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Econometrics and Management Science - Quantitative Finance

Driving Forces Behind Volatility in Both Growth- and Value- Firms

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Abstract

Firms are often valued using the future cash flows they will generate. A proxy for these cash flows are the company earnings. But while these earnings show an arguably predictable trend, the stock prices are considered to be unpredictable. This research will investigate the relation between stock price movement and earnings growth and volatility. It uses the Kalman Filter to establish whether or not a persistent trend can be found in earnings. Then, it will investigate the relation between the earnings and price movement for both growth and value firms. We used the largest firms in the CRSP US Mega Cap Growth and Value Index. We found that the firms in the data set show persistence in earnings growth. But in general, no relation is found between the earnings growth and price movement. For some firms we find that the earning trend shocks has an effect on the trading volume and volatility of the stock price. But no general statement can be made.

Keywords: Kalman filter, Expectation Maximization, Earnings growth, Stock price volatility

Contents

1 Introduction

Understanding volatility of stocks is crucial for professionals in areas such as risk management. Firms are valued according to various models that asses the future cash flows, e.g. discounted cash flow (DCF) model. Kaplan and Ruback (1995) found that the DCF model provides reliable estimates of the market value of a firm. As argued by Chan, Karceski and Lakonishok (2003) “the expected rate of growth in future cash flows (usually proxied by accounting earnings) plays a pivotal role in financial management and investment analysis”. Expected growth in future free cash flows is relevant for valuation of companies, thus it can be reasoned that when the growth potential of a firm changes, the perceived value of the firm changes.

The underlying dynamics of stock prices and company earnings are very different. Namely, stock prices should behave according to a random walk, i.e. an unpredictable process, while underlying earnings of large firms (such as Apple, Google and Amazon) are arguably predictable, because they have been growing steadily over the last decades. Stocks are thought to be priced according to underlying free cash flows of the firm (e.g., DCF model), but they appear to be more volatile than the cash flows they are based on.

This research will investigate whether the volatility of the stock price can be explained by changes in earnings growth. This gives a better understanding of the driving forces behind changes in valuation of firms and is therefore relevant for equity researchers and professionals in financial management. The focus of this thesis is to explore the possibility of changes in growth being one of the reasons behind asset price volatility. If a relationship between earnings growth and volatility can be found, we want to investigate whether this effect is present in both growth and value firms. Investors consider growth firms to be firms that have the ability to outperform the market for a period of time. These firms are currently more present in sectors like technology and alternative energy. Value firms on the other hand, are firms whose stock trade at a lower price relative to what its fundamentals would imply. Usually, the firms that are considered to be value firms are the more well-established companies that have been around for decades.

A possible reason why stock prices are much more volatile than underlying earnings, might be that the growth perspective of the earnings of the firm has a large influence on investors’ appetite and thus the stock pricing. So changes in analysts’ consensus (expected future earnings) may result in even larger price shocks. Therefore, I would like to investigate whether the changes in stock prices are related to changes in earnings growth. Because if such a relationship exists, then it heavily strengthens the hypothesis that volatility in prices is due to the growth perspective. In other words, the valuation depends on the future cash flows of the firm, and thus the changes in valuation depends on the changes in expectations of the future cash flows. If the consensus changes due to some news like an acquisition or other big (macro-economic) event, the expectations of future cash flows might change, which can cause investors to overreact to this prospect and prices might show an even bigger fluctuation as argued by De Bondt & Thaler (1985). As we see, lowering the growth estimate can have huge negative impact on the valuation of the company.

The earnings data from a selection of large listed firms will be modeled according to a local linear trend model, as described in Chapter 3.2.1 of Durbin & Koopman (2012). This model is a specific variant of the general Gaussian state space model that is capable to capture the underlying level and trend of the timeseries data. Using the Kalman filter, the growth will be extracted from the data. The model is estimated using expectation maximization algorithm (EM). After obtaining the filtered earnings, the relationship between the growth of earnings and change in valuation (the volatility) will be explored using linear regressions. Several regressions are performed in this research. We will do regressions on the *earnings trend*, *earnings trend shock* and *absolute earnings trend shock* to see whether these different variables show different results. Next to these regressions, we will also regress the volatility of the stock prices and the daily trading volume. These will also show us the reaction of the investors due to the earnings announcements.
The focus of this research is to investigate whether a relation can be found between the changes in earnings growth and changes in stock prices for both growth and value firms. First we need to establish whether the growth is statistically significant, therefore the first research question will be:

Is there a significant persistence in growth in quarterly earnings for both growth and value firms?

Next, we want to find out whether a relationship exists between growth and volatility. We ask the following:

Can the changes in stock prices be explained by changes in earnings growth?

Finally, if the relationship found in the previous question is significant for both growth and value firms, we want to know whether there is a significant difference between the two subsets, we therefore ask:

If there is a relationship, is this effect different for growth and value firms?

We found that no relation can be found between stock price growth and earnings growth (shock). For some firms in both growth and value category, we found a relation between the (absolute) earnings trend shock and the volatility and trading volume. But no clear pattern for growth- or value- firms can be distinguished. To use these results, professionals in risk management and valuation have to approach each firm case-by-case since there is no general correlation found. If for a firm they find that there is a relation between (absolute) earnings trend shock and the price volatility, they can adjust their risk models or valuations. The results from this research are less suitable to use in large portfolios, since there is no general correlation found for growth- or value- firms, e.g. they cannot use the earnings trend shock to explain the volatility for a whole portfolio of growth firms. The remainder of this paper is arranged as follows. Section 2 gives insight into related literature and earlier discoveries in the field. Section 3 presents the data and discusses key statistics. Section 4 discusses the models framework as well as the methods used in this research. Finally, Section 5 and Section 6 present the results and conclusion of this research respectively.

2 Literature

Since Fama & Miller (1972) introduced the DCF model, discounting cash flows to calculate the value of firms is widely considered to be one of the main strategies, alongside others. In their book, we learn that the value of equity equals the sum of discounted cash flows. In our case of listed firms, these cash flows are dividend payments. Dividend payments are, in turn, dependent on earnings, because earnings are divided over retained earnings and dividend payment. Retained earnings is a part of the profit that will be kept in the firm to cover operating expenses and dividend is the part of revenue that is distributed over the shareholders. That is why this research uses the earnings data of a selection of firms and examines the possible relation between earnings trend and the valuation of the firms.

In a survey article, Giles & LeRoy (1991) conducted a research on whether the stock price volatility is higher than economic models imply. They conclude that the presence of excess volatility in asset prices is statistically supported. However, they cannot agree to why the asset prices are excessively volatile. One possible explanation can be that stock price volatility is linked to movements in discount rates. Another possible explanation can be that of overreaction of investors. A large macro-economic event can have enormous effects on the stock prices because of disturbance among investors. This is strengthened by De Bondt & Thaler (1985) who examined the possible drivers of the overreaction of the market. They argued that, in line with research in experimental psychology, most people overreact to big unexpected events. They found that this behavior resulted in larger price movements. This result suggest that volatility is due to news shocks.

La Porta (1996) found interesting results about the relationship between the expected earnings growth rate and the returns of those stocks. They found that investment strategies that use analysts' expectations obtain high returns on their portfolios. This is especially true when the portfolio is sorted on expected growth rate in earnings. They found that low expected-growth stocks outperformed high expected-growth stocks. As La Porta (1996) argued: "event study evidence suggests that the market was overly pessimistic about the earnings of the low E{g} portfolio and excessively optimistic about the earnings of the high E{g} portfolio". In other words, the markets overreact to the analysts' expectations in the short term. The same statement has been made by De Bondt & Thaler (1985). This overreaction that has been found is valuable for our research, since this research tries to examine whether there is a relation between this volatility and earnings growth shocks. Current research shows us that there is a lot of unexplained volatility in stock prices. So we are building on the results from these papers and try to find what the drivers are of the before mentioned volatility and price overreaction.

This research will explore the possibility of earnings growth being linked to the stock price volatility. For this to be a viable possibility, the earnings need to have a clear trend. If there is no significant movement in the earnings, there is no information for us to extract. Chan, Karceski & Lakonishok (2003) have analyzed the historical growth rates of several indicators of operating performance. They come to the conclusion that no persistence can be found in long-term earnings growth. While the results obtained by Chan, Karceski & Lakonishok (2003) seem like a setback for our research, it need not be. Firstly, the data used by them comprises of all domestic stocks form the year 1951 to 1997. This research on the other hand will focus on a smaller subset of the largest firms in both the CRSP US Mega Cap Growth Index as well as the CRSP US Mega Cap Value Index. Secondly, we will use different models to extract the persistence from the data. Furthermore, they found that although firms have shown large growth rates, these cases appear to be very happening very rarely. We will extend their research by first extracting the growth from the earnings using the Kalman filter. This way, unlike Chan, Karceski & Lakonishok (2003), we will filter out the noise and try to obtain a clear trend in the earnings data.

We are interested in the trend of the earnings, but we do not want the industry trend to blemish the firm specific trend we find after filtering. We extended the local linear trend model found in Durbin & Koopman (2012) by adding an industry component so that we can account for the average industry growth. The local linear trend model is a basic time series model that filters out the noise and accounts for level and trend. Furthermore, to take into account the effect of seasonality, we extend our model described by Durbin & Koopman (2012) with a seasonality variable as described in the book by Harvey (1990). This books uses the notation γ for the seasonality variables and s for lags, where s depicts the number of seasons we want to incorporate into our model. These lagged seasonality variables are included in our extended model described by Durbin & Koopman (2012) to account for cyclical seasonality, we can use this in our research since we are dealing with recurring quarters every year.

3 Data

This research will use the 15 biggest firms of the CRSP US Mega Cap Growth Index and the 15 biggest firms of the CRSP US Mega Cap Value Index. CRSP sorts growth firms using the following factors: future long-term growth in earnings per share (EPS), future short-term growth in EPS, 3-year historical growth in EPS, 3-year historical growth in sales per share, current investment-to-assets ratio, and return on assets. For value firms, CRSP uses the following factors: book to price, forward earnings to price, historic earnings to price, dividend-to-price ratio and sales-to-price ratio. For these firms we will use the quarterly data found in the CRSP/Compustat Merged (CCM) database of the closing price as a proxy for market value since this research is more interested in the change in value and we will use company earnings for which we separate the signal from the noise using the methods discussed in section 4. Since some firms are listed on exchanges for longer than others, each time series has a different number of observations. We exclude firms from our datasets that have too little observations or are missing other crucial variables.

Figure (1) and (2) show the natural logarithm of the earnings per quarter for the firms in the CRSP US Mega Growth and Value Index. We have chosen for this transformation, since the earnings were growing exponentially the last decades. For growth firms we see that most firms are listed after the year 2000, since a substantial part of these firms are in the technology sector. Therefore, we start our dataset from 2004Q1, which effectively excludes Facebook, Visa, MasterCard and Abbvie. For value firms on the other hand, we see that the list includes firms that are around much longer. We set our dataset from 1990Q1, that way we do not have to exclude firms on the basis of this analysis. We do however exclude JP Morgan Chase, Bank of America and Wells Fargo, since the CCM database does not report earnings for these firms. Lastly, we exclude Berkshire Hathaway from our dataset. This firm is a holding firm that owns significant shares of other large firms and thus does not produce goods or and/or services itself. So their earnings are due to the earnings of the firms they own.

Figure 3 shows the scatter plots of the log price data relative to the log earnings for both the growth firms and the value firms. The red line is the OLS estimate. Both plots show a vague but significant linear trend as the OLS estimate indicates. The plots show that the data contain a lot of noise. For the plot of the value firms, we excluded the data of Berkshire Hathaway. Because the price of those shares are extraordinarily high compared to the other share prices, the OLS estimate would be very skewed to those observations. However, this is not an issue for the main analysis of the research, since we will be using the change in log price: $\boldsymbol{\Delta} \log(price)$ and thus the absolute value of the price level has no effect.

Table 1 shows the summary statistics of the earnings of the firms included in our two datasets. The value firms are generally speaking listed longer and thus the dataset contains 113 observations, the growth firms on the other hand contain only 57 observations. The standard deviation is relatively large compared to the mean of the earnings. We did a

Figure 1: Quarterly Log Earnings of selected Growth Firms

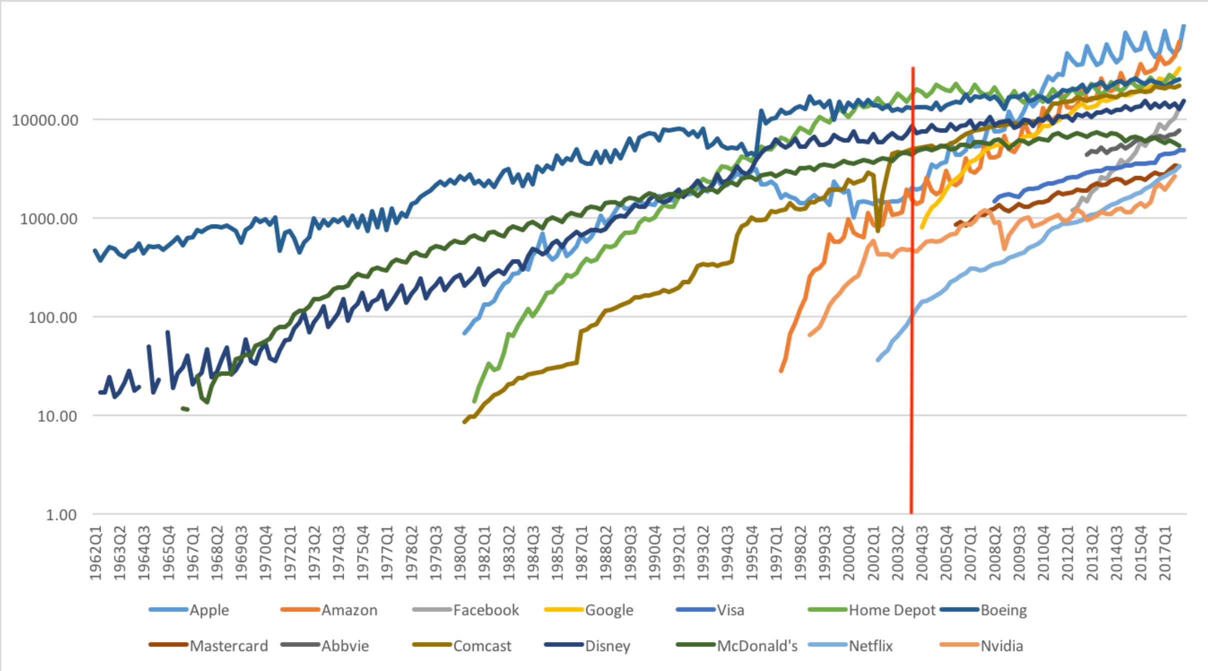
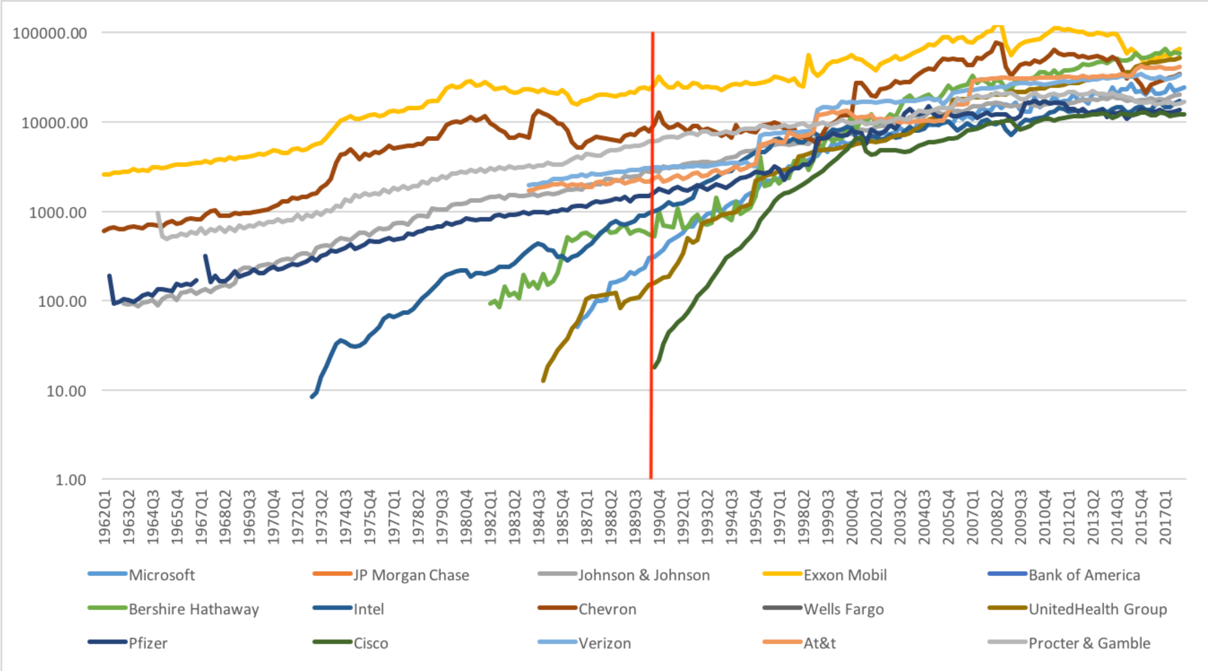


Figure (1) shows that the data for most growth firms are available after the year 2000.
The red line indicates the beginning of our dataset

t-test on the null hypothesis $H_0 : \hat{\mu} = 0$, the p-values are given in the third column. We see that for 11 of the 22 firms, the mean does not significantly differ from zero. In other words half of the firms have a significant change in log earnings quarter-to-quarter. To test the data for heteroskedasticity we follow the test proposed by Engle (1982). The test consists of testing whether the residuals follow an ARCH process using the Lagrange Multiplier method. The last column of the table shows that according to the test, almost all the data is homoskedastic. In other words, no conditional variance is present, except for one value firm: Microsoft. We see that many firms have a larger four period lagged autocorrelation, which is not strange to see with quarterly data.

For the second part of the research, we will use the results from the Kalman filter. The pricing data and the filtered earnings that we obtained after using the Kalman filter will be transformed to do a regression analysis. More precisely, we take first differences of the stock prices and rename this variable the price growth. Next we take the differences of the filtered earnings trend at time t and the predicted earnings trend at time $t-1$ from the model and rename this variable the earnings trend shock. We also define the volatility as the standard deviation of the stock price over 20 trading days after the quarterly earnings announcement.

Figure 2: Quarterly Log Earnings of selected Value Firms



For value firms, the graph shows that data is available earlier than for the growth firms.

The red line indicates the beginning of our dataset

Figure 3: Scatter plot of log prices with respect to log sales for both growth and value firms

Growth Firms | Value Firms

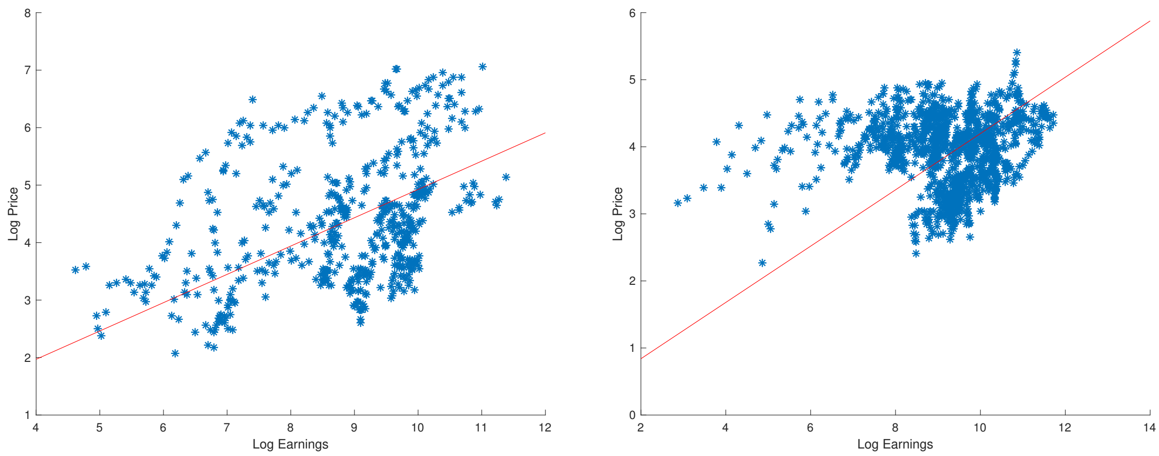


Figure 3 shows the log price of all the firms in each subset relative to the log earnings of all firms. The red line is the estimate of the regression. The estimate suggests that a relation between the two variables can be found. However we can not conclude causation from these figures, since there might be a confounding variable that drives both variables.

Since firms announce their quarterly earnings several weeks after the quarter has ended, the earnings information is not yet incorporated in the price. The announcement

Table 1: Summary Statistics Quarterly Change in Log Earnings

	Firms	Mean	St.dev.	P val.	Skew.	Kurt.	Normality	ρ_1	ρ_4	Heterosked.
Growth	Apple	0.068	0.258	0.055	0.202	2.090	Yes	-0.219	0.926	No
	Amazon	0.067	0.266	0.066	0.380	2.164	Yes	-0.329	0.982	No
	Google	0.070	0.070	0.000	0.022	3.054	Yes	0.180	0.712	No
	Home Depot	0.007	0.127	0.700	0.028	1.414	No	-0.097	0.929	No
	Boeing	0.012	0.096	0.345	-0.194	2.833	Yes	-0.436	0.213	No
	Comcast	0.027	0.047	0.000	1.579	7.806	No	0.166	-0.110	No
	Disney	0.010	0.103	0.452	-0.337	2.086	Yes	-0.643	0.839	No
	McDonald's	0.004	0.060	0.660	0.040	1.953	Yes	0.008	0.771	No
	Netflix	0.063	0.041	0.000	0.924	4.966	No	0.328	0.109	No
	Nvidia	0.032	0.142	0.099	-1.759	10.169	No	-0.039	0.003	No
Value	Microsoft	0.042	0.120	0.000	0.005	2.959	Yes	-0.473	0.680	Yes
	Johnson & Johnson	0.018	0.037	0.000	0.419	2.956	Yes	-0.093	0.426	No
	Exxon Mobil	0.009	0.135	0.482	0.881	14.959	No	-0.048	0.094	No
	Intel	0.027	0.084	0.001	-0.506	4.108	No	0.179	0.436	No
	Chevron	0.013	0.150	0.377	0.753	10.599	No	0.074	0.113	No
	UnitedHealth Group	0.054	0.091	0.000	3.429	16.879	No	0.100	0.120	No
	Pfizer	0.020	0.113	0.062	0.874	7.370	No	-0.134	0.324	No
	Cisco	0.059	0.091	0.000	-0.131	7.528	No	0.674	0.386	No
	Verizon	0.022	0.097	0.020	6.018	45.285	No	-0.007	-0.032	No
	At&t	0.027	0.100	0.006	3.204	16.902	No	0.035	0.101	No
	Procter & Gamble	0.010	0.051	0.049	0.174	4.330	No	-0.051	0.673	No

The p value is calculated from the Student's t test statistic with n-1 degrees of freedom. Normality is tested using the Jarque-Bera test. Conditional variance in the last column is tested using a Lagrange Multiplier test as proposed by Engle (1982).

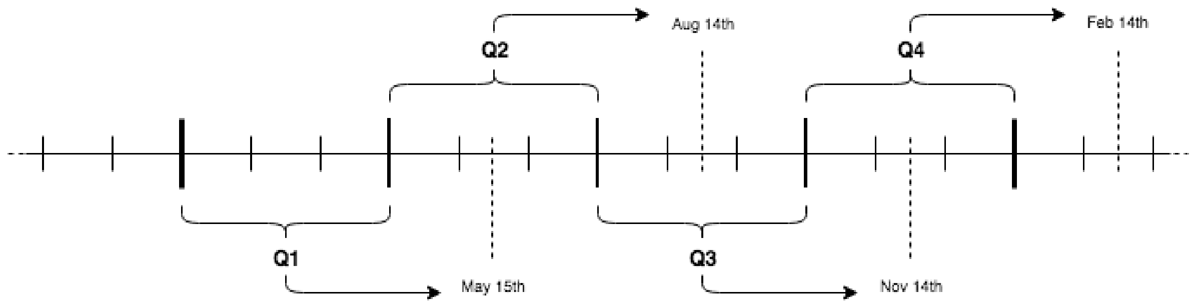
of earnings is usually 1 month after the ending of a quarter, thus to correctly reflect the information in the price we need to take the price after the official earnings announcement. We have chosen for 45 days after the ending of the quarter, because official rules of the Securities and Exchange Commission (SEC) state a deadline of 45 days after the end of the quarter to publish the financial reports. This means that for the first quarter, we take the price on May 15th, this also applies for the remaining quarters. For a visual representation see Figure 4.

Table 2: Variables used in the regressions

Variable Name	Explanation
Price Growth	$Price_t - Price_{t-1}$
Earnings Trend	$FilteredTrend$ (from the Kalman filter)
Earnings Trend Shock	$FilteredTrend_t - PredictedTrend_{t-1}$
Absolute Earnings Trend Shock	Absolute value of the Earnings Trend Shock
Volatility	Stock price standard deviation over 20 trading days after the earnings announcement
Volume	Daily trading volume

$Price_t$ is the stock price of a specific firm at time t, the $FilteredTrend_t$ is the third element of vector $\xi_{t|t}$ and the $PredictedTrend_t$ is the third element of vector $\xi_{t|t-1}$.

Figure 4: Earnings Announcement



The information of quarterly earnings is released 45 days after the ending of the quarter, at the latest. This is according to official rules of the Securities and Exchange Commission.

4 Methodology

In this section the theoretical background of the used models and methods are discussed and explained. First, the local linear trend model will be revisited. Then, a short review of the Kalman Filter and parameter estimation will be provided. Finally, the regressions and their parameters will be addressed.

4.1 Local Linear Trend Model

The Local Linear Trend Model is a specific version of the general linear gaussian state space model that captures both the level and the underlying trend. Since we are interested in the growth of earnings, we will use this model to separate the trend (i.e. growth) and level from the noise. Furthermore, we have seen in the previous section that autocorrelation is present, for this reason we include an extra variable that takes into account the seasonality of the data. The model consists of two parts; the *observation equation* and the *state equation*. This research will follow the notation of Hamilton (1994):

$$\begin{aligned} \mathbf{y}_t &= \mathbf{A}'\mathbf{x}_t + \mathbf{H}'\xi_t + \mathbf{w}_t, \qquad && V[\mathbf{w}_t] = \mathbf{R}, \\ \boldsymbol{\xi}_{t+1} &= \mathbf{F}'\boldsymbol{\xi}_t + \mathbf{v}_{t+1}, && V[\mathbf{v_{t+1}}] = \mathbf{Q}. \end{aligned} \tag{1}$$

Here $\mathbf{y_t}$ is a vector of data, observed at time t, variable $\mathbf{A}$ in our model is equal to zero, since we do not take into account the exogenous variables. Variable $\mathbf{H}$ is a matrix of coefficients that gives the relation of the observations to the state variable $\boldsymbol{\xi}_t$. Variable $\mathbf{F}$ is a matrix consisting of autoregressive coefficients of the time series dependence of the state variables. Variable $\mathbf{w}_t$ and $\mathbf{v}_t$ are the measurement errors for the observations and the states, respectively.

As mentioned before, the model that is used to extract the trend is the so called Linear Local Trend Model (Equation (2)). The main difference from the general model, is that we added a constant vector in the state equation and that the state variable $\boldsymbol{\xi}_t$ contains several variables. Namely, the level, trend and seasonality variable. The resulting model is defined as follows:

$$\begin{aligned} y_t &= \mu_t + \gamma_t + \varepsilon_t, \\ \mu_{t+1} &= \mu_t + \nu_t + \xi_t, \\ \nu_{t+1} &= (1-\phi)\bar{\nu} + \phi\nu_t + \zeta_t, \\ \gamma_{t+1} &= \sum_{j=1}^{s-1} \gamma_{t+1-j} + \omega_t. \end{aligned} \tag{2}$$

Here y_t is a scalar instead of a vector, in our case this will be the earnings of a specific firm at time t. The variable μ_t is the level of the data. We see that the observation equation describes the data as a sum of the level, seasonality component and an error ε_t at time t. In the second line we see that μ_t the level, depends on the level in the previous period plus an error (ξ_t) and the variable ν_t which represents the linear change in level. In other words, this is the trend / growth of the data. In the third line, the autoregressive expression for the trend is given. Because we are interested in the firm-specific growth of each firm, the average growth is added. This is included in the first term of the sum: $\bar{\nu}$. Finally, the fourth line shows the relation of the seasonality in the time series. The variable s denotes the number of seasons per year in the dataset, in our case $s = 4$ since we use quarterly data. This model can be rewritten in vector form so it is coherent with the general form of the linear state space model used in (Hamilton, 1994). The vector form of this model is as follows:

$$y_t = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \mu_t \\ \nu_t \\ \gamma_t \\ \gamma_{t-1} \\ \gamma_{t-2} \end{bmatrix} + \varepsilon_t, \qquad V[\varepsilon_t] = \sigma_\varepsilon^2,$$

$$\begin{bmatrix} \mu_{t+1} \\ \nu_{t+1} \\ \gamma_{t+1} \\ \gamma_t \\ \gamma_{t-1} \end{bmatrix} = \begin{bmatrix} 0 \\ (1-\phi)\bar{\nu} \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & \phi & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \mu_t \\ \nu_t \\ \gamma_t \\ \gamma_{t-1} \\ \gamma_{t-2} \end{bmatrix} + \begin{bmatrix} \xi_t \\ \zeta_t \\ \omega_t \\ 0 \\ 0 \end{bmatrix}, V \begin{bmatrix} \xi_t \\ \zeta_t \\ \omega_t \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \sigma_\xi^2 & 0 & 0 & 0 & 0 \\ 0 & \sigma_\zeta^2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_\omega^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}. \tag{3}$$

Comparing to the general form shown in Equation (1), we see that the **A** matrix is zero, $\mathbf{H}'$ is equal to the vector $\begin{bmatrix} 1 & 0 & 1 & 0 & 0 \end{bmatrix}$, **R** is a scalar, vector **c** equals the constant in the our state equation, **F** equals the relation of the state variable to the lagged state variable in the state equation and **Q** equals the covariance matrix of the state variable with zeros on the non-diagonal. The main difference between this model and the general state space model is the added vector containing the industry growth variable **c**. Because of this added element in the model, the Kalman Filter prediction- and updating- step as well as the smoothing- step are different than usual.

4.2 Kalman Filter

Because the model denoted in Equation (3) differs from the general Gaussian state space model, the prediction- and updating- steps differ to those showcased in Hamilton (1994). Equation (4), Equation (5) and Equation (6) show the prediction-, updating- and smoothing- step as used in this research, respectively.

$$\begin{aligned} \hat{\boldsymbol{\xi}}_{t+1|t} &= \mathbf{c} + \mathbf{F}\hat{\boldsymbol{\xi}}_{t|t}, \\ \mathbf{P}_{t+1|t} &= \mathbf{F}\mathbf{P}_{t|t}\mathbf{F}' + \mathbf{Q}, \end{aligned} \tag{4}$$

$$\hat{\boldsymbol{\xi}}_{t|t} = \hat{\boldsymbol{\xi}}_{t|t-1} + \mathbf{P}_{t|t-1}\mathbf{H}(\mathbf{H}'\mathbf{P}_{t|t-1}\mathbf{H} + \mathbf{R})^{-1}(\mathbf{y_t} - \mathbf{A}'\mathbf{x}_t - \mathbf{H}'\hat{\boldsymbol{\xi}}_{t|t-1}),$$
$$\mathbf{P}_{t|t} = \mathbf{P}_{t|t-1} - \mathbf{P}_{t|t-1}\mathbf{H}(\mathbf{H}'\mathbf{P}_{t|t-1}\mathbf{H} + \mathbf{R})^{-1}\mathbf{H}'\mathbf{P}_{t|t-1}. \tag{5}$$

$$\hat{\boldsymbol{\xi}}_{t|T} = \hat{\boldsymbol{\xi}}_{t|t} + \mathbf{P}_{t|t}\mathbf{F}'\mathbf{P}^{-1}_{t-1|t}(\hat{\boldsymbol{\xi}}_{t+1|T} - \hat{\boldsymbol{\xi}}_{t+1|t}),$$
$$\mathbf{P}_{t|T} = \mathbf{P}_{t|t} - \mathbf{P}_{t|t}\mathbf{F}'\mathbf{P}^{-1}_{t-1|t}(\mathbf{P}_{t+1|t} - \mathbf{P}_{t+1|T})\mathbf{P}^{-1}_{t+1|t}\mathbf{F}\mathbf{P}_{t|t}, \tag{6}$$

The prediction- and updating- steps used in this research are a little different from the steps presented by Hamilton (1994). First, because of the constant containing the average industry growth, the prediction step also includes a constant in the expression. Second, we notice that the updating step does not contain an **A** matrix, this is because our model does not incorporate exogenous variables. The updating- and smoothing- steps on the other hand will remain the same, since the added constant in the model will have no effect on these steps.

4.3 Model Estimation

To estimate the parameters $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$ and $\mathbf{Q}$ we use the Expectation Maximization (EM) method. We opt for the EM method instead of using Maximum Likelihood (ML) estimation for a couple of reasons. While ML is relatively quick and does not need the Kalman Smoother, ML may get stuck in a local maximum and is often problematic when using a state variable with multiple states. Since our state variable $\boldsymbol{\xi}_t$ contains a level, trend and seasonality, we have chosen to use the EM method in this research. The EM method attempts to maximize the log of the function of the data, given the parameters: $L(\boldsymbol{\theta}) = \log f(y_{1:T}|\boldsymbol{\theta})$. This consists of two parts: the Expectation part and the Maximization part. We first rewrite the log likelihood function as presented by Harvey & Peters (1990):

$$\begin{aligned} L(\boldsymbol{\theta}) &= \tilde{E}[\log f(y_{1:T}, \boldsymbol{\xi}_{1:T}|\boldsymbol{\theta})], \\ &= \tilde{E}[\frac{T}{2}\log|\mathbf{R}^{-1}| - \frac{1}{2}\sum_{t=1}^{T}(y_t - \mathbf{H}'\boldsymbol{\xi}_t)'\mathbf{R}^{-1}(y_t - \mathbf{H}'\boldsymbol{\xi}_t) \\ &\qquad + \frac{T}{2}\log|\mathbf{Q}^{-1}| - \frac{1}{2}\sum_{t=1}^{T}(\boldsymbol{\xi}_t - \mathbf{c} - \mathbf{F}'\boldsymbol{\xi}_{t-1})'\mathbf{Q}^{-1}(\boldsymbol{\xi}_t - \mathbf{c} - \mathbf{F}'\boldsymbol{\xi}_{t-1}) \\ &\qquad\qquad + constants. \end{aligned} \tag{7}$$

Where $\boldsymbol{\theta}$ contains the parameters $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$, $\mathbf{Q}$ and $\mathbf{c}$. $\tilde{E}$ denotes the expectation over all $\xi_{1:T}$. To be precise, the operator is defined as follows: $\tilde{E}[\,\cdot\,] := \int ... \int [\,\cdot\,]\, f(\xi_{1:t}|y_{t:T};\boldsymbol{\theta})d\xi_{1:T}$. To obtain the estimates for the parameters in $\boldsymbol{\theta}$ we need to maximize the likelihood function in Equation 7. This can be done analytically, by taking the first derivative with respect to the parameters in $\boldsymbol{\theta}$ and setting that equal to zero. This results in the following expressions for the parameters:

$$\begin{aligned}
\mathbf{F} &= \left(\sum_{t=1}^{T}(\boldsymbol{\xi}_t - \mathbf{c})\boldsymbol{\xi}'_{t-1}\right)\left(\sum_{t=1}^{T}\boldsymbol{\xi}_{t-1}\boldsymbol{\xi}'_{t-1}\right)^{-1}, \\
\mathbf{H}' &= \left(\sum_{t=1}^{T} y_t\boldsymbol{\xi}'_t\right)\left(\sum_{t=1}^{T}\boldsymbol{\xi}_t\boldsymbol{\xi}'_t\right)^{-1}, \\
\mathbf{Q} &= \frac{1}{T}\sum_{t=1}^{T}(\boldsymbol{\xi}_t - \mathbf{c} - \mathbf{F}\boldsymbol{\xi}_{t-1})(\boldsymbol{\xi}_t - \mathbf{c} - \mathbf{F}\boldsymbol{\xi}_{t-1})', \\
\mathbf{R} &= \frac{1}{T}\sum_{t=1}^{T}(y_t - \mathbf{H}'\boldsymbol{\xi}'_t)(y_t - \mathbf{H}'\boldsymbol{\xi}_t)', \\
\mathbf{c} &= \frac{1}{T}\sum_{t=1}^{T}(\boldsymbol{\xi}_t - \mathbf{F}\boldsymbol{\xi}_{t-1}).
\end{aligned} \tag{8}$$

It is clear to see that $\mathbf{F}$ and $\mathbf{H}'$ are to be calculated before $\mathbf{Q}$ and $\mathbf{R}$ are calculated, since they are used in the latter equations. We see though that $\mathbf{c}$ is used in the expression of $\mathbf{F}$ and $\mathbf{F}$ is used in the expression for $\mathbf{c}$. To solve for this, we use the estimate of $\mathbf{c}$ from the previous iteration. But before these equations can be used, we need to take the expectations of these expressions, since the EM method tells us to maximize the expected joint likelihood. Use the following identities proposed by Digalakis, Rohlicek and Ostendorf (1993) to rewrite the expressions found in Equation (8):

$$\begin{aligned}
\tilde{E}[\boldsymbol{\xi}_t] &= \hat{\boldsymbol{\xi}}_{t|T}, \\
\tilde{E}[\boldsymbol{\xi}_t\boldsymbol{\xi}'_t] &= \hat{\boldsymbol{\xi}}_{t|T}\hat{\boldsymbol{\xi}}'_{t|T} + \mathbf{P}_{t|T}, \\
\tilde{E}[\boldsymbol{\xi}_t\boldsymbol{\xi}'_{t-1}] &= \hat{\boldsymbol{\xi}}_{t|T}\hat{\boldsymbol{\xi}}'_{t-1|T} + \mathbf{P}_{t,t-1|T}.
\end{aligned} \tag{9}$$

All the elements in Equation (9) can be obtained through the Kalman Smoother, except for the term $\mathbf{P}_{t,t-1|T}$. This term will be addressed later. Using the identities from Equation (9), we can rewrite the formulas for the parameters $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$, $\mathbf{Q}$ and $\mathbf{c}$ as depicted in Equation (10).

$$
\begin{aligned}
\mathbf{F} &= \left(\sum_{t=1}^{T}(\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{c})\hat{\boldsymbol{\xi}}'_{t-1|T} + \mathbf{P}_{t,t-1|T}\right)\left(\sum_{t=0}^{T-1}\hat{\boldsymbol{\xi}}_{t|T}\hat{\boldsymbol{\xi}}'_{t|T} + \mathbf{P}_{t|T}\right)^{-1}, \\
\mathbf{H}' &= \left(\sum_{t=1}^{T} y_t\hat{\boldsymbol{\xi}}'_{t|T}\right)\left(\sum_{t=1}^{T}\hat{\boldsymbol{\xi}}_{t|T}\hat{\boldsymbol{\xi}}'_{t|T} + \mathbf{P}'_{t|T}\right)^{-1}, \\
\mathbf{Q} &= \frac{1}{T}\sum_{t=1}^{T}((\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{c})(\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{c})' + \mathbf{P}'_{t|T} - \mathbf{F}[\hat{\boldsymbol{\xi}}_{t-1|T}(\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{c})' + \mathbf{P}_{t-1,t|T}] \\
&\qquad - [(\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{c})\hat{\boldsymbol{\xi}}'_{t-1|T} + \mathbf{P}_{t,t-1|T}]\mathbf{F}' + \mathbf{F}[\hat{\boldsymbol{\xi}}_{t-1|T}\hat{\boldsymbol{\xi}}'_{t-1|T} + \mathbf{P}_{t-1,t|T}]\mathbf{F}'), \\
\mathbf{R} &= \frac{1}{T}\sum_{t=1}^{T}(y_t y_t' - \mathbf{H}'\hat{\boldsymbol{\xi}}_{t|T}y_t' - y_t\hat{\boldsymbol{\xi}}'_{t|T}\mathbf{H} + \mathbf{H}'[\hat{\boldsymbol{\xi}}_{t|T}\hat{\boldsymbol{\xi}}'_{t|T} + \mathbf{P}_{t|T}]\mathbf{H}), \\
\mathbf{c} &= \frac{1}{T}\sum_{t=1}^{T}(\hat{\boldsymbol{\xi}}_{t|T} - \mathbf{F}\hat{\boldsymbol{\xi}}_{t-1|T}).
\end{aligned}
\tag{10}
$$

As we established before, all elements are known except for the term $\mathbf{P}_{t,t-1|T}$. To solve for this, we follow the steps of Digalakis, Rohlicek and Ostendorf (1993). They come to the conclusion that $\mathbf{P}_{t,t-1|T}$ can be calculated by using the following expression:

$$
\mathbf{P}_{t+1,t|T} = \mathbf{P}_{t+1|T}\mathbf{P}^{-1}_{t+1|t}\mathbf{F}\mathbf{P}_{t|t}. \tag{11}
$$

If this expression will be calculated alongside the Kalman Smoother we can estimate the parameters $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$, $\mathbf{Q}$ and $\mathbf{c}$.

To ensure a certain structure in the estimates we will only estimate the elements that contain parameters and leave the rest as is. For example, the matrix $\mathbf{F}$ is a matrix with fixed elements (ones and zeros) and with a parameter ϕ. The element ϕ will be calculated as described by Equation (10), the other elements are kept at either zero, one or negative one. Same goes for the vector $\mathbf{c}$, which mostly consists of zeros and one element that has to be estimated. Vector $\mathbf{H}$ on the other hand, only consist of fixed elements, so we do not have to estimate this vector at all.

4.4 Model Framework

To answer the research questions we need to filter the earnings data since the obtained data contains a lot of noise. We will use the aforementioned local linear trend model to estimate the latent level and trend, so we obtain the quarterly growth in earnings for each firm (both growth- and value- firms). Next, we want to research the relation between the earnings growth and the change in firm value. For this we consider the change in quarterly prices of the firms, since the actual size of the firms does not matter, we are just interested in the change in valuation. As a final step, we conduct linear regression of the change in stock price, volatility and trading volume on the growth obtained using the Kalman Filter. We do four regressions using both datasets, such that we can compare the results between growth- and value- firms.

The first step will be to initialise the parameters of the state space model: $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$, $\mathbf{Q}$ and $\mathbf{c}$ and also the state variable $\boldsymbol{\xi}$ (containing level, trend and seasonality) and $\mathbf{P}$ at $t = 0$. Since the model used is a local linear trend model, the $\mathbf{A}$ matrix will be zero. The $\mathbf{H}'$ matrix will be a 1×5 matrix, $\mathbf{c}$ vector will be a 5×1 vector and the $\mathbf{F}$ matrix will be a 5×5 matrix. Scalar $\mathbf{R}$ and matrix $\mathbf{Q}$ are the variance and covariance matrix of the observation equation and the state equation respectively. After the parameters are initialised, the Kalman prediction step and updating step can iteratively be exercised. Through these steps a vector will be obtained containing the state variable at time t given $t-1$ and a vector containing the state variable at time t given t. Next to these states we also evaluate the smoothed state and the cross term mentioned in Equation 11. In the second step, we use the EM method to obtain an estimate for the parameters $\mathbf{H}'$, $\mathbf{F}$, $\mathbf{R}$, $\mathbf{Q}$ and $\mathbf{c}$. The input for the EM expressions will be the vectors obtained in the previous steps and the original data. To find an estimate the two steps given above will be repeated until until the parameters converge.

Now, we have an estimate for all our parameters, we will run the Kalman filter again to obtain new estimates of the state vector on time t given t. These estimates will be used in the following steps as the growth level.

The next question will be approached as follows. After the estimated levels are obtained in the previous step, we will investigate the relationship between the earnings growth and the changes in firm value, represented by the change in quarterly stock prices. This will be done by means of a cross sectional regression with the stock price change as the dependent variable and the earnings growth as independent variable.

Four different regressions will be done; (1) regress the changes in quarterly stock prices of growth- and value- firms on the earnings growth, (2) regress the changes in quarterly stock prices of growth- and value- firms on the earnings growth shock. (3) regress the 20-day stock price volatility of growth- and value- firms on *earnings trend shock* and *absolute* *earnings trend shock*. (4) regress the daily trading volume of growth- and value- firms on *earnings trend shock* and *absolute earnings trend shock*. The estimated parameters will be tested on significance and whether or not there is a reasonable difference between the two datasets.

5 Results

In this section we present the results produced by the models and provide an explanation of these results in an economic context. First, we display the filtered and smoothed data for a selection of firms. Next, we show the results of the regression of the trend on the price differences. Finally, an economic explanation will be provided.

First, we plot the filtered and smoothed trend against the data for a selection of firms to give an idea what the results of the Kalman filter and smoother look like. We have chosen to display one growth firm and one value firm. These plots can be found in Figures 5 and 6. To answer the first research question we consider the filtered trend and its confidence interval. Table 3 shows whether the firms have a significant trend over the majority of the time series or whether the trend is not significantly different from zero based on a 95% confidence interval. We see from the table that almost all firms have a significant trend, this means that the underlying earnings growth of the firms are significant over the time period considered in this research. There can be several explanations. The first is that the firms' business is doing well and therefore is generating more earnings. An other possible explanation is that because of the exponentially growing economy over the last several decades, firm size is also growing as described by Shaffer (2002) and as a result their earnings grow at least with the same rate as the economy. The two firms that do not show a significant trend are both growth firms, these are Home Depot and McDonald's. Furthermore, we observe that the firms that are labeled with **No** or **Yes*** also do not have a significant mean in quarterly change in log earnings according to Table 1, which makes sense because both tables conclude that those firms do not have significant growing earnings.

In Figure 5 the log earnings, the filtered trend, the smoothed trend and the seasonality component are plotted for Amazon. We see that the log earnings plot heavily suggest a strong seasonality pattern, this point is strengthened by the seasonality component plot.

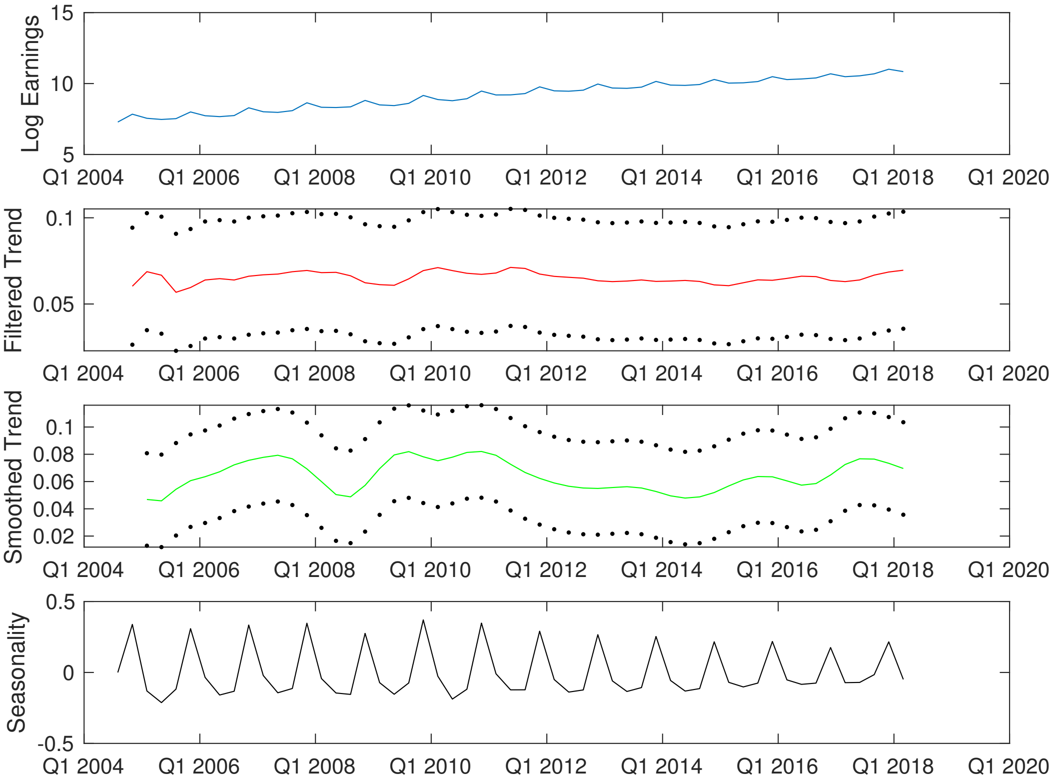
Table 3: Significance of Earnings Trend

Growth Firms	Significant Trend	Value Firms	Significant Trend
Apple	Yes	Microsoft	Yes
Amazon	Yes	Johnson & Johnson	Yes
Google	Yes	Exxon Mobil	Yes*
Home Depot	**No**	Intel	Yes
Boeing	Yes*	Chevron	Yes*
Comcast	Yes	UnitedHealth Group	Yes
Disney	Yes*	Pfizer	Yes
McDonald's	**No**	Cisco	Yes
Netflix	Yes	Verizon	Yes
Nvidia	Yes	At&t	Yes
		Procter & Gamble	Yes

The trend is considered significant if for the majority of the chosen time series the trend is significantly different than zero. If the trend of a firm is on the edge of significance an asterisk is added.

In this plot we see a spike in every fourth quarter of the year. This can be easily explained by a publicly known occurrence, namely that firms with a large retail section have higher earnings during holiday season (Q4). Since Amazon is one of the largest retailers active in multiple countries, the presence of a clear seasonality pattern should not come as a surprise. In contrast to Amazon, we see in Figure 6 that the log earnings of Microsoft do not display such a clear seasonality pattern. This is also observed in the seasonality plot for Microsoft, where we also see a more chaotic pattern. This is not strange, since Microsoft focuses on multiple industries, of which only one is consumer retail. Therefore their sales numbers do not necessarily peak during holiday season as their other divisions are not primarily focused on consumer retail. Furthermore, we found that both firms have significant filtered trend and smoothed trend as indicated by the 95% confidence interval. For almost every point in the range of our dataset we see that the trend is significantly different from zero. We see for Amazon that the filtered trend is significant and steady around 0.06, which means a steady growth over the range of the dataset for Amazon. In contrast to Amazon we see that Microsoft's trend slowly declines over the years. This corresponds with the log earnings plot, where we see that during 1990 until 2000 there

Figure 5: Amazon

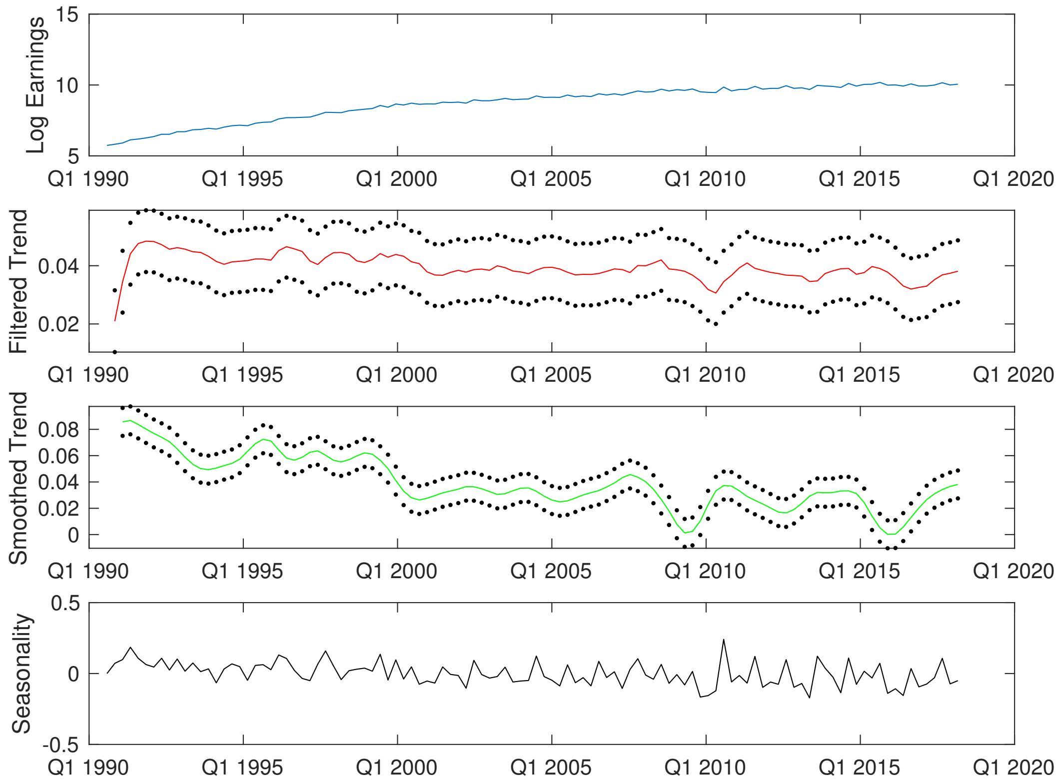


In the second and third subplots, the filtered and smoothed trend are plotted with their 95% confidence intervals as a dotted line. The filtered trend, as seen in the second subplot, corresponds to the steadily increasing log earnings as seen in the first subplot. The spikes in Q4 of the seasonality component also translates well to the first subplot, since we observe a very strong seasonality pattern.

was a relatively large growth in earnings, whereas the growth from 2005 slowly declines. This may indicate that the market for Microsoft is getting saturated.

The results of the regression of the price differences on the earnings trend are given in Table 4. We see that for both growth and value firms the slopes of the regressions are mostly insignificant. The data suggests that there is no relation between the trend of the earnings and the difference in price. For growth firms we observe that all ten firms have insignificant slopes. We can thus say for those firms that the change in earnings have no effect on the price change. In case of value firms we also observe that for almost all firms the slope is insignificant. Only Johnson & Johnson, UnitedHealth Group and Pfizer have significant slopes. This again means that for the majority of value firms there is no relation between the growth of earnings and the growth of stock price. Furthermore, we

Figure 6: Microsoft



In the second and third subplots, the filtered and smoothed trend are plotted with their 95% confidence interval as dotted lines. The declining filtered trend, as seen in the second subplot, corresponds to the slowly declining growth of the log earnings in the first subplot. Also, since there is no clear seasonality pattern in the log earnings, the more chaotic seasonality component in the fourth subplot makes sense.

see that the absolute value of the slope of Johnson & Johnson is very large, as well as the absolute value of the slopes of UnitedHealth Group and Pfizer but to a lesser degree. At first this might seem odd, but if we consider the spread of the data, this makes more sense. If we recall Table 1 we see that the mean of the change in log earnings is very small for Johnson & Johnson. According to the P value in the table the mean of the change in earnings of Pfizer is not even significantly different from zero. This tells us that there very little variation in the earnings. In other words, the slope of Johnson & Johnson might be of considerable size, but if the variation in the earnings is very small, the absolute effect on the price is not terribly big. The same argument can be made for the slope of UnitedHealth Group and Pfizer, since their earnings are fairly consistent. A change in earnings will not translate in a huge change in price because of the small spread of earnings.

We can conclude from the table that in general no relation can be found between the earnings growth and the change in stock price. This was to be expected, since we assume that stock prices are unpredictable. Significant estimates of the regressions would imply the opposite. Namely, that earnings growth is a good predictor for stock price growth. Even if this were to be the case, the market will correct itself for this anomaly, and the information of the earnings announcement will already be processed in the price according to the Efficient Market Hypothesis described by Fama (1965) and thus this relation between change in stock price and earnings growth should cease to exist.

Table 4: Results Regression Price difference on Earnings Trend

Growth Firms	Slope	P. value	Value Firms	Slope	P. value
Apple	-1.622	0.775	Microsoft	-7.120	0.094
Amazon	-2.033	0.788	Johnson & Johnson	-21.863	0.028
Google	0.615	0.886	Exxon Mobil	1.041	0.568
Home Depot	10.161	0.206	Intel	-7.651	0.176
Boeing	1.087	0.901	Chevron	-0.194	0.895
Comcast	-2.743	0.757	UnitedHealth Group	-8.589	0.025
Disney	-16.113	0.181	Pfizer	-8.155	0.026
McDonald's	-4.481	0.634	Cisco	-1.955	0.560
Netflix	-6.903	0.530	Verizon	1.263	0.651
Nvidia	-2.599	0.602	At&t	1.241	0.623
			Procter & Gamble	-6.336	0.550

The table tells us that there is no striking difference between growth and value firms in terms of the significance of the slope, since almost all slopes are not significantly different from zero. Although we do see that that a few value firms have positive slopes, we cannot say that in general there is a relation to be found

To explore the effect that the shocks in earnings growth might have, we regress the price differences on the trend shocks. This regression explores the possible effect of the difference between the expectation of earnings trend and the actual earnings trend on the price differences. By incorporating this variable we can explore how the effect of news influences the investors. Trend shocks are defined as the difference between the filtered earnings trend at time t and the predicted earnings trend at time $t-1$. The results are given in Table 5. Again, we see no significant slopes in the table for growth firms as well as for value firms, except for the value firm Pfizer. This result was expected and is in line with our findings from Table 4. Because from the previous regression we concluded that there is no correlation between the earnings trend and the price difference, it makes sense that a shock in the earnings trend also does not matter and has no effect on the price differences. We can conclude that, in general, there is no relation between the price growth and trend shocks. Which might be a little surprising, since the valuation of firms often times depend on the future cash flows. We would expect that a shock in earnings trend also means that investors adjust their opinion of expected future cash flows and thus the valuation of a firm.

Table 5: Results Regression Price difference on Earnings Trend Shock

Growth Firms	Slope	P. value	Value Firms	Slope	P. value
Apple	-7.092	0.177	Microsoft	-3.394	0.467
Amazon	-1.639	0.669	Johnson & Johnson	2.995	0.856
Google	7.648	0.135	Exxon Mobil	0.608	0.768
Home Depot	12.054	0.251	Intel	-10.337	0.176
Boeing	10.931	0.287	Chevron	-0.169	0.921
Comcast	-7.391	0.629	UnitedHealth Group	-1.426	0.794
Disney	-16.948	0.161	Pfizer	-14.662	0.002
McDonald's	2.100	0.877	Cisco	-2.899	0.512
Netflix	9.981	0.632	Verizon	0.109	0.975
Nvidia	0.849	0.891	At&t	2.129	0.550
			Procter & Gamble	-10.810	0.509

Here we see that for almost all slopes for both growth and value firms not significantly different from zero.

We see from the previous results that the quarter-to-quarter changes in stock prices are not related to the earnings growth or the earnings growth shock. To see whether this is also the case for the volatility after the announcement we will regress the stock price volatility ten days after the earnings announcement on the *earnings trend shock* and the *absolute value of the earnings trend shock*. We have chosen to include the absolute value of the earnings trend shock, because we are interested in whether or not the direction of the shock has an impact on the volatility. The results of this regression are in Table 6.

Table 6: Results Regression Volatility on (Absolute) Earnings Trend Shock

Growth Firms	Trend Shock	P. value	Abs(Trend) Shock	P. value	Value Firms	Trend Shock	P. value	Abs(Trend) Shock	P. value
Apple	10.780	0.501	-29.772	0.140	Microsoft	146.812	0.000	-16.911	0.713
Amazon	28.300	0.262	-84.616	0.004	Johnson & Johnson	272.481	0.016	24.281	0.868
Google	27.335	0.441	-34.899	0.382	Exxon Mobil	-1.124	0.898	39.529	0.005
Home Depot	46.253	0.419	-210.882	0.015	Intel	76.617	0.019	52.548	0.256
Boeing	-30.048	0.482	-50.566	0.469	Chevron	-7.746	0.300	6.241	0.586
Comcast	-65.481	0.672	-81.961	0.671	UnitedHealth Group	31.692	0.245	-19.822	0.609
Disney	-51.232	0.389	-213.765	0.006	Pfizer	78.311	0.001	-52.730	0.124
McDonald's	-242.273	0.002	417.878	0.001	Cisco	85.623	0.000	-39.824	0.083
Netflix	185.183	0.360	-367.419	0.096	Verizon	-44.029	0.073	106.535	0.005
Nvidia	26.856	0.160	7.655	0.770	At&t	9.857	0.691	44.747	0.193
					Procter & Gamble	6.988	0.919	-300.394	0.003

For some firms in both categories a correlation can be found between the absolute earnings trend shock and the volatility after the earnings announcement. For growth firms, we see a few firms that show significant results for absolute trend shocks but insignificant results for trend shock. For value firms we see a few firms that show significant results for one explanatory variable and insignificant results for the other, and vice-versa.

The table shows that some growth firms show a significant result for the absolute earnings trend shock while showing an insignificant result for the earnings trend shock. This is the case for Amazon, Home Depot and Disney. This suggests that for those firms the size of the shock might be more important than the direction of the shock. For McDonald's the table shows that both the trend shock and the absolute trend shock are significantly correlated to the volatility. When we look at the results for the value firms, we see different results. In this category there are four firms that have significant results for the trend shock and none for the absolute trend shock. Microsoft, Johnson & Johnson, Intel, Pfizer, and Cisco have significant parameters for the trend shock while the parameters for the absolute trend shocks are insignificant. This suggests that for these value firms, as opposed to the growth firms mentioned earlier, the direction of the shock is indeed important. On the other hand, there are three value firms that show significant results for absolute earnings trend shock and none for the earnings trend shock. Like with the aforementioned growth firms, it can be argued that the size of the shock might be more important than the direction of the shock.

We see that for most of the growth and value firms the results in the table are not significant. Interesting is that among the significant results, the growth firms mostly show negative slopes and most value firms show positive slopes. Since it seems that a random half of the growth- and value- firms show significant results, we cannot draw conclusions for growth or value firms in general. But we can conclude for the growth and value firms with significant results, that growth firm price volatility is negatively correlated with the absolute earnings trend shock and that value firm price volatility is positively correlated with the (absolute) earnings trend shock. This means that the price volatility after an earnings announcement tend to be lower when the shock in earnings is larger for growth firms. For value firms we see the opposite reaction, the price volatility after an earnings announcement tend to increase after a large earnings shock. But keep in mind that these conclusions are to be made for each firm separately and cannot be used to generalize all growth- or value- firms. This result can be used by professionals that value financial derivatives that involve volatility, such as options. Option traders for example can use this result and anticipate a higher volatility, and thus a higher option price, for certain firms that show a correlation to the (absolute) earnings trend shock.

The results from Tables 5 and 6 suggest that there might be a reaction from investors after an earnings shock since for some firms there is a correlation between the volatility and the (absolute) earnings trend shock. But on the other hand, the results also show that the price is not affected by the shocks in earnings. It might be possible that the investors *do* react to the news and the price fluctuates as a result in the short term but the price does not reach a new level after the news. Therefore it might be useful to examine the trading volume of the stocks. To further investigate the effects that the earnings shocks might have, we regressed daily trading volume on the earnings growth shocks. The results of this regression are in Table 7.

From the table, we see that there are very few significant results for the explanatory variable: *absolute trend shock*. Only one growth firm (Home Depot) and two value firms (Exxon Mobil and Pfizer) show significant results for this variable. For the trend shock, we see three growth firms and seven value firms whose trading volume is correlated to the explanatory variable. So for these growth- and value- firms, the results suggest that earnings trend shock is a good predictor for the daily trading volume. If we compare the significant results to table 6, we see that most value firms with significant trend shocks in table 7 also show significant results in the regression with volatility. This enforces the idea that the volatility and trading volume are linked to one another. While some firms show significant correlation to the explanatory variables we cannot draw any conclusions for growth and/or value firms in general from these results. We can however, say that for

Table 7: Results Regression Daily Trading Volume on (Absolute) Earnings Trend Shock

Growth Firms	Trend Shock	P. value	Abs(Trend) Shock	P. value	Value Firms	Trend Shock	P. value	Abs(Trend) Shock	P. value
Apple	-3.2e+08	0.256	1.8e+08	0.623	Microsoft	-2.7e+09	0.001	-1.2e+09	0.238
Amazon	9.6e+07	0.186	-1.2e+08	0.125	Johnson & Johnson	-2.2e+09	0.018	-7.3e+07	0.952
Google	5.1e+08	0.003	-2.5e+08	0.172	Exxon Mobil	8.6e+07	0.623	6.1e+08	0.020
Home Depot	-2.9e+09	0.000	2.7e+09	0.022	Intel	-3.5e+09	0.000	-2.9e+07	0.979
Boeing	-3.1e+08	0.043	-6.8e+07	0.780	Chevron	5.0e+06	0.936	1.4e+08	0.138
Comcast	2.9e+07	0.990	-1.2e+09	0.674	UnitedHealth Group	-3.3e+08	0.016	7.4e+07	0.707
Disney	-4.9e+08	0.274	7.3e+06	0.989	Pfizer	-1.1e+09	0.031	1.7e+09	0.030
McDonald's	2.1e+07	0.965	2.1e+08	0.784	Cisco	-2.9e+09	0.000	5.5e+08	0.553
Netflix	9.4e+08	0.200	-1.3e+09	0.098	Verizon	-1.06e+08	0.707	-5.8e+08	0.093
Nvidia	-2.0e+07	0.921	2.6e+08	0.359	At&t	-8.7e+08	0.025	7.9e+08	0.137
					Procter & Gamble	-1.1e+09	0.099	8.7e+08	0.383

For very few firms in both categories a correlation can be found between the absolute earnings trend shock and the daily trading volume. However, for value firms we see that seven out of eleven firms show a significant relation between the trend shock and the daily trading volume

specific firms like Google, Home Depot, Microsoft, Exxon Mobil, UnitedHealth Group, Cisco and Verizon the shock in earnings trend has an effect on the daily trading volume of the shares.

In conclusion, while it seems that the price is unaffected by the earnings shocks, the investors do seem to react to this news as suggested by the reaction of some firms in volatility and trading volume. A possible scenario is that the price level does show a reaction in general, but that the price stabilizes very quickly (within a day). Since the used data in this research is of daily frequency, the data does not show these price fluctuations. A promising extension would be to repeat this research using intraday pricing data around the announcement of earnings. This way the possible effect that the earnings shocks have on the intraday price can be explored.

6 Discussion and Conclusion

This research explores the relation between the earnings growth and the price movement for both growth- and value- firms. The Kalman Filter is used to separate the signal from the noise such that we get the underlying trend of the earnings. We then used the obtained trend in the regressions and the results to examine the relation between the trend of the earnings and the price movements of the stock prices and the trading volume as well as to compare the relation between growth- and value- firms. We found that there is no relation between the price growth and the earnings trend shocks for both growth- and value- firms. In addition we found that for some firms in both categories, the price volatility over the 20 trading days after the announcement of the quarterly earnings and the daily trading volume show a reaction to the earnings trend shocks and/or the absolute earnings trend shock. But since this is only the case for some firms, we cannot make general conclusions about the relation between the variables.

Using the Kalman Filter we found that, for 19 out of the 21 firms in our combined dataset, there is a significant growth in quarterly earnings. For only two growth firms there was not a significant growth observed in quarterly earnings, these are Home Depot and McDonald's. The presence of significant earnings growth means that the earnings of those firms are growing significantly over the time period of the dataset. By regressing these results on the price growth and comparing them for the growth and value firms, we find that there is no significant relation between earnings trend (shock) and price difference, for almost all firms in both datasets. We can conclude that price changes cannot be explained by earnings growth and thus according to our findings, and in contrast to public opinion about firm valuation, changes in future earning predictions should not have an impact on the value of a firm.

So while earnings and stock price seem to be growing steadily the last decades, no correlation between the two variables can be found. It seems that both stock prices and earnings are independently appreciating over the course of our dataset. This might come because the firms considered in this research were large firms that survived a lot of other firms. So there already is a bias in favor of these firms, because only firms that survived all these years are included into our dataset. And since we know that markets in general tend to appreciate in value in the long term, it is no surprise that the value of the firms in our dataset also appreciate over the course of our dataset. Besides the growth in stock prices, we know that the economy is growing and as a result earnings of the firms that are still around are also growing.

To further research the correlation between earnings growth and price growth, we suggest that future research includes firms in the dataset that did not survive. In that case a possible outcome is to see that firms with declining stock price also showed negative earnings growth or performed less than expected in the corresponding quarter. What can also happen is that the stock prices of these firms are declining despite their growing earnings. While this might seem unlikely, it is a possible scenario if they can not keep up with their peers. If the latter is the case we can say with even more confidence that there is no correlation between earnings growth and price growth.

For the regressions for volatility and volume we considered two explanatory variables: the *earnings trend shock* and the *absolute earnings trend shock*. For both regressions we found that both earnings trend shocks and absolute earnings trend shocks sometimes have an effect on growth- and value- firms, but not enough to infer a general correlation between the variables. For the regression of volatility on the two explanatory variables we found that for a few growth firms such as Amazon, Home Depot and Disney, the variable *absolute earnings trend shock* is significant while the variable *earnings trend shock* is not. These results suggest that for these growth firms the size of the shock more affects the volatility of the stock price than the actual direction of the shock. These results are also found for a few value firms as well, Exxon Mobil, Verizon and Procter & Gamble. On the other hand, for some of the value firms such as Microsoft, Johnson & Johnson, Intel, Pfizer and Cisco we found the opposite to be true. For these firms the *absolute trend shock* is insignificant while the *trend shock* is significant. In contrast to growth firms, the results suggests that for these particular value firms the direction of the trend shocks more affects the volatility of the stock price than the size of the trend shock. We see that the results show no clear pattern and that we cannot draw general conclusions about the effect of (absolute) earnings trend on the stock price volatility.

For the regression of daily trading volume on the two explanatory variables we found that in case of the variable *absolute trend shock* only 3 out of 21 firms in the combined dataset show significant results while the variable *trend shock* show 10 out of 21 significant results. This suggests that *absolute trend shock* has no effect on the daily trading volume of the growth- and value- firms in this dataset. For the *trend shock* we found that that most significant results were found from the regressions with the value firms. We can say, for almost all value firms in the dataset, that there is a relation between the variable *trend shock* and the daily trading volume 20 days after the earnings announcement. A possible explanation might be that value firms are thought to be more established businesses so investors expect the earnings to be predictable. Because of this, when investors are surprised by the quarterly results, they might be more inclined to re-balance their portfolio which causes the trading volume to increase. This is in contrast to growth firms, which are expected to be more volatile in their earnings. So it could be argued that a shock in earnings for growth firms is less of a surprise than a shock in earnings of value firms, and thus results in less trading since investors already take into account the more volatile earnings.

To further research the effect that the (absolute) earnings trend shock has on volatility, we suggest to take into consideration the intraday pricing data. This research investigated the volatility over a number of trading days after the earnings announcement and does not consider the intraday volatility. We suspect that there might be a lot of trading on the first day after the earnings announcement and therefore the price might be very volatile. With this data, the movement of the price during the day of the earnings announcement can be tracked and then analyses can be done on the relation between the intraday volatility and the earnings trend shock. Another benefit of using the intraday volatility versus the volatility over several trading days is the information that is included. We assume that intraday volatility mainly includes the information of the earnings trend shock, while a multi-day volatility might include other news that happened during several days after the announcement. So by using the intraday data, we exclude information that is not of interest and we only end up with the volatility that is caused by the earnings trend shock.

In conclusion, we learn from the results that we cannot draw general conclusions about the relation between (absolute) earnings trend shocks and the stock price growth, volatility and trading volume for both growth- and value firms. But, while the results do not give us a strong general conclusion, it can still be argued that investors *do* react to earnings shocks as seen by the results from the regression with volume and volatility. We found that there is no significant difference between growth- and value- firms in terms of price-earnings correlation. This is somewhat interesting since the general consensus is that the two types are treated differently by investors. People tend to think of value firms as more long-term investments where shocks in earnings are temporary and do not influence the value. While growth firms are thought to be more volatile in their value and a shock in earnings will have a impact on the valuation of the firm. This turns out to not be the case and we see that whether shocks have an impact on valuation and volatility is very firm-specific.

In order for professionals in risk management and investment analyses to use these results, they have to approach their firm analyses case by case. They cannot group firms into growth- or value- firms and assume that one explanatory variable will explain the volatility or trading volume for all those firms. Some firms show significant results for *absolute trend shock* others for *trend shock* and after knowing this they can use the results in their analyses. The results from this research are less relevant for managers of more diversified portfolios and indices, since they require more general results. Regarding the volatility analysis we can say that, after a firm specific analysis, the results can be used by investment professionals that use volatility in the valuation of financial products, such as options. It can be very useful to be able to anticipate the change in volatility for a firm when news is released about earnings, since the volatility of the underlying affects the valuation of the option.

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7 Appendix

A Initialisation

$$\begin{aligned} Var(y_t - y_{t-1}) &= Var(\mu_t + \varepsilon_t - \mu_{t-1} - \varepsilon_{t-1}), \\ &= Var(\end{aligned} \tag{12}$$

$$\begin{aligned} \sigma_\varepsilon^2 &= \frac{1}{6} Var(y_t - y_{t-1}), \\ \sigma_\xi^2 &= \frac{1}{3} Var(y_t - y_{t-1}), \\ \sigma_\zeta^2 &= (1-\phi)\frac{1}{3} Var(y_t - y_{t-1}), \end{aligned} \tag{13}$$