“Temporary stock market bubbles: further evidence from Germany”

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Temporary stock market bubbles: further evidence from Germany

Abstract

Within the framework of rational bubbles the authors examine the existence of temporary bubbles in the German equity market between 1973 and 2014. Moreover, the bubbles are distinguished between rational price bubbles and intrinsic bubbles that arise from overreaction to fundamentals. Over the last 40 years, four prolonged periods are identified with sharp price increases in the stock market that were not matched by appropriate earnings rises. The "dotcom" boom and the run-up to the 1987 stock market crash are well documented in the literature and the empirical findings support the existence of bubbles during these periods in the German stock market. While the "dotcom" exuberance indicates a rational and an intrinsic bubble, there is only evidence of an intrinsic bubble before the 1987 crash. Furthermore, the researchers are the first to report another rational bubble process between 2009 and 2011 that has not been documented in the literature before and was followed by a 32% fall in the DAX index. However, there is no statistical evidence of a temporary bubble in the German stock market today (March 2013-March 2014). The findings might help portfolio managers to avoid investing into financial bubbles and enable central banks to counteract bubbles at an early stage by tightening monetary policy.

Keywords: stock market, speculative bubbles, valuation models.
JEL Classification: G15, G12, G14.

Introduction

Few weeks after receiving the Nobel Prize in economic science for his work on the empirical analysis of asset prices, Robert Shiller warned of current financial bubbles in international stock markets during an interview in December 2013[1]. At that time the US stock market recorded one of the greatest bull markets in history with an annualized return for the S&P500 of more than 21% after the stock market reached a bottom in March 2009. However, in spite of warning the stock market kept on climbing further and reached an all time high in 2014. The widely observed valuation measure Shiller-PE also showed an excessive level for a prolonged period of time and supported the argument for inflated stock prices. Thus the duration and magnitude of price increase pointed to the existence of a speculative bubble in the US stock market. Generally, the US stock market often acts as leading index for international equities and a prevailing bubble might spread to other major exchanges. On these grounds this article analyzes the German stock index DAX that closely tracked the performance of the S&P500 over the last five years measured in local currency.

The existence of speculative bubbles in international markets has a long history. One of the earliest bubbles that have been documented in the literature is the famous tulip mania during the Dutch golden age and dates back to the period 1634-1637. One hundred odd years later the shares of the British "South Sea Company" and the French "Mississippi Company" are frequently mentioned as examples of speculative bubbles followed by devastating crashes (e.g., Garber, 1989; Garber, 1990; Mackay, 2008). More recent bubbles include, but are not limited to, the roaring twenties stock market bubble, the Japanese asset price bubble during the 1980s and the dotcom bubble at the end of the 1990s.

The main issue with bubbles is not the bubble component itself, but rather the inevitable crash that must follow as has been proposed by the instability hypothesis of Minsky (1986). Also economic experiments indicate that financial markets are prone to boom and bust cycles (for a discussion see inter alia Smith et al., 1988; and Noussair et al., 2001). Suddenly collapsing share prices cause a negative wealth effect and might disrupt the whole economy. With falling stock prices, the wealth of economic agents falls and as a result consumption slows down. Particularly in consumption driven economies this might trigger deterioration in gross domestic product.

There is still a vivid debate about the existence and different types of potential bubble processes in finance and economics today. As the stock market fulfils an essential economic function and in many countries the pension system relies on it as well, it would be extremely helpful to be able to detect bubbles. For instance, central banks show increased interest in the assessment of prospective asset price bubbles again, after the US subprime crisis that was fuelled by inflated house prices, caused one of the biggest global economic meltdowns in history. Moreover, private investors, insurance companies, pension funds, speculators, governments and banks have a natural interest in identifying bubbles at an early stage to protect their investments and probably even counteract.

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[1] For the interview, see: Der Spiegel (2013).

In the literature financial bubbles are generally distinguished between intrinsic and deterministic bubbles. By intrinsic we specify a bubble that depends on the fundamental process, but prices rise disproportionally more than warranted by fundamentals (e.g. corporate profits). If earnings per share increase, stock prices go up as well, but at a higher rate and consequently valuation multiples expand. In contrast, deterministic bubbles do not depend on fundamentals and exhibit time dependent exponential or explosive price increases. However, in theory deterministic bubbles should only occur in assets with an infinite duration like stocks.

The following article verifies the existence of temporary bubbles in the German stock market index DAX between 1973 and 2014. The contribution to the literature is manifold. Unlike earlier studies of the German stock market by Salge (1997), we make use of the aggregate earnings for the DAX index and do not rely on general macroeconomic proxies for earnings. Furthermore, we extend the time frame to include the more recent stock market excesses during the dotcom boom and the period prior to the subprime crisis. Finally, we can indentify an intrinsic bubble that has not been reported in the literature before.

1. Theoretical background on stock market bubbles

1.1. Preface. In neoclassic economic theory the appearance of stock market bubbles is strictly ruled out. Nevertheless, the history of capital markets shows a repeating pattern of inflated share prices followed by prolonged bear markets or crashes. Consequently, academics formulated theoretical models for asset price bubbles. In the following section we will give a brief overview of the most popular definitions. For instance, Kindleberger and Aliber (2005) define a bubble as an extended price increase over 15 to 40 months that subsequently ends in sharply falling prices. Following Brunnermeier and Oehmke (2013) a bubble can be identified by an asset price trading above fundamental value and investors being convinced that prices will continue to rise. A further discussion about bubbles is provided by Barlevy (2007) while Siegel (2003) lists a number of bubble processes that generally resemble the above description.

Summarizing the literature on the meaning of a bubble, it can be characterized by a situation where the price of an asset exceeds the value justified by fundamentals. In the case of share prices, this means that the share price (A_t) consists of a fundamental value (P_t) and a bubble component (B_t).

$$A_t = P_t + B_t. \tag{1}$$

If B_t is significantly greater than zero, a bubble exists. The fundamental value of the stock is often calculated by discounted dividends, cash-flows or earnings models. In that case, the net present value (NPV) of the firm is derived by discounting future revenues. Given the expected earnings (E_t) and an appropriate risk-adjusted discount rate ($1 + i$) we can apply the following formula to calculate the current value of the income stream:

$$P_t = \sum_{j=1}^{\infty} \frac{E_{t+j}}{(1+i)^j}. \tag{2}$$

1.2. Rational bubbles. The theoretical foundation of rational bubbles is based on the hypothesis of rational expectations that was first formulated by Muth (1961). One of the earliest scientific studies of rational bubbles include Flood and Garber (1980), Blanchard and Watson (1982), Flood and Hodrick (1990) as well as Adams and Szafarz (1992). Resuming the general definition of stock market bubbles, the bubble component of a rational bubble has a positive expected value when factoring in the bursting of the bubble. The simplest form of such a bubble is the time dependent deterministic bubble (e.g., Camerer, 1989; Ikeda and Shibata, 1992) as shown next:

$$B_t = B \times (1+K)^t. \tag{3}$$

With $(1 + K) > 1$ the bubble grows over time at rate $1 + K$. As a result, the deterministic bubble depends only on its' realization in the previous period (B_{t-1}) and is also often called a Markovian bubble in the literature (e.g.; Salge, 1997). Furthermore, such a bubble must have existed at all times because (B) needs an initial value greater than one in order to grow over time (e.g., Diba and Grossman, 1987; Diba and Grossman, 1988). For that reason it is also called a permanent deterministic bubble.

Alternatively, the bubble might be triggered by a positive shock and exists only temporarily. If the bubble component is not permanent, at time t the bubble continues with probability π and collapses with probability $1-\pi$:

$$B_t = \begin{cases} (1+K) \times B_{t-1} & \text{with } \pi \\ 0 & \text{with } 1-\pi \end{cases} \quad \pi \times (1+K) > 1. \tag{4}$$

This kind of temporary bubble was introduced by Blanchard and Watson (1982) and is also called a bursting bubble in the literature.

1.3. Intrinsic bubbles. In contrast to rational deterministic bubbles, intrinsic bubbles depend on the fundamental process (for a discussion see Froot and Obstfeld, 1991). Instead of the price bubble (B) we have e.g. dividends (D) or earnings (E) at time t that disproportionally affect share prices:

$$B(E)_t = c \times E_t^{\lambda}. \quad (5)$$

With $c > 0$ and $\lambda > 1$ we get an intrinsic bubble process.

In order to test the discounted earnings or dividends models, cointegration analysis has been applied frequently. In time series econometrics cointegration refers to a long-term equilibrium between two or more non-stationary variables. The methodology dates back to Engle and Granger (1987) and was extended to test for multiple cointegration relationships by Johansen (1991). From the discount model (2) we get:

$$P_t = Expected_t \left[\sum_{j=1}^{\infty} \left(\frac{1}{1+i} \right)^j E_{t+j} \right]. \quad (6)$$

Following Campbell and Shiller (1987) equation (6) can be re-formulated as:

$$P_t - \frac{E_t}{i} = \left(\frac{1}{i} \right) Expected_t \left[\sum_{j=0}^{\infty} \left(\frac{1}{1+i} \right)^j \Delta E_{t+1+j} \right]. \quad (7)$$

Hence, the difference between the stock price and $\frac{E_t}{i}$ is set equal to the net present value of future earnings changes multiplied by $\frac{1}{i}$. This also implies a stationary process in the case of stationary earnings changes (e.g., Campbell et al., 1997). Therefore a stationary linear relationship exists between share prices and earnings for non-stationary earnings and stock prices (integrated of order one I(1)). Thus earnings and share prices are cointegrated. For example Campbell and Shiller (1987), Sung and Urrutia (1995) as well as Timmermann (1995) provided evidence in favor of the net present value model for the US stock market represented by the S&P500 by applying cointegration analysis.

Based on the expectation or evidence of cointegrated earnings and stock prices, a bubble component can be added to equation (1) and tested for its' statistical significance:

$$P_t = C_1 + E_t + E_t^{\lambda}. \quad (8)$$

With C_1 being a constant. Without additional dummy variables to represent the only temporary existence of the bubble, we get a permanent intrinsic bubble.

2. Empirical analysis

2.1. Data. For the empirical analysis we make use of the earnings series, the stock price and the price earnings ratio (PE) of the German stock index (DAX) from Datastream. In order to calculate real stock prices and real earnings we rely on the consumer price index (CPI) for Germany provided by the OECD database. The data is available from January 1973 until March 2014 with the investigation period covering 495 month.

Table 1. Data source

Variable	Source	Period
German stock index (DAX)	Datastream	January 1973 until March 2014
DAX earnings	Datastream	January 1973 until March 2014
DAX PE ratio	Datastream	January 1973 until March 2014
Consumer price index Germany	Bloomberg/ OECD*	January 1973 until March 2014

Note: *Bloomberg ID: OEDEC005 Index (OECD German CPI All Items 2010 = 100).

In order to test for only temporarily existing bubbles, dummy variables are necessary as well. The following chart shows the comparison of real earnings and real share prices over time. Periods where both series drift apart might indicate the build up of a bubble.

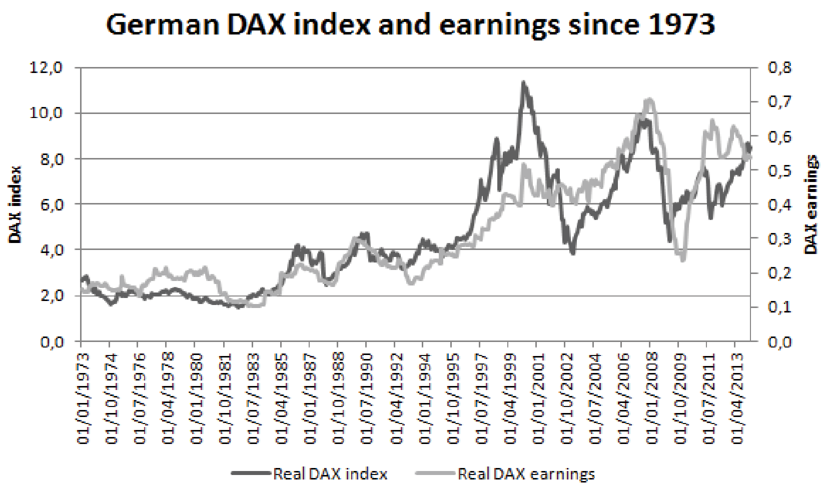

Fig. 1. German DAX index and earnings since 1973

The chart shows a couple of major hypes where prices increased much more rapidly than earnings. Between 1993 and 2000 we saw stock prices move up far ahead of earnings and this period is usually called "New Economy Boom" or "dotcom bubble" in the financial literature (e.g., Sornette and Zhou, 2004). Moreover, the run up prior to the 1987 stock market crash shows a large divergence between earnings growth and share prices. More recently, there seems to be a discrepancy among the DAX and earnings during 2009-2011 and probably 2014. The empirical analysis in the next section will try to verify the existence of bubbles during the above mentioned periods.

As a sharp price increase that does not go along with an equivalent earnings upswing might also arise from a normalization process following a negative shock, we further plot the valuation of the DAX measured by the price earnings ratio (PE) in the following chart.

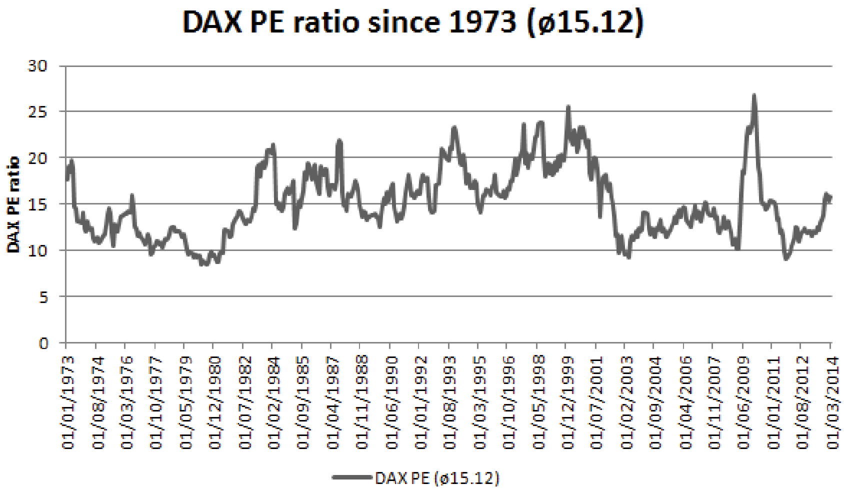

Fig. 2. DAX PE ratio since 1973

The rapid and even explosive increase in the DAX during the "dotcom bubble" and before the 1987 stock market crash was accompanied by large multiple expansions and ended in excessive PEs. This might be a first indication of a potential temporary bubble at those times. However, the chart suggests another noticeable period between 2009 and 2011. Finally, the latest reading of the PE ratio might point to the beginning of an exaggerated valuation level. As a result, the empirical investigation will analyze the existence of four temporary bubbles by including dummy variables for the potential bubble periods (1980-1987, 1993-2000, 2009-2011 and 2013-2014)[1].

2.2. Methodology. In order to determine the properties of the stochastic process and the order of integration respectively, the Augmented Dickey-Fuller unit root test (ADF-test) is applied to all time series (e.g., Said and Dickey, 1984). The ADF test is an extension of the original Dickey-Fuller test (DF-test) that includes lagged endogenous variables in the test equation in order to account for the possibility of a constant and a deterministic trend in the data. The DF-test (e.g., Dickey and Fuller, 1979) is based on the following autoregressive process of order one:

$$y_t = \beta_1 \times y_{t-1} + \varepsilon_t. \qquad (9)$$

If the coefficient β_1 is not smaller than one, we have a non-stationary time series. From that we get the following hypothesis:

H_0: $\beta_1 = 1$ (non-stationary) against H_1: $\beta_1 < 1$ (stationary).

Furthermore, a deterministic trend can be added to equation (9) in order to verify trend stationarity as well. As a cointegration relationship between earnings and share prices implies a stationary PE ratio, the ADF-test can be used to test for a long-term equilibrium between stock prices and earnings.

We employ the following equation to test for temporary rational deterministic bubbles in the stock market:

$$P_t = c_0 + c_1 t + c_2 E_t + c_3^t B_1 + c_4^t B_2 + \\ + c_5^t B_3 + c_6^t B_4 + \varepsilon_t. \qquad (10)$$

Fundamentals are represented by $c_2 E_t$, while $c_3^t B_1$ til $c_6^t B_4$ contain the hypothesized four temporary bubbles and include time dependent dummy variables. The constant c_0 and the time trend $c_1 t$ are also included in the equation to account for non-stationarity in the regression. Hence, equation (10) shows a trend stationary model. As Markovian bubble we use $B_t = \frac{1}{\alpha^t} B$ with $\alpha = \frac{1}{1+i}$ in the

[1] Precise periods: January 1980 until September 1987, January 1993 until March 2000, March 2009 until May 2011 and March 2013 until March 2014.

regression equation (e.g., Salge, 1997). For the interest rate i the German 10-year bond yield from the IMF databank is utilized.

In addition to deterministic bubbles, intrinsic bubbles are analyzed as well in the next step. Instead of the rational deterministic bubble an intrinsic bubble $B(E_t)$ is incorporated as can be seen in equation (5). In order to account for multi colinearity caused by the earnings dependent bubble component, equation (10) is divided by E_t and the price earnings ratio can then be tested for potential temporary bubbles. The division by E_t makes the earnings appear in the denominator and numerator of the bubble term and thus E_t can be eliminated in the intrinsic bubble component (e.g., Salge, 1997). The following equation is applied to test for intrinsic bubbles:

$$\frac{P_t}{E_t} = c_0 \frac{1}{E_t} + c_1 \frac{t}{E_t} + c_2 + c_3^t + c_4^t + \\ + c_5^t + c_6^t + \vartheta_t . \qquad (11)$$

The earnings dependent bubble terms B_1 till B_4 become redundant and the intrinsic temporary bubbles are picked up by the time dependent coefficients c_1^t til c_4^t. Due to economic constraints the value for c_2 must exceed zero while c_3 till c_6 must be greater than one when estimating equation (10) and (11)[1].

3. Empirical results

For the empirical analysis we start with applying the ADF unit root test to the data. As can be seen in table 2, the results support stationarity in first differences I(1) for DAX real earnings and the DAX real price index. If we allow for a constant and time trend the variables are also found to be trend stationary. Hence, when running a regression analysis and using the earnings and share price variables in levels, a time trend must be included or alternatively the variables must be used in first differences. For the PE ratio the ADF test points to stationarity in levels. As the PE ratio is supposed to fluctuate around a positive value, it makes sense to assume a constant in the test equation.

Table 2. ADF-test

Augmented Dickey-Fuller test			
Variable (lag)	Trend & constant	Constant	No constant/trend
DAX (real)	-3.2889* (8)	-1.1351 (1)	0.1760 (1)
Δ DAX (real)	-19.6630*** (0)	-19.6728*** (0)	-19.6640*** (0)
DAX earnings (real)	-3.7063** (5)	-1.5775 (5)	-0.1576 (5)
Δ DAX earnings (real)	-7.4573*** (4)	-7.4613*** (4)	-7.4394*** (4)
DAX PE	-4.0152*** (1)	-3.9189*** (1)	-0.9454 (2)
Δ DAX PE	-15.9851* (1)	-15.9981*** (1)	-16.0140*** (1)

Note: For the maximum lag criterion we make use of the Akaike info criterion (AIC) with a maximum of 12 month. * significance at 10% confidence interval, ** significance at 5% confidence interval, *** significance at 1% confidence interval, Δ means monthly change.

In a next step we estimate the test equation (10) for rational deterministic bubbles by applying multiple regression methodology. The residuals are adjusted for autocorrelation and heteroscedasticity by following the Newey and West (1987) procedure. As can be seen in table 3, all variables are statistically significant except for the bubble component 2013-2014. Furthermore, the coefficient of the deterministic bubble for the period 1980-1987 is smaller than one and does therefore not satisfy the economic restriction. Hence, the regression is re-estimated without the bubbles for the 2013-2014 and the 1980-1987 periods.

Table 3. Deterministic bubble estimation

Dependent variable	DAX			
Sample	1973M01 until 2014M03			
Observations	495			
Estimated equation	$P_t = c_0 + c_1 t + c_2 E_t + c_3^t B_1 + c_4^t B_2 + c_5^t B_3 + c_6^t B_4 + \varepsilon_t .$			
	Coefficient	Standard error	t-statistic	Probability
c_0 (Constant)	-58.157860	36.232960	-1.605109	0.1091
c_1 (Time trend)	0.003098	0.001273	2.433956	0.0153
c_2 (Fundamental component)	10.699640	1.258303	8.503233	0.0000
c_3 (Bubble 1980-1987)	0.740466	0.366573	2.019968	0.0439
c_4 (Bubble 1993-2000)	6.647803	0.950067	6.997195	0.0000
c_5 (Bubble 2009-2011)	15.986420	9.256029	1.727136	0.0848

[1] See e.g., Salge, 1997.

Table 3 (cont.). Deterministic bubble estimation

	Coefficient	Standard error	t-statistic	Probability
c_6 (Bubble 2013-2014)	34.993900	31.477440	1.111714	0.2668
R-squared		0.843241		
Adjusted R-squared		0.841313		
F-statistic		437.508600		
Probably (F-statistic)		0.000000		

In the reduced regression equation all variables are now statistically significant and satisfy the imposed economic restrictions (see table 4). Overall the analysis supports the existence of temporary rational deterministic bubbles for the periods 1993-2000 and 2009-2011. However, the hypothesis of rational price bubbles during the years 1980-1987 and 2013-2014 appears highly unlikely and can almost be ruled out. Nevertheless, the possibility of an intrinsic bubble during these periods remains and in the following step this will be investigated.

Table 4. Reduced deterministic bubble re-estimation

Dependent variable	DAX			
Sample	1973M01 until 2014M03			
Observations	495			
Estimated equation	$P_t = c_0 + c_1 t + c_2 E_t + c_4^t B_2 + c_5^t B_3 + c_6^t B_4 + \varepsilon_t$.			
	Coefficient	Standard error	t-statistic	Probability
c_0 (Constant)	-19.695140	8.531893	-2.308414	0.0214
c_1 (Time trend)	0.003457	0.001186	2.915633	0.0037
c_2 (Fundamental component)	10.277000	1.171291	8.774072	0.0000
c_4 (Bubble 1993-2000)	6.366665	0.937760	6.789225	0.0000
c_5 (Bubble 2009-2011)	13.650380	8.297269	1.645170	0.1000
R-squared		0.841166		
Adjusted R-squared		0.839869		
F-statistic		648.745000		
Probably (F-statistic)		0.000000		

In order to test for intrinsic bubbles in the German stock market, we rely on the test equation (11). As can be seen in Table 5, all variables are statistically significant but in the case of temporary intrinsic bubbles, the bubble compoents during the periods 2009-2011 and 2013-2014 are not satisfying the economic restrictions. Therefore the equation is re-estimated without the bubble terms for periods 2009-2011 and 2013-2014.

Table 5. Intrinsic bubble estimation

Dependent variable	DAX PE			
Sample	1973M01 until 2014M03			
Observations	495			
Estimated equation	$\frac{P_t}{E_t} = c_0 \frac{1}{E_t} + c_1 \frac{t}{E_t} + c_2 + c_3^t + c_4^t + c_5^t + c_6^t + \vartheta_t$			
	Coefficient	Standard error	t-statistic	Probability
c_0 (Constant)	0.127609	0.151105	0.844506	0.3988
c_1 (Time trend)	0.006337	0.000924	6.854760	0.0000
c_2 (Fundamental component)	5.275185	1.004472	5.251697	0.0000
c_3 (Bubble 1980-1987)	1.012182	0.003425	295.5627	0.0000
c_4 (Bubble 1993-2000)	1.070465	0.003191	335.5042	0.0000
c_5 (Bubble 2009-2011)	-0.594998	0.205948	-2.889073	0.0040
c_6 (Bubble 2013-2014)	-0.759137	0.197917	-3.835627	0.0001
R-squared		0.430540		
Adjusted R-squared		0.423539		
F-statistic		61.492050		
Probably (F-statistic)		0.000000		

The reduced test equation shows statistically significant coefficients for all variables and the economically imposed restrictions hold as well. The result indicates an intrinsic stock market bubble during the 1980-1987 and 1993-2000 periods. In contrast, the hypothesized more recent bubble terms during 2009-2011 and 2013-2014 are statistically rejected and a bubble appears highly unlikely. As we found support for a rational deterministic bubble between 2009 and 2011, only for the current episode between 2013 and 2014 the possibility of a bubble is rejected. However, in the estimation result of the test equation for the deterministic bubble, the coefficient for the 2013-2014 bubble satisfied the economically imposed restrictions and a prolonged stock price increase might yield a statistically significant coefficient in the future. We recommend adding the latest data points on a monthly basis in order to re-estimate the model in the future. This might help to detect a significant bubble process at an early stage. Portfolio managers and central banks are advised to use such a model to conduct a forward looking investment strategy and monetary policy.

Table 6. Reduced intrinsic bubble re-estimation

Dependent variable	DAX PE			
Sample	1973M01 until 2014M03			
Observations	495			
Estimated equation	$\frac{P_t}{E_t} = c_0 \frac{1}{E_t} + c_1 \frac{t}{E_t} + c_2 + c_3^t + c_4^t + \vartheta_t$			
	Coefficient	Standard error	t-statistic	Probability
c_0 (Constant)	0.186944	0.145953	1.280848	0.2009
c_1 (Time trend)	0.005627	0.000913	6.162288	0.0000
c_2 (Fundamental component)	7.181707	0.994486	7.221530	0.0000
c_3 (Bubble 1980-1987)	1.014510	0.002635	385.0408	0.0000
c_4 (Bubble 1993-2000)	1.027046	0.001329	772.9343	0.0000
R-squared		0.487301		
Adjusted R-squared		0.483116		
F-statistic		116.431600		
Probably (F-statistic)		0.000000		

Generally, our results also confirm earlier findings by Salge (1997) in favor of an intrinsic bubble in the German stock market between 1980 and 1987. However, unfortunately the study only used data until 1994 and we cannot rely on it to compare our findings for the more recent bubble terms. Furthermore, due to availability constraints the previous research article only used GDP and industrial production as an approximation for earnings. Nevertheless, in the case of intrinsic bubbles it seems more appropriate to make use of the earnings series directly as corporate profits might strongly deviate from the overall economic development at least in the short run.

Conclusion

In this report we have analyzed the existence of temporary stock market bubbles in the German stock market between January 1973 and March 2014. Overall, we could not reject the possible existence of a bubble at the end of the 1990s, prior to the 1987 stock market crash and between 2009 and 2011. For the periods 1980-1987 and 1993-2000 we find support in favor of an intrinsic stock market bubble while a deterministic bubble cannot be rejected for the periods 1993-2000 and 2009-2011. We are the first to identify the 2009-2011 bubble that ended in a correction of the DAX index by 32%. The current fear (in the year 2014) of a contemporary asset bubble in the German stock market is statistically rejected for the case of rational deterministic or intrinsic bubble processes. However, if stock prices increase further, an intrinsic bubble might unfold as the economic restrictions for the size of the coefficients already hold and the bubble is "only" rejected on the basis of statistical significance. Adding the latest data points in the future and re-estimating the model might help to detect a stock market bubble during the formation period. An early verification of a bubble process can aid investors in portfolio management and central banks in monetary policy tightening.

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