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A new empirical approach to explain the stock market yield: A combination of dynamic panel estimation and factor analysis

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Matthias Georg Will

A New Empirical Approach to Explain the Stock
Market Yield: A Combination of Dynamic Panel
Estimation and Factor Analysis

Diskussionspapier Nr. 2011-8

des Lehrstuhls für Wirtschaftsethik
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Abstract

This paper presents an empirical approach that combines competing paradigms of modeling in empirical capital market research. The approach simultaneously estimates the explanatory power of fundamentals, expectations, and historic yield patterns, making it possible to test the extent to which the efficient market hypothesis, fundamental data analysis, and behavioral finance contribute to explaining stock market yield. The core of the approach is a dynamic panel model (Arellano-Bond estimator with an MA restriction of the residuals), complemented with an upstream factor analysis to reduce multicollinearity. Due to the complexity of the data set, a great many parameters that influence the yield can be determined. Highly significant parameter estimates are possible even though the information in the data set is interdependent. For the German stock market (the 160 companies listed in DAX, MDAX, SDAX, and TecDAX), the quarterly yield is analyzed for the period between 2004 and 2009. The model has high explanatory power for the entire observation period, even in light of the fact that the period includes the financial crisis of 2008.

Keywords: Stock Market, Fundamentals, Factor-Analysis, Dynamic Panel Analysis, Arellano-Bond Estimator

JEL-Classification: G12 (Asset Pricing), C33 (Models with Panel Data), C38 (Factor Analysis)

A New Empirical Approach to Explain the Stock Market Yield: A Combination of Dynamic Panel Estimation and Factor Analysis

Matthias Georg Will

Introduction

This paper introduces a new empirical method for analyzing the capital market. It demonstrates that a combination of (1) microeconomic panel estimation with (2) factor analysis is a powerful tool for explaining asset prices. Connecting these two different approaches enables testing competing theories of the equity market, including the efficient market hypothesis, fundamental data analysis, and the significance of behavioral finance. The goal of this article is not to focus on a single, traditional approach to the capital market but to introduce an empirical procedure that enables combining different modeling paradigms.

(1) Microeconomic dynamic panel analysis enables simultaneous measurement of effects regarded as determinants of capital market yield in the asset market literature. The panel model is restricted to quantify the effects of company and economic fundamentals. Contemporaneously, the expectations of market participants are accounted for to evaluate the influence expectations have on behavior. In addition, the influence of historical yield fluctuations on the present yield are measured to show the power of weak form and semi-strong form tests in a joint model.

(2) The objective of factor analysis is to reduce multicollinearity in a comprehensive data set that combines information on companies and macroeconomic variables. The advantage of factor analysis compared to the method of instrumental variables (IV) is that it is not necessary to make a priori assumptions about interdependencies between companies and the economy or about principles of causality in companies.

The paper is structured as follows. Section 1 shows how combining factor analysis and panel estimation reduces modeling problems in empirical capital market approaches. Section 2 of the paper introduces a dynamic panel estimation to explain composition of the current yield by means of historical yields, fundamentals, and expectations. In Section 3, reduction of multicollinearity is described by the factor analysis. The advantage of this method is that it can be applied even when the causalities of interdependent values are unknown or controversial. After reducing the multicollinearity problems, the results of the dynamic panel estimation are presented in Section 4. Most of the estimated parameters are highly significant and the model has high prediction power, even during the financial crisis of 2008. The paper ends with a summary of the main findings.

1. Empirical Modeling Problems that are Solved by the New Approach

The aim of this section is to show how a combination of factor analysis and dynamic panel analysis can solve the modeling problems found in previous empirical capital market research. The model is not intended to handle all of the specific problems of the empirical research, such as the best way of restricting a GARCH model; instead, the focus is on explaining stock market yield using a number of variables in a powerful and consistent way. Therefore, the approach resolves the empirical tradeoff between very specific and, perhaps, not sufficiently complex, models designed to solve particular questions and general approaches that suffer from inefficient or even inconsistent empirical design.

To illustrate how this resolution of such a tradeoff works, (1) I start with looking at the problems inherent in the very specific ARCH and GARCH approaches, followed by (2) a discussion of the empirical weaknesses of existing models used to test the theories. By this means, it is demonstrated how a combination of factor analysis and panel analysis can overcome modeling weaknesses. The new approach makes it possible to test different theories simultaneously and thereby reveals how factor analysis and dynamic panel estimation can be combined to reap the excellent advantages of each. (3) Finally, the data set used for the estimation is presented.

(1) The ARCH and GARCH models provide a great deal of information on how volatility influences current yield or volatility.¹ Most of the models generate significant results, but it is not clear how these results should be interpreted. On the one hand, there are good reasons to argue that the effects are “real”; however, it is also well known that significant parameters are often the result of misspecified and not sufficiently complex models.² For example, the weak-form tests of the yield show historical patterns, but it seems likely that the revealed patterns are caused by dependencies of the fundamentals or shocks, which are not modeled in the ARCH and GARCH models.³ The estimated parameters can be interpreted as proxies for a modeling strategy, which, for the sake of simplicity, avoids inferences about explicit causalities regarding periods experiencing different volatilities. But the models only suggest that exogenous shocks can have an influence on the variance of the yield; the transmission process can be very different. The approach presented in this paper overcomes this difficulty by capturing the reasons for different volatilities by explicitly modeling diverse exogenous variables.

(2) The next part of this section compares dynamic panel estimation with common test procedures, focusing first (a) on the problems of pooling in three- or multi-factor-models. Second (b), it is demonstrated how dynamic panel estimation can combine the weak- and semi-strong-form tests of the efficient market hypothesis. Third (c), I show how the approach is not limited to consideration of hard facts like fundamentals and historical yields, but it is also possible to model the influence of expectations and other psychological factors that have an impact on the behavior of stock traders.

(a) The most common approaches used for evaluating how fundamentals influence yield are the three- or multi-factor models.⁴ The chief weakness of these models is that the estimation technique is not able to handle both the time dimension and single individuals. Therefore, it is necessary to pool individuals, which can lead to statistical artifacts.⁵ In contrast, panel estimation is a powerful tool for evaluating data sets that contain periodically repeated observations for different individuals.⁶ Additionally, the panel method not only quantifies the effects of some company indicators in the mean of a more or less arbitrary portfolio, it can also estimate the impact of a great many parameters for every single stock. Thus, a marginal analysis is possible. Furthermore, the model can incorporate macroeconomic data.

(b) In the literature on the efficient capital market hypothesis, the question of whether historical yield patterns have an impact on current yield is a very important one. Yield patterns would be a strong indication that stock markets are not efficient. Empirical tests have evaluated many sig-

¹ For a good overview of these models' rich possibilities, see Harris/Sollis (2005, pp. 213–258) and for some latest examples in the capital market research Visser (2011), Bernard et al. (2008), McAleer/ Da Veiga (2008), Engle/Rangel (2008).

² Auer (2007, pp. 250–258).

³ Ederington/Guan (2009, pp. 313–322), Hansen/Lunde (2005, pp. 882–888).

⁴ Fama/French (1992, pp. 430–431, 1993, pp. 6–12); Griffin/Lemmon (2002, pp. 2325–2328); Fuertes et al. (2010, pp. 2544–2545).

⁵ Petersen (2009, pp. 436–437).

⁶ Cameron/Trivedi (2005, p. 695).

nificant parameters, hypothesizing an existence of yield patterns.⁷ It is suggested that yield patterns are statistical artifacts of weak-form tests and are not evidence against the efficient market hypothesis.⁸ Whether historical yield patterns exist or whether the patterns found are simply the result of misspecification is not only a theoretical question, it is also a challenge for the testing procedure. A dynamic data generating process estimated in a static model leads to inconsistent results. However, the dynamic panel approach can detect historical dependencies simultaneously with company and macroeconomic indicators. Thus, weak- and semi-strong-form tests can be combined. If there are no historical patterns, the dynamic approach does not become inconsistent, it merely becomes inefficient.

(c) The behavioral finance literature argues that market actors do not behave as rationally as other theories assume for their formal models, such as the efficient market hypothesis.⁹ Consequently, the formal approaches need to more accurately model human behavior, which is, on the one hand, driven by many and complex motives and, on the other, naturally restricted. In addition to historic dependencies and fundamentals, the dynamic panel method can also take into consideration, for example, the expectations of economic agents. It is also feasible to include the interdependencies between expectations, historical patterns, and the fundamentals using factor analysis. The approach is therefore able to test different assumptions not only in formal micro models or experiments, but can empirically test assumptions under real circumstances. Moreover, the model can be enhanced to account for different motives and behavioral restrictions.

(3) The model's use of a multitude of explanatory variables solves two common problems experienced by extant empirical research. First (a), to avoid a model which is not able to handle the complexity of stock markets and to evaluate the influence of expectations, corporate and macroeconomic figures, a comprehensive data set is employed. Second (b), to increase predictive power, the alteration rates of the fundamentals and of their determinants are used.

(a) Compared with the data sets of the three- or multi-factor models or those used in empirical research on the influence of fundamentals,¹⁰ the data set used in this paper is far more comprehensive. As shown in Tables 2 and 4, the parameters for about 40 variables, plus dummy variables, are estimated for the 160 companies listed in the German DAX, MDAX, SDAX, and TecDAX for a period of 24 quarters (2004–2009).

(b) To improve the estimation power, it is not only the alteration rates of fundamentals such as the BE/ME- or E/P-ratio that are considered; the alteration rates of the determinants of the ratios are evaluated. A focus on the determinants of the ratios makes the estimation results more precise because, under realistic conditions, the alteration rates of many ratios cannot be interpreted in a unique way. For example, if the numerator of a ratio changes and, at the same time, the denominator also changes, interpretation of the alteration rate is possible only in the context of the changed figures. In this case, a general interpretation of the alteration rate of the ratio is nearly impossible. Therefore, this paper's approach takes both the alteration rates of the ratios and of the determinants into account.

The panel model designed to combine different explanatory approaches and to appropriately deal with a great many variables in a longitudinal data set is introduced in the next section, after which is presented the factor analysis designed to reduce problems of multicollinearity and enhance the model's predictive power.

⁷ Fama/ French (1988, pp. 265–266; Lo et al. 2000, pp. 1716–1720, 1753).

⁸ Fama/French (1996, pp. 63–66); Malkiel (2003, pp. 10–11).

⁹ Hirshleifer/Teoh (2009, p. 29); Lux (2009, p. 176); Banerjee (1992, pp. 798–799, 816); Bikhchandani et al. (1992, pp. 994–995); Welch (1992, p. 723).

¹⁰ Ou/Penman (1989, S. 307–308 Tables 3 and 4); Greig (1992, S. 440 Table 8); Abarbanell/Bushee (1997, S. 11–16 Tables 11–16); Dechow et al. (2001, S. 102–103 Table 5).

2. A Panel Model to Explain the Yield

2.1 Dynamic Model Restriction

Estimation of the yield is based on historic yields, company and macroeconomic rates of change, and expectations of market participants, which are reflected in the business prospects and in the futures of the exchange rate. To quantify historic yield patterns a dynamic component is introduced. Therefore, the model is restricted as follows:

$$r_{j,t} = \beta_0 + \beta_1 r_{j,t-1} + \dots + \beta_p r_{j,t-p} + \lambda_1 x_{j,t,1} + \dots + \lambda_n x_{j,t,n} + \alpha_j + \varepsilon_{j,t} \quad (1)$$

with $t = p + 1, \dots, T$ and $\varepsilon_{j,t} \sim i.i.d.$ over j and t . The variable $r_{j,t}$ represents the yield of a stock j for the point in time t . The historical dependencies of the stocks are measured by the parameters β_1, \dots, β_p . The exogenous variables or the factor scores (see Section 3) are represented in Equation (1) by the regressors $x_{j,t,1}, \dots, x_{j,t,n}$. The influence of these numbers is considered by the parameters $\lambda_1, \dots, \lambda_n$. As shown in Equation (1), restriction of the model implies that only the yield is dynamic. Thus, independent regressors over time are assumed for the empirical model.

The panel model enables a consistent estimation of effects over time and over individuals.¹¹ The parameters are not influenced by a pooling strategy. Furthermore, marginal analysis is not only possible for an average stock, but also feasible for every stock in the data set. Additionally, the panel analysis can consider unobserved heterogeneity. In Equation (1), α_j is the fixed effect, which is correlated with the regressors and evaluates the unobserved heterogeneity. If unobserved heterogeneity is not considered, the misspecification of the model would cause residuals $(\alpha_j + \varepsilon_{j,t})$ correlated with the regressors $r_{j,t-1}, \dots, r_{j,t-p}$ or $x_{j,t,1}, \dots, x_{j,t,n}$. In that case, estimation of the β - and λ -parameters is inconsistent. By dint of a subtraction via the FD approach, an unbiased estimation is possible even though the fixed effects are correlated with the regressors.¹²

Determination of the fixed effects involves an important implication: the dynamic panel approach allows the consideration of information that cannot be captured in a (mixed) AR model with exogenous regressors. No additional data have to be explicitly surveyed to account for fixed effect. This restriction contains an additional forecast possibility when analyzing the stock market. Determinants of the yield can be found without having to observe the regressors or shocks $\varepsilon_{j,t}$. The fixed effect α_j provides an explanation for different levels of yields that cannot be directly derived from observation. For example, the individual effect may quantify how market participants evaluate the expectations for a company. The variable α_j can thus be interpreted as an individual risk premium that is constant over time.¹³

¹¹ Cameron/Trivedi (2005, p. 697).

¹² Cameron/Trivedi (2005, pp. 700, 763–764).

¹³ For the relationship between risk and return, see Fama/Miller (1972, pp. 281–286). The problem with modeling the unobserved heterogeneity is that it has to be constant over time; especially if the unobserved risk premium varies over time α_j is not able to reflect these changes in an appropriate way. In this case, only the unobserved individual risk, which is constant over time, is quantified. Deviations from the average of the individual long-term risk premium are taken up by the regressors or by the residuum.

Arellano-Bond Estimation for the Dynamic Panel Model

A dynamic approach is taken for estimating the parameters so as to obtain a consistent estimation because of the historic yield patterns. Hence, fixed effects (FE) and random effects (RE) estimations are not consistent for short panels. The regressors are correlated with the residuals, even when both the regressors and the residuals are differenced by their means.¹⁴ Thus, an estimation approach capable of explicitly taking into account historical dependencies and the exogenous variables is needed. These requirements for a consistent estimation are fulfilled only by the Arellano-Bond estimator. In the first step, (1) Equation (1) is replaced by a panel model with first differences, thus making possible a consistent estimation of the parameters for the historic yield patterns and the exogenous variables if, in the second step, (2) the model is adapted to the behavior of stock market shocks.

(1) If Equation (1) is changed to a first-differences (FD) model, we obtain:

$$\Delta r_{j,t} = \beta_1 \Delta r_{j,t-1} + \dots + \beta_p \Delta r_{j,t-p} + \Delta \mathbf{x}'_{j,t} \lambda + \Delta \varepsilon_{j,t} \quad (2)$$

with $t = p+1, \dots, T$ and $\varepsilon_{j,t} \sim i.i.d.$ over j and t . For example $\Delta r_{j,t}$ is $\Delta r_{j,t} = r_{j,t} - r_{j,t-1}$. Even if the assumption of independent residuals $\varepsilon_{j,t}$ is valid, $\Delta r_{j,t-1}$, for instance, is correlated with $\Delta \varepsilon_{j,t}$ because of the dynamic process. Coincidentally, in the FD model, $\Delta \varepsilon_{j,t}$ is not correlated with $\Delta r_{j,t-k}$ or $\Delta x_{j,t-k}$ for $k \geq 2$. The dynamic parameters accordingly can be estimated by lagged endogenous variables or by their differences. For example, $r_{j,t-1}$ may be instrumented by $r_{j,t-2}$ or $\Delta r_{j,t-2} = r_{j,t-2} - r_{j,t-3}$.¹⁵ With this approach, both FE and RE models can be estimated consistently by 2SLS or GMM. The 2SLS approach for the estimation is not as efficient as the GMM estimator (Arellano-Bond estimator).¹⁶ In contrast to the 2SLS approach, the GMM estimator uses in the first step a weighting matrix to estimate in the second step the parameters on the basis of the weighting matrix. The weighting matrix prevents a correlation of the lagged variables with the second difference by a forward subtraction.¹⁷

(2) Furthermore, the residuals of Equation (1) are modeled by a MA process because of hysteresis effects of the stock market shocks. For the 2SLS and GMM methods, a robust estimation of the variance-covariance matrix is possible if the error term is heteroscedastic. However, the robust estimation is inconsistent if the residuals are partially correlated. If the shocks cause fluctuations, which is plausible, effects of hysteresis bias the estimation of the stock market yield.¹⁸ Hence, the temporary dependencies of the residuals $\varepsilon_{j,t}$ violate the i.i.d. assumption. The Arellano-Bond test for missing autocorrelations of the residuals suggests partial correlations of the residuals for pure panel AR(p) models. Accordingly, the residual $\varepsilon_{j,t}$ of Equation (1) is generated by an MA process.

Note that a consistent estimation of the parameters is not possible if the residuals are correlated across units. For the quarterly data used here, the effects of correlated residuals across the

¹⁴ Nickel (1981, p. 1418); Cameron/Trivedi (2005, pp. 764–765). However, a FE or RE approach would be consistent if the data set is a long panel. In other words, a panel with a large number of points in time and a comparatively low number of individuals can be estimated by the FE or RE approach.

¹⁵ Anderson/Hsiao (1981, p. 604).

¹⁶ Arellano/Bond (1991, p. 285).

¹⁷ Arellano/Bond (1991, p. 279).

¹⁸ Fama (1976b, pp. 149–151).

units are negligible compared to those for shorter periods such as days or weeks. For quarters, it can be assumed that some shocks hit several stocks, but these shocks are superimposed by shocks that have an influence only on single stocks. The results of different weak-form tests on the quarterly data suggest that shocks that hit only single stocks are mainly responsible for changes of the yield.¹⁹

Also note that under the FD approach, it is not possible to estimate variables that are constant over time, for example, the business sector dummy. These variables are dropped by the subtraction.²⁰

3. Factor Analysis for a Reduction of Multicollinearity

This section introduces the factor analysis used for the data set. The aim of factor analysis is to reduce problems of multicollinearity so as to enable an efficient estimation of the parameters by the dynamic panel model. Subsection 3.1 discusses the consequences of multicollinearity for the estimation and presents the interdependencies in the data set. In Subsection 3.2, estimation of the factor loadings and factor scores is shown. Subsection 3.2 introduces a powerful selection mechanism that replaces the exogenous variables explained by the common factors. Finally, in Subsection 3.4, the determined factors are introduced.

3.1 Multicollinearity in the Data Set

Factor analysis is employed to reduce multicollinearity. This section explains why interdependent variables lead to poor estimation results. To reveal the multicollinearity in the applied data set, a product-moment correlation is performed. In the next subsection, the factor analysis is introduced and implemented.

If the explanatory variables of a formal model are interdependent it implies imperfect multicollinearity. Indeed, imperfect multicollinearity leads to an efficient and unbiased estimation of the overall model. However, the estimation accuracy of the single parameters declines. The estimated variance of the parameters suffering from multicollinearity becomes larger, leading to insignificant t-tests. The situation is different if the overall model is tested for significance (such as a F-test). In contrast to t-tests, the confidence intervals of the test procedures for the significance of the overall model are narrowed.²¹ Multicollinearity makes the overall model appear to be more significant than it is.

To prevent the problem of multicollinearity, correlation analyses are applied. In addition to identifying spurious correlations, the correlation analysis can quantify linear dependencies between two explanatory variables.²² The correlation analysis in this article is implemented with continuous parameters such as the binary dummies. The dummies refer to real dichotomous criteria and thus do not need to be artificially dichotomized. Consequently, a correlation analysis can

¹⁹ The weak-form tests are not included here in the interests of saving space, but are available on request. These tests are pure panel AR(q) models that gauge the influence of historic yields on current yield. For the analysis of correlated shocks over time, the dynamic GMM or IV estimation with a MA component for the residuals is used. For the quantification of correlated shocks across units and over time, the Driscoll-Kraay approaches are used. The results of the GMM, IV, and Driscoll-Kraay methods are not significantly different. Therefore, models that do not consider the shocks across units are appropriate.

²⁰ Cameron/Trivedi (2005, S. 705).

²¹ Auer (2007, pp. 484–485, 490–491).

²² Baum (2006, p. 85).

be performed via the product-moment correlation.²³ The product-moment correlations among the variables of Table 1 indicate that the data set suffers from strong multicollinearity (only correlations larger than 0.3 are shown in Table 1).

Table 1: Product-Moment Correlation Within the Data Set

Note: Only correlation coefficients with a absolute value larger than 0.300 are shown. An overview of all the variables is given in Table 2.

TECDAX-Dummy	to	Software-Dummy:	0.308 *
SDAX-Dummy	to	MDAX-Dummy:	-0.354 *
Market Cap (log)	to	DAX-Dummy:	0.729 *
Market Cap (log)	to	SDAX-Dummy:	-0.398 *
Market Cap (log)	to	Not-in-an-Index-Dummy:	-0.397 *
Total Common Equity (Change)	to	Total Assets (Change)	0.302 *
Liquidation Value (Change)	to	Total Assets (Change)	0.778 *
Total Operating Expenses (Change)	to	Revenues (Change):	0.532 *
EBT (Excl. Unusual Items, Change)	to	Operating Income (Change):	0.977 *
EBT (Incl. Unusual Items, Change)	to	Operating Income (Change):	0.987 *
EBT (Incl. Unusual Items, Change)	to	EBT (Excl. Unusual Items, Change):	0.987 *
Price-Earnings-Ratio (Incl. Unus. Items)	to	Price-Earnings-Ratio (Excl. Unusual Items)	0.427 *
Levered Free Cashflow (Change)	to	EBT (Incl. Unusual Items, Change):	0.611 *
Total Current Assets (Change)	to	Total Cash & Short Term Inv. (Change):	0.326 *
Net Debt (Change)	to	Total Cash & Short Term Inv. (Change):	0.366 *
Liquidity 2 (Change)	to	Liquidity 1 (Change):	0.603 *
Liquidity 3 (Change)	to	Liquidity 2 (Change):	0.993 *
Liquidity 3 (Change)	to	Liquidity 1 (Change):	0.999 *
Golden Rule (Change)	to	Inventory (Change):	0.694 *
Business Expectations (Change)	to	Euro Bund Future (Change):	-0.564 *
Business Expectations (Change)	to	M2 Without M1 (Change):	-0.400 *
M2 Without M1 (Change)	to	M1 (Change):	-0.562 *
M3 Without M2 (Change)	to	M1 (Change):	-0.411 *
M3 Without M2 (Change)	to	M2 Without M1 (Change):	0.374 *
Key Interest Rate (Change)	to	M2 Without M1 (Change):	0.385 *
Key Interest Rate (Change)	to	M3 Without M2 (Change):	0.317 *
HCPI (Change)	to	M3 Without M2 (Change):	0.331 *
Exchange Rate (Change)	to	Business Expectations (Change):	-0.316 *
Exchange Rate (Change)	to	M2 Without M1 (Change):	-0.303 *

Legend: * p < 0.1

Sources: Capital IQ, EZB, ifo Institut für Wirtschaftsforschung e. V., ariva.de, Deutsche Börse AG, own calculations.

One way to deal with this multicollinearity is to instrument the exogenous variables. The instrument variable method is able to handle the interactions in the empirical model. There is an IV

²³ Bortz (2004, pp. 224–230).

method for panel estimation;²⁴ however, an alternative to IV estimation is a factor analysis conducted prior to the panel estimation. In contrast to the IV method, the factor analysis needs no ex ante assumptions about causality. Also, as will be shown, factor analysis can reveal dependencies that are not obvious when employing correlation analysis. Thus, a model in which the IV method is used is not able to discover all the dependencies. As a consequence, the IV method is less powerful than the approach used in this paper. In the next step, the factor analysis is conducted to reveal the causalities.

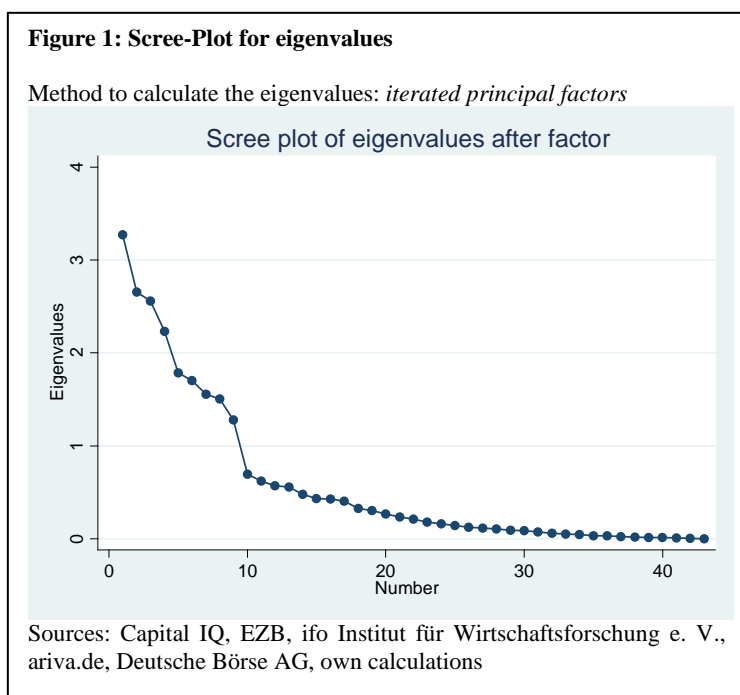
3.2 The Non-Iterative Principal-Factor Approach

Factor analysis is capable of coping with multicollinearity. Factor analysis is used to create a data set that is nearly free of multicollinearity. Therefore, the factor analysis is implemented prior to conducting the panel estimation. The factor scores, being uncorrelated and representing the causal structure of the data set, are taken as exogenous variables of the factor analysis. In this section, the functionality of the non-iterative principal factor approach is described.

The way factor analysis handles interdependencies is to separate the variance of the exogenous variables.

The part of the variance that is common to other variables is segregated from the part of the variance that is specific to that variable.²⁵ Next, common factors are formed out of the common variance. The specific variance determines the (theoretical) specific factor. The main difference between this approach and principal component analysis is what the factors explain. The aim of principal component analysis is to explain the total variance by a minimum of factors. In contrast, the aim of factor analysis is to explain the original variables by revealing causality in the data set.

Below, (1) the basic model of the factor analysis is shown. Then, (2) the



optimal number of factors is determined. Finally, (3) the restrictions of the approach and the estimated factor loadings are presented.

(1) The basic model of the factor analysis for the non-longitudinal application is:

$$x_n = \kappa_{n,1}f_1 + \kappa_{n,2}f_2 + \dots + \kappa_{n,m}f_m + s_n \quad (2)$$

The exogenous variable is described by x_n , f_m is the common factor, and $\kappa_{n,m}$ is the appropriate factor loading of the explained variable x_n . For the specific factor of the exogenous variable x_n , the residuum s_n is formed. The specific factors s_n cannot be explained by the common

²⁴ Cameron/Trivedi (2009, pp. 281–289).

²⁵ Backhaus et al. (2006, pp. 291–293).

factors f_m and the factor loadings $\kappa_{n,m}$.²⁶ According to the model restrictions of Equation (2), only linear combinations can be identified among the exogenous data. Before the theory of factor estimation is discussed, Equation (2) is adapted to fit the panel data. The new model is:

$$x_{n,t} = \kappa_{n,1}f_{1,t} + \kappa_{n,2}f_{2,t} + \dots + \kappa_{n,m}f_{m,t} + s_{n,t} = \boldsymbol{\kappa}'_n \mathbf{f}_t + s_{n,t} \text{ for } t = 1, \dots, T \quad (3)$$

with $\boldsymbol{\kappa}'_n = [\kappa_{n,1}, \dots, \kappa_{n,m}]'$ and $\mathbf{f}_t = [f_{1,t}, \dots, f_{m,t}]'$.

(2) Nine factors are sufficient to reproduce most of the information originally contained by the exogenous variables. Both the scree test and the Kaiser criteria (Figure 1) recommend nine factors as an optimal number. Because of the high KMO criteria of the data set (Table 2),²⁷ a great many of the exogenous variables can be substituted for by the nine factors, meaning that these variables have a low level of uniqueness (see Table 2). Increasing the number of factors to the maximum of 43 does not result in much additional explanatory power for the common factors. Because of the selection criteria (see Subsection 3.3), it is desirable that the uniqueness of the variables polarize to either zero or one.

(3) The factor loadings are calculated using the principal-factor approach based on the communalities estimated by the multiple coefficient of determination.²⁸ No iterative calculation of the communalities is made. The iterative process would minimize the specific factors, but the structure of the data produces Heywood cases.²⁹ To reveal and clarify the factor pattern, it is rotated by the orthogonal varimax rotation (Table 3). Tests of correlated factors (not shown) confirm that the varimax rotation is consistent because of uncorrelated factors. For the panel estimation the factor scores are calculated by the regression analysis.

3.3 A Selection Criterion for the Application of the Exogenous Variables in the Panel Estimation

As Table 2 illustrates, not all the exogenous variables can be substituted for by the nine factors. A panel estimation of the yield using only those nine factors entails a large loss of information. Therefore, the exogenous variables demonstrating a high level of uniqueness (> 0.5) are adopted in the panel estimation. The variables that can be sufficiently represented by the factors (i.e., uniqueness < 0.5) are replaced with the common factors. As the specific factors cannot be estimated, a reduction of the variables having a high degree of uniqueness is not feasible in the panel estimation; the result would be a model with biased parameters.

Alternatively, if exogenous variables with a low KMO value (< 0.5) are not incorporated by the factor analysis, the estimated factor scores will be inconsistent. Similar to the removal of variables in the regression analysis, if the significance tests of the variables show a high probability of error, the estimated parameters will be biased.³⁰

²⁶ Jolliffe (2002, pp. 151–152).

²⁷ Kaiser (1970, S. 404–406).

²⁸ Backhaus et al. (2006, S. 289–290); Mukhopadhyay (2009, S. 343–344).

²⁹ The same happens when the maximum likelihood (ML) estimator is used. Therefore, the ML approach is not applied in this paper. Note that the ML approach is only consistent when the data are normally distributed. This is an additional restriction and is not valid for the capital market, especially in light of the crisis of 2008, which led to extraordinary capital market patterns. The principal-component approach is not used either because this approach assumes that communalities equal one. This is a very restrictive assumption, especially when it is expected that the specific factors include additional information.

³⁰ Auer (2007, S. 264).

Table 2: KMO criteria and Uniqueness

exogenous, metrical variable	KMO criteria			Uniqueness		
	all variables	reduced (>0.5)	DELTA	43 factors (iterated)	9 factors (iterated)	9 factors (not iterated)
Revenues	0.7798	0.5788	-0.2010	0.1359	0.2059	0.2329
Cost Of Goods Sold	0.7963	0.8830	0.0867	0.1339	0.2032	0.2262
Total Operating Expenses	0.7675	0.6002	-0.1673	0.0926	0.2019	0.2255
Operating Income	0.4128			0.6604	0.9705	* 0.9528
Net Interest Expenses	0.5203	0.6838	0.1635	0.7451	0.9947	* 0.9944
EBT Excl. Unusual Items	0.5495	0.6144	0.0649	0.7189	0.9412	* 0.8900
EBT Incl Unusual Items	0.4819			0.1113	-1.0005	0.3686
Total Cash And Short Term Investments	0.4996			0.0035	-0.2398	0.0746
Total Receivables	0.3918			0.6301	0.9787	* 0.9729
Inventory	0.5414	0.5085	-0.0329	0.0573	0.1434	0.1213
Total Current Assets	0.6530	0.6933	0.0403	0.2664	0.5441	0.4854
Total Assets	0.5526	0.5743	0.0217	-0.0268	0.0675	0.2884
Total Current Liabilities	0.7388	0.8484	0.1096	0.7528	0.9315	* 0.9250
Long Term Debt	0.4818			0.8817	0.9990	* 0.9990
Common Stock	0.7247	0.6679	-0.0568	0.2777	0.3806	0.3698
Retained Earnings	0.4234			0.7275	0.9978	* 0.9975
Total Common Equity	0.5459	0.5195	-0.0264	0.0590	0.4044	0.3299
Outstanding Shares	0.5405	0.3777	-0.1628	0.0425	0.0289	0.1817
Net Debt	0.3550			0.7788	0.9920	* 0.9927
Working Capital	0.6427	0.7382	0.0955	0.7883	0.9778	* 0.9757
Net Working Capital	0.4614			0.7335	0.9977	* 0.9976
Levered Free Cash Flow	0.5401	0.4964	-0.0437	0.8075	0.9803	* 0.9795
Unlevered Free Cash Flow	0.4476			0.9090	0.9983	* 0.9982
Euro Bund Future	0.4796			0.3240	0.6384	* 0.5768
M1	0.6763	0.6462	-0.0301	0.3527	0.6024	* 0.5917
M2 without M1	0.5555	0.6545	0.0990	-0.0111	0.3267	0.3310
M3 without M2	0.7622	0.7398	-0.0224	0.3675	0.5815	* 0.5976
Key Interest Rate	0.7025	0.7041	0.0016	0.3799	0.6872	* 0.6782
HCPI	0.6242	0.7088	0.0846	0.4662	0.8448	* 0.8378
Business Expectations	0.5086	0.5542	0.0456	0.0546	0.0113	0.2491
Exchange Rate (Price Quotation)	0.3859			0.3108	0.7346	* 0.6710
Price-Earnings-Ratio (ecl. Unus. Items)	0.3063			0.9131	0.9989	* 0.9989
Price-Earnings-Ratio (incl. Unus. Items)	0.4513			0.8328	0.9973	* 0.9970
Cash-Flow-Ratio (levered free)	0.4559			0.2928	0.8055	* 0.5485
Liquitation Value (Proxy)	0.6844	0.5713	-0.1131	0.3892	0.6985	* 0.6580
Liquidity 1	0.5433	0.6717	0.1284	0.0123	0.2498	0.0778
Liquidity 2	0.5366	0.5114	-0.0252	-0.0103	-0.0225	0.0207
Liquidity 3	0.5331	0.5099	-0.0232	0.0062	0.0649	0.0262
Debt-Equity-Ratio	0.4076			0.3736	0.8459	* 0.7927
Golden Rule of Balance Sheet	0.5392	0.5097	-0.0295	0.0581	0.0243	0.1232
Diff. Cash-Flow-Definitions	0.4435			0.7425	0.9973	* 0.9971
Market Cap (log)	0.5723	0.4890	-0.0833	0.7870	0.9735	* 0.9716
Net Property Plant And Equipment	0.6229	0.6223	-0.0006	0.6381	0.8602	* 0.8495
Sum	0.5852	0.5762	-0.0090			

Note: all the variables, apart from the logarithmized market cap, are quarterly alteration rates;
* Uniqueness > 0.5

Sources: Capital IQ, EZB, ifo Institut für Wirtschaftsforschung e. V., ariva.de, Deutsche Börse AG, own calculations

Table 3: Rotated factor loadings

Note: Only factor loadings are printed, which absolute value is bigger than 0.1, all variables, apart from the logarithmized market cap, are quarterly alteration rates.

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9
Revenues	0.8659								
Cost Of Goods Sold	0.8545					0.2040			
Total Operating Expenses	0.8697								
Operating Income									0.2012
Net Interest Expenses									
EBT Excl. Unusual Items									0.3287
EBT Incl Unusual Items									0.7934
Total Cash And Short Term Invest.					0.9529		0.1263		
Total Receivables							0.1402		
Inventory	0.1507					0.9243			
Total Current Assets	0.1574	0.1599			0.2381		0.6317		
Total Assets	0.1801						0.8150		
Total Current Liabilities		-0.1971					0.1823		
Long Term Debt									
Common Stock			0.7889						
Retained Earnings									
Total Common Equity	0.1060		-0.7679		0.1049		0.1984		
Total Shares Outstanding			0.9008						
Net Debt									
Working Capital							0.1331		
Net Working Capital									
Levered Free Cash Flow							0.1410		
Unlevered Free Cash Flow									
Euro Bund Future								0.6374	
M1	0.1373			-0.6106					
M2 without M1				0.7803				0.2274	
M3 without M2	-0.1237			0.6053			0.1294		
Key Interest Rate	0.1401			0.5288			0.1002		
HCPI				0.3917					
Business Expectations				-0.3061				-0.8093	
Exchange Rate (Price Quotation)				-0.2769				0.4976	
Price-Earnings-Ratio (ecl. Unus. It.)									
Price-Earnings-Ratio (incl. Unus. It.)									
Cash-Flow-Ratio (levered free)									0.6708
Liquidation Value (Proxy)	0.1072			0.1398			0.2990	0.4635	
Liquidity 1		0.2777			0.9188				
Liquidity 2		0.9775			0.1467				
Liquidity 3		0.9821							
Debt-Equity-Ratio		-0.1456					0.4124	0.1044	
Golden Rule of Balance Sheet	0.1335					0.9263			
Diff. Cash-Flow-Definitions									
Market Cap (log)				0.1119					
Net Property Plant And Equipment							0.3792		

Sources: Capital IQ, EZB, ifo Institut für Wirtschaftsforschung e. V., ariva.de, Deutsche Börse AG, own calculations

Therefore, the selection criterion, which variables are substituted for by the nine common factors is based on degree of uniqueness. To see, how suitable this criterion is, it's focused on the average of the uniqueness. Now, two groups are built: In the first group the variables are collected, whose uniqueness is less than 0.5. In the second group are variables with a uniqueness bigger than 0.5. The average uniqueness of the variables having a degree of uniqueness less than 0.5 is 0.22. The average uniqueness of the variables having a degree of uniqueness above 0.5 is 0.86. Hence, there is evidence that the factor analysis is able to reduce multicollinearity in the data set without a large loss of information if the variables with a high degree of uniqueness are retained and employed in the dynamic panel estimation.

3.4 Calculated Factors

According to the factor loading matrix in Table 3, the nine estimated factors are (1) market adjustment, (2) liquidity, (3) outstanding shares, (4) money supply, (5) cash and short-term investments, (6) golden rule of balance sheet, (7) total assets, (8) business expectations, and (9) extraordinary profits.

When interpreting these results, it must be kept in mind that the factors found reflect quarterly rates of change in the fundamentals and expectations. In contrast to the correlation analysis, the factor loadings prove that there is an interdependence between business data and macroeconomic changes. The factor scores are estimated by the factor loadings as described in the previous section. The calculated factor scores are uncorrelated. However, correlation analysis reveals a dependence between some remaining exogenous variables and the factor scores (not shown). For example, the factor "money supply" and variables closely linked to money supply, such as M1, M3 (without M2), and the key interest rate, are correlated (the correlation coefficient is between 0.59 and 0.69).

An additional factor analysis on basis of the already extracted factor scores and the remaining exogenous variables minimally simplifies the data set at the cost of losing a large amount of information. Furthermore, interpreting the factors becomes difficult. Additionally, a second and separate factor analysis was performed for the EBT (without unusual items) and operating income. These two variables are very strongly correlated (0.98). Using the above non-iterative principal-factor method, an additional factor - (10) profits from operating activities - is generated.

4. Interpretation of the Estimated Results

This section investigates how expectations, the historic yield, and company and macroeconomic fundamentals influence current stock market yield. The parameters are estimated by the dynamic panel model set out in Section 2. Prior to estimating the parameters, the factor analysis described Section 3 was run to reduce multicollinearity. Subsection 4.1, below, is a general guide to interpreting the parameters of Table 4. The most important results of the estimation are set forth in Subsection 4.2. Finally, the results of some test statistics used to evaluate the quality of the overall model are discussed in Subsection 4.3.

4.1 General Interpretation of the Parameters in the Arellano-Bond Approach

Due to the preceding factor analysis and separation of the data set by levels of uniqueness, multicollinearity is no longer a problem. Therefore, the precision of the parameters is not affected by the problem of interdependent exogenous variables and a clear interpretation of the parameters is possible. Due to the FD approach employed, each parameter can be generally interpreted as follows:³¹

(a) Membership in a stock market index increases the quarterly yield by the amount of the estimated parameter. When belonging to an index, the dummy has the value of one.

(b) The alteration rates of the metric, not of the logarithmized variables, influence the yield by the amount of the rate of the estimated parameters. It is noteworthy that the estimated parameters are mostly in the tenths or hundredths. However, this is plausible because an increase of the dependent variable of, say, 20% would cause an increase in the yield of 2% per quarter(!) when the estimated parameter is 0.1. Of course, this is a singular effect, since the model assumes that the exogenous numbers are independent over time.

(c) The logarithmized market value is interpreted as a semi-elasticity. According to the model, a 100% increase in the market value would lead to an 8–12 percentage point increase in the yield per quarter. Compared with empirical findings in the literature,³² market value has a positive, not a negative, effect on the yield. The meaning of the estimated results is discussed in the next section.

4.2 Explicit Estimation Results of the Arellano-Bond Approach

The following interpretation focuses on those parameters found to be significant at $p < 0.1$. For the interpretation of the estimated parameters (1) the historical dependencies are very interesting. Afterwards (2) the index dummies are described. The first fundamentals, which are discussed, are (3) the different sorts of borrowed capital. Continuing, (4) the influence of assets and (5) the dividend payout on the yield are described. As assumed in this paper, it can be shown, that (6) the alteration rates of the fundamentals have a small prediction power. And (7) the expectations of the economic agents have a significant influence on the yield. These parameters are at first glance counter-intuitive, but some good reasons exist, which explain the counter-intuition convincingly. (8) The change in money supply, in contrast to (9) the interest rates and the rate of inflation has a low predictive power. Then, (10) the influence of the market value is discussed. Finally, (11) the constant is interpreted.

(1) The most interesting result is the influence of historical yield. The parameters are not dominant and the p -value is nearly always above 0.1. Incidentally, this is not a consequence of the factor analysis. A dynamic panel estimation based on the original data (without the factor scores) provides identical results regarding the historical dependencies (values not shown). The assumption of the efficient market theory that dependencies over time are statistical artifacts of a misspecification of the empirical model cannot be rejected. Indeed, the efficient market hypothesis finds support in results set out in Table 4. The dependencies calculated in other papers, especially in weak-form tests, thus do not constitute a valid criticism of the efficient market theory.

³¹ Cameron/Trivedi (2005, pp. 717, 757).

³² Banz (1981, pp. 12–15); Fama/French (1992, pp. 432–439).

This is not really new, but a confirmation of the empirical results of models, which are less complex.³³ Very weak dependencies are still found, but the parameters usually have a low significance level. Including fundamentals and expectations in the model leads to weak historical dependencies compared to a model that considers only historical yields. In contrast to Fama and French's three-factor model, here it is shown that the influence of historical yields is not dependent on the portfolio.³⁴ Thus, the dynamic panel model is a superior method of testing the efficient market hypothesis.

(2) The index dummies are not only highly significant, they are also positive. Compared to the DAX, companies listed on other indices earn higher returns. The companies not listed on the DAX are usually smaller companies that exploit new markets by way of innovations and catch up growth. Compared to the big companies listed on the DAX, the increase of the yield captures the innovative strength and catch-up growth.

(3) An increase of long-term debt is interpreted as a negative signal by investors. In this context, consideration of current liabilities is interesting, although the parameters are not significant, which is due to a high estimation variance. However, the parameter is notably negative in every model and is very high compared to the other parameters. Stock markets appear to react very sensitively to changes in current liabilities. This is plausible as liquidity and short-term liabilities are strongly linked. An increase in liquidity leads to a lower yield. Investors may interpret this ratio as an indicator of poor liquidity management. Investors might wonder why a company needs so much liquidity. This is exactly what the liquidity factor scores reveal: positive factor scores imply an outstanding liquidity.

(4) The negative influence of the liquidation value can be explained analogously. The parameters of the total assets, the golden rule of the balance sheet, and the net assets have a positive sign and thus the liquidation value sends different signals to investors, compared to the determinants of this figure. Like liquidity, there must be an equilibrium in the capital market. Values below the efficient equilibrium signal that a cheap investment is possible for risk neutral investors or if the risks are correctly anticipated or hedged; values above the equilibrium look like a bad deal for risk neutral investors.

(5) Companies not distributing their profits to the owners and instead reinvesting the money are treated significantly worse by the capital market. An analogous situation exists when outstanding shares are increased. Market participants interpret a company's increase of equity to invest worse than other kinds of capital allocation via the capital market. In other words, it appears that market participants do not interpret an increase in equity as a means of enabling catch-up growth or increasing rents from innovations, but as contingent. It looks like the institution of the capital market is regarded as more trustworthy to allocate capital efficiently than the intra-firm allocation.

(6) It is surprising that the various cashflow and profit indicators have no significant impact on yield. This is particularly true for the price-earnings ratios. If the shareholders invest according to expected profits, the current rates of change in earnings are evaluated very differently. These results are not a contradiction of the fundamental approach or the efficient market hypothesis; both theories assume that market prices reflect not only current trends but also expectations.³⁵

(7) Regarding the pricing of expectations factor, the parameter value is counterintuitive at first sight: the algebraic sign is negative. This is also true of the parameters for the Euro Bund

³³ Fama/French (1988, pp. 265–266); Malkiel (2003, pp. 10–11).

³⁴ Fama/French (1996, pp. 63–66).

³⁵ Fama (1970, pp. 387–388); Graham/ Dodd (1934, p. 24).

Future. The usual assumption, a parallel course for stocks and expectations, does not hold. However, for investors, it is very profitable to invest non-cyclically: a sustainable investment strategy is to buy shares during an economic downturn and sell them during a boom. This non-cyclical investment explains the negative algebraic signs of the Euro Bund Future and the expectations.

This non-cyclical investment strategy leads to a partial smoothing of the stock market's cyclical price movements. Of course, the net effect is pro-cyclical, and it is this pro-cyclical effect that is perceived by economic indicator research. The model used in this paper handles the effects of the trade cycle in two ways. In one, the macroeconomic indicators are evaluated and, in the other, the business data of every firm are considered. As a result, the transmission of economic shocks is modeled by the business figures, the macroeconomic rates, and by expectations of market participants. Thus, it is not surprising that some parameters differ from those found in research on economic indicators, which only focuses on some macroeconomic variables.

(8) The variables and factors describing the development of the money supply have poor prediction power as indicated by their significance levels. By trend a negative dependence on the yield can be extracted. There are various explanations for figures. On the one hand, multicollinearity may be responsible for the predicted results. On the other hand, the period covered by the data set includes the financial crisis of 2008, which prompted the central bank to increase the money supply drastically to bolster the financial system.³⁶ The increased money supply was a crisis indicator, and during a capital market crisis, willingness to invest in stocks declines. Alternatively, the link between money supply and the stock market yield may also be indefinite.

(9) The negative correlation between interest rates and yield is just as plausible as the negative influence of inflation. An increase in the key interest rate raises the cost of debt,³⁷ which has a negative effect on expected profit and reduces the stock market yield. If a change in the inflation rate is interpreted as uncertainty about the future,³⁸ the estimated parameter is reasonable.

(10) As mentioned earlier, the algebraic sign of the logarithmized market value is plausible. According to the hypothesis espoused by fundamental data analysts, this relationship is reasonable. Investors prefer companies with a high market value because such an evaluation is a good signal of a secure investment. However, it is not obvious that an enhancing effect of the market value is the consequence. Market participants have strong incentives to model their behavior not only on the behavior of other participants but to also use private information to their own advantage.³⁹

The negative dependence between market value and yield could be a consequence of restrictions of the models used by Banz, Fama, and French. For example, in their most comprehensive models, only market capitalization, book-to-market ratio, ratio of the shares to the market value, and the earnings-price ratio are taken into account. A reduction of variables that have explanatory power leads, as previously discussed, to biased point and interval estimates and to incorrect hypothesis tests.⁴⁰

³⁶ EZB (2010d, pp. 106–112).

³⁷ Tomann (1997, p. 95).

³⁸ Blanchard/Illing (2006, p. 730). Because of the range of variation in inflation in the Euro area, it is generally unlikely that the inflation rate is an indicator of uncertainty. However, remember that the financial crisis of 2008 took place during the period of observation. Therefore, the rate of inflation, which is linked to monetary policy, can be interpreted as an indicator of uncertainty for this period.

³⁹ Grossmann (1977, S. 441–443); Fama/French (2007, pp. 671, 683).

⁴⁰ Auer (2007, pp. 250–258).

(11) An additional interesting finding is the sign of the constant. If all detected change rates are zero and the overall economic development as well as the dummies are not taken into consideration, stagnation of the company would cause a permanent decrease of the stock market yield. Econometrically, this represents a negative time trend.⁴¹ Therefore, the data generating process can be described as trend stationary.⁴²

Indeed, the data generating process of the stock market is a supermartingale,⁴³ which contradicts the assumption of a constant or increasing rate of return.⁴⁴ However, the results are very plausible if the capital market is regarded as an institution that forces the listed companies to be companies in the Schumpeterian sense. The stock market enforces innovations and can be seen as an alternative to the Schumpeterian banker as *ephor* of the economy (*Ephor der Verkehrswirtschaft*).⁴⁵

4.3 Power of the Overall Model

The results presented above are extensive and in some cases cast doubt on assumptions made by practitioners and theoreticians when explaining capital market returns. However, the model shows the influence of changing fundamentals and expectations. The effect on yield is in many cases statistically significant. Moreover, the dependence is measured in quarters instead of for very short-term horizons, as is usually the case in classical event studies. The validity of the results is confirmed by the Wald- χ^2 -values of the different models. The Wald- χ^2 -values are, perhaps, a bit high due to remaining (but very low) multicollinearity,⁴⁶ but as the results of the Wald- χ^2 -tests are very clear, this seems to be unproblematic.

Arellano-Bond tests were conducted to test for autocorrelated differentiated error terms. There is some serial autocorrelation in the quarterly estimates. The null hypothesis, that $Cov(\Delta\varepsilon_{j,t}, \Delta\varepsilon_{j,t-1}) = 0$, cannot be rejected at a high significance level. The error terms are thus partially correlated. Therefore, the MA restriction of the dynamic panel model is necessary.

Sargan tests on overidentified restrictions were implemented for each model restriction. The results were inconsistent since Sargan tests require independently and normally distributed residuals. Thus, the test results should be interpreted cautiously. Because the results are very straightforward (p -values between 36 and 100%) and the results of the 2SLS and the GMM approaches differ only marginally, the GMM estimates can be used as an alternative modeling strategy.⁴⁷

Summary

The approach taken in this paper combines factor analysis and panel estimation. Hence, extremely complex theoretical issues can be investigated as to their explanatory contribution to capital mar-

⁴¹ Cameron/ Trivedi (2009, p. 264).

⁴² Enders (2004, pp. 156–157).

⁴³ Fama (1970, S. 387, 393–394); Schmid/Trede (2006, S. 127–128).

⁴⁴ Fama (1976b, pp. 137–151).

⁴⁵ Schumpeter (1997, p. 110).

⁴⁶ Cameron/Trivedi (2005, p. 136, 2009, p. 386).

⁴⁷ Results of the Arellano-Bond and Sargan tests not shown.

ket theory. Expectations and company and macroeconomic fundamentals can be considered and a link between weak-form and semi-strong-form tests is possible, too. Therefore, a powerful estimation of the influence of static exogenous variables and dynamic endogenous variables is possible.

(1) The goal of factor analysis is to generate an uncorrelated data set, which is a necessary precondition for a powerful panel estimation. However, in a extensive data set, like the one used here, interdependencies are common. The aim is to reduce multicollinearity without a loss of information. Depending on the data set, many empirical findings can be extracted, including, for example, the interdependence of different company data at the intra-company level. Or in other words: Is there a universal production technology that determines the rates of change in the company's figures? Analogously, factor analysis can be applied to macroeconomic data as an alternative to methodologically complex macroeconomic models.⁴⁸ In particular, the main advantage of factor analysis is its ability to identify dependencies without making assumptions about macroeconomic interactions. At the same time, the interdependence of macroeconomic and company data can be identified, which is not possibly when correlation analysis is employed. Factor analysis is also capable of handling expectations. Thus, it is possible to discover how subjective expectations influence yield. Even distinguishing between a direct influence and an indirect influence via the company and macroeconomic fundamentals is possible.

(2) Dynamic panel analysis is able to estimate the effects of individual determinants of the yield simultaneously because multicollinearity is reduced via the factor analysis. In addition, a dynamic model can take time series effects into account. Therefore, the Arellano-Bond estimator is applied. Also, the moving average process of capital market shocks can be modeled by a MA restriction of the shocks. Due to these restrictions, the panel estimation of the yield is a very powerful method for testing various factors of the yield. In the cases of the dotcom bubble of 2000–2005, as well as the financial crisis of 2008, both of which at least partially occurred during the observation period (2004–2009), the model performed very well in explaining movements of the German stock market. Supplementary subjective information can be included to test hypotheses from the field of behavioral finance. Moreover, the same approach can be extended to investigate what the CAPM is really explaining, or how periods with high volatility affect the stock market yield.

(3) The innovative aspect of combining factor analysis and panel estimation is the simultaneous consideration of different theories. The approach presented in this paper illustrates very clearly that each and every theory does not have to be examined in isolation. The approach allows bringing together previously competing theories in a kind of meta-model to test them empirically. This opens up a new scientific discourse: the important question is no longer which theory explains the capital market best, but to what extent the different theories can work together to explain the capital market.

The approach described in this paper is in its infancy but I hope that its potential is clear and inspires further empirical effort. The alternative—continuing to expand on already existing theories and, consequently, focusing on the differences between them—does not appear to be a useful path if the final objective is an encompassing and thorough explanation of how the capital market works. In many cases, the extant, highly specialized models are a black box. That is, the numbers they produce are significant, but what, exactly, do they signify? The approach presented in this paper is intended as way of opening that box.

⁴⁸ Breitung/Eickmeier (2005, pp. 1–2).

Table 4: Dynamic panel estimation of the quarterly yield (ARMA)

Endogenous variable: quarterly yield	(5,3) 2 Ins, 2SLS	(5,3) 3 Ins, 2SLS	(5,3) 2 Ins, GMM	(5,3) 3 Ins, GMM	(5,4) 2 Ins, 2SLS	(5,4) 3 Ins, 2SLS
L1.yield	0.1133	0.0894	0.1080	0.0704	0.0871	0.0459
L2.yield	0.0520	0.0471	0.0481	0.0492	0.0193	0.0216
L3.yield	-0.0002	-0.0084	-0.0011	-0.0116	-0.0160	-0.0200
L4.yield	-0.0406	-0.0442	-0.0361	-0.0460	-0.0738 *	-0.0723 **
L5.yield	0.0303	0.0190	0.0303	0.0202	0.0007	0.0004
MDAX	0.2137 *	0.2126 *	0.2112 *	0.2390 *	0.2004 **	0.2036 **
SDAX	0.2996 **	0.3000 **	0.3036 **	0.3224 **	0.2625 **	0.2617 **
TECDAX	0.2666 *	0.2759 *	0.2611 *	0.2883 *	0.2801 **	0.2880 **
Not in an index	0.3368 **	0.3352 **	0.3378 **	0.3590 **	0.3667 **	0.3665 **
Index change	-0.0327	-0.0376	-0.0254	-0.0271	-0.0338	-0.0363
IFRS	0.0103	0.0105	0.0103	0.0104	0.0077	0.0072
Net Interest Expenses	-0.0018	-0.0018	-0.0039	-0.0041	-0.0017	-0.0017
Total Receivables	-0.0053	-0.0050	-0.0057	-0.0047	-0.0052	-0.0067
Total Current Liabilities	-5.0501	-4.7564	-4.1749	-3.8885	-3.7543	-3.9047
Long Term Debt	-0.0218 **	-0.0214 **	-0.0289 ***	-0.0285 ***	-0.0235 ***	-0.0222 ***
Retained Earnings	-0.0274 ***	-0.0269 ***	-0.0269 ***	-0.0255 ***	-0.0242 **	-0.0234 **
Net Debt	0.0071 *	0.0068 *	0.0085 *	0.0083 *	0.0068 *	0.0062 *
Working Capital	-0.1133 **	-0.1067 **	-0.1095 *	-0.0975 *	-0.1045 **	-0.1029 **
Net Working Capital	0.0244	0.0296 *	0.0224	0.0288	0.0211 *	0.0186 **
Levered Free Cashflow	-0.0015	-0.0017	-0.0007	-0.0006	-0.0014	-0.0017
Unlevered Free Cashflow	0.0152	0.0142	0.0055	-0.0040	0.0103	0.0086
Euro Bund Future	0.0359 ***	0.0328 ***	0.0322 ***	0.0296 ***	0.0292 ***	0.0256 ***
M1	-0.0328 ***	-0.0308 ***	-0.0279 ***	-0.0264 ***	-0.0352 ***	-0.0345 ***
M3 (without M2)	0.0016	0.0028	-0.0003	0.0020	0.0108	0.0124
Key Interest Rate	-0.0270 **	-0.0254 **	-0.0257 ***	-0.0226 **	-0.0170 **	-0.0140 **
HCPI	-0.0120 *	-0.0117 **	-0.0113 **	-0.0112 **	-0.0147 **	-0.0132 ***
Exchange Rate (Price Quotation)	0.0086	0.0075	0.0107	0.0083	0.0036	0.0022
Price-Earnings-Ratio (ecl. Unus. It.)	0.0104 *	0.0103 *	0.0084	0.0084	0.0109 *	0.0101 *
Price-Earnings-Ratio (incl. Unus. It.)	0.0009	0.0009	0.0023	0.0047	0.0003	0.0006
Cash-Flow-Ratio (levered free)	-0.0069	-0.0070 *	-0.0056	-0.0048	-0.0076 *	-0.0076 *
Cash-Flow-Ratio (levered free)	-0.2556 ***	-0.2527 ***	-0.2710 ***	-0.2628 ***	-0.2497 ***	-0.2448 ***
Liquidation Value (Proxy)	0.0017	0.0011	-0.0008	0.0000	0.0012	0.0008
Diff. Cash-Flow-Definitions	-0.0038	-0.0034	-0.0031	-0.0028	-0.0023	-0.0020
Market Cap (log)	0.1289 **	0.1289 **	0.1233 **	0.1280 **	0.0993 **	0.1014 **

Net Property Plant And Equipment	1.4290 *	1.4095 *	1.6432 **	1.8233	1.3036 *	1.2318
Market Adjustment (Factor)	0.0128 ***	0.0128 ***	0.0127 ***	0.0130 ***	0.0132 ***	0.0131 ***
Liquidity (Factor)	-0.0363 ***	-0.0360 ***	-0.0384 ***	-0.0356 **	-0.0317 ***	-0.0323 ***
Outstanding Shares (Factor)	-0.0343 ***	-0.0348 ***	-0.0365 ***	-0.0374 **	-0.0305 **	-0.0310 ***
Money Supply (Factor)	-0.0286	-0.0282	-0.0227	-0.0255	-0.0369 *	-0.0418 **
Cash and Short-Term Invest. (Factor)	-0.0041	-0.0041	-0.0014	-0.0015	-0.0039	-0.0038
Golden Rule (Factor)	0.0161 ***	0.0164 ***	0.0164 ***	0.0171 ***	0.0146 ***	0.0138 ***
Total Assets (Factor)	0.0614 ***	0.0613 ***	0.0638 ***	0.0606 ***	0.0588 ***	0.0581 ***
Business Expectations (Factor)	-0.0540 ***	-0.0523 ***	-0.0476 ***	-0.0494 ***	-0.0455 ***	-0.0462 ***
Extraordinary Profits (Factor)	0.0138 **	0.0142 **	0.0118 *	0.0108	0.0151 **	0.0144 **
Profits from Operating Act. (Factor)	-0.0298	-0.0257	-0.0336	-0.0183	-0.0227	-0.0188
Constant	-0.2608 **	-0.2558 **	-0.2401	-0.2494	-0.2266 **	-0.2319 **
N	1470	1470	1470	1470	1470	1470
wald-chi2	4.10E+03	4.00E+03	3.10E+03	2.80E+03	3.30E+03	3.40E+03

Endogenous variable: quarterly yield	(5,4) 2 Ins, GMM	(5,4) 3 Ins, GMM	(5,5) 2 Ins, 2SLS	(5,5) 3 Ins, 2SLS	(5,5) 2 Ins, GMM	(5,5) 3 Ins, GMM
L1.yield	0.0928	0.0584	0.0653	0.0506	0.0865	0.0553
L2.yield	0.0155	0.0153	0.0247	0.0279	0.0255	0.0170
L3.yield	-0.0200	-0.0161	-0.0207	-0.0197	-0.0236	-0.0180
L4.yield	-0.0667 *	-0.0617 *	-0.0694 **	-0.0676 **	-0.0632 **	-0.0544 *
L5.yield	0.0068	0.0040	0.0002	-0.0043	0.0094	-0.0073
MDAX	0.2203 *	0.1801 *	0.1792 *	0.1785 *	0.1860	0.1948 *
SDAX	0.2738 **	0.2364 **	0.2372 **	0.2363 **	0.2310 *	0.2527 *
TECDAX	0.2922 **	0.2624 **	0.2410 **	0.2419 **	0.2336 **	0.2662 **
Not in an index	0.3775 **	0.3421 **	0.3176 **	0.3159 **	0.3126 **	0.3436 **
Index change	-0.0250	-0.0297	-0.0376	-0.0377	-0.0226	-0.0317
IFRS	0.0069	0.0059	0.0071	0.0080	0.0100	0.0033
Net Interest Expenses	-0.0019	0.0003	-0.0020	-0.0024	-0.0025	-0.0020
Total Receivables	-0.0045	-0.0073	-0.0066 *	-0.0069 *	-0.0068	-0.0086
Total Current Liabilities	-2.6866	-0.3251	-3.2579	-3.1291	-2.4334	-5.0062
Long Term Debt	-0.0290 ***	-0.0285 ***	-0.0231 ***	-0.0228 ***	-0.0253 ***	-0.0242 ***
Retained Earnings	-0.0279 ***	-0.0266 **	-0.0225 **	-0.0222 **	-0.0226 *	-0.0198
Net Debt	0.0070	0.0067 *	0.0067 *	0.0066 *	0.0071	0.0077 *
Working Capital	-0.0852	-0.0829	-0.1099 **	-0.1057 **	-0.1047 *	-0.0851 *
Net Working Capital	0.0196	0.0142	0.0199 *	0.0205 *	0.0186	0.0197 *

Levered Free Cashflow	-0.0019	-0.0029	-0.0016	-0.0016	-0.0008	-0.0008
Unlevered Free Cashflow	-0.0008	0.0067	0.0122	0.0101	-0.0060	0.0033
Euro Bund Future	0.0287 ***	0.0266 ***	0.0252 ***	0.0240 ***	0.0256 ***	0.0223 ***
M1	-0.0310 ***	-0.0282 ***	-0.0335 ***	-0.0327 ***	-0.0272 ***	-0.0276 ***
M3 (without M2)	0.0069	0.0072	0.0109	0.0113	0.0068	0.0066
Key Interest Rate	-0.0185 **	-0.0165 **	-0.0144 **	-0.0136 **	-0.0166 **	-0.0151 **
HCPI	-0.0133 ***	-0.0129 ***	-0.0136 ***	-0.0130 ***	-0.0145 ***	-0.0117 ***
Exchange Rate (Price Quotation)	0.0084	0.0079	0.0043	0.0038	0.0077	0.0084
Price-Earnings-Ratio (ecl. Unus. It.)	0.0104	0.0077	0.0105 *	0.0102 *	0.0078	0.0086
Price-Earnings-Ratio (incl. Unus. It.)	-0.0033	-0.0003	0.0012	0.0010	0.0010	0.0021
Cash-Flow-Ratio (levered free)	-0.0074	-0.0081 *	-0.0075 *	-0.0072 *	-0.0076	-0.0070 *
Cash-Flow-Ratio (levered free)	-0.2642 ***	-0.2636 ***	-0.2487 ***	-0.2466 ***	-0.2677 ***	-0.2660 ***
Liquidation Value (Proxy)	-0.0006	-0.0042	0.0009	0.0007	-0.0023	0.0002
Diff. Cash-Flow-Definitions	-0.0028	-0.0025	-0.0009	-0.0007	-0.0007	-0.0020
Market Cap (log)	0.0964 *	0.0837 **	0.0855 **	0.0859 **	0.0802 *	0.0817
Net Property Plant And Equipment	1.6861	1.4183	0.9823	0.9727	0.9539	1.5089
Market Adjustment (Factor)	0.0131 **	0.0125 ***	0.0110 **	0.0109 **	0.0105 *	0.0095 *
Liquidity (Factor)	-0.0330 **	-0.0327 **	-0.0312 ***	-0.0304 ***	-0.0335 **	-0.0361 ***
Outstanding Shares (Factor)	-0.0319 **	-0.0326 **	-0.0303 **	-0.0303 **	-0.0319 ***	-0.0324 ***
Money Supply (Factor)	-0.0284	-0.0282 *	-0.0362 *	-0.0379 **	-0.0229	-0.0266
Cash and Short-Term Invest. (Factor)	-0.0044	-0.0034	-0.0032	-0.0032	-0.0052	-0.0026
Golden Rule (Factor)	0.0165 ***	0.0150 ***	0.0143 ***	0.0140 ***	0.0155 ***	0.0145 ***
Total Assets (Factor)	0.0638 ***	0.0651 ***	0.0593 ***	0.0588 ***	0.0667 ***	0.0640 ***
Business Expectations (Factor)	-0.0434 ***	-0.0440 ***	-0.0436 ***	-0.0441 ***	-0.0393 **	-0.0404 ***
Extraordinary Profits (Factor)	0.0139 *	0.0134 *	0.0143 **	0.0139 **	0.0148 *	0.0143 **
Profits from Operating Act. (Factor)	-0.0174	-0.0206	-0.0233	-0.0225	-0.0215	-0.0273
Constant	-0.2088	-0.1425	-0.2009 **	-0.1986 **	-0.1905	-0.2345 *
N	1470	1470	1470	1470	1470	1470
wald-chi2	2.70E+03	3.80E+03	3.10E+03	3.10E+03	2.90E+03	2.90E+03

Legend: * p<.1; ** p<.05; *** p<.01

Note: all the variables, apart from the logarithmized market cap, are quarterly alteration rates; because of the estimation method the number of the observed companies is reduced from 159 to 126

Source: Capital IQ, EZB, ifo Institut für Wirtschaftsforschung e. V., ariva.de, Deutsche Börse AG, own calculations

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