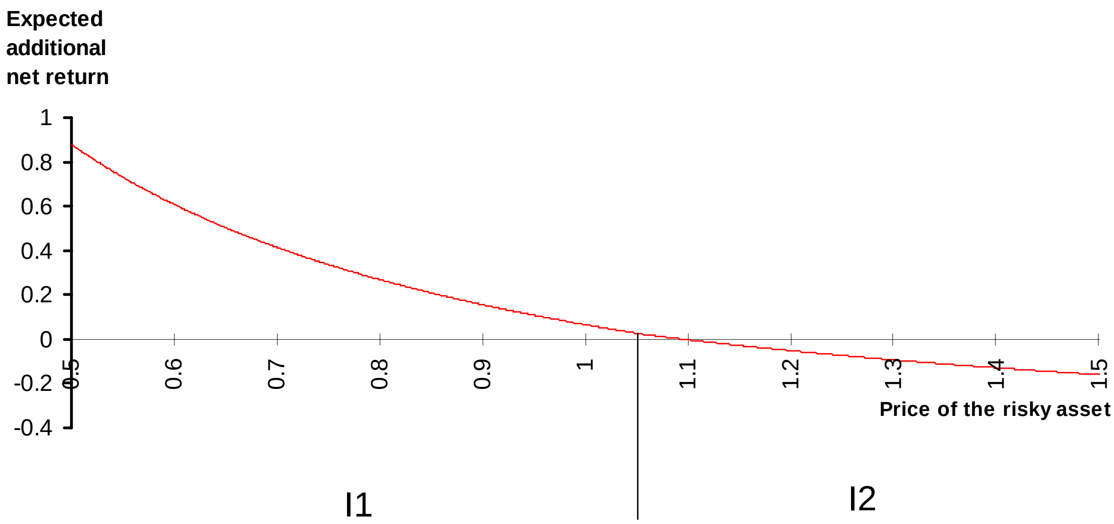



Figure 4: Example for $ANR_r^E$ with $r_s = 1.1$, $w_u = w_d = 0.5$, $r_u = 2$, $r_d = 0.5$, $q = 0.65$, and $i = 1.15$.

Table 4: Results of Section 3.1

| Risk Shifting Condition | Bubble Condition | Bubble |
|---|---|---|
| $q \cdot \frac{i}{r_s} < \frac{r_d}{w_u \cdot (r_u - r_d)}$ | | No |
| $q \cdot \frac{i}{r_s} \geq \frac{r_d}{w_u \cdot (r_u - r_d)}$ | $w_u \cdot q \cdot \left(\frac{r_u}{P^f} - i\right) - \frac{w_d \cdot r_d}{P^f} \leq 0$ | No |
| $q \cdot \frac{i}{r_s} \geq \frac{r_d}{w_u \cdot (r_u - r_d)}$ | $w_u \cdot q \cdot \left(\frac{r_u}{P^f} - i\right) - \frac{w_d \cdot r_d}{P^f} > 0$ | Yes |

With (13), (14), and (15) we have shown that margin loans can cause a stock market bubble. From (13) it can be seen that if (14) and (15) hold, the investor is willing to bid up the price of the risky asset above its fundamental value.

# 4 New insights into some of the empirical results concerning margin regulation

The idea behind the Federal Reserve's authorization to regulate margin loans via an initial margin requirement in 1934 was the supposition that there is a positive relationship between the amount of margin debt outstanding and the level and volatility of stock prices, and that the level of margin debt can be influenced by changes of the level of the initial margin requirement in the form that raising (lowering) the requirement leads to a decrease (an increase) of the amount of margin debt.

As it can be seen from Figure 5, there has been a considerable amount of empirical research on these supposed relationships. Most of the studies focused on the question whether there is a link between the level of the initial margin requirement and stock price volatility. The conclusion of these studies is that no undisputed evidence of the efficacy of margin regulation to control the volatility of stock prices has been provided.[37]

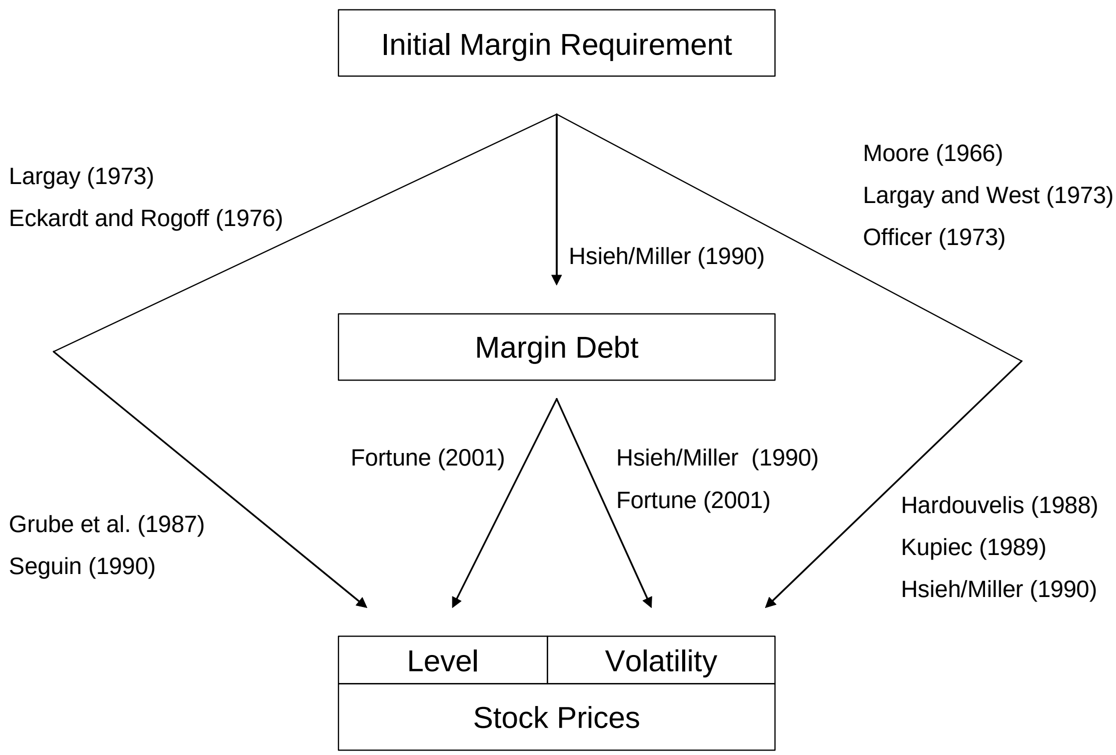



Figure 5: Survey of empirical studies.

We will now take a closer look at the results concerning two of the supposed relationships by analyzing whether the empirical findings can be analytically confirmed by our model.

[37] For a review of studies about the efficacy of margin regulation see Chance (1990), France (1991), Kupiec (1997), and Fortune (2001).

## 4.1 The relationship between the level of margin debt outstanding and the level of stock prices

Fortune (2001) explicitly examined the linkage between the amount of margin loans outstanding and stock returns for the S&P 500 as well as for the NASDAQ Composite during the period from 1975 to 2001[38] in an empirical study using a jump diffusion model of stock returns. He showed that the level of margin debt outstanding does have a statistically significant effect on stock returns in the subsequent month and that this effect is stronger for the NASDAQ than for the S&P 500. Moreover, he found that a high level of margin debt indicates an additional upward (downward) pressure in a bull (bear) market which supports the pyramiding/depyramiding hypothesis.

To analyze whether our model theoretically confirms the empirical finding of a (positive) relationship between the level of margin debt and stock prices, we can have a look at the first derivative of the price the investor is maximally willing to pay for the risky asset when a security loan is available, $P^c$, with regard to the amount $q$ the investor borrows. If there is such a connection, $\partial P^c/\partial q$ must be positive, because a higher $q$ means a higher level of margin debt outstanding.

As we have shown with (11), for $q \cdot i/r_s < r_d/(w_u \cdot (r_u - r_d))$ the maximum price the investors are willing to pay for the risky asset when a margin loan is available, $P^c$, is $E(r_r)/i$ and thus not influenced by $q$. So, for this case $\partial P^c/\partial q$ is

$$\frac{\partial P^c}{\partial q} = \frac{\partial \left( \dfrac{w_u \cdot r_u + w_d \cdot r_d}{i} \right)}{\partial q} = 0. \tag{16}$$

As a first result it can be seen from (16) that for $q \cdot i/r_s < r_d/(w_u \cdot (r_u - r_d))$ the level of margin loans outstanding has no direct effect on the maximum price the investors are willing to pay for the risky asset.[39]

A different result can be derived for the case that $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$. As it can be seen from (13), the maximum price of the risky asset for this case is $P^c = P^f \cdot w_u \cdot q \cdot r_u/(P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d)$. So, $\partial P^c/\partial q$ is

$$\frac{\partial P^c}{\partial q} = \frac{\partial \left( P^f \cdot \dfrac{w_u \cdot q \cdot r_u}{P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d} \right)}{\partial q}. \tag{17}$$

[38] As there has been no active margin policy since 1974, a possible distortion of the results by a change of the initial margin requirement is prevented.

[39] However, some authors presume that there is an indirect effect of changes of the Federal Reserve's initial margin requirement that is operating through changes of the investors' expectations arising from an announcement effect, see e.g. Moore (1966), Seguin (1990), Shiller (2000), or Fortune (2001).

(17) is $> 0$ if

$$\begin{aligned} P^f \cdot w_u \cdot r_u \cdot (P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d) &> P^f \cdot w_u \cdot q \cdot r_u \cdot P^f \cdot w_u \cdot i \\ \Leftrightarrow P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d &> P^f \cdot w_u \cdot q \cdot i \\ \Leftrightarrow w_d \cdot r_d &> 0. \end{aligned} \tag{18}$$

Therefore, with (17) and (18) we have shown that there is a positive relationship between the amount of margin debt outstanding and the maximum price the investors are willing to pay for the risky asset $P^c$ for $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$, hence if the investor expects a total return of zero in the low payoff state of the risky asset for the case that he makes use of the margin loan, and $r_d > 0$, hence if he expects a total return higher than zero in the low payoff state when he refuses the margin loan offer. This result theoretically confirms the empirical result of Fortune (2001).

A closer look at the condition for the existence of this relationship, $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$, sheds light on Fortune's observation that the impact of the level of margin loans outstanding on stock prices is only weak for the S&P 500, but particularly strong for the NASDAQ Composite.

This is due to the fact that the more risky the investors assume a stock to be, in terms of $(r_u - r_d)/r_d$, the more likely it is that $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$ holds. Stocks listed at the NASDAQ Composite are commonly believed to bear a higher risk than those listed at the S&P 500.[40] So, it is reasonable to assume that this condition holds for more stocks of the NASDAQ Composite than of the S&P 500.

The results of Section 4.1 are summed up in Table 5.

Table 5: Results of Section 4.1

| Condition | $P^c$ | $\frac{\partial P^c}{\partial q}$ | Sign |
|---|---|---|---|
| $q \cdot \frac{i}{r_s} < \frac{r_d}{w_u \cdot (r_u - r_d)}$ | $\frac{E(r_r)}{i}$ | 0 | 0 |
| $q \cdot \frac{i}{r_s} \geq \frac{r_d}{w_u \cdot (r_u - r_d)}$ | $\frac{P^f \cdot w_u \cdot q \cdot r_u}{P^f \cdot w_u \cdot q \cdot i + w_d \cdot r_d}$ | $\frac{w_d \cdot r_d}{(P^f \cdot w_u \cdot q \cdot i \cdot + w_d \cdot r_d)^2}$ | $\geq 0$ |

[40] See Fortune (2001), Schwert (2002), or Eraker et al. (2003).

## 4.2 The relationship between the level of the initial margin requirement and the level of stock prices

From $\partial P^c/\partial q$ yet another question that has been empirically investigated can theoretically be analyzed, because the loan-to-value ratio $r$, which is the maximum $q$ the investor is able to lend, can easily be transformed to an initial margin requirement $m$ by $1/(1+r) = m$. Therefore, for example, if $r = 0.25$, which means that an investor with a portfolio worth 1 $ is able to maximally borrow 0.25 $, $m$ is $1/1.25 = 0.8$ which is exactly the equity financed part of the new portfolio.[41]

Most of the empirical studies motivated by margin regulation concentrate on the question whether the Federal Reserve's initial margin requirement is an efficient tool to control the *volatility* of stock prices. However, there are some studies that explicitly analyze whether there is a relationship between the level of the initial margin requirement and the *level* of stock prices.

The Federal Reserve Board sets a minimum initial margin requirement that applies to all margin-eligible stocks. Securities exchanges like the New York Stock Exchange can moreover impose additional margin requirements at their discretion. Largay (1973) examined the price effects associated with the imposition of such a special initial margin requirement of 100% for the 1968-1969 period. He found that the price of stocks placed under the 100% margin restriction tended to rise sharply before the special restriction and then to decline after the 100% margin restriction was imposed. Eckardt and Rogoff (1976) confirmed Largay's result of a price decline immediately after the imposition of the 100% margin requirement for a longer sample period.

The Over the Counter (OTC) Act of 1968 extended the security credit regulations of the Securities and Exchange Act to OTC stocks. In 1969 the OTC regulations were implemented with the introduction of the "Official List of OTC Margin Stocks", which contains all margin eligible stocks and is periodically updated. Grube et al. (1987) found that non-marginable OTC stocks experience a statistically significant abnormal positive price appreciation when they gain margin eligibility. Seguin (1990) reported that the announcement of margin eligibility is associated with a positive abnormal return of about 2 percent.

In contrast to the results of these margin eligibility studies (ME Studies), Largay and West (1973) and Grube et al. (1979), who analyzed the stock market's response to a change of the Federal Reserve's initial margin requirement (MR Studies), found that neither increases nor decreases in the margin requirement had a statistically significant effect on S&P 500 returns on the day of the change or over the days following the change.

[41] Of course, this holds only before a new evaluation of his initial portfolio containing $1/P^f$ units of the risky asset with the new price $P^c$ takes place.

Therefore, the empirical results concerning the question whether initial margin regulation is an effective tool to influence the level of stock prices are mixed. We will now theoretically analyze this question. If the level of the margin requirement has an inverse influence on stock prices, $\partial P^c/\partial m$ must be negative which means that $\partial P^c/\partial r > 0$ and thus $\partial P^c/\partial q > 0$.[42]

Thus, in view of our results in Section 4.1 we can conclude that the level of stock prices is inversely related to the level of the initial margin requirement for $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$ and $r_d > 0$. Having a closer look at the differences between ME Studies and MR Studies can possibly explain where the divergence of the result of these two types of studies stems from.

There are two important differences between ME Studies and MR Studies. First, while ME Studies only investigate the effect of raising $m$ to 100% respectively reducing $m$ from 100% to a lower level, the samples of MR Studies contain all changes of the initial margin requirement during the sample period. Second, while ME Studies analyze the effect of gaining or losing margin eligibility on the price of the regarding stock, MR Studies investigate the reaction of a stock index to a change of the Federal Reserve's $m$.

We will now discuss two possible problems that can occur when the relationship between the level of the initial margin requirement and the level of stock prices is empirically tested and hereby try to explain why the results differ for the two types of studies.

1. It is possible that the Federal Reserve's initial margin requirement is not binding for the investors. For example, if the equity financed part of the investors' portfolio is 90% and the Federal Reserve raises $m$ from 60% to 70% or lowers $m$ from 70% to 60%, the investors are not affected by the regulation.[43]
   There are two possible reasons for the investors to borrow less than they are allowed to by $m$.
   First, because the Federal Reserve's initial margin requirement only defines a minimum requirement and banks and securities exchanges are free to demand a higher equity position on the date of a margin loan financed transaction. Hence, if the Federal Reserve raises $m$ to or lowers $m$ from a level that is below the bank's/securities exchange's initial margin requirement the investors are not affected by such a change.
   Second, because it is possible that the investors decide to not fully make use of the margin loan offer, hence $q < r$.[44] A rise of the Federal Reserve's initial margin requirement (hence lowering the loan-to-value ratio) has no effect on the investors if after the rise $q < r$ (still) holds. Lowering the initial margin requirement (hence rising $r$) is ineffective if before the change $q < r$ holds.

[42] Concluding from $\partial P^c/\partial q > 0$ that $\partial P^c/\partial m < 0$, we implicitly assume that $m$ and $r$ are binding. We will later discuss this assumption.
[43] We do not consider a possible announcement effect from a changing of the initial margin requirement, see footnote 39 on page 20.
[44] The importance of this point is one of the results of Luckett (1982).

Both possible reasons are relevant as both, banks[45] and securities exchanges[46], sometimes impose a higher margin requirement than that demanded by the Federal Reserve. And as Fortune (2000) shows, the investors not fully make use of the offered margin loan as between 1985 and 2000 the aggregate amount of debit balances at broker-dealers per dollar of potential margin debt never exceeded 50%.
Therefore, the samples used to empirically analyze the influence of a change in the initial margin requirement on stock prices actually should have been limited to changes of $m$ when $m$ was binding after the rise (before the lowering). Hence, the results of these studies are distorted. The distortion is likely to be less for the results of the ME Studies than for those of the MR Studies. This is due to the fact that rising (lowering) the initial margin requirement to (below) 100% has always an influence on the investors if the bank's/securities exchange's requirement is below 100% and the investors want to make use of the margin loan ($q > 0$).

2. We have shown in Section 4.1 that $\partial P^c/\partial q$ can only be positive for stocks for which $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$ holds at least after (before) the rise (lowering) of $q$. Therefore, if the empirically tested sample mainly contains stocks for which this inequality does not hold, it is obvious that no statistically significant effect will be observed.
The MR Studies analyzed the relationship between the level of the Federal Reserve's initial margin requirement and the level of stock prices for the S&P 500, which contains 500 U.S. large-cap stocks and hence covers a large proportion of the market capitalization.[47] Investors' expectations concerning the riskiness of a stock partly depend on from which sector of the economy the company is.[48] The S&P 500 (and thus the sample of the MR Studies) contains large-cap stocks from all sectors of the economy, hence both, stocks which the investors assume to be risky as well as stocks they believe to be relatively safe.
For the stocks of his sample, Largay (1973) found that "stocks placed under the 100% margin restrictions typically had exhibited rapid price appreciation and heavy trading volume before the margins were imposed". Eckardt and Rogoff (1976) confirmed this finding for their sample as their results indicate that "a significant positive relative price change occurred during the ten trading days prior to the imposition date". Hence, the prices of the stocks put under a special restriction seem to have raised rapidly before the margin requirement of 100% was imposed. A sharp rise in the price of a stock is commonly believed to result in a higher risk of that stock.
The more risky a stock is, in terms of $(r_u - r_d)/r_d$, the more likely it is that $q \cdot i/r_s \geq r_d/(w_u \cdot (r_u - r_d))$ holds. Therefore, a possible reason for the different results of the studies of Largay (1973) and Eckardt and Rogoff (1976) on the one hand and the MR Studies on the other hand could be that (14) held for more

[45] Charles Schwab for example had margin requirements of 100% for a short list of stocks when the Federal Reserve's initial margin requirement was only 50%, see Fortune (2001).
[46] See Largay (1973) and Eckardt and Rogoff (1976).
[47] Standard&Poor's recommends the S&P 500 as an ideal proxy for the total U.S. stock market as it covers 80% of its market capitalization.
[48] For example, stocks from the technology sector are widely believed to bear an above average risk while stocks from the energy sector are seen as relatively safe.

stocks of the samples of Largay (1973) and Eckardt and Rogoff (1976) than of the MR Studies' samples.

# 5 The effectiveness of margin regulation to prevent the emergence of a stock market bubble caused by margin loans

There is a consensus that asset price bubbles can lead to financial crises and hence economic policymakers should prevent the emergence of bubbles.[49] We will now show that with the initial margin requirement the Federal Reserve has an ingenious tool to prevent the emergence of a stock market bubble caused by the excessive use of margin loans.

In Section 3.1 we have shown that margin loans can only cause a bubble if (14) and (15) hold. These conditions can be transformed to

$$\begin{aligned} q \cdot \frac{i}{r_s} &\geq \frac{r_d}{w_u \cdot (r_u - r_d)} \\ \Leftrightarrow q &\geq \frac{r_s}{i} \cdot \frac{r_d}{w_u \cdot (r_u - r_d)} \geq 0 \end{aligned} \tag{19}$$

and

$$\begin{aligned} w_u \cdot q \cdot \left(\frac{r_u}{P^f} - i\right) - \frac{w_d \cdot r_d}{P^f} &> 0 \\ \Leftrightarrow w_u \cdot q \cdot r_u - w_u \cdot q \cdot i \cdot P^f &> w_d \cdot r_d \\ \Leftrightarrow q \cdot w_u \cdot (r_u - i \cdot P^f) &> w_d \cdot r_d \\ \Leftrightarrow q &> \frac{w_d \cdot r_d}{w_u \cdot (r_u - i \cdot P^f)} > 0 \\ \text{as} \\ w_u \cdot q \cdot \left(\frac{r_u}{P^f} - i\right) - \frac{w_d \cdot r_d}{P^f} &> 0 \\ \Leftrightarrow r_u &> \underbrace{\frac{w_d \cdot r_d}{w_u \cdot q}}_{>0} + i \cdot P^f. \end{aligned} \tag{20}$$

As $r$ is the maximum $q$ the investors are able to borrow and $r = 1/m - 1$, the Federal Reserve can prevent the emergence of a bubble by setting $m$ to an appropriate level.

[49] See e.g. Kaminsky and Reinhart (1998), Allen and Gale (2000), or Allen (2001).

Therefore, by setting $m$ to a level that

$$\begin{aligned} \frac{1}{m} - 1 &< \frac{r_s}{i} \cdot \frac{r_d}{w_u \cdot (r_u - r_d)} \\ \Leftrightarrow m &> \frac{1}{\frac{r_s}{i} \cdot \frac{1}{w_u} \cdot \frac{r_d}{(r_u - r_d)} + 1} \end{aligned} \tag{21}$$

or

$$\begin{aligned} \frac{1}{m} - 1 &\leq \frac{w_d \cdot r_d}{w_u \cdot (r_u - i \cdot P^f)} \\ \Leftrightarrow m &\geq \frac{1}{\frac{w_d}{w_u} \cdot \frac{r_d}{(r_u - \frac{i}{r_s} \cdot E(r_r))} + 1} \end{aligned} \tag{22}$$

the emergence of a margin loan caused bubble can be avoided.

From (21) it can be seen that the minimally necessary $m$ to prevent a risk shifting problem depends on how risky the investors assume the risky asset to be in terms of $(r_u - r_d)/r_d$, how optimistic the investors are in terms of $w_u$, and how big the difference between the bank's demanded repayment and the return of the safe asset is.

Since 1974 the initial margin requirement has been fixed at 50%. This single level is obligatory for all stocks. However, a closer look at (21) reveals that the margin requirement should be higher for stocks with certain characteristics as they are particularly susceptible to bubbles than for others. It can be seen that the development of a bubble is more likely the more risky, in terms of $(r_u - r_d)/r_d$, the investors assume an asset to be and the more optimistic, in terms of $w_u$, the investors are about a high future payoff of a stock. Therefore, by using a single initial margin requirement for all stocks regardless of how risky the investors assume them to be and how optimistic the investors are about a high future payoff, $m$ is too low for certain stocks and too high for others.

Of course the Federal Reserve cannot estimate the investors' beliefs about $w_u$, $r_u$ and $r_d$ for each stock with an absolute precision. But, nevertheless, there are some conclusions about how the Federal Reserve's margin policy should look like from a theoretical point of view that can be drawn from (21).

- In times of great optimism about stocks (in terms of a high $w_u$) a high $m$ is appropriate to prevent a risk shifting problem caused by the use of margin loans. This result supports the calls at the Federal Reserve to return to its active margin policy during the stock market boom in the late 1990's.[50]

- $m$ should be higher for stocks that are commonly believed to bear an above average risk (in terms of $(r_u - r_d)/r_d$) than for stocks that are assumed to be relatively safe. A practicable way would be to establish different initial margin requirements for stocks of companies from different sectors. For example, the stocks of high-tech firms are widely seen as particularly risky and hence require a higher $m$. Higher margin requirements for certain stocks are already imposed from time to time by securities exchanges[51] and banks[52].

The goal behind the imposition of the initial margin requirement to prevent the supposed possible negative consequences of margin lending could have been achieved most easily by just completely prohibiting margin lending (hence $m$=100%). However, the Federal Reserve except in 1946 has always set $m$ to a level below 100% as it can be seen from Figure 6. So, it seems that the Federal Reserve wants to limit margin lending only as much as absolutely necessary by its regulation.

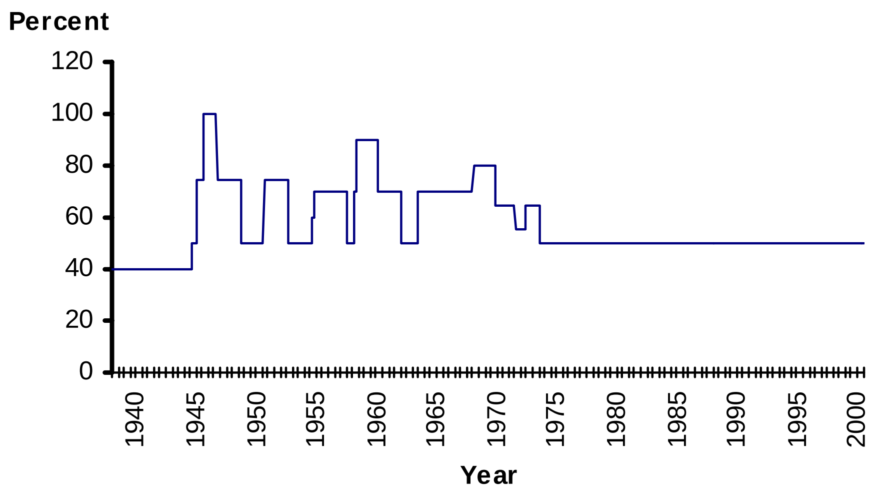



Figure 6: Level of the Federal Reserve's initial margin requirement. Source: Fortune (2000), p. 21.

Therefore, as

[50] See e.g. Shiller (2000).
[51] See Largay (1973) and Eckardt and Rogoff (1976).
[52] See footnote 45 on page 23.

$$
\begin{aligned}
\frac{w_d \cdot r_d}{w_u \cdot (r_u - i \cdot P^f)} &\geq \frac{r_s \cdot r_d}{i \cdot w_u \cdot (r_u - r_d)} \\
\Leftrightarrow w_d \cdot i \cdot r_u - w_d \cdot i \cdot r_d &\geq r_s \cdot r_u - r_s \cdot i \cdot P^f \\
\Leftrightarrow w_d \cdot i \cdot r_u - w_d \cdot i \cdot r_d &\geq r_s \cdot r_u - w_u \cdot r_u \cdot i - w_d \cdot r_d \cdot i \\
\Leftrightarrow w_d \cdot i &\geq r_s - w_u \cdot i \\
\Leftrightarrow i &\geq r_s
\end{aligned}
$$

the Federal Reserve should concentrate on (22) when it determines $m$.

As

$$
\frac{\partial \left( \dfrac{w_d \cdot r_d}{w_u \cdot (r_u - \frac{i}{r_s} \cdot E(r_r))} \right)}{\partial w_u}
\Leftrightarrow \frac{0 - w_d \cdot r_d \cdot r_u \cdot (1 - \frac{i}{r_s} \cdot 2 \cdot w_u)}{(w_u \cdot (r_u - i \cdot P^f))^2} \tag{23}
$$

and

$$
\frac{\partial \left( \dfrac{w_d \cdot r_d}{w_u \cdot (r_u - \frac{i}{r_s} \cdot E(r_r))} \right)}{\partial r_u}
\Leftrightarrow \frac{0 - w_d \cdot r_d \cdot w_u \cdot (1 - \frac{i}{r_s} \cdot w_u)}{(w_u \cdot (r_u - i \cdot P^f))^2} \tag{24}
$$

and

$$
\begin{aligned}
&\frac{\partial \left( \dfrac{w_d \cdot r_d}{w_u \cdot (r_u - \frac{i}{r_s} \cdot E(r_r))} \right)}{\partial r_d} \\
\Leftrightarrow &\frac{w_d \cdot (w_u \cdot r_u - \frac{i}{r_s} \cdot w_u^2 \cdot r_u - w_u \cdot \frac{i}{r_s} \cdot w_d \cdot r_d) - w_d \cdot r_d \cdot (-w_u \cdot \frac{i}{r_s} \cdot w_d)}{(w_u \cdot (r_u - i \cdot P^f))^2} \\
\Leftrightarrow &\frac{w_d \cdot w_u \cdot r_u \cdot (1 - \frac{i}{r_s} \cdot w_u)}{(w_u \cdot (r_u - i \cdot P^f))^2},
\end{aligned} \tag{25}
$$

for (22) no unequivocal results concerning the relationship between the minimum necessary $m$ and $w_u$, $r_u$, or $r_d$ can be derived as the sign of the derivations of the right side of (22) with regard to $w_u$, $r_u$, and $r_d$ depends on the how high $i$, $r_s$, and $w_u$ are.

# 6 Conclusions

In this paper we derived four major results:

1. Margin loans can cause a bubble in the price of a risky asset (Section 3).
2. The level of margin debt can have a positive influence on stock prices (Section 4.1).
3. The level of the initial margin requirement can have a negative influence on stock prices (Section 4.2).
4. The initial margin requirement is an ingenious tool to prevent the emergence of a stock market bubble caused by the excessive use of margin loans (Section 5).

Still, there remains the conclusion of most of the empirical studies that there is no statistically significant association between the level of the Federal Reserve's initial margin requirement and stock prices and hence that margin regulation is inefficient.

Hsieh and Miller (1990) found a statistically significant relation between the level of the initial margin requirement and the amount of margin debt outstanding as well as between the level of margin credit and the volatility of stock prices. However, on net balance they found no statistically significant association between the level of the requirement and stock price volatility. Therefore, the supposed relationships seem to exist, the net effect, however, is only very weak.

The reason for this is that margin debt only plays a minor role in reality. Figlewski (1984) found that the total volume of margin credit has never exceeded 2% of the value of stocks traded at the NYSE between 1959 and 1984. Fortune (2000) confirmed this result by showing that between 1985 and 2000 the total amount of margin debt has always been lower than 3% of the market capitalization at NYSE and NASDAQ.[53]

The chances to nevertheless empirically find a statistically significant relation between the level of the initial margin requirement and stock price volatility can possibly be improved by using a sample that is different from the one that has been employed in the existing studies. We have shown in Section 4.1 with (16), (17), and (18) that the level of stock prices can only be influenced by margin regulation if there is a risk shifting problem. Therefore, from (21) it can be seen that a change of $m$ has only an effect on the price of stocks for which $m < 1/(r_s/i \cdot 1/w_u \cdot r_d/(r_u - r_d) + 1)$ holds at least after (before) the lowering (raising) of $m$. So, for example, if $m$ is raised from 50% to 60%, this change has no effect at all on all those stocks for which an initial margin requirement of 50% has already been sufficient to prevent the risk shifting problem. Possible ways to cope with this problem in an empirical study could be to limit the sample to very risky stocks (in

[53] Even at the height of the stock market boom in 1929 it never exceeded 10% of the value of listed equities, see Brady (1988).

terms of a high $(r_u - r_d)/r_d)$ or to margin requirement changes from a very low level. So, by using a different sample a statistically significant relationship can possibly be shown.

The model presented in this paper can be extended in many different ways. As Fortune (2000) showed for 1985-2000, in reality there is a great gap between the amount of margin debt outstanding and the amount the investors are maximally able to borrow. So, either the initial margin requirement has been sufficient to prevent the risk shifting problem for most of the stocks or there are factors that keep investors from using margin loans to maximize their profits which are excluded from our model. This could be for example the existence of alternative instruments to achieve leverage like derivative securities, investors' risk aversion or the loss of reputation. Fortune (2001) provides an excellent discussion about further possible reasons for the missing efficacy of margin regulation that are not included in our model. Among others, he mentions the existence of close substitutes for margin loans, e.g. mortgage debt and home equity loans, the growth of derivative securities like stock index futures, and advances in risk management methods which allow brokers to set appropriate house margin requirements. Another simplification of our model is the assumption that the bank only grants one single security loan to the investor. A kind of a pyramiding process can possibly be shown in a multi-period model if a rise in the price of the risky asset leads to another security credit on the risen value of the initial portfolio. Furthermore, the optimal behavior of the bank can explicitly be investigated. In our analysis $i$ and $r$ are given exogenously. However, it is likely that the bank tries to avert the risk shifting problem and by that prevents that the necessary condition for the formation of a margin loan caused bubble can hold.

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