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„Bubble Detection in the Stock Market: Introducing a new Generation of Models"

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MASTER THESIS

Bubble Detection in the Stock Market: Introducing a new Generation of Models

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Declaration of Authorship

I, Moritz Obexer, declare that this thesis titled, 'Bubble Detection in the Stock Market: Introducing a new Generation of Models' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a Master degree at this University.

- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.

- Where I have consulted the published work of others, this is always clearly attributed.

- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.

- I have acknowledged all main sources of help.

- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:
_____

Date:
_____

"what I am proposing is that we try to identify bubbles in real time, try to develop tools to address those bubbles, try to use those tools when appropriate to limit the size of those bubbles and, therefore, try to limit the damage when those bubbles burst."

William C. Dudley

Acknowledgements

Inhaltsangabe

In dieser Masterarbeit geht es um ökonometrische Tests zur Detektion von zukünftigen „Finanzblasen" im Aktienmarkt.

Im ersten Teil der Arbeit wird definiert, was unter dem Begriff der „Finanzblasen" zu verstehen ist. Es wird erklärt unter welchen Bedingungen und in welchen Formen diese vorkommen können und wie man diese erkennen kann.

Im zweiten Teil der Arbeit wird dem Leser ein zusammenfassender, historischer Überblick über vergangene Finanzblasen gegeben. Einzelne historische und aktuellere Finanzblasen werden dabei genauer beschrieben, damit der Leser versteht, dass Finanzblasen ein immer wiederkehrendes Phänomen unserer Wirtschaftsgeschichte sind.

Im dritten Teil werden historische, ökonometrische Tests zur Detektion solcher Blasen beschrieben. Dabei wird, im ersten Abschnitt, auf das jeweilige Testmodell eingegangen. Im zweiten Abschnitt werden die Ergebnisse des Tests beschrieben und gezeigt, warum keiner dieser Tests optimal ist.

Im vierten Teil der Arbeit werden dann drei moderne Tests beschrieben und analysiert. Auch hier wird zuerst das Testmodell erklärt und dann die passenden Ergebnisse der jeweiligen Tests beschrieben.

Im fünften; und zentralen Teil der Arbeit; wird ein neuer Finanzblasentest, basierend auf einem anderen, vorher vorgestellten Test, eingeführt. Im ersten Abschnitt wird das Testmodell Schritt für Schritt erklärt. Dieses angepasste Modell wird dann auf historische Daten angewandt. Die Ergebnisse des Tests werden im dritten Abschnitt beschrieben und analysiert.

In den letzten beiden Teilen der Arbeit wird noch auf die verwendeten Daten eingegangen und die Arbeits- und Vorgehensweise beim Verfassen der Arbeit wird genauer beschrieben.

Im letzten Teil werden alle Endergebnisse nochmal zusammengefasst.

Abstract

This work focuses on the econometric detection of bubbles in the stock market. In the first part different types of bubbles are presented and analysed. In the second part historic bubble detection models are explained. All of these models are not optimal for detecting bubbles appropriately. After this a new generation of models to empirically test for bubbles will be presented. In the last section a new model will be introduced. For all presented models empirical results will be shown.

Bubble Detection in the Stock Market: Introducing a new Generation of Models

Moritz Obexer B.Sc.

August 18, 2014

Contents

1. Introduction

Wiliam C. Dudley, the president and CEO of the Federal Reserve Bank New York, in April 2010 said:

> "...what I am proposing is that we try to identify bubbles in real time, try to develop tools to address those bubbles, try to use those tools when appropriate to limit the size of those bubbles and, therefore, try to limit the damage when those bubbles burst . . ." [1]

In recent days a lot of famous economists, central bankers and politicians all around the globe focus on this common topic: bubbles. How are they formed? Why do they happen? Which one will burst next? Can we predict them? And if yes, how?

Although some famous economists, like Fama in 1965 in his work about the Efficient Market Hypothesis, denied the existence of bubbles[2]; nowadays, looking backwards, the existence of bubbles is undeniable. Especially since the bursting of the Real-Estate-Bubble in 2007 in the US, which led to the severest recession in modern history since the Great Depression, bubbles are known to everybody.[3]

Although bubbles became very common in the last 15 years, they are not a phenomenon of our modern world. Their trace can be followed back until the Dutch Golden Ages, 1637, where one of the worlds most famous bubbles of all time bursted: the Tulip mania or tulipomania. 377 years ago some single tulip bulbs sold for more than 10 times the annual income of a skilled craftsman by the time.[4]

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[1]William C. Dudley, President and Chief Executive Officer; Speech: "Asset Bubbles and the Implications for Central Bank Policy"; April 2010; http://www.npr.org/blogs/money/2010/04/new_york_fed_president_central.html; 21.06.2013; 16:52.

[2]Compare Fama,(1965): "The behaviour of stock-market prices"; Journal of Business 38(1); 34-105.

[3]Compare Temin and Voth, (2004): "Riding the South Sea Bubble"; Forthcoming, AER; 2-10.

[4]Compare Van der Veeen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

The first academic who considered bubbles in financial markets was John Maynard Keynes in 1936. He stated that bubbles could be formed due to irrational investors.[5] In fact one of the most famous definitions of bubbles was given years later by a famous Yale professor. In 2005 professor Robert Shiller said:

> "Irrational exuberance is the psychological basis of a speculative bubble. I define a speculative bubble as a situation in which news of price increases spurs investor enthusiasm, which spreads by psychological contagion from person to person, in the process amplifying stories that might justify the price increases and bringing in a larger and larger class of investors, who, despite doubts about the real value of an investment, are drawn to it partly through envy of others' successes and partly through a gambler's excitement. We will explore the various elements of this definition of a bubble throughout this book."[6]

A bubble can be defined in many different ways, as will be explained later. Sure is that a bubble can distort agents investment incentives, leading to overinvestment or underinvestment in an over- or underpriced asset. The bursting of a bubble, caused by a certain trigger event, can lead to serious impaired balance sheets of financial institutions, single households and even whole states in the economy. This could slow down real economic activity and therefore growth. To avoid this it is crucial to understand the circumstances under which bubbles can arise and why prices can systematically deviate from their fundamental value over a longer period in time.

Furthermore all bubbles, as will be explained later, do have common features. It is essential to define those similarities to predict and avoid bubbles in the future.

This work will not answer the question if bubbles can emerge or not. This has been answered and proven. My work focuses on the detection of bubbles on an econometrical basis.

The first part is a general introduction in which a first overview on the topic is given.

In the second part various types of bubbles described in the existing literature will be presented. An overview of the different types of bubbles will be given.

In the third part an overview of bubble history with focus on the last 15 years is given, in order to explain the effects of bubbles on everybody. Furthermore a closer look at the period from 2000 until now will be taken to explain the events that happened during this time.

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[5] Compare Keynes, (1936): "The General Theory of Employment, Interest and Money"; Chapter 12; https://www.marxists.org/reference/subject/economics/keynes/general-theory/ch12.htm; 20.07.2014; 19:44.

[6] Robert Shiller, University of Princeton; http://press.princeton.edu/chapters/s7922.html; 14.07.2014; 10:56.

In the fourth part eight traditional empirical ways to detect bubbles in the stock market will be summarized. As will be explained later, all of these bubble tests do lack in three different issues:

- The first one is the basic question if a given bull market is either driven by fundamental values or by a bubble.

- Secondly, all the presented models are based on very specific and detailed assumptions.

- Thirdly, most of the tests, do not explain the structure of the bubble element, they just confirm their existence.

In the fifth part a new generation of bubble detection models is introduced. As will be presented also these bubble tests are not free from crucial assumptions and will lack in different issues.

In the sixth part a new bubble test will be presented. The test will be based on one of the newly introduced tests in the fourth part but will have a different economic reasoning behind it.

In the seventh the used data will be explained. In the eighth part the applied methodology will be explained.

In the last part a conclusion is drawn.

In the discussion of the state of the literature this thesis follows closely the master thesis of Weites and von Maravic (2010) submitted to Aarhus University. I extend their analysis by introducing an alternative test in the sixth part.

2. Literature Review on Bubbles

2.1. Overview

This section will focus on the different types of bubbles described in the historical literature.

As first the five phases of Minsky, who was the first to provide an informational characterization of bubbles and associated busts will be described. Then models of rational bubbles will be described. Rational bubbles can only be sustained if their presence allows for an improvement on the allocation in the economy; this means that even in these rational models, some sort of frictions must be present.[1] Then, a closer look at these possible frictions will be taken. It will be shown that if the bubble is fuelled by credit, the burst will be bigger and more painful.[2] Finally, the focus will be on heterogeneous-beliefs models, which are associated with high trading volume, which can often be observed in practice.[3]

This part is based on Whalen (1999), Brunnermeier (2008)and Brunnermeier and Oehmke (2012). All literature sources can be found in the Bibliography. If additional references were considered it will be directly mentioned in the according footnote.

2.2. The Minsky Model

The first one to provide an informal characterization of bubbles and the associated busts was Hyman Minsky. Minsky identified five distinguished stages in a typical bubble cycle. An initial displacement, followed by a boom, which leads to euphoria among investors, which results in profit taking among some investors until asset prices reverse and the last phase begins: panic.[4] Although there are various interpretations of this cycle, the general pattern of bubble activity remains fairly consistent. In the next paragraph a closer look at each of these five distinguished phases will be taken.

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[1]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398.

[2]Compare Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper, NO. 200; 14.

[3]Compare Harrison and Kreps, (1978): "Speculative Investor Behaviour in a Stock Market with Heterogeneous Expectations"; Quarterly Journal of Economics,89; 323-336.

[4]Compare Whalen, (1999): "Hyman Minsky's Theory of Capitalist Development"; Institute for Industry Studies, Cornell University; 2-3.

The following description of the model presented by Minsky will be based on Whalen (1999).[5] Whalen describes the Minsky model as follows: a displacement occurs when investors get enamoured by a new paradigm. Examples for such new paradigm could be an innovative new technology or a financial innovation or historically low interest rates. All of these displacements lead to a change in investors expectations about future profits and growth. A positive change leads to a boom phase in the considered asset. The main characteristics of this boom phase are low volatility, credit expansion and an increase in investment. During a boom phase prices rise slowly at first but then gain momentum as more and more participants enter the market. During this phase the asset in question attracts a lot of investors, therefore trading volume increases. The fear of missing a once-in-a-lifetime opportunity spurs more speculation, drawing an increasing number of participants into the market. This is the point where prices start to exceed the actual fundamental value of the security. This phase is followed by a phase of euphoria. During this, caution is thrown to the wind, asset prices and trading volume starts to skyrocket until valuations reach extreme levels.[6]

After some time some investors start to question the situation but still buy the asset as they are still confident that they can sell the asset for an even higher price in the future. During the profit taking phase smart investors start to sell out positions and to take their profits. Then a trigger event happens. Even a relatively minor event can trigger the bursting of a bubble. The panic stage starts. Asset prices reverse course and descend as fast as they had ascended. Investors and speculators, faced with margin calls and plunging values of their holdings, now want to liquidate them at any price. As supply overwhelms demand, asset prices start to slide downwards sharply, the bursting of the bubble begins. The downward spirals keeps going until prices start to stabilize again; at which point the circle starts again.[7]

All past bubbles can be fitted to the Minsky model. Therefore a lot of the literature on financial bubbles tries to formalize Minskys narrative. Most of these models are good at explaining parts of it but not all of the Minsky framework.

With this provided information the reader should be able to see that all bubbles presented in the history part later on do actually follow the Minsky concept.

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[5]Compare Whalen,(1999): "Hyman Minsky's Theory of Capitalist Development"; Institute for Industry Studies, Cornell University.

[6]Compare Whalen, (1999): "Hyman Minsky's Theory of Capitalist Development"; Institute for Industry Studies, Cornell University; 2-3.

[7]Compare Whalen, (1999): "Hyman Minsky's Theory of Capitalist Development"; Institute for Industry Studies, Cornell University; 2-3.

2.3. Rational Bubbles without any Friction

This section will be based on Brunnermeier (2008) and on Brunnermeier and Oehmke (2012). If additional references were considered it will be directly mentioned in the according footnote.

According to Brunnermeier the basic assumption of rational bubbles without friction is that investors hold a bubble asset because they expect the price of the asset to rise in the future.[8] The fundamental implication behind all rational bubble models is that, as long as the bubble continues, the price of the asset will grow further; this explosive characteristic of the price path can be observed during the run-up phases of many financial crises.[9]

Formally, according to Brunnermeier and Oehmke[10]:

$$p_t = E_t \left[\frac{p_{t+1} + d_{t+1}}{1 + r_{t+1}} \right]. \tag{2.1}$$

Where p_t is the price at time t, d_{t+1} is the dividend payment at time $t+1$ and r_{t+1} is the net return. Therefore the current price of an asset is defined as the discounted expected future price of the asset itself plus the dividend payment in the next period.[11]
For simplicity reasons, it is assumed that the expected return required by the rational trader to hold the asset is constant over time. Therefore $E_t[r_t + 1] = r$, for all t; which by solving equation (1) forward and using the law of iterated expectations, means that [12]

$$p_t = E_t \left[\Sigma_{\tau=1}^{T-t} \frac{1}{(1+r)^\tau} * d_{t+\tau} \right] + E_t \left[\frac{1}{(1+r)^{T-t}} * p_T \right]. \tag{2.2}$$

Therefore "...the equilibrium price is given by the expected discounted value of the future dividend stream paid from $t+1$ until T plus the expected discounted value of the price at time T."[13]

At this point Brunnermeier and Oehmke distinguish between securities with finite maturity and securities with infinite maturity.[14]
"For securities with finite maturity the price after maturity, say T, is zero, $p_t = 0$. Hence

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[8]Compare Brunnermeier,(2008): " Bubbles"; The New Palgrave Dictionary of Economics, Palgrave Macmillan; 1.
[9]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14-17.
[10]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.
[11]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.
[12]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.
[13]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.
[14]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.

the price of the asset, p_t, is unique and simply coincides with the expected future discounted dividend stream until maturity."[15]

"For securities with an infinite maturity, $T \to \infty$, the price, p_t, only coincides with the future expected discounted value of the future dividend stream, call it,fundamental value, v_t, if the so-called transversality condition holds."[16] Therefore:

$$\lim_{T \to \infty} E_t \left[\frac{1}{(1+r)^T} * p_{t+T} \right] = 0. \tag{2.3}$$

"Without imposing the transversality condition, $p_t = v_t$ is only one of many possible prices that solve the above expectational equation. Any price $p_t = v_t + b_t$, decomposed in the fundamental value, v_t, and a bubble component, b_t, such that

$$b_t = E_t \left[\frac{1}{(1+r)} * b_{t+1} \right]. \tag{2.4}$$

is also a solution."[17]

This equation shows that "...the bubble component b_t has to grow in expectation with the rate of r."[18] Due to this fact many potential rational bubbles are eliminated by a backward induction argument. An ever-growing commodity bubble would make the asset so expensive that investors would buy a substitute. In other words a rational bubble can only exist if the required return is lower or equal to the growth rate of the whole economy.[19] An overlapping generations model with an over accumulation of private capital the economy can be led to a dynamically inefficient stage.[20]

But the rational bubble model also suffers some shortcomings. First of all, the fact that a bubble must be present when the asset starts trading; it cannot start within a rational bubble model.[21] Furthermore rational bubbles can often be eliminated by a zero-sum argument of a general equilibrium.[22] If the economy is interim Pareto efficient a rational bubble cannot be formed.[23] In a bubble stage the seller of the underlying bubble asset would be better off due

[15]Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 14.

[16]Brunnermeier,(2008): "Bubbles"; New Palgrave Dictionary of Economics, Palgrave Macmillan; 4.

[17]Brunnermeier,(2008): "Bubbles"; in New Palgrave Dictionary of Economics, Palgrave Macmillan; 4.

[18]Brunnermeier, (2008): "Bubbles"; New Palgrave Dictionary of Economics, Palgrave Macmillan; 4.

[19]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 15.

[20]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 15.

[21]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 15-16.

[22]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 15-16.

[23]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 15-16 and Kreps, (1977): "A Note on Fulfilled Expectations Equilibria"; Journal of

to the interim Pareto efficiency of the initial allocation. This would make the buyer worse off; therefore the buyer won't be willing to buy the overpriced asset.[24]

In a situation with asymmetric information between investors the zero-sum argument still holds as long as investors have common priors.[25]
According to Brunnermeier the basic condition for a bubble to exist in such an environment is that the bubble is not commonly known to all investors.[26] Not every investor knows, that all the other investors also know that the price of an asset exceeds the value of a possible dividend stream. This condition allows a finite bubble to exist under the following necessary conditions, explained by Allen, Morris, and Postlewaite:[27]

"(i), it cannot be common knowledge that the initial allocation is interim Pareto efficient as mentioned above. That is, there have to be gains from trade or at least some investors have to think that there might be gains from trade. (ii), investors have to remain asymmetrically informed, even after inferring information from prices and net trades. This implies that prices cannot be fully revealing. (iii), investors must be constrained from (short) selling their desired number of shares in at least one future contingency for finite bubbles to persist".[28]
Other authors confirm that in addition to asymmetric information, short sale constraints or trading restrictions are necessary for rational bubbles to persist.[29]

Economic Theory, 14; 32-43.

[24]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16.

[25]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16.

[26]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16.

[27]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16 and compare Allen, Morris and Postlewaite, (1993): "Finite Bubbles with Short Sale Constraints and Asymmetric Information"; Journal of Economic Theory, 61(2); 206-229.

[28]Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16.

[29]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 16 or Morris, Postlewaite and Shin, (1995): "Depth of Knowledge and the Effect of Higher Order Uncertainty"; Economic Theory, 6; 453-467 or Conlon, (2004): "Simple Finite Horizon Bubbles Robust to Higher Order Knowledge"; Econometrica, 72(3); 927-936.

2.4. Overlapping Generations Frictions and Market Incompleteness

This section will be based on Brunnermeier and Oehmke (2012), Diamond (1965) and De Marzo, Kaniel and Kremer (2008). If additional references were considered it will be directly mentioned in the according footnote.

Samuelson developed a model in which a bubble can exist due to a friction, which is inherent in the structure of the underlying economic model: the model of fiat money in an overlapping generations (OLG) model.[30] Fiat money has an intrinsic value of zero, but can have a positive value in equilibrium.[31] Without fiat money a transfer of wealth is not possible in an overlapping generation model; it serves as a store value in such models.[32]

Diamond was the first to develop such a model. Diamond showed that in the competitive equilibrium, the interest rate is equal to the marginal productivity of capital; therefore, according to the golden rule, under the optimal allocation, the marginal productivity of capital is equal to the population growth rate.[33] Diamond proofs that in an overlapping generation model this is not necessarily the case. Capital accumulation can exceed the golden rule, which makes the marginal productivity of capital lower than the population growth rate which makes the economy dynamically inefficient; the only way to restore efficiency is by government debt.[34]

Recent literature deals with the additional introduction of borrowing constraints. Martin and Ventura built a model in which entrepreneurs are allowed to borrow only a portion of their future firm value.[35] In such an environment "...bubbles not only have a crowding out effect, but can also have a 'crowding-in' effect, and thus allow a productive subset of entrepreneurs to increase investments. Because of this crowding-in effect, bubbles can exist and increase effi-

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[30]Compare Samuelson, (1958): "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money"; Journal of Political Economy, 66(6); 467-482.

[31]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 17.

[32]Compare Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 17 or Diamond,(1965): "National Debt in a Neoclassical Growth Model"; American Economic Review, 55(5); 1126-1150 and Samuelson, P. A.(1958): "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money"; Journal of Political Economy, 66(6); 467-482.

[33]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 17 and Diamond (1965): "National Debt in a Neoclassical Growth Model"; American Economic Review, 55(5); 1126-1150.

[34]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 18 and Diamond,(1965): "National Debt in a Neoclassical Growth Model"; American Economic Review, 55(5); 1126-1150.

[35]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 17 and Martin and Ventura, (2011): "Economic Growth with Bubbles"; American Economic Review.

ciency, even if the economy absent the bubble is dynamically (constrained) efficient."[36]

Another model based on an overlapping generation model was created by DeLong, Shleifer, Summers and Waldmann in 1990.[37] This model is based on the relative price of two assets with an identical and deterministic cashflow stream.[38] Due to irrational noise traders the misspricing might go even further. It makes rational risk-averse arbitrageurs, with finite horizons, reluctant to take on positions that fully equate both. So that arbitrageurs only partially trade against the misspricing. "In this model, it is thus the combination of short horizons, risk aversion, and noise trader risk that allows the bubble to persist."[39]

Bubbles are still possible in a finite horizon of OLG models as DeMarzo, Kaniel, and Kremer showed in 2008.[40] They built a model in which different generations of investors form different cohorts. Markets are incomplete because unborn investors cannot trade with this generations of investors.[41] "This leads to a pecuniary externality that creates endogenous relative wealth concerns among agents. The intuition is that, within a generation, the utility of one agent depends on the wealth of other agents."[42] Wealthy, middle aged investors drive up asset prices and make it more expensive to save for retirement. This could lead to severe herding behaviour. Investors will imitate the portfolio choices of other agents in their cohort to avoid being poor. These relative wealth concerns cannot be eliminated throughout prior trade.[43] Still, future young investors benefit as borrowing costs go down.

"Relative wealth concerns make trading against the crowd risky and can generate incentives for investors to herd into the risky asset, thus driving up its price".[44] "Intuitively, investors are willing to buy an overpriced asset in order not to be priced out of the market in the next period."[45] DeMarzo, Kaniel, and Kremer show that, when investors are sufficiently risk averse,

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[36]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 17.

[37]Compare DeLong, Shleifer, Summers and Waldmann, (1990): "Noise Trader Risk in Financial Markets"; Journal of Political Economy, 98; 703-738.

[38]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 18 or DeLong, Shleifer, Summers and Waldmann, (1990): "Noise Trader Risk in Financial Markets," Journal of Political Economy, 98; 703-738.

[39]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 18.

[40]Compare DeMarzo,Kaniel and Kremer, (2008): "Relative Wealth Concerns and Financial Bubbles"; Review of Financial Studies, 21(1); 19-50.

[41]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19 or DeMarzo, Kaniel and Kremer, I. (2008): "Relative Wealth Concerns and Financial Bubbles"; Review of Financial Studies, 21(1); 19-50.

[42]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19.

[43]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19.

[44]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19.

[45]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19.

the risky asset can have a negative risk premium in equilibrium, even though its cash flow is positively correlated with aggregate risk.[46]

2.5. Informational Frictions

This section will be based on Brunnermeier and Oehmke (2012). If additional references were considered it will be directly mentioned in the according footnote.

As explained, rational investors sometimes are not able to eliminate an emerging bubble due to risk; according to Brunnermeier and Oehmke this risk can take two different forms: "First, there is fundamental risk: The fundamental value may jump unexpectedly, justifying the high price. In this case, investors that trade against the bubble turn out to be 'wrong' and lose money. Second, even if investors that lean against the bubble are 'right', they may lose money if the price of the asset temporarily rises further, temporarily widening the mispricing..."[47]

The second big class of frictions that make a bubble persist according to Brunnermeier and Oehmke are informational frictions. Abreu and Brunnermeier in 2003 show that for risk-neutral traders it can be even optimal to temporarily ride the bubble, so that they can increase their profit from an increase in the bubble asset.[48] This allows the bubble to grow larger and to delay its bursting. The uncertainty about the other rational investors and the fear of loosing money, caused by exiting the market, makes it profitable to ride the bubble for single investors. Only a group of investors exiting the market simultaneously can cause the bursting of the bubble.[49] In the next paragraph this model will be discussed in detail.

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[46]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19 or DeMarzo, Kaniel and Kremer, (2008): "Relative Wealth Concerns and Financial Bubbles"; Review of Financial Studies, 21(1); 19-50.

[47]Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19.

[48]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19 and compare Abreu and Brunnermeier, (2003): "Bubbles and Crashes"; Econometrica, 71(1); 173-204.

[49]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 19-20 and Abreu and Brunnermeier, (2003): "Bubbles and Crashes"; Econometrica,71(1); 173-204.
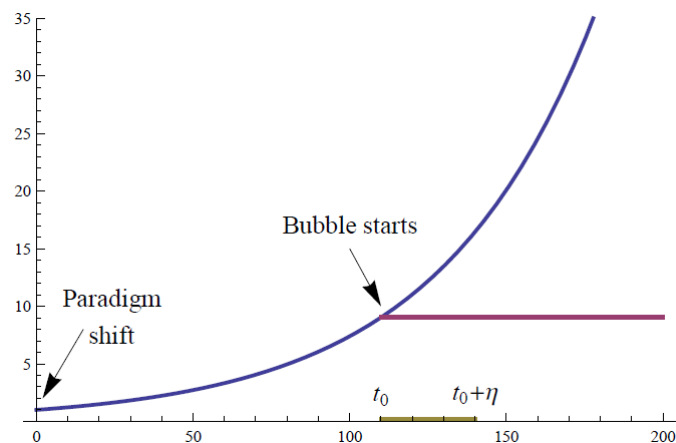
Figure 2.1.: Explosive bubble path and sequential awareness in the model of Abreu and Brunnermeier

In the model of Abreu and Brunnermeier the increase in prices "...is initially supported by an increase in fundamental value".[50]

Figure 2.1 shows that the fundamental value of the asset rises until $t = 110$. In this stage the bubble phase starts; the price starts to deviate from fundamental value.[51] According to Abreu and Brunnermeier from this point on "...individual traders become sequentially aware that the price is too high."[52] In Figure 2.1, the first investor starts to realize this at a pricelevel of $t = 110$ and the last one only at a level of $t = 140$.[53] "The key assumption is that each trader does not know when, relative to other traders, he learns about the bubble."[54] Therefore the starting point of his learning and the size of the bubble is not known to the investor.[55] This implicates that a trader who realizes the bubble at t = 110 calculates the fundamental lower than a trader who realizes the bubble state at a later point in time. Due to the sequential awareness it is never known to all investors in the market at the same time that a bubble has emerged.[56]

Furthermore in their model a synchronization problem arises because they assume that a single trader alone is not able to cause the bubble to burst; each trader tries to predict the

[50]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[51]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[52]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[53]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[54]Brunnermeier and Oehmke,(2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[55]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20 and compare Abreu and Brunnermeier (2003): "Bubbles and Crashes"; Econometrica,71(1); 173-204.

[56]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

crash but at the same point he still tries to ride the bubble as long as possible.[57]

One of the biggest findings of the theoretical work on synchronization risk was provided by Cutler, Poterba and Summers in 1989.[58] They found out that also a relatively insignificant event can trigger large price movements.[59]

2.6. Delegated Investment and Credit Bubbles

This section will be based on Brunnermeier and Oehmke (2012). If additional references were considered it will be directly mentioned in the according footnote.

Another big problem when it comes to bubbles is that most institutional investors do not invest their own money. Institutional investors finance their trades either by raising more equity, debt, or both. Often such investors are in charge of investing other people's money. People who give money to such institutions are unsure about the skills of the fund manager. Portfolio managers may take higher risks or they might buy bubble assets to increase their profits which could lead to a serious conflict.[60]

Allen and Gorton showed that professional fund managers can have an incentive to buy a bubble asset because if they would not, their clients could think that they have low skills and are not talented enough to define an undervalued assets.[61] These fund managers promote the bubble even further in the expense of their uninformed client investors. Furthermore such managers have limited liabilities. They do profit from a potential upside of a trade but won't be accounted for the downside. The classic risk-shifting problem arises.[62]

Nevertheless, "..delegated investing becomes a positive-sum game for bad fund managers, thus overcoming the zero-sum argument that usually rules out the existence of bubbles."[63] In equilibrium, good managers subsidize bad managers and investors on average earn their cost

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[57]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20 and compare Abreu and Brunnermeier (2003): "Bubbles and Crashes"; Econometrica, 71(1); 173-204.

[58]Compare Cutler, Poterba and Summers, (1989): "What Moves Stock Prices?"; Journal of Portfolio Management, 15; 4-12.

[59]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 20.

[60]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22.

[61]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22 and Allen and Gorton, (1993): "Churning Bubbles"; Review of Economic Studies, 60; 813-836.

[62]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22.

[63]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22.

of investment.[64] Also Sato concludes that the incentive to ride a bubble for a single investor is bigger than the incentive to correct the mispricing.[65]

Allen and Gale created a credit bubble model, which is based on the riskshifting argument: investors can borrow money from the bank to invest in a risk-free or/and in a risky asset.[66] They assume that borrowing can only take the form of debt. Furthermore the lending bank is not able to control investors fund allocation. The main goal of investors is to maximize their levered portfolio.[67] Investors, in such cases, have limited liabilities, if the value of their investment falls such that investors default and do not repay their debt to the bank.[68] Furthermore Allen and Gale show that "...the equilibrium price of the risky asset exceeds the equilibrium price in an economy in which the same amount of funds is invested directly, such that no riskshifting problem exists. In this sense, the model predicts that investment financed by credit can lead to bubbles."[69]

According to Jensen and Meckling a shift of risk can lead to serious distortions in a bubble phase[70]: fund managers that suddenly realize that they are under water due to their investment in an overpriced asset, may have incentives to "...double down"[71] or "...gamble for resurrection".[72] Gambling for resurrection could be rational for an individual fund manager, although it prolongs the bubble.[73]

[64]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22 and compare Allen and Gorton, (1993): "Churning Bubbles"; Review of Economic Studies, 60; 813-836.

[65]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22 and Sato, (2009): "Ranking Concerns of Fund Managers and the Persistence of Bubbles"; Working Paper, London School of Economics.

[66]Compare Allen and Gale, (2000): "Bubbles and Crises"; The Economic Journal, 110(460); 236-255.

[67]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 23.

[68]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 22.

[69]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 23.

[70]Compare Jensen and Meckling, (1976): "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure"; Journal of Financial Economics, 3(4); 305-360.

[71]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 23.

[72]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 23.

[73]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 23 and compare Jensen and Meckling, (1976): "Theory of the Firm: Managerial Behaviour, Agency Costs and Ownership Structure"; Journal of Financial Economics, 3(4); 305-360.

2.7. Heterogeneous-Beliefs Bubbles

This section will be based on Brunnermeier and Oehmke (2012). If additional references were considered it will be directly mentioned in the according footnote.

The last class of models is based on the idea of heterogeneous beliefs among investors in the market which, under certain circumstances, can generate bubbles.[74] Investors do belief different things and have different expectations based on prior belief distributions.[75] Furthermore investors can agree to disagree even after they shared all their information. This heterogeneous believs can cause a serious overpricing of securities in the market in combination with short-sale constraints.[76] Optimistic traders push asset prices up, pessimists are not able to balance it because they are not allowed to short-sale the asset.[77]

In the next section a closer look on a dynamic model, provided by Harrison and Kreps in 1978, to explain this phenomenon will be taken.[78] In a dynamic model with heterogeneous beliefs the price of an asset can exceed the valuation of the most optimistic investor in the economy. This is possible due to the fact that the currently optimistic holder of the asset has the option to resell this asset in the future, at an even higher price.[79] The critical assumption of the model says that less optimistic investors are not allowed to short the asset. [80]

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[74]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24.

[75]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24.

[76]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24.

[77]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24 and compare Jensen and Meckling, (1976): "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure"; Journal of Financial Economics, 3(4); 305-360.

[78]Compare Harrison and Kreps, (1978): "Speculative Investor Behaviour in a Stock Market with Heterogeneous Expectations"; Quarterly Journal of Economics, 89; 323-336.

[79]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24 and compare Harrison and Kreps (1978): "Speculative Investor Behaviour in a Stock Market with Heterogeneous Expectations"; Quarterly Journal of Economics, 89; 323-336.

[80]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24 and compare Harrison and Kreps, (1978): "Speculative Investor Behaviour in a Stock Market with Heterogeneous Expectations"; Quarterly Journal of Economics, 89; 323-336.
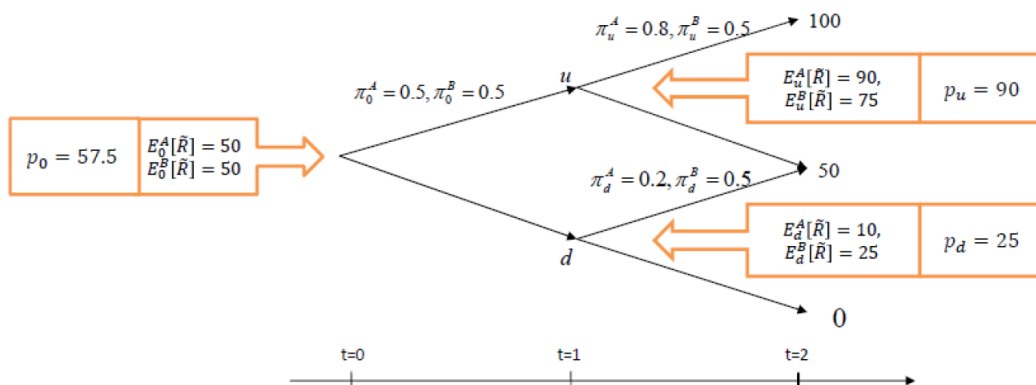
Figure 2.2.: A simple economy with heterogeneous beliefs.

Figure 2.2 provides the simple model by Harrison and Kreps in 1978: there are two traders, A and B. These trader do have heterogeneous beliefs π^A and π^B. [81] "Both traders value the asset at $E_0^A[v] = E_0^B[v] = 50$ if they have to hold it until $t = 2$. However, if they have the option to resell the asset in $t = 1$; this changes. Trader B now anticipates that he can sell the asset to investor A, in the up-state, u, where investor A is an optimist. Vice versa, A expects to sell the asset to B in the down-state, d, where B is an optimist. Taking into account this option to resell, both investors are willing to pay $p_0 = 57,5$ at time $t = 0$, even though they both expect the asset to pay off only 50. The price of the asset thus exceeds even the most optimistic agent's valuation of the asset."[82]

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[81]Compare Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 24-25.

[82]Brunnermeier and Oehmke, (2012): "Bubbles, Financial Crises, and Systemic Risk"; NBER Working Paper No. 18398; 25.

3. History

In this section a historic overview on some of the bubbles which formed and bursted in economic history will be given. In the first part three historical bubbles will be presented; after that the focus will be on the last fifteen years in order to show that bubbles became a very common feature in the world economy in recent history. I won't go into detail on how they happened and why they happened. For the purpose of this thesis it is just important that the reader recognizes that bubbles were and are a common economic feature.

Bubbles caused huge economic problems all around the world. Therefore finding an effective way to detect future bubbles, the purpose of my thesis, is more than necessary.

    In the first part the oldest documented bubble will be described: the Dutch Tulip Mania. The Dutch Tulip Mania affected the prices of Tulip bulbs, which became incredible high in the 1630s.[1]

In the second part the South Sea Bubble will be explained; another example of a historical bubble.[2]

In the third part the biggest historic bubble will be explained: the development in the US in the 1920s which led to the huge stock market crash of October 1929. One of the sharpest and most abrupt collapses in the stock market history, which then swapped over to the real economy and caused a severe recession in the 1930s.[3]

In the fourth section the first fifteen years of the new millennium will be explained which, as will be explained, were a sequence of bubbles. The results will be summarized in the last part.

    This part is based on the work of different authors. All literature sources can be found in the Bibliography. If additional references were considered it will be directly mentioned in the according footnote.

    The scope of this part is to give a short overview of passed bubbles. The reader should understand that bubbles are a common feature in our economical history. For the interested reader additional sources of information on the single bubbles are directly mentioned in the according section- footnotes.

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[1]Compare Van der Veeen, (2009): "The Dutch Tulip Mania:The Social Politics of a Financial Bubble"; Department of International Affairs,University of Georgia; 1-10.

[2]Compare Temin and Voth, (2004): "Riding the South Sea Bubble"; Forthcoming, AER; 5-9.

[3]Compare Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 17-20.

3.1. The Dutch Tulip Mania

This section will be based on Van der Veen (2009). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The best-documented oldest example of early bubbles is the world famous Dutch Tulip Mania from 1634 until 1637.[4] Tulip mania, as the name says, was a period in the Dutch Golden Age, in which the prices for the shortly introduced bulbs of tulips reached extraordinarily high levels and then suddenly collapsed.[5]
Around 1630 Tulips were imported to Holland, where they became fashion until they became an expensive luxury good. In the 1630s a virus, known as mosaic virus, afflicted the tulips and caused the tulip bulb to change color, making it look like flames. Merchants started to speculate on tulips bulbs, by buying huge amounts in one season and reselling them in the next season. Prices went through the roof. A price of a single tulip bulb reached four times the income of a ship worker in Holland by the time.[6] The bubble grew so big that Tulip bulbs became the fourth leading export product of the Netherlands. In 1637 merchants began to significantly sale their tulips. Panic began to spread and massive selling took place. The government tried to stop the sells through positive propaganda and some repurchases but it was worthless.[7] Over a short period a tulip ended up being worth the same as an onion.[8]
The first recorded speculative bubble in our history was born.[9]

3.2. The South Sea Bubble

This section will be based on Temin and Voth (2004). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The South Sea Company was one of the most prestigious businesses in the 1720s in Britain. Owning stocks was considered a privilege. To restore faith in the beleaguered government's credit worthiness the South Sea Company bought ten million pounds of government debt in

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[4]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; Abstract.

[5]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

[6]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

[7]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

[8]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

[9]Compare Van der Veen, (2009): "The Dutch Tulip Mania: The Social Politics of a Financial Bubble"; Department of International Affairs, University of Georgia; 1-10.

1720.[10] In exchange it was given the monopoly over all trade to the South Seas. When Britain ended the war over the Southsea and started to exchange gold and silver for cotton and woollen goods, investors started to predict huge future earnings for the company. Furthermore, the directors of the company offered to fund the entire national debt, amounting to 31 million pounds, shortly after the monopoly was given.[11]

This fact initiated the speculation on the stock price.
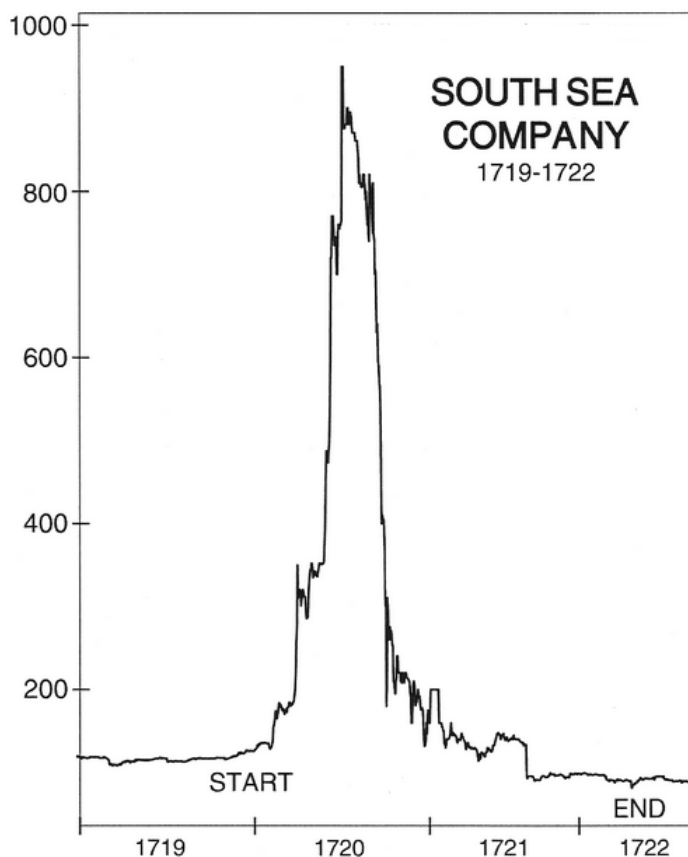
Figure 3.1.: The South Sea Company stock price

The stock promptly rose from 130 to 300 pounds. Five days after, there was a new issue of stock at 300 pounds. The issue could be bought 60 pounds down and the rest in eight easy payments. There was a huge excess in demand, and the price increased even further reaching 340 pound within days. The company announced another new issue of stock at a price of 400 pounds, and there was still an excess demand among the public. Within a month the stock was 550 pounds, and still going up. Eventually, the price rose nearly up to 1000 pounds. At that point directors and officers decided to sell their participations during the summer. As this news hit the market the stock fell, panic set in and the price eventually collapsed.[12]

Figure 3.1 shows the stock price evolution of the South Sea Company stock in these years.

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[10]Compare Temin and Voth, (2004): "Riding the South Sea Bubble"; Forthcoming, AER; 4-9.
[11]Compare Temin and Voth, (2004): "Riding the South Sea Bubble"; Forthcoming, AER; 5-6.
[12]Compare Temin and Voth, (2004): "Riding the South Sea Bubble"; Forthcoming, AER; 5-9 and 23.

3.3. The 1920s U.S Stock Market Bubble

This section will be based on different publications by different authors. A big part was based on Mishkin and White (2002) and on Malkiel (1973). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The most spread explanation for what happened in the stock market during this decade is that a huge bubble was formed during the rapid growth of the 1920s together with an irrational element and an expansion of credit in the form of broker loans that additionally leveraged investors.[13] This facts led to the stock market crash of October 1929, which "...was one the sharpest and most abrupt collapses."[14] "On two days October 28-29, the Dow Jones fell a total of 24 percent, down 19.6 percent for the month and down a further 22 percent in November."[15] Although there was a short and mild recovery in the early 1930,the whole economy of the United States and later the worldeconomy continued shift down for the next two years, producing the severest long term market decline in our economic history.[16]
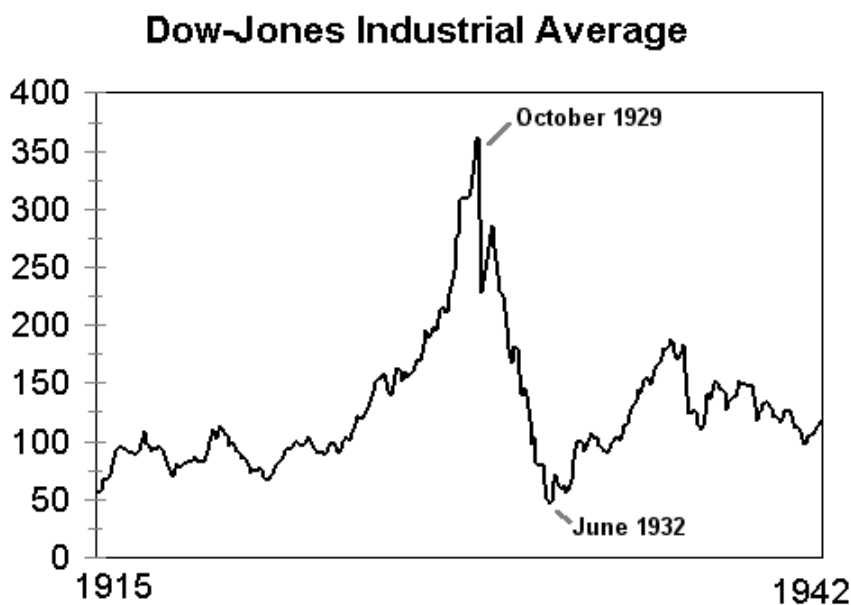
Figure 3.2.: The Big Crash of 1929

In this next section a closer look on what happened in the 1920s will be taken.
In the 1920's the US experienced great economic conditions. A lot of new large commercial and

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[13]Compare Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 17.

[14]Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 17.

[15]Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 18.

[16]Compare Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 18.

industrial enterprises were formed and started to grew very fast. The whole investment banking sector was created during this time. Both, new and old corporations, issued massive amounts of equity to finance their new plants and their needed equipment. "Between 1922 and 1929, America's real GNP grew at an average annual rate of 4.7 percent, and the unemployment rate fell from 6.7 percent to 3.2 percent."[17]

In July 1929 the Federal Reserves Index of Industrial Production began to fall. In August and September, some other indices of the Federal Reserve began to drop as well. These data arrived to the market during a period of a rise in real interest rates in the U.S and European countries: these two factors forced stockholders to dramatically change their expectations; sales began to raise and the collapse began to took place step by step.[18]

"The stock market crash of October 1929 was one of the sharpest and most abrupt collapses."[19] It led to a period of deep recession commonly known as the Great Depression.

3.4. The first fifteen Years of the New Millennium

This section will be based on different publications by different authors. A big part was based on Sornette and Woodard (2010) and on The Squam Lake Report (2011). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The first 10 years of the New Millenium were characterised by a series of bubbles. In this section a brief overview of these years and a short explanation of the happened events during that time will be given.

3.4.1. The Internet Bubble

The Internet Bubble or Dot.com Bubble is the biggest stock-market bubble of all time. Its burst in March of 2000 caused over 5 trillion Dollars of market value losses.[20]

At the end of the 1990s the Internet represented a new technology, it offered new business opportunities that promised to revolutionize the world. Investors were willing to throw their money at almost any business that had a connection with the Internet. Without doubt the bubble also encouraged a large number of useful new technology start ups, but it also encouraged

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[17]http://www.discoverthenetworks.org/viewSubCategory.asp?id=310; 14.07.2014; 17:02.

[18]Compare Malkiel, (1973): "A random Walk Down Wall Street: the time tested strategy for successful investment"; W. W. Norton and Company,Inc.; 5.

[19]Mishkin and White, (2002): "U.S. Stock Market Crashes and their Aftermath: Implications for Monetary Policy"; Working Paper 8992; National Bureau of Economic Research; 17.

[20]Compare http://ac360.blogs.cnn.com/2009/11/24/the-dot-com-bubble-how-to-lose-5-trillion/; 14.07.2014; 17:07.

vast misallocation of resources over the whole economy.[21] Most of the new companies were not viable and went bankrupt after the big burst. During the bubble over a trillion dollar was poured into telecommunication investments.[22] Still the bursting of the dot-com bubble led to a relatively short and mild recession in economic activity.
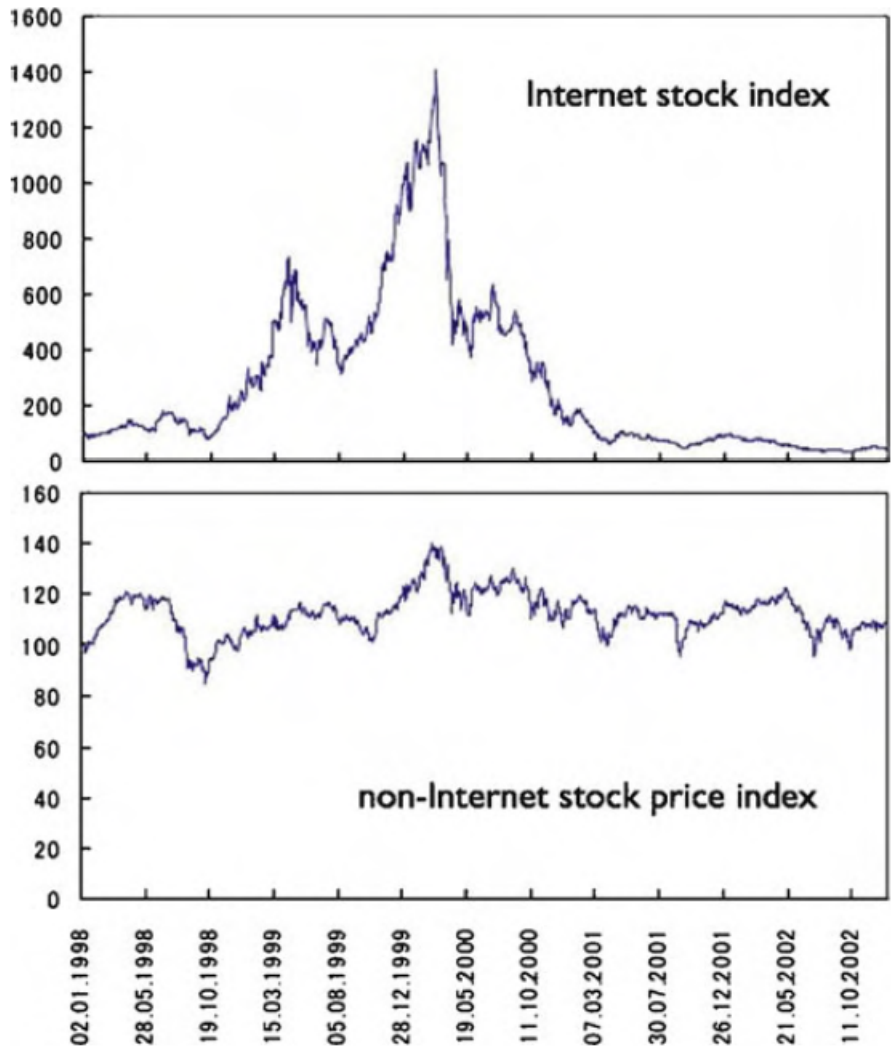
Figure 3.3.: The Dot.com Bubble

Figure 3.3 shows that the non-Internet stock price index remained basically flat from 1998 to 2002. "In contrast, the Internet stock index was multiplied by factor 14 from 1998 to its peak in the first quarter of 2000, and then shrunk with a great crash followed by a jumpy decay to below its initial value at the end of 2002. The contrast between the behaviour of these two indices over the same 4-years interval cannot be more shocking."[23]

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[21]Compare Sornette and Woodard, (2010): "Financial Bubbles, Real Estate Bubbles, Derivative Bubbles, and the Financial and Economic Crisis"; Econophysics Approaches to Large-Scale Business Data and Financial Crisis; 127.

[22]Compare http://www.forbes.com/sites/steveschaefer/2012/04/13/bernanke-on-why-the-subprime-blowup-was-so-much 14.07.2014; 17:16.

[23]Sornette and Woodard, (2010): "Financial Bubbles, Real Estate Bubbles, Derivative Bubbles, and the

3.4.2. The Years between 2003 and 2007

After the crash of the Dot.com bubble the Federal Reserve Bank of the US decreased the Fed rate to provide cheaper money to the system. In general a lowering of the Fed rate makes borrowing cheaper, giving more leverage to firms to invest for the future. The goal of the Fed by the time was to boost the economy by cheap credit and thereby guarantee future growth.[24]

Afterwards the Fed was often attacked that this monetary policy has been influenced significantly by the troubles of the stock market. Fed Chairman A. Greenspan, in 2003, argued that the Fed needed to set low interest rates to prevent the US economy from deteriorating so much that it would follow a deflationary spiral, often referred to as a liquidity trap, a situation in which conventional monetary policy loses all traction.[25] Greenspan's critics continue to debate about the influence of the exceptionally low Fed rates in 2002 and 2003; according to them, the low fed fund rate was the biggest cause for the following real estate bubble.[26]
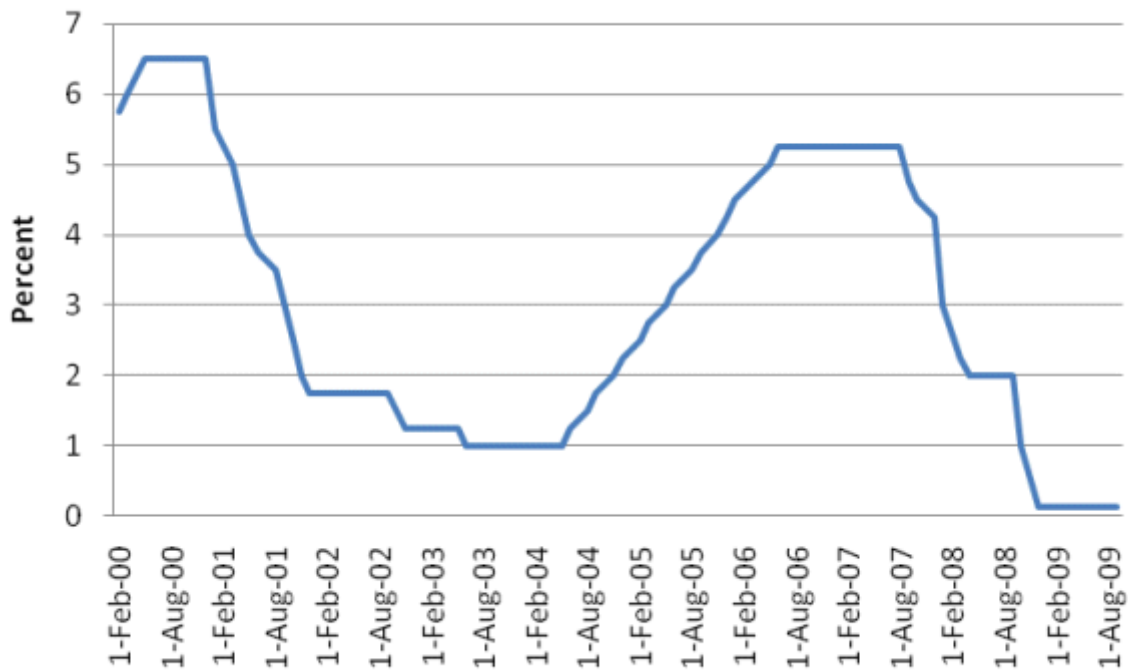
Figure 3.4.: The Fed Fund Rate

Financial and Economic Crisis"; Econophysics Approaches to Large-Scale Business Data and Financial Crisis; 127.

[24]Compare Holt, (2009): "A Summary of the Primary Causes of the Housing Bubble and the Resulting Credit Crisis: A Non-Technical Paper"; The Journal of Business Inquiry 2009, 8, 1; 120-129.

[25]Compare Holt, (2009): "A Summary of the Primary Causes of the Housing Bubble and the Resulting Credit Crisis: A Non-Technical Paper"; The Journal of Business Inquiry 2009, 8, 1; 122-124.

[26]Compare Compare Holt, (2009): "A Summary of the Primary Causes of the Housing Bubble and the Resulting Credit Crisis: A Non-Technical Paper"; The Journal of Business Inquiry 2009, 8, 1; 122-124.

Of course the great real estate and leverage bubble is not totally the Feds fault. The literature names different reasons for the building of the bubble: Relaxed standards for mortgage loans, irrational exuberance, higher risk-taking by financial institutions, greed and the introduction of new financial products are just some of these.[27]

In my work I don't want to go in to detail about the causes and events of the great real estate and leverage bubble. For the purpose of this thesis its just important to give the reader a general overview of the happened events during that time.

3.4.3. The Great Real Estate and Leverage Bubble of 2007

After the Dot.com bubble burst banks changed their way of providing mortgages loans to individuals: in the past banking institutions would give mortgage loans to individual home owners and then keep those loans as assets on their books. This would results in a loss for the bank if a single home owner would not be able to repair its loan. During the 2000s this system changed: "Banks would continue to originate mortgage loans but would hold them for only a brief period of time, after which they would be sold to an investment banking institution, which would package the mortgages into mortgage-backed securities. The mortgage-backed securities themselves would be sliced into various 'tranches'. The first (or senior) tranches,would have first claims on principal and interest payments, and the lower tranches would have only residual claims. Through this system, by a kind of alchemy, the investment banks would produce very highly-rated securities on the senior tranches, even though the underlying mortgages might have been of relatively low quality (so-called sub-prime mortgage loans). This system led to a deterioration in lending standards. If the originating institution was only holding the mortgage for a few days, the lending officers were far less careful to ensure the credit worthiness of the borrower of the mortgage debt instrument over the long term. As originators, banks were joined by other lenders, especially mortgage-finance companies."[28] Furthermore the federal government sponsored enterprises, such as the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation, and therefore encouraged originators to make credit available to borrowers with less than perfect credit.[29] The result was a "...vast additional sums of money available for the purchase of housing"[30] and an increasing amount of

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[27]Compare Holt, (2009): "A Summary of the Primary Causes of the Housing Bubble and the Resulting Credit Crisis: A Non-Technical Paper"; The Journal of Business Inquiry 2009, 8, 1; 120-129 or "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Blundell-Wignall, Atkinson and Lee, (2008): "The Current Financial Crisis: Causes and Policy Issues"; Financial Market Trends, OECD 2008; 1-13.

[28]Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 12.

[29]Compare Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 12.

[30]Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 12.

debt carried by consumers.[31]

A further problem at the time was, that financial institutions tended to carry a far lower equity reserves than in previous years with a correspondingly large increase in debt.[32] Moreover, a substantial share of the debt was short-term rather than long-term, subjecting these institutions to the possibility that they would be unable to roll over their indebtedness during a time of crisis.[33] All this led to an enormous bubble in the real estate market. Prices of houses exploded.[34] Between 2000 and 2006 home prices nearly doubled as shown in Figure 3.5.
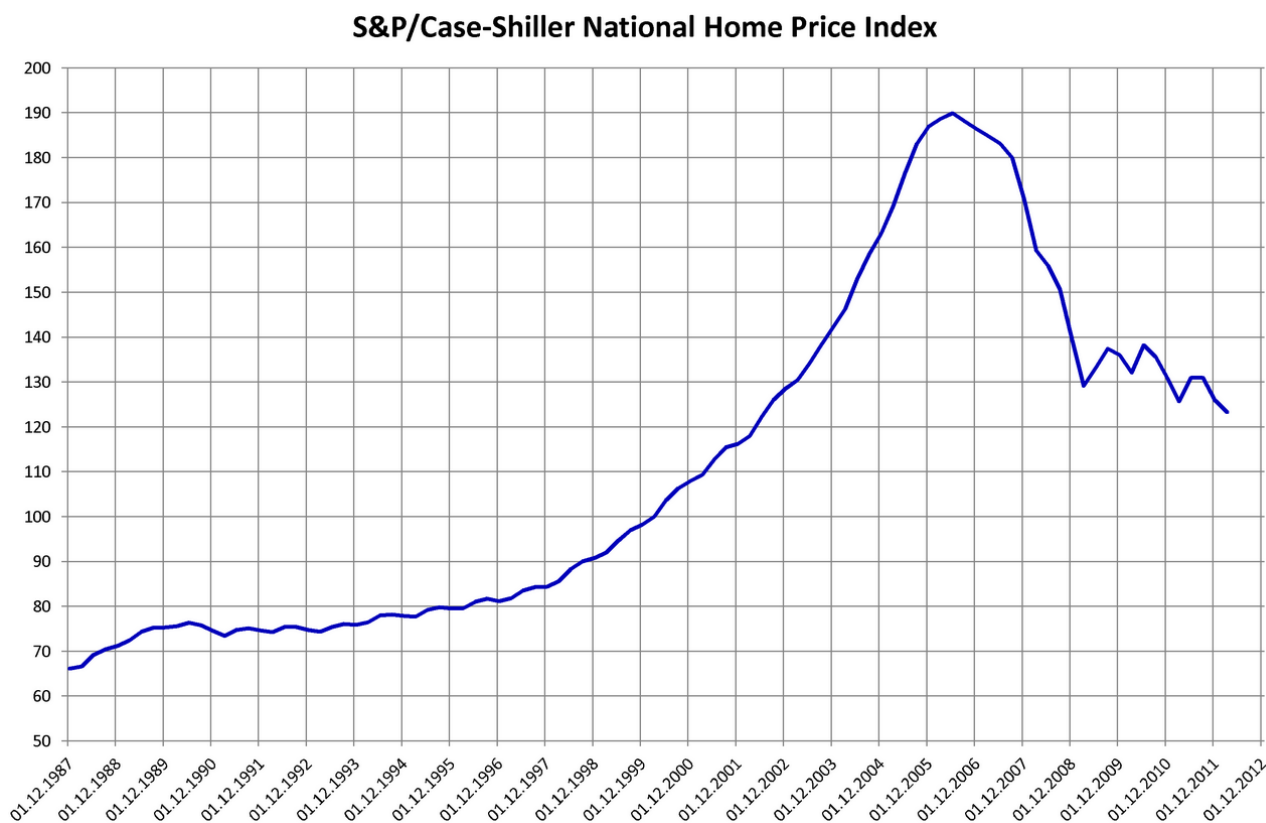
Figure 3.5.: The Case-Shiller Index

But then, as figure 3.5 shows, in the last quarter of 2005 house prices began to reverse. The bubble began to burst. The decline in prices had huge influence on the market. Many homeowners found out that due to the price drop their houses were worth less than the amount of the money owed on their mortgage. Defaults began to spread and some homeowners simply

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[31]Compare Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 12.

[32]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner, (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[33]Compare "The Squam Lake Report: Fixing the Financial System", 2010; Princeton University Press or Helleiner,(2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[34]Compare Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 11-13.

returned their keys to their houses to the lenders which allowed them to legally stop servicing their loans. [35]

This caused a decrease in the value of the vast amounts of mortgage-backed securities (MBS). Due to this also the MBS-sector was in a huge bubble by that time, as Figure 3.6 shows.
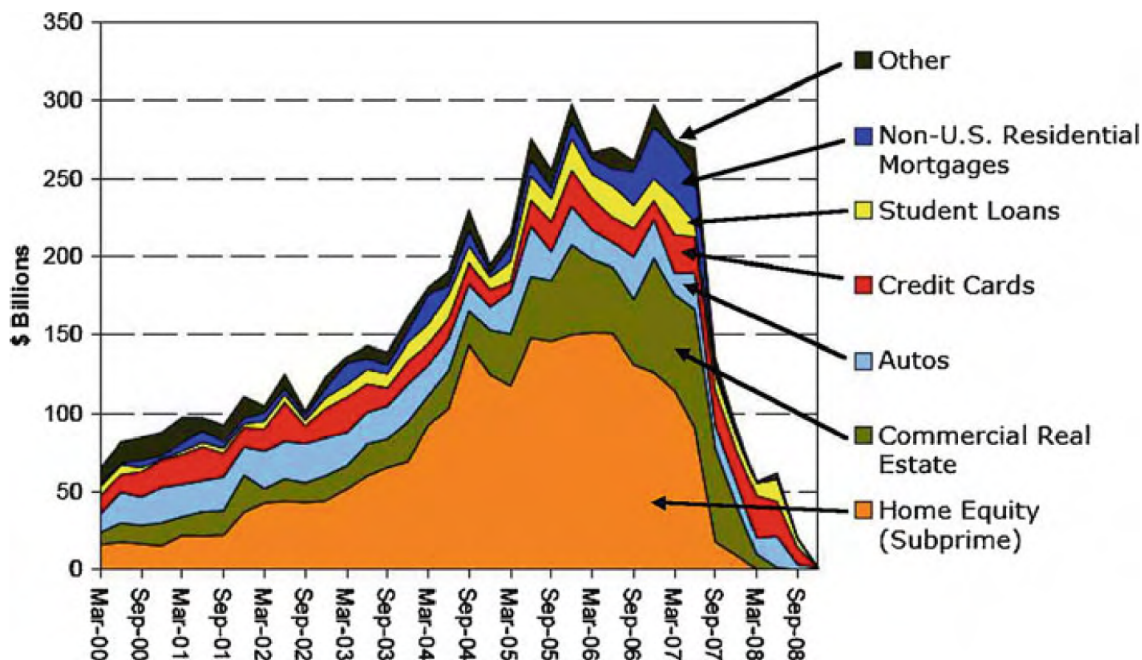
Figure 3.6.: The Asset Backed Securities Market

Figure 3.6 shows the total holding of mortgage related securities of different financial institutions until the peak in March 2007. In 2007 the first signs of accelerating loan payment defaults started to be felt on the MBS market. The bursting of the built bubble began.[36]
Many of the MBS were unstable, since they were linked to two key unstable processes: the value of houses and the loan rates; furthermore MBS and collateral debt obligations (CDO) written on them constituted new types of derivatives.[37] Due to their complexity and the lack of experience, investors may have provided the seed for unrealistic expectations of low risks and large returns.[38] Since these complex securities were mainly held by highly leveraged institutions during the bust a major panic ensued. All credit markets froze up and institutions

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[35]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[36]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner, (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[37]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[38]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

became unable to roll over their short-term indebtedness.[39]

The bursting of the the great real estate and leverage bubbles caused a series of negative events in the economic history of the world, which led to a deep global recession.[40]

3.5. Summary

The overview of historical bubbles clarifies that bubbles and their bursting are common features in our economic history. Bubbles are no black swan events[41], but an inherent part of capitalism. In all stages of our history bubble bursts were followed by severe disruptions in real economic activity, as discussed, which in some cases even led to severe recessions. Furthermore Malkiel stated that "bubbles are particularly dangerous when they are associated with a credit boom phase and widespread increases in leverage for both consumers and financial institutions."[42] Moreover, "credit boom bubbles are the ones that pose the greatest danger to real economic activity." [43]

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[39]Compare "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[40]I wont go into details here, because an analysis of those events would go beyond the scope of my thesis. For further information read: "The Squam Lake Report: Fixing the Financial System"; 2010, Princeton University Press or Helleiner (2011): "Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy"; Annu. Rev. Polit. Sci. 2011, 14; 67-87.

[41]The term black swan was created by Nassim Nicholas Taleb in his book: "The Black Swan: The Impact of the Highly Improbable Fragility"; Random House; 2007.

[42]Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 14.

[43]Malkiel, (2010): "Bubbles in Asset Prices"; Princeton University, CEPS Working Paper NO. 200; 14.

4. Bubble Test History

In the first two section of this thesis was explained that bubbles do not only exist, but even are a common feature in our economic history. It was discussed what bubbles are and how they can emerge. This section will focus on their detection.

This part of my work is based on the work of different authors. All literature sources can be found in the Bibliography. If additional references were considered it will be directly mentioned in the according footnote.

The structure of this chapter follows the structure of Weites and von Maravic (2010.)

In the first part of the chapter a short overview of the eight most famous and valid econometric models for bubble detection of the past 40 years will be given. After explaining them it will be shown that all these models have certain limitations and shortfalls, which will be explained based on the individual empirical results of each test.
The first economist, who actually started to test bubbles econometrically, was Robert Shiller in 1979, followed by Le Roy and Porter in 1981.[1] Shiller, as first, introduced an easy detection model based on the present value of stock prices. Like common economic literature Shiller assumed, that the price of a stock is based on the value of the future expected dividend payments. He designed its test to test if the efficient market hypothesis and the present value model do hold in the real world.[2] The first economists who used this model to detect bubbles in the market were Blanchard and Watson in 1982.[3] A lot of different models diverge from the original one by Shiller but they all follow the same pattern. All these kinds of test can be grouped under the category of variance bounds tests. [4]

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[1]Compare Le Roy and Porter, (1981): "The present-value relation: tests based on implied variance bounds"; Econometrica, 49; 555-574 and Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; American Economic Review, 71; 421-436.

[2]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; American Economic Review, 71; 421-436.

[3]Compare Blanchard and Watson, (1982): "Bubbles, rational expectations, and financial markets"; NBER Working paper, No. 945; 14-22.

[4]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 10-14.

4.1. The Variance Bounds Tests

This section will be based on Shiller (1981), Malkiel (2010) and other authors. If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

According to Shiller the price of a stock in the market is "...formed as the present value of subsequent detrended real dividends..."[5] The future estimated dividend payments are based on the efficient market model. Shiller examines if there is a dependence between the variance of a stock and the variance of the dividends.[6]:

$$p_t^* = \sum (1/1 + r)^i * d_{t+i} \tag{4.1}$$

Where the stock price p_t is formed as the expected value of the ex post rational price:

$$p_t = E_t * p_t^* \tag{4.2}$$

The stock price, p_t, is the optimal forecast of the rational price, p_{t*}. The error made due to prediction is the difference between the actual price and the forecasted price:[7]

$$u_t = p_t^* - p_t \tag{4.3}$$

The forecast is not correlated with the error term, which means that the covariance between the actual price and the error term must be zero; therefore the variance of the uncorrelated variables equals the sum of their variances.[8]

$$var(p^*) = var(u) + var(p) \tag{4.4}$$

Due to the fact that variances cannot be negative and according to the basic economic theory, it can be said that "...the variance of the actual price cannot exceed the variance of the ex post rational price."[9] Therefore:

$$var(p) \leqslant (p^*) \tag{4.5}$$

This is the crucial assumption of the test.

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[5]Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; Abstract.

[6]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 1-5.

[7]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 2.

[8]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 2-3.

[9]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 12.

Blanchard and Watson stated that this assumption is violated, if the variance of the stock is larger than the variance of the ex post rational price; if this is the case, then market prices are no longer driven by fundamental values: the stock is in a bubble-situation.[10] This is the oldest and most basic econometric bubble detection test.

The biggest problem of the Variance Bounds Test are the ex post rational price and the choice of an adequate discount rate. [11]

As mentioned in the section before, the ex post rational price is based on the present value of future dividends.[12] The choice of the appropriate discount rate is the second big issue of the test: Shiller, in his test, used a constant discount rate, which of course, in fact, is not constant over time.[13] He applied the test on the Standard and Poor's Composite Stock Price Index for a period of 108 years from 1871 until 1979.[14] Shiller found out that the variance of stock prices differs much more than expected from the dividend variance. Dividends appear to be a smooth time series, whereas stock prices are much more volatile. Therefore the variance bound is clearly violated. This deviation in variances according to Shiller clearly reflects a bubble-state.[15]

Shillers Variance Bounds test model suffered some critique as bubble detection test over the last decades. In 1986 and 1994 Flood, Hodrick and Kaplan declared strong concerns about the adequacy of the test to detect bubbles. According to them the test is based on the fundamental value of the past actual outcomes and does not incorporate past agents beliefs about future alternations.[16] According to them, the test could conclude that there is a bubble state due to the non-observability of some variables; consequently they conclude that there is no evidence of bubbles based on this test.[17]

Similar critique can be found in Hamilton and Whiteman in 1986.[18]

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[10]Compare Blanchard and Watson, (1982): "Bubbles, rational expectations, and financial markets"; NBER Working Paper 945; 17.

[11]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 13.

[12]Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; Abstract.

[13]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 1.

[14]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 4.

[15]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; NBER Working Paper 456; 21-22.

[16]Compare Flood, Hodrick and Kaplan, (1986): "An evaluation of recent evidence on stock price bubbles"; NBER Working Paper no. 1971; 11-14.

[17]Compare Flood, Hodrick and Kaplan, (1986): " An evaluation of recent evidence on stock price bubbles"; NBER Working Paper no. 1971; 11-14 and Flood, Hodrick and Kaplan (1994): "An evaluation of recent evidence on stock price bubbles", in Flood and Garber: "Speculative Bubbles, Speculative Attacks, and Policy Switching"; 105-133.

[18]Compare Hamilton and Whiteman, (1985): "The observable implications of self-fulfilling expectations";Journal of Monetary Economics, 16; 353-373.

4.2. West Bubble Test of 1987

This section will be based on West (1987). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

A second test for detecting bubbles was proposed by West in 1987.[19] The Null-hypothesis of the test says that the stock price is formed by the efficient market model, developed by Brealey and Myers in 1981.[20] The alternative hypothesis, based on the theory by Blanchard and Watson, states that the stock price is formed by the efficient market model and an additional speculative bubble component.[21]

West defines two different ways on how to determine the expected discounted value on past and present dividends and then compares them.[22] The first way of determine them is based on a regression of the stock prices on lagged dividends; the second one is based on a discount rate and a so called ARIMA equation: an Autoregressive, Integrated Moving Average function for estimating dividends.[23] West states that H_0 and H_1 should lead to the same result, although H_1 does not account for the bubble. In the Null-hypothesis the estimated coefficients will be inconsistent if the bubble is correlated with the regressors; in the alternative hypothesis the bubble won't have this effect.[24]

Wests bubble test is formed as follows: the Null-hypothesis consists of the stock price, p_t, the dividend, d_t, the discount factor, b and the correlated error term, u_t.

$$p_t = b(p_{t+1} + d_{t+1}) - b[p_{t+1} + d_{t+1} - E(p_{t+1} + d_{t+1} \mid I_t)] = b(p_{t+1} + d_{t+1}) + u_t \qquad (4.6)$$

From this equation the discount factor, b, will be determined.

The values of p_t and p_{t+1} are determined by a no arbitrage condition. The next step is to determine the expected dividends from an ARIMA process:[25]

$$d_{t+1} = \mu + \phi_1 d_t + ... + \phi_q d_{t-q+1} + u_{t+1}. \qquad (4.7)$$

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[19]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 553-580.

[20]Compare Brealey and Myers, (1981): "Principles of corporate finance", McGraw-Hill Book Co.,New York.

[21]Compare Blanchard and Watson, (1982): "Bubbles, rational expectations, and financial markets"; NBER Working Paper 945; 26.

[22]Compare West,(1987): "A specification test for speculative bubbles", Quarterly Journal of Economics,August 1987; 555-561.

[23]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics,August 1987; 555-561.

[24]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 555-561.

[25]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 557.

In order to determine p_t by using expected future dividends an OLS equation is formed:

$$P_t^f = \sum_{i=1}^{\infty} (1/1+r)^i E_t(d_{t+1} \mid \Omega_t) = \overline{\beta} d_t. \tag{4.8}$$

where

$$\overline{\beta} = [\phi/(1+r)]/[1 - \phi/(1+r)] \tag{4.9}$$

and then regressed on present and past dividends:

$$P_{t=\alpha+\beta_{tdt+\varepsilon_t}}. \tag{4.10}$$

The regression compares the beta values from equation(4.8) and equation (4.9). If the betas have the same value, then the stock price is determined only by its fundamental value.[26]
West applied his model on the Standard and Poors Composite Stock Price Index over the period from 1871 to 1980 and the Dow Jones Index from 1928 until 1978. He proved that equation (4.6) and equation (4.7) do hold over the period, but also that the estimated coefficients of equation (4.8) differ from the ones estimated in equation (4.6) and equation (4.7).[27] According to West this means that bubbles exist although in his work he did not discover any bubble evidences with varying discount rates.[28]

Also Wests model is not free of assumptions. Gurkaynak criticised it in 2008. First, according to Gurkaynak, West based his test on a non stationary time series, which is very hard to detect with certainty and secondly, the model predicts future dividends based on values of past dividends; investors in the real market take in consideration much more factors to predict future earnings and dividends.[29]
Dezbaksh and Demirguc-Kunt in 1990 pointed out that the Hausmann-test, used by West to reject the Null-hypothesis, favours a rejection of the Null. Applying other tests they get different results.[30]
Still it appears obvious that changes in the assumptions, another significance test or allowing the discount rate to vary over time, can deliver a completely other result.

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[26]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 561-565 and Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 14-15.

[27]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 565-570.

[28]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 577 and 578.

[29]Compare Gurkaynak,(2005): "Econometric tests of asset price bubbles: taking stock"; Finance and Economics Discussion Series Divisions of Research and Statistics and Monetary Affairs Federal Reserve Board Washington, D.C.; 11-17.

[30]Compare Dezbakhsh and Demirguc-Kunt, (1990): "On the presence of speculative bubbles in stock prices"; Journal of Financial and Quantitative Analysis 25, 1; 101-112.

4.3. Diba and Grossman Bubble Test

This section will be based on Diba and Grossmann (1988). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The Bubble-test designed by Diba and Grossman in 1988 is based on stationary properties of the stock and its fundamentals; the model tests if there is a relation between the stock price and the dividends.[31]

Diba and Grossmans bubble test is formed as follows: the test states a relation between the current stock price and the present values of the next periods expected stock price, the next periods dividends and an unobservable variable.[32]

$$P_t = (1 + r)^{-1} E_t(P_{t+1} + \alpha d_{t+1} + u_{t+1}). \tag{4.11}$$

The stock price at time t is related to a constant interest rate, denoted by r, a constant that gives a relation between the expected dividends relative to expected capital gains, denoted by α, a future dividend, denoted by d_{t+1} and an error term, denoted by μ_{t+1}. Therefore the fundamental component of the stock according to Diba and Grossman can be defined as:[33]

$$F_t = \sum_{j=1}^{\infty} (1 + r)^{-j} E_t(\alpha d_{t+j} + u_{t+j}). \tag{4.12}$$

The stock-price in time t is therefore composed by the fundamental value plus the additional bubble component:[34]

$$P_t = B_t + F_t. \tag{4.13}$$

This process follows a stochastic difference equation:[35]

$$B_{t+1} - (1 + r)B_t = z_{t+1}. \tag{4.14}$$

If z is not zero a bubble exists.[36]

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[31]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER Working Paper 1779; 5-7.

[32]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 5.

[33]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 5-6.

[34]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 6.

[35]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 6.

[36]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 6-9.

Diba and Grossman empirically tested their model on a dataset published in 1988. They found out, that in the used dataset no explosive rational bubbles exist in the stock market.[37] Also Diba and Grossmans model was criticised by other economists. Again, the results strongly depend on the test applied to detect the bubble situation. Furthermore, according to Weites and von Maravic, it could be that the assumptions of stationarity of the unobservable variable is wrong.[38]

In addition since the test is based on analysing the stationarity properties of stock prices and dividends, it only can be applied over a longer period of time.[39]

4.4. Froot and Obstfeld Bubble Test

This section will be based on Froot and Obstfeld (1991). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Froot and Obstfeld designed a bubble test in 1991, where they distinguished two different kinds of bubbles: rational bubbles and intrinsic bubbles.[40] According to Froot and Obstfeld rational bubbles are caused by extraneous economic factors, intrinsic bubbles are caused by endogenous economic factors.[41] Froot and Obstfelds model is based on endogenous economic factors and is therefore more appropriate to explain the fluctuations in stock prices than one based on extrageneous factors.[42]

In their model they assume a non linear relationship between the fundamental value and the stock price. A persistent deviation from the fundamental value is possible. That would mean that with a constant fundamental value also the bubble would remain constant.[43] Froot and Obstfelds bubble test is formed as follows: the fundamental value of the stock is based on the dividends paid out, therefore

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[37]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 20.

[38]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 19.

[39]Compare Diba and Grossman, (1985): "Explosive rational bubbles in stock prices?"; NBER; Working Paper No. 1779; 20.

[40]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1189-1214.

[41]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1189-1214.

[42]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1191-1193 and 1208-1209.

[43]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1193-1194.

$$Pv_t = kD_t. \tag{4.15}$$

The variable k indicates the relationship between the dividend, D_t, and the fundamental value, Pv_t. K exists because dividends follow a geometric martingale process,[44]

$$d_{t+1} = \mu + d_t + \xi_{t+1}, \tag{4.16}$$

where μ represents dividends growth and, d_t, denotes the logarithmic dividends at time t. The bubble, B, is not linearly related with the dividend at time t, d_t:

$$B(D_t) = cD_t^\lambda. \tag{4.17}$$

Where c is a constant and λ is the positive root of

$$\lambda^2\sigma^2 + \lambda\mu - r = 0. \tag{4.18}$$

Therefore the stock price can be determined as,

$$P_t = c_0 D_t + cD_t^\lambda + \varepsilon_t. \tag{4.19}$$

To adopt for non collinearity this equation is divided by D_t.[45] The testing model is created by

$$P_t/D_t = c_0 + cD_t^{\lambda-1} + \eta_t. \tag{4.20}$$

The Null-hypothesis states that $c_0 = k$ and $c = 0$, which would mean that no bubble exists. The alternative-hypothesis implies a $c_0 = 0$ and a $c > 0$.[46]
Froot and Obstfeld tested their model on the Standard and Poors stock price and dividend index over a period of 88 years, from 1900 until 1988. They found out that stock prices overreact to changes in dividends. The factor c is significantly statistical positive. Furthermore they explained that stock price volatility is so high due to high dividends and a given non linear relationship of dividends with stock prices.[47]

Also this test was heavily criticised in the literature: Froot and Obstfeld themselves stated that only because of the assumption that the logarithmic dividends do follow a martingale

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[44]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1193-1194.
[45]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1198.
[46]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1200.
[47]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1991-1200.

cannot be rejected, it does not necessarily mean that it is true that they do.[48] Furthermore it is not possible to conclude if deviations from present value prices are stationary or non stationary; a stationary deviation from present value prices would be the case in a non bubble state; a non stationary deviation would suggest a bubble state.[49]

Acker and Hunter in 1999 argued that a non linear relationship might be caused by the chosen dividend payout strategy. Therefore a non linear relation is not caused by a bubble but by a management decision.[50]

Although Ma and Kanas showed that the model holds for the US stock market from 1871 to 1996 and confirms that there is a non linear relationship between dividends and stock prices, according to them it is questionable, if this could be defined as a bubble.[51]

4.5. Wu Bubble Test

This section will be based on Wu (1997). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Wu, in 1997, built a model to test for rational bubbles. Also in Wu's test models bubbles are defined as deviations from the fundamental value of a security.[52] The unique factor of the model is that it allows and shows negative bubbles. Wu uses the natural logarithm to express the present value model. Negative bubbles are possible, negative stock prices are not.[53] The ln stock return is defined as:

$$q = k + \psi E_t p_{t+1} + (1 - \psi)d_t - p_t, \tag{4.21}$$

where q represents the log return rate. ψ is the ratio of stock price of $p + d$; p_t is the log of the stock price and d_t is the log of the dividend:

$$k = -ln((\psi) - (1 - \psi)ln(1/\psi - 1). \tag{4.22}$$

[48]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1991-1200.

[49]Compare Froot and Obstfeld,(1989): "Intrinsic bubbles: the case of stock prices"; NBER Working Paper No.3910; 14 and 20.

[50]Compare Ackert and Hunter, (1999): "Intrinsic bubbles: the case of stock prices"; American Economic Review; 1372-1376.

[51]Compare Ma and Kanas, (2004): "Intrinsic bubbles revisited: evidence from non linear cointegration and forecasting"; Journal of Forecasting, 23; 237-250.

[52]Compare Wu,(1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

[53]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

If i goes to infinity the price $p_{t+1} = 0$, therefore p_t follows:

$$p_t = (k - q)/(1 - \psi) + (1 + \psi) \sum_{i=0}^{\infty} \psi^i E_t(d_{t+1}) + b_t = p_t^f + b_i, \qquad (4.23)$$

where p_t^f is the fundamental value, p_t and b_t is the speculative bubble. Therefore:

$$\Delta p_t = (1 - \psi)\Sigma_{i=0}^{\infty}\psi^i[E_t(d_{t+i}) - E_{t-1}(d_{t+i-1}) + \Delta b_t = \Delta p_t^f + \Delta p_t. \qquad (4.24)$$

The logarithmic dividends do follow an ARIMA, as assumed, where h is determined by the data and the error[54]:

$$\Delta d_t = \mu + \Sigma_{j=1}^{h}\varphi_j\Delta d_{t-j} + \delta_t. \qquad (4.25)$$

By forming a companion form matrix and by assuming that the bubble process is linear[55]:

$$b_t = (1/\psi)b_{t-1} + \eta_t, \qquad (4.26)$$

where η_t has a mean of zero and is non-correlated serially and with the dividends innovation.[56]

Wu tested his model empirically using the Kalman filter to compute the optimal estimate of a bubble in each period. Adopting the model to the Standard and Poors 500 and to its associated dividends deflated by the Consumer Price Index (CPI), Wu concludes that bubbles are a substantial and statistically significant part of stock prices.[57]

Also Wu's model isn't free of assumptions and was therefore hardly criticised by other economists. Gurkaynak in 2005 argued that bubbles can never be negative and that deviations from fundamental value do not have to be based on bubbles. They could also be due to a misspecification of the model. Moreover the model, according to Gurkaynak, is to complicated and very technical.[58]

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[54]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

[55]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

[56]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 35; 309-319.

[57]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

[58]Compare Gurkaynak , (2005): "Econometric tests of asset price bubbles: taking stock"; Finance and Economics Discussion Series Divisions of Research, Statistics and Monetary Affairs Federal Reserve Board Washington, D.C.; 22 and 26-27.

4.6. Van Norden Bubble Test

This section will be based on van Norden (1996). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Van Norden was the first economist to introduce so called regime switching tests.[59] Regime switching tests are based on the idea, that bubbles can be detected by looking for time-varying patterns in stock market data; such time-varying patterns can be found in connections between returns and fundamentals, in the stationary behaviour of asset prices or in the approximated fundamental values.[60]
Van Norden defines a bubble as a positive, or even negative, deviation from the fundamental value of an asset.[61] His test is just relevant for detecting collapsing bubbles; bubbles that are expected to keep growing, to collapse partially or completely. Van Norden distinguished two cases: state S, the bubble continues to grow and state C, the bubble collapses partially or completely.[62] Van Nordens bubble test is formed as follows:

$$E_t(B_{t+1}/C) = u(B_t).\tag{4.27}$$

According to Van Norden the size of the bubble impacts the expected size of the collapse; moreover the probability of the bubble to keep growing is diminishing with the increasing size of the bubble and the likelihood of collapse of the formed bubble increases with size of the bubble.[63] Van Nordens model is based on the following switching regression:

$$E_t(\Delta B_{t+1} \mid S) = \alpha_s + \beta_s B_t,\tag{4.28}$$

$$E_t(\Delta B_{t+1} \mid C) = \alpha_c + \beta_c B_t,\tag{4.29}$$

$$Pr(state_{t+1} = S) = \Phi(\lambda + \eta B_t),\tag{4.30}$$

$$Pr(state_{t+1} = C) = 1 - Pr(state_{t+1} = S).\tag{4.31}$$

The model implies collapsing bubbles when $\beta_s > 0$, $\beta_c < 0$, $n < 0$.[64]

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[59]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada.

[60]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 3-10 and 28-30.

[61]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 3 and 17-18.

[62]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 6-7.

[63]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 7-10.

[64]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 7-10.

The central question is, if the switching regression model offers a better explanation of the behaviour of ΔB_{t+1} than the two alternative models.[65] The first of these models assumes that ΔB_{t+1} follows a normal distribution in both states, S and C,

$$\Delta B_{t+1} \sim N(\alpha_s, \alpha_s) \text{ when state}_{t+1} = S, \tag{4.32}$$

$$\Delta B_{t+1} \sim N(\alpha_c, \alpha_c) \text{ when state}_{t+1} = C, \tag{4.33}$$

$$Pr(state_{t+1} = S) = \Phi(\lambda). \tag{4.34}$$

The Null-hypothesis states that:

$$\beta_s = \beta_c = \eta = 0. \tag{4.35}$$

According to Van Norden, if the Null is rejected, there is a connection between the bubble and the probability of the regimes of C or S.[66] The second model tests

$$\beta_s = \beta_c, \alpha_c \text{ and } \eta = 0, \tag{4.36}$$

$$\Delta B_{t+1} = \alpha + \beta B_t + e_{t+1}, \tag{4.37}$$

$$e_{t+1} \sim N(0, \sigma_s) \text{ with probability } \Phi(\lambda_q), \tag{4.38}$$

$$e_{t+1} \sim N(0, \sigma_c) \text{ with probability } 1 - \Phi(\lambda_q). \tag{4.39}$$

In this test Van Norden uses a Wald Test.[67] A non switching linear regression model is tested:

$$\beta_s = \beta_c. \tag{4.40}$$

The excess return is used as a purported measure of bubbles:

$$x_t = (P_t + D_t)/(P_{t-1}) - i_t = [(P_t)/(P_{t-1})] * DY_t - i_t, \tag{4.41}$$

where x_t stands for the monthly excess return, P_t denotes the level of the stock index, D_t denotes the level of the stock dividend index, DY_t denotes the monthly dividend yield and i_t denotes the monthly yield on alternative investments.[68]

Van Norden tested his model empirically on stock market data from the Toronto Stock Exchange Composite Index (TSE) and the Standard and Poors 500 Index, using periods of 41

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[65]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 7-10.

[66]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 10-15.

[67]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 10-15.

[68]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 7-10.

and 50 years. Both of the tests fail to reject the Null of no regime switching.[69]

Also this bubble test is not assumption free and completely perfect. The main issue about this test is, that it can only detect bubbles if they are already collapsed. This makes this bubble test useless in detecting bubbles before they burst.[70]

4.7. Philips, Wu and Yu Bubble Test

This section will be based on Phillips, Wu and Yu (2008). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The central idea of Philips, Wu and Yu's bubble test is that bubbles might be indicated by the occurrence of explosive behaviour of stock prices together with non explosive behaviour of dividends: a bubble is detected if there is a statistical switch to explosive autoregressive behaviour in the underlying time series.[71] Philips, Wu and Yu apply an augmented Dickey-Fuller Test to the time series in order to test for a unit root against the alternative of an explosive root.[72]

$$x_t = \mu_x + \delta x_{t-1} + \sum_{j=1}^{J} \phi_j \Delta x_{t-j} + \varepsilon_{x,t}, \varepsilon_{x,t} \sim NID(0, \sigma_x^2) \tag{4.42}$$

The estimation ensue with the least square method. J stands for the lag operator and NID for the independent and normal distribution.[73] In a next step the sample is divided into sub samples and every sub sample is tested with the ADF-technique.[74]

$$ADF_r \Rightarrow \frac{\left(\int_0^r W dW\right)/}{\left(\int_0^r W^2\right)} \tag{4.43}$$

Where W denotes a Brownian motion. Under the Null-Hypothesis of a unit root and no explosive stock prices each sub samples shows:[75]

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[69]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 31-34.

[70]Compare van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; International Department, Bank of Canada; 28-30.

[71]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699.

[72]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 8.

[73]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 8.

[74]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 8.

[75]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 8-9.

$$\underset{r\varepsilon[r_{0,1}]}{sup} ADF_r \Rightarrow \underset{r\varepsilon[r_{0,1}]}{sup} \frac{\left(\int_0^r W dW\right)/}{\left(\int_0^r W^2\right)} \tag{4.44}$$

To prove the existence of a bubble the critical values from the Dickey-Fuller t-statistic are compared with the time series of the ADF. For the starting date of the bubble they assume the smallest value of r for which the ADF is larger than the critical value.[76]

Philips, Wu and Yu used the Nasdaq composite price index and the Nasdaq dividend series for their empirical testing. To convert the nominal into a real series they used the Consumer Price Index on a sample of 389 observations from 1973 to 2005. The test detected a strong exuberance in prices from 1995 to 2001 with a clear peak in 2000.[77]

Also Philips, Wu and Yu's test results were criticised by other authors. Homm and Breitung in 2009 claimed that the estimator is downward biased with a high standard deviation and that the test is based on the crucial assumption of a constant discount rate.[78] According to Homm and Breitung an advantage of this test, is that a detection of very recent bubbles and still existing bubbles is possible and that a specific starting and ending date of the bubble can be found.[79]

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[76]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 8-9.

[77]Compare Phillips,Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699; 16-22.

[78]Compare Homm and Breitung, (2009): "Testing for speculative bubbles in stock markets a comparison of alternative methods"; University of Bonn; 9-11.

[79]Compare Homm and Breitung, (2009): "Testing for speculative bubbles in stock markets a comparison of alternative methods"; University of Bonn; 23-24.

4.8. General Shortcomings of all presented Bubble Detection Tests

After looking at the literature of past bubble tests, this section will resume the general shortcomings and problems of the presented models. After that three new bubble detection tests will be introduced.

This section will be based on Weites and von Maravic (2010). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Although some of the presented models do have an economic reasoning, all of them are based on strong assumptions. The first and biggest assumption is that none of the models is able to efficiently estimate the fundamental value of an asset. Therefore it is impossible for the proposed models and tests to distinguish between a change in the fundamental value of a security and a bubble state.[80]

A second factor is that all proposed models are crucially based on individual certain assumptions, which are very sensitive. Most of the assumptions are due to simplicity and therefore not broadly validated by other researchers.[81]

The third big factor is that all tests only reveal poor facts on the distinguished bubble characteristics like size, volume or single dates.[82]

The main issue still, as mentioned several times, is the problem of a clear differentiation between the fundamental value of an asset and a given bubble. As long as there is no common agreement on how to correctly define the fundamental value there wont be any chance to detect a bubble correctly. Today for every test that actually detects a bubble, there is another test that disputes it.[83]

As was explained, the most adopted technique to approximate the fundamental value is the present value model, using historic dividend values. However historic dividends are not the best indicators for historic fundamental prices and therefore not necessarily correct measures for future ones.[84]

Flood and Garber show that it is not appropriate to use historic data to define the fundamental value of an asset. According to them actual dividends do not reflect historic agents beliefs about the future. Furthermore additional variables, which are unobservable to researchers, will impact

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[80]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[81]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[82]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[83]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[84]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

the fundamental value.[85]

As all these variables cannot be incorporated and past fundamentals can not be observed, fundamental values can always just be approximated in existing bubble tests.[86] This implies the use of additional assumptions about discount rates and future dividends, which makes every single test and every single test result sensitive to the imposed assumptions.[87] By a change in the underlying assumptions test results could change dramatically. Gurkaynak even states that it depends on individual taste of the researcher and on his/her personal preference that makes him/her choose between a detected bubble stage and a fundamental-based explanation of stock price behaviour.[88]

Therefore this provided bubble tests teach us very little about whether bubbles even really exist or not; as they cannot be consistently detected in all the mentioned tests.[89]

In the next section a new generation of bubble detection models will be introduced. All these new tests were presented by Weites and von Maravic in 2010.[90] After the explanation of the testing procedure it will be analysed if these tests are able to detect bubbles appropriately.

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[85]Compare Flood and Garber,(1983): "A model of stochastic process switching"; Journal of Economic Perspectives 4; 85-102.

[86]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[87]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[88]Compare Gurkaynak, (2005): "Econometric tests of asset price bubbles: taking stock"; Finance and Economics Discussion Series Divisions of Research and Statistics and Monetary Affairs; Federal Reserve Board Washington, D.C.; 27.

[89]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 32-33.

[90]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 34-81.

5. More recent Approaches of Bubble Tests

In this section five new detection models, introduced by Weites and von Maravic in 2010, which clearly differ from the classic models, will be introduced.[1] These new models should enhance, enrich and diversify the presented historic bubble test models.

This part of my work is based on the work of Weites and von Maravic (2010). Also the structure of this chapter follows the structure of Weites and von Maravic (2010). All models, results and drawn conclusions in this part are based on their work. The single sections should be seen as a brief summary of their work. For the purpose of my thesis this summary is necessary, so that the reader will be able to understand the newly introduced test in the next part. For more detailed information the reader should read the original work by Weites and von Maravic, published in 2010.[2] If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Weites and von Maravic introduced these new tests in 2010. The first test takes a deeper look at growth expectations in the markets and tries to find out if they are excessive or not. The test should reveal how optimistic investors are towards the future. The underlying tool of the test is the Gordon Growth Model.[3]
The second test consists of two versions: A and B, it considers irrational exuberance and is based on the Price/Earnings-ratio. It will be explained that according to this test changes in fluctuation can be explained either by changes in the stock risk or can be driven by bubbles.[4]
The third test, again, consists of version A and version B and completely differs from all known tests. Jarrow, Protter and Shimbo introduced a bubble detection test based on bounded lives like stock options, in which they showed that European put options never contain bubbles from

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[1]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 46-54.

[2]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 46-54.

[3]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56.

[4]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56-72.

the underlying stock whereas Calls could do so.[5] Jarrow, Protter and Shimbo developed two different tests. The first one is based on the Black-Scholes-Merton model. The second one proves the bubble element in the call option via the put option and detects the bubble in the underlying asset. The biggest advantage of this model by Jarrow, Protter and Shimbo is that the stocks fundamental value does not need to be estimated.[6]

In the next section a closer look at every single model introduced by Weites and von Maravic in 2010 will be taken.

5.1. The Dividends Growth Expectation Test

This section is based on Weites and von Maravics introduced Dividend Growth Expectation Test.[7]

In this section the Dividends Growth Expectation Test will be presented to the reader. The test, according to Weites and von Maravic, is based on growth expectations of the market. They divided the presented test in six main parts: In the first part the economic reasoning of the approach is explained. In the second part the econometric model itself is presented. In the third part an excursus on stock repurchases is made. In the fourth part the Gordon Growth Model is applied. In the fifth part assumptions and details on which the test is based are explained and analysed. The last part shows how excessive growth expectations in the market are detected and how big the bubble is.[8]

In the following section the Dividend Growth Expectation Test will be explained in detail. As said before, the test is based on growth expectations. Growth expectations contain information about the mood and psychology of the market: if future growth is expected to be low the market is in a depressive state; if they are high there is a lot of optimism in the market.[9] The basis of this test was influenced by De Long and Schleifer in 1991: they stated that bubbles are created by an excessive investor optimism.[10]

The Dividends Growth Expectation test, introduced by Weites and von Maravic in 2010, is

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[5]Compare Jarrow, Protter and Shimbo, (2007): "Asset price bubbles in complete markets"; http://ms. mcmaster.ca/~grasselli/JarrowProtterShimbo07.pdf; 14.07.2014; 09:08.

[6]Compare Jarrow, Protter and Shimbo, (2007): "Asset price bubbles in complete markets"; http://ms. mcmaster.ca/~grasselli/JarrowProtterShimbo07.pdf; 14.07.2014; 09:08 and Weites and von Maravic (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72-81.

[7]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56.

[8]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35.

[9]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 36.

[10]Compare DeLong and Schleifer, (1991): "The stock market bubble of 1929: Evidence from closed-end mutual funds"; The Journal of Economic History; 675-700.

based on the Gordon Growth Model:

$$E[growth] = r - \left[\frac{Div}{stockprice} \right], \tag{5.1}$$

where Div denotes the dividend and r denotes the discount rate. The basic idea of the test is very simple: if growth expectations reach much higher levels, compared to their historical levels, the market is in a bubble state. Without a bubble state, the expected growth should be consistent with the historical dividend trend.[11]

According to Brealey and Myers the stock price is described as:

$$P_t = bE(D_{t+1} + P_{t+1}) \mid I_t, \tag{5.2}$$

$$b = 1/(1+r), \tag{5.3}$$

where P_t is the stock price in period t, r is a non-negative discount rate, D is the dividend and I_t is the information set available at time t.[12]

The definition of the price over a longer period therefore is:

$$P_t = \sum_{i=1}^{n} b^i E(D_{t+1} \mid I_t) + b^n E(P_{t+n} \mid I_t). \tag{5.4}$$

As "...stocks have an infinitive lifetime, the transversality condition applies."[13]:

$$\lim_{n \to \infty} b^n E(P_{t+n} \mid I_t) = 0. \tag{5.5}$$

The formula states that the fundamental stock price is determined by its risk adjusted infinite expected future dividends stream:

$$P*_t = \sum_{i=1}^{\infty} b^i E(D_{t+i} \mid I_t) = 0. \tag{5.6}$$

"In consensus with the literature, the bubble is described as the difference between P_t and P_t^*".[14]

$$B_t = P_t - P_t^*. \tag{5.7}$$

As mentioned before, the testing model is based on the Gordon Growth Model from 1962, in

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[11]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 36.

[12]Compare Brealey and Myers, (1981): "Principles of corporate finance", McGraw-Hill Book Co.,New York.

[13]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-A survey and new tests"; Aarhus School of Business, University of Aarhus; 37.

[14]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-A survey and new tests"; Aarhus School of Business, University of Aarhus; 37.

which it is assumed that the dividends grow by a constant factor g.[15] Therefore the fundamental stock price is determined by

$$P_t^* = \frac{(D_{t+1})}{(r - g^*)},$$ (5.8)

where the values of P_t^* and g^* are based on the underlying dividends. "Therefore, it is assumed to be fundamental."[16] Rearranging leads to,

$$g^* = r - (D_{t+1})/(P_t^*).$$ (5.9)

If the market is bubble free the value of B_t will be zero.[17] So that:

$$P_t = (D_{t+1})/(r - (g^* + g_B)_t = P_t^* + B_t,$$ (5.10)

$$(g^* + g_B)_t = r - (D_{t+1}/P_t),$$ (5.11)

where g_{B_t} stands for the markets growth expectation excessive to the fundamental dividends growth. If g_{B_t} is not zero, "...the stock price is not determined by the fundamental growth expectations of its underlying dividends."[18] r denotes the discount rate, which is assumed to be constant for two reasons. First,the dividends grow with a constant trend. Therefore it is reasonable to assume the same fact for the applied discount rate. Secondly, as the specific variation of varying discount rate is based on an assumptions, multiple conclusion could arise.[19] The discount rate is determined by:

$$e^r = (P_{t+1} + d_t)/P_t + \varepsilon,$$ (5.12)

$$\varepsilon \sim N(0, \sigma).$$ (5.13)

As said, if the market is bubble free, then $(g^* + g_b) = g^*$, which would mean that g_b is zero.[20] Therefore the Null hypothesis of the test states:

[15]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[16]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[17]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[18]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[19]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 41.

[20]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 42.

$$\textbf{H0: There is no bubble in growth expectations} \qquad (5.14)$$

$$g_b = 0, \qquad (5.15)$$

$$(g^* + g_B)_t = e^{\mu^* + \sigma^2/2}. \qquad (5.16)$$

This will be tested with the t-statistic:

$$(t) = ((g^* + g_B)_t - e^{\mu^* + \sigma^2/2})/\sigma. \qquad (5.17)$$

Weites and von Maravic rearranged the formula to obtain a more suitable σ; therefore the equation becomes the following:[21]

$$P_t^{-1} = (r - (g^* + g_B)_t)/(D_{t+1}), \qquad (5.18)$$

$$(D_{t+1}P_t) = r - (g^* + g_B)_N + \varepsilon_t. \qquad (5.19)$$

"Using maximum likelihood, $(g^* + g_B)_N$ and its associated σ can be determined over N periods."[22] This makes a bubble detection over the whole period possible.[23] Additonally, according to Weites and von Maravic, if the Null-hypothesis is rejected, using the values obtained, the fundamental stock price can be determined and the exact size of the bubble can be calculated by: [24]

$$B_t = P_t - P_t^*. \qquad (5.20)$$

Also this model is, as all the presented historical models are, not free from any downside. "First, the value is determined from a probability distribution, meaning that determinant values are not necessarily the real values, but just acceptably close enough (according to a normal distribution) to the real values." [25] Moreover also this model is based on assumptions, which were criticized before.[26]

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[21]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[22]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[23]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[24]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[25]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[26]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

5.2. Price/Earning Ratio Tests

This section is based on Weites and von Maravics introduced Price/Earnings-ratio Tests.[27]

The price-to-earnings ratio, in short P/E ratio, is calculated by market price per share divided by annual earnings per share. An alternative way of calculation is by the ratio of total market capital value over total earnings.[28]

Weites and von Maravic divided the testing procedure in three steps: in the first section the economic background of the model is explained and the econometric applicability of the P/E Ratio for the presented test is analysed. Secondly, the test itself will be explained. As a third step the relationship between the stock returns and the P/E ratio and the relationship between the volatility of the stock return and the P/E ratio is explained and tested.[29]

The basic idea of this test came from Perez in 2009.[30] Perez studied the great stock market crash of 1929 and the bubbles in the late 1990s and found out that during this times, the P/E ratio began to grow extremely fast, so far that it started to detach from the underlying stock price.[31] Based on Perez findings Weites and von Maravic took the P/E ratio as an appropriate measurement for a bubble state and based on this build an econometrical test.[32]

Based on the central thesis of the Capital Asset Pricing Model, an increase in the P/E ratio is caused by a decrease in volatility, which means that the stock becomes less risky. If the P/E ratio decreases again, the stock becomes riskier again. In a bubble state this relation is broken and exactly the opposite can happen: the P/E ratio increases and the stock becomes riskier.[33]

Weites and von Maravic in 2010 formed two different models: the Return Test Model and the Risk P/E Ratio Test Model. In this next section both models will be explained.[34]

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[27]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56-72.

[28]Compare http://people.stern.nyu.edu/adamodar/pdfiles/pe.pdf; 14.04.2014; 22:15.

[29]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56.

[30]Compare Perez, (2009): "The double bubble at the turn of the century: technological roots and stractural implications"; Cambridge Journal of Economics; 33; 779-805.

[31]Compare Perez, (2009): "The double bubble at the turn of the century: technological roots and stractural implications"; Cambridge Journal of Economics; 33; 779-805.

[32]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56.

[33]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56.

[34]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 56-72

5.2.1. The Return Test Model

The Return Test Model is based on the crucial assumption that the future value of the stock is determined by its future earnings.[35] Formally:

$$P_t(1+r) = P_{t+1} + D_t = P_t + E_t, \tag{5.21}$$

where r denotes the stock return and E_t denotes the earnings in time t. D_t denotes the dividends and P the stock price. By rearranging the terms the relation between the stock return and the P/E ratio can be stated as:[36]

$$E_t = P_t(1+r) - P_t = P_t r, \tag{5.22}$$

$$r = E_t/P_t = (P_t/E_t)^{-1}, \tag{5.23}$$

$$P_t/E_t = r^{-1}. \tag{5.24}$$

"...the Price/Earnings-ratio is basically the inverse of the stock return in a no bubble situation."[37] Perez in 2009, as mentioned above, stated that during a bubble state the stock returns and the P/E ratios increase.[38] Here, in the Price/Earning Ratio Tests this is a clear contradiction to the formula above. Weites and von Maravic, based on this, stated their hypothesis on:[39]

$$H_0 : (P_t/E_t)^{-1} = r \Rightarrow \text{no bubble.} \tag{5.25}$$

The return of the stock is

$$r = ((P_{t+1} + d_{t+1})/P_t) - 1. \tag{5.26}$$

For testing it:

$$(t) = ((P_t/E_t)^{-1} - r)/\sigma. \tag{5.27}$$

A big problem in this testing procedure is the double counting of earnings: earnings, which

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[35]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 57.

[36]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 57.

[37]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 58.

[38]Compare Perez, (2009): "The double bubble at the turn of the century: technological roots and structural implications"; Cambridge Journal of Economics; 33; 779-805

[39]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 58.

are not paid out but reinvested are counted again in the next period. Therefore negative bubbles are overestimated and positive ones underestimated, which makes the test more conservative in comparison to other tests using the Price/Free-Cash-Flow ratio.[40]

5.2.2. Risk-Price/Earning Ratio Test

Weites and von Maravic based this test on the central assumption of the CAPM. The CAPM says that there is a linear relation between the stock return and the market return, determined by the correlation of the stock with the market and the volatility; therefore any portfolio can be formed as a combination of the efficient market portfolio and a risk free asset. By combining different holdings in both, the volatility and the return can be adjusted individually.[41] All possible combinations together can be expressed as the Capital Market Line.[42]

The market portfolio, as said, is a combination of individual stocks and therefore has a relationship between its return and the associated volatility. Adjusted by the market correlation in order to filter out the unsystematic risk,it can be rewritten as:[43]

$$r_s = r_f + \gamma p \sigma_s + \varepsilon(0, \sigma_{rs}). \tag{5.28}$$

"With γ as the linear relationship between the systematic risk of the stock return and the return excessive to the risk free rate and p as the market correlation."[44]
Combining this equation with the CAPM formula it can be deducted that:

$$(r_s - r_f) = p \frac{\sigma_s}{\sigma_m}(r_m - r_f) = \gamma p \sigma_s, \tag{5.29}$$

therefore

$$p \frac{\sigma_s}{\sigma_m} = \beta, \tag{5.30}$$

which means that,

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[40]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 58.

[41]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

[42]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

[43]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

[44]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

$$\gamma = \frac{r_m - r_f}{\sigma_m}. \tag{5.31}$$

Combining the formulas leads to

$$(\frac{P_t}{E_t})^{-1} = r_f + \gamma p \sigma_s + \varepsilon(0, \sigma_{rs}). \tag{5.32}$$

From this equation Weites and von Maravic conclude that ".. γ should be a positive number."[45]

If the risk of the expected return grows, the associated required return should react in the same direction and grow.[46]
According to Perez findings of 2009, the P/E ratio can rise independently from the volatility in the market during a bubble.[47]

Therefore γ would be negative; which has the consequence that the Null-Hypothesis, according to Weites and von Maravic can be stated as:[48]

$$H_0 : \gamma > 0; \text{ There is no bubble in the return of the stock.} \tag{5.33}$$

Taking a closer look at the explanatory power, it must be determined "...whether γ does explain a linear relationship between the inverse Price/Earnings-ratio and the stock return's volatility. Next, this determines how large the change is that γ lays above zero (no bubble), against the chance that it lays below zero (a bubble)."[49]

According to Weites and von Maravic this method is conservative. First, earnings can be double-counted as mentioned above and secondly, "..the 'no-bubble-value' of γ is unknown. This testing method only explains why it should be above or below zero."[50]

Weites and von Maravic applied the test to the Standard and Poors Composite Stock Price Index over a period from 1881 to 2006.[51]

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[45]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

[46]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59.

[47]Compare Perez, (2009): "The double bubble at the turn of the century: technological roots and structural implications"; Cambridge Journal of Economics; 33; 779-805.

[48]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 60.

[49]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 60.

[50]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 60.

[51]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 61.

Also here Shillers dataset was used.[52] Shiller cyclically adjusted the P/E ratio by dividing the monthly quotes by the preceding ten year moving average of inflation adjusted earnings of the Standard and Poors 500 companies with the CPI index from the Federal Reserve Bank of St. Louis and used the 10-year treasury rate as risk free rate.[53]

As mentioned, Shiller's data is based on monthly rates, which includes annual dividend payments. To avoid this problem the model is applied from one year to the next year by determining the return from January of one year to January of the next year; the market correlation p is 1 and Gamma is calculated with maximum likelihood.[54]
Also this newly introduced tests by Weites and von Maravic do have some negative aspects according to the test developers themselves "one critical aspect is the sample size."[55] The divided sub-samples are too small, which "...can lead to size distortion and can bias the results significantly."[56] Furthermore, "Shiller smoothed the earnings with the effect of more stable earnings with a lower standard deviation. This manipulation of the data can bias the results."[57] The only bubble the test is able to detect is the previously explained Dot.com bubble at the beginning of the new millennium. Therefore, according to Weites and von Maravic, "as no other bubbles are detected, the test and its results can be described as conservative but reasonable"[58]

5.2.3. The Appropriateness of the Models

In the next section the appropriateness of the Return Test Model and the Risk-P/E Ratio Test introduced by Weites and von Maravic in 2010 will be analysed.[59]

Appropriateness of the Return Test:

According to Weites and von Maravic the main problem about the test is that "there is no model (yet) which perfectly explains the price and the return of a stock."[60] Intuitively, however, the idea of basing the stock price on future earnings is reasonable. By taking a closer look

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[52]http://www.econ.yale.edu/~shiller/data.htm; 04.03.2013; 16:12.

[53]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 61-62 and http://www.econ.yale.edu/~shiller/data.htm; 04.03.2013; 16:17.

[54]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 63.

[55]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 70.

[56]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 70.

[57]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 70.

[58]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 70.

[59]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 70-72.

[60]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 71.

at the used data, "on the long run...the return and the inverted Price/Earnings-ratio seem to be almost the same..."[61] This makes the test for the long run plausible. However, according to Weites and von Maravic "this means that the detection of bubbles over a short period is less accurate, although this would probably be more relevant then bubbles over a long period."[62]

Appropriateness of the Risk-P/E Ratio Test:

According to Weites and von Maravic the economic reasoning behind the model holds: "if the volatility increases and thereby the risk associated with the expected returns, the price an investor is willing to pay for the expected return (and potential earnings) will decrease and thereby the Price/Earnings-ratio decreases. Therefore,γ should be positive."[63] Still the true value of γ is not observable, the only distinction that can be made, is if $\gamma > 0$, which would mean that there is a bubble situation in the market; or $\gamma < 0$, which would mean that there is a non bubble situation in the analysed market.[64]

Therefore, according to Weites and von Maravic, the test can be classified "...as an indicator for bubbles rather than a discrete bubble detection method."[65]

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[61]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 71.

[62]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 71.

[63]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 71.

[64]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 71.

[65]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72.

5.3. Option Based Tests

This section is based on Weites and von Maravics introduced Option Based Tests.[66]

This section introduces two new models designed by Weites and von Maravic in 2010,which are based on the work of Jarrow, Protter and Shimbo of 2007, who provided a new solution in the bubble detection theory by using derivative securities.[67]

This two tests clearly differ from the models presented until now. The main difference is that these tests are based on "...local geometric martingales rather than geometric martingales for stock price processes."[68]

Thanks to arbitrage, stock prices follow a martingale and therefore, the present value of the price of the underlying stock can be calculated by discounting the expected future value of the according price of the stock.[69]

"Therefore, if an unexpected event happens the stock price will change. In other words, the price process will shift to another local martingale."[70]

Jarrow, Protter and Shimbo consider "...two fundamental theorems of asset pricing: First, there is no arbitrage in the market in the sense of no free lunch with vanishing risk (NFLVR), if and only if there exists an equivalent probability measure, (Q), for the non negative stochastic price process, (S). Since S is a non negative value, it is a local martingale. The way how S is exactly formed depends on whether or not there exist a bubble and its associated characteristics. Second, there are several local martingales that can be used to determine the fundamental price. However, in an incomplete market the market and fundamental price are not necessarily the same."[71]

Jarrow, Protter and Shimbo introduced a new theory on how bubbles could form: according to them, more local martingales can be present in the market over time; a change in them only can be caused by a change in the underlying fundamental.[72] "More practically, this means that

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[66]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72-81.

[67]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72-81.

[68]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72.

[69]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72.

[70]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 73.

[71]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 73.

[72]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 73.

from an infinitive number of local martingales, the market chooses a unique measure Q_0, this determines the fundamental price of a derivative. A change in the measure Q_1 can create a bubble."[73]

Given this Jarrow, Protter and Shimbo show that European put options have to be bubble free; according to them only calls can contain bubbles.[74]

To give a better distinction Jarrow, Protter and Shimbo consider three different bubble types: "Type 1, the asset has an infinite life. Type 2, the asset's life is finite and unbounded. Type 3, the asset's life is bounded."[75]

Based on this distinction Jarrow, Protter and Shimbo formulate two theorems:[76]

Theorem 1: European Style Put price:

$$P_t(K) = P_t^*(K), \tag{5.34}$$

where K denotes the strike price, P_t denotes the market price of the European put option and P_t^* denotes the according fundamental value of the asset.[77]

"The above theory holds, because if an rational investor had a K amount of money to invest and $E[P_{maturity}] < K$, it would be more profitable to hold a K amount of money in the risk free money market." [78]

Theorem 2: European Style Call price: [79]

$$C_t(K) - C_t^*(K) = S_t - E_{Q^{t*}}[S_T] \tag{5.35}$$

Where K denotes the strike price, C_t denotes the market price of the European style call option, C_t^* denotes the according fundamental value, S_T denotes the stock price at price $t = T$

[73]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 73.

[74]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74 and Jarrow, Protter and Shimbo (2007): "Asset price bubbles in complete markets"; http://ms.mcmaster.ca/~grasselli/ JarrowProtterShimbo07.pdf; 14.07.2013; 12:45

[75]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74 and Jarrow, Protter and Shimbo (2007): "Asset price bubbles in complete markets"; http://ms.mcmaster.ca/~grasselli/JarrowProtterShimbo07. pdf; 14.07.2013; 12:45.

[76]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74.

[77]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74.

[78]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74.

[79]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74.

and $E_{Q^{t*}}[S_T$ denotes the present value of the expected value of the stock price; therefore the fundamental price of the stock itself.[80]

Since "...the put-call-parity almost always holds in practice, with and without a bubble: "[81]

$$C_t(K) - P_t = S_t - K. \tag{5.36}$$

As explained before, there can not be a bubble in the strike price and the put, according to Weites and von Maravic, "...the bubble element in both the C_t and S_t has to be equal. Further, as put and call options are driven by the same underlying, they should follow the same local martingale."[82] Therefore from a shift in the underlying local martingale a bubble could be deducted.[83]

5.3.1. Black-Scholes-Merton Model Test

Weites and von Maravic based these two tests on the world famous Black-Scholes-Merton model. The model is based on the determination of the put option on the underlying asset so that:[84]

$$P(S,t) = Ke^{-r(T-t)}N(-d_2) - SN(-d_1), \tag{5.37}$$

$$d_1 = \frac{ln(\frac{S}{K}) + (\frac{\sigma^2}{2} + r)(T-t)}{\sigma(T-t)^{1/2}}, \tag{5.38}$$

$$d_2 = d_1 - \sigma(T-t)^{1/2}. \tag{5.39}$$

The new variables in this equation are r, which denotes the risk free rate in the market, N, which stands for a normal distribution, σ, which denotes the volatility of the according underlying stock and T, which denotes the time of maturity.[85]

All values of all variables can be found in the market; except the stock price and the volatility of the according underlying are unknown.[86] "These are determined using maximum likelihood." [87]

[80]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 74.

[81]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 75.

[82]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 75.

[83]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 75.

[84]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 75.

[85]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[86]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[87]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-

This delivers more than one result for the two variables; but only one can be defined as the correct fundamental value. In order to determine the correct one, according to Weites and von Maravic four steps are taken:[88]

"1.: A set of different European put options on the same underlying the same time to maturity and with different strike prices are considered.

2. S and σ are determined for the first put option using maximum likelihood.

3. Using the values of S and σ as starting values, the S and σ are determined for the next put option. This process will continue until all options were used.

4. Next, the process will be repeated from step 2 (using the last obtained values from 3 as starting values) up to step 4, until convergence. However, it is known that some of the assumptions of the Black-Scholes-Merton model are not realistic (e.g constant volatility), meaning the model does not give the exact real values. Therefore, complete convergence is not expected. It can be assumed that after 100 iterations the method is acceptably close to convergence."[89]

As the according value of the fundamental of the stock price and the according volatility of the according returns are determined by comparing the according fundamental value of the according stock price with the according stock price in the market, it can be determined if there is a bubble in the according market price or not.[90] "Howewer, to statistically determine if the market contains a bubble, the returns for the testing purposes need to be determined as the significance will be tested based on the determined volatility of returns." [91]

Weites and von Maravic applied a t-statistic to verify the size of the bubble:[92]

$$(t) = \frac{r_s - r_s^*}{\sigma}. \tag{5.40}$$

Where r_s denotes the market stock return and r_s^* denotes the fundamental stock return.[93]

A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[88]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[89]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[90]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[91]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 76.

[92]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 77.

[93]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 77.

5.3.2. The Put-Call-Martingale Test

Weites and von Maravics Theorem 1, as mentioned above, states that there can not exist a bubble in the market put-option.[94] Furthermore the put-option follows a local martingale, which, according to Weites and von Maravic, can be determined as a Brownian motion:[95]

$$log p_t - log p_t \sim N\left[(\mu - \frac{\sigma^2}{2})(T-t); \sigma^2(T-t)\right],$$ (5.41)

Where p_t denotes the European put option in the market and N denotes a normal distribution. Therefore the value of α can be determined as:

$$\alpha = (\mu - \frac{\sigma^2}{2}).$$ (5.42)

For a certain time interval α can be determined as:

$$\alpha = \frac{\sum_{t=1}^{n} log_{p_t+1} - log_{p_t}}{n}.$$ (5.43)

The variance can be determined as:

$$\sigma^2 = \frac{\sum_{t=1}^{n} (\alpha - log_{p_t+1} - log_{p_t})^2}{n}.$$ (5.44)

By replacing the *log* of the put with the *log* of the call, a t-test can be applied to test for bubbles:[96]

$$(t) = \frac{\mu_c \mu_p}{\sigma (t-t)^{1/2}}.$$ (5.45)

If the t-test "...does not reject the existence of a bubble, the size of the assumed bubble can be determined by using the put's distribution values to determine the fundamental call price. Theorem 2 explains the difference between the fundamental call price and the market's call price in both the bubble element of the call option and the underlying stock price." [97]

According to Weites and von Maravic "The main strength of this model in comparison to existing theory lies in its economical interpretation."[98] Until this point unknown news and informations can reach the market and cause a shift in the the present martingale process; stock prices, which are following this martingale process at this time will shift and adopt the newly

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[94]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 77.

[95]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 77.

[96]Compare Weites and von Maravic,(2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 78.

[97]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 78.

[98]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 78.

established martingale process. This reasoning makes the idea of a local martingale more realistic and easier to understand than a continuously constant one.[99]

However also these two models contain some downside according to Weites and von Maravic.[100] The Black-Scholes-Merton Test is based on historical data "...to significantly determine the existence of a bubble..."[101] Furthermore the determined option price is calculated closely to the actual price in the market, but the exact value is not determined due to the underlying model.[102] According to Weites and von Maravic "the model also assumes a constant volatility which is unrealistic. Practically for this testing approach, it makes it very questionable if convergence for steps 1 to 4 would ever be reached. If not, this harms the validity of the determined fundamental values of the stock price and stock return volatility."[103]

The biggest strength of the Put-Call-Martingale Test, in comparison to all the other presented models, is the waiver of a lot of underlying, basic assumptions. Still detecting the right moment of a martingale shift in the market is very hard to do, since such shifts do happen constantly over time.[104]

"However, as there are still theoretical assumptions involved in both tests, the actual functionality in practice still has to be proven from empirical application."[105]

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[99]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 78-79.

[100]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 79.

[101]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 79.

[102]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 79.

[103]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 79.

[104]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 80.

[105]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 80.

5.4. Test Results

In this section the empirical results of all the presented bubble tests will be shown and explained. The result of every single test will be explained, it will be explained which data was used and which bubbles were detected. An additional comment to the single results will be given. The empirical test results of each bubble test were directly taken from the original developers of the single tests. If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

The Variance Bounds Test

The Variance Bounds Test was tested on the Standard and Poors 500 Index over a period from 1871 until 1979 and the Dow Jones-IA from 1928 until 1979. The test detected no bubble in the underlying time interval. [106]

West Bubble Test

West tested the Standard and Poors 500 Index over a period from 1871 until 1980 and the Dow Jones-IA from 1928 until 1978. West found some evidence for an existing bubble, but did not specify when.[107]

Diba and Grossman Bubble Test

Diba and Grossman tested the Standard and Poors 500 Index over a period from 1871 until 1979. Also their test is not able to detect a bubble over the sample period.[108]

Froot and Obstfeld Bubble Test

Froot and Obstfeld tested the Standard and Poors 500 Index over a period from 1900 until 1988. They found some evidence for bubbles, but also they were not able to predict when the bubble would happen. [109]

Wu Bubble Test

Wu tested the Standard and Poors 500 Index over a period from 1871 until 1992. Wu produced a time series of the bubble element and therefore found a permanently existing positive or

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[106]Compare Shiller, (1981): "Do stock prices move too much to be justified by subsequent changes in dividends?"; American Economic Review, 71; 421-436.

[107]Compare West, (1987): "A specification test for speculative bubbles"; Quarterly Journal of Economics; 553-580.

[108]Compare Diba and Grossman, (1988): "Explosive rational bubbles in stock prices?"; American Economic Review, 78; 520-530.

[109]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1193-1194.

negative bubble in the Index.[110]

Van Norden Bubble Test

Van Norden tested the Standard and Poors 500 Index over a period from 1947 until 1997 and the TSE Index from 1956 until 1997. Also his test does not find any bubble over the tested period at all. [111]

Philips, Wu and Yu bubble Test

Philips, Wu and Yu tested the NASDAQ over a period from 1973 until 2005. They detected a big bubble from June 1995 until July 2001. Not only it is the first test that focuses on sub samples; but it is also the first to detect a bubble and to determine a precise start and end of it.[112]

The Dividends Growth Expectation Test

The Dividends Growth Expectation Test was applied to the Standard and Poors 500 Index over a period from 1871 until 2009. It detected a distinct bubble from 1961 until 1970, a bubble from 1991 until 2009 and a bubble with less probability from 1891 until 1900.[113]

The Return Test Model

The Return Test Model was applied to the Standard and Poors 500 Index over a period from 1881 until 2008. It found no bubble during this interval.[114]

The Risk-Price/Earning Ratio Test

The Risk-Price/Earning ratio Test was applied to the Standard and Poors 500 Index over a period from 1881 until 2008. It detected a clear bubble from 1996 until 2000. [115]

The Black-Scholes-Merton Model Test and the Put-Call-Martingale Test

Neither the Black-Scholes-Merton Model Test nor the Put-Call-Martingale Test was empirically tested until now. They both promise to detect bubbles in the short and the long run, but

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[110]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry, 35; 309-319.

[111]Compare Van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; Journal of Applied Econometrics, 11; 219-251.

[112]Compare Phillips, Wu and Yu, (2008): "Explosive behavior in the 1990s Nasdaq: when did exuberance escalate asset values?"; Cowles Foundation Discussion Paper No. 1699.

[113]Compare Weites and von Maravic (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56.

[114]Compare Weites and von Maravic (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 57-72.

[115]Compare Weites and von Maravic (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 59-72.

without empirical testing no further comments can be made.[116] "However, as there are still theoretical assumptions involved in both tests, the actual functionality in practice still has to be proven from empirical application."[117]

5.5. Model critique and comparison

As explained in the previous section the results do differ a lot among the presented tests.

In this section the historical bubble tests will be compared to the newly introduced detection models developed by Weites and von Maravic in 2010. The goal of this part is to give the reader a better overview regarding the application of the single models, their detection power and their advantages and disadvantages.
This section will be based on Weites and von Maravic(2010). If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

As seen the presented models differ a lot from each other. Still nearly all researchers do agree on the theoretical determination of the fundamental value of the underlying stock and the bubble component.[118] All models define them as:

$$P_t^* = \Sigma_{i=1}^{\infty} \left(\frac{1}{1+r} \right)^i d_{t+1}, \tag{5.46}$$

And define the bubble in the market as:

$$B_t = P_t^* - P_t. \tag{5.47}$$

Although all models agree on the definition, the determination of future dividend payments and also the fundamental discount rate can not be determined without any additional individual assumption chosen by researchers.[119]
Looking at the bubble element Diba and Grossman , Froot and Obstfeld and Jarrow, Protter and Shimbo agree that negative bubbles cannot exist due to free disposal.[120] Diba and Gross-

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[116]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 72-81.

[117]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 80.

[118]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 81.

[119]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 81.

[120]Compare Jarrow, Protter and Shimbo,(2007): "Asset price bubbles in complete markets"; http://ms. mcmaster.ca/~grasselli/JarrowProtterShimbo07.pdf and Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1189-1214.

man even go a step further and argue that due to this fact also positive bubbles cannot exist.[121] On the other hand Wu and Van Norden include negative bubbles although there does not exist an economical interpretation why bubbles could be negative.[122]

Wu, Froot and Obstfeld state that bubbles can also exist over a longer period of time.[123] Van Norden on the other hand states that bubbles grow and collapse frequently.[124] Until now no consensus among researchers has been found.

Also regarding the detection method the presented tests do differ from each other.[125]

5.6. Summary

As explained in the previous sections all of the bubble detection models, also the newly introduced ones by Weites and von Maravic, are not extensively able to detect bubbles ex ante appropriately. Although some of the presented models do have strong economic reasoning, all of them are based on strong assumptions.

Since in all presented models the determination of the underlying fundamental value is based on assumptions and bubbles are determined as the deviation from this value; detected bubbles do highly depend on the individual assumptions of the testing procedure.[126] Most of the assumptions are due to simplicity, therefore very sensitive and therefore rarely validated by other researchers. Moreover all tests only reveal poor information about the bubble characteristics like size, volume or single dates.[127]

Also the newly introduced tests are not optimal bubble detection models. The Growth Expectation Test does detect several bubbles in the period from 1871 until 2009 but also this test is based on crucial individual, heavily criticised, assumptions.[128]

The Price/Earning Ratio Test detects no bubbles in the estimation window respectively detects

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[121]Compare Diba and Grossman, (1988): "The theory of rational bubbles in stock prices"; The Economic Journal, 98; 746-754.

[122]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry 35; 309-319 and Van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; Journal of Applied Econometrics, 11; 219-251.

[123]Compare Wu, (1997): "Rational bubbles in the stock market: accounting for the U.S. stock price volatility"; Economic Inquiry 35; 309-319 and Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1189-1214.

[124]Compare Van Norden, (1996): "Regime switching as a test for exchange rate bubbles"; Journal of Applied Econometrics, 11; 219-251.

[125]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 81-85.

[126]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 88-89.

[127]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 88-89.

[128]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 88.

a bubble from 1996 until 2000. Although the economic reasoning behind the test does hold, also this model is based on crucial assumptions.[129]

The Option Based Test is also based on sensitive assumptions which could bias a future empirical testing of the model.[130]

Based on these findings von Maravic and Weites conclude "...that there is still no econometric model which can reliably tell investors whether there is a bubble in the market. The application of different models might give an indication. However, the determination of the existence of a bubble seems to be mainly a matter of personal interpretation."[131] The main problem as mentioned lies in the determination of the fundamental value of the stock or asset price. Weites and von Maravic conclude that "as long as there is not a single way to determine the fundamental stok price, different assumptions lead to different findings."[132]

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[129]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 88.

[130]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 88.

[131]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-A survey and new tests"; Aarhus School of Business, University of Aarhus; 89.

[132]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-A survey and new tests"; Aarhus School of Business, University of Aarhus; 88.

6. A new Bubble Detection Test

This part represents the central part of this thesis. In this part an attempt to look at bubbles in the stock market from an alternative point of view is made. A new bubble test, based on the previously presented Dividends Growth Expectation Test by Weites and von Maravic, will be developed.[1] Therefore the reader should be informed that the structure of the newly developed test in this part, closely follows the model introduced by Weites and von Maravic in 2010.[2] Since the structure of the test partially coincides with the Dividends Growth Expectation Test, presented in a previous part, similar conclusion can be applied to the newly introduced bubble test. If additional references were considered it will be directly mentioned in the according footnote. All literature sources can be found in the Bibliography.

Moreover the reader should be warned that the presented model should not be seen as a new test but more as an additional hint if there is a bubble in the stock market or not. The background of the new test will be explained as first. The data, on which the model was tested will be explained in the second part. The testing procedure will be explained in the third section and a first graphical analysis will be provided. In the fourth section the new bubble test will be introduced. The model will be build in this section and the empirical results will be presented. Again the reader should be warned that the presented model should not be seen as a new test but more as an additional hint if there is a bubble in the stock market or not.

The basic idea behind the newly introduced test is the linear relationship between the book-value of equity of a single firm and the corresponding market-value of equity of the selected firm in the short and long run.[3]

The book value is the value of an asset according to its balance sheet account balance. The value is based on the original cost of the asset less any depreciation, amortization or impairment

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[1]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56

[2]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56

[3]Compare Bartholdy, Paere and Willett, (2000): "A Theoretical and Empirical Analysis of the Relationship between Markets and Book Values"; Aarhus School of Business, University of Aarhus; 22.

costs made against the asset.[4] According to CRSP[5] the company's book value can be calculated as,

$$BW = ATQ - LTQ + TXDITCQ - PSTKRV \qquad (6.1)$$

,where BW denotes the company's book value; ATQ denotes the total value of assets, LTQ denotes the total liabilities, TXDITCQ denotes the deferred taxes and investments and PSTKRV denotes the total, preferred stock capital.[6] The market value can be calculated by multiplying the number of outstanding shares with the current market price of a single share.[7]

6.1. Background

Studies of accounting numbers in capital market research are consistent with the simple view that, book values have a long-term relationship with market values and that market returns are related to book returns.[8]

Here the focus lies especially on the relationship between market value returns and related book value returns.

The idea behind it is to interpret the book value of equity as the underlying fundamental value of the asset. Therefore, by comparing the return from period t to period $t+1$ of the book value with the returns from period t to period $t+1$ of the market value a bubble element could be detected. If the change in the market value by far exceeds the change in the book value then the value of the underlying asset deviates from the fundamental value. This could conclude that the asset is in a bubble phase.

6.2. Data, Testing Procedure and Graphical Analysis

As underlying Index for the testing procedure the Dow Jones Industrial Average Index (DJIA) was selected. The Dow Jones is one of the most famous stock market indices all over the world. It was created by the Wall Street Journal editor and Dow Jones and Company co-founder Charles Dow in 1896. The index shows how 30 large privately owned companies based in the United States have traded during a standard trading session in the stock market. The value of

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[4]Compare Berk and DeMarzo, (2011): "Corporate Finance."; Second Edition, Global Edition; Pearson Education Limited; Glossary.

[5]Compare https://wrds-web.wharton.upenn.edu/wrds/; 17.06.2013; 10:33.

[6]Compare CRSP, Center of Research in Security Prices,(2012): "CRSP U.S. Equity Indexes Methodology Guide."; 23.

[7]Compare Berk and DeMarzo, (2011): "Corporate Finance."; Second Edition, Global Edition; Pearson Education Limited; Glossary.

[8]Compare Omura, (2005): "The Relationship between Market Value and Book Value for five selected Japanese Firms"; Queensland University of Technology; 1.

the Dow Jones is calculated as the sum of the included prices in the index divided by a divisor, which changes whenever one of the component stocks has a stock split or whenever a stock dividend is given to investors . Therefore a consistent value for the index can be generated.[9]

The data used for all future calculations was downloaded from CRSP[10] and is on a quarterly basis, as book values are published quarterly. The sum of the single book values of the historical components of the Dow Jones Industrial Average was calculated considering any change in the index over the chosen period. Then the returns for each period were calculated. The same was done with the according market values.

Year	Total Bookvalue	BV-Return	Total Marketvalue	MV-Return
1980	1611945680,00	13,74%	3166255819,28	14,93%
1981	1833493390,00	2,80%	3638977813,09	-9,23%
1982	1884910970,00	9,37%	3303100160,95	19,61%
1983	2061620110,00	17,77%	3950838102,51	20,27%
1984	2428017970,00	12,61%	4751672985,89	-3,74%
1985	2734155640,00	6,93%	4936290240,89	27,66%
1986	2923758800,00	5,49%	6301668121,53	22,58%
1987	3084317860,00	7,32%	7724584783,37	2,60%
1988	3310100950,00	2,05%	7925423987,73	11,85%
1989	3378008710,00	6,97%	8864586730,28	26,96%
1990	3613402440,00	1,12%	11254479312,76	-4,34%
1991	3653743320,00	-9,59%	11765083956,48	20,32%
1992	3303295200,00	2,82%	14155749016,43	4,17%
1993	3396452490,00	10,67%	14746043750,42	13,72%
1994	3758774840,00	16,51%	16769200952,97	2,14%
1995	4379434060,00	13,09%	17128061853,37	33,45%
1996	4952489460,00	10,62%	22857398543,32	26,01%
1997	5478581370,00	17,34%	28802607904,44	22,64%
1998	6428798800,00	19,32%	35323518334,00	16,10%
1999	7670765680,00	22,62%	44885981467,00	25,22%
2000	9406120560,00	7,54%	49907589183,00	-6,18%
2001	10115306170,00	3,51%	43010353532,00	-7,10%
2002	10470291500,00	20,52%	33088193141,00	-16,76%
2003	12618860870,00	21,74%	38213045655,00	25,32%
2004	15362214530,00	1,61%	40806616994,00	31,50%
2005	15609708720,00	12,50%	37193709861,00	-6,10%
2006	17560573470,00	0,43%	42531966540,00	16,29%
2007	17635581860,00	-18,22%	45230043878,00	6,43%
2008	14421973710,63	32,31%	31915326087,00	-33,84%
2009	19081742300,74	10,08%	35358450258,00	18,82%
2010	21004691800,70	5,68%	38005290925,00	11,02%
2011	22198735770,15	2,39%	38081379224,00	5,53%
2012	22728463960,02		43724588521,00	

Figure 6.1.: The Dow Jones Industrial Average component firms: Book- and market values

[9]Compare Sullivan and Sheffrin, (2003): "Econmomics: Principles in action."; Upper Saddle River, New Jersey 07458: Pearson Prentice Hall; 290.

[10]Compare https://wrds-web.wharton.upenn.edu/wrds/; 17.06.2013; 10:39.

Figure 6.1 shows the output for the used data from the period of 1980 until 2012 on a yearly basis. The sum of total book- and market values was calculated for each year by summing up the book- or market-value at the end of the fiscal year. The returns were calculated according to

$$r_t = \frac{V_{t+1} - V_t}{V_t}. \tag{6.2}$$

Where r_t denotes the return in time t, V_{t+1} denotes the value of the book or market-value at time $t+1$ and V_t denotes the value of the book or market value at time t.

Figure 6.2.: The Dow Jones Industrial Average component firms: Yearly Changes of Book- and market values

Figure 6.2 shows changes of book- and market values on a yearly basis from the period of 1980 until 2012.

Its obvious to see that the returns from year t to $t+1$ of the book and market values do differ. Figure 6.3 overlaps the two graphs from Figure 6.2 to give a better overview at this fact.
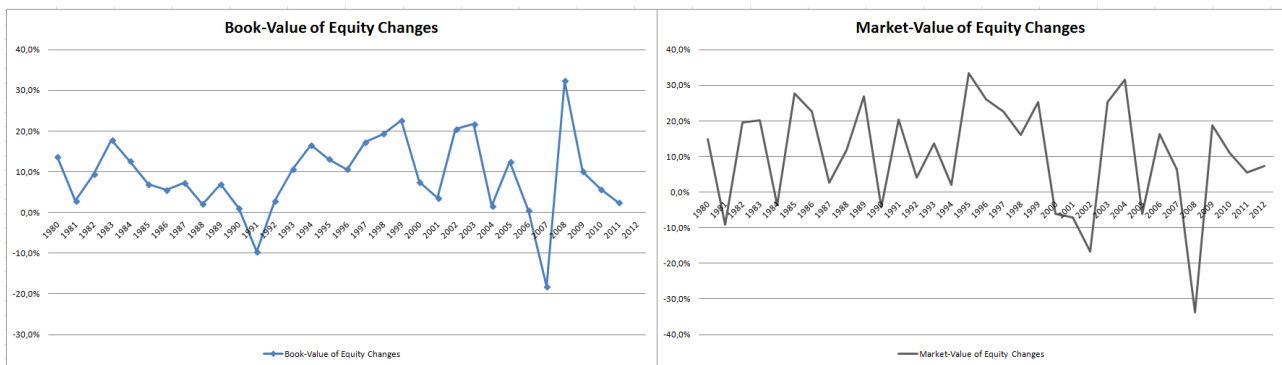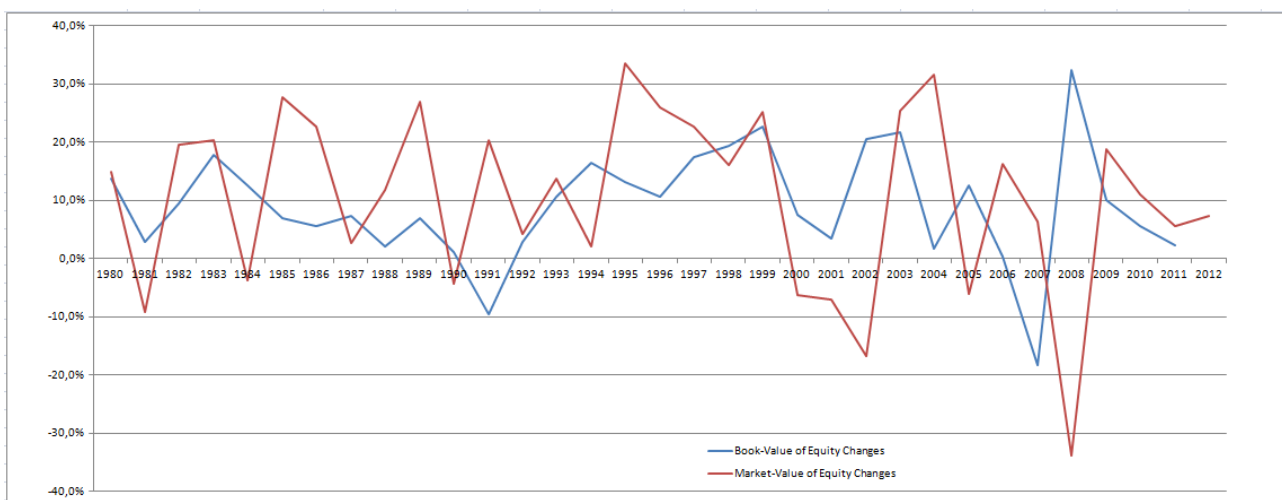

Figure 6.3.: The Dow Jones Industrial Average component firms: Yearly Changes of Book- and market values

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As we can see from Figure 6.3 there is no constant linear relationship between the book values and the according market values in the sample. This means that the assumed constant linear relationship between the market returns to book returns is clearly violated; especially in the periods from 2000 until 2005 and from 2006 until 2009. If the the book value is now considered as the fundamental value of the asset it can be concluded that the change in the market value is not related to the change of the underlying fundamental, the book value. Therefore the underlying asset could be in a bubble-phase.

In the next section a closer look on the sub sample from 2006 until 2012 will be taken. The sub sample will be analysed on a quarterly basis.

Figure 6.4 shows the data for the sub sample period from 2006 until 2012 on a quarterly basis.

Date	Total Market Value	MW-Change	Total Book Value	BW-Change	Dow-Jones-Index	DJ-Change
2006Q1	42.097.836.431	0,6%	14.513.190.370	18,9%	11003,62	3,7%
2006Q2	42.359.778.889	6,7%	17.255.591.910	2,2%	11186,66	1,7%
2006Q3	45.192.679.146	5,1%	17.642.818.070	2,2%	11273,68	0,8%
2006Q4	47.494.785.714	0,5%	18.022.970.800	-1,7%	12168,72	7,9%
2007Q1	47.745.311.728	4,3%	17.721.649.410	1,1%	12461,70	2,4%
2007Q2	49.779.013.060	1,5%	17.914.817.120	-1,5%	13224,62	6,1%
2007Q3	50.544.693.035	-4,0%	17.641.098.800	2,6%	13485,62	2,0%
2007Q4	48.509.281.455	-6,4%	18.094.146.610	-1,1%	13516,90	0,2%
2008Q1	45.392.808.108	-7,6%	17.890.181.290	0,4%	12386,38	-8,4%
2008Q2	41.937.663.413	-6,0%	17.953.151.740	-0,6%	12510,91	1,0%
2008Q3	39.408.062.807	-17,3%	17.850.270.170	-12,7%	11322,40	-9,5%
2008Q4	32.584.100.451	-11,5%	15.577.653.500	0,5%	8810,05	-22,5%
2009Q1	28.830.643.734	4,9%	15.652.853.810	12,3%	7757,77	-11,9%
2009Q2	30.233.351.206	13,8%	17.573.604.120	6,1%	8330,92	7,4%
2009Q3	34.403.636.212	6,1%	18.638.222.220	8,1%	9221,33	10,7%
2009Q4	36.500.858.996	5,3%	20.155.005.960	1,0%	10171,07	10,3%
2010Q1	38.451.684.424	-7,4%	20.352.366.030	3,0%	10469,05	2,9%
2010Q2	35.621.927.632	7,2%	20.963.887.490	2,7%	10565,12	0,9%
2010Q3	38.193.295.643	5,5%	21.533.481.540	2,0%	10389,61	-1,7%
2010Q4	40.293.324.419	5,7%	21.959.039.500	3,3%	11239,60	8,2%
2011Q1	42.589.883.954	-0,9%	22.676.514.330	2,4%	12024,70	7,0%
2011Q2	42.218.801.342	-12,6%	23.221.171.990	0,0%	12365,37	2,8%
2011Q3	36.879.776.382	8,0%	23.231.429.540	-1,2%	11647,55	-5,8%
2011Q4	39.839.772.798	8,3%	22.952.807.790	1,0%	11798,65	1,3%
2012Q1	43.153.617.737	-0,4%	23.179.825.400	1,2%	12847,53	8,9%
2012Q2	42.985.065.386	4,6%	23.448.061.960	2,1%	12760,67	-0,7%
2012Q3	44.974.421.183	-3,4%	23.939.055.500	-1,4%	13113,50	2,8%
2012Q4	43.455.058.730	8,6%	23.611.817.000	-0,1%	13140,36	0,2%

Figure 6.4.: The Dow Jones Industrial Average component firms: Quarterly Changes of Book- and market values compared with the Dow Jones Index from 2006 until 2012

Also in the analysed sub sample its perceptible that there is no constant linear relationship between the analysed book values and the according market values. The constant linear relationship between the market returns to book returns is, again, clearly violated; especially in the periods from 2007 Q3 until 2009 Q2 and in the period from 2010 Q1 until 2011 Q2. These findings would be consistent with the history presented in a previous part. The collapse of Lehman Brothers, the problems of Greece to repay its debt and the general Euro crisis would fit these dates.

Figure 6.5 shows the quarterly changes of book- and market values from the period of 2006 until 2012 to provide a better overview.
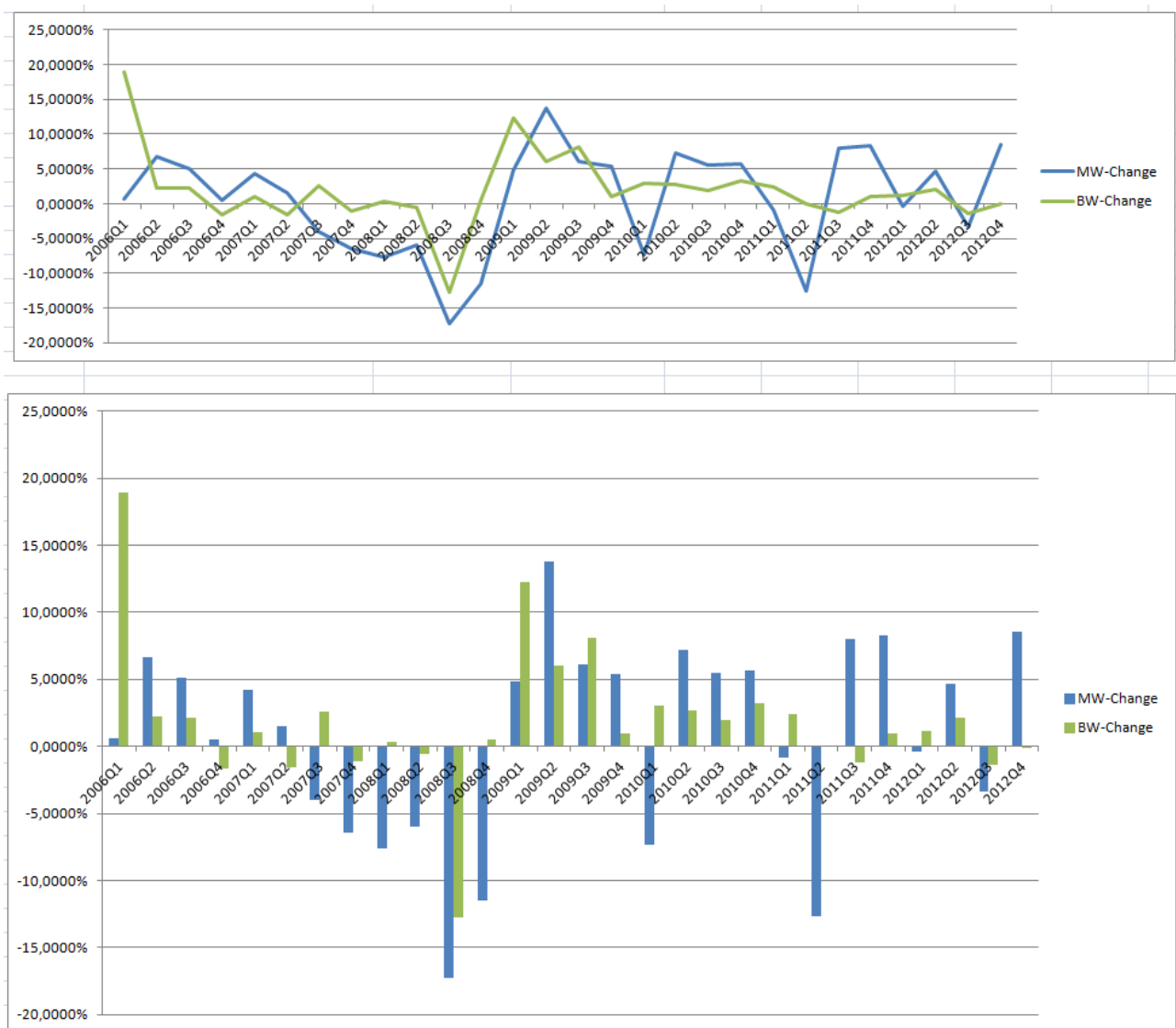

Figure 6.5.: The Dow Jones Industrial Average component firms: Quarterly Changes of Book-
and market values

Figure 6.5 delivers an interesting, but obvious, fact: market values fluctuate much more than book values and therefore are much more volatile. Due to the made assumption of treating the

book value as a fundamental value a change in the market value could only be justified if and only if the fundamental value, the book value, changed. This change would, obviously, occur after the book value changed. Therefore a change in the book value in period t should result in an immediate change of the market value, which then could be seen in period $t + 1$. Due to this consideration two further points arise:

First, if there is no change in the book value in period t the market value should not change in period $t + 1$. If the book value does change and the market value reacts, the reaction should contain the same change and direction as the fundamental change in the book value. This fact could make a proximate prediction of near future market values possible.

Secondly, and more interesting for this thesis, a severe deviation from the change of the fundamental book value in the change of the market value could conclude a bubble.

In the next section it will be tested if the book value in t has an influence in the market value in time $t + 1$. Subsequent a new test model with which the bubble and the size of the bubble can be detected will be provided. The new bubble test model will be based on the previous presented Dividend's Growth Expectation Test, introduced by Weites and von Maravic in 2010. Therefore the econometric, statistical and mathematical conclusions will coincide in various steps of the model.[11]

Before doing this the reader has to be reminded and warned that also the newly introduced bubble detection model will not be free of assumptions. Generally the provided bubble detection test should be seen as an addition to the existing bubble tests and therefore should always be used in addition to one of the previously explained models to detect a bubble.

The first and crucial assumption on which the newly introduced bubble test is based, is the fact that the book value of equity will be considered as the fundamental value of the underlying company. This of course is fundamental assumption. First, although the book value of equity of a single firm can be defined as its total assets minus intangible assets and liabilities in the praxis book values may variably include goodwill, intangible assets, or both. And secondly the book value is probably not an ideal proxy for a fundamental value. Still the reader must be informed that finding a better proxy as underlying fundamental value is very hard.

A second assumption relies on the results provided by Bartholdy and Willett in 2000. They found out that there is a relation between the book value of equity and the according market value. [12]

Furthermore it is assumed that the investor has free access to all published book values at any time. If this is given, the investor knows the fundamental value of the underlying company respectively the fundamental stock price.

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[11]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56.

[12]Compare Bartholdy, Paere and Willett, (2000): "A Theoretical and Empirical Analysis of the Relationship between Markets and Book Values"; Aarhus School of Business, University of Aarhus; 22.

The regression output in Figure 6.7 delivers the result of the test if the book value in t has an influence in the market value in time $t+1$.
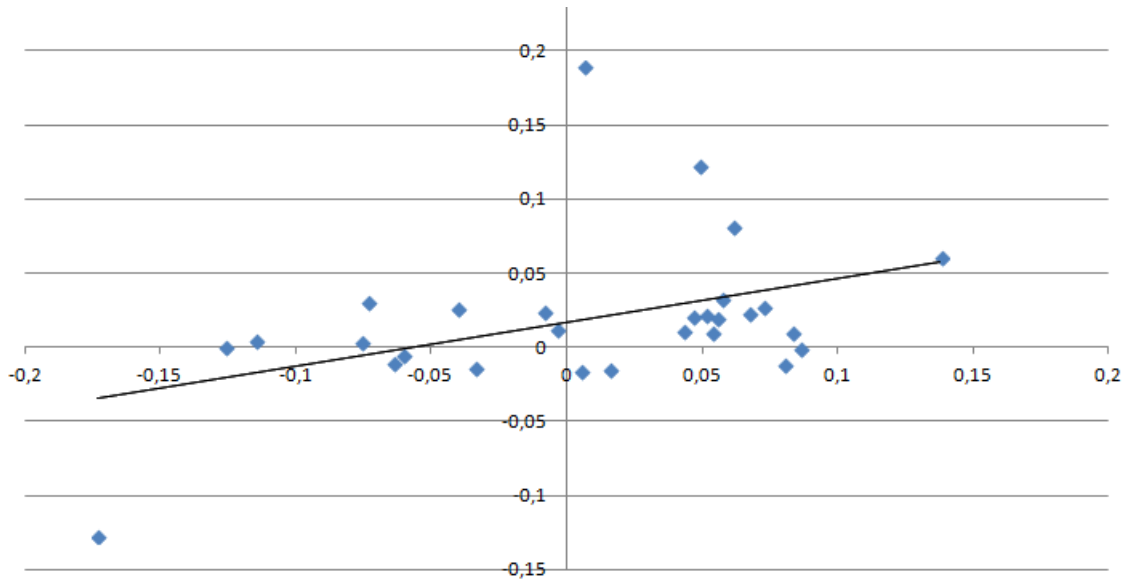

Figure 6.6.: Regression Graphically

Regression-Statistic	
Multiple R	0,423313489
R Square	0,17919431
Adjusted R Square	0,14762486
Standard Error	0,069106393
Observations	28

ANOVA

	df	SS	MS	F	F critical
Regression	1	0,027107762	0,027107762	5,676193669	0,024796447
Residual	26	0,124168033	0,004775694		
Total	27	0,151275795			

	Coefficient	Standard Error	t-Statistic	P-value
Intercept	-0,004453092	0,013897725	-0,320418813	0,751211903
Book Vaue Change	0,602752566	0,252994142	2,382476373	0,024796447

Figure 6.7.: Regression Output

As we can see from the regression output in Figure 6.7 the P-value of $0,024796447$ is smaller than the assumed significance level of $0,05$. This means that the influence of the book value in time t on the market value of time $t+1$ is significant. Therefore a variation in the market value (also) exists due to a variation in the underlying book value, among other factors. Still the R-squared level is relatively low with $0,14762486$. Therefore only approximately 15 per cent of a change in the market value can be explained by a change in the underlying book value.

Since the regression output delivers a significant result, the new developed testing model will be applied to the underlying data to proof the existence of a bubble in the market.

6.3. Introducing a new Bubble Test

In this section a new bubble test will be created and introduced. The new test is based on the Dividends Growth Expectation Test, introduced by Weites and von Maravic in 2010.[13] Therefore the econometric, statistical and mathematical conclusions will coincide in various steps with the original model.

6.3.1. The Model

Although, as explained in previous sections, there are many different perceptions about bubbles in the literature, still nearly all researchers do agree on the theoretical determination of the fundamental stock price. Generally the stock price is determined as:

$$P_t = bE(D_{t+1} + P_{t+1})|I_t. \tag{6.3}$$

$$b = \frac{1}{(1+r)} \tag{6.4}$$

Where P_t denotes the stock price in period t, b denotes the discount factor, D_{t+1} denotes the value of the future dividend, P_{t+1} denotes the future stock price, both of them, since they are future values, are expected, which is denoted by E, given the available information in time t, denoted by I_t.

The idea behind the newly introduced bubble test, again, is simple: the book value of equity of a distinct firm will be considered as the fundamental price of the underlying asset. Therefore a change in the book value of today will be defined as the present value of the expected future change of the book value plus the expected future change of the market value, conditional to the available information of today.
Formally,

$$\Delta BV_t = bE(\Delta MV_{t+1} + \Delta BV_{t+1})|I_t. \tag{6.5}$$

with

$$b = \frac{1}{(1+r)} \tag{6.6}$$

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[13]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 35-56.

Where ΔBV_t denotes the change in the book value in period t, b denotes the discount factor, ΔMV_{t+1} denotes the future change of the market value, ΔBV_{t+1} denotes the future change in the book value. Since both of them are future values, they are expected, which is denoted by E. They are expected on the available information in time t, which is denoted by I_t.

Therefore, if the equation is applied over n periods, it results that:

$$\Delta BV_t = \Sigma_{i=1}^n b^i E(\Delta MV_{t+1}|I_t) + b^n E(\Delta BV_{t+n}|I_t). \tag{6.7}$$

Here an assumption, established by Weites and von Maravic in 2010, comes into account. Weites and von Maravic assumed that "since it is assumed that stocks have an infinite lifetime, the transversality condition applies."[14] The same fact must be assumed in the newly introduced bubble test for the underlying firms. Therefore:

$$lim_{n\to\infty} b^n E(\Delta BV_{t+n}|I_t) = 0. \tag{6.8}$$

Again, here a conclusion by Weites and von Maravic comes into account. They stated that the fundamental value change "...is determined by its risk adjusted infinite expected future dividends stream alone...."[15] Applying this conclusion to the new bubble test it can be stated that:

$$\Delta BV_t^* = \Sigma_{i=1}^\infty b^i E(\Delta MV_{t+1}|I_t). \tag{6.9}$$

As we saw in a previous sections, the literature agrees on the fact that a bubble is described as the difference between the fundamental and the price in the market at a given time. In this new bubble test a bubble is defined as:

$$B_t = \Delta BV_t - \Delta BV_t^*. \tag{6.10}$$

Where B_t denotes the bubble in time t, ΔBV^t the change in book value in time t and ΔBV_t^* denotes the fundamental value change.

Also this newly introduced bubble test will be based on the Gordon Growth Model, as it is in the underlying model introduced by Weites and von Maravic in 2010:[16]

$$\Delta BV_t = \Sigma_{i=1}^\infty \frac{\Delta MV_t(1+g)^i}{(1+r)^{i+1}} = \frac{\Delta MV_t(1+g)}{r-g} = \frac{\Delta MV_{t+1}}{r-g}. \tag{6.11}$$

Where g denotes the constant period growth of the market value changes and r is a discount

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[14]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 37.

[15]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 37.

[16]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 39.

rate. The equation for the fundamental book value change therefore is given by:

$$\Delta BV_t^* = \frac{\Delta MV_{t+1}}{r-g}. \tag{6.12}$$

Rearranging it provides the fundamental growth expectation of the market value changes:

$$g = r - \frac{\Delta MV_{t+1}}{\Delta BV_t^*}. \tag{6.13}$$

If the market contains a bubble, B_t will show a non-zero value:

$$\Delta BV_t = \frac{\Delta MV_{t+1}}{r-(g^*+g_B)_t} = \Delta BV_t^* + B_t. \tag{6.14}$$

Therefore:

$$(g^*+g_B)_t = r - \frac{\Delta MV_{t+1}}{\Delta BV_t}. \tag{6.15}$$

Where g_{Bt} denotes the markets growth expectation excessive to the fundamental market value changes growth. If $g_{Bt} \neq 0$ there is a bubble. If $g_{Bt} > 0$, the markets growth expectations can be interpreted as excessive to the fundamental market value growth.[17]

Also this newly introduced bubble test, as the underlying bubble detection test introduced by Weites and von Maravic in 2010, "...does not suggest that if $g_{Bt} \neq 0$, the market has wrong expectations about future growth..."[18] of book value changes. "It rather means that..."[19] the book value changes are "...not determined by fundamental growth expectations of its underlying..."[20] market values.

6.3.2. Testing Procedure

In this section, in the first part, the testing procedure of the newly introduced bubble detection test will be explained. In the second part the test will be applied to historic data, the results of the test will be shown subsequently.

In the new bubble detection test a discount rate of r will be assumed; to empirically test the model the 3 Months Euribor rate will be taken since the values are on a quarterly basis.

Also in the newly introduced bubble test, analogously to Froot and Obstfeld, the newly introduced $log\Delta MV$ process is declared as a geometric martingale process which will continue

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[17]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[18]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[19]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

[20]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 40.

also in the future.[21]

$$log\Delta MV_t = \mu^* + log\Delta MV_{t-1} + \xi_t. \tag{6.16}$$

$$\xi_t \sim N(0, \sigma). \tag{6.17}$$

Where μ^* stands for the trend growth of the calculated logarithmic changes in the market value over this period.[22] Therefore it can be concluded that,

$$(g^* + 1) * (e^{\sigma^2/2})^{-1} = e^{\mu^*}. \tag{6.18}$$

$$log(g^* + 1) - \sigma^2/2 = \mu^*. \tag{6.19}$$

Based on this Weites and von Maravic conclude that the "...determination of the fundamental price from the Gordon Growth Model is in fact a stochastic process..."[23] This fact can be adopted here, so that:

$$\Delta BV^* = \Delta MV_{t+1}(e^r - e^{\mu^*+\sigma^2/2})^{-1}. \tag{6.20}$$

If there is no bubble, then $(g^* + g_B) = g^*$, which concludes that $g_B = 0$. Particularly this would mean that the annual growth expectations are equal to the annual growth from the market value changes geometric martingale. If this is true, the following hypothesis can be stated:[24]

H_0: **There is no bubble in the underlying growth expectations;** $g_B = 0$, **which would mean that** $(g^* + g_B)_t = e^{\mu^*+\sigma^2/2}$.

This will be tested by:

$$(t) = \frac{(g^* + g_B)_t - e^{\mu^*+\sigma^2/2}}{\sigma}. \tag{6.21}$$

Where (t) is the t-statistic to determine the level of significance of the tested parameters. A very small change in $g^* + g_B$ will have a big to huge impact on the associated ΔBV.[25] "Simultaneously, in the Gordon Growth Model $g^*+g_B < r$ will hold in any case. This means...,it

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[21]Compare Froot and Obstfeld, (1991): "Intrinsic bubbles: the case of stock prices"; American Economic Review, 81; 1189-1214.

[22]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 41.

[23]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection-A survey and new tests"; Aarhus School of Business, University of Aarhus; 42.

[24]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 42.

[25]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 42.

is very unlikely to detect bubbles."[26] Therefore, also in the newly introduced bubble test, the equations will be rearranged in the following way as it was rearranged by Weites and von Maravic in 2010:[27]

$$\Delta BV_t^{-1} = \frac{r - (g^* + g_B)_t}{\Delta MV_{t+1}}. \tag{6.22}$$

$$\left(\frac{\Delta MV_{t+1}}{\Delta BV_t}\right) = r - (g^* + g_B)_N + \varepsilon_t. \tag{6.23}$$

$$\varepsilon_t \sim N(0, \sigma) \tag{6.24}$$

On this point the same implication as in the underlying model applies: "Using maximum likelihood, $(g^* + g_B)_t$ and its associated σ can be determined over N periods. ...it can be tested whether there was a bubble present during the whole period. However, the test shows only low detection power in case that bubbles are only temporally present in the sample. If N increases so does σ, while $(g^* + g_B)_t$ is unrelated to N. Meaning, the larger N the more unlikely it is to detect a bubble."[28] A division into sub samples is therefore useful.

If the test does reject H_0, a determination of the fundamental value is possible. Furthermore the exact size of the bubble can be calculated.[29]

However, according to Weites and von Maravic, this fact "...should be interpreted as an indication rather than a factual exact amount of the bubble, for two reasons: First, the value is determined from a probability distribution, meaning that determinant values are not necessarily the real values, but just acceptably close enough (according to a normal distribution) to the real values. Second, one should be aware of the fact that some assumptions made in this method have been criticized before when used in other methods." [30] The exact same consideration can be applied to the newly introduced bubble test.

6.3.3. Data and Test Results

In this section the empirical results of the new bubble test will be reported. In the first part the applied data will be described. The second part will report the results of the econometric

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[26]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 42.

[27]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 42-43.

[28]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[29]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

[30]Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 43.

test. The last section deals with a discussion about the detection power and the adequacy of the newly introduced bubble test.

The data underlying the test is based on a quarterly basis over the years from 2006 Q1 until 2013 Q1. All calculation steps were applied to this data.
Figure 6.8 delivers the results of the t-test for the underlying data sample. The hypothesis of no bubble is rejected in all periods except in Q3 of 2012. That means that according to the newly introduced bubble test a bubble can be detected over the whole sub sample except in Q3 of 2012.

The results are based on 29 observations and a significance level of $0,05$. Also by applying a significance level of 0,01 and 0,1 the newly introduced test delivers the same result.

Period	Time	T-Statistic	Absolute Value	Critical value for a significance level of 5%	Result
1	2006Q1	-14,3364	14,3364	2,048	Rejected
2	2006Q2	-13,4312	13,4312	2,048	Rejected
3	2006Q3	-13,2803	13,2803	2,048	Rejected
4	2006Q4	-14,4780	14,4780	2,048	Rejected
5	2007Q1	-13,3523	13,3523	2,048	Rejected
6	2007Q2	-13,6967	13,6967	2,048	Rejected
7	2007Q3	-15,5024	15,5024	2,048	Rejected
8	2007Q4	-12,1679	12,1679	2,048	Rejected
9	2008Q1	-16,7455	16,7455	2,048	Rejected
10	2008Q2	-15,3745	15,3745	2,048	Rejected
11	2008Q3	-13,4452	13,4452	2,048	Rejected
12	2008Q4	-16,0054	16,0054	2,048	Rejected
13	2009Q1	-14,0541	14,0541	2,048	Rejected
14	2009Q2	-12,2903	12,2903	2,048	Rejected
15	2009Q3	-13,8355	13,8355	2,048	Rejected
16	2009Q4	-12,8019	12,8019	2,048	Rejected
17	2010Q1	-18,4398	18,4398	2,048	Rejected
18	2010Q2	-13,2186	13,2186	2,048	Rejected
19	2010Q3	-13,3063	13,3063	2,048	Rejected
20	2010Q4	-13,0199	13,0199	2,048	Rejected
21	2011Q1	24,9534	24,9534	2,048	Rejected
22	2011Q2	-14,6987	14,6987	2,048	Rejected
23	2011Q3	-13,9829	13,9829	2,048	Rejected
24	2011Q4	-12,3278	12,3278	2,048	Rejected
25	2012Q1	-14,2489	14,2489	2,048	Rejected
26	2012Q2	-13,5528	13,5528	2,048	Rejected
27	2012Q3	-1,1978	1,1978	2,048	Not Rejected
28	2012Q4	-12,5875	12,5875	2,048	Rejected
29	2013Q1	-13,7581	13,7581	2,048	Rejected

Figure 6.8.: T-test Results

Although the results of the test fit the appearance history of bubbles over the tested sub sample, it has to be said that the test does not look at bubbles in a conservative way and tends

to detect too many bubbles due to low standard deviations.[31] Furthermore the sample size can be criticised. The sub sample consists of 29 observations. This means that there are only 28 degrees of freedom which can generally lead to size distortions and therefore can bias the results.

The biggest problem in this alternative testing procedure is, as in all other presented models, the fundamental value.
Declaring the book value of equity as the underlying fundamental value is a fundamental assumption. First because although the book value of equity of a single firm can be defined as its total assets minus intangible assets and liabilities in the praxis book value may variably include goodwill, intangible assets, or both.
And secondly the book value is probably not an ideal proxy for a fundamental value. To some extent if market values deviate a lot from book values, it could be a sign of a bubble; but definitely not a fact.
The economic reasoning behind the test is clearly given. Still this alternative bubble test can not be seen as a distinct bubble test but more as an adequate indicator if a bubble exists or not.

Also other researchers in the past already provided similar toeholds for their analysis. Fama and French in 1992 [32] and Kothari and Shanken in 1996 [33] analysed if high market-to-book ratios predict low future returns, which would mean that prices were too high and that there was a bubble.

According to the provided findings the conclusion can be drawn that also this alternative econometric detecting model does not perfectly detect bubbles in a specific market. Although the economic reasoning behind the test does hold, the big and main problem, as mentioned, lies in the determination of the fundamental value of the stock or asset price, as it is in all other presented models.

Nevertheless the empirical results seem to be partially plausible and confirm the historical events, although they rather give an additional indication about bubbles than statistical proof for their existence.

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[31]Compare Weites and von Maravic, (2010): "How to detect bubbles in stock prices? Econometric bubble detection- A survey and new tests"; Aarhus School of Business, University of Aarhus; 53.

[32]Compare Fama and French, (1992): "The Cross-Section of Expected Stock Returns."; The Journal of Finance, Vol. 47, No.2.

[33]Compare Kothari and Shanken, (1996): "Book-to-market, dividend yield, and expected market returns: A time series analysis"; The Journal of Finance, Vol. 44, 1997.

7. General Data and Sample

In this part the analysed data and the analysed sample will be explained. In the first part the underlying data to which the different tests were applied will be explained; in the second part the underlying sample will be explained.

In the overview of the literature of historical econometric bubble detection tests and in the section where the new generation of bubble tests was introduced the data used was directly taken from the according individual test. Which data and sample was used and applied to the individual test was directly explained when the individual test was presented.

In the section where a new bubble test is presented the used data was taken from CRSP.[1] The test was applied to the Dow Jones Industrial Average Index on a yearly and quarterly basis over the period from 1980 until 2012. The results are shown in yearly frequency over the whole period and in quarterly frequency over the sub sample period from 2006 until 2012.
The returns or changes of book- and market values of equity were calculated in MS Excel and then processed in R. The obtained results can be found in the regarding section.

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[1] Compare https://wrds-web.wharton.upenn.edu/wrds/; 17.06.2013; 10:33.

8. Methodology

In this part the applied research methods and the applied data processing methods will be explained.

The research included an extensive review of the existing literature about bubble detection, the comparison of the traditional models, the finding of more recent models and the search for adequate data to test these models.

The literature review consists of a summary on general findings on bubbles.

The history part consists of a short overview of bubble history. Three historic examples of bubbles are mentioned and explained. Furthermore an overview, based on different findings in the literature, of the first years of the new millennium is given.

In the next session a detailed overview of the literature of historical econometric bubble detection tests is given. This overview is based on the different findings, directly taken from the individual work of the researchers. Each of the models is explained. Strength and weaknesses are pointed out and comments found in other literature are reviewed. The main goal is to give a historical overview of past approaches. A second goal is to create a basis of knowledge so that the introduction of the new, more complex, models will be easier to understand for the reader. All of the reported results are based on the findings of the individual researchers who presented the discussed test.

In the forth part five new bubble tests, designed by Weites and von Maravic in 2010, are introduced. With the empirical research a verification of explanatory power and adequacy of the new introduced tests is given. Furthermore appropriate adjustment suggestions which emerged from studying the literature are provided. The data used for the empirical tests is explained in a detailed section before every test. Moreover the newly introduced models are compared with each other and with the traditional models. After this the results provided by the developers of the test are shown, explained and criticised.

In the last part a new bubble test is provided. The theoretical background is taken from an advanced study of the bubble detection literature. To empirically test the newly introduced test appropriate data was taken from CRSP.[1] The data was downloaded from CRSP and then processed in MS Excel and R. The various tables and diagrams were all created in MS Excel. The whole work was composed in Tex Maker 10, an open source LaTex program.

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[1]Compare https://wrds-web.wharton.upenn.edu/wrds/; 17.06.2013; 10:33.

9. Conclusion

All presented models do have an economic reasoning behind it and are able to detect certain bubbles in the tested sample as explained. Still all models, also the newly introduced bubble test, do have downsides. The right estimation of the fundamental value and the taken assumptions of each model are the biggest issue in all provided models.

Although the literature about bubble detection has tremendously grown over the last years further research has to be done. Some important insights were already provided but there are still a lot of open questions:

- The first one is still a basic question: how do bubbles actually start? Still we do not have any insights on how bubbles start. Some findings about how they build and on how they survive were given, but in the most models bubbles have to be present from the beginning.

- Secondly, on the bursting of a bubble itself further research has to be done. What are the relevant factors that cause a bubble to burst? How will it burst, when will it burst and can we predict it?

- Thirdly, the reaction of central banks has to be overlooked. Should central banks include bubbles as target in their policy actions? If yes, how? If not, why not?

These are just a few selected questions out of a big pool. It is clear that the research field is still new and that a lot of work has to be done. But it is also sure that there will be plenty enough future bubbles that will either approve future findings or not.

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Page 73 - Figure 6.6: "Regression Graphically".

Page 73 - Figure 6.7: "Regression Output".

Page 79 - Figure 6.8: "T-Test Results".

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