A Study about Intercompany Disparities and its Impact on the Macroeconomy
-An Empirical Study in the Stock Market-

企業間格差と企業間格差がマクロ経済に与える影響についての研究
―株式市場における実証研究―

A Dissertation Presented to
the Graduate School of Arts and Sciences
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アーツ・サイエンス研究科提出博士論文

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Abstract

The study of macroeconomic tail risk by intercompany disparities is one of the new research fields in recent macroeconomics. These studies theoretically show that if there are large disparities relating to business scale and gains among firms, idiosyncratic shocks to major firms can cause large macroeconomic fluctuations. This study investigates whether idiosyncratic firm-level shocks to large firms cause the aggregate fluctuations, paying attention to company fundamentals as intercompany disparities. Since company fundamentals are reflected in market stock prices via investors in the stock market, company fundamentals can be estimated by using regression model in which financial indicators per share are explanatory variables for market stock prices. The data used in this study was collected a large database containing the financial statement and stock information of firms listed worldwide for the period 2003-2016.

First, I show that company fundamentals for market stock price estimated with the panel two-way fixed regression model are well reflected in market stock prices The merit of the panel two-way fixed effects model can control two unobservable factors, including individual fixed effects and time fixed effects. The estimated model has quite high explanatory power. Second, I show that how market stock prices deviate from company fundamentals in the late 2000s when the stock market experienced stock price bubble during 2005 to 2007 and subsequent global financial crisis in 2008. Defining divergence rates as the deviation rate of market stock price from company fundamentals and paying attention to the means of divergence rates, I find that market stock prices were overvalued against company fundamentals during the period 2005-2007 and were undervalued significantly against company fundamentals in 2008. In the subsequent period, market stock prices were found to be equivalent to company fundamentals on average. Third, I find that approximately 70 % of the variation in aggregate fluctuations can be explained by idiosyncratic firm-level shock to the top 100 largest firms in the stock market using market capitalization as a firm size. Idiosyncratic firm-level shocks are estimated based on the deviation of market capitalization from company fundamentals for each firm and each year. Using the panel two-way fixed effects regression model in which cash flow and book value are explanatory variables for market capitalization, company fundamentals for market capitalization were estimated. The explanatory power of the regression model is quite high showing the same level as that of market stock prices Namely, company fundamentals for market capitalization are well reflected in market capitalization. This study empirically shows the macro tail risk by intercompany disparities in the stock market. Different from real economy, firm-level shock to quite small number of large firms cause the aggregate fluctuations in financial economy.

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Contents

Preface

The study of macroeconomic tail risk caused by intercompany disparities is one of the new research fields in recent macroeconomics. These studies show that if there are large disparities relating to business scale and gains among firms, shock to major firms can cause large macroeconomic fluctuations. Gabaix (2011), one of the pioneers in this fields, theoretically shows that the idiosyncratic movements of the largest 100 firms cause macroeconomic business cycles, if the distribution of firm size is fat-tailed. Relatedly, Acemoglu, et al. (2012, 2013, 2015) theoretically shows the possibility of large economic downturns, that is, macro tail risk, by the spread of microeconomic shocks via input-output linkages, if the firm is the center of a network of firms.

On the empirical sides, Carvalho and Gabaix (2013) investigate the hypothesis that macroeconomic fluctuations are primitively the results of many microeconomic shocks. They defined fundamental volatility as the volatility that would arise from an economy made entirely of idiosyncratic sectoral shocks or firm level shocks. They analyzed the postwar U.S. economy and extended the analysis to four major economies: France, Japan, Germany, and the United Kingdom. The explanatory power of fundamental volatility is found to be quite good, supporting the view that the key to macroeconomic volatility might be found in microeconomic shocks. Di Giovanni, Levenchnko, and Mejean (2014) used French firms' annual sales data in their study and found that the firm-specific component contributes substantially to aggregate sales volatilities. The authors emphasized the direct role of shocks to individual firms and their propagation through input-output linkages. They decomposed the firm-specific components suggesting that there are two mechanisms for how firms translate their shocks into aggregate volatility. The first mechanism, as in the study of Gabaix (2011), suggests that when firm size distribution is fat-tailed, the idiosyncratic shock to large firms directly contributes to aggregate fluctuations. The second mechanism implies that aggregate fluctuations are caused by idiosyncratic shock due to input-output linkage across the economy. The decomposition reveals that firm linkage is approximately three times as important as the direct effects of firm shock in driving aggregate fluctuations.

Many empirical studies related to macro tail risk have been conducted in recent years. Those studies focus on macro variables in the real economy, such as sales, output, investment, and export, and show that idiosyncratic firm shocks to a single sector/firm can have sizable effect. In this research, paying attention to corporate value as a measure of intercompany disparities, whether microeconomic shocks to large firms cause the aggregate fluctuations is investigated. In the stock market, the valuation of stock is called intrinsic value for stock, which indicates intrinsic corporate value. In this study, corporate values are referred to as company fundamentals and company fundamentals are considered as being reflected in market stock prices. The data used in this research is from the OSIRIS database provided by Bureau van Dijk, containing the financial statement and stock information of firms listed worldwide. The stock information and financial statement of firms are derived from their annual firm data during the research period from 2003 to 2016.

Chapter 1 begins with the construction of an econometric model to examine whether market stock prices can correctly reflect company fundamentals. The econometric model is a panel regression model using two financial indicators per share as explanatory variables for the market stock price. The two financial indicators are cash flow per share and book value per share, which are representative variables commonly used to evaluate a firm's business performance. A panel two-way fixed effects regression model is performed. The explanatory power of the panel regression model results is quite high, indicating that the adjusted R squared value is 0.961, explaining 96% of the variation. The panel two-way fixed effects regression model estimates unobservable factors, including individual fixed effects and time fixed effects. Individual fixed effects account for individual firms' heterogeneity and time fixed effects reflects external shocks common to all firms. The estimates of the panel two-way fixed effects regression model are referred to as theoretical values, and company fundamentals are defined as the values that remove time fixed effects from the theoretical value and calculated. Company fundamentals contain financial information and individual fixed effects as non-financial information.

Examining whether the distributions of stock market prices and those of company fundamentals follow a power-law for each year, the distribution of the company fundamentals as well as those of market stock prices were found to follow a power-law. The power-law exponents range from 2.0 to 2.4 implying that the distributions of both stock market price and company fundamentals are fat-tailed. Empirical findings of the relationship between market stock prices and company fundamentals show that market stock prices well reflect company fundamentals.

Chapter 2 discusses the reasons why market stock prices deviate from company fundamentals. Calculating the divergence rate that is defined as the deviation of market stock price from company fundamentals estimated in previous chapter, the means of the divergence rates were found to be greatly changing from positive values to negative values in the late 2000s. In the financial economy, the efficient-market hypothesis states that all financial prices always accurately reflect all public information. According to the efficient-market hypothesis, market stock prices would correctly reflect company fundamentals, that is, the means of the divergence rates would be zero. Whereas the behavior financial view claims that investors are not necessarily rational swaying their emotion or psychological situation. Therefore, if the mean of the divergence rate greatly deviates from zero, it suggests that some external shock common to all firms, such as the global financial crisis of 2007-2008, has occurred.

Chapter 3 investigates whether microeconomic shocks to large firms cause aggregate fluctuations using market capitalization. Following the approach proposed by Gabaix (2011), the granular hypothesis is investigated for its hold on the stock market using market capitalization. Applying the panel regression model constructed in Chapter 1 to market capitalization instead of market stock price, company fundamentals for market capitalization is calculated. Defining firm-specific shock as the deviation of market capitalization from company fundamentals, 'granular residuals' which are constructed and used as simple measures of shocks to the top 100 largest firms in Gabaix (2011) were calculated. Using granular residuals calculated based on market capitalization, the granular hypothesis on the stock market is examined. Regressing the growth of aggregate market capitalization on granular residuals using Ordinally Least Squared (OLS) regression model, the explanatory power of granular residuals is evaluated based on the R-squared value. The granular residuals of the top largest firms were calculated, and explanatory powers of granular residuals were evaluated. Furthermore, using the granular regression results, the firms or industries which play a dominant role in determining aggregate fluctuations were investigated.

This study found that the granular hypothesis can be strongly accepted and that quite small number of the top largest firms can be classified as granular economy in the stock market. With respect to the industrial contribution to aggregate market capitalization growth, the energy and capital goods industries played a major role in determining aggregate fluctuations during the research period from 2003 to 2016.

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Chapter 1 Company Fundamentals Values for Stock Prices: An Empirical Study using Panel Data for Financial Indicators per Share

1.1 Introduction

The valuation of stock is called intrinsic value for stock, which indicates the intrinsic corporate value and reflects company fundamentals. To estimate corporate value, various practical valuation methods and models for corporate values have been designed. Multiples model and discounted present value models are models to evaluate corporate values. By explicitly using information from financial statements or forecast accounting data based on financial information, these models estimate corporate values.

Multiples models are conventional models and widely used. The Price-to-Earnings Ratio (PER) and the Price-to-Book Ratio (PBR) are representative multiple models. The Discounted Dividend Model (DDM), the Discounted Cash Flow Model (DCFM), and the Residual Income Model (RIM) are representative models based on discounted present values. Palepu, Healy, and Bernard (2004) considers the DDM to be a basic model for estimating the equity value and explains that the DCFM and the RIM are deformed DDMs, changing dividends to free cash flow, and profit and book value, respectively. Thus, these three models are theoretically equivalent. However, they differ in their practical applicability when 'real' data with finite horizons are introduced. To assess the comparative practical performance of the three models, many empirical studies have been conducted using actual data or data forecasted to a finite horizon to estimate the equity value.

Penman and Sougiannis (1998), Francis et al. (2000), and Courteau et al. (2000) are representative of these empirical studies. Each study compared the DDM, the DCFM, and the RIM using data for U.S. firms. Penman and Sougiannis (1998) estimated models using actual data and analyzed the relations between the actual and estimated value using valuation errors. Francis et al. (2000) estimated models using Value Line forecast data and compared the models' accuracy using a regression analysis as well as valuation errors. Courteau et al. (2000) estimated models using Value line forecast data and compared the models' accuracy using valuation errors. In addition to these three studies, several other empirical studies comparing alternative equity valuation models have been reported, including Bernard (1995), Jorgensen, Lee, and Yoo (2011), and Heinrichs et al. (2013). Bernard (1995) compared the RIM to the DDM using Value Line annual forecast data based on a regression analysis. Jorgensen, Lee, and Yoo (2011) assessed the valuation accuracy of the Abnormal Earnings Growth Model (AEGM)[1] compared to the RIM. Heinrichs et al. (2013) extended the DDM, the DCFM, and the RIM by correcting the dirty surplus accounting and employing a consistent terminal value calculation.

The estimation of capital cost is an important part in estimating models based on the discounted present value models. Considering the risk for profit in the future carefully, the appropriate capital cost is estimated. Usually, the capital cost is estimated based on asset pricing models, including the capital asset pricing model (CAPM) and the Fama-French 3 factor model (Fama and French, 1993). Many empirical studies estimate the capital cost following the CAPM. Penman and Sougiannis (1998) applied several calculations for the equity cost of capital including the CAPM and the Fama-French 3 factor model and reported that there is little difference in the results with different calculations.

Models to estimate the corporate values listed above, including the DDM, the DCFM, and the RIM, are commonly used by analysts and fund managers. Using different approach to the valuation of stock from the models described above, this study utilizes panel data analysis to estimate the company fundamentals which are reflected on market stock prices.

This study aims to investigate how stock markets evaluate corporate values, estimating the company fundamentals values for stock prices. To estimate company fundamentals following Kaizoji and Miyano (2018), a panel regression model is constructed using two financial indicators per share - cash flow per share and book value per share – as explanatory variables for market stock price. These financial indicators are representative variables commonly used to evaluate a firm's business performance. The annual firm data for a 14-year period (2003-2016) from 3,917 industrial firms globally listed are used to perform the panel regression model.

The panel regression model used in this study is the panel two-way fixed effects regression model. The two-way fixed effects model can estimate two fixed effects; the individual fixed effects that account for an individual firm's heterogeneity; and the time fixed effects that indicate variables fluctuating over time. The individual effects are constant over time and the time fixed effect are common to all firms. Merits of the panel two-way fixed effects regression model can estimate unobservable factors as the individual fixed effects and the time fixed effects.

Referring to estimates of the panel two-way fixed effects regression model as the theoretical values, the company fundamentals are defined as the values that exclude the time fixed effects from the theoretical value. To examine the relationship between the market stock price and the

[1] The Abnormal Earnings Growth Model (AEGM) was offered as an alternative approach to RIM by Ohlson and Juettner-Nauroth (2005).

company fundamentals, correlation coefficients between the market stock price and the company fundamentals are calculated for each year. The Spearman rank correlation coefficients as well as the Pearson product-moment correlation coefficients are around 0.98. The correlation between the market stock price and the company fundamentals were found to be quite high. Next, how the distribution of the market stock price coincide with the distribution of the company fundamentals is examined. It is well-known that the distribution of stock market return is fat-tailed. Examining whether the distributions of the market stock price and the distributions of the company fundamentals follow power-law distribution, both the distributions of the market stock price and those of the company fundamentals were found to follow a power-law distribution. Comparing the power-law exponents of the market stock price with those of the company fundamentals for each year, there was little difference between those power-law exponents. The distribution of the market stock price was found to approximately coincide with the distribution of the company fundamentals.

The company fundamentals estimated with the panel two-way fixed regression model include both financial information and no-financial information. The estimated individual fixed effects represent non-information, that is, the firms' idiosyncratic qualities. Analyzing the individual fixed effects estimated in the model paying attention to the country and industry, the disparities of the level of individual fixed effects among counties are found to be obvious, whereas those among industries are found to be vague.

Total 3,917 firms' data are used together in the world regression model and the regression results are analyzed. The 3,917 firms are from 67 countries which are in four regions[2]. Dividing the 3,917 firms into four regions including Asia, America, Europe, and the rest of the world, regional panel regression models are constructed, and the regression results are analyzed at the regional level.

The main finding in this study: (1) company fundamentals estimated from the panel regression model are well reflected in the market stock price. (2) The reason why the distribution of the market stock price follows a power-law is the power-law behavior in the company fundamentals. (3) The economic environment in countries greatly influences stock market behavior. (4) The regional panel regression models obtain approximately the same explanatory power as the world model.

The rest of this article is organized as follows: Section 2 describes the data used in this study and tests the power-law for the market stock price, Section 3 explains the panel regression model and calculates the company fundamentals, Section 4 discusses the relationship between the

[2] Regions and countries are presented in Table D.1 in Data section in this chapter.

market stock price and the company fundamentals, Section 5 analyzes the individual fixed effects, Section 6 analyzes the regional data, Section 7 offers concluding remarks.

1.2. Data

The data used in this study was collected from the OSIRIS database provided by Bureau van Dijk, containing the financial statement and stock information of firms listed worldwide. The market stock price, cash flow per share, and book value per share of firms are derived from their annual firm data. Firms that have no missing data in relation to the variables of interest from 2003 to 2016 were selected. Excluding firms in the financial and insurance industries, a total of 3,917 firms were selected from the database.

1.2.1 Overview of data: market stock price

Table 1 shows the percentage share of the number of firms by class in market stock price level. From the table, a few firms' market stock prices are extremely high, while many firms' market stock prices are very low. Descriptive statistics and Gini coefficients of the market stock price is shown in Table 2. The skewness presented in Table 2 show that distributions of the market stock price have long tails in right side, that is, fat-tailed distributions. Gini coefficients presented in Table 2 range from 0.74 to 0.84 during the observation period indicating a large inequality. From these statistics, there seemed to be obvious disparities among the firms' market stock prices, implying that the distribution of the market stock price follows a power-law distribution.

Table 1 Percentage share of the number of firms by class in market stock price level

Year	below 1 $	1–10 $	10–100 $	100–1000 $	above 1000 $
2003	26.0	35.7	36.7	1.6	0.1
2004	24.1	32.0	41.9	1.9	0.1
2005	22.8	28.1	46.5	2.3	0.2
2006	20.3	29.0	47.3	3.1	0.3
2007	14.9	36.2	44.8	3.8	0.4
2008	23.6	37.3	36.8	2.2	0.2
2009	16.2	38.5	42.3	2.8	0.2
2010	14.5	36.7	45.2	3.2	0.3
2011	17.5	34.1	45.1	3.0	0.3
2012	16.9	33.7	45.4	3.6	0.3
2013	15.5	32.1	47.0	4.9	0.4
2014	13.8	33.4	46.9	5.4	0.5
2015	13.9	33.9	46.4	5.3	0.5
2016	14.3	30.8	48.1	6.3	0.5

Notes: The 3,917 firms are classified into five classes based on market stock price level. The five class are, 'above 1000 $', '100-1000$', '10-100$', '1-10$', and 'below 1$'. More than 90 percent of firm' market stock prices are below 100$, while less than 0.5 percent of firm' market stock prices are above 1000$. The unit of market stock price is US$

Table 2 Descriptive statistics of market stock price for each year. (Table 2 is presented next to the Reference Section in this chapter)

1.2.2 Power-law distribution for market stock price

As seen above, the distribution of the market stock price can be considered to follow a power-law distribution. Here, the market stock prices used in this study were examined to see if they follow a power-law distribution.

The distribution of the power law has a probability density function as follows:

$$p(x) = Cx^{-\alpha} \qquad (1)$$

where, α is a constant parameter of the distribution which is known as the exponent or scaling parameter and C is a normalization constant. The exponent of a power-law typically lies in the range $2 < \alpha < 3$, although there are occasional exceptions[3].

A popular way to estimate power-law exponents is the method proposed in Gabaix and Ibragimov (2011), where power law exponents are estimated using an OLS regression: regressing log(rank) on a constant and log(size). In this study, "The poweRlaw package" developed by Gillespie (2015) is used to test and estimate the power-law exponent. This package estimates the lower bound on power-law, $x_{\min}$ before estimating the power law exponent α using a maximum likelihood estimation (MLE) method. This procedure enables α to be accurate. This package is closely related to the statistical framework presented by Clauset et al. (2009) and provides an easy interface to the techniques proposed by them[4].

Table 3 shows the estimated power-law exponents and the number of firms in the tail for the market stock price for each year. The estimated exponents range from 2.03 to 2.47, that is, the distribution of the market stock price in each year follows a power-law distribution. To test the power-law hypothesis, bootstrapping with 3000 simulations was performed, recording the p-values. The p-values based on the bootstrapping simulations in the fourth column of Table 3 satisfy the statistical significance level, $p > 0.1$ [5]. Therefore, the power law hypothesis is accepted in the market stock prices used in this study. Overall, the estimated exponents are low

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[3] The associated cumulative distribution function, $P(X > x) \simeq x^{-(\alpha-1)}$ is widely used instead of density function in Equation (1).

[4] The statistical framework for estimating power-law exponent proposed by Clauset et al. (2009) is summarized in Appendix A.

[5] Clauset et al. (2009) suggests rejecting the hypothesis of goodness of fit of the observed data with respect to the theoretical model if the p-value is lower than 0.1.

and most of them are closed to 2.0. A lower exponent suggests bigger disparities in the market stock prices. Figure 1 shows the complementary cumulative distributions of the market stock price for the selected period from 2007 to 2010. There are a few differences among their slopes in the tails as the power-law exponents depicted in Table 3.

Table 3 Estimated power-law exponents for market stock price

Year	exponent	number of firms in the tail	P−value
2003	2.19	120	0.34
2004	2.07	95	0.30
2005	2.09	110	0.23
2006	2.14	158	0.37
2007	2.07	139	0.27
2008	2.47	37	0.87
2009	2.10	147	0.24
2010	2.04	120	0.13
2011	2.03	141	0.34
2012	2.06	139	0.78
2013	2.03	125	0.65
2014	2.08	98	0.65
2015	2.39	26	0.93
2016	2.26	28	0.67

Notes: The number of firms in the tail are the upper tail of the distribution that follow a power-law. The p-value is calculated by bootstrapping 3000 times simulations. The estimated power-law exponents are close to 2.0 in most years, lying typical range $2 < \alpha < 3$.

Figure 1: Complementary cumulative distribution of the market stock price for the period from 2007 to 2010. (Figure 1 is presented in Figure Section in this chapter)

1.3. Analysis of Panel Data

To estimate the company fundamentals for the market stock prices, a panel regression model is constructed using panel data for financial indicators per share for the market stock price.

1.3.1 Explanatory variables for market stock price

In our previous studies (Kaizoji and Miyano, 2016,2018), the company fundamentals were calculated using three financial indicators per share - dividends per share, cash flow per share, and book value per share - as explanatory variables for market stock price. Firms that have no missing data in relation to the variable of interest from 2003 to 2016 were selected. However, the data of dividends per share was not available in many firms, more than 1,000 firms, during the observation period[6] Therefore, in this study, two financial indicators per share - cash flow per

[6] To construct log-linear regression model, non-positive data are not available. There are a lot

share and book value per share – are used as explanatory variables for market stock price. In the database, OSIRIS, the cash flow per share is defined as net income plus depreciation divided by the number of outstanding shares of company stock and the book value per share is defined as capital plus the other shareholders' funds divided by the number of outstanding shares of company stock.

1.3.2 Panel regression model

Performing a panel regression model for the market stock price, the company fundamentals are calculated. Two financial variables, cash flow per share and book value per share, are explanatory variables for the market stock price. The distribution of the market stock price is highly skewed as described in the previous section and those of the cash flow per share and the book value per share are similarly skewed. Assuming the relationship between market stock price and financial indicator per share to be logarithmic linear, the econometric model can be written as follows:

$$\ln Y_{it} = a + b_1 \ln X_{1,it} + b_2 \ln X_{2,it} + u_{it} \qquad i = 1,\ldots,N \ ; \quad t = 1,\ldots,T \qquad (2)$$

where, Y_{it} denotes market stock price for firm i in year t. a is a constant term. $X_{1,it}$ denotes cash flow per share for firm i in year t; $X_{2,it}$ denotes book value per share for firm i in year t, and u_{it} denotes the error term.

Using the panel least square method[7], Equation (2) is estimated. In the panel regression model, the error term u_{it} can be assumed to be divided into a pure disturbance term and an error caused by other factors. Assuming a two-way error component model with respect to error, factors other than pure disturbance are (a) factors due to unobservable individual effects and (b) factors due to unobservable time effects. Thus, the error term can be written as follows:

$$u_{it} = \mu_i + \lambda_t + \varepsilon_{it} \qquad (3)$$

where, μ_i denotes the unobservable individual effects constant for time series; λ_t denotes the unobservable time effects constant for cross section; ε_{it} denotes pure disturbance.

To estimate individual effects and time effects, a panel two-way fixed effects regression model is selected by using a model selection test provided the EViews software package.[8]
Combing Equation (2) and (3), the two-way fixed effects regression model can be written as

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of non-positive dividend per share. Kaizoji and Miyano (2016,2018) used unbalanced panel data, but in this study, balanced panel data is necessary to estimate individual fixed effects for all firms.

[7] To perform panel regression model, EViews software package is used.

[8] EViews provide redundant fixed effects test and Hausman test as model selection test. Redundant tests the joint of significance of all effects and the joint significance of the individual and time effects separately. Hausman test is for the selection of the random model.

follows:

$$\ln Y_{it} = a + b_1 \ln X_{1,it} + b_2 \ln X_{2,it} + \mu_i + \lambda_t + \varepsilon_{it} \qquad (4)$$

Table 4 shows the results of the panel two-way fixed effects regression model. The standard errors presented in Table 4 of the estimates are modified using the White period method, as heteroskedasticity and serial correlation are detected in residuals. The p-values of the coefficients are very close to zero, indicating that estimates are statistically significant. The R-squared value (0.964) and adjusted R-squared value (0.961) are quite high, confirming that the estimated model has quite a high explanatory power.

Table 4 Results of estimates for the two-way fixed effects regression model

	a	b1	b2
Coefficient	1.399	0.341	0.365
Std. Error	0.045	0.010	0.029
t-Statistic	30.836	34.743	12.454
p-Value	0.000	0.000	0.000
R-squared	0.964		
Adjusted R-squared	0.961		

Notes: Total panel (balanced) observations are 54,838. The p-values of coefficients indicate statistical significance. The standard errors are modified using the White period method.

The estimates of the panel two-way fixed effects regression model for market stock price are written as follows:

$$\ln \hat{Y}_{it} = \hat{a} + \hat{b}_1 \ln X_{1,it} + \hat{b}_2 \ln X_{2,it} + \hat{\mu}_i + \hat{\lambda}_t \qquad (5)$$

where, hatted symbols, $\hat{Y}_{it}$, $\hat{a}$ $\hat{b}_1$, $\hat{b}_2$, $\hat{\mu}_i$, and $\hat{\lambda}_t$ denote estimates derived from the model, Equation (4). $\hat{Y}_{it}$ is called theoretical value of market stock price. $\hat{\mu}_i$, $\hat{\lambda}_t$ are estimated individual fixed effects and time fixed effects, respectively.

The merit of the panel two-way fixed effects regression model is to obtain estimates of unobservable factors as the time fixed effects and the individual fixed effects. The time fixed effects are common for all firms. Figure 2 shows the time fixed effects reported separately for each year. As seen in Figure 2, the stock market was strongly affected by the global financial crisis of 2007- 2008. Figure 3 shows the distribution of the individual fixed effects, which are constant over time for all firms. Since EViews estimate fixed effects using the least squares dummy variable (LSDV) model, the restrictions, $\sum_{i=1}^{N} \mu_i = 0$ and $\sum_{t=1}^{T} \lambda_t = 0$, are imposed. That is, the values of the individual fixed effects, μ_i and the time fixed effects, λ_t indicate deviation from average price, $\hat{a}$, constant term estimated from model[9].

[9] The estimating procedure for fixed effects is summarized in Appendix B.

Figure 2: Time fixed effects. (Figure 2 is presented in Figure Section in this chapter.)

Figure3: The Distribution of the individual fixed effects. (Figure 3 is presented in Figure Section in this chapter.)

1.3.3 Company Fundamentals

The company fundamentals are defined as the values excluding the time fixed effects from the theoretical values. Therefore, the individual fixed effects are retained in the company fundamentals. The reason for eliminating the time fixed effects term is that these indicate external shocks that reflect various financial and economic shocks on the market stock price and are common to all firms. Whereas the individual fixed effects are retained since these effects represent the individual firm's unobservable heterogeneity as reflected in its market stock price and constant for time series. By our definition of the company fundamentals, the logarithmic form of the company fundamentals is written as follows:

$$\ln \tilde{Y}_{it} = \ln \hat{Y}_{it} - \lambda_t = \hat{a} + \hat{b}_1 \ln X_{1,it} + \hat{b}_2 \ln X_{2,it} + \hat{\mu}_i \qquad (6)$$

where, $\tilde{Y}_{it}$ denotes company fundamentals for firm i in year t and $\hat{a}$, $\hat{b}_1$, $\hat{b}_2$, $\hat{\mu}_i$, and $\hat{\lambda}_t$ are estimates from model, Equation (4).

As seen in Equation (6), company fundamentals contains both estimates from financial information - cash flow per share ($\hat{b}_1 \ln X_{1,it}$) and book value per share ($\hat{b}_2 \ln X_{2,it}$) and estimates non-financial information - unobservable factor ($\hat{\mu}_i$). Technologies, ideas, know-how, brand-name, quality of employees, and the ability of management are all unobservable factors, and they are one of the important parts of corporate value. Therefore, the company fundamentals estimated from the model can be the intrinsic corporate value. The individual fixed effects estimated in this study are further analyzed in Section 1.5.

1.4. Relationship between market stock price and company fundamentals

In this section, how well market stock prices represent company fundamentals estimated with the panel two-way fixed effects model is examined.

1.4.1 Redefinition of company fundamentals

In the previous section, constructing the log-linear panel regression model Equation (4), the logarithmic form of the company fundamentals is defined as Equation (6). To make the structure of the company fundamentals clear, both sides of Equation (6) is multiplied by the exponent function. The company fundamentals are redefined as follows:

$$\tilde{Y}_{it} = e^{\hat{a}} (e^{\hat{\mu}_i} X_{1,it}^{\hat{b}_1} X_{2,it}^{\hat{b}_2}) \qquad (7)$$

where, $\tilde{Y}_{it}$ is company fundamentals for firm i in year t. $X_{1,it}$ and $X_{2,it}$ are cash flow per share and book value per share for firm i in year t, respectively. $\hat{\mu}_i$ is individual fixed effect for firm i. $\hat{a}$, $\hat{b}_1$, and $\hat{b}_2$ are estimates from the model Equation (4). That is, the company fundamentals can be determined by multiplying variables - $X_1^{\hat{b}_1}$, $X_2^{\hat{b}_2}$, and $e^{\hat{\mu}_i}$ - that explain corporate values.

1.4.2 Correlation between market stock price and company fundamentals

As described in the previous section, the panel regression model in this study is confirmed to have high explanatory power that explains 96 % of the variation in market stock price. How closely do company fundamentals relate with market stock price for each year? Using the market stock price and the redefined company fundamentals, correlation coefficients are calculated. Table 5 shows the correlation coefficients both the Pearson product-moment correlation and the Spearman rank correlation, for the period 2003-2016. Although the Pearson correlation coefficients are a little high compared to the Spearman correlation coefficients, overall, the company fundamentals are highly correlated with market stock prices. Especially, the correlation coefficients for the periods 2009 and 2014 are quite high in both Pearson and Spearman. Figure 4 shows a scatter diagram of the logarithmic company fundamentals plotted against the logarithmic market stock price, using pooled data for the period (2003-2016).

Table 5 Correlation between market stock price and company fundamentals

year	Pearson correlation	Spearman rank correlation
2003	0.971	0.964
2004	0.989	0.973
2005	0.986	0.973
2006	0.994	0.982
2007	0.997	0.979
2008	0.997	0.974
2009	0.999	0.985
2010	0.999	0.985
2011	0.999	0.985
2012	0.999	0.985
2013	0.999	0.984
2014	0.999	0.981
2015	0.999	0.972
2016	0.999	0.974

Notes: The Pearson product-moment correlation coefficients and the Spearman rank correlation coefficients are calculated for each year during the observation period 2003-2016. The Pearson coefficients are quite high after 2009, indicating 0.999.

Figure 4: A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price. (Figure 4 is presented in Figure Section in this chapter.)

1.4.3 Distribution of market stock price and company fundamentals

By redefining the company fundamentals as the form in Equation (7), the distribution of the company fundamentals can be thought to follow a power-law distribution, since the distribution of power-law has a density function form $p(x) = Cx^{-\alpha}$ described in Section 1.2. where it is confirmed that the distributions of the market stock price follow a power- law distribution. The high correlation of the company fundamentals with the market stock price suggest that the distributions of the company fundamentals follow a power-law like the distribution of the market stock price. Using a power-law test procedure as described in Section 1.2, the power-law exponents for the company fundamentals are estimated. The distributions of the company fundamentals were confirmed to follow a power-law distribution as expected.

Table 6 shows the results of the power-law test, where the estimated power law exponents and the number of firms in the tail for the company fundamentals are reported for each year. The estimated power-law exponents range from 2.07 to 2.34. The estimated exponents of the company fundamentals are a little high on average comparing with those of market stock prices shown in Table 3. However, overall, there are few differences between these two distributions for each year.

Table 6 Estimated power-law exponents for company fundamentals

Year	exponent	number of firms in the tail	P-value
2003	2.090	112	0.41
2004	2.092	100	0.30
2005	2.212	149	0.12
2006	2.268	205	0.10
2007	2.345	300	0.85
2008	2.292	42	0.83
2009	2.199	209	0.22
2010	2.115	148	0.22
2011	2.290	41	0.89
2012	2.230	47	0.86
2013	2.080	118	0.35
2014	2.071	122	0.43
2015	2.115	127	0.25
2016	2.102	122	0.78

Notes: The number of firms in the tail are the upper tail of the distribution that follow a power-law. The p-value is calculated by bootstrapping 3000 times simulations. The estimated power-law exponents range from 2.07 to 2.34, lying typical range $2 < \alpha < 3$.

Figure 5 (1) shows the complementary cumulative distribution of the market stock price and the company fundamentals in 2007 when the exponent of the company fundamentals is slightly higher than that of the market stock price. Figure 5 (2) shows the complementary cumulative distribution of the market stock price and the company fundamentals in 2015 when the exponent of the company fundamentals is slightly lower than that of the market stock price. As seen in Figure 5(1) and 5(2), the complementary cumulative distribution of the market stock price and that of the company fundamentals appear to be almost the same except those in the upper tails where the distribution follows a power-law. Figure 5 suggests that the distribution of the company fundamentals roughly coincides with the distribution of the market stock price except the upper tail of the distributions. Furthermore, Figure 6 shows the distributions of the logarithmic market stock price and the distribution of the logarithmic company fundamentals using pooled data for the period 3003-2016. Visually, the distribution of the market stock price almost coincides with that of the company fundamentals.

Figure 5 (1): The complementary cumulative distribution of the market stock price and the company fundamentals in 2007.
Figure 5 (2): The complementary cumulative distribution of the market stock price and the company fundamentals in 2015.
(Figure 5 (1) and (2) are presented in Figure Section in this chapter.)

Figure 6: The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016). (Figure 6 is presented in Figure Section in this chapter.)

Investigating how well the company fundamentals are reflected in the market stock price focusing on the relationship between the market stock price and the company fundamentals, the company fundamentals were found to be well reflected in the market stock price based on the correlation coefficients, power law exponents, and distributions.

1.5. Individual fixed effects as non-financial information

The individual fixed effects estimated from the panel two-way fixed effects regression model represent firm's unobservable idiosyncratic qualities. The company fundamentals defined in this study include these individual fixed effects as non-financial information. The distribution of the individual fixed effects is shown in Figure 3. Since the individual fixed effects are calculated using an LSDV model, the mean of the individual fixed effects equals to zero. Thus, the individual fixed effects indicate the deviation from the average market stock price as described in Section 1.3.2. In this section, firms with high individual fixed effect and firms with low individual fixed effect are investigated, paying attention to their countries and industries[10].

[10] Using 4-digit Global Industry Classification Standard (GICS) code, 3917 firms are classified into 21 industries. Table D.2 in Data section shows industry name with numbers of firms.

First, the top 10 firms with the highest individual fixed effects and the bottom 10 firms with the lowest individual fixed effects were investigated. Table 7 (1) shows the top 10 firms with highest individual fixed effects and Table 7 (2) shows the bottom 10 firms with the lowest individual fixed effects. From Table 7 (1) and 7 (2), the top 10 firms with the highest individual fixed effects are almost all European firms, whereas the bottom 10 firms with the lowest individual fixed effects are mainly Asian firms. The disparities in the level of individual fixed effects among the regions are obvious. With respect to industries, however, disparities in the level of the individual fixed effects between the top 10 highest firms and the bottom 10 lowest firms is vague.

Table 7 (1) The top 10 highest individual fixed effects firms

rank	individual fixed effect	country name	industry name	average market stock price (US$)
1	2.88	Switzerland	Food & Beverage & Tabaco	35548.11
2	2.33	Switzerland	Commercial & Professional Services	1475.80
3	2.17	Poland	Consumer Durables & Apparel	961.98
4	2.14	Switzerland	Capital Goods	1546.03
5	2.07	Germany	Capital Goods	231.23
6	1.99	France	Consumer Durables & Apparel	215.57
7	1.98	Switzerland	Health Care Equipment & Services	230.91
8	1.97	Switzerland	Materials	1094.76
9	1.95	United States	Consumer Durables & Apparel	77.35
10	1.88	Netherlands	Energy	77.00

Notes: Nine firms out of the top 10 highest firms are European firms. The top 10 highest firms are from seven industries. The average market stock price means the average for the period from 2003 to 2016 (Unit: US$). From the average market stock price, the top 10 highest firms are not always top class in market stock price.

Table 7 (2) The bottom 10 lowest individual fixed effects firms

rank	individual fixed effect	country name	industry name	average market stock price (UD$)
1	−4.44	Venezuela, Bolivarian Republic of	Telecommunication Services	0.55
2	−3.36	China	Transportation	0.46
3	−2.66	Indonesia	Software & Services	0.02
4	−2.61	Thailand	Automobiles & Components	0.39
5	−2.52	Philippines	Capital Goods	0.07
6	−2.51	China	Media	0.05
7	−2.5	China	Software & Services	0.05
8	−2.46	Bermuda	Real Estates	0.03
9	−2.43	China	Utilities	0.39
10	−2.41	Cayman Islands	Retailing	0.04

Notes: Seven firms out of the bottom 10 lowest firms are Asian firms. The bottom 10 lowest firms are from nine industries. The average market stock price means the average for the period from 2003 to 2016 (Unit: US$). From the average market stock prices, market stock prices in the bottom 10 lowest firms are quite low and are almost all bottom class in market stock price level.

To see the difference of the individual fixed effects levels among the regions, total 3,917 firms are divided into four regions: Asia, America, Europe, and the rest of the world. In addition, each reason is divided into three sub-regions respectively. Asia includes East Asia, Southeast Asia, and South Asia. America includes North America, Central America, and South America. Europe includes North Europe, West Europe, and East Europe. The rest of the world includes the Middle East, Africa, and Oceania.

Table 8 (1) and 8 (2) show the descriptive statistics of the individual fixed effects for each sub-region and for each industry, respectively. As seen in Table 8 (1), the mean of the individual fixed effects in North America shows the highest level and that in West Europe shows the second highest level. Those in North Europe and East Europe are relatively high compared to other sub-regions. While the means of the individual fixed effects in Southeast Asia and in Central America are quite low. With respect to industry depicted in Table 8 (2), the mean of the individual fixed effects in the Health Care Equipment & Services industry shows the highest and the mean of the individual fixed effects in the Real Estates industry is the lowest. However, an industry with extremely high or low individual fixed effects does not exist.

Table 8 (1) Descriptive statistics of the individual fixed effects by sub-region.
Table 8 (2) Descriptive statistics of the individual fixed effects by industry.
(Table 8 (1) and (2) are presented next to the Reference Section in this chapter)

Next, Figure 7 (1)-(4) show the distribution of the individual fixed effects for each region. The distributions for Asia are shown in Figure 7(1) and those of America are shown in Figure 7(2). These two figures clearly show the differences in the three sub-regions of each region. In Asia, most parts of the distribution in Southeast are negative. In America, also most parts of the distribution in Central America are in the negative side, on the other hand, most parts of the distribution for North America are in the positive side.

The distributions for Europe are shown in Figure 7(3) and those of rest of the world are shown in Figure 7(4). In these two figures, the distribution of the three sub-regions in each region are relatively similar shape compared to Figure 7(1) and 7(2). The individual fixed effects of most firms, more than 70 percent, in Europe are positive. In the rest of the world, the individual fixed effects in the three sub-regions are nearly even distributed in both the negative side and the positive side.

Figure 7 (1), (2), (3), and (4): The distribution of the individual fixed effects of the Asian group, the American group, the European group, and the rest of the world group, respectively. (Figure 7 (1) to (4) are presented in Figure Section in this chapter.)

As seen in Table 8 (1), it is obvious that firms with high individual fixed effects are in both North America and West Europe. Although Canadian firms and United States' firms are in North America, the individual fixed effects of firms in the United States are high compared to Canadian firms and more than 93 percent of them are positive effects[11]. In this study, 23 countries are in Europe and the firms with high individual fixed effects are concentrated in West Europe and notably those firms with high individual fixed effects are concentrated in Switzerland. The individual fixed effects of firms in Switzerland are all positive and range from 0.13 to 2.88. As seen in Table 7 (1), half of the firms in the top 10 firms with high individual fixed effects are in Switzerland. It is also obvious that firms with low individual fixed effects are in both Southeast Asia and Central America. In this study, 5 countries are in Southeast Asia and firms with low individual fixed effects are concentrated in both Indonesia and Philippines. Those firms in both countries are almost all negative. Similarly, the individual fixed effects in Bermuda are quite low compared to those firms in other countries in Central America and most of them are negative.

From these statistics in this study, the individual fixed effects representing the firms' idiosyncratic qualities are greatly dependent on the country. That is, economic environments in the country seem to influence stock market's behavior. Under a market economy in developed countries, non-financial information such as technologies, ideas, and the quality of employees, have a strong influence, whereas in developing countries non-financial information has little influence in stock market. As described above, the levels of the individual fixed effects among industries are diverse. Thus, clear differences among industries were not found.

1.6. Analysis at regional level

In the previous sections, from Section 1.2 through Section 1.5, total 3,917 firms listed worldwide are analyzed. The results from a panel regression of 3,917 firms are analyzed together. In this section, the relationship between the market stock price and the company fundamentals at a regional level are investigated, using panel regression models by region. Henceforth, the model based on the total data from 3,917 firms' data is called the "world model" and the models constructed in this section are called the "regional model". The total 3,917 firms are divided into 4 regions, which are the same as in Section 1.5,

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[11] Descriptive statistics of individual fixed effects for each country are shown in Table D.3 in Data Section in this chapter. Countries with less than five firms are omitted in Table D.3.

1.6.1 Overview of regional data: market stock price

Table 9 (1) shows the descriptive statistics of the logarithmic market stock prices in the period 2003-2016 for 4 regions and Table 9 (2) shows the descriptive statistics of the market stock price in the period 2003-2016 for the 12 sub-regions. From Table 9 (1), the mean of Europe is the highest and that of Asia is the lowest. While the median of America is the highest and those of the rest of the world is the lowest. From Table 9 (2), the mean of Southeast Asia is extremely low compared to those of East Asia and South Asia. The low mean of Asia presented in Table 9 (1) is due to Southeast Asia. Similarly, the mean of North America is extremely high compared to those of Central America and South America. On the other hand, in Europe and the rest of the world, there is little difference among the sub-regions. The statistics of the market stock price by region suggests the statistics of individual fixed effects by region. The high market stock prices imply high individua fixed effects although there are some exceptions. Figure 8 shows the distribution of market stock prices in the period 2003-2016 by region. Figure 8 shows that the shape of the distribution of America and Asia are different from those of Europe and the rest of the world which appears roughly as a bell shape.

Table 9 (1) Descriptive statistics of the logarithmic market stock price in the period 2003-2016 by region

region	Mean	Median	Std. Dev.	Kurtosis	Skewness	Observations
Asia	1.20	1.55	1.89	−0.02	−0.50	29,764
America	2.65	3.15	1.76	2.52	−1.57	12,670
Europe	3.01	2.99	1.53	1.02	0.30	9,590
The rest of the world	1.50	1.43	1.52	0.52	0.31	2,814

Table 9 (2) Descriptive statistics of the logarithmic market stock price in the period 2003-2016 by sub-region. (Table 9(2) is presented next to the Reference Section in this chapter)

Figure 8: The distribution of the market stock price in the period 2003 through 2016 by region. (Figure 8 is presented in Figure Section in this chapter.)

1.6.2 Power-law distribution for the market stock price at the regional level.

Examining whether the market stock price in each region follows the power-law distribution, power-law exponents are estimated by regions. In Table 10, the estimated power-law exponents and the number of the tail firms are reported for each year for each region.

As described in Section 1.2.2, the exponent of a power-law probability density function $p(x) = Cx^{-\alpha}$, typically lies in the range $2 < \alpha < 3$, although there are occasional exceptions.

As seen in Table 10, the exponents of Asia and Europe lie in a typical range $2 < \alpha < 3$. The exponents of the rest of the world are a little lower, but close to 2.0. However, the exponents of America range from 3.10 to 4.07, and they are high compared to those of Asia and Europe. To make the differences clear, Figures 9(1) – (4) show the complementary cumulative distribution of the market stock price for each region in selected year, 2007. The red vertical line indicates the lower bound on power-law, $x_{\min}$. The data above the lower bound $x_{\min}$ are included in the calculations of the power-law exponents.

Table 10 Estimated power-law exponent for market stock price by region

	Asia		America		Europe		The rest of the world	
year	exponent	number of firms in the tail	exponent	number of firms in the tail	exponent	number of firms in the tail	exponent	number of firms in the tail
2003	2.945	274	4.077	178	2.062	184	2.076	49
2004	3.028	240	4.064	158	2.067	225	1.835	125
2005	2.867	182	3.986	202	2.071	221	1.819	117
2006	2.631	300	3.762	156	2.077	221	1.864	104
2007	2.514	295	3.667	153	2.046	213	1.927	81
2008	2.587	299	3.464	206	1.998	199	1.760	124
2009	2.586	293	3.792	147	2.052	218	1.914	76
2010	2.567	298	3.297	304	2.041	205	1.974	64
2011	2.617	289	3.511	243	1.950	241	1.744	136
2012	2.420	235	3.645	182	1.954	240	2.025	62
2013	2.390	2.8	3.438	196	1.932	279	1.910	76
2014	2.343	164	3.338	215	1.948	232	1.821	119
2015	2.254	111	3.159	182	1.938	233	1.862	104
2016	2.588	300	3.103	237	1.931	240	1.830	113

Notes: The exponents for Asia and Europe lie in a typical power-law exponent range. Those in the rest of the world are close to 2.0. Exponents for America are higher than other regions.

Figure 9 (1), (2), (3), and (4): The complementary cumulative distribution for Asia in 2007, for the America in 2007, for Europe in 2007 and for the rest of the world in 2007, respectively. (Figure 9 (1)-(4) are presented in Figure Section in this chapter.

1.6.3 Analysis of panel data at a regional level

Following the panel regression model described in Section 1.3.2, the panel two-way fixed effects regression models are performed by region. The model equation is the same as the world model Equation (4) in Section 1.3.2. Table 11 shows the panel regression results for each region.

The coefficients are all statistically significant. The adjusted R-squared values of each region range from 0.93 to 0.96. Hence, the explanatory powers of the regional model are approximately the same level as that of the world model.

Table 11 Results of estimates for the panel two-way fixed effects regression model by region

region	a	b1	b2	R−squared	adj. R−squared
Asia	0.9967	0.3097	0.444	0.962	0.959
	(75.19)	(58.86)	(49.63)		
America	2.109	0.343	0.2071	0.958	0.954
	(110.85)	(43.12)	(20.25)		
Europe	1.5326	0.3461	0.4496	0.945	0.941
	(51.42)	(38.91)	(34.07)		
The rest of the world	1.4585	0.4337	0.4121	0.935	0.929
	(49.09)	(25.27)	(16.63)		

Notes: Total panel (balanced) observations: 29,764 (Asia), 12,670 (America), 9,590 (Europe), 2,814 (the rest of the world). Numbers in parenthesis are t-statistics. The estimates are statistically significant based on t-statistics.

Figure 10 shows the time fixed effects reported separately for each year by region. As described before, the time fixed effects reflect external and various temporal shocks including financial shock. From Figure 10, the stock market in all regions is strongly affected by the global financial crisis of 2007-2008, although that impact on the rest of the world is less than other three regions.

The time fixed effects for America are contrasted to those for Europe. The time fixed effects for America are negative or close to zero before 2008 and very high after 2013. On the other hand, those for Europe are very high before 2008 and much lower after 2013. The time fixed effects for Asia are close to those for the world model depicted in Figure 2.

Figure 10: The time fixed effects by region. (Figure 10 is presented in Figure Section in this chapter.)

The company fundamentals for market stock price by region are calculated based on the definition of company fundamentals described in Section 3.1.3. That is, company fundamentals at regional level are calculated by excluding the regional time fixed effects from the regional theoretical values, respectively.

1.6.4 Relationship between market stock price and company fundamentals by region

How well does the market stock price represent company fundamentals at a regional level? First, the regional scatter diagram of the logarithmic company fundamentals plotted against the logarithmic market stock price using pooled data for the period (2003-2016) are shown in Figure 11 (1)-(4). In all figures, the relationship between the market stock price and the company fundamentals is highly positive and show quite high correlation coefficients.

Figure 11 (1), (2), (3), and (4): A scatter diagram of the logarithmic company fundamentals plotted against the logarithmic market stock price in Asia, in America, in Europe, and in the rest of the world, respectively.
(Figure 11 (1)-(4) are presented in Figure Section in this chapter.)

Next, the company fundamentals in logarithmic form are redefined by multiplying exponent function and calculated the correlation coefficients between the market price and the company fundamentals for each year for each region. The correlation coefficients are presented in Table 12. Both the Pearson product moment correlation coefficients and the Spearman rank correlation coefficients are quite high for each year for each region. There are few differences among regions.

Table 12 Correlation coefficients between market stock price and company fundamentals by region for each year

	Asia		America		Europe		The rest of the world	
Year	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
2003	0.827	0.970	0.809	0.910	0.976	0.939	0.943	0.907
2004	0.895	0.977	0.979	0.934	0.991	0.957	0.940	0.926
2005	0.895	0.980	0.990	0.945	0.990	0.963	0.949	0.956
2006	0.902	0.986	0.983	0.953	0.996	0.969	0.975	0.957
2007	0.931	0.980	0.974	0.950	0.999	0.968	0.982	0.964
2008	0.902	0.902	0.981	0.931	0.998	0.962	0.907	0.957
2009	0.929	0.986	0.990	0.961	0.999	0.978	0.951	0.972
2010	0.976	0.986	0.993	0.961	0.999	0.979	0.948	0.975
2011	0.948	0.989	0.993	0.964	1.000	0.976	0.955	0.969
2012	0.951	0.986	0.992	0.962	0.999	0.976	0.920	0.964
2013	0.968	0.983	0.985	0.955	0.999	0.976	0.989	0.970
2014	0.960	0.979	0.988	0.952	1.000	0.975	0.922	0.973
2015	0.933	0.971	0.984	0.928	0.999	0.956	0.883	0.953
2016	0.969	0.975	0.987	0.941	0.999	0.958	0.864	0.936

Notes: Pearson indicates product moment correlation coefficients. Spearman indicates rank correlation coefficients.

Finally, testing whether the distributions of company fundamentals in each region follow the power-law distribution, power-law exponents are estimated following the same procedure as the world model. In Table13 the estimated power-law exponent of the company fundamentals and the number of tail firms are reported for each year. Comparing the power-law exponent of the company fundamentals reported in Table 13 with those of the market stock price reported in Table 10, there are a few differences among them. However, with respect to power-law exponents, relationships between the market stock price and the company fundamentals among regions are almost same.

Figure 12 (1) – (4) show the distribution of the logarithmic market stock price and company fundamentals using pooled data for the period (2003-2016) by region. Visually, the distributions of the market stock price roughly coincide with the distributions of the company fundamentals in all regions.

Investigating the relationship between the market stock price and the company fundamentals by region, the market stock prices were found to well represent the company fundamentals at a regional level, based on the correlation coefficients, power-law exponents, and distributions.

Table 13 Estimated power-law exponent for company fundamentals by region

year	Asia		America		Europe		The rest of the world	
	exponent	number of firms in the tail	exponent	number of firms in the tail	exponent	number of firms in the tail	exponent	number of firms in the tail
2003	2.856	294	3.419	280	2.011	204	1.865	110
2004	2.736	231	3.866	141	2.005	214	1.949	74
2005	2.742	300	3.291	318	2.032	205	1.951	73
2006	2.639	300	4.087	127	2.031	199	1.975	65
2007	2.649	297	3.619	243	2.046	188	1.886	96
2008	2.768	272	3.788	235	2.043	229	1.839	110
2009	2.672	299	3.758	181	2.049	201	2.049	42
2010	2.585	193	3.656	215	2.202	33	1.898	87
2011	2.637	239	3.673	238	2.162	35	1.817	108
2012	2.589	229	3.843	139	2.040	189	1.826	115
2013	2.550	300	3.698	162	2.043	181	1.840	98
2014	2.191	182	3.716	151	2.035	183	1.789	120
2015	2.549	200	3.755	135	2.006	192	1.822	120
2016	2.467	154	3.615	200	2.021	191	1.834	121

Notes: The estimated exponents for Asia, Europe lie in a typical range of $2 < \alpha < 3$, and those for the rest of the world are close to 2.0. The exponents for America are higher than other regions.

Figure 12 (1), (2), (3), and (4): The distribution of the market stock prices and the company fundamentals for the pooled data (2003—2016) in Asia, America, Europe, and the rest of the world, respectively.
(Figure 12 (1)-(4) are presented in Figure Section in this chapter.)

1.7. Concluding remarks

This study investigates how stock markets evaluate corporate values. Using panel regression analysis in which the cash flow per share and book value per share serve as explanatory variables for the market stock price, the company fundamentals for the market stock price are estimated. The company fundamentals are calculated by removing the time fixed effects from the theoretical values, which are estimates from the panel two-way fixed effects regression model. The data used in this study are the firms' annual data from 3,917 firms globally listed for a 14-year period (2003-

2016). The explanatory power of the panel regression model shows a high adjusted R-squared value, 0.96.

To examine the relationship between the market stock price and the company fundamentals, first, the correlation coefficients between the market stock price and the company fundamentals were calculated for each year. Both the Pearson product-moment correlation coefficients and Spearman rank correlation coefficients were quite high. The Person coefficients range from 0.971 to 0.999 and the Spearman coefficients range from 0.964 to 0.985. Next, whether the distribution of the market stock price coincide with that of the company fundamentals was examined. By overviewing the market stock price data used in this study, the distributions of the market stock price can be fat-tailed and were confirmed by a power law test. Accordingly, the power law for the distributions of the company fundamentals were tested. The company fundamentals were found to follow the power law distribution. Furthermore, the power law exponents of the distributions of the company fundamentals were not different from those of the market stock price. The distributions of the market stock price roughly coincided with those of the company fundamentals. The company fundamentals estimated in this study were found to be well reflected in the market stock price.

The individual fixed effects estimated from the panel two-way fixed effects regression model was an unobservable factor representing the idiosyncratic firm's quality as non-financial information. Paying attention to countries and industries, firms with high individual effects and firms with low individual effects were analyzed. The firms with high individual effects are concentrated in United States and Switzerland and firms with low individual fixed effects are concentrated in Indonesia and the Philippines. The level of the individual fixed effects is greatly dependent on each country. With respect to industries, the levels of the individual fixed effects are diverse among industries and there is no clear difference among the industries.

In this study, a panel regression model was constructed using data from 3,917 firms and the results are analyzed as a world model. Furthermore, the 3,917 firms were divided into four regions, including Asia, America, Europe, and the rest of the world, and analyzed at a regional level. The four regional panel regression models have high explanatory powers indicating an adjusted R-squared values ranging from 0.93 to 0.96, which are approximately the same level of explanatory power as the world model. Analyzing the relationship between the market stock price and the company fundamentals at regional level, the market stock prices were found to well represent the company fundamentals even at a regional level.

Appendix A: Estimating power-law exponent

Caluset et al. (2009) proposed a statistical framework that identifies a power-law distribution and estimates a power-law exponent in the empirical data. The summary of the statistical frameworks below.

A.1 Estimation for power-law exponent

The probability density function of a continuous power-law distribution is expressed as follows:

$$p(x)dx = \Pr(x \le X < x + dx) = Cx^{-\alpha}dx \qquad \text{(A1)}$$

where, X is the observed value, C is a normalized constant, α is power-law exponent.

The normalized constant, C is calculated using the normalization requirement:

$$1 = \int_{x_{\min}}^{\infty} p(x)dx = C\int_{x_{\min}}^{\infty} x^{-\alpha}dx = \frac{C}{1-\alpha}\left[x^{-\alpha+1}\right]_{x_{\min}}^{\infty} \qquad \text{(A2)}$$

If $\alpha > 1$, then the equation (A2) gives

$$C = (\alpha - 1)x_{\min}^{\alpha-1} \qquad \text{(A3)}$$

Substituting (A3) into equation (A1), the probability function of a power-law can be written as follow:

$$p(x) = \frac{\alpha - 1}{x_{\min}}\left(\frac{x}{x_{\min}}\right)^{-\alpha} \qquad \text{(A4)}$$

If the lower bound $x_{\min}$ is known and the empirical data distribution can be assumed to follow a power-law, the parameter α can be estimated by the maximum likelihood estimator (MLE)method.

$$\hat{\alpha} = 1 + n\left[\sum_{i=1}^{n} \ln\frac{x_i}{x_{\min}}\right]^{-1} \qquad \text{(A5)}$$

where, x_i, $i = 1,\ldots,n$ are observed values of x such that $x_i \ge x_{\min}$. $\hat{\alpha}$ denotes estimates derived data.

A.2 Estimating lower bound, $x_{\min}$

The case that empirical data follows a power-law distribution for all values of x does not usually occur. Normally, a power-law applies only for values of x greater than some minimum value, $x_{\min}$, that is, only the tail of the distribution follows a power-law. Thus, it is important to estimate the lower bound, $x_{\min}$ on power-law behavior before calculating the parameter α by the MLE method described above.

Caluset et al. (2009) proposed the approach for estimating $x_{\min}$, choosing the value of $x_{\min}$

that makes the probability distribution of the empirical data and the best-fit power-low model as similar as possible above $\hat{x}_{\min}$. The distance between the two probability distributions is measured using a Kolmogorov-Smirnov (KS) statistic.

$$D = \max_{x \geq x_{\min}} |S(x) - P(x)| \qquad \text{(A6)}$$

where , $S(x)$ is the complementary cumulative distribution function (CDF) of the data for the observations with a value of at least $x_{\min}$ and、 $P(x)$ is the CDF for the power-law model that best fits the data in the region $x \geq x_{\min}$. The estimate $\hat{x}_{\min}$ is the value of $x_{\min}$ that minimizes D . Using this $\hat{x}_{\min}$ in equation (A5), the parameter α can be estimated accurately.

A.3 Testing the power-law hypothesis

Tests of the estimate parameter for α and $x_{\min}$ use a bootstrapping simulation. The test procedure is as follows.

First, compute the KS statistic for the empirical data and the theoretical model with the MLE parameters estimated for the empirical data: Next, generate a large number of synthetic data sets following the theoretical model with the MLE parameters estimating empirical data. Third, for each synthetic data set, compute its own MLE parameters and fit to the theoretical model with the estimated parameters. Record the KS statistic for the fits. Last, count what fraction of the time the resulting KS statistic for synthetic data sets is larger than or equal to the KS statistic for the empirical data. This fraction measures the fitness significance, p-value.

Clause et al. (2009) suggests rejecting the hypothesis of goodness of fit of the observed data with respect to the theoretical model if the p-value is lower than 0.1.

Appendix B: Estimating individual fixed effects and time fixed effects

According to Baltagi (2013), the procedure to estimate the individual fixed effects and the time fixed effects in a two-way error component regression model is as follow:

To simplify, a regression model is one explanatory variable, x , for dependent variable y , expressed in equation (B1),

$$y_{it} = a + bx_{it} + \mu_i + \lambda_t + \varepsilon_{it} \qquad \text{(B1)}$$

Averaging over time gives

$$\bar{y}_i = a + b\bar{x}_i + \mu_i + \bar{\varepsilon}_i \qquad \text{(B2)}$$

Averaging over individuals gives

$\bar{y}_t = a + b\bar{x}_t + \lambda_t + \bar{\varepsilon}_t$ (B3)

Averaging across all observations in equation (B1) gives

$\bar{y} = a + b\bar{x} + \bar{\varepsilon}$ (B4)

where restriction $\sum_{i=1}^{N} \mu_i = 0$ and $\sum_{t=1}^{T} \lambda_t = 0$ are imposed.

Subtracting (B2) and (B3) from (B1), gives

$y_{it} - \bar{y}_i - \bar{y}_t = b(x_{it} - \bar{x}_i - \bar{x}_t) + (\varepsilon_{it} - \bar{\varepsilon}_i - \bar{\varepsilon}_t) - a$ (B5)

From (B4), we get $a = \bar{y} - b\bar{x} - \bar{\varepsilon}$ and substitute this into (B5)

We can deduce that

$(y_{it} - \bar{y}_i - \bar{y}_t + \bar{y}) = b(x_{it} - \bar{x}_i - \bar{x}_t + \bar{x}) + (\varepsilon_{it} - \bar{\varepsilon}_i - \bar{\varepsilon}_t + \bar{\varepsilon})$ (B6)

Estimating model equation (B6) using OLS regression, we obtain $\hat{b}$

μ_i and λ_t are given by

$\hat{\mu}_i = (\bar{y}_i - \bar{y}) - \hat{b}(\bar{x}_i - \bar{x})$ (B7)

$\hat{\lambda}_t = (\bar{y}_t - \bar{y}) - \hat{b}(\bar{x}_t - \bar{x})$ (B8)

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Tables

Table 2 Descriptive statistics of market stock price for each year

Year	Mean	Median	Std. Dev.	Minimum	Maximum	Kurtosis	Skewness	Gini coef.
2003	18.2	6.3	151.6	0.001	8,934	3026.6	52.2	0.7
2004	23.5	7.9	243.3	0.003	14,714	3357.8	55.9	0.8
2005	28.0	9.6	278.6	0.002	16,705	3243.7	54.6	0.8
2006	34.5	10.3	412.1	0.005	25,164	3490.4	57.4	0.8
2007	40.0	9.7	572.4	0.006	35,335	3649.8	59.3	0.8
2008	25.0	6.2	344.4	0.003	21,247	3639.6	59.2	0.8
2009	30.5	8.3	400.4	0.005	24,653	3608.7	58.8	0.8
2010	36.6	9.4	519.0	0.005	32,021	3641.5	59.2	0.8
2011	35.9	9.5	538.8	0.003	33,362	3694.8	59.8	0.8
2012	39.8	9.8	608.5	0.005	37,655	3686.6	59.7	0.8
2013	50.5	11.4	868.7	0.004	53,954	3741.8	60.4	0.8
2014	51.7	11.6	928.3	0.003	57,790	3776.7	60.8	0.8
2015	55.9	11.1	1202.1	0.004	75,214	3856.9	61.7	0.8
2016	55.8	12.5	980.5	0.004	60,925	3748.6	60.4	0.8

Unit: US$

Table 8(1) Descriptive statistics of individual fixed effects in the period 2003-2016 by sub-region

sub-region	Mean	Median	Std. Dev	Kurtosis	Skewness	Minimum	Maximum	observations
East Asia	−0.13	−0.08	0.58	2.38	−0.77	−3.36	1.80	1645
Southeast Asia	−1.00	−1.08	0.64	0.76	0.46	−2.66	1.53	390
South Asia	−0.14	−0.20	0.73	−0.29	0.02	−2.11	1.42	91
North America	0.64	0.68	0.47	1.63	−0.75	−1.81	1.95	749
Central America	−0.85	−0.94	0.86	−0.51	0.28	−2.46	1.23	123
South America	−0.38	−0.29	0.92	11.29	−2.61	−4.44	1.04	33
North Europe	0.21	0.23	0.48	0.55	−0.07	−0.99	1.72	118
West Europe	0.40	0.40	0.62	0.51	0.17	−1.54	2.88	520
East Europe	0.24	0.28	0.65	1.11	0.12	−1.38	2.17	47
Middle East	0.06	0.01	0.49	0.33	0.32	−1.06	1.31	52
Africa	0.16	0.18	0.61	−0.11	0.05	−1.31	1.53	61
Oceania	−0.06	0.00	0.62	0.33	−0.18	−1.55	1.72	88

Table 8 (2) Descriptive statistics of individual fixed effects in the period 2003-2016 by industries

Industry names	Mean	Median	Std. Dev	Kurtosis	Skewness	Minimum	Maximum
Energy	0.16	0.22	0.65	0.85	−0.65	−2.19	1.88
Materials	−0.17	−0.12	0.73	0.16	−0.33	−2.23	1.97
Capital Goods	0.00	0.06	0.72	0.26	−0.41	−2.52	2.14
Commercial & Professional Services	0.18	0.21	0.71	0.71	−0.50	−1.97	2.33
Transportation	−0.19	−0.19	0.76	1.17	−0.50	−3.36	1.72
Automobiles & Components	−0.23	−0.22	0.61	1.62	−0.42	−2.61	1.31
Consumer Durables & Apparel	−0.17	−0.12	0.85	0.16	−0.21	−2.38	2.17
Consumer Services	−0.03	0.09	0.76	0.17	−0.45	−2.28	1.83
Media	0.01	0.13	0.69	1.43	−0.82	−2.51	1.42
Retailing	0.10	0.14	0.70	0.70	−0.61	−2.41	1.69
Food & Staples Retailing	0.04	0.01	0.65	0.77	−0.53	−2.11	1.19
Food, Beverage & Tabaco	0.13	0.15	0.76	0.70	−0.23	−2.21	2.88
Food & Staples Retailing	0.38	0.50	0.72	−0.13	−0.54	−1.21	1.80
Health Care Equipment & Services	0.40	0.52	0.73	1.42	−0.94	−2.32	1.98
Pharmaceuticals, Biotechnology Life Sciences	0.24	0.35	0.77	0.78	−0.82	−2.29	1.69
Software & Services	0.31	0.35	0.71	2.80	−1.07	−2.66	1.64
Technology Hardware & Equipment	0.00	0.04	0.73	0.75	−0.49	−2.35	1.77
Semiconductor & Semiconductor Equipment	0.28	0.41	0.72	−0.29	−0.63	−1.47	1.30
Telecommunication Services	−0.13	0.03	0.85	11.01	−2.57	−4.44	1.52
Utilities	−0.02	0.18	0.69	1.59	−1.03	−2.43	1.70
Real Estate	−0.25	−0.15	0.94	−0.91	−0.26	−2.46	1.56

Table 9 (2) Descriptive statistics of logarithmic market stock in the period 2003-2016 by sub-region

region	sub−region	Mean	Median	Std. Dev.	Kurtosis	Skewness	Observations
Asia	East Asia	1.76	2.02	1.52	0.09	−0.37	23,030
	Southeast Asia	−1.15	−1.15	1.55	0.22	0.02	5,460
	South Asia	1.10	1.08	1.27	−0.18	−0.05	1,274
America	North America	3.26	3.33	0.89	1.90	−0.37	10,486
	Central America	−0.56	−0.88	1.97	0.11	0.58	1,722
	South America	0.78	0.74	1.48	2.39	−0.77	462
Europe	North Europe	2.49	2.51	1.30	2.67	0.44	1,652
	West Europe	3.11	3.14	1.56	0.91	0.26	7,280
	East Europe	3.17	3.21	1.48	0.40	−0.02	658
The rest of the world	Meddle East	1.60	1.45	1.35	1.87	0.86	728
	Africa	2.00	1.94	1.69	−0.08	0.14	854
	Oceania	1.09	1.12	1.37	−0.13	−0.11	1,232

Figures

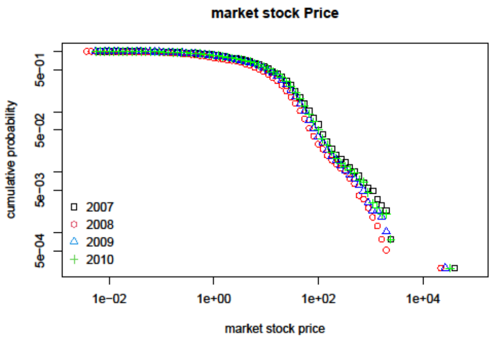

Figure 1 Complementary cumulative distribution of the market stock price for the period from 2007 to 2010: The estimated power-law exponent in 2008 is 2.47, while that in 2010 is 2.04. The upper tails of these distributions look roughly straight.

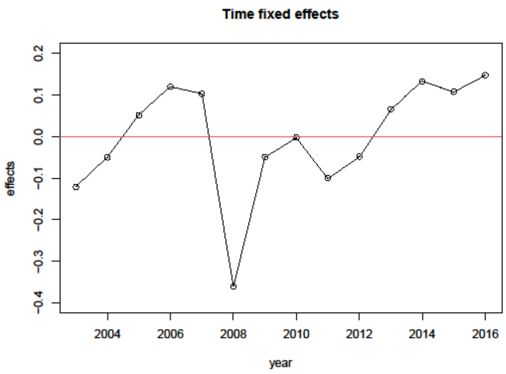

Figure 2 Time Fixed Effects: The time fixed effects indicate an external shock to firms that reflect various and temporary shocks common to all firms. The time fixed effects clearly show the global financial crisis of 2007-2008.

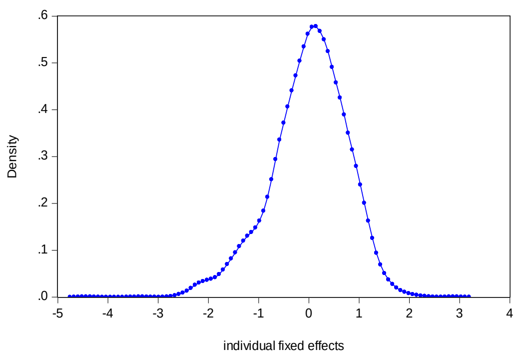

Figure 3 The distribution of the individual fixed effects: The mean of the individual fixed effects equals zero. The distribution is skewed to the left side. The distribution is drawn using a density plot.

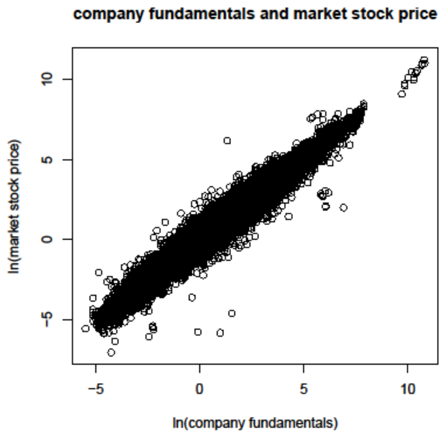

Figure 4 A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price: The correlation between the company fundamentals and the market stock price is 0.979. It is obvious that the relationship between the company fundamentals and the market stock price is highly positive.

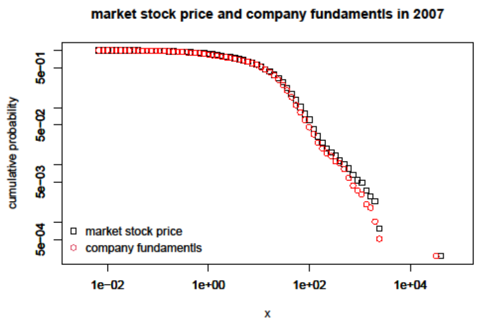

Figure 5(1) The complementary cumulative distribution of the market stock price and the company fundamentals in 2007: The power-law exponent for the market stock price is 2.07 and that for the company fundamentals is 2.35. The number of firms in the tail for the market stock price is 139, while that for the company fundamentals is 300.

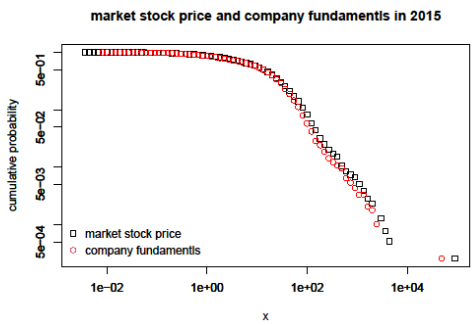

Figure 5(2) The complementary cumulative distribution of the market stock price and the company fundamentals in 2015: The power-law exponent for the market stock price is 2.39 and that for the company fundamentals is 2.10. The number of firms in the tails for the market stock price is 26, while that for the company fundamentals is 127.

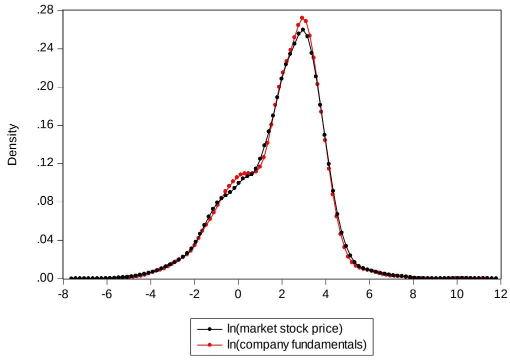

Figure 6 The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016): Visually, the distribution of the market stock price coincides with that of the company fundamentals. The distribution is drawn using a density plot.

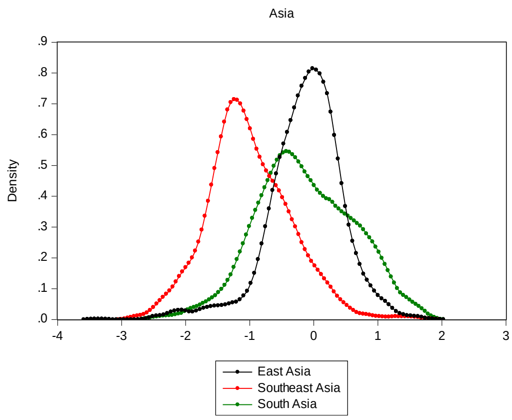

Figure 7(1) The distribution of the individual fixed effects of the Asian group: The individual fixed effects of the firms in Southeast Asia are quite low compared to those of the firms in East Asia. The distribution is drawn using a density plot.

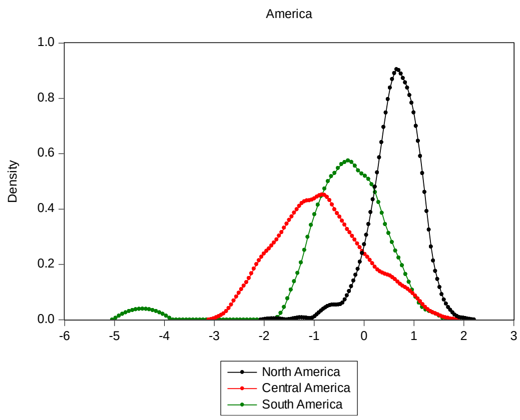

Figure 7(2) The distribution of the individual fixed effects of the American group: The individual fixed effects of the North American firms are almost all positive and concentrated around 1.0. The distribution is drawn using a density plot.

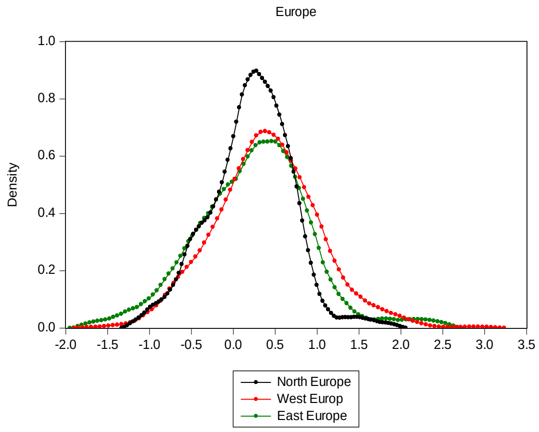

Figure 7(3) The distribution of the individual fixed effects of the European group: There seems to be little difference among the sub-regions. The distribution is drawn using a density plot.

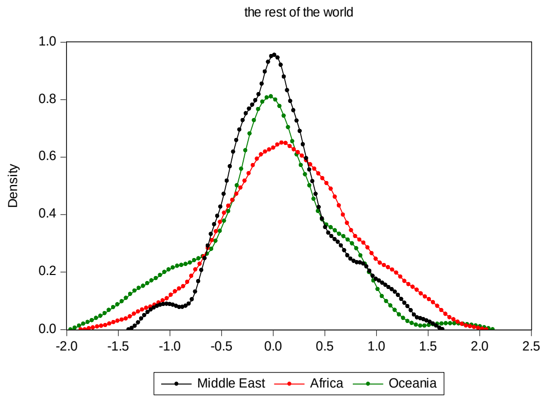

Figure 7(4) The distribution of the individual fixed effects of the rest of the world group: The individual fixed effects in the three sub-regions are roughly evenly distributed in both the negative side and positive side. The distribution is drawn using a density plot.

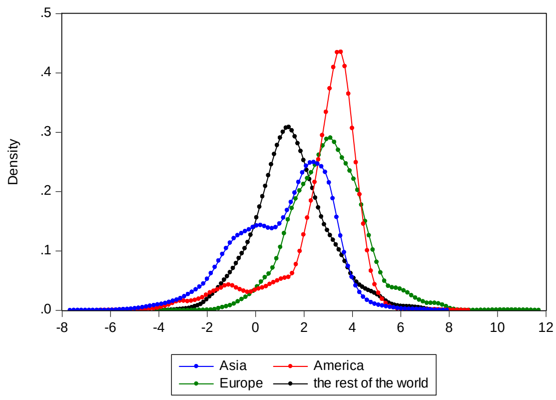

Figure 8 The distribution of the market stock price in the period 2003-2016 by region: The shapes of the distributions of Europe and the rest of the world appear roughly to be bell shape, whereas that of America is sharp and Asia has two peaks. The distribution is drawn using a density plot.

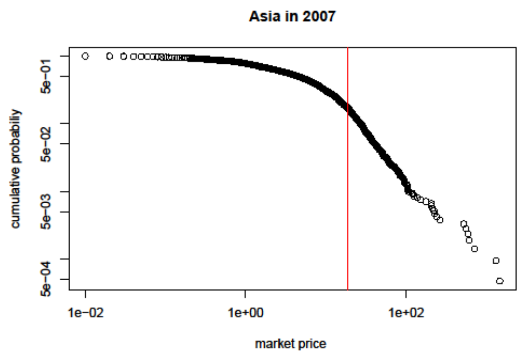

Figure 9(1) The complementary cumulative distribution for Asia in 2007: The red vertical line indicates a lower bound on the power-law, $x_{\min}$ (18.72). The data above the lower bound $x_{\min}$, 295 firms in Asia, are included in the calculation of the exponent.

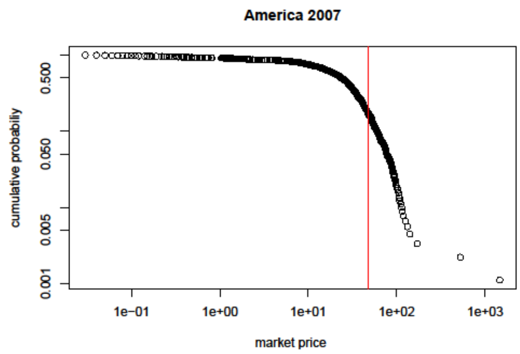

Figure 9(2) The complementary cumulative distribution for America in 2007: The red vertical line indicates a lower bound on the power-law, $x_{\min}$ (48.13). The data above the lower bound $x_{\min}$, 153 firms in America, are included in the calculation of the exponent. The upper tail of the distribution looks like sharp straight line, indicating a high power-law exponent.

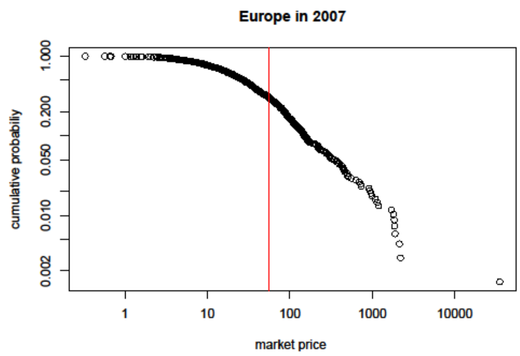

Figure 9(3) The complementary cumulative distribution for Europe in 2007: The red vertical line indicates a lower bound on the power-law, $x_{\min}$ (54.95). The data above the lower bound $x_{\min}$, 213 firms in Europe, are included in the calculation of the exponent.

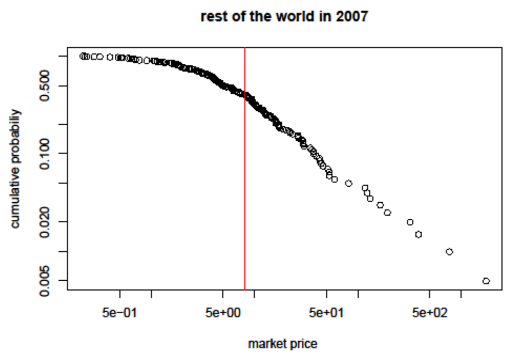

Figure 9(4) The complementary cumulative distribution for rest of the world in 2007: The red vertical line indicates a lower bound on the power-law, $x_{\min}$ (8.08). The data above the lower bound $x_{\min}$, 81 firms in the rest of the world, are included in the calculation of the exponent.

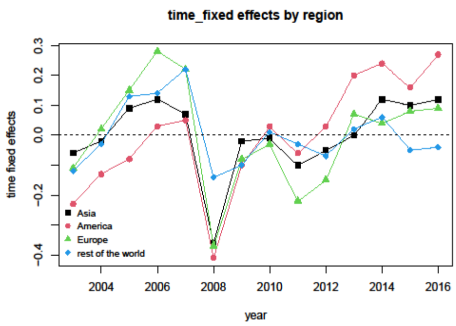

Figure 10 The time fixed effects by region: The time fixed effects indicate external shocks to all firms that reflect various temporary shocks common to all firms. The scales of shocks are different by region, however, the shock caused by the global financial crisis of 2007-2008 are almost all the same around the world, although the scale of the shock in the rest of the world is smaller compared to the other regions.

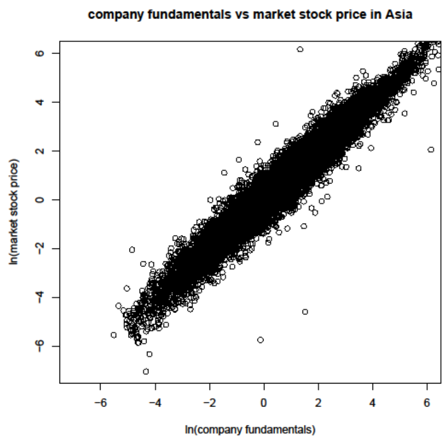

Figure 11(1) A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price in Asia: The correlation between the company fundamentals and the market stock price is 0.978.

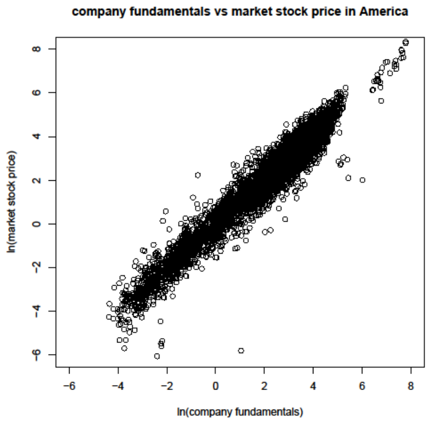

Figure 11(2) A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price in America: The correlation between the company fundamentals and the market stock price is 0.973.

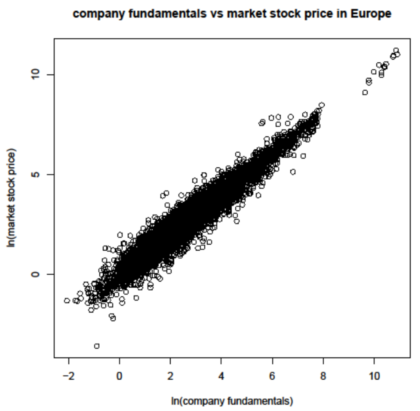

Figure 11(3) A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price in Europe: The correlation between the company fundamentals and the market stock price is 0.965.

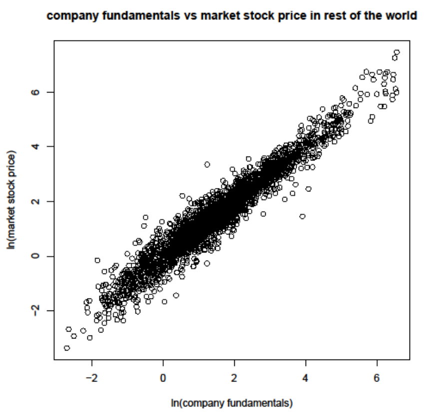

Figure 11(4) A scatter diagram of the logarithmic company fundamentals against the logarithmic market stock price in the rest of the world: The correlation between the company fundamentals and the market stock price is 0.964.

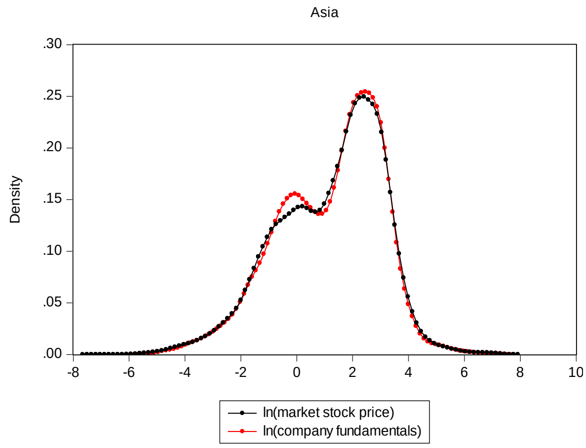

Figure 12(1) The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016) in Asia: The distribution is drawn using a density plot.

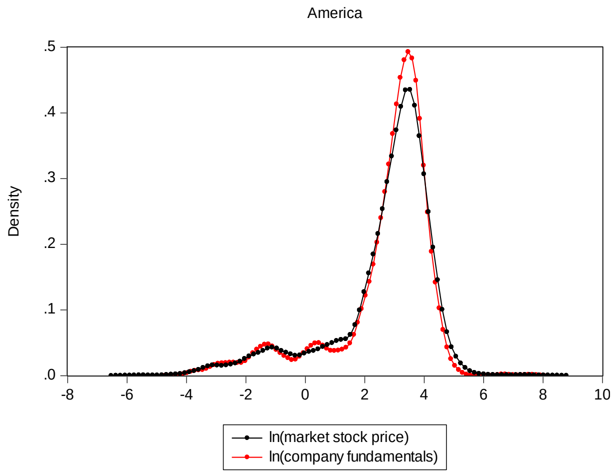

Figure 12(2) The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016) in America: The distribution is drawn using a density plot.

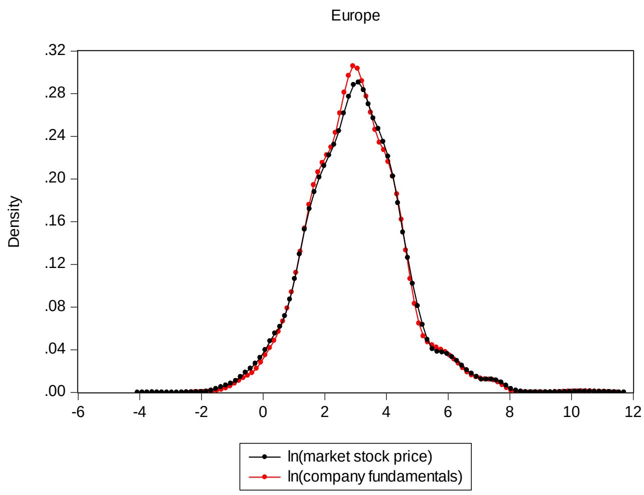

Figure 12(3) The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016) in Europe: The distribution is drawn using a density plot.

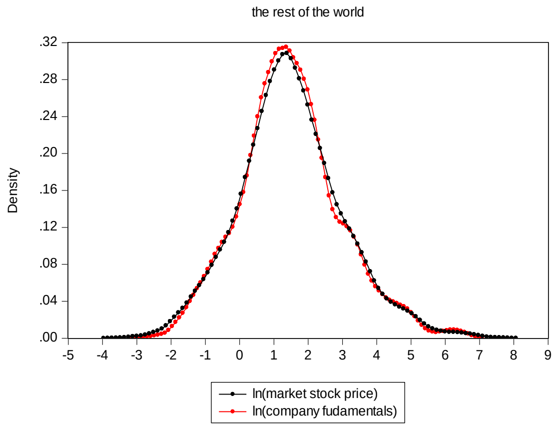

Figure 12(4) The distribution of the market stock price and the company fundamentals for the pooled data (2003-2016) in the rest of the world: The distribution is drawn using a density plot.

Data

Table D.1 The country name with the number of firms by region

region	sub region	country code	country name	number of firms
Asia	East Asia	JP	Japan	1068
		CN	China	330
		KR	Korea, Republic of	130
		TW	Taiwan, Province of Chania	71
		HK	Hong Kong	46
	Southeast Asia	MY	Malaysia	159
		TH	Thailand	73
		SG	Singapore	67
		ID	Indonesia	57
		PH	Philippines	34
	South Asia	IN	India	89
		LK	Sri Lanka	2
America	North America	US	United States	673
		CA	Canada	76
	Central America	BM	Bermuda	73
		KY	Cayman Islands	28
		MX	Mexico	17
		CW	Curacao	3
		PA	Panama	1
		BS	Bahamas	1
	South America	CL	Chile	19
		BR	Brazil	6
		AR	Argentina	4
		PE	Peru	3
		VE	Venezuela, Bolivarian Republic of	1
Europe	North Europe	SE	Sweden	46
		FI	Finland	34
		NO	Norway	21
		DK	Denmark	17
	West Europe	FR	France	135
		DE	Germany	103
		GB	United Kingdom	82
		CH	Switzerland	45
		IT	Italy	42
		BE	Belgium	26
		ES	Spain	23
		NL	Netherlands	23
		GR	Greece	16
		PT	Portugal	12
		IE	Ireland	6
		LU	Luxembourg	7

Table D.1 continued

region	sub region	country code	country name	number of firms
	East Europe	AT	Austria	19
		PL	Poland	14
		CZ	Czechia	4
		LV	Latvia	4
		HU	Hungary	3
		SI	Slovenia	2
		HR	Croatia	1
the rest of the world	Middle East	IL	Israel	17
		JO	Jordan	16
		KW	Kuwait	10
		QA	Qatar	4
		OM	Oman	2
		TR	Turkey	1
		BH	Bahrain	1
		CY	Cyprus	1
	Africa	MA	Morocco	11
		EG	Egypt	6
		TN	Tunisia	5
		GA	Gabon	1
		ZA	South Africa	36
		MU	Mauritius	1
		LR	Liberia	1
	Oceania	AU	Australia	67
		NZ	New Zealand	19
		MH	Marshall Islands	1
		PG	Papua New Guinea	1
			Total	3,917

Note: Country codes are based on ISO 3166

Table D.2 Industry name with number of firms based on 4-digit GICS code

sector name	industry code	industry name	number of firms
Energy	1010	Energy	145
Martials	1510	Martials	498
Industrials	2010	Capital Goods	642
	2020	Commercial & Professional Services	145
	2030	Transportation	209
Consumer Discretionary	2510	Automobiles & Components	147
	2520	Consumer Durables & Apparel	208
	2530	Consumer Services	139
	2540	Media	96
	2550	Retailing	195
Consumer Staples	3010	Food & Staples Retailing	76
	3020	Food, Beverage & Tabaco	277
	3030	Household & Personal Products	38
Health Care	3510	Health Care Equipment & Services	127
	3520	Pharmaceuticals, Biotechnology Life Sciences	108
Information Technology	4510	Software & Services	166
	4520	Technology Hardware & Equipment	216
	4530	Semiconductor & Semiconductor Equipment	45
Communication Services	5010	Telecommunication Services	60
Utilities	5510	Utilities	163
Real Estates	6010	Real Estate	217
		Total	3,917

Table D.3 Descriptive statistics of individual fixed effects for each country (2003-2016)

region	country code	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum	observations
Asia	CN	−0.47	−0.31	0.73	0.82	−1.03	−3.36	1.08	330
	HK	−0.74	−0.72	0.66	−0.49	−0.30	−2.16	0.52	46
	JP	0.00	0.01	0.44	0.24	0.18	−1.43	1.69	1068
	KR	0.13	0.08	0.66	0.64	−0.02	−2.38	1.80	130
	TW	−0.49	−0.61	0.44	1.45	1.05	−1.39	1.05	71
	ID	−1.24	−1.22	0.70	0.77	0.43	−2.66	1.00	57
	MY	−1.00	−1.13	0.62	2.03	0.98	−2.21	1.53	159
	PH	−1.24	−1.28	0.69	−0.04	0.44	−2.52	0.43	34
	SG	−0.81	−0.97	0.59	−0.99	0.24	−1.84	0.34	67
	TH	−0.90	−0.91	0.59	1.09	0.33	−2.61	0.77	73
	IN	−0.12	−0.16	0.73	−0.24	−0.02	−2.11	1.42	89
America	CA	0.18	0.19	0.49	0.53	−0.60	−1.30	1.05	76
	US	0.69	0.71	0.44	2.03	−0.73	−1.81	1.95	673
	BM	−1.12	−1.16	0.72	0.23	0.53	−2.46	0.93	73
	KY	−0.82	−0.85	0.92	−0.45	0.21	−2.41	1.06	28
	MX	−0.18	−0.24	0.43	−0.29	0.11	−0.94	0.63	17
	CL	−0.07	−0.03	0.54	−0.32	−0.03	−1.01	1.04	19
	BR	−0.53	−0.72	0.63	3.10	1.59	−1.17	0.65	6

Table D.3 continued

region	country code	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum	observations
Europe	DK	0.58	0.64	0.43	1.97	0.88	0.00	1.72	17
	FI	0.18	0.20	0.40	−0.92	−0.20	−0.57	0.85	34
	NO	−0.10	0.01	0.48	−0.83	−0.52	−0.99	0.58	21
	SE	0.24	0.28	0.45	0.67	0.03	−0.76	1.42	46
	BE	0.69	0.72	0.48	−0.15	0.26	−0.14	1.74	26
	CH	1.16	1.07	0.60	0.21	0.63	0.13	2.88	45
	DE	0.41	0.39	0.54	0.31	0.32	−0.77	2.07	103
	ES	0.29	0.29	0.44	2.42	0.58	−0.61	1.54	23
	FR	0.51	0.54	0.49	0.84	−0.13	−0.96	1.99	135
	GB	0.15	0.10	0.52	−0.48	0.23	−0.88	1.28	82
	GR	−0.19	−0.20	0.56	−0.30	−0.12	−1.27	0.86	16
	IE	0.70	0.63	0.46	0.42	0.42	0.08	1.42	6
	IT	−0.20	−0.23	0.60	0.15	0.27	−1.54	1.19	42
	LU	0.45	0.45	0.66	−0.59	0.00	−0.52	1.38	7
	NL	0.56	0.49	0.39	5.21	1.77	0.06	1.88	23
	PT	−0.30	−0.49	0.42	0.24	1.18	−0.72	0.52	12
	AT	0.33	0.54	0.61	2.80	−1.55	−1.38	1.12	19
	PL	0.24	0.22	0.76	2.48	1.07	−0.98	2.17	14
the rest of the world	IL	0.28	0.14	0.48	−1.37	0.44	−0.31	1.05	17
	JO	−0.03	0.04	0.25	−0.46	−0.70	−0.50	0.34	16
	KW	−0.32	−0.25	0.46	−0.99	−0.58	−1.06	0.20	10
	EG	0.01	−0.04	0.47	1.26	0.30	−0.67	0.76	6
	MA	0.72	0.78	0.60	−1.79	−0.12	−0.10	1.53	11
	TN	0.05	0.13	0.34	−0.73	0.12	−0.36	0.51	5
	ZA	0.03	0.08	0.54	−0.43	−0.05	−1.10	1.18	36
	AU	−0.03	0.02	0.66	0.09	−0.21	−1.55	1.72	67
	NZ	−0.20	−0.15	0.46	0.82	−0.78	−1.26	0.65	19

Note: countries with less than 5 firms are omitted in Table D.3

Chapter 2 Divergence rate of market stock price from company fundamentals

2.1. Introduction

The financial crisis of 2007-2008, also called the subprime mortgage crisis, originated in the United States as a result of the collapse of the US housing market. As more and more subprime borrowers defaulted and as home prices continued to decline, mortgage-backed securities (MBSs) based on subprime mortgages lost value. The crisis was not limited to the United States since MBSs generated from the U.S. housing market had been bought and sold in other countries, particularly in Western Europe. By 2007 the steep decline in the value of MBSs had caused major losses at many banks, hedge funds, and mortgage lenders. In April 2007 New Century Financial Corp., one of the largest subprime lenders, filed for bankruptcy and soon afterward many other subprime lenders ceased operations. In August, France's largest bank, BNP Paribas, announced billions of dollars in losses and another large U.S. firm, American Home Mortgage Investment Corp., declared bankruptcy. The crisis in the United States deepened still more in 2008 and financial institutions worldwide suffered severe damage, reaching a climax with the bankruptcy of Lehman Brothers on September 15, 2008, which was the largest bankruptcy in US history. The crisis sparked the Great Recession that began in the United States officially in December 2007 and ended in June 2009 and thus extended over 18 months.

Paying attention to the stock market in the United States for the period 2005 to 2010, including the period for the financial crisis of 2007-2008, stock prices greatly varied from the highest level to the lowest level during the period. The US housing market was at the height of its bubble in 2005 and housing prices peaked in 2006[12]. While, in the stock market, the Standard and Poor's Composite Stock Price Index (S&P 500) in 2005 had been slowly rising from 1186.19 in January to 1248.29 in December, a 5.24 percent rise[13]. In 2006, the S&P 500 index had been quickly rising from 1268.80 in January to 1418.30 in December, a 11.78 percent rise. In 2007, the S&P 500 index had been rising quickly and peaked on October 9, marking a high of 1565.15. The subsequent S&P 500 index marked a bottom of 682.55 on March 5, 2009. The index had declined 56.4 percent in 17 months. The response of stock prices to the financial crisis that originated in the United States was somewhat delayed. However, after the bankruptcy of Leman

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[12] source: Case -Shiller Home Price Indices depicted in Shiller (2005)

[13] Source: Daily Standard and Poor's Composite Stock Index are from "Dowheikin" (https://doweikinman.blog69.fc2.com/blog-entry-136.html)

Brothers in September 2008, the index declined from 1207.09 on September 22 - one week after the bankruptcy - to 899.22 on October 10, a 25.5 percent decline in 18 days. In 2010, the index recovered its level in 2005. From these facts, it is clear that the stock market in United States experienced a stock price bubble during the period between 2006 and 2007 and suffered a large stock market crash in October 2008.

The efficient-market hypothesis emerged as a prominent theory in the late 1960s with the work of Fama(1965) as a start. The hypothesis is a theory in financial economics and asserts that all financial prices always accurately reflect all public information. According to the hypothesis, stock prices follow a "random walk" over time, implying that price changes are unpredictable. In 1970, Eugen Fama published a review of the theoretical and empirical literature on the efficient market model (See Fama (1970)). After Fama's influential review paper, the efficient-market hypothesis and the random walk hypothesis have been tested using data on stock markets in many studies published in scholarly journals of finance and economics. The literature on the evidence for the hypothesis is well developed.

On the contrary, investors and researchers disputed the efficient-market hypothesis both empirically and theoretically, asserting that the efficient-market hypothesis cannot explain the emergence and collapse of bubbles in the stock market. Shiller (1981) argued that stock prices are too volatile to accord with efficient markets. LeRoy and Porter (1981) econometrically supported Shiller's notion. From the behavioral view of finance, scholars claim that investors are not necessarily rational, swaying with their emotion or psychological situation. Therefore, there is a possibility that stock prices greatly deviate from fundamentals when investors face an emerging bubble. Richard Thaler, a behavior economist, published a regular column in The Journal of Economic Perspectives from 1987 to 1990 titled Anomalies. Thaler documented individual instances of economic behavior that seemed to violate traditional microeconomic theory. Thaler (1987) analyzed peculiar behavior of stock prices describing seasonal movement in security prices and concluded that additional econometric and experimental investigations are necessary to understand anomalies in stock prices. De Bondt and Thaler (1989b) discussed whether stock prices are unpredictable as the efficient-market hypothesis asserts. The authors state in their introduction, "Indeed, stock prices do appear to be somewhat predictable. In particular, if one takes a long-term perspective (3-7 years)." However, the authors state in their concluding remarks, "anomalies are common because the theories are unusually well-developed, and the data is unusually rich. The real challenge facing this field is to develop new theories of asset pricing that are consistent with known empirical facts and offer new testable predictions."

Numerous empirical studies have been reported, including both supporting the hypothesis and criticizing the hypothesis, however, they have not been scientifically proven. Shiller, a scholar of behavioral finance, states in his book "whether or not we ultimately agree with it, we must at least take the efficient market theory seriously" (See Shiller (2015)).

This study aims to examine whether the volatility of market stock prices in the late 2000s can be explained by the efficient-market hypothesis, using the results of the panel regression model constructed in Chapter 1, where the company fundamentals for market stock prices are estimated with a panel regression model. In the panel regression model. market stock price is a dependent variable and the cash flow per share and the book value per share are explanatory variables for the market stock price. These financial indicators are the representative variables commonly used to evaluate a firm's business performance. The data used in the study is annual data collected from 3,917 firms globally listed[14] for the period from 2003 to 2016. The data was collected from the OSIRIS database provided by Bureau van Dijk. The 3,917 firms have no missing data in relation to the variables of interest, including the market stock price, cash flow per share, and book value per share, for the period 2003-2016 from the database and excluded firms in the financial and insurance industries. Figure 1 shows the mean of the logarithmic market stock price for the 3,917 worldwide firms used in this study. As seen in Figure 1, the mean of the market stock price in 2007 marked 1.98, and that in 2008 marked a bottom of 1.46. This implies that the financial crisis originated in the United States simultaneously extended to the world.

Figure1: The mean of the logarithmic market stock price. (Figure1 is presented in Figure Section in this chapter.)

The company fundamentals are defined as the values that remove time the fixed effects form theoretical values which are the estimates from the panel two-way fixed effects regression model[15]. To investigate how the market stock prices deviate from the company fundamentals, the divergence rate is defined as the logarithmic difference between the market stock price and the company fundamentals and calculated. According to the efficient-market hypothesis, the market stock prices would accurately reflect the company fundamentals. That is, the divergence rates would be around zero.

The market stock prices were found to deviate substantially from the company fundamentals during the period 2006-2008. The means of the divergence rates are positive values for the period

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[14] The 3,917 firms are from 67 countries and approximately two-third of them are Japan (1068 firms), Untied States (673 firms), China (330 firms) and West Europe (520 firms). The country name with the number of firms by region are depicted in Table D.1 in Data Section in Chapter 1.

[15] The panel two-way fixed effects regression mode estimates two fixed effects: the individual fixed effects and the time fixed effects. The individual fixed effects account for an individual firm's heterogeneity. The time fixed effects reflect external various shocks common to all firms.

from 2006 to 2007 but shifted from positive to a large negative value in 2008. The market stock prices were overvalued against the company fundamentals during the stock market bubble period from 2006 to 2007, while in 2008, they were undervalued against the company fundamentals due to the global financial crisis. After a drastic fall in 2008, the means of the divergence rates were approaching zero, indicating that the market stock prices were normally valued against the company fundamentals. Based on this, it seems that the stock bubble of 2006 and 2007, and the subsequent stock crash of 2008 cannot be explained by the efficient-market hypothesis but rather can be explained by the behavioral view of finance, and the investors' emotional or psychological situation.

This chapter is organized as follows: Section 2 describes the divergence rates of the market stock price from the company fundamentals and investigates the divergence rate. Section 3 calculates the divergence rate at a regional level. Section 4 gives concluding remarks.

2.2 Divergence rate of the market price from the company fundamentals

The divergence rate between the market stock price and the company fundamentals is defined as

$$D_{it} = \ln Y_{it} - \ln \tilde{Y}_{it} \qquad (1)$$

where, D_{it} denotes the divergence rate for firm i in year t. Y_{it} denotes the market stock price for firm i in year t. $\tilde{Y}_{it}$ denote the company fundamentals for firm i in year t. D_{it} is a logarithmic form of the difference between Y_{it} and $\tilde{Y}_{it}$, thus refers to the divergence rate of the market stock price from the company fundamentals. The divergence rate, D_{it} is calculated for each firm for each year.

Figure 2 shows the time series of the mean of the divergence rates. As seen in Figure 2, the mean of the divergence rates is more than 0.1 for the period from 2006 to 2007 and for the period from 2014 to 2016, suggesting that the market stock prices are overvalued against the company fundamentals. The period from 2006 to 2007 is the so-called bubble period. After that, the mean of the divergence rate sharply fell from 0.1 to -0.36 in 2008. This suggests that the market stock prices are undervalued against the company fundamentals. The period 2008 is the year when the global financial crisis accelerated after the bankruptcy of a large investment bank, Leman Brothers, September 2008. This implies that stocks were, on average, bought excessively from 2006 to 2007, and on average, overly sold in 2008. The mean of the divergence rates for the period from 2009 to 2010 were approaching zero, indicating a recovery to a normal level. In 2010, the mean of the divergence rates was very close to zero, implying that the market stock prices fully reflect the company fundamentals. The mean of the divergence rates for the period from 2010 to 2011 somewhat fell and after that, they continued rising. Paying attention to the period from 2006 to 2013, the magnitude of the change in the means of the divergence rates implies that the efficient-market hypothesis cannot explain the volatility in the stock market.

Figure 2: The time series of the mean of the divergence rate for the period from 2003 to 2016. (Figure 2 is presented in Figure Section in this chapter.)

Table 1 shows descriptive statistics of the divergence rates for each year over a 14-year period from 2003 to 2016.

Table 1 Descriptive statistics of the divergence rate for each year

Observations: 3,917 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
2003	−0.12	−0.10	0.49	9.51	−0.80	−5.64	2.81
2004	−0.05	−0.03	0.42	18.95	−1.14	−6.79	2.54
2005	0.05	0.07	0.43	2.21	−0.24	−3.62	2.16
2006	0.12	0.12	0.35	4.00	−0.01	−3.10	2.49
2007	0.10	0.06	0.36	1.36	0.56	−1.38	2.34
2008	−0.36	−0.34	0.41	17.48	−0.29	−6.13	4.84
2009	−0.05	−0.07	0.31	2.06	0.47	−1.34	1.75
2010	0.00	−0.03	0.30	2.34	0.62	−1.53	1.81
2011	−0.10	−0.11	0.29	3.87	0.18	−1.78	2.06
2012	−0.05	−0.06	0.31	10.42	−0.73	−4.01	1.70
2013	0.07	0.05	0.32	4.36	−0.14	−3.25	1.63
2014	0.13	0.12	0.33	3.54	−0.14	−2.96	1.86
2015	0.11	0.09	0.41	3.19	−0.06	−3.20	2.77
2016	0.15	0.14	0.40	4.39	−0.38	−3.22	2.18

The means of the divergence rates are equivalent to the time fixed effects estimated in the panel two-way fixed effects regression model since, as described above, the company fundamentals are defined as the values that remove the time fixed effects form theoretical values. The time fixed effects indicate an external shock and reflects various and temporary shocks common to all firms. That is, the means of the divergence rates represent a global shock to individual firms. Unless firms were hit with a global shock, such as the financial crisis of 2007-2008, the mean of the divergence rates would be around zero. That is, the market stock prices would correctly reflect company fundaments.

The distribution of the divergence rate is investigated for each year. Figure 3(1) shows the distributions for the period from 2006 to 2008, which includes the period before and during the global financial crisis. The figure shows clearly that the distribution of the divergence rate shifted drastically towards the negative side from 2007 to 2008 indicating the stock crash in 2008. The distributions of the divergence rate during the period 2006-2007 indicate the stock bubble just before the stock crash. While Figure 3(2) shows the distributions of the divergence rate for the period from 2009 to 2013, which is neither a bubble nor a crash in the stock market but rather is relatively normal.

Figure 3 (1): The distributions of the divergence rate for the period 2006-2008.
Figure 3 (2): The distributions of the divergence rate for the period 2009-2013.
(Figure 3 (1) and (2) are presented in Figure Section in this chapter.)

2.3. Divergence rate of the market price from the company fundamentals at a regional revel

In this section, the divergence rates are analyzed at a regional level using the company fundamentals estimated from the regional panel regression models performed in Chapter 1. As described in Section 1.6 in Chapter 1, the 3,917 firms are divided into four regions, including Asia, America, Europe, and the rest of the world. The divergence rates at regional level are calculated.

Table 2 and Figure 4 show the means of the divergence rates in the period 2003 to 2016 by region[16]. As described in the previous section, the means of the divergence rates are equivalent to the tine fixed effects estimated in the panel regression model. Figure 4 clearly indicates that there are some differences in the time fixed effects at a regional level. In the late 2000s when the stock price bubble and the subsequent global financial crisis affected the world economy, all four regions are affected to a greater or lesser extent. In Europe, the means of the divergence rates are more than 0.2 for the period from 2006 to 2007. Similarly, in the rest of the world, the means of the divergence rates are more than 1.4. On the other hand, in America, the means of the divergence rates are close to zero for the period from 2006 to 2007 and negative in 2005. Those in Asia are approximately the same as those in the world. In 2008, the means of the divergence rates in all regions sharply fell from positive side to negative, although the fall in the rest of the world is not sharp compared to the other three regions. In 2010, the means of the divergence rates are around zero indicating that the stock market in all regions recovered to a normal level.

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[16] The descriptive statistics of the divergence rates by region are shown in Table 3 (1)-(4) presented next to the Reference Section in this Chapter.

Table 2 The mean of the divergence rates by region for each year

Year	Asia	America	Europe	the rest of the world
2003	−0.06	−0.23	−0.11	−0.12
2004	−0.02	−0.13	0.02	−0.03
2005	0.09	−0.08	0.15	0.13
2006	0.12	0.03	0.28	0.14
2007	0.07	0.05	0.22	0.22
2008	−0.36	−0.41	−0.37	−0.14
2009	−0.02	−0.10	−0.08	−0.10
2010	−0.01	0.03	−0.03	0.01
2011	−0.10	−0.06	−0.22	−0.03
2012	−0.05	0.03	−0.15	−0.07
2013	0.00	0.20	0.07	0.02
2014	0.12	0.24	0.04	0.06
2015	0.10	0.16	0.08	−0.05
2016	0.12	0.27	0.09	−0.04

Observations: 2126 firms in Asia, 905 firms in America, 685 firms in Europe, 208 firms in the rest of the world.

Figure 4: The mean of the divergence rates for the period from 2003 to 2016 by region. (Figure 4 is presented in Figure Section in this chapter.)

2.4 Concluding remarks

In this study, the divergence rates of the market stock price from the company fundamentals are investigated. The company fundamentals for the market stock price are estimated in Chapter 1, where the panel two-way fixed effects regression analysis is performed using the financial indicators – cash flow per share and book value per share – as explanatory variables for the market stock price[17]. The company fundamentals are calculated by removing the time fixed effects from the theoretical prices. The market stock prices were found to deviate substantially from the company fundamentals during the period 2006-2008. The means of the divergence rates are positive for the period from 2006 to 2007, suggesting that the market stock prices were on average overvalued during the bubble period. On the other hand, the mean of the divergence rates drastically declined to a large negative value in 2008, suggesting that the market stock prices were on average undervalued due to the stock market crash caused by the global financial crisis. After the sharp fall in 2008, the means of the divergence rates were approaching zero, indicating that the stock market recovered to a normal level. These results suggest that the stock market

[17] The explanatory power of the panel regression model is quite high showing the adjusted R-squared value of 0.96.

under the bubble and the collapse of the bubble economy cannot be explained by the efficient-market hypothesis, but rather can be explained by behavior view of finance. In addition to analysis at the world level, divergence rates at a regional level are analyzed. Although there are some differences among regions, similar results to the analysis of the world are found. Thaler (1987) pointed out that anomalies in the stock market were based on seasonal price movements, focusing on very short-term price movements. This study analyzed the divergence rate between the market stock prices and the company fundamentals using annual data and discuss why the market stock price deviates from the company fundamentals in the late 2000s. Even price movement based on annual data cannot be explained by the efficient-market hypothesis.

This study provides empirical evidence of the excessive volatility in stock prices in the late 2000s, for the periods before and during the global financial crisis. More than 13 years have passed since the global financial crisis of 2007-2008 and world economy has been continuously changing. The movement of stock price for the mid-to-long term is of interest for my future research.

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Tables

Table 3 (1) Descriptive statistics of the divergence rates for Asia

Observations: 2126 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
2003	−0.06	−0.03	0.49	10.37	−0.98	−5.62	2.80
2004	−0.02	0.02	0.41	2.64	−0.35	−2.21	2.67
2005	0.09	0.14	0.46	0.37	−0.29	−1.60	1.94
2006	0.12	0.14	0.34	2.52	0.03	−1.64	2.59
2007	0.07	0.02	0.37	1.41	0.74	−1.36	1.97
2008	−0.36	−0.34	0.41	31.12	−0.43	−6.10	4.84
2009	−0.02	−0.05	0.31	1.19	0.42	−1.33	1.63
2010	−0.01	−0.06	0.31	1.51	0.67	−1.51	1.61
2011	−0.10	−0.12	0.27	3.29	0.55	−1.60	1.69
2012	−0.05	−0.08	0.31	15.49	−0.66	−4.09	1.70
2013	0.00	−0.02	0.32	1.86	0.42	−1.57	1.62
2014	0.12	0.09	0.33	1.66	0.28	−1.50	1.42
2015	0.10	0.05	0.40	1.45	0.47	−1.68	2.56
2016	0.12	0.09	0.37	1.36	0.31	−1.33	1.70

Table 3 (2) Descriptive statistics of the divergence rates for America

Observations: 905 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
2003	−0.23	−0.24	0.49	8.39	−0.84	−4.01	2.00
2004	−0.13	−0.14	0.46	54.22	−3.60	−6.84	1.81
2005	−0.08	−0.09	0.37	11.30	−0.62	−3.67	2.14
2006	0.03	0.01	0.33	16.62	0.01	−3.17	2.97
2007	0.05	0.02	0.32	3.91	0.82	−1.14	2.30
2008	−0.41	−0.36	0.42	5.43	−0.30	−2.65	2.62
2009	−0.10	−0.11	0.29	3.32	0.61	−1.34	1.37
2010	0.03	0.00	0.29	3.62	0.71	−1.38	1.54
2011	−0.06	−0.05	0.28	4.87	−0.16	−1.96	1.70
2012	0.03	0.03	0.30	8.11	−0.94	−2.37	1.43
2013	0.20	0.19	0.32	9.05	−0.88	−2.45	1.65
2014	0.24	0.24	0.33	5.33	−0.61	−2.16	1.76
2015	0.16	0.17	0.42	3.63	−0.54	−2.39	1.70
2016	0.27	0.28	0.39	3.39	−0.69	−2.19	1.38

Table 3 (3) Descriptive statistics of the divergence rates for Europe

Observations: 685 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
2003	−0.11	−0.11	0.47	2.01	0.34	−1.80	1.97
2004	0.02	0.00	0.39	1.99	0.66	−1.01	2.00
2005	0.15	0.13	0.35	2.42	0.48	−1.46	1.87
2006	0.28	0.25	0.33	0.81	0.37	−1.01	1.64
2007	0.22	0.21	0.33	0.85	0.19	−1.12	1.35
2008	−0.37	−0.36	0.40	0.79	−0.25	−1.84	1.07
2009	−0.08	−0.08	0.30	3.29	0.57	−1.17	1.52
2010	−0.03	−0.04	0.27	4.16	0.05	−1.61	1.58
2011	−0.22	−0.20	0.31	3.60	−0.54	−1.94	1.14
2012	−0.15	−0.13	0.32	0.98	−0.48	−1.50	0.79
2013	0.07	0.08	0.31	1.12	−0.24	−1.23	1.13
2014	0.04	0.05	0.33	0.87	−0.40	−1.43	1.09
2015	0.08	0.12	0.42	3.64	−0.68	−1.97	2.22
2016	0.09	0.13	0.43	4.44	−0.74	−2.71	2.23

Table 3 (4) Descriptive statistics of the divergence rates for the rest of the world

Observations: 201 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
2003	−0.12	−0.17	0.54	2.31	0.72	−1.62	2.11
2004	−0.03	−0.02	0.40	2.09	0.43	−1.06	1.90
2005	0.13	0.09	0.36	−0.18	0.40	−0.65	1.08
2006	0.14	0.12	0.39	0.86	−0.20	−1.14	1.12
2007	0.22	0.23	0.36	1.00	−0.58	−1.06	1.08
2008	−0.14	−0.14	0.43	2.00	0.22	−1.72	1.69
2009	−0.10	−0.09	0.33	1.45	−0.30	−1.28	0.89
2010	0.01	0.02	0.30	1.03	0.07	−0.95	1.01
2011	−0.03	−0.02	0.33	1.09	−0.35	−1.26	0.87
2012	−0.07	−0.06	0.34	0.69	−0.26	−1.26	0.91
2013	0.02	0.03	0.32	0.34	−0.25	−0.93	0.86
2014	0.06	0.05	0.33	1.56	−0.12	−1.24	1.14
2015	−0.05	−0.04	0.42	0.57	−0.15	−1.35	0.98
2016	−0.04	−0.02	0.49	3.09	−0.62	−2.46	1.29

Figures

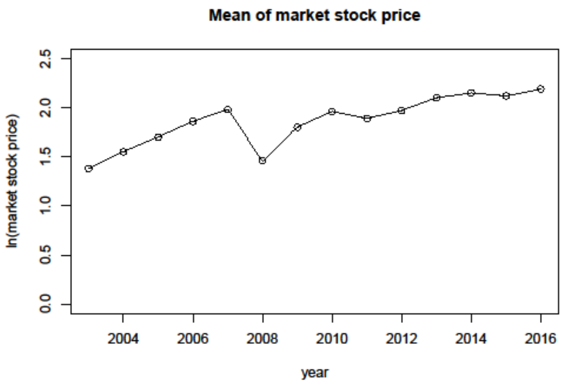

Figure 1 The mean of the logarithmic market stock price: market stock price of 3,917 worldwide firms in the period 2003 through 2016.

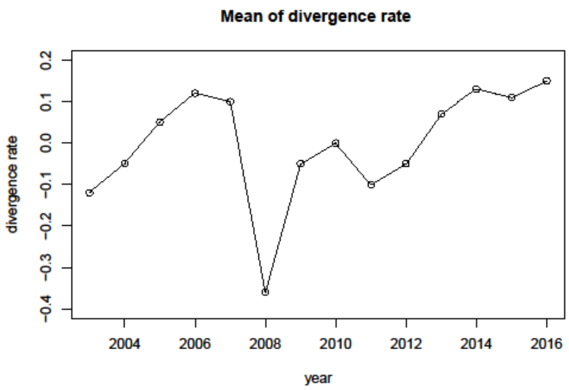

Figure 2 The time series of the mean of the divergence rate for the period from 2003 to 2016.

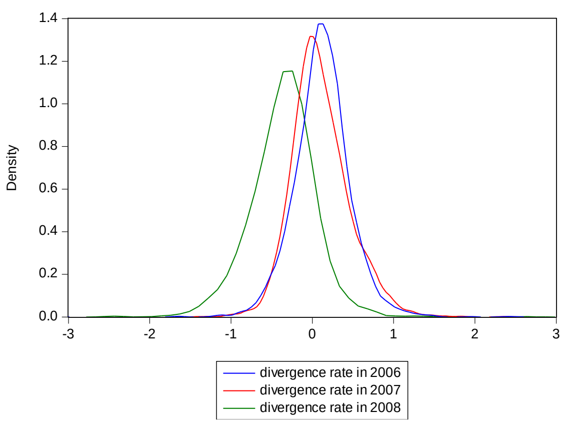

Figure 3 (1) The distributions of the divergence rate for the period 2006-2008: Distributions during period 2006 to 2007 are slightly positive side. However, the distribution drastically shifts from the positive side to negative side in 2008. The distribution is drawn using a density plot

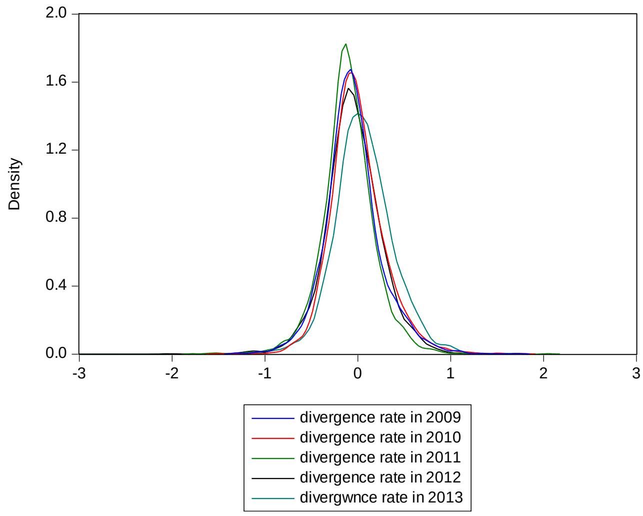

Figure 3 (2) The distribution of the divergence rate for the period 2009-2013: The distributions are approximately stable indicting a normal term. The distribution is drawn using a density plot.

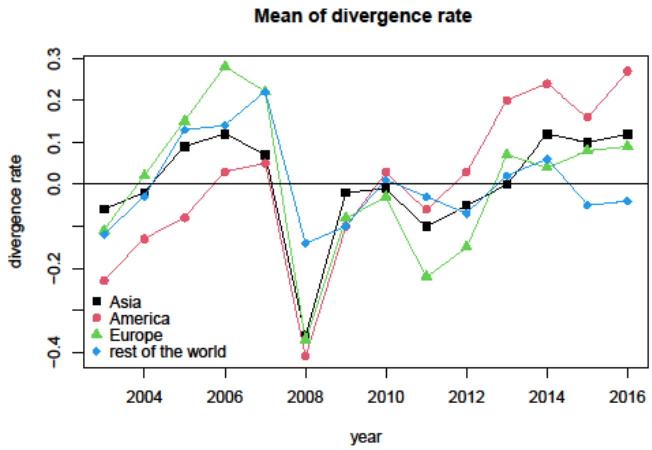

Figure 4 The mean of the divergence rates for the period from 2003 to 2016 by region: the market stock prices in Europe are extremely overvalued against the company fundamentals during period from 2006 to 2007.

Chapter 3 Granular Hypothesis on Stock Market

3.1 Introduction

The granular hypothesis introduced by Gabaix (2011) is one of the most influential ideas in recent years[18]. The granular hypothesis holds that idiosyncratic firm-level shocks to large firms can affect the aggregates level through their size in the economy. According to the findings of Gabaix (2011), the idiosyncratic movements of the largest 100 firms in the United States explain about one-third of the variations in output growth. Against the predominant traditional argument that individual firm shocks average out in the aggregate, Gabaix(2011) showed that when the distribution of firm sizes is fat-tailed, the central limit theorem does not apply. Gabaix (2011) presented a proposition that describes how the firm size volatility converges as the number of firms goes to infinity when the firm size distribution is fat-tailed. According to the proposition, if the distribution of the firm size has thin tails, that is, finite variance, the size of the aggregate fluctuation should have a size proportional to $1/\sqrt{N}$, where N is the number of firms, indicating that idiosyncratic fluctuations disappear in the aggregate if there is a large number of firms N . He demonstrates that if the firm size is a power-law distribution, idiosyncratic shocks to large firms do not cancel out and can generate aggregate fluctuations. He concludes that studying very large firms can offer a useful perspective about open issues in macroeconomics.

Literature related to Gabaix (2011) are Acemoglu et al. (2012), di Giovanni and Levchenko (2012), Carvalho and Gabaix (2013), and di Giovanni, Levchenko, and Mejean (2014). In addition to these studies, many empirical studies following the approach proposed by Gabaix (2011) have been conducted, including the studies of Karasik et al. (2016), Hogen et al. (2017), Ebeke and Eklou K. M. (2017), Popova (2019), among others. They focused on explaining fluctuations in macro variables in the real economy, such as sales, investment, exports, and unemployment. These studies define firm-level shocks as the deviations of the growth of the variables of interest from the average growth rate of all firms or across industries as Gabaix (2011) proposed as the simplest specification.

This study investigates the granular hypothesis on the stock market, focusing on explaining

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[18] Many economic fluctuations are attributable to the incompressible "grain" of economic activity, the large firms. Gabaix (2011) calls this view, the "granular" hypothesis.

the fluctuation of macro variables in the stock market based on market capitalization. The approach used to estimate idiosyncratic firm-level shocks is different from that of other existing studies. Using the panel two-way fixed effects regression model, firm-level shocks are defined as the deviations of market capitalization from company fundamentals and calculated. In Chapter 1, a panel two-way fixed effects regression model[19] was constructed in which cash flow per share and book value per share are explanatory variables for the market stock price and estimate the company fundamentals for the market stock price using the results of the panel regression model. The model results in a good performance and company fundamentals are well reflected in the market stock price.

In this this study, using market capitalization instead of the market stock price, the company fundamentals for market capitalization are estimated from the panel two-way fixed effects regression model. In the regression mode, market capitalization is a dependent variable, and cash flow and book value are explanatory variables for market capitalization. The data used in this study was data from 3,917 firms which was the same firms as in Chapter 1. The panel regression model results in a good performance, revealing that all coefficients are statistically significant, and the adjusted R- squared value is quite high (0.963). Referring to the estimates of the panel two-way fixed effects regression model as theoretical values, company fundamentals are defined as the values that exclude the time fixed effects from the theoretical value. The distribution of market capitalization is examined to see if it follows a power-law like the market stock price. The distribution of market capitalization was found to follow a power-law, that is, a fat-tailed distribution.

The 'granular residuals' of the top largest firms were calculated, using the idiosyncratic firm-level shock estimated with the panel two-way fixed effects regression model and weighted firms' size in the economy. Granular residuals were constructed and used as a simple measure of shocks to the top largest firms according to Gabaix (2011). Regressing aggregate market capitalization growth on granular residuals using the ordinally least square (OLS) regression model, explanatory power of granular residuals can be derived and evaluated based on the adjusted R-squared value that explains variation in the aggregate fluctuations. Furthermore, using granular residuals to calculate the individual firms and regression results, the individual firms' contributions to aggregate growth was calculated to investigate the individual industry's contribution to aggregate fluctuations.

The main findings in this study are as follows: (1) The top 100 largest firms' market

[19] Assuming a two-way error component model with respect to error, the panel two-way fixed effects regression model estimates individual fixed effects and time fixed effects as unobservable factors other than pure disturbance.

capitalization account for a significant share of the aggregate market capitalization in the world economy (approximately 50% on average in data of 3,917 firms). (2) Approximately 70% of the variation in aggregate market capitalization growth can be explained by idiosyncratic firm-level shocks to the top 100 largest firms, which is greater than their share of the aggregate. (3) Apart from market capitalization, the idiosyncratic firm-level shocks to the top largest firms also greatly affect macro variables, such as Price-to-Sales Ratio (PSR) and Price-to-Book Ratio (PBR)[20]. (4) Drastic aggregate fluctuations during the period (2007-2009) are mainly driven by large firms in the energy and capital goods industries.

The rest of this article is organized as follows. Section 3.2 describes the data used in this study and the power-law test for market capitalization; Section 3.3 describes how firm-specific shocks are estimated with the panel regression model for market capitalization; Section 3.4 describes how granular residuals are constructed and calculated; Section 3.5 performs granular regression and presents results; Section 3.6 investigates which firms and industries play a dominant role in aggregate market capitalization growth; Section 3.7 offers concluding remarks.

3.2 Data

The data used in this study was collected from the OSIRIS database provided Bureau van Dijk, containing financial statement and stock information of firms listed worldwide. The market capitalization, cash flow, and book value of the firms was derived from the annual firm data. The firms have no missing data in relation to the variables of interest from 2003 to 2016 and firms in the financial and insurance industries were excluded. A total 3,917 firms were selected from the database, and they are the same as the firms used in Chapter 1. The firms were from 67 counties and classified into 21 industries using the four-digit Global Industry Classification Standard (GICS) code.

3.2.1 Overview of data: market capitalization

Table 1 demonstrates that market capitalizations are highly concentrated. The average share of the top 10 largest firms is approximately 15 %, and that of the top 100 largest firms is approximately 50 % of total market capitalization, respectively. The top largest firms represent a large part of the total market capitalization, implying that the distribution of market capitalization follows a power-law distribution. Table 2 presents the descriptive statistics of the market capitalization and Gini coefficients of market capitalization. The Skewness presented in

[20] In this study, PSR is defined as the ratio of the aggregate market capitalization to aggregate operating value and PBR as the ratio of the aggregate market capitalization to the aggregate book value. Thus, PSR and PBR are treated as macro variables in this study.

Table 2 indicates that distributions have long tails in right side. The Gini coefficients presented in the last column in Table 2 are close to 1, implying that there are large inequalities in market capitalizations. From these statistics, the distributions of market capitalization can be fat-tailed distributions.

Table 1 Percentage share of large firms in market capitalization

Observations: 3,917 firms

Year	top 10	top 20	top 50	top 100
2003	19.3	29.0	45.5	57.1
2004	17.8	26.9	42.6	54.5
2005	15.8	24.1	38.4	51.2
2006	14.6	22.9	37.2	50.1
2007	14.5	22.6	37.4	50.4
2008	15.7	24.9	40.2	53.2
2009	12.5	20.9	35.1	47.9
2010	12.3	19.9	34.1	46.6
2011	13.8	22.3	36.0	48.2
2012	14.7	22.7	36.3	48.1
2013	12.9	20.9	34.9	47.0
2014	13.3	21.1	34.7	46.7
2015	13.6	21.7	35.2	47.2
2016	13.1	20.8	34.6	46.3
average	14.6	22.9	37.3	49.6

Note: average shares are calculated for the period (2003-2016)

Table 2 Descriptive statistics of market capitalization (Million US $)

Observations: 3,917 firms

Year	Mean	Median	Std. Dev.	Kurtosis	Skewness	Gini coef.
2003	2922.4	259.1	14410.1	202.8	12.7	0.87
2004	3245.7	300.1	15220.8	238.3	13.3	0.86
2005	3639.8	368.1	15437.1	204.6	12.2	0.86
2006	4347.2	433.2	17708.2	198.0	11.7	0.85
2007	4907.2	491.9	20036.7	196.9	11.7	0.85
2008	3197.4	290.1	14075.1	247.7	12.8	0.86
2009	3981.5	470.8	14791.4	123.7	9.5	0.84
2010	4496.0	562.7	16241.4	131.0	9.6	0.84
2011	4422.4	507.5	17280.2	178.2	11.2	0.84
2012	4890.1	560.7	20016.7	312.3	14.1	0.84
2013	5532.6	662.5	20662.6	149.5	10.3	0.84
2014	5842.2	722.5	22172.7	207.6	11.7	0.84
2015	5558.4	742.9	21562.3	246.9	12.6	0.83
2016	5878.8	804.8	22205.7	215.4	11.9	0.83

3.2.2 Power-law distribution of market capitalization

A power-law distribution is a key assumption of the granular hypothesis. According to the proposition presented by Gabaix (2011), if the distribution of market capitalization, X_i, follows a power-law distribution, $\mathrm{P}(X_i > x) = a^{-\varsigma}$ for $x > a^{1/\varsigma}$, with exponent $\varsigma \geq 1$, then, as the number of firms, $N \to \infty$, the standard deviation of X_i, is as follows:

(a) $\sigma_X \sim \frac{v_\varsigma}{\ln N}\sigma$ for $\varsigma = 1$

(b) $\sigma_X \sim \frac{v_\varsigma}{N^{1-1/\varsigma}}\sigma$ for $1 < \varsigma < 2$

(c) $\sigma_X \sim \frac{v_\varsigma}{N^{1/2}}\sigma$ for $\varsigma \geq 2$,

where, v_ς is a random variable.

When exponent $\varsigma = 1$ (Zipf's law), the volatility decays according to $1/\ln N$. If exponent $1 < \varsigma < 2$, the distribution has fat tails and the volatility decays according to $1/N^{1-1/\varsigma}$. If exponent $\varsigma > 2$, then the distribution has thin tails, that is, finite variance, the volatility decays according to $1/\sqrt{N}$. The proposition sates that if the distribution has fat tails ($\varsigma < 2$), then the volatility decays much more slowly than $1/\sqrt{N}$.

Hence, in our data, market capitalization is examined to see if it follows the power-law distribution. The distribution of the power-law has a probability density function as follows:

$$p(x) = Cx^{-\alpha} \qquad (1)$$

where, α is a constant parameter of the distribution known as the exponent or scaling parameter and C is a normalization constant. The exponent of the power-law typically lies in the range $2 < \alpha < 3$, although there are occasional exceptions[21].

To estimate a power-law exponent, a popular way proposed by Gabaix and Ibragimov(2011) is widely used. However, this study uses 'the poweRlaw package' developed by Gillespie (2015). This package first estimates the lower bound on power-law, $x_{\min}$, and next power-law exponent, α is estimated based on $x_{\min}$ using the maximum likelihood estimation (MLE) method. This procedure enables α to be accurate. This package is closely related to the statistical framework presented by Clauset et al. (2009)[22]

In Table 3, the estimated power-law exponent, and the number of firms in the tail for market capitalization are reported for each year. The estimated exponents range from 2.086 to 2.382,

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21 The cumulative distribution function, $P(X > x) = x^{-(\alpha-1)}$ also follows a power-law. Gabaix (2011) and many others use this form instead of density function, Equation (1). Thus exponent ς in the proposition described above is equal to $\alpha - 1$

22 The theoretical framework for estimating power-law exponent by Clauset et al. (2009) is summarized in Appendix.

that is, the distribution in each year follows a power-law distribution. The numbers of firms in the tail presented in the third column of Table 3 are within 7 % of the total for the 3,917 firms. The power-law hypothesis is tested using bootstrapping with 3000 simulations and record as p-values. The p-values based on the bootstrapping in the fourth column of Table 3 satisfy the statistical significance level, $p > 0.1$ [23]. The distribution of market capitalization was confirmed as following the power-law. Furthermore, the estimated parameters in Table 3 are verified using EViews software package which provides built-in empirical distribution tests. From the fifth to the seventh column show the p-value for the method of Cramer-von Mises, Watson, and Andersson-Darling, respectively[24]. Except the p-value for Anderson-Darling method, the p-values are large relative to those of bootstrapping[25].

Table 3 Estimated power-law exponent for market capitalization

year	exponent	Number of firms in the tail	p-value			
			Bootstrapping	Cramer-von Mises	Watson	Anderson-Darling
2003	2.086	298	0.23	0.519	0.473	0.001
2004	2.175	226	0.19	0.669	0.589	0.000
2005	2.157	290	0.12	0.346	0.672	0.001
2006	2.245	222	0.10	0.275	0.328	0.000
2007	2.375	137	0.26	0.449	0.715	0.000
2008	2.176	195	0.42	0.278	0.614	0.000
2009	2.275	210	0.33	0.233	0.398	0.000
2010	2.324	196	0.16	0.404	0.780	0.000
2011	2.382	150	0.17	0.624	0.687	0.000
2012	2.333	177	0.17	0.521	0.669	0.000
2013	2.333	181	0.31	0.336	0.397	0.000
2014	2.373	164	0.21	0.526	0.823	0.000
2015	2.298	189	0.24	0.555	0.815	0.000
2016	2.325	198	0.21	0.530	0.862	0.000

Note: KS (Kolmogorov-Smirnov) statistics is used in Bootstrapping.

Figure 1 depicts the complementary cumulative distribution of market capitalization during the selected research period (2006-2011). As depicted in Figure 1, there seems to be little difference in the years. The power-law exponents in Table 3 lie in a narrow range and are close to 2.

[23] Clauset et al. (2009) suggest rejecting the hypothesis of goodness of fit of the observed data with respect to the theoretical model if the p-value is lower than 0.1.

[24] EViews use the computational techniques of test statistics and p-values based on Anderson-Darling (1952, 1954), Csorgo and Faraway, J. (1996), and Davis and Stephens (1989).

[25] Clauset et al. (2009) suggests that Anderson-Darling statistic is seemed to be highly conservative, requiring many samples in the tail of distribution.

Figure 1: Complementary cumulative distribution of market capitalization during the research period (2006-2011). (Figure 1 is presented in Figure Section in this chapter.)

3.3 Estimating firm-specific shock

To estimate the idiosyncratic firm-specific shocks, a panel regression model was constructed. In Chapter 1, company fundamentals for the market stock price were calculated using a panel regression model in which the market stock price is a dependent variable, and the cash flow per share and book value per share are as explanatory variables for the market stock price. That panel regression model shows a high explanatory power. In this study, applying the same model to the aggregate data, the company fundamentals for market capitalization are calculated. The idiosyncratic firm specific socks are defined as the deviations of market capitalization from the company fundamentals and estimated.

3.3.1 Panel regression model

The company fundamentals for market capitalization are calculated by performing a panel two-way fixed effects regression model for market capitalization using two financial variables, cash flow and book value, as explanatory variables. Assuming the relationship between market capitalization and these financial variables to be logarithmic linear, the panel two-way fixed effects model can be written as follows:

$$\ln Y_{it} = a + b_1 \ln X_{1,it} + b_2 \ln X_{2,it} + \mu_i + \lambda_t + \varepsilon_{it} \qquad i = 1, \ldots, N \;\; ; \;\; t = 1, \ldots, T \qquad (2)$$

where, Y_{it} denotes market capitalization for firm i in year t; a is a constant term; $X_{1,it}$ denotes the cash flow for firm i in year t; $X_{2,it}$ denotes the book value for firm i in year t, μ_i denotes the unobservable individual fixed effects for firm i constant for time series; λ_t denotes the unobservable time fixed effects in year t constant for cross-section, and ε_{it} denotes pure disturbance

Table 4 shows the results of the panel two-way fixed effects regression model. The standard errors presented in Table 4 of the estimates are modified using the White period method, as heteroskedasticity and serial correlation are detected in residuals.

Table 4 Results of estimates for the panel two-way fixed effects regression model

Total panel (balanced) observations: 54,838

	a	b1	b2
Coefficient	−3.765	0.349	0.481
Std. Error	0.194	0.010	0.018
t−Statistic	−19.44	36.18	26.81
p−Value	0.000	0.000	0.000
R−squared	0.965		
Adjusted R−squared	0.963		

The p-values of the coefficients are very close to zero, indicating that the estimates are statistically significant. The R-squared value (0.965) and adjusted R-squared value (0.963) are quite high, confirming that the regression model has high explanatory power.

3.3.2 Company fundamentals for market capitalization and firm- specific shocks

The estimates of the two-way fixed effects model for market capitalization are written as follows:

$$\ln \hat{Y}_{it} = \hat{a} + \hat{b}_1 \ln X_{1,it} + \hat{b}_2 \ln X_{2,it} + \hat{\mu}_i + \hat{\lambda}_t \qquad (3)$$

where, the hatted symbols, $\hat{Y}_{it}$, $\hat{a}$ $\hat{b}_1$, $\hat{b}_2$, $\hat{\mu}_i$, and $\hat{\lambda}_t$ denote estimates derived from the model, Equation (2). $\hat{Y}_{it}$ is called the theoretical value of market capitalization for firm i in year t. The individual fixed effects represent non-financial information contained in the intrinsic company value. The time fixed effects account for external shocks and reflect various shocks common to the whole economy. Therefore, the company fundamentals are defined as the values that remove the time fixed effects from the theoretical values of market capitalization. The logarithmic form of the company fundamentals can be written as follows:

$$\ln \tilde{Y}_{it} = \ln \hat{Y}_{it} - \hat{\lambda}_t = \hat{a} + \hat{b}_1 \ln X_{1,it} + \hat{b}_2 \ln X_{2,it} + \hat{\mu}_i \qquad (4)$$

where, $\tilde{Y}_{it}$ denotes the company fundamentals for firm i in year t.

Figure 2 shows the scatter of the logarithmic company fundamentals plotted against the logarithmic market capitalization using pooled data for the period (2003-2016). Figure 2 suggests that the relationship between the company fundamentals and market capitalization is highly positive. The company fundamentals for market capitalization are well reflected in market capitalization.

Figure 2: Scatter diagram of the logarithmic company fundamentals plotted against the logarithmic market capitalization. (Figure 2 is presented in Figure Section in this chapter.)

Using the company fundamentals described above, firm-level shocks are estimated. As company fundamentals are calculated using both financial and non-financial data (i.e., individual fixed effects), company fundaments can represent the intrinsic company value. However, market capitalization is defined as the total market value of all outstanding shares and refers to corporate value evaluated by the stock market. Thus, market capitalization can be volatile. Therefore, the firm-specific shocks are defined as the deviations of market capitalization from company fundamentals. The firm-specific shock can be written as follows:

$$D_{it} = \ln Y_{it} - \ln \tilde{Y}_{it} \qquad (5)$$

where, D_{it} denotes firm-specific shocks for firm i in year t. D_{it} is the logarithmic form of the difference which refers to deviation rates of market capitalization from the company fundamentals. If the company fundamentals are normally reflected in market capitalization, the deviation would be zero. Therefore, D_{it} represents the firm-specific shocks that are unexpected.

3.4. Constructing granular residual

Gabaix (2011) construct the 'granular residual' Γ_t, as a simple measure of shocks to the top largest firms. The granular residuals are defined as the sum of the idiosyncratic firm-level shocks, weighted by size, and written as follows:

$$\Gamma_t = \sum_{i=1}^{K} \frac{S_{i,t-1}}{Y_{t-1}} \hat{\varepsilon}_{it} \qquad (6)$$

where, Γ_t denotes granular residual in year t. K is the number of the top largest firms, $S_{i,t-1}$ and Y_{t-1}, denote sales of firm i and GDP in year $t-1$, respectively. $\hat{\varepsilon}_{it}$ denotes the estimated idiosyncratic firm-level shock of firm i in year t. Gabaix (2011) based his calculation on GDP fluctuations, using granular residuals in Equation (6).

In this study, following the definition of the granular residual in Equation (6), the granular residuals are defined as follows:

$$\Gamma_t = \sum_{i=1}^{K} \frac{y_{i,t-1}}{Y_{t-1}} D_{it} \qquad (7)$$

where, Γ_t denotes granular residual in year t. $y_{i,t-1}$ denotes the market capitalization for firm i in year $t-1$; Y_{t-1} denotes the aggregate market capitalization in the economy in year $t-1$; D_{it} denotes firm-specific shock for firm i in year t which are estimated using the panel regression model described in previous section. K is the number of the top largest firms used to calculate the granular residual. K indicates the granular size of the economy.

In most empirical studies that follow the approach by Gabaix (2011), they calculate the granular residuals of the top 100 largest firms and evaluate the explanatory power of the granular residuals. In the study of Gabaix (2011), the granular residual is calculated for the top 100 largest firms using US sales of the top 100 largest non-oil firms in Compustat data from 1951 to 2008, where the sum of the sales of the top 100 largest firms is approximately 30 % in GDP. However, Gabaix (2011) does not mention the granular size of the economy in his study. In this study, market capitalization is used as firm size to calculate an individual firms' weight. The top 100 largest firms' market capitalization accounts for a significant share of the aggregate market capitalization (on average, it is 49.9 %). As presented in Table 1, even the top 50 largest firms' market capitalization accounts for a 37.3% share of aggregate market capitalization. Therefore, in this study, the granular residual of the top 10, 20, and 50 largest firms as well as the top 100 largest firms are calculated,

3.5 Granular residual and aggregate fluctuations

Using the granular residuals calculated based on firm-specific market capitalization shocks, whether the granular hypothesis holds on the stock market is examined. The study of Gabaix (2011) tests the granular hypothesis by regressing the growth rate of GDP on the granular residual. He evaluates the explanatory power of the granular residual based on the R-squared value derived from an ordinally least squared (OLS) regression model.

In this study, the granular regressions model is written as follows:

$$GY_t = c + \beta_1 \Gamma_t + \beta_2 \Gamma_{t-1} + u_t \quad (8)$$

where, GY_t denotes the growth rate of the aggregate market capitalization; Γ_t and Γ_{t-1} are contemporaneous and lagged granular residuals calculated in the previous section, and u_t is the error term. Equation (8) is estimated using an OLS regression model.

In Table 5, the results of the granular regression are presented. Table 5 shows the results of regression four cases, the top10, 20, 50, and 100 largest firms. Idiosyncratic firm-level shocks at the top largest firms (i.e., granular residuals) are positively correlated with contemporaneous aggregate growth, but negatively correlated with lagged aggregate growth. The regression results of the top100 largest firms yield an adjusted R squared value of 0.713, implying that the granular residual of the top 100 largest firms explains 71% of the variation in aggregate growth. This is more than 49.9% of the average share of the top 100 largest firms in aggregate market capitalization. In addition to the top 100 largest firms, the explanatory power of the granular residuals of the top10, 20, and 50 largest firms are tested. According to the adjusted R squared values presented in Table 5, the granular residual of the top 10 largest firms explains 34% of the variation in aggregate growth, and that of the top 20 and 50 largest firms explain 45% and 51% of the variation in aggregate growth, respectively. The adjusted R squared value sharply increases from the top 10 to the top 20 firms and moderately increases from the top 20 to the top100 firms.

Table 5 Results of granular regression for growth of aggregate market capitalization

K	share	c		β1		β2		R2	Adj. R2
Top10	14.7%	0.063		9.811	**	−7.598	**	0.457	0.336
		(1.53)		(2.62)		(−2.44)			
Top20	23.1%	0.055		5.289	**	−5.202	**	0.549	0.449
		(1.53)		(2.97)		(−3.07)			
Top50	37.5%	0.052		4.074	***	−3.863	***	0.601	0.512
		(1.52)		(3.44)		(−3.35)			
Top100	49.9%	0.049	*	2.752	***	−2.689	***	0.766	0.713
		(1.95)		(4.91)		(−4.79)			

Notes: The dependent variable is the growth of aggregate market capitalization. The explanatory variables are granular residuals calculated based on the firm-specific shocks defined as the deviations of market capitalization from the company fundamentals. The numbers in parentheses are t-statistic. ***, **, * indicate significant levels of 1%, 5%, 10%, respectively. The share is the average share for the period (2003-2015). K is the number of top large firms.

The average shares of the aggregate market capitalization of the top large firms are presented in the second column of Table 5. Although the share of the aggregate market capitalizations of the top 10 largest firms is only 14.7 %, it explains 33.6 % of the variation in aggregate growth. The situations of the top 20, 50 and 100 largest firms are the same. These top largest firms are responsible for the variation in aggregate growth more than the average share of the aggregate market capitalization. The explanatory power of the granular residual in this study is higher than that of other empirical studies. One of the reasons might be that market capitalization is variable in the financial economy instead of variables in the real economy, such as sales and exports. As presented in Table1, market capitalization is highly concentrated in the top largest firms, in which the sum of the market capitalization of the top 100 largest firms is almost half of the total.

In addition, using macro aggregates other than market capitalization, such as PSR and PBR[26], the impact on idiosyncratic firm-level stock market shock is investigated. Regressing growth of PSR and growth of PBR on granular residuals calculated based on firm specific market capitalization shocks, regression model Equation (8) is performed.

The results of the regression analysis are presented in Table 6 and 7. The adjusted R squared values of the regression results presented in Table 6 and 7, indicate that the granular residuals of the top 100 largest firms explain 86% of the variation in PSR growth and 93% of the variation in PBR growth. The impacts of the granular residual on PSR and PBR are somewhat stronger than the aggregate market capitalization. Thus, the aggregate fluctuations in the stock market are almost all determined by the top 100 largest firms' behavior.

Table 6 Results of granular regression for growth of PSR

K	share	c	β1		β2		R2	Adj. R2
Top10	14.7%	0.035	10.190	**	−9.538	**	0.526	0.421
		(0.85)	(2.72)		(−3.06)			
Top20	23.1%	0.021	5.626	***	−6.230	***	0.629	0.546
		(0.58)	(3.24)		(−3.77)			
Top50	37.5%	0.018	4.676	***	−4.840	***	0.756	0.701
		(0.62)	(4.71)		(−5.00)			
Top100	49.9%	0.015	3.026	***	−3.245	***	0.889	0.864
		(0.76)	(7.31)		(−7.83)			

Notes: The dependent variable is growth of PSR. The explanatory variables are the granular

[26] In this study, PSR and PBR are treated as macro variable described in footnote of Section 3.1

residuals calculated based on the deviations of the market capitalization from the company fundamentals as firm-specific shocks. The numbers in parenthesis are t-statistics, ***, **, *** indicate significance levels of 1%, 5%, 10%, respectively. The share is the average share for the period (2003-2015).

Table 7 Results of granular regression for growth of PBR

K	share	c	β1		β2		R2	Adj. R2
Top10	14.7%	0.003	8.200	***	−6.998	***	0.593	0.502
		(0.10)	(3.30)		(−3.38)			
Top20	23.1%	−0.006	4.530	***	−4.597	***	0.709	0.645
		(−0.27)	(4.12)		(−4.39)			
Top50	37.5%	−0.009	3.685	***	−3.502	***	0.837	0.800
		(−0.53)	(6.34)		(−6.18)			
Top100	49.9%	−0.012	2.356	***	−2.274	***	0.943	0.930
		(−1.21)	(11.07)		(−10.67)			

Notes: The dependent variable is growth of PBR. The explanatory variables are granular residuals calculated based on the deviations of market capitalization from the company fundamentals as firm-specific shocks. The numbers in parenthesis are t-statistics, ***, **, *** indicate significance levels of 1%, 5%, 10%, respectively. The share is the average share for the period (2003-2015).

The granular residuals perform well in explaining the aggregate fluctuations in the stock market. Furthermore, a small number of the top largest firms、 such as the top 10 or 20 largest firms, greatly affects aggregate fluctuations in the stock market than the real economy. The granular hypothesis was found to hold in the stock market. Figure 3 shows the growth of the aggregate variable in the stock market, including market capitalization, PSR, PBR. All three variables drastically fluctuate from 2007 to 2009, indicating the influence of the global financial crisis of 2007-2008.

Figure 3: Growth of the aggregate variables in the stock market. (Figure 3 is presented in Figure Section in this chapter.)

3.6 Individual industry's contributions to aggregate fluctuations

In this section, using the granular regression results, investigations were done to determine which firms or industries played a dominant role in determining the aggregate fluctuations of market capitalization. However, the members of the top large firms change over time. For example, a firm may be ranked far below the top 100 largest firms at the beginning of an observation period (2003-2016) but may be ranked in the top-class firms at the latter half of the period.

3.6.1 Identifying top-ranked firms

To investigate an individual firms' contributions to aggregate fluctuations, it is necessary to identify the top large firms that are ranked among the top 100 largest firms throughout the observation period (2003-2016). Calling these large firms, the 'top-ranked firms' instead of the top large firms, the top-ranked firms are identified based on their average annual rank during the observation period. The 3917 firms are ranked for each year during observation period 2003-2016 based on their market capitalization and calculated average annual rank for the observation period[27]. Thus, a firm whose average annual rank is the least is the top-ranked firm, whereas a firm whose average annual rank is the highest is the least-ranked firm. The top 100 ranked firms in this study are listed with industry, country code, and their average market stock prices during the observation period (2003-2016) in Table 8.

Table 8 The top 100 ranked firms: (Table 8 is presented next to the Reference Section in this chapter)

The market stock prices of the top-ranked firms in market capitalization are very low, although some exceptions exist. Approximately two-thirds of their average market stock prices during the research period (2003-2016) were less than 50 US$. Thus, the number of outstanding shares of the top ranked firms in market capitalization was quite large. Different from market stock price, 42 firms out of the top 100 ranked firms were US firms, whereas most of firms with high market stock price were West European firms as described in Chapter 1.

Hereafter, the top 100 ranked firms' data are used for analysis. The firms ranked above the 50th rank keep their annual ranks within the top 100 rank throughout the observation period, however, firms ranked below the 50th rank do not always keep their annual ranks above the 100th rank. Hence, the top 50 ranked firms stably keep their position in the top class, whereas the top 100 ranked firms contain firms whose fluctuations in the annual rank during the observation period were large.

3.6.2 Calculating individual firm's contribution

After regressing the aggregate market capitalization of growth on the granular residuals of the top-ranked firms[28], the regression results presented in Table 9 were obtained. Overall, the regression results are consistent with those in Table 5. The explanatory power of the granular residuals of the top-ranked firms are a little high than those of the top large firms, except those of the top 100 largest firms, although the average shares of the top-ranked firms in the aggregate

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[27] Market capitalization used in this study are annual firm data

[28] Performing granular regressions of Equation (8), the adjusted R squared values of each regression are derived for the top10,20 ,50 and 100 ranked firms.

market capitalization presented in the second column of Table 9 are slightly smaller than those presented in Table 5. This is because the top 100 ranked firms contain firms whose annual rank are not stable, whereas the top 10, 20, and 50 ranked firms stably keep their position in the top class.

Table 9 Results of granular regression of top tanked firm for growth of aggregate market capitalization

K	share	c		β1		β2		R2	Adj. R2
Top10	13.1%	0.062		8.401	**	−7.995	**	0.491	0.377
		(1.53)		(2.64)		(−2.73)			
Top20	21.5%	0.065		6.452	***	−5.940	***	0.594	0.504
		(1.53)		(3.33)		(−3.37)			
Top50	36.4%	0.052		4.116	***	−3.975	***	0.662	0.587
		(1.52)		(3.83)		(−3.80)			
Top100	48.5%	0.051	*	3.026	***	−2.882	***	0.751	0.696
		(1.95)		(4.77)		(−4.60)			

Note: The dependent variable is the growth of the aggregate market capitalization. The explanatory variables are granular residuals calculated based on the deviation of market capitalization from the company fundamentals as firm specific shocks. The numbers in parenthesis are t-statistics, ***, **, *** indicate significance levels of 1%, 5%, 10%, respectively. The share is the average share for the period (2003-2015).

Using the granular regression results in Table 9, the individual firms' contribution to aggregate growth was calculated as follows:

$$\hat{c}_{it} = \hat{\beta}_1 \Gamma_{it} + \hat{\beta}_2 \Gamma_{it-1} \qquad (9)$$

where, $\hat{c}_{it}$ denotes an individual firms' contribution growth to the aggregate growth of firm i in year t, $\hat{\beta}_1$ and $\hat{\beta}_2$ are estimated parameters from the regression model, Equation (8). Γ_{it} and Γ_{it-1} are the granular residual for firm i in year t and the lagged granular residuals for firm i. Using the estimated parameters of the top 100 ranked firms, $\hat{\beta}_1 = 3.026$ and $\hat{\beta}_2 = -2.882$ in the last line of Table 9, the individual firms' contribution to aggregate growth, $\hat{c}_{it}$, was calculated for the top 100 ranked firms.

Table 10 presents firms with the highest and lowest contribution growth[29] in each year from 2005 to 2016. The individual firms' contribution growth to aggregate growth is quite small. However, the fluctuations are quite large. There seems to be a salient phenomenon that a firm's contribution changes from the highest to the lowest, or from the lowest to highest, in a year. For example, APPLE's contribution changes from the highest in 2012 to the lowest in 2013, and it changes from the lowest in 2013 to the highest in 2014. Similar movements were observed with

[29] Firm's contribution growth is not firm's actual growth rate, but is estimated using Equation (9)

EXXON MOBIL (from 2013 to 2014), GENERAL ELECTRIC (from 2015 to 2016), ROCHE (from 2009 to 2010), NESTLE (from 2010 to 2011), and ASTRAZENECA (from 2007 to 2008). These top ranked firms play a dominant role in determining the aggregate fluctuation of market capitalization.

Table 10 Contribution to aggregate market capitalization growth by firms

Year	Highest firm	industry code	contribution growth (%)	Lowest firm	industry code	contribution growth (%)
2005	TOYOTA	2510	1.04	COCONOPHILLIPS	1010	▲ 1.5
2006	EXXON MOBIL	1010	1.45	EBAY INC	4510	▲ 0.7
2007	CHINA MOBILE	5010	2.09	ASTRAZENECA	3520	▲ 2.2
2008	ASTRAZENECA	3520	1.55	GENERAL ELECTRIC	2010	▲ 4.5
2009	DAIMLAR	2510	1.44	ROCHE	3520	▲ 1.8
2010	ROCHE	3520	2.58	NESTLE	3020	▲ 1.2
2011	NESTLE	3020	1.17	BP PLC	1010	▲ 1.6
2012	APPLE	4520	1.04	ORACLE	4510	▲ 1.1
2013	EXXON MOBILE	1010	1.08	APPLE	4520	▲ 3.0
2014	APPLE	4520	2.71	EXXON MOBIL	1010	▲ 0.8
2015	GENERAL ELECTRIC	2010	6.67	TOYOTA	2510	▲ 0.1
2016	CHEVRON	1010	1.01	GENERAL ELECTRIC	2010	▲ 4.4

Notes: Industry codes are shown in Table 11. ▲ indicates negative sign.

Next, to identify the industry that plays a major role in determining the aggregate market capitalization fluctuations, the individual firms' contribution to aggregate growth, $\hat{c}_{it}$, is aggregated into individual industries. The top 100 ranked firms were classified into 21 industries based on the four-digit GICS code. Table11 presents the number of firms in each industry with their total share. Only four industries, the energy industry, the capital goods industry, the pharmaceutical, biotechnology & life sciences industry, and the telecommunication services industry had more than 10 firms. Seventeen industries had a few firms.

Figure 4 shows the contribution growth of each industry to the aggregate growth fluctuations during the period (2005-2016). The figure reveals that the energy and capital goods industries greatly affect the aggregate growth fluctuation. As depicted in Figure 3, the aggregate market capitalization fluctuated drastically during the research period (2007-2009), implying an influence from the global financial crisis of 2007-2008. The drastic fluctuations for the period 2007-2009 was driven largely by firms in the energy and capital goods industries. These two industries mainly comprise firms, such as those listed in Table 10. The energy industry consists of firms, such as EXXON MOBILE, CHEVRON, COCONOPHILLIPS, and BP PLC. The capital goods industry consists of firms, such as GENERAL ELECTRIC, and SIEMENS[30].

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[30] Although SIEMENS does not appear in Table 10, this firm is ranked 24th and the second large firms in capital goods industry.

Figure 4: Industrial contribution to aggregate market capitalization growth. (Figure 4 is presented in Figure Section in this chapter.)

Table 11 Industry of the top 100 ranked firms

industry code	industry group	number of firms	average share (%)
1010	Energy	12	8.3
1510	Materials	5	1.7
2010	Capital Goods	12	4.7
2020	Commercial & Professional Services	0	0
2030	Transportation	4	0.8
2510	Automobiles & Components	6	2.4
2520	Consumer Durables & Apparel	3	0.7
2530	Consumer Service	0	0
2540	Media	3	1.1
2550	Retailing	4	1.3
3010	Food & Staples Retailing	3	1.8
3020	Food, Beverage & Tabaco	8	4.2
3030	Household & Personal Products	1	0.4
3510	Health Care Equipment & Services	1	0.5
3520	Pharmaceuticals, Biotechnology & Life Sciences	10	5.6
4510	Software & Services	5	4
4520	Technology Hardware & Equipment	4	3.2
4530	Semiconductors & Semiconductor Equipment	3	1.6
5010	Telecommunication Services	11	5.3
5510	Utilities	4	0.9
6010	Real Estate	1	0.2
Total		100	48.7

Note: The average share indicates the industry's market capitalization share in total during the observation period (2003-2015).

Finally, how the individual industries affect the aggregate fluctuation is investigated using granular regression. As shown above, the energy and capital goods industries play a major role in aggregate fluctuation. Focusing on these two industries, the aggregate market capitalization growth is regressed on the granular residuals of these two major industries. Table 12 shows the regression results of the two industries. The regression of the energy industry yields 0.647 adjusted R squared, explaining about 65% of the variation in the aggregate market capitalization growth. That of the capital goods industry yields 0.339 adjusted R squared. The regression results of the top100 ranked firms (see Table 9) indicate that the energy and capital goods industries have quite a large influence on the aggregate fluctuation.

Table 12 Results of granular regression of major industry for growth of aggregate market capitalization

Industry	share	c		β1		β2		R-squared	Adj. R squared
Energy	8.3%	0.061	*	9.654	***	−8.796	***	0.712	0.647
		(2.09)		(4.18)		(−4.00)			
Capital Goods	4.7%	0.043		10.390	**	−10.158	**	0.459	0.339
		(1.08)		(2.44)		(−2.28)			

Notes The dependent variable is the growth of the aggregate market capitalization. The explanatory variables are the industrial granular residuals calculated based on the individual firms' granular residuals. The numbers in parenthesis are t-statistics, ***, **, *** indicate significance levels of 1%, 5%, 10%, respectively. The share is the average share for the period (2003-2015).

3.7 Concluding remarks

This study investigates the granular hypothesis on the stock market. The data used in this study was the market capitalization of 3,917 firms listed worldwide over a 14-year period (2003-2016). The idiosyncratic firm-level shocks are defined as the deviations of market capitalization from company fundamentals, which are calculated with the panel two-way fixed effects regression model for market capitalization using cash flow and book value as explanatory variables. The extent to which the idiosyncratic firm-level shocks of the stock market on the top largest firms explain aggregate macroeconomic fluctuations in the world economy was investigated. Furthermore, using the individual firm-level granular residuals to estimate the industrial contributions to the aggregate market capitalization growth, analyses were done to determine which industries played a major role in the aggregate fluctuations.

The idiosyncratic firm-level shock on the top 10 largest firms were found to explain approximately 30% of the variation in the aggregate market capitalization growth in the world economy, and the idiosyncratic firm-level shocks on the top 20, 50, and 100 largest firms explain approximately 40%, 50%, and 70%, of the variation in the aggregate market capitalization growth, respectively. The explanatory powers of the granular residuals are more than their share in the aggregate fluctuation. To investigate whether idiosyncratic market capitalization shocks affect aggregate variables other than market capitalization, such as PSR, and PBR, granular regression models were performed using the growth of PSR and growth of PBR as a dependent variable, respectively. The explanatory power of granular residuals for these two were higher than market capitalization

Regarding the industrial contribution to the aggregate market capitalization growth, the energy and capital goods industries are found to drive drastic fluctuations during the research period (2007-2009), implying an influence from the global financial crisis.

This study investigates the granular hypothesis on the stock market, using data from firms from the worldwide economy, but not a closed economy, such as a country, industry, or region. The granular hypothesis is strongly accepted in this study and quite a small number of large firms can be classified as a granular economy in the stock market.

This study uses data from 2003 to 2016, including the stock market crash of 2008, however, the data period for the analysis is short than that of other related studies. In a future study, the data period will be expanded to the current year.

Appendix. Estimating power-low exponent

Caluset et al. (2009) proposed a statistical framework that identifies the power-law distribution and estimates power-law exponents in empirical data. The statistical framework is summarized below.

A.1 Estimation for power-law exponent

The probability density function of a continuous power-law distribution is expressed as follows:

$$p(x)dx = \Pr(x \le X < x + dx) = Cx^{-\alpha}dx \qquad \text{(A1)}$$

where, X is the observed value, C is a normalized constant, α is power-law exponent.

The normalized constant, C is calculated using the normalization requirement:

$$1 = \int_{x_{\min}}^{\infty} p(x)dx = C\int_{x_{\min}}^{\infty} x^{-\alpha}dx = \frac{C}{1-\alpha}\left[x^{-\alpha+1}\right]_{x_{\min}}^{\infty} \qquad \text{(A2)}$$

If $\alpha > 1$, then the equation (A2) gives

$$C = (\alpha - 1)x_{\min}^{\alpha-1} \qquad \text{(A3)}$$

Substituting (A3) into equation (A1), the probability function of a power-law can be written as follow:

$$p(x) = \frac{\alpha - 1}{x_{\min}}\left(\frac{x}{x_{\min}}\right)^{-\alpha} \qquad \text{(A4)}$$

If the lower bound $x_{\min}$ is known and the empirical data distribution can be assumed to follow a power-law, the parameter α can be estimated by the maximum likelihood estimator (MLE)method.

$$\hat{\alpha} = 1 + n\left[\sum_{i=1}^{n} \ln \frac{x_i}{x_{\min}}\right]^{-1} \quad \text{(A5)}$$

where, x_i, $i = 1, \ldots, n$ are observed values of x such that $x_i \geq x_{\min}$. $\hat{\alpha}$ denotes estimates derived data.

A.2 Estimating lower bound, $x_{\min}$

The case that empirical data follows a power-law distribution for all values of x does not usually occur. Normally, a power-law applies only for values of x greater than some minimum value, $x_{\min}$, that is, only the tail of the distribution follows a power-law. Thus, it is important to estimate the lower bound, $x_{\min}$ on power-law behavior before calculating the parameter α by the MLE method described above.

Caluset et al. (2009) proposed the approach for estimating $x_{\min}$, choosing the value of $x_{\min}$ that makes the probability distribution of the empirical data and the best-fit power-law model as similar as possible above $\hat{x}_{\min}$. The distance between the two probability distributions is measured using a Kolmogorov-Smirnov (KS) statistic.

$$D = \max_{x \geq x_{\min}} \left| S(x) - P(x) \right| \quad \text{(A6)}$$

where, $S(x)$ is the CDF (complementary cumulative distribution function) of the data for the observations with a value of at least $x_{\min}$ and、$P(x)$ is the CDF for the power-law model that best fits the data in region $x \geq x_{\min}$. The estimates $\hat{x}_{\min}$ is the value of $x_{\min}$ that minimizes D. Using this $\hat{x}_{\min}$ in equation (A5), the parameter α can be estimated accurately.

A.3 Testing the power-law hypothesis

Tests of the estimate parameters for α and $x_{\min}$ use a bootstrapping simulation. The test procedure is as follows.

First, compute the KS statistic for the empirical data and the theoretical model with the MLE parameters estimated for the empirical data: Next, generate a large number of synthetic data sets following the theoretical model with the MLE parameters estimating empirical data. Third, for each synthetic data set, compute its own MLE parameters and fit to the theoretical model with the estimated parameters. Record the KS statistic for the fit. Last, count what fraction of the time the resulting KS statistic for synthetic data sets is larger than or equal to the KS statistic for the empirical data. This fraction measures the fitness significance, p-value.

Clause et al. (2009) suggests rejecting the hypothesis of goodness of fit of the observed data with respect to the theoretical model if the p-value is lower than 0.1.

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Tables

Table 8 The top 100 ranked firms

rank	company name	industry code	country code	average market stock price (US$)
1	EXXON MOBIL CORP	1010	US	76.6
2	MICROSOFT CORPORATION	4510	US	31.0
3	GENERAL ELECTRIC COMPANY	2010	US	27.2
4	WALMART INC.	3010	US	59.4
5	NESTLE S.A.	3020	CH	51.8
6	PFIZER INC	3520	US	25.8
7	CHEVRON CORPORATION	1010	US	87.2
8	NOVARTIS AG	3520	CH	62.7
9	CHINA MOBILE LIMITED	5010	HK	9.4
10	TOYOTA MOTOR CORPORATION	2510	JP	48.8
11	AT&T INC.	5010	US	32.1
12	INTERNATIONAL BUSINESS MACHINES CORP	4510	US	133.4
13	BP PLC	1010	GB	8.3
14	COCA-COLA COMPANY (THE)	3020	US	31.7
15	TOTAL S.A.	1010	FR	57.2
16	INTEL CORP	4530	US	25.8
17	CISCO SYSTEMS INC	4520	US	22.5
18	VERIZON COMMUNICATIONS INC	5010	US	40.6
19	ORACLE CORP	4510	US	25.4
20	SAMSUNG ELECTRONICS CO., LTD.	4520	KR	858.0
21	PEPSICO INC	3020	US	71.0
22	SANOFI	3520	FR	83.3
23	ROCHE HOLDING AG	3520	CH	187.0
24	SIEMENS AG	2010	DE	97.5
25	ENI S.P.A.	1010	IT	23.6
26	CONOCOPHILLIPS	1010	US	59.5
27	HOME DEPOT INC	2550	US	59.4
28	SCHLUMBERGER N.V.	1010	CW	66.3
29	ALTRIA GROUP, INC.	3020	US	49.0
30	QUALCOMM INC	4530	US	49.5
31	NTT DOCOMO INC	5010	JP	17.5
32	AMGEN INCORPORATED	3520	US	87.2
33	WALT DISNEY CO	2540	US	46.8
34	ABBOTT LABORATORIES	3510	US	48.4
35	L'OREAL SA	3030	FR	123.8
36	UNITED TECHNOLOGIES CORPORATION	2010	US	77.5
37	SAP SE	4510	DE	59.2
38	BHP BILLITON LIMITED	1510	AU	25.6
39	BRITISH AMERICAN TOBACCO P.L.C.	3020	GB	38.3
40	DEUTSCHE TELEKOM AG	5010	DE	16.6
41	3M COMPANY	2010	US	103.0
42	COMCAST CORPORATION	2540	US	32.9
43	APPLE INC.	4520	US	48.1
44	DAIMLER AG	2510	DE	63.7
45	BRISTOL-MYERS SQUIBB COMPANY	3520	US	36.6
46	STATOIL ASA	1010	NO	21.2
47	LVMH MOET HENNESSY - LOUIS VUITTON SE	2520	FR	130.4
48	BASF SE	1510	DE	66.6
49	ASTRAZENECA PLC	3520	GB	50.6
50	HONDA MOTOR CO LTD	2510	JP	31.4

Table 8 continued

rank	company name	industry code	country code	average market stock price (US$)
51	NIPPON TELEGRAPH AND TELEPHONE CORPORATION	5010	JP	26.5
52	BAYER AG	3520	DE	80.4
53	RIO TINTO PLC	1510	GB	48.9
54	DIAGEO PLC	3020	GB	20.6
55	CNOOC LIMITED	1010	HK	1.3
56	CANON INC	4520	JP	38.3
57	ORANGE	5010	FR	22.3
58	ENEL SPA	5510	IT	6.3
59	OCCIDENTAL PETROLEUM CORP	1010	US	67.2
60	HONEYWELL INTERNATIONAL INC	2010	US	61.9
61	RELIANCE INDUSTRIES LIMITED	1010	IN	7.9
62	CATERPILLAR INC	2010	US	71.5
63	LOWE'S COMPANIES, INC.	2550	US	38.3
64	TEXAS INSTRUMENTS INC	4530	US	36.3
65	BHP BILLITON PLC	1510	GB	22.8
66	EBAY INC	4510	US	36.6
67	BAYERISCHE MOTOREN WERKE AG	2510	DE	71.4
68	NISSAN MOTOR CO LTD	2510	JP	9.4
69	HENNES & MAURITZ AB	2550	SE	28.2
70	TELSTRA CORPORATION LIMITED	5010	AU	3.7
71	TARGET CORP	2550	US	55.6
72	AMERICA MOVIL S.A.B. DE C.V.	5010	MX	1.0
73	SINGAPORE TELECOMMUNICATIONS LTD	5010	SG	2.4
74	DANONE	3020	FR	63.4
75	TAKEDA PHARMACEUTICAL CO., LTD.	3520	JP	48.4
76	IBERDROLA SA	5510	ES	7.4
77	UNION PACIFIC CORP	2030	US	50.8
78	TEVA PHARMACEUTICAL INDUSTRIES LIMITED	3520	IL	43.3
79	LOCKHEED MARTIN CORP	2010	US	112.8
80	TESCO PLC	3010	GB	5.4
81	EMERSON ELECTRIC CO	2010	US	45.5
82	ABB LTD	2010	CH	17.8
83	KDDI CORPORATION	5010	JP	14.0
84	IMPERIAL OIL LIMITED	1010	CA	36.8
85	VIVENDI	2540	FR	27.8
86	SOUTHERN CO	5510	US	39.8
87	MITSUBISHI CORPORATION	2010	JP	20.5
88	L'AIR LIQUIDE SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE	1510	FR	87.4
89	NIKE INC	2520	US	33.7
90	COSTCO WHOLESALE CORP	3010	US	79.4
91	DENSO CORPORATION	2510	JP	35.2
92	SCHNEIDER ELECTRIC SE	2010	FR	58.5
93	EXELON CORPORATION	5510	US	44.3
94	CANADIAN NATIONAL RAILWAY COMPANY	2030	CA	54.1
95	SUN HUNG KAI PROPERTIES LIMITED	6010	HK	11.9
96	IMPERIAL BRANDS PLC	3020	GB	35.1
97	FEDEX CORP	2030	US	102.9
98	GENERAL DYNAMICS CORP	2010	US	85.2
99	DEUTSCHE POST AG	2030	DE	25.2
100	SONY CORPORATION	2520	JP	32.3

Figures

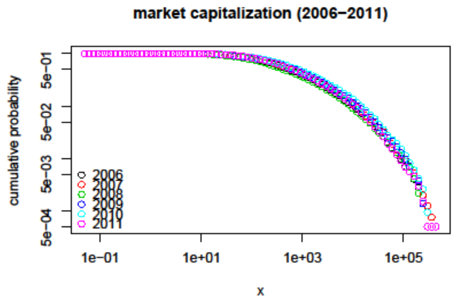

Figure1 Complementary cumulative distribution of market capitalization during the research period (2006-2011).

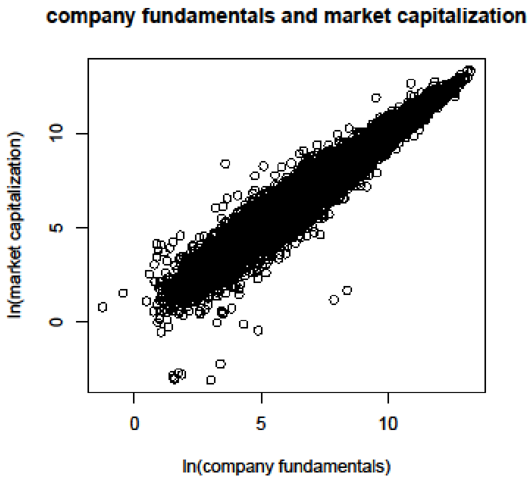

Figure 2 Scatter diagram of the logarithmic company fundamentals plotted against the logarithmic market capitalization using pooled data for the period (2003-2016). The correlation between the market capitalization and the company fundamentals is 0.981.

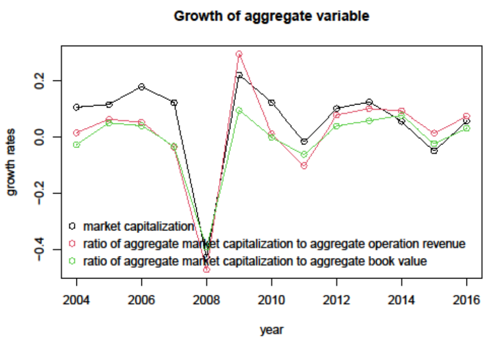

Figure 3 Growth of the aggregate variables in the stock market. All three variables, including market capitalization. PSR, and PBR, drastically fluctuate from 2007 to 2009, indicating the influence of the global financial crisis of 2007-2008.

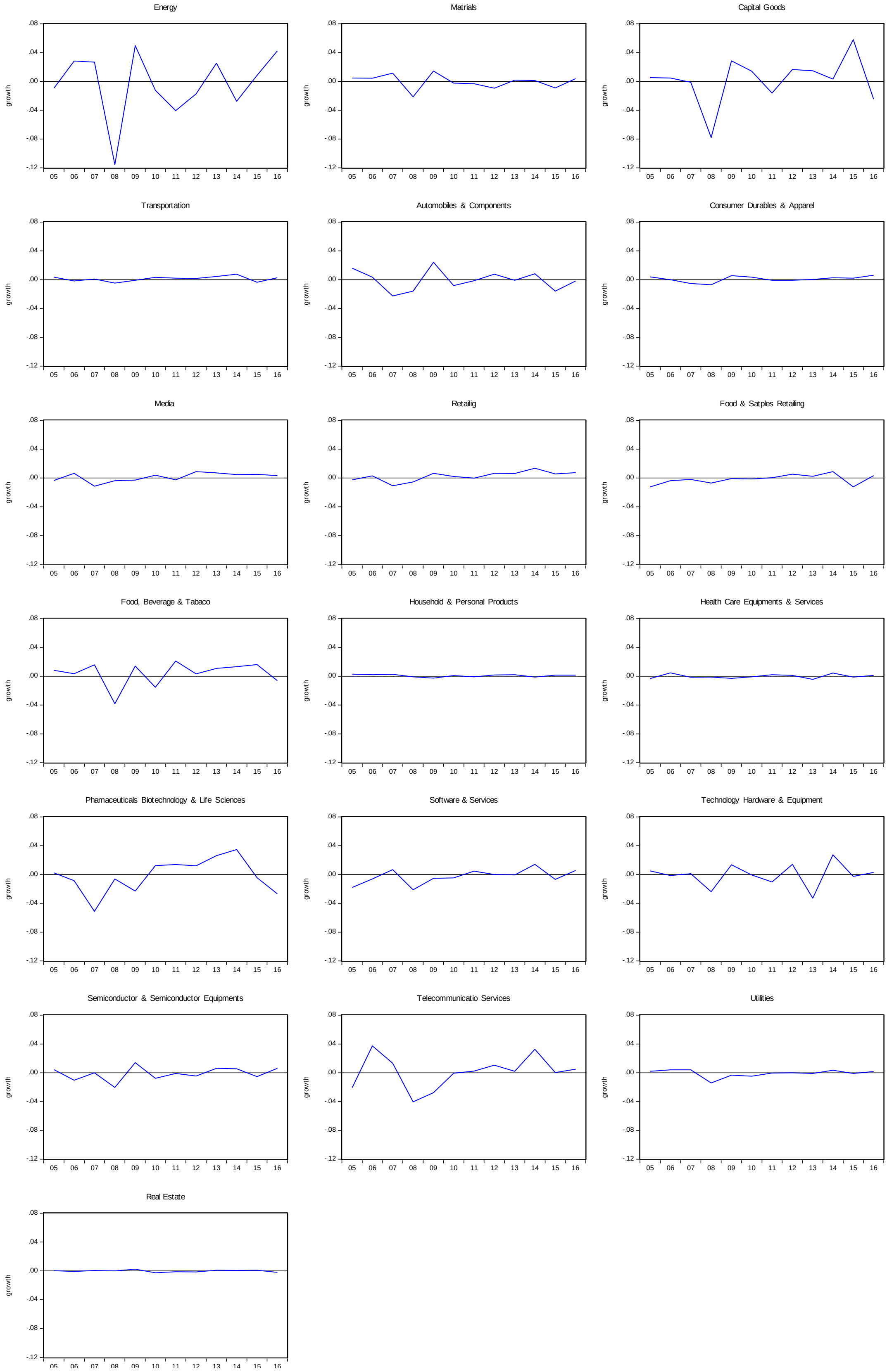

Figure 4 Industrial contribution to aggregate market capitalization growth.

Final Chapter

This research empirically investigated macro tail risk in the stock market. Market stock prices are determined in the stock market, where investors evaluate stock value for corporate values using all available information about the targeted firms.

To estimate corporate values from the market stock price, an econometric model was constructed using panel data for financial indicators per share from a total of 3,917 industrial firms listed worldwide. The econometric model is the panel two-way fixed effects regression model in which the market stock price is a dependent variable, and cash flow per share and book value per share are explanatory variables for the market stock price. These financial indicators are representative variables that are commonly used to evaluate a firm's business performance. The panel two-way fixed effects regression model enables us to estimate two fixed effects: unobservable individual fixed effects and unobservable time fixed effects. The explanatory power of the panel regression model is high indicating an adjusted R-squared value, 0.96. Referring to the estimates of the panel two-way fixed effects regression model as theoretical values, the company fundamentals are calculated without controlling for individual fixed effects but controlling for time effects in the theoretical values. Thus, the company fundamentals can represent intrinsic corporate values. Examining relationship between market stock prices and company fundamentals, company fundamentals were found to be well reflected in the market stock price.

Applying the panel two-way fixed effects regression model to market capitalization instead of the market stock price, using cash flow and book value as explanatory variables for market capitalization, the company fundamentals for market capitalization were calculated. The model results in good performance, indicating high explanatory power. The distributions of the company fundamentals for market capitalization were found to follow a power-law distribution.

The granular hypothesis introduced by Gabaix (2011) holds that idiosyncratic firm-level shocks to large firms can affect the aggregate through their size in the economy. Following the approach proposed by Gabaix (2011), the granular hypothesis on the stock market was investigated using market capitalization as a macro variable in the stock market. Defining idiosyncratic firm-level shocks to firms as the deviations of market capitalization from the company fundamentals, granular residuals were calculated. Regressing the growth of the aggregate market capitalization on granular residuals using the OLS model, a high R-squared value was obtained. Thus, the granular hypothesis is strongly accepted in this study. This research empirically showed support for the use of the granular hypothesis on the stock market using market capitalization. Furthermore, firm-level shocks to quite a small number of the top largest firms were found to cause the aggregate fluctuations in the stock market compared with the real economy.