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Excess Volatility in European Equity Style Indices - New Evidence

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July 2006 No. 16

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Abstract

Are financial markets efficient? One proposition that seems to contradict this is Shiller's finding of excess volatility in asset prices and its resulting rejection of the discounted cash flow model. This paper replicates Shiller's approach for a different data set and extends his analysis by testing for a long-run relationship by means of a cointegration analysis. Contrary to previous studies, monthly data for an integrated European stock market is being used, with special attention to equity style investment strategies. On the basis of this analysis' results, Shiller's findings seem questionable. While a long-run relationship between prices and dividends can be observed for all equity styles, a certain degree, but to a much smaller extent than in Shiller's approach, of excess volatility cannot be rejected. But it seems that a further relaxation of Shiller's assumptions would completely eliminate the finding of an overly strong reaction of prices to changes in dividends. Two interesting side results are, that all three investment styles seem to have equal performance when adjusting for risk, which by itself is an indication for efficiency and that market participants seem to use current dividend payments from one company as an indication for future dividend payments by other firms. Overall the results of this paper lead to the conclusion that efficiency cannot be rejected for an integrated European equity market.

Keywords: Equity Market Efficiency; Discounted Cashflow; Excess Volatility; Variance Bound Test, Cointegration Tests
JEL-Codes: G12; G14

Zusammenfassung

Sind die Finanzmärkte effizient? Das Ergebnis von Shillers (1981) berühmter Untersuchung über "Excess Volatility" in Aktienpreisen verneinte diese Frage. Demnach wären Vermögenspreise nicht als diskontierte Summe aller zukünftigen Einkommensströme (Present Value) darstellbar. Dieser Aufsatz wendet Shillers Ansatz auf einen anderen Datensatz an und erweitert ihn um einen Test auf eine langfristige Beziehung zwischen Preisen und Dividenden (cointegration test). Es werden monatliche Daten von drei verschiedenen Investmentstrategien für einen europäischen Gesamtmarkt verwendet. Die Resultate bestätigen Shillers Ergebnisse nur bedingt. Während mit dem Koointegrationstest für alle drei Investmentstrategien eine langfristige Beziehung zwischen Preisen und Dividenden gefunden werden kann, lässt sich "Excess Volatility", wenn auch in deutlich geringerem Umfang als es Shiller ausweißt, nicht ablehnen. Eine weitere Lockerung von Shillers Annahmen dürfte die übermäßige Reaktion der Preise auf Veränderungen in Dividendenzahlungen komplett eliminieren. Zwei interessante Randergebnisse sind, dass alle drei Investmentstrategien auf risikoadjustierter Basis die gleiche Performance aufweisen, und dass Marktteilnehmer offensichtlich aktuelle Dividendenzahlungen eines Unternehmens als Prädiktor für zukünftige Zahlungen anderer Unternehmen heranziehen. Alles in allem lässt sich auf Basis dieser Ergebnisse sagen, dass Effizienz in einem europäischen Gesamtaktienmarkt nicht abgelehnt werden kann.

Schlagwörter: Aktienmarkteffizienz; Discouned Cashflow; Excess Volatility; Variance Bound Tests; Kointegration
JEL-Codes: G12; G14

Contents

1 Introduction

From an economics perspective the role of financial markets in an economy is the optimal allocation of resources and the provision of risk sharing/diversification possibilities for its participants. Both aspects are crucial factors in economic growth. But in order to be able to fulfill these tasks, financial markets need to be efficient. Inefficient markets could, for example, quite possibly direct funds into less than optimally profitable projects. Hence financial market efficiency has for a long time been a much followed research topic. By the late 70s and early 80s the hypothesis of efficient financial markets, due to its intuitive structure, but also based on early empirical work (Fama, 1970) seemed to be one of the "real" success stories in economics. Michael Jensen, one of the cocreators of the Efficient Market Hypothesis[1], even was led to saying that *"there is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient markets hypothesis" (Jensen, 1978, p. 95).* But as usual in economics, as soon as such a strong declaration has been made, the tide tends to turn and in the early 1980s financial market efficiency was highly debated. One of the topics that initiated the discussion was the phenomenon of excess volatility, which clearly contradicts an efficient discounted cash flow model. Originally introduced in the late 1970s for long-term interest rates, Shiller (1979), LeRoy & Porter (1981) and Shiller (1981) adapted this concept to equity markets. It is especially Shiller's contribution (1981) that became one of the most influential papers in the question of market efficiency. The articles that have followed since then, which commented and criticized Shiller's work (1981), had several things in common: Firstly, they mostly either covered US stock market data or, when looking at Europe, analyzed data for specific countries but not Europe as a whole. Secondly, most analyses use annual data and thirdly, usually standard broad market indices were being used as the data basis. It is in these three aspects this study tries to broaden the view. In the past few decades, the European stock markets have developed considerably and not just since the introduction of the Euro are they increasingly integrating.(Hardouvelis, Malliaropulos and Priestley, 2006) The increased competition among the European exchanges and their attempts to concentrate their industry is just one among an array of indications for this integration. In fact one could assume that such phenomena as "home market bias" (Levy and Sarnat, 1970, for example) might actually have declined. At the same time, the data history for European wide indices reached a sufficient length, so that now, it makes sense to analyze an integrated European stock market as a whole, rather than looking at its components by analyzing country specific stock markets.

Furthermore, there seems to be a discrepancy between studies focusing on the general, more long-term characteristics of the stock markets by using annual data and those basing their analysis on monthly or even higher frequency data. While more

[1] The Efficient Market Hypothesis was introduced by Fama in 1965 and 1970, but it was developed by his team of researcher at the University of Chicago, from where Jensen was a graduate.

recent papers of the former tend to retain the discounted cash flow model, e.g. Barsky & De Long (1993) and Cuthbertson & Hyde (2002), the latter, on the other hand, find anomalies and excess returns (Lee and Swaminathan, 2000). But why should a fundamental relationship, that holds in the case of annual data cease to exist on the basis of monthly data? It is hence the attempt of this study to transfer the methods and approaches usually adopted by papers using annual data to a monthly data framework and by doing so either to confirm a general difference between the behavior in a sub-annual and annual environment, or to state that the discounted cash flow model holds for both annual and sub-annual data.

Finally, considering their continuously increasing popularity, the inherent contradiction to market efficiency of their underlying investment idea and the lack of studies covering them in a European wide framework, equity style investment indices (i.e. Value, Growth etc.) are a prime test subject for this study.[2]

It is the aim of this study to examine in how far excess volatility is a problem in an integrated European stock market and therewith in how far the discounted cash flow approach to asset pricing can be rejected or retained. In general, the analysis will proceed as follows. After giving the reader an insight into Shiller's original work (Shiller, 1981) and its main critical points, as discussed in the relevant literature, the results section will start by trying to reproduce Shiller's (1981) results. The next step will be to extend his work by relaxing some strict and unrealistic assumptions. The adaptation of the models and the data to a monthly framework will play a central role. The study will conclude with a short summary of results and some indications as to where the next step of research should lead.

[2] In short equity style investment tries to earn abnormal riskadjusted returns by investing in shares according to specific characteristics. For example, a Value investor prefers shares with a low P/E-ratio, as he/she considers them to be "'cheap"'. For an introduction to equity style investment the reader should refer to " The Handbook of Equity Style Management" (Coggin, Fabozzi and Arnott, 1997).

2 Literature review

The following section will give the reader an introduction into the relevant academic literature since the original papers by LeRoy & Porter (1981) and Shiller (1981) up to the present developments. At this point it should be noted that in its function as an introduction this section will try to be as broad as possible and hence will touch developments beyond the scope and aim of the particular analysis.

2.1 The Original Work

The discounted cash flow model, as used by Shiller (1981) states that if equity markets are efficient, current prices (P_t) should be nothing but the sum of expected future discounted dividends (i.e. the present value):

$$P_t = \sum_{k=0}^{\infty} \gamma^{k+1} E_t(D_{t+k}) \tag{1}$$

where

$\gamma = \frac{1}{1+r}$ is the constant discount factor ($0 < \gamma < 1$)

r is one period constant required return (risk-free rate plus a risk compensation)

E_t is mathematical expectations

D_{t+k} is dividends k-periods into the future. Dividends for period t are being paid at $t + 1$.

Clearly equation 1 is a first best case scenario, which requires perfect foresight, but in a world characterized by uncertainty about the future the following should hold:

$$P_t = E_t(P_t^*) \tag{2}$$

where $P_t^* = \sum_{k=0}^{\infty} \gamma^{k+1} D_{t+k}$ is the perfect foresight price equivalent to equation 1.

So, P_t is the mathematical expectation of P_t^*. Or to put it differently, P_t is the optimal forecast of P_t^* :

$$P_t^* = P_t + u_t \tag{3}$$

where u_t is the forecast error.

Taking the variance on both sides of equation 3 one gets:

$$\begin{aligned} var(P^*) &= var(P + u) && (4) \\ \Leftrightarrow var(P^*) &= var(P) + var(u) + 2 \cdot covar(P, u) && (5) \end{aligned}$$

Since P_t is an optimal forecast of P_t^*, $E_t(u_t)$ should be zero, as on average the forecast error should not be systematic. Furthermore and more importantly, u_t and P_t are independent, which means that $covar(P_t, u_t) = 0$. Considering these facts in combination with equation 5, it follows that:

$$\Rightarrow var(P^*) = var(P) + var(u) \tag{6}$$

$$\Rightarrow var(P^*) \geq var(P) \tag{7}$$

Or, expressed in the more easily interpretable concept of standard deviations:

$$\sigma(P^*) \geq \sigma(P) \tag{8}$$

This inequality is the best known of three variance bounds Shiller developed in his 1981 paper and forms the basis for most investigations into the excess volatility debate.

In order to test equation 7, Shiller used real annual data for dividends and prices from the S&P Composite Index for the years 1871 - 1979 and from the Dow Jones Industrial Average for the years 1928 to 1979. In a further preparation, he detrended prices and dividends by a long-run growth factor, $\lambda^{t-T} = (1+g)^{t-T}$, where g is the growth rate and T is the base year of the used price index, so that at $t = T$ nominal price equal real, growth adjusted price. By regressing the natural log of prices on an intercept and a time trend ($(P_t) = c + \beta t + \varepsilon_t$) and setting $\lambda = e^{\beta}$, Shiller determined the growth factor.[3] To put it differently, Shiller divides equation 1 by λ^{t-T} and multiplies it by $\frac{\lambda^{k+1}}{\lambda^{k+1}}$. Further by defining $\lambda\gamma = \frac{(1+g)}{(1+r)} = \overline{\gamma} = \frac{1}{1+\overline{r}}$, $g < r$ and $\overline{\gamma} < 1$, he arrives at:

$$p_t = \sum_{k=0}^{\infty} (\lambda\gamma)^{k+1} E_t d_{t+k} = \sum_{k=0}^{\infty} \overline{\gamma}^{k+1} E_t d_{t+k} \tag{9}$$

By taking unconditional expectations of equation 9, it can be shown that the discount rate ($\overline{r}$) equals the ratio of the mean detrended real dividends and the mean detrended real prices:

$$\overline{r} = \frac{E(d)}{E(p)} \tag{10}$$

But as will be appreciated, calculating the perfect foresight price (p^*) from equation 9 is not possible, as it is an infinite series. One way to approximate equation 9,

3 At this point it should be noted that Shiller's analysis relyed upon three major assumptions: constant discount rate, constant growth rate and stationary dividend series. Each of these assumptions are subject to critisism, as the reader will see in a later section of this literature review.

if the dividend series is long enough, is to set a terminal value and calculate (p^*) recursively from terminal value to $t = 0$.

$$p_t^* = \overline{\gamma}\left(p_{t+1}^* + d_t\right) \tag{11}$$

Shiller (1981) set the terminal value of p^* equal to the average value of p_t and showed that using a higher or lower terminal value acts as if one did add or subtract, respectively, an exponential trend to p^*. But a different trend should not fundamentally change the series' variance.

So the final variance bound test looks as follows:

$$var(p^*) \geq var\,(p) \tag{12}$$

or

$$\sigma(p^*) \geq \sigma\,(p) \tag{13}$$

In his results Shiller showed that $\sigma\,(p)$ is 5.6 times as great at $\sigma\,(p^*)$ for the S&P Composite and 13.8 times in the case of the Dow Jones Industrial Average. In other words, assuming a constant discount rate, a stationary dividend series and a constant growth rate actual prices were too volatile to be justified by the discounted cash flows and their resulting present value.

A major downside of this approach is that it stops short of a statistical test of significance, which was delivered by LeRoy and Porter (1981). Still they come to a similar conclusion as Shiller.

2.2 Criticisms of the Original Work

Before coming to the critics of Shiller's (1981) work, an important advantage of his approach should also be noted. Besides being very intuitive and fairly easy to implement, characteristic always sought after in a test, the used variance bounds are insensitive to misalignment of the data. Because it is not always certain when dividends were paid, it can come to shifts in the observations and hence to misalignments between prices and dividends. Since the variance bounds are only concerned with the two series variances or standard deviations a possible misalignment is of no consequence.

As the reader can imagine, it did not take long for Shiller's (1981) and LeRoy and Porter's (1981) results to be criticized, especially, as their finding went against the general orthodoxy at the time. Most of the criticism hinged upon the three assumptions taken by Shiller: 1. a stationary dividend process; 2. a constant growth rate in prices and dividends; 3. a constant discount rate of market participants.

Firstly, Marsh and Merton (1986), Kleidon (1986a and 1986b) and Gillies & LeRoy (1991) as well as Barsky & De Long (1993) showed that Shiller's (1981) results are sensitive to the characteristics of the underlying dividend process. Should dividends not be stationary, the inequalities in 8 and 13 would not hold. While Gillies and LeRoy (1991) saw the nonstationarity of dividends as a problem, but questioned its significance, Kleidon (1986b) showed that if dividends follow a random walk, the variance of p^* rises dramatically and excess volatility seems far less certain. It is this assumption that will play a central role in the following analysis.

Secondly, the assumption of a constant growth rate has been criticized. Barsky and DeLong (1993), for example, footing their analysis on the Gordon model (1962), and assuming a complex non-stationary dividend process, explained that excess volatility can be accounted for by variations in the dividend growth rate.

Thirdly and similarly to the criticism of constant growth rates, Kleidon (1988b), Gillies & LeRoy (1991), Cochrane (1992), Cuthbertson & Hyde (2002) and even Shiller (1981) himself questioned the use of constant discount rates. Shiller (2003), by applying an array of proxies for varying discount rates (e.g. interest rates and intertemporal marginal rate of substitution for consumption) came to the conclusion that discounts rates would have to vary unrealistically much to be a feasible explanation of the degree of volatility in prices. Cochrane (1992), on the other hand for example, showed that changing discount rates can indeed explain most of the excess volatility.

For more general criticisms, Nelson and Kang (1984), Kleidon (1986b), Marsh and Merton (1986) and Campbell and Shiller (1987) strongly doubted the validity of the removal of a geometric trend from the non-stationary price and dividend series. Further, Ackert and Smith (1993) argued that dividends, as used by Shiller (1981) are not covering all cash flows, as they do not encompass profits from share repurchases and takeovers. Using accordingly adjusted data, they were unable find convincing evidence of excess volatility. Finally, Flavin (1983)and Merton (1986a) noted that the variance bounds, as used by Shiller (1981) showed a small sample bias towards rejecting the stated inequalities.

So in summary it should be noted that, especially newer studies, e.g. Cochrane (1992), Ackert & Smith (1993), Cuthbertson & Hyde (2002) and Heaney (2004), find little clear evidence opposing the present value model as implied by efficient markets.

3 Data and Results

The following analysis used indices from the data and index provider MSCI-Barra, which seemed most appropriate against alternative data sets as they cover the longest time span, are being calculated for the necessary investment strategies, are being well documented and are freely available. The indices cover EU15 plus Switzerland, i.e. a significant proportion of Europe and come in the form of a broad standard index (Standard), a Value, and a Growth index. All data is USD denominated. Since neither index is provided with a corresponding dividend series, the necessary data had to be retrieved in a different way. All indices are available as both price as well as performance indices. While the former only cover prices of the underlying constituents, the latter reinvests the distributed dividends.[4] It hence is possible to extract a dividend series from these two types of indices. Starting with the equation used to calculate the performance index, as taken from the MSCI website:

$$PF_t = PF_{t-1} \cdot (\frac{D_t + P_t}{P_{t-1}}) \tag{14}$$

It follows that dividend can be received from:

$$D_t = \left(\frac{PF_t}{PF_{t-1}} \cdot P_{t-1} \right) - P_t \tag{15}$$

where D_t = dividend index

PF_t = performance index

P_t = price index

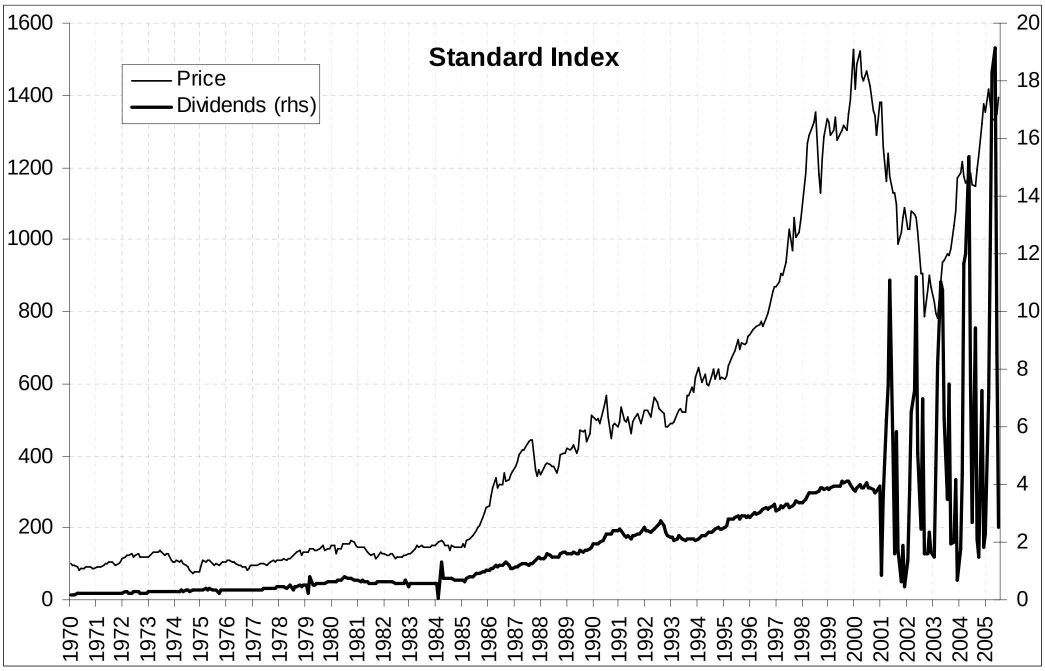
While obtaining the dividend series, a major flaw of the data was revealed. At the beginning of the year 2001 MSCI-Barra changed its methodology. Up to 31. Dec. 2000 dividends were incorporated in the index by reinvesting $\frac{1}{12}th$ of the annual dividend yield of the total index each month - essentially a smoothing of dividends

4 Furthermore, each performance index is available as a gross and as a net index. While the gross index reinvests the whole dividend as paid by the company, the net index considers tax deductions. It was decided to primarily use and present the results as obtained from the net indices. They are the relevant series for the largest group of investors and do not artificially exclude a friction, (i.e. taxes), from the data. It should be pointed out, though, that the following results do not substantially differ in quality from the ones obtained using the gross indices, which have been used to verify the results. The main difference in the results between net and gross dividends concentrated on the fact that the multivariate models built with gross index seemed to more frequently suffer from autocorrelation than those constructed with net dividends.

For more information on the methodology used to calculate the indices, the reader should refer to the corresponding section on the MSCI-Barra website (www.msci-com).

took place. After 01.01.2001 all relevant indices were transformed to daily performance indices, which reinvest the distributed dividends when the corresponding share price is reported "ex-dividend", resulting in a stable seasonal pattern in sub-annual dividend payments. This is not particularly surprising. Companies will hold their shareholder's meeting a few months after the end of their financial year and a further short time afterwards, potential dividend payments will be made. Since in most cases the end of the financial year of companies ends at the end of a particular quarter (the end of quarter 4 seems to be the most popular), payments from several corporations are clustered together in a small number of months. The resulting pattern is quite stable, as not many factors will move a company to change the end of its financial year. It hence can even be assumed that the found pattern did also exist before Jan. 2001.[5] It is clear, that a structural break in the data between Dec. 2000 and Jan. 2001 was the result of MSCI's methodological shift. But clearly the data after the change in the methodology reflects reality much closer. Figure 1 illustrates this break in the data on the example of the Standard index.

Figure 1: Price and Dividend Series for the Standard Index (Original Data)



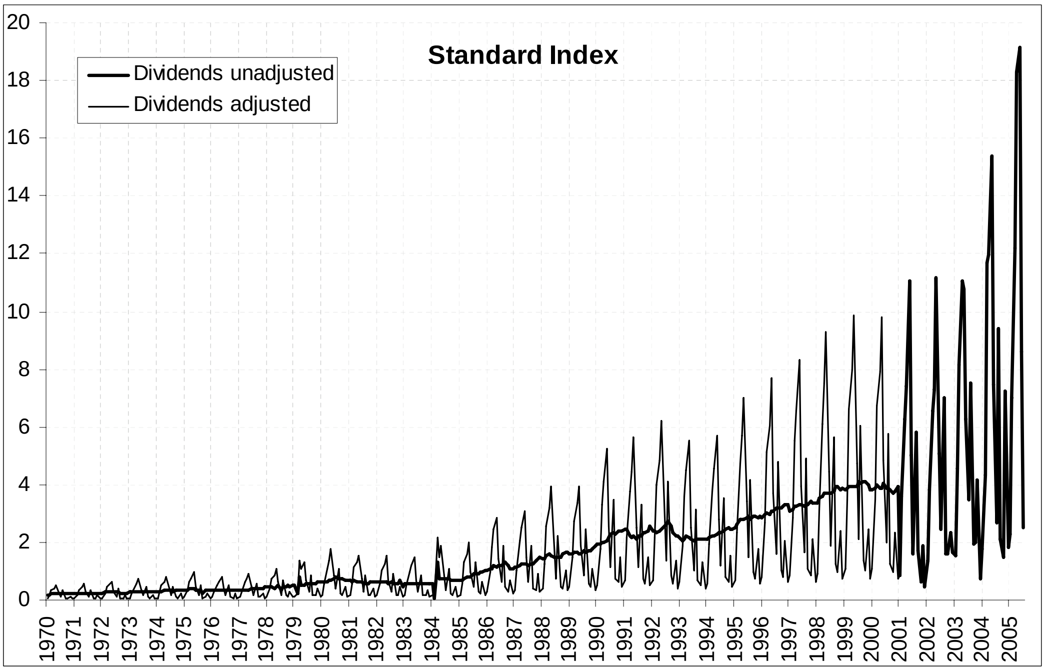
Source: MSCI-Barra; own calculations

Typically in such a situation, one would try to either find another data set or to work with two sub-periods or a dummy variable. An alternative appropriate data set could not be obtained and sub-periods seemed impractical, as either the period is too short (post-Jan. 2001) or the period did not reflect reality properly (pre-Dec.

[5] A cross check with data from S&P resulted in the conclusion that in fact dividend payment patterns are relatively stable over time.

2000). But as the monthly dividend payments after 2000 clearly follow a stable seasonal pattern, and one can assume that this seasonal pattern was unchanged throughout the whole sample period, it seems plausible to approximate the authentic non-smoothed dividend series prior to 2001 by extending the seasonal pattern to the data prior to Jan. 2001. After obtaining the seasonal factors using the Census ARIMA X-12[6] procedure and applying it to the data, the new (”seasonally”) adjusted dividend series (figure 2) resulted, which eliminated the structural break.[7]

Figure 2: Dividend Series for the Standard Index (Original and Adjusted Data)



Source: MSCI-Barra; own calculations

Furthermore, in accordance with Shiller's approach, all indices were deflated by a consumer price index for the EU15 (Jan. 2001 = 100)[8] as obtained from the OECD, in order to receive real prices.

Table 1 is a list of information about the deflated data sets. Two things become apparent. Firstly, as should be the case, the adjustment for the seasonal pattern does not fundamentally change the mean of the dividend series. Secondly, although their volatilities increased, the rise was less than one would expect from figure 2.

In the following, Shiller's 1981 analysis will be reproduced for the given data set and it will be tested whether his results still hold. The analysis will then be extended

6 All econometric estimations were calculated with Eview 5.

7 It should be pointed out, that in the following the main focus was put on the adjusted dataset, but in order to validate the results all tests were also conducted for original/unadjusted data.

8 The original base date is 2000, but since the SmallCap index does not cover any date prior to Jan. 2001, a rebasing seemed appropriate.

Table 1: Data Overview

			Start	End	Observations	Sum	Mean	Variance	Std. Deviation
Standard	prices		31.12.1969	31.07.2005	427	290363.14	680.01	106161.99	325.83
	dividends	original data	31.01.1970	31.07.2005	427	594.12	1.3914	0.4863	0.6973
		adjusted data				596.17	1.3962	1.3416	1.1583
Value	prices		31.12.1974	31.07.2005	367	333315.79	908.22	241192.75	491.11
	dividends	original data	31.01.1975	31.07.2005	367	789.86	2.1522	1.9973	1.4133
		adjusted data				787.59	2.1460	3.8061	1.9509
Growth	prices		31.12.1974	31.07.2005	367	313709.38	854.79	174387.73	417.60
	dividends	original data	31.01.1975	31.07.2005	367	499.54	1.3612	0.4520	0.6723
		adjusted data				500.70	1.3643	1.1466	1.0708

all indices are USD-denominated and in real-terms as deflated by the OECD EU15 CPI

Source: MSCI-Barra, OECD, ow n calculations

by the testing for excess volatility when assuming the dividend process follows a random walk. By doing so Shiller's (1981) restrictive assumption of stationarity will be loosened and his perfect foresight approach will be dropped in exchange for a degree of forecasting by the market participants. Finally, the so far simple benchmarking analysis of the present value model will be extended by testing for a long-run log-linear relationship between prices and dividends. This approach will be based on Gordon's (1962) growth model. A cointegration relationship will be tested through the means of a Johansen test for cointegration (Johansen, 1991).

3.1 Replication of Shiller's Results

Table 2: Results of Volatility Bounds

	Shiller 1981		Heaney 2004	MSCI Standard		MSCI Value		MSCI Growth	
	S&P Data	Modified Dow Jones Data	Australian Stock Price Data	original data	adjusted data	original data	adjusted data	original data	adjusted data
E(p)	145.5	982.6	2967.463	980.4270945		1463.885763		1298.718935	
E(d)	6.989	44.76	140.201	2.111631632	2.12738828	3.791817435	3.802747678	2.235736856	2.251478865
$\bar{r} = E(d)/E(p)$	0.048	0.456	0.047	0.026423867	0.026382551	0.038343854	0.038145987	0.023853859	0.023888048
$\beta = \ln(\lambda)$	0.015	0.019	0.017	0.031823757		0.056601513		0.047694335	
$cor(p, p^*)$	0.392	0.163	0.193	0.690165236	0.706658764	0.292250266	0.291437664	0.18990414	0.181594519
$\sigma(d)$	1.481	9.828	36.575	0.861180044	1.824384391	1.588948177	3.317875655	0.824643451	1.796109619
$\sigma(p)$	50.12	355.9	976.549	357.5446785	357.5446785	364.2433525	364.2433525	334.8576563	334.8576563
$\sigma(p^*)$	8.968	25.8	378.596	29.29249577	29.41916115	69.10369573	69.13333953	34.89020142	34.97013259
$\sigma(p)/\sigma(p^*)$	**5.588760036**	**13.79457364**	**2.579395979**	**12.20601622**	**12.15346273**	**5.270967764**	**5.268707616**	**9.597469852**	**9.575532933**

Terminal value in P* was set to the average of P in accordance with Shiller (1981).

$\bar{r}$ and β for reasons of comparability are annual rates

Table 2 shows the results for the test of excess volatility, when exactly following Shiller's (1981) approach. Besides the figures for the MSCI-Barra indices used here, Shiller's original results as well as some numbers for the Australian Stock Market, as calculated by Heaney (2004) are also included for informative purposes. In the case of the MSCI-Barra indices the results for the unaltered data, as a means of verification, were also included.

The most important result is that for all series excess volatility can clearly be observed and the volatility of prices ($\sigma(p)$) surpasses the volatility of the perfect foresight prices ($\sigma(p^*)$) by between 5.3 and 12.2 times. Furthermore, the degree of excess volatility is not fundamentally different from the earlier results by Shiller (1981) and Heaney (2004) , which were between 2.58 and 13.79 Also, the above described seasonal adjustment procedure, which introduced a seasonal pattern to the data prior to 01.01.2001, has, although increasing the standard deviation of the dividend series, left the results virtually unchanged.

Table 3: Unit Root Tests for Price and Original as well as adjusted Dividend Data

			levels			**first differences**			
			ADF Statistic	Prob	Lags	ADF Statistic	Prob.	Lags	
Standard Index	Adjusted Data	Log Prices	-0.5074	0.89	0	-19.4943	0	0	I(1)
		Log Dividends	-0.3767	0.91	23	-5.3633	0	22	I(1)
	Original Data	Log Prices	-0.5074	0.89	0	-19.4943	0	0	I(1)
		Log Dividends	-1.3870	0.59	13	-18.2602	0	10	I(1)
Value Index	Adjusted Data	Log Prices	-0.3209	0.92	0	-19.2471	0	0	I(1)
		Log Dividends	-0.5329	0.88	24	-4.0915	0	23	I(1)
	Original Data	Log Prices	-0.3209	0.92	0	-19.2471	0	0	I(1)
		Log Dividends	-0.9798	0.76	13	-7.4693	0	12	I(1)
Growth Index	Adjusted Data	Log Prices	-0.8857	0.79	0	-18.6556	0	0	I(1)
		Log Dividends	-0.6351	0.86	48	-3.5688	0.01	47	I(1)
	Original Data	Log Prices	-0.8857	0.79	0	-18.6556	0	0	I(1)
		Log Dividends	-1.8844	0.34	17	-6.5718	0	16	I(1)

All ADF-tests were conducted including an exogenous intercept.
For Standard, Value and Growth: Automatic based on SIC, MAXLAG=72
For SmallCap: Automatic based on SIC, MAXLAG=18
Using AIC to automatically select the lag-length will lead to either identical or very similar results.
MacKinnon one-sided p-values
Critical values at a 5% level of significance for Standard, Value and Growth: -2.87; for SmallCap: -2.88.

As stated earlier, Kleidon (1986b) criticized Shiller's work for his assumptions about the dividend process. Table 3 shows the results of a unit root test for log prices and log dividends of the according indices in the original as well as the adjusted form In all cases, clear signs of persistence can be observed - all indices are integrated at the order one [I(1)] - and Kleidon's (1986) hypothesis of a nonstationary dividend process cannot be rejected. In fact Kleidon assumes dividends to follow a random walk, for which one can find at least two arguments. Firstly, it is assumed that under the weak form efficiency market prices should follow a random walk (Fama, 1970). It seems consequential, that if prices and dividends form a relationship, dividends need to be a random walk process as well. Secondly, a random walk in dividends allows for a simple way to introduce forecasting of market participants into the analysis. Shiller uses all information available from hindsight to calculate the present value at time t. Market participants, on the other hand, can only use the information available at time t. They have to form expectations about the future path of dividends in order to arrive at a present value evaluation. If dividends do in fact follow a random walk, it seems plausible to assume that market participants form their expectations on the basis of the last dividend payment, as the best forecast of a random walk process is its last observation. In the following p^* (hereafter denoted by p^*_{rw}) was re-estimated under the assumption of dividends following a random walk.

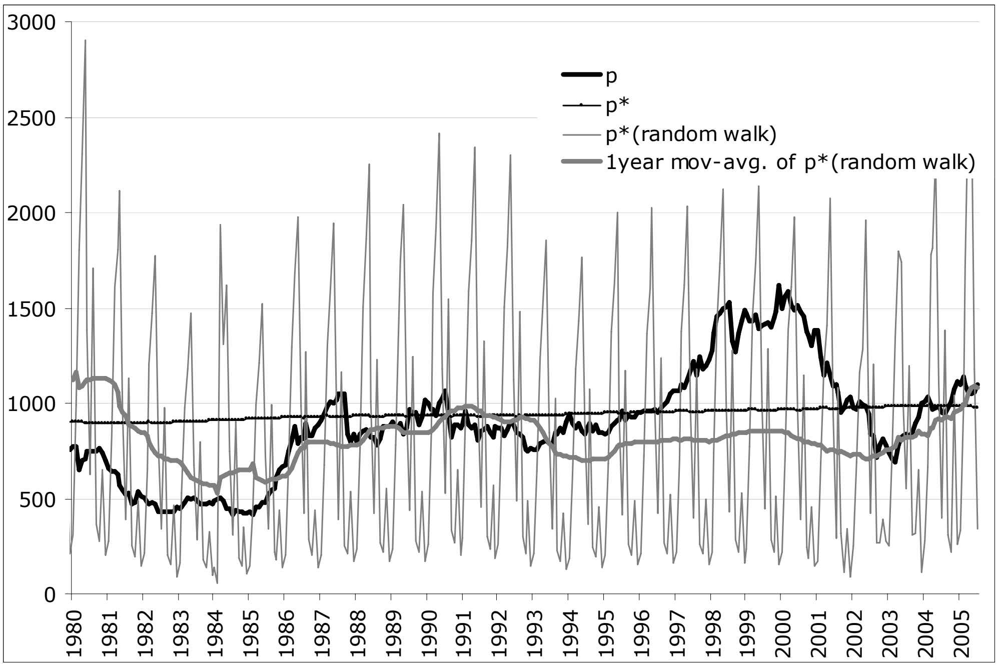
$$p^*_{rw_t} = \frac{d_{t-1}}{\overline{r}} \tag{16}$$

Table 4: Results for Volatility Bounds Assuming a Nonstationary Dividend Series

	Shiller 1981		Heaney 2004	MSCI Standard		MSCI Value		MSCI Growth	
	S&P Data	Modified Dow Jones Data	Australian Stock Price Data	original data	adjusted data	original data	adjusted data	original data	adjusted data
E(p)	145,5	982,6	2967,463	980,4270945		1463,885763		1298,718935	
E(d)	6,989	44,76	140,201	2,111631632	2,12738828	3,791817435	3,802747678	2,235736856	2,251478865
$\overline{r} = E(d)/E(p)$	0,048	0,456	0,047	0,026423867	0,026382551	0,038343854	0,038145987	0,023853859	0,023888048
$\beta = \ln(\lambda)$	0,015	0,019	0,017	0,031823757		0,056601513		0,047694335	
$cor(p, p^*_{rw})$	0,392	0,163	0,193	0,690165236	0,706658764	0,292250266	0,291437664	0,18990414	0,181594519
$\sigma(d)$	1,481	9,828	36,575	0,861180044	1,824384391	1,588948177	3,317875655	0,824643451	1,796109619
$\sigma(p)$	50,12	355,9	976,549	357,5446785	357,5446785	364,2433525	364,2433525	334,8576563	334,8576563
$\sigma(p^*_{rw})$	8,968	25,8	378,596	395,0864043	839,801022	504,3574894	1061,865381	418,206002	912,1000693
$\sigma(p)/\sigma(p^*)$	**5,588760036**	**13,79457364**	**2,579395979**	**0,904978442**	**0,425749278**	**0,72219281**	**0,343022156**	**0,800700264**	**0,3671282**

$\overline{r}$ and β for reasons of comparability are annual rates

Figure 3: P, P^*, and P^*_{rw} Comparison



Source: MSCI-Barra; own calculations

The results of this approach can no longer support the hypothesis of excess volatility (table 4). While the figures for the adjusted as well as the unaltered data are again leading to identical conclusions, albeit being slightly different in magnitude[9], p^*_{rw} is much more volatile than p. Clearly, criticizing Shiller's (1981) results seems to be well founded.

Figure 3 plots p as well as p^* and p^*_{rw} on the example of the Standard index. As the reader can clearly see, p^*_{rw} is much more volatile than p^* and p. But another thing becomes clear, p^*_{rw} in its general tendency, as indicated by a 12-month moving average of p^*_{rw}, follows p much more closely, than p^*.[10] In fact it seems, by assuming a simple forecasting procedure, i.e. future dividends are due to the underlying non-stationary dividend process predicted by taking last periods dividends, the discounted cash flow model explains large parts of the underlying price movements.

3.2 Extending Shiller's Work

An alternative approach to testing the discounted cash flow hypothesis is to directly test for a long-run relationship between dividends and prices. Following Gordon (1962) and Barsky and DeLong (1993):

$$P_t = \frac{D_t\,(1+g)}{r-g} \tag{17}$$

This is the well known static Gordon Growth Model (GGM) and it can be seen as an extension to equation 16. In fact, if one assumes constant r and g, the discounted cash flow model can be reduced to equation 17. The GGM assumes a random walk in dividends, but by including a growth factor adds a further level of anticipation, i.e. a more complex forecasting procedure than in the case of equation 16. To be precise, if one was to assume, that investors re-estimate g at any given time, based on past experience, one would actually receive a model of adaptive expectations (Barsky and Long, 1993), which corresponds to the dynamic GGM. For the purpose of simplicity, though, it is assumed that g is a constant. Taking logarithms and rearranging, the following simple relationship between prices and dividends results:

$$\ln(P_t) = \ln\left(\frac{1+g}{r-g}\right) + \ln(D_t) \tag{18}$$

$$\Leftrightarrow p_t = c + d_t \tag{19}$$

where $p_t = \ln(P_t)$; $c = \ln\left(\frac{1+g}{r-g}\right)$, which is assumed to be constant; $d_t = \ln(D_t)$.

[9] Obviously, the random walk process translated the greater volatility of d in the adjusted case into a greater volatility of p^*_{rw}.

[10] The ratio of the standard deviations between p and a 12-months moving average of p^*_{rw} is 1.1788, so much closer to the hypothesised unity.

If the coefficient of d_t should not be significantly different from one, the discounted cash flow model could not be rejected.

If one was to use annual data for the indices and hence annual dividend payments, this log-linear relationship could be used for the following analysis without any adaptations needed, but since monthly data is being used, an addition to this model has to be introduced. In any given month only a portion of all companies incorporated in one of the indices is paying dividends, but at the same time the price of the whole index is changing. In other words, there is a mismatch between D_t, which only covers a (from month to month changing) fraction of the whole index, while P_t always represents all constituents. One possible way of dealing with this situation would be to use a rolling sum of the past 12 dividend payments:

$$P_t = \frac{1+g}{r-g} \sum_{t=0}^{11} D_t \tag{20}$$

$$\ln(P_t) = \ln\left(\frac{1+g}{r-g}\right) + \ln\left(\sum_{t=0}^{11} D_t\right) \tag{21}$$

$$p_t = c + ds_t \tag{22}$$

where $ds_t = \ln\left(\sum_{t=0}^{11} D_t\right)$.

The disadvantage of this rolling sums model is that one loses parts of the specific information of the monthly data, as the price is always a result of a full year's sum of dividend payments. An alternative approach requires an assumption and some explanation. It is not uncommon, that a dividend announcement by a major market competitor is seen as an indicator for the whole market or specific sub-sections of the equity market. So in other words, one could assume that today's dividend payments are being treated as a good indicator for the payments of the remaining constituents of the index. This assumption though, can only be plausible in two cases:

- 1. The companies represented by the index are highly homogeneous, so that fundamental changes which are relevant to one company will affect all others as well.

- 2. The index, covering many sectors and heterogeneous shares, is considerably large. In this case, every month also a large heterogeneous number of constituents pay dividends. As a result this fraction of dividends can once again be seen as an indication of dividends to come.

The indices, which are being used in this study are irrespective of specific industries and cover several hundred shares. They should hence qualify for case No. 2. Still the seasonality in the monthly dividend data has to be considered, so that the following form seems appropriate:

$$p_t = c + d_t + \sum_{i=1}^{11} dum_i \tag{23}$$

where dum_i are seasonal dummies for each month.[11]

This set-up, hereafter called dummy model, has two main advantages: 1. The inclusion of the dummies preserves the additional information contained in the monthly data in comparison to annual data. 2. Should the relationship hold and the results are comparable to analyses based on annual data, it can be assumed that monthly dividend payments are indeed being used as a predictor for coming dividends.

In the following, the analysis was conducted for both equations 22 and 23. While the focus clearly lies on equation 23, equation 22 serves as a benchmark, which should lead to similar results as a study with yearly data.

Table 5: Johansen Test for Cointegration

Dummy Results

	Standard Index (48 lags)			Value Index (48 lags)			Growth Index (48 lags)		
Trace Statistic	Eigenvalue	Statistic	Prob[a]	Eigenvalue	Statistic	Prob[a]	Eigenvalue	Statistic	Prob[a]
No cointegrating vector	0.035358	14.84994 **	0.0624	0.059298	20.81957 *	0.0072	0.053616	18.88989 *	0.0148
At most one cointegrating vector	0.003282	1.242567	0.265	0.004332	1.380547	0.24	0.004286	1.365851	0.2425
	=> one cointegrating vector			**=> one cointegrating vector**			**=> one cointegrating vector**		
Maximum Eigen-Value Statistic									
No cointegrating vector	0.035358	13.60737 **	0.0633	0.059298	19.43903 *	0.0069	0.053616	17.52404 *	0.0147
At most one cointegrating vector	0.003282	1.242567	0.265	0.004332	1.380547	0.24	0.004286	1.365851	0.2425
	=> one cointegrating vector			**=> one cointegrating vector**			**=> one cointegrating vector**		

[a]MacKinnon-Haug-Michelis (1999) p-values

* denotes a rejection of the null hypothesis at a 5% level of significance; ** denotes a rejection of the null hypothesis at a 10% level of significance

Exogenous dummy variables: JAN FEB MAR MAY JUN JUL AUG SEP OCT NOV DEC

Results are for VECs with intercepts in both the VARs and the error correction vector.

Rolling Sums

	Standard Index (60 lags)			Value Index (60 lags)			Growth Index (60 lags)		
Trace Statistic	Eigenvalue	Statistic	Prob[a]	Eigenvalue	Statistic	Prob[a]	Eigenvalue	Statistic	Prob[a]
No cointegrating vector	0.04874	18.45477 *	0.0174	0.043125	13.44227 **	0.0996	0.081372	25.81044 *	0.001
At most one cointegrating vector	0.002016	0.716317	0.3974	0.001483	0.43794	0.5081	0.002616	0.772691	0.3794
	=> one cointegrating vector			**=> one cointegrating vector**			**=> one cointegrating vector**		
Maximum Eigen-Value Statistic									
No cointegrating vector	0.04874	17.73845 *	0.0136	0.043125	13.00433 **	0.0783	0.081372	25.03775 *	0.0007
At most one cointegrating vector	0.002016	0.716317	0.3974	0.001483	0.43794	0.5081	0.002616	0.772691	0.3794
	=> one cointegrating vector			**=> one cointegrating vector**			**=> one cointegrating vector**		

[a]MacKinnon-Haug-Michelis (1999) p-values

* denotes a rejection of the null hypothesis at a 5% level of significance; ** denotes a rejection of the null hypothesis at a 10% level of significance

Exogenous dummy variables: JAN FEB MAR MAY JUN JUL AUG SEP OCT NOV DEC

Results are for VECs with intercepts in both the VARs and the error correction vector.

[11] The sum of the dummies comprises of only 11 months, as the constant c is included in the relationship. An estimation of the relationship including 12 monthly dummies and an intercept (c) would lead to perfect multicolinearity, as the sum of all dummies equals the intercept. In the results below the month april has been arbitrarily omitted.

Conducting a Johansen test for cointegration (Johansen, 1991), in order to test for the log-linear relationship between dividends and prices, delivered the results depicted in figure 5.[12]

As always the model selection procedure is of crucial importance when using in a Johansen test for cointegration. Considering the strong seasonal pattern in the dividend data, special attention was given to serial correlation. For this purpose unrestricted VARs with lags up to 60 months covering only full years (i.e. 12, 24, 36, 48 and 60 months) were tested.[13] A combination of the standard information criteria (e.g. Akaike (AIC), Schwarz (SIC) etc.) as well as a general evaluation of the residuals for normality and serial correlation, lead to the model selection. (Johansen, 1995) This selection was backed up by Lagrange Multiplier (LM) and Portmanteau tests for residual autocorrelation in the corresponding VECM.[14] For the models using seasonal dummies 48 lags and for the rolling sums specification 60 lags were being used. As the reader can see in table 5, in the case of the models using seasonal dummies, the evidence for a cointegrating relationship between dividends and the according prices is quite strong. When comparing these results to the ones received from the rolling sums models, one thing becomes apparent: The results are generally similar. One can conclude that in general there seems to be a long-run relationship between prices and dividends and this result holds for both monthly models. As stated earlier, the rolling sums model is in essence very similar to a model just working with annual data for which this long-run relationship has been observed in several other studies, so the result of table 5 does not come as a surprise. But in the dummy model a cointegrating relationship indicates that indeed monthly dividend payments seem to be used as an indication for future dividend payments.

The first thing that comes to the attention when looking at the cointegrating equation (e.g. in the Standard index case: $1p_t - 1.877473d_t - 6.494741$) in table 6 is the fact that the estimated intercept (C) in the cointegrating vectors (i.e. the constant discount rate of the model) are largely the same across the indices. While this is at first a bit surprising, a look at the components of (C) allows some further insight. The estimates for (r), the required constant return, largely correspond to expectations: Growth requires the largest returns, in order to compensate for the risk associated with payments in the distant future, Value requires less than Growth but more than Standard in order to compensate the increased risk of investing in just a section of the market, and Standard requires the smallest (r). On the other hand, the growth rates of d_t level the differences in (r). To put it differently, is seems as if higher level of risk (r) are being compensated by higher degrees of return (g), so that in a de facto risk-adjusted manner, all investment strategies perform roughly

12 The precondition for cointegration - both time series have to be integrated at the order 1, I(1) - is fulfilled, as can be seen in table 3.

13 The fact that the monthly figures showed a strong seasonal element and each month only covers partial information, led to the decision to include only full-year lags, as it ensured, that the model never had to rely upon incomplete information.

14 Both LM and Portmanteau tests require a stationary VAR-process, hence they were only used for the VECM representation, as (see figure 3) all time series are I(1). (Lütkepohl, 2005)

the same. This is an interesting side-effect to this study and in itself an indication for efficiency.[15]

Table 6: Cointegrating Vector

Cointegrating Vector (seasonal dummy model)

		Standard Index (48 lags)	Value Index (48 lags)	Growth Index (48 lags)
Cointegrating Equation:	p_t	1	1	1
	d_t	-1.877473	-1.820969	-2.08436
		-9.48392	*-19.0897*	*-8.94542*
	C	-6.494741	-6.034552	-6.694801
implicit required rate of return (r), annualized		0.07474198	0.08289005	0.14825399
mean annulalized growth of d_t		0.05544018	0.05225234	0.13134112

restricting dividend coefficient to -1

		Standard Index (48 lags)	Value Index (48 lags)	Growth Index (48 lags)
Cointegrating Equation:	p_t (-1)	1	1	1
	d_t (-1)	-1	-1	-1
	C	-6.446277	-6.346751	-6.694777
implicit required rate of return (r), annualized		0.07570884	0.07459487	0.1482544
Chi-square		7.737552	15.57179	11.59975
Probability		0.005408	0.000079	0.00066

Small, italic figures are the t-statistics

A further point in table 6 concerns the dividend coefficients of the cointegrating vector (i.e. the dividend elasticity of prices). Just as in earlier studies, e.g. Barsky & De Long (1993) it can be inferred that they are highly significant. In fact, an alternative estimation, restricting them to -1, which would be implied by the strict discounted cash flow model and Shiller's (1981) set up, clearly showed that the dividend elasticity of price is larger than one and in fact much closer to 2.[16] (see the appropriate Chi-squared or Probability values in table 6).[17] In other words, some degree of excess volatility seems to remain even when adopting the static GGM. Finally, taking the results from table 5 and table 6 leads to a further interesting deduction. As hypothesized above, the dummy model and the rolling sums models do deliver very comparable results. This leads to the conclusion that market participants do indeed seem to use current dividend payments as a predictor for coming payments, in order to arrive at a current price evaluation on the basis of a full set of information.

[15] It should be pointed out that in all cases $(g) < (r)$ holds, which is a precondition for the GGM.

[16] A restriction to -2 of the coefficient for d_t in the cointregrating vector cannot be rejected in the standard and growth cases. For the value index restrictions to -1.75 and -1.9 cannot be rejected.

[17] Only results for the dummy model have been reported here, as the rolling sums approach delivers virtually the same figures. The dividend elasticity with respect to price in the long-term relationship (cointegration vector) are 2.07, 1.795, and 1.97 for the Standard, Value, and Growth indices, respectively. All coefficients are highly significant and tests restricting these coefficients to -1 are all clearly rejected, as well.

4 Conclusion

The initial set-up of this analysis replicated Shiller's (1981) approach, and just as he did for the US stock markets, excess volatility was found for all of the used European wide indices. But as soon as some extensions to Shiller's model were introduced, the variance bounds were not violated anymore and excess volatility ceased to be a problem. Dividends were allowed to be non-stationary, for which an ADF-test provided the indication. To simulate this situation dividends were assumed to follow a random walk By doing so Shiller's perfect foresight approach was dropped and some rudimental form of foresight - yesterday's dividends were used to determine today's appropriate price, rather than the discounted sum of all future dividends up to some terminal value - was introduced. Both the non-stationarity and the simple model of foresight introduced a level of uncertainty into Shiller's approach. It is hence not surprising that the volatility of prices increased substantially in the wake of these changes to the model.

In a next step the static Gordon Growth Model (GGM) was introduced. It represents a further extension to the prior tested model, which just relied upon a random walk, by assuming a more sophisticated forecasting procedure, while still remaining in the discounted cash flow framework. A test for cointegration found that there is a long-run log-linear relationship between prices and dividends. But it also became clear that the long-run elasticity of prices to dividends is significantly larger than one, as would be needed if the discounted cash flow model were to hold and it could hence not be retained in a one-to-one fashion.

Two side-results can also be reported. Firstly, all style indices reported roughly the same discount rates in the GGM. This is at first sight surprising, but when taking a closer look, one can see how larger required returns (r) are compensated by larger dividend growth rates (g). Or to put it differently, generally riskier assets (i.e. Growth) require greater return and are being compensated by greater growth rates in dividends. In other words, market participants essentially treat all indices the same, which gives the rise to the hypothesis, that if one was to compensate investors separately for higher risk, i.e. eliminating risk, all three indices would roughly perform the same; no index outperforms the other on a risk adjusted basis. This in itself is an argument for market efficiency. Secondly, the monthly data models seem to imply, that prices are being formed on the basis of just partial information about the dividends of the whole index. In fact, dividend payments in one month seem to serve as an indicators for dividend payments in the coming months.

In conclusion it can be said that in the face of the above results Shiller's (1981) conclusion do seem to be exaggerated; his assumptions are too strict. Although the existence of excess volatility cannot be rejected for an integrated European equity market, its degree seems to be much smaller than in Shiller's analysis. Furthermore, this study has by far not explored all possible sources of volatility. For example, as the dividend growth rate (g) and for the required return (r) are very close to each other, prices become very sensitive to changes in (r) (Campbell, Lo and MacKinlay, 1997, p. 256). In other words, if one was to let (r) fluctuate over time, a further element of volatility would be introduced into the model and the remaining degree of excess volatility can most likely be stripped away from the model. The same tendency should result from letting (g) vary over time. But to look at this will be the task of another study. Furthermore, the two side-results gave an interesting insight into the workings of the european equity market. Especially, the fact that all three indices seem to have roughly the same discount factor clearly is an argument against the different investment strategies; neither seems to deliver additional risk-adjusted returns, which is also pointing towards efficiency.

It seems indeed, that market efficiency cannot be rejected for an integrated european equity market.

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