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Master Thesis Financial Economics

Share Repurchases in Germany; Motivations based on Stock Performance and Price Efficiency

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I examine whether share repurchase announcements lead to abnormal returns in Germany on the short-run and on the long-run based on a hand-collected dataset. I find a positive abnormal return on the announcement date and a negative abnormal returns for the period before the announcement, but for the long-run I only find an abnormal return for high book-to-market firms, indicating that undervaluation is the main motive for a share buyback. I also test whether actual open-market buybacks have a positive effect on the price efficiency and a negative effect on the level of idiosyncratic risk, but I find no evidence for such a relation. The absence of such a relation gives an indication that managers in Germany perform a share buyback to correct for overreaction of the market to prior public information. Another motivation seems to be distributing cash to shareholders, because of the relatively high number of announcements made by less undervalued firms.

Table of contents

Introduction

It was in the early 1980's when share repurchases became an economically significant phenomenon in the United States (Bagwell & Shoven, 1989). Share repurchases were getting more and more popular among firms in the United States In the following years. Already in 2003 and 2004, share repurchases were almost of the same magnitude as aggregate dividends for the U.S. firms (Skinner, 2008). Share repurchases were not very important in Europe until 1998. For the period 1980 to June 1998, the Securities Data Corporation (SDC) reports only 489 share repurchase announcements made by European firms. 60% of these announcements were made by companies which are listed in the United Kingdom (Rau & Vermaelen, 2002). According to Rau and Vermaelen (2002), there are multiple reasons for the lack of repurchase activity by European firms. The reason for German firms is that share repurchases were forbidden until June 1998 (Rau & Vermaelen, 2002). A Goldman Sachs study from 1999 foresees an upcoming popularity for share buybacks in Germany, because of the changes in the regulations in 1998 (Ikenberry, Lakonishok, & Vermaelen, 2000). The share buyback activity has indeed considerably grown in Germany after the introduction of the new regulations (El Houcine & Boubaker, 2013). Several studies have been done on this topic, mostly for the United States. The results suggest that repurchasing firms earn positive abnormal returns in the short-run and in the long-run after the repurchase announcement and that the share prices become more efficient following an open-market share buyback (Chan, Ikenberry, & Lee, 2007; Rau & Vermaelen, 2002; Ikenberry, Lakonishok, & Vermaelen, 1995; Busch & Obernberger, 2016).

This paper investigates the effects of share buybacks on stock performance and share price efficiency, and relates these effects to different buyback motivations. This is done by testing whether there are abnormal returns after a share repurchase announcement and whether share buybacks have an effect on the price efficiency and on the information content of the stock prices. I use data for the German firms that are currently listed on the DAX, MDAX, SDAX or TecDAX. For the abnormal returns, I study the announcement date (short-term) return and the long-term announcement return based on a one-year period after the announcement. Both the short-term and the long-term performance are based on announcements for open-market share buybacks and announcements for tender offer buybacks. The information content is defined as the amount of information incorporated into the share price and the price

efficiency is defined as the degree to which all available information is incorporated into the share price. I only use the open-market executed share buybacks for testing the relation between share buybacks and price efficiency and between share buybacks and the information content. I formulate four alternative hypotheses and I test these hypotheses based on an unique hand-collected dataset containing all share repurchase announcements made and all open-market executed share buybacks done by currently listed German firms. My main result is that there is an abnormal return on the short-term and on the long-term following a share repurchase announcement, which is mostly based on the pre-announcement performance. I find no evidence for a relation between share buybacks and price efficiency or between share buybacks and the information content of share prices. Together, this indicates that share repurchases are often driven by an overreaction of the market to prior public information, and not by new information about the future performance of the stock.

My baseline hypothesis reads that share repurchase announcements are done, because managers want to signal undervaluation of their stock to potential investors by bringing new information into the market about the future stock performance. Potential investors react to this signal to the market, believing the stock is undervalued, and this would cause an abnormal short-term return. Multiple prior papers report a short-term abnormal return after a buyback announcement (Ikenberry, Lakonishok and Vermaelen, 1995; Ikenberry, Lakonishok and Vermaelen, 2000; Seifert and Stehle, 2005; Hackethal and Zdantchouk, 2006).

When buyback announcement are made because of undervaluation, this means that in an efficient market the share price should go to the true value after the announcement. If the announcement would cause such a reaction, the firm could cancel the buyback right after the announcement, but such a cancellation is hardly ever happening (Ikenberry, Lakonishok, & Vermaelen, 1995). This is because the average return following an repurchase announcement is around 3% based on prior studies, and managers never have the timing ability to recognize such a small undervaluation. Apparently, the market has some skepticism when it comes to the undervaluation. Therefore, the adjustment of the share price is slower than just the announcement date and this could result in an abnormal return for a longer period of time (Ikenberry, Lakonishok, & Vermaelen, 1995). Also, because a high Book-to-Market ratio is an indicator for undervaluation according to Ikenberry, Lakonsihok and Vermaelen (1995),

I should observe a higher abnormal return for high Book-to-Market firm compared to low Book-to-Market firms.

The most commonly mentioned reason for a buyback in the academic literature is signaling (Louis & White, 2007). “Firms use share repurchase announcements to signal to the market that their shares are undervalued” according to the *signaling hypothesis* (Rau & Vermaelen, 2002). Louis and White (2007) also find evidence that managers intentionally use share buybacks to signal undervaluation to the market (Louis & White, 2007). The use of financial decisions as vehicles for signaling firm value was already proposed by Ross (1977), Leland and Pyle (1977) and Bhattacharya (1979) (Comment & Jarrell, 1991). Insiders of the firm have more information than the shareholders and investors based on the *information asymmetry hypothesis* (Brockman & Chung, 2001). When managers use the new information to do a share repurchase, they signal the market by bringing new information into the market. This suggests that a buyback would lead to the incorporation of new information into the market, which would mean that share repurchases make share prices go to their fundamental value, leading to a more efficient market. Busch and Obernberger (2016) find that there is a positive relation between open-market executed share buybacks and price efficiency, and also that there is a negative relation between share buybacks and the idiosyncratic risk in the share price.

My first alternative hypothesis reads that firms do share repurchases based on undervaluation, which is caused by the overreaction of the market to negative public information in the past (*the overreaction hypothesis*). In this case, I should observe an abnormal return, because the market corrects for the overreaction. Seifert and Stehle (2005) report a significant negative abnormal return in the period before the announcement, indicating that the announcement is made to signal such an undervaluation to the market. The abnormal return should be higher for high Book-to-Market firms, because a high Book-to-Market ratio is a proven indicator for poor performance in the past (Peyer & Vermaelen, 2009). When the Book-to-Market ratio of a firm is high, this means that the firm has a high book value compared to their market value, indicating a relatively low share price (Ikenberry, Lakonishok, & Vermaelen, 1995). Therefore, based on the *overreaction hypothesis*, I would expect more high Book-to-Market firms to perform a share buyback, and getting higher returns compared to low Book-to-Market firms following the buyback announcement.

When a high Book-to-Market ratio is an important indicator for the performance after the announcement, this means that the abnormal return after the buyback is not based on new information about the future performance of the stock. A correlation between past performance and the performance after the announcement means that the post-announcement performance is not based on new information given to the market (Peyer & Vermaelen, 2009). To be in line with the *overreaction hypothesis*, I should observe no relation between share repurchases and the information content of the stocks.

My second alternative hypothesis is that managers use share buybacks for their own good, the *management incentive hypothesis*. Managers can have multiple reasons to do so. First of all, they can have a stock-performance based compensation, which gives them an incentive to drive up the share price to directly improve their compensation. Secondly, they want to create more shareholder value, to keep the shareholders satisfied, and to get more potential investors to invest in the company. Also, It allows the managers to distribute cash to the shareholders, without diluting the per-share value of the stock. This may be of particular interest when the managers hold stock options of the firm. By using repurchases instead of dividends, the firm can keep the per-share value stable. Therefore, a firm that compensates its executives with large numbers of stock options can find it favorable to use share repurchases to distribute cash to the shareholders instead of using dividends (Dittmar, 2000).

When an increase in the share price after a buyback announcement is observed, but this is not based on a poor pre-announcement performance, and the efficiency of the share price is getting lower following a share buyback, this could be an indicator that managers try to manipulate the share price. In this case, the share buybacks are not driven by prior performance and therefore, the performance after the announcement should also not be dependent on the Book-to-Market ratio. Busch and Obernberger (2016) find a positive relation between share repurchases and the price efficiency of the stock, and a negative relation between share repurchases and the idiosyncratic risk in a stock. When the share price is driven up, while the price efficiency is negatively influenced by the share buyback, this could be an indicator for manipulation of the share price by the managers. This is because the stock is only getting further away from its fundamental value following the share buyback (Busch & Obernberger, 2016).

My third alternative hypothesis is that share buybacks are only used as an way to distribute cash to shareholders (*the free cash flow hypothesis*). When this is the reason for firms in Germany to perform a share buyback, I should observe no abnormal return following an announcement. By distributing cash to shareholders, firms try to prevent agency problems within the firm (Andres, Betzer, Doumet, & Theissen, 2014). In this case, the announcement would contain no signal about undervaluation, giving potential investors no intention to buy the stock after the announcement.

I find an abnormal return of 1.62% for the share buyback announcement date, ascending to 2.90% in the 25 days following the announcement. Before the announcement, I observe an abnormal return of -3.51%. For the one year after the announcement, I observe an abnormal return of 4.94%, but this result is not statistically significant. High Book-to-Market firms show a significant positive abnormal return of 17.52% for the year after the announcement, compared to an insignificant positive abnormal return of 5.44% for low Book-to-Market firms. Lastly, I find no evidence for a relation between repurchase activity and the price efficiency, and also no evidence for share buybacks to affect the idiosyncratic risk in the stock. The results concerning the high abnormal returns for high Book-to-Market firms, together with the lack of increasing price efficiency and decreasing idiosyncratic risk following a buyback, are not in line with my baseline hypothesis, but are in line with the *overreaction hypothesis*, which reads that managers perform a share buyback to correct for the overreaction of the market to negative publicly available information in the past. Because of the lack of a negative effect of the buybacks on price efficiency, I must reject the *management incentive hypothesis*, and following the high number of announcement made by low Book-to-Market firms, I cannot reject the *free cash flow hypothesis.*

This paper shows the differences in regulations between Germany and the United States when it comes to share repurchases. Based on these differences, and on the relatively short period of legality of repurchasing shares in Germany compared to the United States, my paper on the short- and long-run performance of German stocks after the share repurchase announcements and on the effect of open-market executed share repurchases on price efficiency and idiosyncratic risk in Germany complements the results found for the United States in an ideal way. My paper gives a broad view on the effects of share repurchases for the German market, making it possible to get insights on the motivations for German firms to do share repurchase. Multiple papers have looked at the short- and long-term performance after an

announcement for Germany, but this paper contributes to the existing literature by combining the performance of stocks following share buybacks and the effect of share buybacks on the price efficiency of stocks for the German market to find out the true motivations. As far as I know, this is not done before for the German market.

In part 2 I review some more literature concerning share repurchases, I show the differences in regulations between German and the United States, and I discuss the effect of a share buyback on the firm value. In part 3 the collection of the data, the variable construction and the methodology is discussed. Part 4 contains the summary statistics of the data, the results for the abnormal return around the announcement date and the results concerning price efficiency and idiosyncratic risk. In part 5 I conclude the paper by summarizing the most important results.

Theory

2.1 Literature Review

Ikenberry, Lakonishok and Vermaelen (1995) report that undervaluation is the most given reason when managers are asked why they are doing a share buyback. Already in 1998, Stephens and Weisbach report evidence on a negative relation between share repurchase activity and the prior stock price performance (Stephens & Weisbach, 1998). Andres, Betzer, Doumet and Theissen (2014) confirm the findings of negative share price performance prior to the repurchase announcement and report positive and significant announcement day abnormal returns (Andres, Betzer, Doumet, & Theissen, 2014). The price increase from buyback announcements is greater when insider wealth is at risk and following negative net-of-market stock returns (Comment & Jarrell, 1991). This finding concerning insider wealth supports the *management incentive hypothesis*, which says that if managers get a compensation which partly consists of stock options, managers get an incentive to drive up the share price, but also to lower the shares outstanding to get higher earnings per share (Dittmar, 2000). Firms are also more likely to repurchase shares when their market values are low relative to their book values (Baker & Wurgler, 2002).

Some prior studies even show a higher announcement day return for German firms compared to firms in the United States (Seifert & Stehle, 2005; Hackethal & Zdantchouk, 2006). One of the reasons for this could be that traders have more certainty about the share repurchase program being actually executed in Germany compared to the United States (Seifert & Stehle, 2005). Therefore, more traders will

invest in a German firm announcing a share repurchase than in a U.S. firm announcing a share repurchase. The higher demand for the stocks of the German firm at the announcement date compared to the stocks of a U.S. firm would make the announcement date return (short-run return) for the German firm higher compared to the return for the U.S. firm.

As I mentioned in the introduction, the announcement day return is most of the time too low to determine for the managers based on their timing ability. Therefore, it is reasonable that the undervaluation is bigger than only the announcement day return, indicating that repurchasing firms have an abnormal return for a longer period of time after the share repurchase announcement. Ikenberry, Lakonishok and Vermaelen (1995) find that firms, which perform a share repurchase, outperform the market with 12.1% based on a four year buy-and-hold strategy. To measure this, they have constructed a portfolio which contains shares of share repurchasing firms in the United states for a period of four years between 1980 and 1990 (Ikenberry, Lakonishok, & Vermaelen, 1995). In 2000, they measure the long-run performance after a share repurchase announcement in Canada using a 3-year holding strategy and they report an abnormal return of 7% per year (Ikenberry, Lakonishok, & Vermaelen, 2000). On the other hand, Fama (1998) argues that the long-run performance measured after a share repurchase depends on the methodology being used and that the positive long-term return disappears when the calendar-time portfolio approach is used (Fama, 1998). Peyer and Vermaelen (2009) find a positive abnormal return on the long-term, also when they use the calendar-time portfolio approach of Fama. Rau and Vermaelen (2002) find a negative long-term (one year) return for firms in the United Kingdom. They blame the regulations of the United Kingdom for the different outcome compared to the United States. The firms in the United States can use superior information to buy back their shares when these are undervalued, and for firms in the United Kingdom this is less likely because of regulatory provisions (Rau & Vermaelen, 2002). Most papers on the long-term performance show positive abnormal returns, and based on the market timing and *undervaluation hypothesis*, it is plausible that there is an abnormal return over a longer period of time. Besides, Ikenberry, Lakonishok and Vermaelen (1995) find a higher long-term abnormal return for firms with a high Book-to-Market ratio and this finding supports the *undervaluation hypothesis*. According to Peyer and Vermaelen (2009), a higher abnormal return after an announcement for high Book-to-Market firms indicates that the prior performance of the stock is the driver of

the abnormal returns following a buyback announcement, because the Book-to-Market ratio is a good measure for the past performance (Peyer & Vermaelen, 2009).

The signal of a share buyback is that the managers want to make the potential investors believe that the share is undervalued, but the strength of the signal depends on the buyback method (Dobbs & Rehm, 2005; Ikenberry, Lakonishok, & Vermaelen, 1995). The signaling power of the share buyback announcement is stronger when a tender offer is done compared to when an open-market buyback is done. When firms do a tender offer, they give a premium on the share price, indicating that they really believe that their shares should be traded for a higher price. This makes the undervaluation signal to the market stronger compared to a situation where they do not pay a premium, like in an open-market buyback (Vermaelen, 1981). Comment and Jarrell (1991) find that Dutch-auction self-tender offers and open-market share repurchase programs are weaker signals of stock undervaluation than fixed-price self-tender offers. Firms pay more than the share price most of the time when doing a fixed-price self-tender offer, indicating that they are convinced of the fact that their share is undervalued (Comment & Jarrell, 1991).

A share price moving towards its true value based on the information given by the share repurchase indicates that the share price becomes more efficient following a share repurchase. A recent study by Busch and Obernberger (2016) focuses on the relation of open-market share repurchases with the price efficiency of the stocks and with the level of idiosyncratic risk in the stocks for the United States. They find evidence for a positive relation between share repurchases and the efficiency of stock prices after negative information comes in to the market, and they find a negative effect of open-market share buybacks on the level of idiosyncratic risk in the stocks (Busch & Obernberger, 2016). They also test whether these open-market share repurchases incorporate private information into the stock price, which increases the noise in stock returns, but they find no evidence for this (Busch & Obernberger, 2016).

The *free cash flow hypothesis* is an alternative motivation to buy back own shares. The agency conflict between shareholders and managers is the starting point of the *free cash flow hypothesis*. Share repurchases are mostly done with cash, which makes share buybacks an outgoing cash flow, and therefore share buybacks reduce the free cash flow. By lowering the free cash flow, share repurchases can reduce the agency costs of the firm. Agency costs occur because of the differences in interests between managers and shareholders and this is called the agency problem. Following

this, share repurchases should be more likely in firms in which the agency problem is more severe (Andres, Betzer, Doumet, & Theissen, 2014). So, firms with higher levels of free cash flow and thus a higher level of excess cash should be more likely to announce a share repurchase program. Another measure for cash flow is the EBITDA (Operating profit before depreciation) scaled by the total value of its assets (Andres, Betzer, Doumet, & Theissen, 2014). Therefore, a high EBITDA to assets ratio could result in a higher level of repurchase activity. Repurchase activity is very sensitive to earnings or components of earnings, while dividends are hardly influenced by earnings (Von Eije & Megginson, 2008; Lee & Rui, 2007). Also, based on the *free cash flow hypothesis*, firms with lower leverage should be more likely to announce a repurchase program (Andres, Betzer, Doumet, & Theissen, 2014). This is because leveraged firms have the obligation to pay their interest, which lowers the free cash flow and this already results in fewer agency problems and thus lower agency costs.

2.2 German regulations concerning share buybacks

The “Corporation Control and Transparency Act” (KonTraG) or “Act on Control and Transparency of Enterprises” made some major changes in May 1998 for repurchasing shares in Germany (Zdantchouk & Hackethal, 2005). Share buybacks were illegal in Germany until 1998, but the Corporation Control and Transparency Act changed the regulations and permitted the share buybacks (Kim, Schremper, & Varaiya, 2005). After these changes, it became possible for German firms to buy back their own shares on the basis of an authorization by the shareholders in a shareholders’ meeting (International Law Office, 1999). To ensure that the risk of improper intervention is limited, that shareholder interests are protected, and that companies will not profit from private information, strict regulations are introduced by the German government when it comes to share repurchases (Ginglinger & Hamon, 2005).

The United States already had regulations concerning share buybacks before the German government permitted share repurchases and introduced their share repurchase regulations. Nevertheless, there are some important aspects in which the regulations of Germany differ from those of the United States. Firms in Germany first have to get approval for a specified share repurchase program in the their annual shareholder meeting. The maximum number of shares that can be bought under a program cannot exceed 10% of the total outstanding shares. Also, the repurchase has to done with distributable profits and should be executed within a maximum period of

18 months (Kim, Schremper, & Varaiya, 2005). Firms have to report the open-market share repurchase to the investing public via the Deutsche Gesellschaft für Ad-hoc-Publizität (DGAP), based on the German Securities Trading Act (Wertpapierhandelsgesetz). Management must report the reason for the transaction, its volume and the price paid per share at the following shareholder meeting.

The regulations in Germany are very strict, especially compared to the U.S., which is one of the most unregulated countries when it comes to share repurchases. Firms in the United States only need to obtain approval from their company board, not from their shareholders, and are only required to publicly announce the establishment of a repurchase program. Also, there is no limit on the number of shares that can be bought back by a firm and there are no general restrictions to protect creditors. Moreover, the shares bought back by U.S. firms do not have to be cancelled out and can be held as treasury shares (Vermaelen, 2005). U.S. firms do not even need to disclose the details of any actual repurchase transactions to authorities or to shareholders (Zdantchouk & Hackethal, 2005). Therefore, U.S. firms announcing a share repurchase is nothing more than an intention, while in Germany the actual start of the repurchase activities has to be announced (Seifert & Stehle, 2005). So, even though German firms are permitted now to buy back shares, the regulations in Germany are still very different from those in the United States.

2.3 The different share buyback methods

There are four different ways of buying back own shares. The most straightforward way is the open-market share buyback. When a firms does an open-market share buyback, it buys the shares directly from the market for the current market price. Most of the time the board gives a maximum number of shares to buy of the market. Considering the costs of a buyback, this method of repurchasing shares is the most efficient.

Second, there is the fixed-price self-tender offer. Using this method, the firm proposes to buy a fixed number of shares for a fixed price per share. For example, a maximum of 100.000 shares with a share price of 10 euro per share. Most of the time, this price is higher than the current market price. If there are more shares offered to the firm by the shareholders than the maximum number of shares, the firm will buy from all different shareholders on a pro-rata basis.

Thirdly, there is the Dutch-auction self-tender offer. This method works mostly the same as the fixed-price offer, but instead of a fixed price, there is a range of acceptable prices. For example, the firm sets a maximum of 100.000 shares and a price range of 8 euro till 12 euro. The shareholders can quote the minimum price at which they want to sell their shares. In the end, the firm will start counting at the shares which have the lowest quote price, so first the shares which are quoted at 8 euro, and it will stop counting when it reaches the 100.000 shares. The price of the last share (the 100.000th share) will be the price paid for all the 100.000 shares. So, if the 100.000th share is offered for 10 euro, all 100.000 shares which have been quoted below the price of this share will be bought for 10 euro each.

Lastly, there is the repurchase by direct negotiation. The company negotiates with some of its large shareholders over the number of shares the firm will buy back and the price the firm will pay for the shares. The price will be above the market price most of the time. This method is mostly used when the firm wants to keep away a possible takeover attempt (Finance Train, sd).

2.4 Further insights in share buybacks

Next to signaling undervaluation, one of the most mentioned motivations for buying back shares is to reduce the shares outstanding and, by this way, getting higher earnings per share (EPS-ratio) (Dobbs & Rehm, 2005). Managers can have EPS-based target compensations and by using share buybacks they can reach these targets. Nevertheless, driving the EPS-ratio up by this was, does not signify an increase in underlying performance or value (Dobbs & Rehm, 2005). It is very important for managers to understand the real effects of buying back own shares. To make these effects more clear, I will give an example of a firm's situation before a buyback and after a buyback.

The consequences of a buyback for the firm value can be seen in figure 1. Before the buyback, the firms holds 200 million in cash. All of the cash is used to buy back own shares, therefore cash is 0 after the buyback. One of the consequences is that the total equity value of the firms declines by the amount invested in the own shares. Net income decreases by the amount of interest the firm gained from holding cash in the situation before the buyback, because there is no cash left after the buyback. As can be seen in the figure, Earnings per share (EPS) increases when the shares are bought back. What this example makes clear is that a share buyback does

increase Earnings per share, but lowers the equity value of the firm. The impact of the buyback on the share price comes from changes in the company's capital structure and, more important, from the signal a buyback sends, but not from better company performance (Dobbs & Rehm, 2005).

Share buyback, hypothetical example[1]

	Before	After
Balance sheet		
Cash, € million	200	0
Operating assets, € million	580	580
Total assets, € million	780	580
Equity, € million	780	580
Value		
Value of operations, € million	1,300	1,300
Cash, € million	200	0
Total equity value, € million	1,500	1,300

	Before	After
Income statement		
Earnings before interest, taxes (EBIT), € million	94	94
Interest, € million	6	0
Net income, € million	**100**	**94**
Shares outstanding, million	100.0	86.7
Share price, €	15.00	15.00
Earnings per share (EPS), €	1.00	1.08
P/E	15.0	13.8
Return on invested capital (ROIC)[2]	**16%**	**16%**

[1]Excludes corporate taxes; assumes cost of equity = 10%, cost of debt = 3%, growth = 5%.
[2]Posttax EBIT ÷ operating capital.

Figure 1: Share Buyback Example (Source: Dobbs & Rehm (2005); The Value of Share Buybacks)

Another consequence of buying back own shares is the tax shield following a buyback. For this consequence to be the motivation for a share buyback is not very likely. Nevertheless, using the excess cash in the company to buy back shares or using debt to buy back shares, gives the company some advantages when it comes to taxation. By this way, the company's value does increase slightly following a buyback (Dobbs & Rehm, 2005). The interest paid, when you finance with debt, is deductible from the income before taxation and therefore lowers the firm's taxable income. Holding excess cash gives the company interest income, which is taxable and therefore using the excess cash to buy back shares also lowers the taxable income of the firm. By this way, holding a lot of excess cash brings the shareholders in disadvantage (Dobbs & Rehm, 2005).

Buying back shares is also a way to distribute cash to shareholders, as mentioned in the introduction. Repurchasing stock in the open-market is the preferred method of distributing cash to shareholders in the U.S. equity markets (Grullon &

Michaely, 2002). For decades, U.S. corporations have overwhelmingly preferred to pay out cash in the form of dividends rather than share repurchases, despite the relative tax advantage of capital gains over ordinary income. This entirely changed in the 1980's. Share repurchases as a percentage of total dividends increased from 13.1 percent in 1980 to 113.1 percent in 2000 (Grullon & Michaely, 2002). But why did the firms not shift earlier from dividends to share repurchases as their cash pay-out policy? It is possible that most firms were afraid to violate the anti-manipulative provisions of the Securities Exchange Act (SEA) of 1934. After the Securities and Exchange Commission adopted Rule 10b-18, which provides a safe harbor to repurchasing corporations, the repurchase activity grew significantly. One year after the approval of rule 10b-18, the repurchase activity tripled, which indicates that this is indeed the reason for the shift to share repurchases as the cash pay-out policy (Grullon & Michaely, 2002).

Does this mean that paying dividends is substituted by repurchasing shares as the way to distribute cash to shareholders? Grullon and Michaely (2002) report that, for the United States, firms finance their share repurchases with funds which otherwise should be used for paying out cash dividends. These findings indicate that dividends are being substituted for share repurchases (Grullon & Michaely, 2002). Nevertheless, Von Eije and Megginson (2008) report that in Europe dividends and share repurchases are complements and that repurchases are much more sensitive to earnings compared to dividends (Von Eije & Megginson, 2008). Lee and Rui (2007) also find that repurchases are much more sensitive to earnings than dividends, but they report that share repurchases and dividends are imperfect substitutes (Lee & Rui, 2007). Busch and Obernberger (2016) report that a higher propensity to pay out dividends has a positive effect on the volume that can be repurchased in the next quarter, indicating that share repurchases and dividends are complements (Busch & Obernberger, 2016). Based on these papers, it is hard to say whether share repurchases and dividends are complements or substitutes.

Data & Methodology

To examine share repurchases in Germany, it is important that the share repurchase information is available. I collect the repurchase data for the firms which are currently listed on the DAX, MDAX, SDAX and TecDAX, because the data regarding these firms is easier to obtain and more complete compared to the data for firms which are not

listed anymore on one of these indices. A total of 160 firms are currently listed on these indices. The share repurchase data, so for the announcements and for the open-market buybacks, is collected for the period of 2004 till 2016. The reason I am not taking the first years after the change in regulation (in 1998) into account, is the availability of the data for these years. Most firms do not have the data for these years published on their websites, and also the online archive of the "Deutsche Gesellschaft für Ad-Hoc Mitteilungen" is not accessible for these years. All of the repurchase data, except for the part of the announcements that is collected through the Thomson One database, is hand-collected.

3.1 Collecting the data

For the share repurchase announcement data of the listed firms, I use the ad-hoc message database in the online archive of the "Deutsche Gesellschaft für Ad-Hoc Mitteilungen", the Thomson-One database and the websites of the listed firms. The online archive of the "Deutsche Gesellschaft für Ad-Hoc Mitteilungen" reports the ad-hoc messages made by listed firms to report a share repurchase announcement. Because of the uncertainty regarding the completeness of the data, the Thomson One database and the websites of the listed firms are also used as sources for share repurchase announcement data. The Thomson One database appeared to be more complete when it comes announcements made in the first couple of years of the time period. Because not all repurchase announcements were announcement in an ad-hoc message, the ad-hoc message database in the online archive of the "Deutsche Gesellschaft für Ad-Hoc Mitteilungen" is not complete when it comes to the announcements. By also using the Thomson One database and the websites of the listed firms, I complete my dataset concerning the share repurchase announcements. In total, I construct a dataset containing of 232 share repurchase announcements made by 79 firms. 20 Announcements were made on the same day where another ad-hoc message of the firm was reported. These announcements are excluded, because the announcement effect cannot be measured adequately (Seifert & Stehle, 2005). I lose another 16 announcements, because some firms are not available in Compustat. Therefore, I end up with 196 announcements. The average size of an announced share repurchase program is 3.71 percent of the shares outstanding. If the ad-hoc message is published after the trading hours I allocate the observation to the next trading day.

I do not use all of the announcements for the one-year buy-and-hold abnormal return. Announcements made by the same firm that are within a timeframe of a year from each other are excluded, because the one-year abnormal return cannot be calculated adequately when there is another announcement in the same period. This second announcement could influence the abnormal return of the first announcement. Also, one year of share prices after the announcement are needed to calculate the abnormal return using a buy-and-hold strategy. Therefore, the announcements made in 2016 are also excluded from the dataset. For the long-run one-year performance, I end up with a total of 139 announcements.

I collect the data for the open-market executed share repurchases from the websites of the listed firms. In most cases, these firms report their share repurchases on their website and in the other cases they report it in their annual reports, which can be downloaded from their websites. Share repurchase programs that are not executed in the open-market are excluded from the dataset. I construct a dataset with a total of 58 repurchasing firms, which together executed 187 repurchase programs and 886 repurchasing months. Because some firms are not available in Compustat, I end up with a total of 7,908 firm months and with 180 buyback programs, which consist of 790 repurchasing months.

The data concerning the open-market executed buybacks is not reported in the same way by all firms, therefore I need to make some assumptions to get a usable dataset. When the share buybacks are reported weekly, it sometimes occurs that a reported week falls into two separate months. In this case, the number of shares bought back is divided between these two months. For example, when two of the five trading days of this week are falling in August, and three of five trading days in September, then 40 percent of the share bought back are reported for August and 60 percent for September. Also, when there are no notifications on the website about share issues, I assume that the total number of outstanding shares is constant over time. When only the amount of money is announced for a share buyback program, this amount is divided by the average price paid for a share. By this way the number of shares that the firm could have bought for this amount is calculated and used as the size of the program. Lastly, when a repurchase program is ended in a certain month, and a new program is started in the same month, then the announced program size for this month will be remaining announced volume from the previous program added

to the announced size of the new program. The announced program size for the following months will be only the new announced program size.

I collect the daily closing prices of the firms and of the DAX, MDAX, SDAX and TecDAX from the Compustat Global database. The daily closing prices from Compustat Global are not adjusted for stock-splits, therefore I manually adjust all of the closing prices as if there has never been a stock-split. Without adjusting the closing prices, it would be impossible to calculate proper daily and monthly returns.

To estimate abnormal returns and to estimate the price efficiency variables, I have to compare the actual rate of return for all stocks on a specific day to the expected rate of return of the market portfolio on that day. I use the daily change of the CDAX index, which is the composite index of all stocks traded on the Frankfurt Stock Exchange that are listed in the General Standard or Prime Standard market segments, market capitalization weighted, as the expected rate of return of the market portfolio (Bastin, 2017). To calculate the daily changes of the CDAX index, I need the daily closing prices of this index. These are collected from the Bloomberg database. Advantages of using the CDAX as the market portfolio are that it is an easy approach to use and that there is no need for an estimation period (Seifert & Stehle, 2005; Hackethal & Zdantchouk, 2004). The CDAX as the market portfolio is a very well-known method and used in many other papers (Meric, Ratner, & Meric, 2008; Seifert & Stehle, 2005; Hackethal & Zdantchouk, 2004; Hackethal & Zdantchouk, 2006). Furthermore, this approach has a good capability to estimate short-term abnormal returns when using the cumulative abnormal return approach (Campbell, Lo, & MacKinlay, 1997). The CDAX index is also a good estimator for the long-term market return when using the buy-and-hold strategy for calculating the abnormal returns (Ikenberry, Lakonishok, & Vermaelen, 1995).

3.2 Analyzing the buyback data

Figure 2 shows the deviation of the announcements in the dataset over the years. As can be seen in the figure, the number of announcements is not stable over time. I observe a peak in the repurchase announcements during the year 2008. That is the same years as where I observe a peak in the number of announcements, the number of repurchasing firms and the total number of repurchasing months. After 2008, in 2009 and 2010, the figure shows a drop in the announcements made. In the remaining years, the number of announcements stays mostly constant. I observe the

same pattern in figures A and B in Appendix A, where the number of announcements per year is replaced by the number of repurchasing firms per year and the total number of repurchasing months per year. Figure 3 shows the value of the CDAX during the time period.

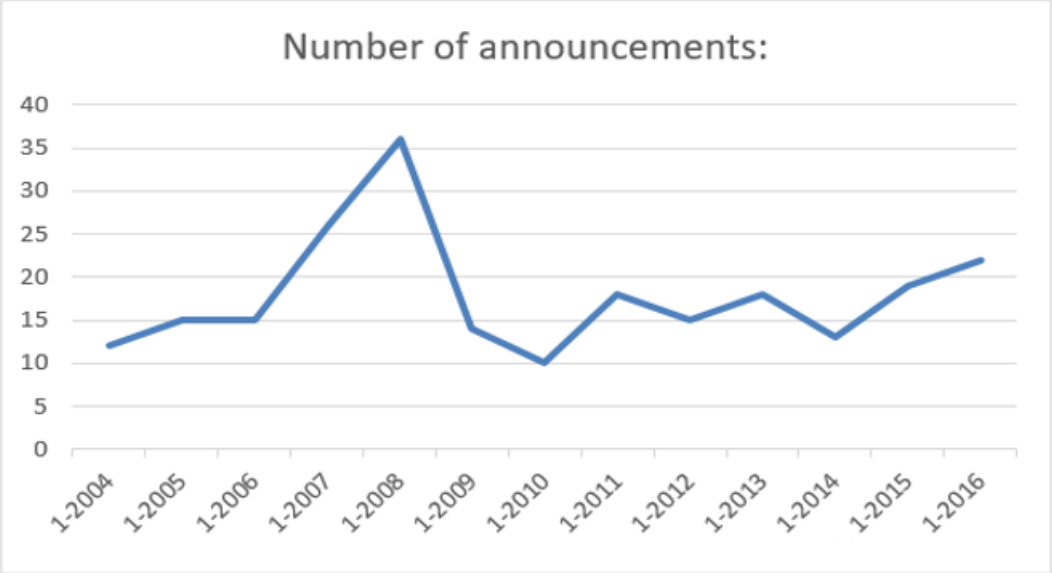

Figure 2: Number of announcements over the years

The year 2007 shows a rise in the share buyback activity and in the CDAX value, which is not in line with the undervaluation theory. In the year 2008, the CDAX lost almost 50 percent of its value, because of the European financial crisis, while on the other hand there is a peak in the buyback activity during this year (Van Essen, Engelen, & Carney, 2012). Considering the theory I discussed regarding market timing and undervaluation, it is reasonable that multiple managers made the decision to repurchase own shares during 2008, because they were trying to time the market. The share prices went down with almost 50% on average during this year and they tried to use this drop in the share price by buying back own shares based on their timing ability. In 2009, the number of repurchase announcements drops, which can be explained in the same way as the peak in 2008.

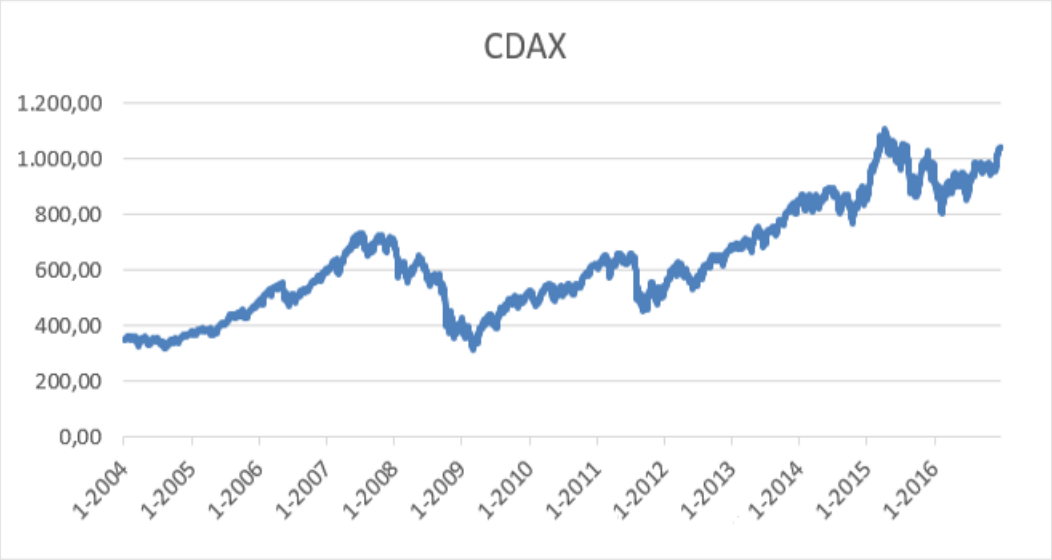

Figure 3: CDAX value from 2004 till 2016

Figure 3 shows that the CDAX increases its value with around 20 percent in 2009. An increase in share prices should result in a drop in the number of share buybacks based on the market timing and undervaluation theory, and that is also what I observe for these years. Looking at the year 2010, I also observe a drop in the share buyback activity and a rise in the value of the CDAX. For the remaining years, the buyback activity is quite stable, while the value of the CDAX is almost constantly rising. My announcement data not fully support the *undervaluation* and *market timing* theory by showing that a drop in the CDAX index not always leads to a peak in the total number of share repurchase announcements, and a rise in the CDAX index not always leads to a drop in the number of share repurchase announcements. Nevertheless, a note has to be made regarding the reliability of these observations, because they are only based on the data figure. By testing whether there is an abnormal announcement return on the short-run and on the long-run, I can determine whether announcements are really made to signal undervaluation to the market.

3.2.1 Dividends

In the theory section I already discussed some factors that could affect the share buyback activity. In the following figures, I compare the trend of these discussed factors with the trend of two buyback activity measures. Because the values of the different factors are not comparable with the numbers of the buyback activity, I adjust all numbers to the same average in every figure. I do not report numbers in the figures,

because it is impossible to interpret these numbers because of the adjustment of the numbers to the same average. That the numbers are not interpretable is no problem in this case, because I want to compare the trend of the different factors with the repurchase activity measures to get an indication of the relation between the different factors and the repurchase activity.

Figure 4 shows the changes in *dividends scaled to assets* over the years, compared to two measures of share buyback activity; the total number of repurchasing firms per year and the total repurchasing months per year. When it comes to dividends compared to the buyback activity, a comparable trend is shown by the figure. It seems like the buyback measures are moving with the dividend measure in the same direction. This indicates that dividends and share repurchase activity are complements, as reported by Busch and Obernberger (2016) and Von Eije and Megginson (2008). As I have shown before, the share prices in 2008 went down with more than 40%. When firms hold their dividend rate stable, which is based on their share price, than a lower value of dividend to assets follows (ceteris paribus). In such a case, it is more favorable for a firm to do a share buyback, because this also distributes cash to your shareholders, but it does not lower your share price like a dividend payment.

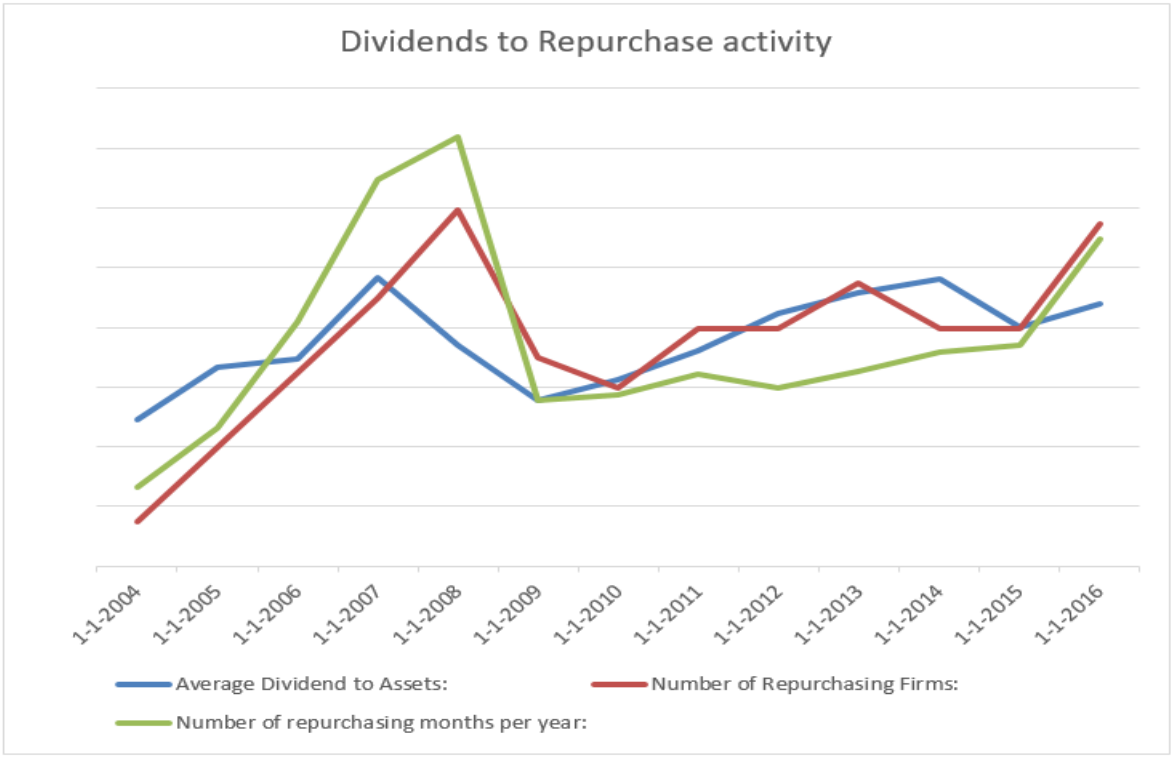

Figure 4: Dividends compared to Buyback activity

3.2.2 Cash

In figure 5 I make the same comparison as I did in figure 4, only this time I use *cash to assets* instead of *dividends to assets*. As can be seen in figure 5, cash scaled by assets is mostly stable over time. Some small movements can be observed, and share buyback activity moves with cash as I would expect them to move based on the *free cash flow hypothesis*. As I discussed in the *Theory* part, high values of cash lead to more buyback activity, because firms look for a way to lower their cash levels to prevent agency problems and lower their agency costs (Andres, Betzer, Doumet, & Theissen, 2014). This would mean that if cash is high, I should observe more repurchase activity. So, the line of the share buyback activity should follow the line of *cash to assets*. Even though the cash line is not moving much, I indeed observe the repurchase activity following the movement of the *cash to assets* line, only the movements in the buyback activity are much bigger. Therefore, the figure seems to support the *free cash flow hypothesis*, but as I mentioned before, it is hard to make such statements based on only a data figure.

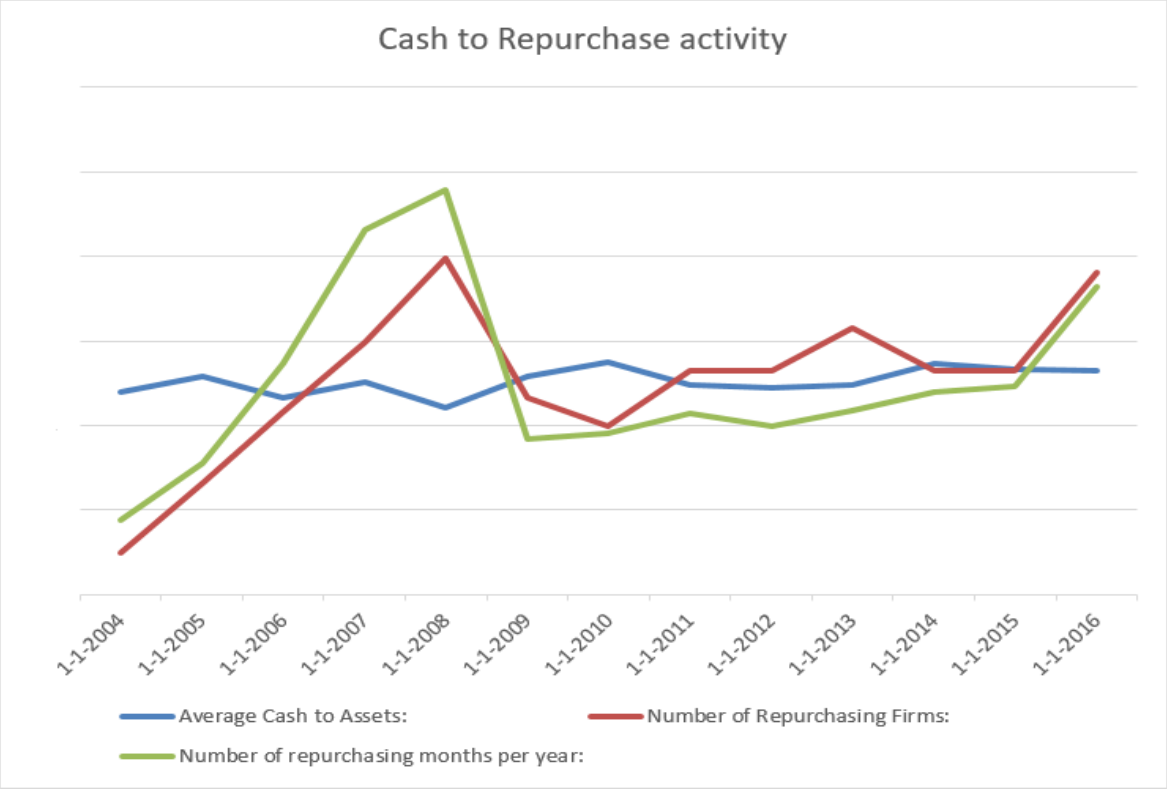

Figure 5: Cash compared to buyback activity

3.2.3 EBITDA

When comparing *EBITDA to assets* to the buyback activity, I should expect to see the same pattern as when I compared cash with the buyback activity based on the fact that EBITDA is also a measure for cash flow. I observe that EBITDA to assets and the buyback activity measures are showing the same pattern. The buyback activity shows stronger changes than the EBITDA, but the pattern is mostly the same. Only in the last year, where the buyback activity shows a big increase compared to the year before and the EBITDA is staying mostly stable, the pattern is different. The stronger movement could be because of the high sensitivity of share repurchase activity to changes in the earnings of the firm (Von Eije & Megginson, 2008; Lee & Rui, 2007). Compared to figure 5, I observe a delay in the movement of EITDA compared to cash, which is probably because EBITDA is driven by cash. Busch and Obernberger (2016) show that the significant positive effect of EBITDA on repurchase activity disappears when cash is added to the regression (Busch & Obernberger, 2016).

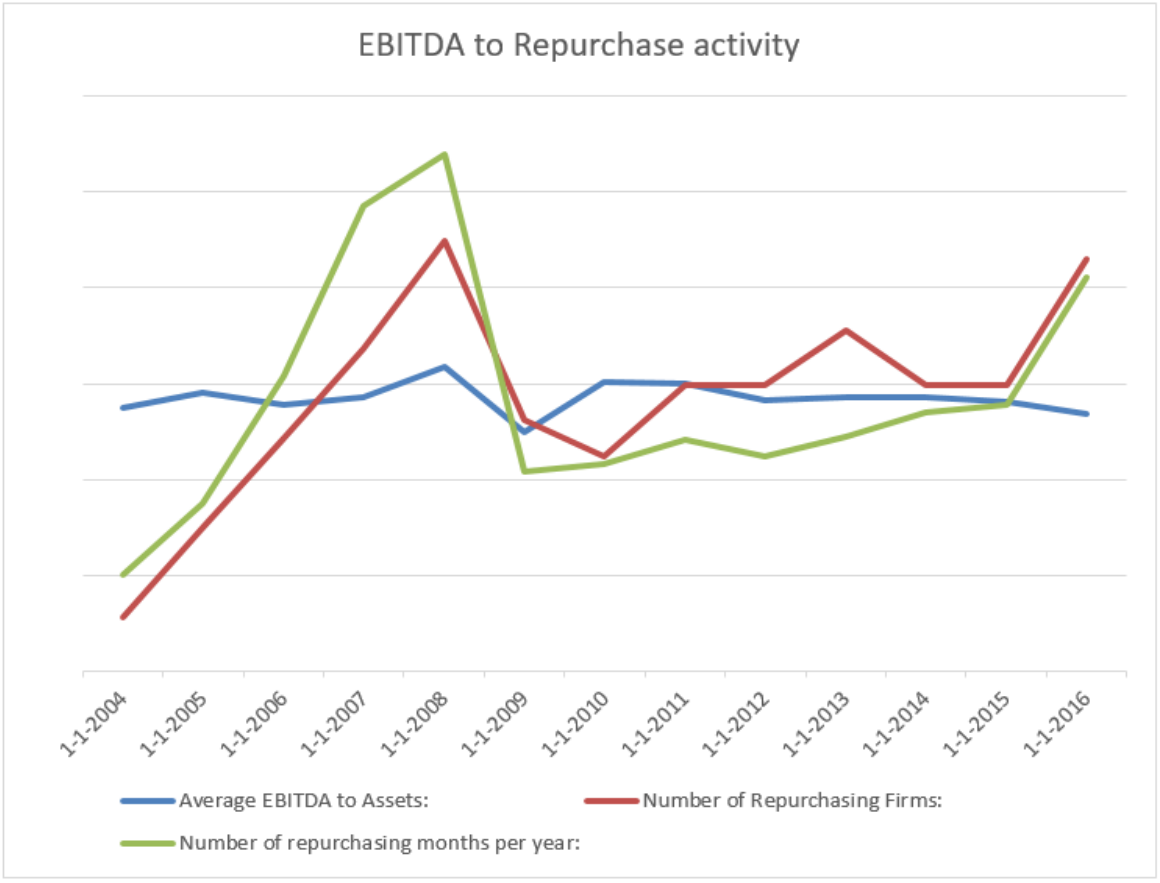

Figure 6: Operational profit before depreciation compared to buyback activity

3.2.4 Leverage

In figure 7 I compare the trend of the average *leverage* with the trend of the buyback activity. Based on the *free cash flow hypothesis*, when comparing *leverage* and buyback activity, I should observe movement in the opposite direction (Andres, Betzer, Doumet, & Theissen, 2014). *Leverage* is not changing as much as the buyback activity, but the movement is most of the time in the opposite direction. Only in 2008, both *leverage* and buyback activity are showing an increase compared with the year before. Based on figure 7, I observe that the data concerning *leverage* and buyback activity seems to support the *free cash flow hypothesis*. In the part 4 I will test whether dividends, cash, EBITDA and leverage have an effect on share buyback activity in line with the *free cash flow hypothesis*.

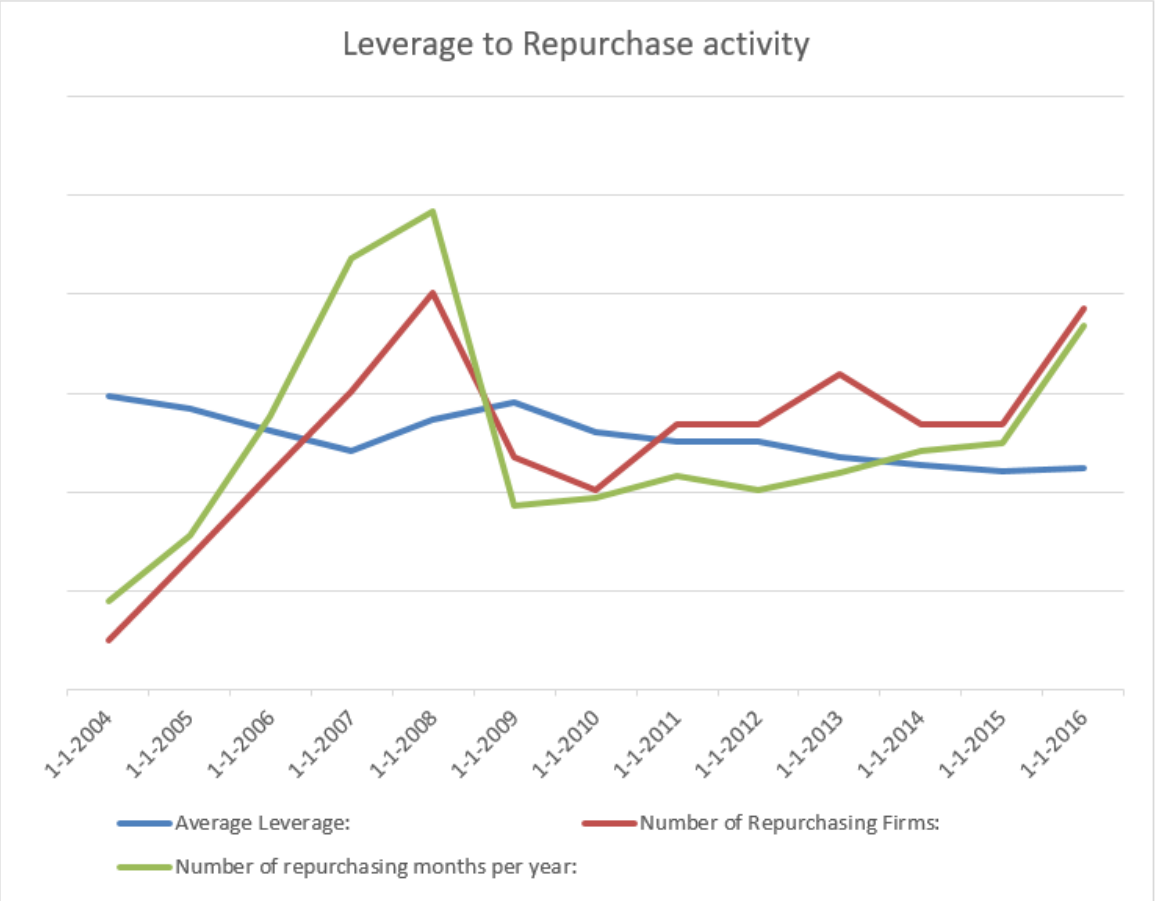

Figure 7: Leverage compared to buyback activity

3.3 Methodology

3.3.1 Short-term abnormal return

The method used in this paper to calculate the short-term abnormal return is the "rebalancing strategy" using the cumulative abnormal return. This is the same method as in Ikenberry, Lakonishok and Vermaelen (1995) and Seifert and Stehle (2005) and is a generally known method for calculating abnormal returns. By using this method, I will determine whether there is a significant difference in return between a stock and the market on the announcement date and in the period before and after the announcement. I use a timeframe of 51 days, 25 days before the announcement and 25 days after the announcement. By this way, I can test whether there is an significant negative return before the announcement and a positive significant return on the announcement date and in the days following the announcement. To calculate the average 50-day standard deviation, I use the 50 days before the 51-days event window to make sure there is no influence from the announcement on the average 50-day standard deviation. This makes the whole timeframe as follows;

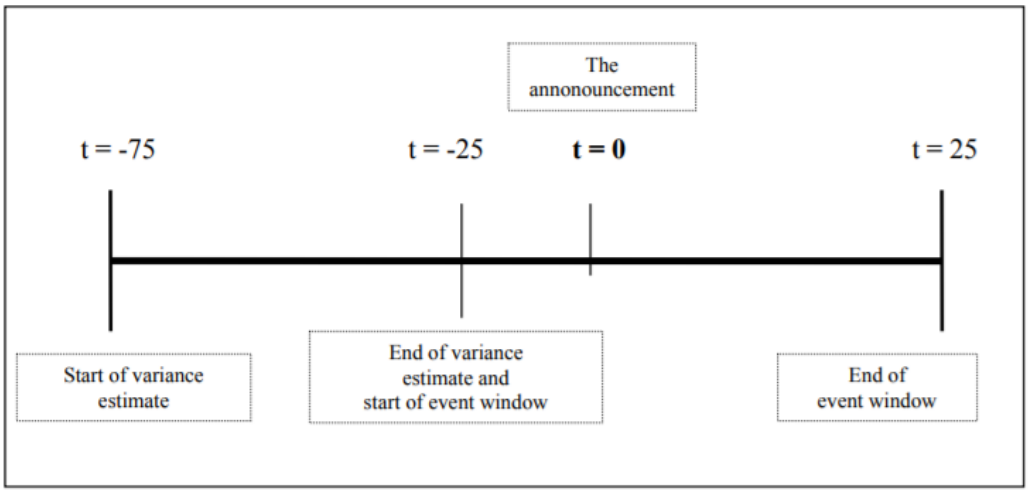

Figure 8: Time window for the short-term announcement part (Seifert & Stehle, 2005)

So, first I calculate the average cumulative abnormal return using the rebalance strategy. As can be seen in the following formula, it is based on the equal-weighted average abnormal return of all announcements (N):

$$\overline{CAR_T^{RS}} = \sum_{t=1}^{T}\left[\frac{1}{N}\sum_{i=1}^{N}\left(1 + AR_{i,t}\right)\right] \quad (1)$$

CAR is the average cumulative abnormal return from t=1 to T using the rebalance strategy and N is the number of observed announcements (Seifert & Stehle, 2005). As can be seen in the formula 2, I calculate the abnormal return of a firm-announcement (i) on a day (t), so for every announcement made by a firm the abnormal return is calculated. This is done by subtracting the market return (daily return of the CDAX index) on the announcement day from the return of firm (i) on the announcement day:

$$AR_{i,t} = R_{i,t} - E[R_{i,t}] \qquad (2)$$

Then, I sum the abnormal returns of firm (i) for all days in the time period. I now have the CAR of each firm for the chosen time period. To calculate the average CAR, I add the CARs of all announcements made by the firms and divide this total CAR by the total number of announcements made. By this way, I have calculate the average CAR for the chosen time period. This is done for each of the 51 days, for the 25 days prior to the announcement, for the announcement date with the 25 days following the announcement, for the 25 days following the announcement and for the total time window of 51 days.

To test whether these average CARs are statistically significant, I have to calculate the average 50-day standard deviation of the returns. This is done by using the following formula:

$$\overline{\hat{\sigma}_{50}}(AR^{RS}) = \sum_{i=1}^{N} \frac{1}{N} \sqrt{\frac{1}{49} \sum_{1}^{50} (AR_{i,t} - \overline{AR_t})^2} \qquad (3)$$

The timeframe for calculating the standard deviation is 75 days before the announcement till 25 days before the announcement, because in this period the estimated average standard deviation is not influenced by the announcement effects (Seifert & Stehle, 2005). To calculate the average daily standard deviation over this period, I first calculate the squared abnormal return for every day in this period and make a summation per firm. The squared values are used, because I want to have the extreme values of the variance in the abnormal returns. So I sum the squared abnormal returns for the 50 days (49 returns) and divide this by 49. Following this, I take the

square root of the outcome to calculate the true extreme values of the variance. I now have the average daily standard deviation per announcement. By adding these average daily standard deviations together and dividing it by 196, which is the number of announcements, I get the average daily standard deviation.

I now have the average CAR per firm per time period, the average daily standard deviation, the number of days in the time period and the number of announcements. This is all I need to calculate the T-value as can be seen in the following formula:

$$T_T^{RS} = \sqrt{N}\frac{\overline{CAR_T^{RS}}(mul)}{\sqrt{T} * \overline{\hat{\sigma}_{50}}(AR^{RS})} \quad (4)$$

where CAR is the average cumulative abnormal return, estimated using the rebalance strategy, N is the number of announcements, T is the time period and Ơ is the average daily standard deviation of the abnormal return (Seifert & Stehle, 2005). With the T-value and the degrees of freedom, which is the number of observations minus one, I am able to look up the p-value and determine whether the CARs are significantly different from zero for the time period used.

3.3.2 Long-term abnormal return

For the long-run performance I use the buy-and-hold abnormal return (BHAR) method, the same method as Ikenberry, Lakonishok and Vermaelen (1995). Peyer and Vermaelen (2009) use a different method for calculating the long-term abnormal return. They combine the Fama and French three factor model with Ibbotson's RATS methodology to compute abnormal returns. Advantage of this methodology is that changes in the riskiness of the equity from before to after the share buyback, due to changes in the leverage, are better accounted for (Peyer & Vermaelen, 2009). Peyer and Vermaelen (2009) find a higher economic magnitude compared to Ikenberry, Lakonishok and Vermaelen (1995), but the general results are mostly the same. Peyer and Vermaelen (2009) also use a different method, the calendar-time portfolio approach of Fama (1998), where a portfolio is made for every calendar month, containing all firms that had an event in the past 12 months in the case of a one-year abnormal return, and this approach gives qualitatively similar results as the RATS methodology.

Despite the advantages of the methods used by Peyer and Vermaelen (2009), I have multiple reasons to use the BHAR methodology for the long-term abnormal return. First, I already use Ikenberry, Lakonishok and Vermaelen (1995) as my benchmark for calculating the short-term abnormal return, so when also using the same method for calculating the long-term abnormal return as in their paper, I can make a good comparison with the abnormal returns of the Ikenberry, Lakonishok and Vermaelen (1995) paper. Secondly, I use the BHAR methodology to calculate abnormal returns, because this method "accurately represents investor experience" when it comes to long-term investments (Lyon, Barber, & Tsai, 1999).

First, I have to create a benchmark based on the German market. To keep in line with the short-run performance and because it is the best proxy for the German market , I use the CDAX index as the benchmark to compare the abnormal return with. Only this time, the buy-and-hold return is calculated for the stocks and also for the CDAX index. The difference in the buy-and-hold return between every stock and the CDAX index gives the buy-and-hold abnormal return. This is the same approach Ikenberry, Lakonishok and Vermaelen (1995) describe in their research, but only with one benchmark (Ikenberry, Lakonishok, & Vermaelen, 1995). The BHAR is then calculated using the following formula:

$$\mathrm{BHAR}_i(h) = \prod_{t=1}^{h}(1 + R_{i,k_i+t}) - \prod_{t=1}^{h}(1 + R_{b,k_i+t}) \qquad (5)$$

where Ri is the return of stock i, Rb is the return of the benchmark portfolio and h is the event period in months (Knif, Kolari, & Pynnonen, 2013). So, first I add one to the returns of the firms and the return of the benchmark, because this will make it possible to use the product of the monthly returns to get the one-year buy-and-hold return. Second, I take the product of the first twelve monthly returns per firm to get the one-year buy-and-hold return. After that, the one-year buy-and-hold abnormal return per firm is calculated by subtracting the buy-and-hold return of the benchmark from the buy-and-hold returns of the firms.

Now, I have an one-year abnormal return for every announcement. To get the average abnormal return, I take the summation of all the abnormal returns and divide this by the number of announcements, as can be seen in the following formula:

$$\overline{\mathrm{BHAR}}(h) = \frac{1}{n}\sum_{i=1}^{n} \mathrm{BHAR}_i(h) \quad (6)$$

where n is the number of announcements in the sample (Knif, Kolari, & Pynnonen, 2013).

To test the null hypothesis, which is that there is no abnormal return, I use a conventional t-statistic as in Lyon, Barber and Tsai (1999):

$$t_{\mathrm{bhar}} = \frac{\overline{\mathrm{BHAR}}(h)\sqrt{n}}{s_{\mathrm{bhar}}} \quad (7)$$

where BHAR is the average buy-and-hold abnormal return, n is the number of announcements and s is the yearly standard deviation of the buy-and-hold abnormal return (Knif, Kolari, & Pynnonen, 2013).

I use the same methodology to test whether high book-to-market firms have higher one-year abnormal returns than low book-to-market firms. I make quintiles based on the book-to-market ratio of the firm for every year in the dataset. Following this, I calculate the buy-and-hold abnormal return for firms which are in the highest quintile during their announcement, and for firms which are in the lowest quintile during their announcement. By this way I can compare the abnormal returns of the high book-to-market firms and the low book-to-market firms.

3.3.3 Price efficiency and Idiosyncratic risk

To test whether open-market share buybacks have a positive effect on price efficiency, I use a methodology based on the Busch and Obernberger (2016) paper. In the general regressions the measure of efficiency and the measure of idiosyncratic risk are being regressed on a measure of repurchase activity, the lagged value of the dependent variable and some control variables. Two measures for repurchase activity are used, the number of shares repurchased divided by shares outstanding and the remaining volume of shares that can be repurchased in the current repurchase program (Busch & Obernberger, 2016). One of the repurchase measures at the time is regressed on

return (lagged or contemporaneous), the size of the repurchase program, and the month of the program.

First the efficiency measure is used as the dependent variable with a lagged value of the efficiency measure as one of the independent variables;

$$Efficicency_{i,t} = \alpha + \delta Efficiency_{i,t-1} + \beta Rep_{i,t} + \sum_{l=1}^{l=K} \gamma_l Control_{i,l,t} + \mu_i + \eta_t + u_{i,t}, \quad (8)$$

and second, the same regression is used with idiosyncratic risk as the dependent variable with a lagged value of idiosyncratic risk as one of the independent variables;

$$IdiosyncraticRisk_{i,t} = \alpha + \delta IdiosyncraticRisk_{i,t-1} + \beta Rep_{i,t} + \sum_{l=1}^{l=K} \gamma_l Control_{i,l,t} + \mu_i + \eta_t + u_{i,t}. \quad (9)$$

Rep is the Repurchase intensity or Remaining share volume. Repurchase intensity is defined as the number of shares purchased in a month, divided by the number of shares outstanding at the end of the previous month. Remaining share volume is the number of shares which are still left to be bought in the current program at the beginning of month t. Efficiency is the measure for price delay, which is based on the r-squared of the base model and the r-squared of the extended model, as discussed above. The R-squared is the explanatory power of the model. A R-squared of 0.20 (20%) indicates that 20% of the change in the dependent variable is explained by the model. As a measure for idiosyncratic risk, the r-squared of the base model is used. Control represents all the control variables being used in the model, μ is a time-invariant firm fixed effect and u is a month fixed effect. I use the firm fixed effects and the time fixed effects to make sure that the results are neither driven by unobserved heterogeneity in the cross section, nor driven by unobserved macroeconomic factors (Busch & Obernberger, 2016).

3.4 Variable construction

For the part concerning the *price efficiency* and *idiosyncratic risk*, I have to construct a variable that indicates price efficiency and a variable that indicates idiosyncratic risk. To test for the price efficiency I use price delay as in Hou and Moskowitz (2005). To calculate *Delay*, I need the daily stock prices of all firms that are repurchasing during the time period, and I need the daily values of the CDAX, which represents the DAX, MDAX, SDAX and TecDAX. Furthermore, I need one-year of prior data to measure price delay, so I collect the daily stock returns for the period 2003 to 2016. To estimate the delay variable, I first have to estimate the r-squared of the *Base model*. In the base model the daily return of a certain stock is taken as the dependent variable, and the daily return of the market index is taken as the only independent variable. So, I regress the daily return of one of the stocks from the dataset (at a certain moment in each year) on the CDAX index return:

$$r_{i,t} = \alpha_i + \beta_i^0 r_{m,t} + \varepsilon_{i,t} \text{ (Base model)} \quad (10)$$

Following this, I also have to estimate the r-squared of the *Extended Market model*. The extended market model has the daily return of a certain stock in the dataset as the dependent variable and the daily return of the CDAX index as an independent variable. Difference with the base model is that five lagged returns of the CDAX index, so the returns of the five previous days of the CDAX index, are also added to the regression as independent variables, giving the following regression:

$$r_{i,t} = \alpha_i + \beta_i^0 r_{m,t} + \sum_{n=1}^{5} \beta_i^n r_{m,t-n} + \varepsilon_{i,t} \text{ (Extended market model)} \quad (11)$$

Based on the r-squared of the base model and the r-squared of the extended market model, I calculate the measure of price delay by doing one minus the ratio of the R-squared of the base model and the R-squared of the extended market model (Hou & Moskowitz, 2005):

$$Delay = 1 - \frac{R^2_{base}}{R^2_{extended}} \quad (12)$$

The idea behind this measure is that when the explanatory power of the lagged market returns, which are the 'extra' independent variables in the extended market model compared to the base model, makes the r-squared higher, the delay of new information being fully incorporated into the stock prices is higher. A higher price efficiency of a stock, which means that the new information is faster incorporated into the prices, gives a smaller difference in explanatory power between the base model and the extended market model. So, when the price efficiency increases, the delay measure decreases (Busch & Obernberger, 2016).

For the idiosyncratic risk, I want to measure the amount of idiosyncratic information incorporated into stock prices. This is done by determining the degree of co-movement between individual stock returns and the market return. I use two measures for this co-movement; the r-squared of the base model and the correlation between the market return and the stock return (Morck, Yeung, & Yu, 2000). Both measures are estimated for each month with daily returns (Busch & Obernberger, 2016).

Results

4.1 Summary statistics

In table 1 the descriptive statistics of the variables used in the regressions is shown. The table contains also some information on the repurchase programs. No information regarding the share repurchase announcements is given in this table. The analysis concerning the abnormal announcement return is done without regressions, as can be seen in the previous part, and consists of only the returns of the different stocks and the market return to calculate the abnormal return. The summary statistics concerning the announcement return are given in table 2.

4.1.1 Summary statistics; price efficiency and idiosyncratic risk

At first table 1 shows the dependent variables, which are Delay, R-squared and the extreme value of Market Correlation. When comparing the values of these variables to the values of the same variables in the Busch and Obernberger (2016) paper, there are some differences noticeable. Both R-squared, 6.12% compared to 26.84%, and Market correlation, 0.193 compared to 0.456, have lower values than they have in the comparable paper, while Delay shows a higher value, 0.811 compared to 0.504. The

Delay variable is partly based on the R-squared variable, so that would suggest that Delay is high because of the low value of R-squared. A mean value of 0.811 for Delay, which is calculated using the R-squared of the base model with a mean value of 6.12%, gives a mean value of the R-squared of the extended market model of 32.38% (see formula 12). By doing the same calculation for the Busch and Obernberger (2016), a mean value of 54.11% is found for the R-squared of the extended market model. This makes clear that the difference in Delay is mostly caused by the big difference in the R-squared of the base model. All of these numbers indicate that the information to the market is slower and less adequately incorporated into the stock prices in German compared to the United States.

Descriptive statistics

Variable	*Mean*	*Median*	*SD*	*SD (within firm)*	*1st Perc.*	*99th Perc*	*N*
Delay	0,811	0,895	0,213	0,212	0,131	1,000	7905
R-squared	6,12%	2,47%	10,15%	9,89%	0,00%	50,65%	7907
|Market Correlation|	0,193	0,157	0,155	0,154	0,003	0,712	7907
Repurchase measures							
Repurchase Volume (Mill.)	6,48	0,00	44,7	39,6	0,00	174,0	7911
Repurchase Intensity	0,05%	0,00%	0,23%	0,37%	0,00%	0,98%	7911
Repurchase Intensity (TV)	0,65%	0,00%	3,51%	4,96%	0,00%	15,27%	7911
Remaining Volume	0,35%	0,00%	1,55%	1,36%	0,00%	8,94%	7911
Repurchase measures in repurchase months							
Repurchase Volume (Mill.)	64,8	12,5	137,0	19,4	0,03	621,0	790
Repurchase Intensity	0,48%	0,35%	0,55%	0,17%	0,01%	2,86%	790
Repurchase Intensity (TV)	6,48%	4,04%	9,26%	2,35%	0,04%	30,46%	790
Remaining Volume	3,50%	2,29%	3,62%	0,91%	0,00%	14,93%	790
Program descriptives							
Program Month	5	4	5	1	1	23	180
Program Size (scaled)	4,34%	2,65%	4,83%	0,66%	0,00%	18,87%	180
Control variables							
Book-to-Market	0,724	0,561	0,543	0,322	0,077	2,878	7889
Cash to Assets	12,68%	8,23%	14,36%	5,14%	0,26%	65,79%	7878
Dividend to Assets	1,92%	1,10%	3,16%	1,31%	0,00%	15,94%	7890
EBITDA to Assets	0,034	0,030	0,030	0,019	-0,037	0,135	6588
Leverage	0,510	0,498	0,264	0,098	0,050	0,982	7889
Market Cap. (Mill.)	10100	1670	17700	3610	30	75900	7910
Return	0,007	0,010	0,098	0,095	-0,293	0,257	7900
Total Assets (Mill.)	76200	2367	267000	186000	49	1730000	7890
Trading Volume	0,117	0,087	0,110	0,031	0,002	0,466	789
Volatility	0,020	0,017	0,011	0,010	0,007	0,061	7907

Table 1: Summary statistics price efficiency part
In table 1 are the summary statistics reported for all variables which are used in the price efficiency regressions. The table also reports some information on the repurchase programs, and on the repurchase variables in the repurchase months. I report the mean, the median, the standard deviation, the value of the first percentile of the distribution, the value of the 99th percentile of the distribution and the number of observations for each variable. None of the variables is expressed in natural logarithms.

The CDAX as the market portfolio is a very well-known method when using a market portfolio based on the German market (Meric, Ratner, & Meric, 2008; Seifert & Stehle, 2005; Hackethal & Zdantchouk, 2004; Hackethal & Zdantchouk, 2006). It is currently the most prominent proxy for the German market portfolio, which makes it hard to believe that the differences are caused by the choice for the CDAX as market portfolio (Stehle & Schmidt, 2015).

One reason for the differences could be that it is harder for investors to get information on the German firms than on the U.S. firms (Allen & Gale, 1995). Investors and shareholders make decisions based on information and without publicly available information it is hard for investors to make a decision. Reason for this is the domination of the banks in Germany when it comes to the financial markets. Banks regulate the information coming to the market, making the availability of public information about listed firms in Germany very small compared to the United States (Allen & Gale, 1995). This is not the case for information about share repurchases in Germany, because of the strict regulations about reporting the share buyback to the shareholders. Nevertheless, it could cause the difference in mean values for delay in getting other information incorporated to the market, explaining the difference in the Delay values and especially the difference in the R-squared values of the base model between this paper and the Busch and Obernberger (2016) paper.

The second part of table 1 shows the four different repurchase measures. These repurchase measure numbers are based on all firm months in the dataset, so not only the months in which firms bought back their own shares. The median takes the value in the middle when all values are sorted, and because of the fact that there were no buybacks in more than half of the months, the median value for all these repurchase measures should be zero. As can be seen in table 1, they all have a median value of zero as I expected.

First repurchase measure is the *Repurchase volume* in millions. The mean of the repurchase volume is 6.48 million compared to 12.8 million in the Busch and Obernberger (2016) paper. The *Repurchase intensity* shows a mean value of 0.05 percent, meaning that firms bought back 0.05 percent of their shares on average, based on the shares outstanding at the end of the previous month. Busch and Obernberger (2016) report a higher mean of 0.16 percent.

The next repurchase measure is *Repurchase intensity (TV)*, which is the total number of shares bought back during a month scaled by the total trading volume of

the firm during that month. The mean value is 0.65 percent compared to 1.64 percent in the comparable paper.

The last repurchase measure is *Remaining volume*, which is the remaining volume that still can be bought back under the program at the beginning of the month, scaled by assets. This measure shows a mean value of 0.35 percent compared to 4.54 percent in the Busch and Obernberger (2016) paper.

Most of the values of the repurchase measures are higher in the Busch and Obernberger (2016) paper than the values I find. Reason for this is that I have a lower ratio of repurchasing months compared to total trading months than they have in their paper. Based on the summary statistics of Busch and Obernberger (2016), one out of four months is a repurchasing month, while in my paper this is one out of ten. Reason for this difference is the difference in popularity of share repurchases among German firms and U.S. firms. Busch and Obernberger (2016) report that for their time period, 2004 till 2010, 58% of the pay-outs was distributed through share repurchases, while Von Eije and Megginson (2008) report that in Europe and Germany in 2005 the share repurchases have a value of little more than half of the value of the cash dividends, meaning that share repurchases only account for around 35% (Busch & Obernberger, 2016; Von Eije & Megginson, 2008). This difference in popularity of share repurchases between the U.S. and Germany is caused by multiple factors according to Vermaelen (2005). First of all the more strict regulations for the firms in Germany, compared to the regulations in the United States. Second, the difference in tax issues between the countries. Third, the attitude towards shareholder value maximization and lastly, because of the absence of stock options in executive compensation packages (Vermaelen, 2005). The number of observations for all of the discussed repurchase measures is 7,911, which is equal to the total number of trading months in the dataset.

The same repurchase measures are reported again in table 1 under R*epurchase measures in repurchase months*. Difference is that only the numbers of a firm for a certain month are taken into account if this firm buys back shares in this particular month. This also explains the number of observations for these four measures. The number of observations is the same as the total number of repurchasing months of all firms together, which is 790, and this means that on average every firm buys back shares in one out of ten months. An average of one out of ten also explains why the mean values of these repurchase measures are around ten times bigger than the values of the repurchase measures based on all trading months.

My values for the repurchase measures in repurchase months are quite similar to the ones reported in Busch and Obernberger (2016). Differences in the values of the repurchase measures in all trading months and repurchase measures in repurchase months are smaller in their paper, because of the higher ratio of repurchasing months compared to all of the trading months.

Table 1 also reports some descriptive statistics of the share buyback programs. *Program month* is the number of months since the announcement and has a mean value of five months. So, on average a firm starts its buyback program five months after the announcement. The value for the 99th percentile is 23 months, which seems unrealistic, because an authorization by the board for buying back shares lasts only 18 months. Nevertheless, the authorization does not have to start at the same day as the day the announcement is made. Therefore, it is possible to have a program starting more than 18 months after the announcement. Mean value of the program month is much lower than the value reported in Busch and Obernberger (2016), 5 compared to 16. The 18 months rule in Germany could be a reason for this difference, because firms will only make the announcement if they are quite sure they are going to do a buyback in the near future. *Program size*, which is the total number of shares that can be bought back within the program scaled by the number of shares outstanding, has a mean value of 4.34% compared to a value of 6.59% in Busch and Obernberger (2016). Reason for this could be that the size of the program is much more regulated in Germany than it is in the United States. Following this, there are smaller differences in the program size for German firms, as the lower standard deviation is also suggesting.

Last category of table 1 are the *control variables.* The Book-to-Market ratio, which is the book value of the firm divided by the market value of the firm, has a mean value of 0.724, suggesting that the market values of the firms are bigger than the book values of the firms on average. Busch and Obernberger (2016) report almost the same value. Then, I report the Cash to assets with a mean value of 12.68%. This variable is the cash held by a firm divided by the value of the assets. In the other paper a slightly higher value of cash to assets is reported. Dividend to assets is the total amount of dividends paid divided by the value of the assets and is more than twice as high than in the Busch and Obernberger (2016) paper, 1.92% and 0.92%. The difference can be explained by the higher popularity for share repurchases relative to dividends in the United States compared to Germany. In Germany, dividends are relatively more popular compared to share repurchases than in the United States (Busch &

Obernberger, 2016; Vermaelen, 2005; Von Eije & Megginson, 2008). EBITDA scaled by assets has a mean value of 0.034, which is not very different from the 0.027 of the other paper. Leverage is the ratio of the total book value of debt to the total value of the assets. I report a value of leverage of 0.510, which means that the book value of debt is slightly bigger than the book value of equity on average for the German firms. The value for leverage in the Busch and Obernberger paper is slightly lower with a value of 0.435.

The average market capitalization of the firms in my dataset is 10,100 million, which is twice as big as the average market capitalization of the firms in Busch and Obernberger (2016). The dataset of Busch and Obernberger contains a lot more firms, where my dataset contains only the firms currently listed on the DAX, MDAX, SDAX and TecDAX (160 firms), Busch and Obernberger report data on all firms listed on the NYSE, AMEX, and NASDAQ (over 6000 firms). The 1st percentile value of my dataset is almost three times higher than the same value in their dataset, while their 99th percentile value is higher. This indicates, together with my higher mean value, that their dataset consists of a lot of small firms relatively compared to my dataset.

The reported total assets in my paper are 76,200 million on average, which is higher than the reported total assets of Busch and Obernberger (2016). This difference could be explained in the same way I explained the difference in market capitalization. The trading volume is the total monthly trading volume of a firm, excluding the repurchase volume and scaled by the shares outstanding of the firm. The mean is 0.117, which indicates that 11.7% of the outstanding shares are traded during a month on average, repurchases not taken into account. This is lower than the 0.189 reported in the comparable paper.

I report an average return of 0.7% per month, where Busch and Obernberger (2016) report an average monthly return of 0.8%. This gives an annual return of 8.4% in my paper, compared to 9.6%. Volatility is the standard deviation of the daily returns over one month and with a mean value of 0.02 it is slightly lower than in the Busch and Obernberger (2016) paper.

All of the variables used for the price efficiency and idiosyncratic risk analyses can be found in the table in Appendix C, together with the definition of the variables and the sources of the variables.

4.1.2 Summary statistics; announcement day return

In table 2 I report the summary statistics concerning the announcement day abnormal return. The estimated mean value for the abnormal returns on the announcement date is 1.62%, which indicates that firms which make a share repurchase announcement outperform the market by 1.62% on the announcement day. These results are in line with other comparable international results. Vermaelen (1981) finds an abnormal return of approximately 1% for announcements made in the United States, based on the period 1962 till 1977. He uses a dataset based on announcements made for open-market buybacks and announcements made for tender offers (Vermaelen, 1981). Ikenberry, Lakonishok and Vermaelen (1995) report an initial abnormal return of 2.58% for open-market buyback announcements in the United States from 1980 till 1990 (Ikenberry, Lakonishok, & Vermaelen, 1995).

Descriptive statistics/results for the AR on the announcement date

Summary statistic:	*Value:*
Mean	1,616%
Median	1,038%
Maximum	21,87%
Minimum	-24,92%
# Positive	129 (65,82%)
# Negative	67 (34,18%)

Table 2: Summary statistics abnormal return of announcement date. This table shows the summary statistics of the abnormal return on the day of the announcement. It shows the mean abnormal return, the median abnormal return, the minimum and maximum abnormal return and the number of positive and negative abnormal returns, all for the announcement date.

For the United Kingdom, Rau and Vermaelen (2002) observe an abnormal return of 1% on the announcement date for the period 1985 till 1998. They use all announcements made in this period, making no distinction between the different buyback methods (Rau & Vermaelen, 2002). Seifert and Stehle (2005) report an abnormal return of 4.79% for the open-market buyback announcements made in the period May 1998 until January 2003 by German firms (Seifert & Stehle, 2005).

The papers which only take the open-market buyback announcements into account, report higher abnormal returns than those which also take tender offers into account. This contradicts Comment and Jarrell (1991), who find that open-market share repurchases and Dutch-auction self-tender offers are weaker signals of undervaluation than fixed-price self-tender offers (Comment & Jarrell, 1991).

Hackethal and Zdantchouk (2006) observe an abnormal return of 1.5% on the announcement date, which is in line with the abnormal announcement day return I observe (Hackethal & Zdantchouk, 2006). Nevertheless, all mentioned papers report results for different time periods and/or different countries, making it hard to compare the exact results.

Next to the mean, I also report the median of the announcement date abnormal return. With a value of 1.038% it is lower than the mean value of the abnormal return. This is in line with the findings of Seifert and Stehle (2005) who also report a lower median value compared to the mean value.

Furthermore, I report the maximum abnormal return observed in the dataset, which is 21.87%, and the minimum abnormal return, which is -24.92%. Of all announcement date abnormal returns, around 66% is positive and 34% is negative, compared to 80% positive and 20% negative in Seifert and Stehle (2005).

4.2 Results of the Analyses

First, I test the abnormal returns on the 50 days around the announcement date. Following this, the long-term abnormal return is tested by estimating the one-year abnormal return after the announcement, making a distinction between low book-to-market and high book-to-market firms. For the las, I test the price efficiency effect based on different measures. I show the results of an analysis based on the repurchase measures, *Repurchase intensity* and *Remaining volume*, and based on all results, I conclude with discussing the different hypotheses.

4.2.1 Short-term announcement return

In table 3 the average daily abnormal returns around the announcement day are displayed. On the left side of the table the abnormal returns for the 25 days before the announcement are given. Most of the 25 days before the announcement show a negative abnormal return, 18 out of 25. Seifert and Stehle (2005) show a negative abnormal return in 23 out of the 24 days before the announcement (Seifert & Stehle, 2005). Reason for the difference in the number of returns is that I also take the return into account from day -25 based on the difference between day -26 and day -25, while Seifert and Stehle (2005) take the difference (return) between day -25 and -24 as their starting point. Same holds for the days after the announcement, which are shown at the right hand side of the table. 16 out of the 26 days show a positive abnormal return

including the announcement day, compared to 13 out of 25 in the Seifert and Stehle (2005) paper.

Most of the daily abnormal returns are not statistically significant, but the announcement day is statistically significant at a 1% level and is with a value of 1.62% also economically significant. Compared to the estimated abnormal return for the announcement date reported by Seifert and Stehle (2005), the abnormal return in this paper is much lower. Figure 9 is based on table 3 and shows the movement of the average daily abnormal returns for the 51 days around the announcement. The peak in the middle is at the announcement date, showing an abnormal return of 1.616% as I mentioned before.

Daily abnormal returns for the period t-25 till t+25 from the announcement date

Day:	*Avg. AR:*	*t-stat.:*	*Sign.:*	*CAR:*	*Day:*	*Avg. AR:*	*t-stat.:*	*Sign.:*	*CAR:*
-25	0,007%	0,0377		0,007%	0	1,616%	4,6526	1%	-2,014%
-24	-0,364%	-1,3368		-0,357%	1	0,208%	0,7992		-1,806%
-23	-0,161%	-0,912		-0,518%	2	0,395%	1,4628		-1,411%
-22	-0,215%	-1,3272		-0,733%	3	-0,139%	-0,6696		-1,550%
-21	0,055%	0,2053		-0,679%	4	-0,090%	-0,4578		-1,640%
-20	-0,313%	-1,4122		-0,991%	5	0,277%	1,4088		-1,363%
-19	0,107%	0,551		-0,884%	6	0,087%	0,4439		-1,276%
-18	-0,093%	-0,4198		-0,977%	7	0,025%	0,1092		-1,251%
-17	-0,151%	-0,6899		-1,128%	8	0,324%	1,5717		-0,927%
-16	0,172%	0,8748		-0,956%	9	-0,349%	-1,9376	10%	-1,276%
-15	-0,185%	-0,9827		-1,141%	10	0,020%	0,0921		-1,256%
-14	0,088%	0,484		-1,053%	11	0,188%	0,8863		-1,068%
-13	-0,159%	-0,8519		-1,212%	12	-0,111%	-0,5899		-1,179%
-12	-0,413%	-2,2076	5%	-1,625%	13	-0,062%	-0,3245		-1,241%
-11	0,212%	1,1731		-1,413%	14	0,099%	0,4888		-1,142%
-10	-0,197%	-0,8397		-1,610%	15	0,067%	0,3436		-1,075%
-9	-0,385%	-1,6909	10%	-1,995%	16	0,301%	1,3126		-0,774%
-8	-0,424%	-1,9522	10%	-2,420%	17	0,064%	0,3028		-0,710%
-7	-0,541%	-2,0866	5%	-2,961%	18	-0,041%	-0,2269		-0,750%
-6	-0,205%	-0,8187		-3,166%	19	0,105%	0,5666		-0,645%
-5	-0,038%	-0,199		-3,204%	20	-0,156%	-0,819		-0,801%
-4	-0,140%	-0,5725		-3,344%	21	0,498%	2,6821	1%	-0,303%
-3	-0,142%	-0,6518		-3,486%	22	-0,128%	-0,6774		-0,432%
-2	-0,293%	-1,2986		-3,778%	23	0,137%	0,705		-0,295%
-1	0,149%	0,6028		-3,629%	24	-0,325%	-1,819	10%	-0,620%
					25	-0,024%	-0,129		-0,643%

Table 3: The average daily abnormal return on each day of the 51-day time period around the announcement. This table shows the average abnormal return for each day of the 51-day timeframe, the t-statistic and significance level of these average abnormal returns, and the cumulative abnormal returns over the whole timeframe, based on the average abnormal returns.

Under CAR, table 3 also reports the cumulative abnormal return over the time period. As can be seen in table 3, the cumulative abnormal return is becoming more and more negative during the 25 days before the announcement date. After the announcement date, the abnormal returns are most of the time positive, bringing the cumulative abnormal return almost back to zero. The movement of the CAR is shown in figure 10. Figure 10 shows in a perfect way that the cumulative abnormal return is going down until the announcement date, indicating that undervaluation is the main driver for firms to start a share buyback program. On the announcement date and the 25 days after, the cumulative abnormal return is going up almost till the same level as where it started 25 days before the announcement, but it never becomes positive during the 51 day time period as can be seen in the last row of table 4.

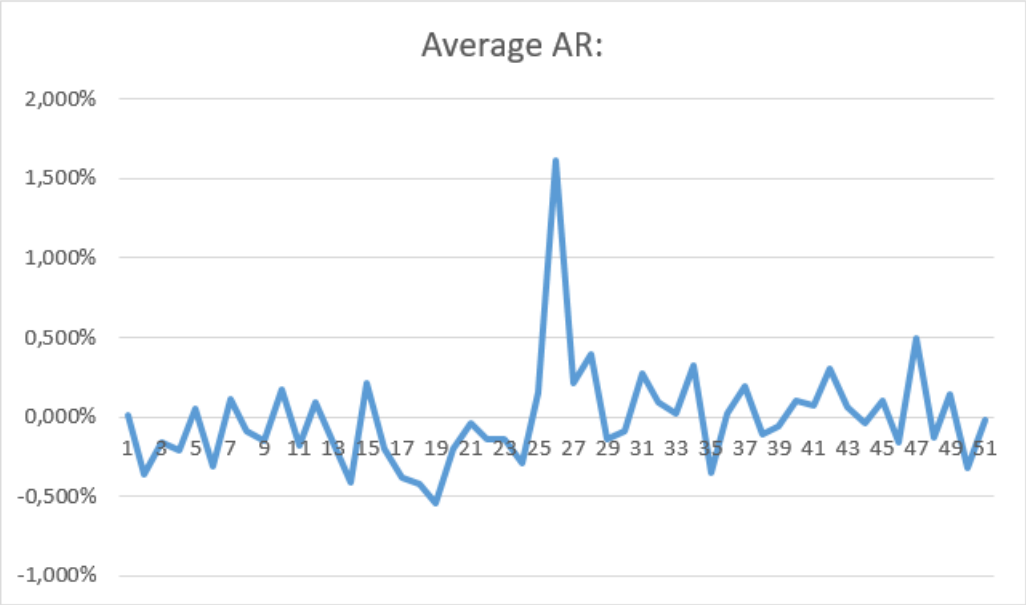

Figure 9: The daily abnormal returns during the 51 days around the announcement date

In the 25 days before the announcement a negative *cumulative abnormal return* of -3.51% is estimated. This observation is statistically significant at a 1% level. This result is in line with Seifert and Stehle (2005) and Hackethal and Zdantchouk (2006) and makes it already less likely that the share buybacks are done based on the *management incentive hypothesis*. The negative *cumulative abnormal return* from this period of time is more than twice as big as the positive announcement day return. Seifert and Stehle (2005) report a return of -6.43% for the same timeframe, which is also bigger than their reported positive announcement day return, and Hackethal and

Zdantchouk (2006) report a return of -7.54% for the period of 30 days till two days before the announcement.

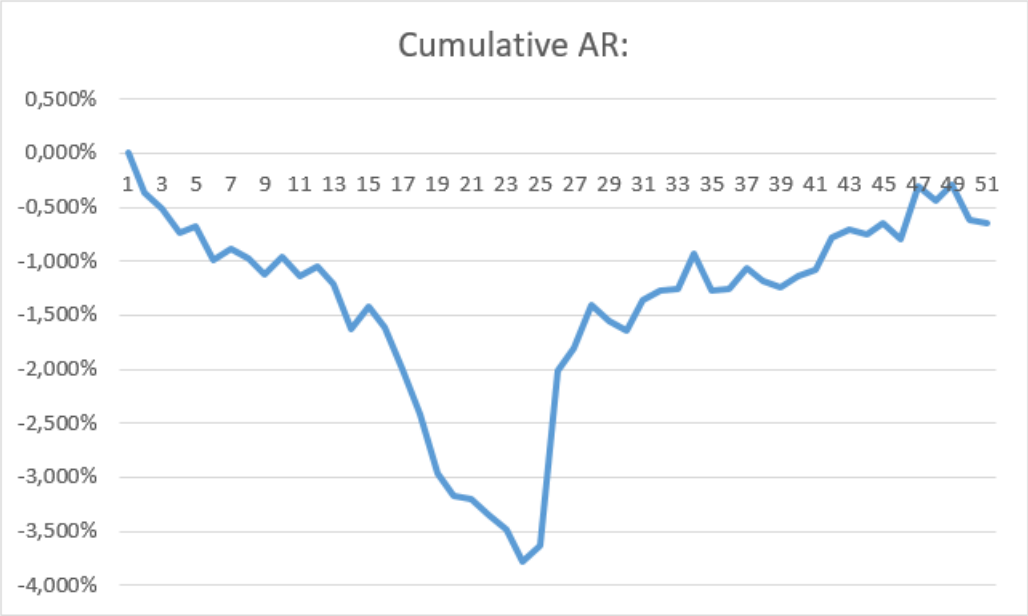

Figure 10: Cumulative abnormal return during the 51 days around the announcement date

The timeframe based on the 25 days after the announcement shows a positive *cumulative abnormal return* of 1.23%, but this observation is not statistically significant. When the announcement day is included into the timeframe of the 25 days after the announcement, making it a timeframe of 26 days, I find a positive *cumulative abnormal return* of 2.90% that is significant at a 1% level. Seifert and Stehle (2005) also show a bigger *cumulative abnormal return* for this timeframe.

Over the whole timeframe, I observe a negative *cumulative abnormal return* of -0.70%, but this observation is not statistically significant. This observation is slightly less negative compared to the finding of Seifert and Stehle (2005), who also report a statistically insignificant negative *cumulative abnormal return*.

Results of the short-term announcement effect

Timeframe:	*Avg. CAR:*	*t-stat.:*	*Sign.:*	*N(observations):*	*T(# days):*
t0 till t25	2,900%	3,4260	1%	196	26
t1 till t25	1,233%	1,5081		196	25
t-25 till t-1	-3,513%	-4,2322	1%	196	25
t-25 till t25	-0,699%	-0,8426		196	51

Table 4: The average cumulative abnormal return for different timeframes. This table shows the average abnormal returns for different periods of time around the announcement date, together with the t-statistic and the significance level of the abnormal return, the number of observations based on the announcement, and the number of days in the timeframe.

My results for the short-term announcement return, as reported in table 4, are in line with my baseline hypothesis and with my first alternative hypothesis, which both read that share buybacks are done to signal undervaluation to the market. Based on the negative abnormal return prior to the announcement, it is less likely that these abnormal returns are because of the intention of managers to drive the share price above the fundamental value. My results are in line with Seifert and Stehle (2005) and Hackethal and Zdantchouk (2006) when it comes to the sign of the announcement date abnormal return and the sign of the pre- and post-announcement returns. The average daily standard deviation of the abnormal returns I observe is 0.0232, compared to 0.0333 in the paper of Seifert and Stehle (2005), making it plausible that there are bigger movements in their observed abnormal returns over time.

4.2.2 Long-term announcement return

As I showed in the previous part, the average announcement day return is 1.62%. Based on the announcement day and the 25 days after the announcement, I find an average abnormal return of 2.90%. I discussed in the introduction of this paper that such an undervaluation is impossible to time for managers. Therefore, it could be that there is an abnormal return over a longer period of time.

Results of the long-term (one-year) announcement effect

Avg. BHAR:	*t-stat.:*	*Sign.:*	*N(observations):*
All firms:			
4,935%	1,3854		139
High B/M firms:			
17,519%	1,8182	10%	19
Low B/M firms:			
5,443%	0,6734		27

Table 5: Long-term abnormal return based on the buy-and-hold strategy. This table shows the average one-year abnormal return after an announcement for all firms, for the high Book-to-Market firms and for the low Book-to-Market firms. Also, the t-statistic and the significance level of the average abnormal return are shown. The number of announcements is shown in the last column.

Table 5 shows the average abnormal return based on a one-year buy-and-hold strategy. The average one-year abnormal return when the announcements of all firms are taken into account is 4.94%, but this abnormal return is, probably also because of the low number of observations, not statistically significant. This result is therefore not

fully in line with my baseline hypothesis, which reads that there is a positive abnormal return in the year after the announcement. Ikenberry, Lakonishok and Vermaelen (1995) find an average one-year abnormal return of 2.09% for the U.S. market for the period from 1980 till 1990 (Ikenberry, Lakonishok, & Vermaelen, 1995). A higher abnormal return for the German market could be expected, as I explained at the beginning of the paper, but because of the statistical insignificance of the result it is impossible to make a good comparison.

Because the Book-to-Market ratio is an indicator for undervaluation, I would expect high book-to-market firms to show a higher abnormal return than low book-to-market firms. For the announcement to be taken into account, firms had be in the highest or lowest book-to-market quintile during the year in which they made the announcement. So, when a firm makes an announcement in 2009 and this firm is in the highest quintile in 2009, then the announcement is taken into account by calculating the average abnormal return for high Book-to-Market firms. This is the same for the low Book-to-Market firms. The difference in observations can be explained in the same way. Apparently, there were only 19 firms that belonged to the highest Book-to-Market quintile in the year of their announcement, and 27 firms that belonged to the lowest Book-to-Market quintile in the year of their announcement. High Book-to-Market firms show an one-year abnormal return of 17.52% on average, which is statistically significant at a 10% level despite the low number of observations. Low Book-to-Market firms show an insignificant abnormal return of 5.44%. Based on these results it seems that high Book-to-Market firms earn a higher return after an announcement compared to low Book-to-Market firms, which is in line with my baseline hypothesis and with my first alternative hypothesis, and is also in line with Ikenberry, Lakonishok and Vermaelen (1995) and Peyer and Vermaelen (2009).

The higher number of observations for the announcements made by low Book-to-Market firms, combined with the insignificant abnormal return on the long-term, are indicators that firms not only do a share buyback based on undervaluation, but also based on other motivations. This could be in line with the *free cash flow hypothesis*, but based on the results regarding the abnormal returns, it is likely that only a part of the firms use the *free cash flow hypothesis* as their main motivation to do a share buyback.

4.2.3 Price efficiency and idiosyncratic risk

4.2.3.1 Analysis of Repurchase activity

There are multiple reasons to do an analysis on my repurchase variables; *Repurchase Intensity* and *Remaining Volume*. First of all, I want to test the relevance of the instruments, which are *Program month* and *Program size*. Second, such an analysis makes it possible for me to see whether the lagged value of *Repurchase Intensity* is a good proxy for the contemporaneous *Repurchase Intensity*. Thirdly, it gives me the opportunity to analyze the effects of the additional drivers of repurchase activity (Busch & Obernberger, 2016). I do this analysis based on the same regressions as I discussed in the price efficiency methodology, regression 8 and 9, but with the repurchase activity measures as the dependent variables.

In the first two columns of table 6 I analyze *Repurchase Intensity*. *Program month* and *Program Size* both show statistically significant effects. *Program month* has a positive value in the first column, but this changes to a negative value after the lagged value of *Repurchase Intensity* is added to the regression in the second column. The positive value for *Program month* in the first column is not in line with Busch and Obernberger (2016), who already report a negative value for this instrument in the first column. The negative value for Program month in table 6 is in line with Busch and Obernberger (2016), and indicates that the repurchase intensity is highest in the first months of the program. *Program size* has a positive effect on the *Repurchase Intensity* in both the first and the second column, which is in line with what I expect; a higher repurchase intensity when the size of the program is larger.

In the second column is the lagged value of the *Repurchase intensity* added to the regression. If this lagged value of *Repurchase intensity* is a weak proxy for contemporaneous *Repurchase intensity*, it would be very hard to obtain significant results, because using a noisy measure for an independent variable biases the coefficient estimates towards zero (Busch & Obernberger, 2016). The lagged value of *Repurchase intensity* shows a value of 0.55. Looking at the R-squared within the firms, so the R-squared excluding the variance already explained by the fixed effects, I observe an increase from 0.0625 to 0.3427 when the lagged value of *Repurchase intensity* is added to the regression. This increase in the R-squared is much bigger compared to the increase in Busch and Obernberger (2016). Based on these results, I conclude that the lagged value of *Repurchase intensity* is the best predictor I have.

Analysis of repurchase activity

Dependent variable:	Repurchase Intensity	Repurchase Intensity	Remaining Volume
Method:	OLS	OLS	OLS
Repurchase Intensity (t-1)		0,5486***	
		52,14	
Program month (t) (ln)	0,0004**	-0,0003**	0,0029***
	2,13	*-2,20*	*2,60*
Program size	0,0425***	0,0221***	0,2134***
	10,65	*6,56*	*8,25*
Return > 0	0,0010**	-0,0002	-0,0040
	1,97	*-0,53*	*-1,25*
Return < 0	-0,0040***	-0,0027***	-0,0014
	-8,71	*-7,10*	*-0,49*
Book-to-Market (t-3)	0,0001	0,0001	0,0015**
	1,17	*0,81*	*2,28*
Total Assets (t-3) (ln)	0,0001	0,0000	-0,0027***
	0,93	*0,78*	*-6,21*
Cash to assets (t-3)	0,0007	0,0005	0,0057**
	1,47	*1,22*	*1,97*
EBITDA to assets (t-3)	0,0027**	0,0015*	0,0382***
	2,46	*1,64*	*5,34*
Dividends to assets (t-3)	-0,0026**	-0,0012	-0,0226***
	-2,16	*-1,21*	*-2,85*
Leverage (t-3)	-0,0007**	-0,0004	-0,0011
	-2,08	*-1,26*	*-0,52*
Constant	-0,0002	-0,0002	0,0224***
	-0,31	*-0,46*	*5,99*
R^2 (within firm)	0,0625	0,3427	0,0502
Observations	6435	6435	6435
Month FE and Firm FE	Yes	Yes	Yes

*Table 6: Analysis on the effect of different variables on the repurchase activity. This table shows the effect of different variables on the repurchase activity. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the Program month results in a 0.0004 change in the standard deviation of the Repurchase Intensity. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

When looking at the control factors, most values show the right sign based on the expectations, but not all are statistically significant. The *Repurchase intensity* is not driven by prior positive returns, but prior negative returns show a significant effect on *Repurchase intensity* and this is in line with Dittmar (2000). Based on the *undervaluation hypothesis*, I would expect that a higher *Book-to-Market* ratio leads to a higher repurchase activity, but *Book-to-Market* shows an insignificant positive effect. *Cash to assets* has the expected sign based on the *free cash flow hypothesis*, but is

also not statistically significant. When looking at *EBITDA to assets*, I observe a positive significant value, which is in line with the *free cash flow hypothesis*. The results for *Cash to assets* and *EBITDA to assets* are different from Busch and Obernberger (2016), who report a significant positive effect for *Cash to assets* and non-significant positive effect for *EBITDA to assets*. Based on the first column, it seems that *Dividends to assets* has a negative effect on the repurchase activity, which indicates that dividends and share repurchases are substitutes. When looking at the second column, *Dividends to assets* has no statistical significant effect on the *Repurchase intensity* anymore, making it hard to give a proper conclusion concerning dividends. This negative relation between repurchase activity and dividends is not what I expected based on figure 4 and it is also not in line with Busch and Obernberger (2016) and Von Eije and Megginson (2008). A negative relation between dividends and share buyback activity suggests that they are complements. *Leverage* shows a negative effect on share buyback activity in the first column, which is in line with the *free cash flow hypothesis*, but the significance disappears when the lagged value of Repurchase intensity is added to the regression.

In the third column I use Remaining volume, which is the number of shares that still can be bought back at the beginning of the month scaled by the shares outstanding at the beginning of the program, as the measure for repurchase activity. Program size shows a very high positive effect on the Remaining volume, which is in line with the expectations. Busch and Obernberger (2016) also find a positive value for Program size, but their value for Program size is even higher compared to mine. The *Program month* shows a significant negative value, which seems very odd to me. I would expect Program month to be negative, because when executing a buyback program, the remaining volume should become smaller and smaller. It is hard for me to come up with an explanation for this result and the result is also not in line with the Busch and Obernberger (2016) paper.

Most control variables show the same sign direction as in the first two columns. Book-to-Market, Cash to assets and EBITDA to assets all show a significant positive effect on this repurchase activity measure, which is in line with the *undervaluation hypothesis* and the *free cash flow hypothesis*. The Dividends to assets shows a significant negative value, which indicates that share repurchases are substitutes for dividends in Germany. The result for leverage indicates there is no relation between leverage and the repurchase activity and contradicts the *free cash flow hypothesis* by

this way. The prior returns have no effect on the *Remaining volume*, giving the *Remaining volume* measure an advantage over the *Repurchase intensity* measure. The measures for efficiency are likely to be moved by prior returns, and because Remaining volume is not driven by returns, there is less chance for co-movement between the repurchase activity measure and the efficiency measure. Besides, *Remaining volume* is fixed at the beginning of the month, which makes it possible to exclude reverse causality in the subsequent analyses (Busch & Obernberger, 2016).

4.2.3.2 Delay

Table 7 shows the effects of the different buyback activity measures on *Delay*. I do not use the estimated *Repurchase Intensity* as in Busch and Obernberger (2016), which is estimated by using the instruments, *Program month* and *Program size*, because of the contradictory outcomes in the first two columns of table 6.

I performed an Hausman test to see whether I should use firm fixed effects and time fixed effects or random effects. The null hypothesis is that I should use random effects, and the alternative hypothesis is that I should use fixed effects. As can be seen in table 7, I find a probability of 0.000 based on the Hausman test and therefore I must reject the null hypothesis and use the fixed effects model.

In the first column of table 7 the lagged value of *Repurchase Intensity* is used as an independent variable. Lagged *Repurchase Intensity* shows an insignificant positive effect on *Delay*, which is not in line with Busch and Obernberger (2016). In table A in the Appendix I report the effect of the lagged value of *Repurchase Intensity* on *Delay* using a different method and using multiple control variable combinations to get a broad view of the effects of the different variables. Table A shows that the effect of the lagged *Repurchase Intensity* on *Delay* stays the same, no matter what combination of control variables is used. I use the Generalized Least Squares random effects model in column 2 of table A, B and C, but using a different model has no effect on the outcome for the lagged *Repurchase Intensity*. When looking at table 7 again, all other repurchase activity measures seem to have a negative effect on *Delay*, but only the lagged value of the *Repurchase Intensity (TV)* shows a statistically significant negative effect.

The influence of repurchases on delay

Dependent variable:	Delay				
Method:	OLS	OLS	OLS	OLS	OLS
Repurchase Intensity (t-1)	1,0680				
	0,81				
Repurchase Intensity (t)		-0,3908			
		-0.33			
Remaining Volume (t)			-0,0194		
			-0,11		
Repurchase Intensity (TV) (t-1)				-0,1399**	
				-2,00	
Repurchase Intensity (TV) (t)					-0,1038
					-1,49
Delay (t-1)	0,1716***	0,1715***	0,1716***	0,1712***	0,1713***
	15,13	*15,13*	*15,13*	*15,10*	*15,11*
Return (t-1) > 0	-0,030182	-0,0277	-0,0288	-0,0285	-0,0273
	-0,63	*-0,58*	*-0,60*	*-0,60*	*-0,57*
Return (t-1) < 0	0,0634802	0,0612	0,0626	0,0619	0,0604
	1,35	*1,30*	1,33	*1,32*	*1,28*
Market Cap. (t-1) (ln)	-0,0260***	-0,0263***	-0,0261***	-0,0261***	-0,0263***
	-5,29	*-5,37*	*-5,29*	*-5,31*	*-5,38*
Book-to-Market (t-3)	-0,0214**	-0,0216**	-0,0213**	-0,0213**	-0,0216**
	-2,37	*-2,46*	*-2,36*	*-2,36*	*-2,47*
Volatility (t-1) (ln)	0,0042	0,0043	0,0043	0,0042	0,0044
	0,67	*0,68*	*0,68*	*0,67*	*0,70*
Trading Volume (t-1) scaled	-0,0134	0,0235	0,0182	0,0373	0,0289
	-0,21	*0,41*	*0,33*	*0,70*	*0,55*
Constant	1,2650***	1,2706***	1,2664***	1,2680***	1,2721***
	11,42	*11,56*	*11,42*	*11,45*	*11,57*
R^2 (within firm)	0,0349	0,0349	0,0348	0,0353	0,0351
Observations	7724	7724	7724	7724	7724
Firm FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Hausman test			0.000		

*Table 7: The effect of different buyback activity measures on Delay. This table shows the effect of different Repurchase measures and control variables on Delay. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a 1.0680 change in the standard deviation of Delay. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown. The Hausman value shows that a fixed effects model should be used.*

Interesting is the difference in sign and significance between the lagged *Repurchase Intensity* and the lagged *Repurchase Intensity (TV)*. The difference in the two measures lays in the fact that they are scaled by a different factor, *Repurchase Intensity* is scaled by the shares outstanding at the end of the previous month and *Repurchase Intensity (TV)* is scaled by the number of shares traded over the current month. When the lagged value of the *Trading Volume* is higher, information comes

faster to the market, because every trade gives information to the market and a higher trading volume means more trades (Boehmer & Wu, 2013). Therefore, I expect the *Trading Volume* to have a negative effect of *Delay*. The lagged *Trading Volume* shows a negative effect on *Delay* in the first column, but this effect is not statistically significant. This effect of the lagged *Trading Volume* becomes positive in column 4, but this effect is also not statistically significant. Considering this change in the sign of the lagged *Trading Volume* when *Repurchase Intensity (TV)* is used as the repurchase measure and the fact that *Repurchase Intensity (TV)* is based on the monthly trading volume, it seems that the negative effect of *Repurchase Intensity (TV)* on *Delay* is partly based on the negative effect of the *Trading Volume* on *Delay*. This could be a reason for the difference between the effect of *Repurchase Intensity* on *Delay* and the effect of *Repurchase Intensity (TV)* on *Delay*.

Table A in the appendix shows the importance of the different control variables, making it clear that the *Market capitalization* and the *Book-to-Market* ratio are the most important control variables. Taking the positive return factor, negative return factor, *Volatility* and *Trading Volume* out of the regression has almost no effect on the within firm r-squared of the model, showing the minimal explanatory power of these control variables.

The other measures for repurchase activity all show an insignificant negative effect on *Delay* and this makes it hard to determine the true relation between share repurchase activity and *Delay*.

Then the interpretation of the values in table 7. Lagged *Repurchase Intensity (TV)* shows a value of -0.1399, which means that for every increase of one in the within-firm standard deviation of *Repurchase Intensity (TV),* the within-firm standard deviation of *Delay* goes down with 0.1399. Together with the value of the standard deviation within the firm given in table 1, which is 0.212 in the case of *Delay*, I can calculate the change in *Delay* in percentage points. In this case, an increase by one of the within-firm standard deviation of the lagged *Repurchase Intensity (TV)* gives a (-0.1399 * 0.212 =) 0.0297 percentage points decrease in *Delay* (Busch & Obernberger, 2016; Boehmer & Wu, 2013). Nevertheless, because of the different outcomes when using other repurchase measures, I cannot give a general conclusion about the relation between share buyback activity and *Delay*. Therefore, I find no evidence for the German market that share repurchases make prices more efficient.

Looking at the control variables in table 7, the *Market capitalization* shows a significant negative effect on *Delay*, which is in line with Hou and Moskowitz (2005). In general, information concerning bigger firm comes faster to the market and also the trading volume is higher for bigger firms, making the information incorporate faster into the market (Boehmer & Wu, 2013; Hou & Moskowitz, 2005). The *Book-to-Market* shows a significant negative effect, which contradicts my expectations and is not in line with Busch and Obernberger (2016).

4.2.3.3 R-squared and Market Correlation

The influence of repurchases on R-squared

Dependent variable:	R-squared				
Method:	OLS	OLS	OLS	OLS	OLS
Repurchase Intensity (t-1)	-0,0225				
	-0,04				
Repurchase Intensity (t)		0,3494			
		0,67			
Remaining Volume (t)			0,0682		
			0,85		
Repurchase Intensity (TV) (t-1)				0,0526*	
				1,69	
Repurchase Intensity (TV) (t)					0,0361
					1,17
R-squared (t-1)	0,3933***	0,3932***	0,3933***	0,3930***	0,3930***
	36,55	*36,54*	*36,55*	*36,53*	*36,52*
Market Cap. (t-1) (ln)	0,0130***	0,0130***	0,0130***	0,0130***	0,0130***
	6,01	*6,07*	*6,05*	*6,02*	*6,08*
Book-to-Market (t-3)	0,0139***	0,0138***	0,0139***	0,0139***	0,0138***
	3,49	*3,56*	*3,49*	*3,50*	*3,57*
Trading Volume (t-1) scaled	-0,0146	-0,0220	-0,0225	-0,0232	-0,0197
	-0,52	*-0,87*	*-0,91*	*-0,98*	*-0,84*
Constant	-0,2499***	-0,2508***	-0,2521***	-0,2507***	-0,2512***
	-5,18	*-5,24*	*-5,22*	*-5,20*	*-5,25*
R^2 (within firm)	0,1564	0,1565	0,1565	0,1567	0,1566
Observations	7724	7724	7724	7724	7724
Firm FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Hausman test			0.000		

*Table 8: The effect of different buyback activity measures on the R-squared. This table shows the effect of different Repurchase measures and control variables on R-squared. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a -0.0225 change in the standard deviation of R-squared. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown. The Hausman value shows that a fixed effects model should be used.*

The influence of repurchases on Market Correlation

Dependent variable:	Market Correlation				
Method:	OLS	OLS	OLS	OLS	OLS
Repurchase Intensity (t-1)	-0,0265				
	-0,03				
Repurchase Intensity (t)		0,2762			
		0,33			
Remaining Volume (t)			0,0511		
			0,39		
Repurchase Intensity (TV) (t-1)				0,1129**	
				2,24	
Repurchase Intensity (TV) (t)					0,0695
					1,39
R-squared (t-1)	0,2288***	0,2288***	0,2288***	0,2284***	0,2287***
	20,34	*20,34*	*20,34*	*20,31*	*20,33*
Market Cap. (t-1) (ln)	0,0199***	0,0199***	0,0199***	0,0199***	0,0199***
	5,75	*5,76*	*5,77*	*5,77*	*5,77*
Book-to-Market (t-3)	0,0224***	0,0223***	0,0223***	0,0224***	0,0224***
	3,58	*3,58*	*3,58*	*3,58*	*3,58*
Trading Volume (t-1) scaled	-0,0204	-0,0265	-0,0267	-0,0383	-0,0299
	-0,45	*-0,65*	*-0,67*	*-1,01*	*-0,79*
Constant	-0,2925***	-0,2927***	-0,2941***	-0,2943***	-0,2936***
	-3,79	*-3,79*	*-3,81*	*-3,82*	*-3,81*
R^2 (within firm)	0,0572	0,0572	0,0572	0,0578	0,0574
Observations	7724	7724	7724	7724	7724
Firm FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Hausman test			0.000		

*Table 9: The effect of different buyback activity measures on the Market Correlation. This table shows the effect of different Repurchase measures and control variables on Market Correlation. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a -0.0265 change in the standard deviation of Market Correlation. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown. The Hausman value shows that a fixed effects model should be used.*

I report my results concerning the effect of the buyback activity on the *R-squared* and on the *Market Correlation* in table 8 and 9. In this section it is not about the speed in which information incorporates into the stock price, but about the kind of information that is incorporated into the stock prices. If firms incorporate firm-specific information, idiosyncratic risk should go up, but if firms provide price support, the idiosyncratic risk should go down (Busch & Obernberger, 2016).

In table 8 and 9 four out of five repurchase measures show a positive effect on the *R-squared* and the *Market Correlation*. In line with the results in table 7, the lagged value of the *Repurchase Intensity (TV)* is the only measure that shows a statistically

significant effect in table 8 and 9. This indicates that the repurchase activity has a positive effect on the *R-squared* and the *Market Correlation*, but I cannot make a general conclusion based on these results. It seems that there is no unambiguous relation between share buybacks and idiosyncratic risk for the German market. Based on the only significant factor, an increase by one of the firm-within standard deviation of the lagged *Repurchase Intensity (TV)* gives a (0.0526 * 0.0989 =) 0.0052 percentage points increase in the *R-squared*. Following the same method, an increase by one of the firm-within standard deviation of the lagged *Repurchase Intensity (TV)* gives a (0.1129 * 0.1540 =) 0.0174 percentage points increase in the *Market Correlation*.

In table D and E in the appendix, I report results for *R-squared* based on the different repurchase measures with different combinations of control variables and also when the analysis is based on a Generalized Least Squares random effects method. I do the same for Market Correlation in table F and G in the appendix. The results are mostly the same when playing around with the different control variables, especially for the Book-to-Market ratio and also then the GLS random effects model is used. When Book-to-Market is the only control variable in both the R-squared and Market Correlation regressions, it does not show a statistically significant effect. Only when Market Capitalization is added to the regression, Book-to-Market becomes statistically significant. Apparently, these two variables complement each other in a perfect way. In line with the results for Delay, leaving out Trading Volume as a control variable barely affects the r-squared (within firm) of the model.

When looking at the control variables, I report a significant positive effect for both Market Capitalization and Book-to-Market. The positive effect of Market Capitalization is in line with the expectations, larger firms generally have a higher R-squared, suggesting there is less noise in the stock prices of these firms. The results for Book-to-Market is not as I expected, because a high Book-to-Market ratio is an indicator for undervaluation, and undervalued firms are likely to have higher idiosyncratic risk. Following this, it is reasonable to expect a negative Book-to-Market effect. The positive Book-to-Market value is also not in line with Busch and Obernberger (2016). Trading Volume does not have a significant effect on the R-squared nor on the Market Correlation, which is in line with Busch and Obernberger (2016).

4.2.4 Comparing the results for price efficiency and idiosyncratic risk

Looking back at the results for price efficiency and idiosyncratic risk, especially when it comes to the lagged *Repurchase Intensity* and the contemporaneous *Remaining Volume*, I observe some differences compared to Busch and Obernberger (2016). In the Busch and Obernberger (2016) paper, a significant negative effect of these two repurchase activity measures on *Delay* and a significant positive effect on *R-squared* and *Market Correlation* is reported (Busch & Obernberger, 2016). I do not observe any significant effect on *Delay*, *R-squared* and *Market Correlation* for both measures and this is not in line with my baseline hypothesis, which reads that buybacks make the prices more efficient and lower the idiosyncratic risk of a stock. The results are also not in line with my second alternative hypothesis, which reads that share buybacks have a negative effect on the efficiency of share prices. These results are in line with my first alternative hypothesis, which reads that buying back shares is about correcting for an overreaction to public information in the past, not bringing new information to the market.

Conclusion

Prior research on share buybacks for the German market focuses on the abnormal return following an announcement based on undervaluation. Busch and Obernberger (2016) showed for the U.S. market that open-market share buybacks increase the price efficiency of the stocks, and lowers the level of idiosyncratic risk in the stocks. Signaling undervaluation to the market can be based on correcting for an overreaction of the market, or bringing new information to the market, making prices more efficient. In this paper, I combined the two approaches, about abnormal returns and price efficiency, to test the effects of share repurchases in Germany and to examine in which way different buyback motivations play a role for German firms.

So, what are the effects of share buybacks in the German market? I find evidence for a short-term abnormal return after a share buyback announcement. On the long-term (one-year after the announcement) I find an insignificant positive abnormal return. I do the same analysis based on firms which are in the highest Book-to-Market quintile during their announcement, and this gives a significant positive abnormal return. These findings are in line with my expectation regarding undervaluation and give evidence that undervaluation is the most important motivation for firms to do a share buyback. The fact that more low Book-to-Market firms perform

a share buyback is an indication that the *free cash flow hypothesis* is also used as a motivation for a share buyback, and this is in line with my second alternative hypothesis.

For the relation between share repurchases and price efficiency and between share repurchases idiosyncratic risk, I find no significant relationship, indicating that share buybacks have no effect on the efficiency of share prices, and level of idiosyncratic risk in the stocks. Based on the absence of this relation, I cannot accept my baseline hypothesis about abnormal returns based on new information regarding the future performance of the stock. These results are more in line with my first alternative hypothesis, which reads that firms perform a share buyback, because they want to correct for the overreaction of the market to prior public information. The *management incentive hypothesis* can also not be expected, which is probably because of the fact that in Germany, less managers have stock-performance based compensations compared to the United States according to Vermaelen (2005). This makes it less likely that driving up the share price really is the motivation for German managers, although creating more shareholder value could also be a motivation to drive up the share price. The third alternative hypothesis seems to be supported by the fact that not only undervalued firms that perform a share buyback, making it possible that distributing cash to shareholders is also a motivation for performing a share buyback, as already reported by Andres, Betzer, Doumet and Theissen (2014).

Based on these results, it is hard to give an uniform conclusion. The effects of share repurchases in Germany do not point out one dominant motivation for a share repurchase and following this, it seems that there multiple motivations for German managers to perform a share buyback, as Peyer and Vermaelen (2009) already reported for the United States. Nevertheless, most firms seem to perform a share buyback to control for overreacting of the market in the past.

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Appendix

1.1 Appendix A

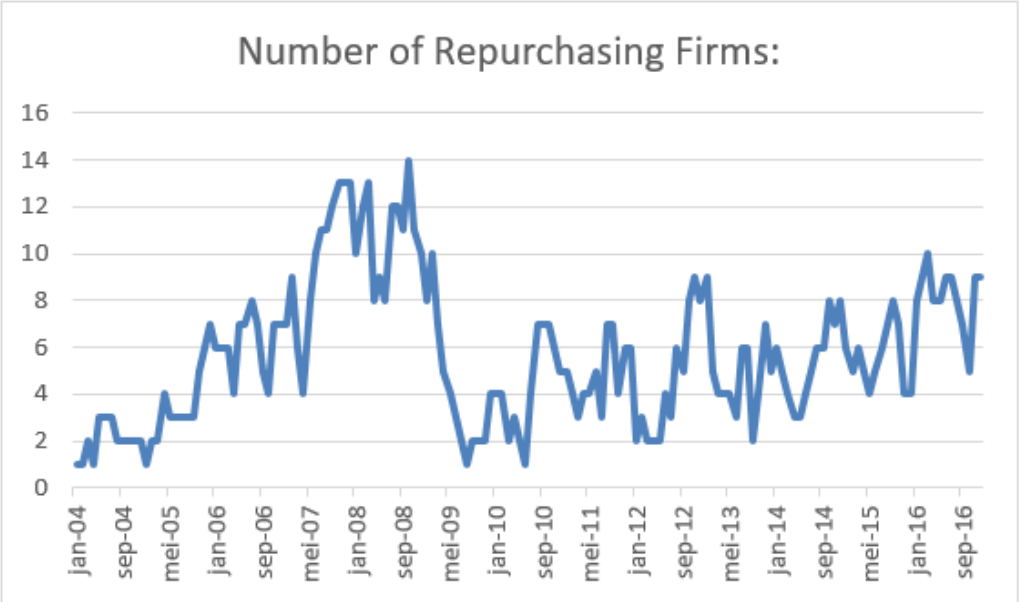

Figure A: The number of repurchasing firms per year

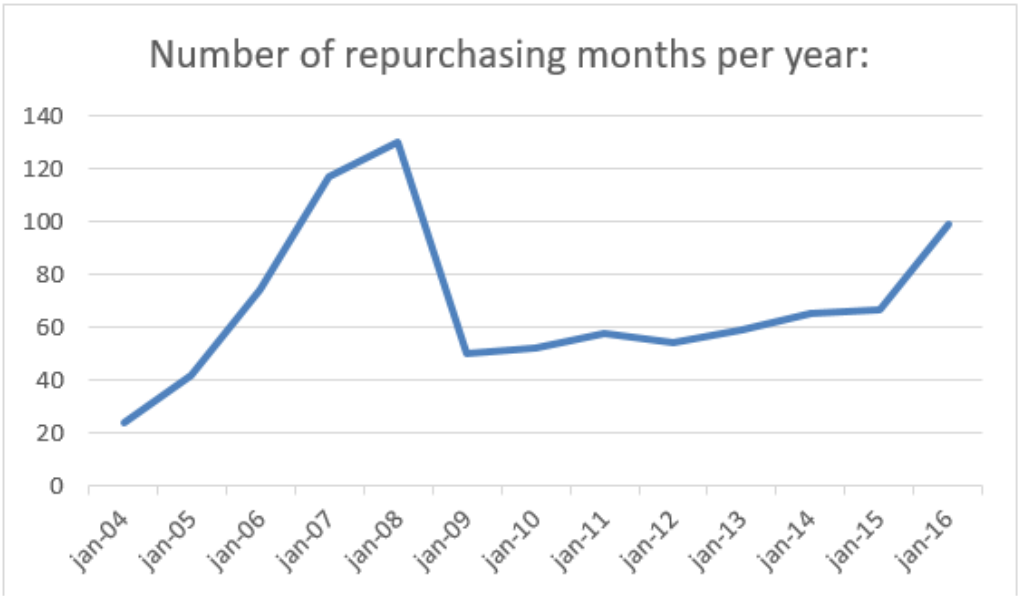

Figure B: The total number of repurchasing months per year

1.2 Appendix B

The influence of repurchases on delay

Dependent variable:	Delay								
Method:	OLS	GLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Repurchase Intensity (t-1)	1,0680	1,0700	0,8943	0,8562	0,9433	0,7621	1,1085	0,8674	0,8598
	0,81	*0,82*	*0,83*	*0,80*	*0,87*	*0,71*	*0,84*	*0,80*	*0,80*
Delay (t-1)	0,1716***	0,1825***	0,1762***	0,1732***	0,1754***	0,1759***	0,1766***	0,1717***	0,1717***
	15,13	*16,16*	*15,66*	*15,41*	*15,49*	*15,64*	*15,71*	*15,16*	*15,15*
Return (t-1) > 0	-0,0301818	-0,0276128	0,003998						
	-0,63	*-0,58*	*0,09*						
Return (t-1) < 0	0,0634802	0,0451342	0,0168424						
	1,35	*0,96*	*0,40*						
Market Cap. (t-1) (ln)	-0,0260***	-0,0023*		-0,0166***				-0,0261***	-0,0260***
	-5,29	*-1,79*		*-5,02*				*-5,44*	*-5,33*
Book-to-Market (t-3)	-0,0214**	-0,0001			0,0112*			-0,0215**	-0,0215**
	-2,37	*-0,03*			*1,79*			*-2,48*	*-2,47*
Volatility (t-1) (ln)	0,0042	0,0078				0,0087			0,0006
	0,67	*1,29*				*1,58*			*0,10*
Trading Volume (t-1) scaled	-0,0134	-0,0246					-0,019		
	-0,21	*-0,41*					*-0,30*		
Constant	1,2650***	0,7461***	0,6677***	1,0251***	0,6594***	0,7025***	0,6672***	1,2461***	1,2466***
	11,42	*21,52*	*68,71*	*14,25*	*62,97*	*28,78*	*70,48*	*11,49*	*11,48*
R^2 (within firm)	0,0349	0,0317	0,0307	0,0339	0,0310	0,0311	0,0308	0,0347	0,0347
Observations	7724	7724	7845	7850	7724	7850	7850	7724	7724
Firm FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table A: Lagged value of Repurchase Intensity as the independent variable

*This table shows the effect of different Repurchase measures and control variables on Delay. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a 1.0680 change in the standard deviation of Delay. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown. The Hausman value shows that a fixed effects model should be used.*

Dependent variable:	Delay					
Method:	OLS	GLS	OLS	OLS	GLS	OLS
Repurchase Intensity (t)	-0,3908	-0,4924	-0,2959			
	-0.33	*-0,42*	*-0,28*			
Remaining Volume (t)				-0,0194	-0,0409	-0,0024
				-0,11	*-0,24*	*-0,01*
Delay (t-1)	0,1715***	0,1825***	0,1716***	0,1716***	0,1825***	0,1716***
	15,13	*16,16*	*15,16*	*15,13*	*16,16*	*15,15*
Return (t-1) > 0	-0,0277	-0,0258		-0,0288	-0,0262	
	-0,58	*-0,55*		*-0,60*	*-0,55*	
Return (t-1) < 0	0,0612	0,0428		0,0626	0,0442	
	1,30	*0,91*		1,33	*0,94*	
Market Cap. (t-1) (ln)	-0,0263***	-0,0023*	-0,0262***	-0,0261***	-0,0023*	-0,0262***
	-5,37	*-1,80*	*-5,45*	*-5,29*	*-1,80*	*-5,44*
Book-to-Market (t-3)	-0,0216**	-0,0003	-0,0216**	-0,0213**	-0,0002	-0,0216**
	-2,46	*-0,06*	*-2,49*	*-2,36*	*-0,05*	*-2,49*
Volatility (t-1) (ln)	0,0043	0,0078		0,0043	0,0078	
	0,68	*1,29*		*0,68*	*1,27*	
Trading Volume (t-1) scaled	0,0235	0,0140		0,0182	0,0094	
	0,41	*0,26*		*0,33*	*0,18*	
Constant	1,2706***	0,7465***	1,2480***	1,2664***	0,7463***	1,2478***
	11,56	*21,54*	*11,51*	*11,42*	*21,52*	*11,49*
R^2 (within firm)	0,0349	0,0316	0,0346	0,0348	0,0316	0,0346
Observations	7724	7724	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	No	Yes

Table B: Contemporaneous Repurchase Intensity and Remaining Volume as the independent variables

*This table shows the effect of different Repurchase measures and control variables on Delay. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the Repurchase Intensity results in a -0.3908 change in the standard deviation of Delay. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

Dependent variable:	Delay					
Method:	OLS	GLS	OLS	OLS	GLS	OLS
Repurchase Intensity (TV) (t-1)	-0,1399**	-0,1558**	-0,1311*			
	-2,00	*-2,26*	*-1,91*			
Repurchase Intensity (TV) (t)				-0,1038000	-0,1243*	-0,0999
				-1,49	*-1,82*	*-1,46*
Delay (t-1)	0,1712***	0,1819***	0,1712***	0,1713***	0,1821***	0,1714***
	15,10	*16,12*	*15,12*	*15,11*	*16,13*	*15,14*
Return (t-1) > 0	-0,0285	-0,0257		-0,0273	-0,0253	
	-0,60	*-0,54*		*-0,57*	*-0,54*	
Return (t-1) < 0	0,0619	0,0437		0,0604	0,0420	
	1,32	*0,93*		*1,28*	*0,90*	
Market Cap. (t-1) (ln)	-0,0261***	-0,0025*	-0,0262***	-0,0263***	-0,0025*	-0,0262***
	-5,31	*-1,93*	*-5,46*	*-5,38*	*-1,88*	*-5,46*
Book-to-Market (t-3)	-0,0213**	-0,0005	-0,0217**	-0,0216**	-0,0005	-0,0217**
	-2,36	*-0,12*	*-2,50*	*-2,47*	*-0,11*	*-2,50*
Volatility (t-1) (ln)	0,0042	0,0076		0,0044	0,0078	
	0,67	*1,25*		*0,70*	*1,28*	
Trading Volume (t-1) scaled	0,0373	0,0282		0,0289	0,0203	
	0,70	*0,57*		*0,55*	*0,41*	
Constant	1,2680***	0,7507***	1,2506***	1,2721***	0,7497***	1,2498***
	11,45	*21,64*	*11,53*	*11,57*	*21,61*	*11,53*
R^2 (within firm)	0,0353	0,0321	0,0351	0,0351	0,0319	0,0349
Observations	7724	7724	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	No	Yes

Table C: Contemporaneous Repurchase Intensity (TV) and Lagged Repurchase Intensity (TV) as the independent variables

*This table shows the effect of different Repurchase measures and control variables on Delay. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity (TV) results in a -0.1399 change in the standard deviation of Delay. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

The influence of repurchases on R-squared

Dependent variable:	R-squared								
Method:	OLS	GLS	OLS	OLS	OLS	OLS	OLS	GLS	OLS
Repurchase Intensity (t-1)	-0,0225	-0,0729	-0,1992	-0,2331	-0,0572	-0,1953			
	-0,04	*-0,13*	*-0,42*	*-0,49*	*-0,10*	*-0,41*			
Repurchase Intensity (t)							0,3494	0,3172	0,1659
							0,67	*0,61*	*0,35*
R-squared (t-1)	0,3933***	0,4028***	0,3879***	0,3986***	0,3916***	0,3931***	0,3932***	0,4029***	0,3931***
	36,55	*37,68*	*36,52*	*37,09*	*36,90*	*36,53*	*36,54*	*37,68*	*36,53*
|Market Correlation| (t-1)									
Market Cap. (t-1) (ln)	0,0130***	0,0020***	0,0073***			0,0130***	0,0130***	0,0020***	0,0130***
	6,01	*3,58*	*4,96*			*6,06*	*6,07*	*3,58*	*6,07*
Book-to-Market (t-3)	0,0139***	0,0011		-0,0024		0,0139***	0,0138***	0,0011	0,0139***
	3,49	*0,56*		*-0,87*		*3,58*	*3,56*	*0,58*	*3,59*
Trading Volume (t-1) scaled	-0,0146	-0,0164			-0,0127		-0,0220	-0,0247	
	-0,52	*-0,62*			*-0,45*		*-0,87*	*-1,03*	
Constant	-0,2499***	-0,0056	-0,1182***	0,0393***	0,0378***	-0,2506***	-0,2508***	-0,0057	-0,2511***
	-5,18	*-0,46*	*-3,75*	*16,36*	*30,01*	*-5,24*	*-5,24*	*-0,47*	*-5,25*
R^2 (within firm)	0,1564	0,1535	0,1514	0,1524	0,1487	0,1564	0,1565	0,1536	0,1564
Observations	7724	7724	7852	7724	7852	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes

Table D: Lagged Repurchase Intensity and Contemporaneous Repurchase Intensity as independent variables

*This table shows the effect of different Repurchase measures and control variables on R-squared. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a -0.0225 change in the standard deviation of R-squared. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

Dependent variable:	R-squared								
Method:	OLS	GLS	OLS	OLS	GLS	OLS	OLS	GLS	OLS
Repurchase Intensity (TV) (t-1)	0,0526*	0,0542*	0,0466						
	1,69	*1,77*	*1,53*						
Repurchase Intensity (TV) (t)				0,0361	0,0384	0,0318			
				1,17	*1,27*	*1,04*			
Remaining Volume (t)							0,0682	0,0605	0,0425
							0,85	*0,81*	*0,56*
R-squared (t-1)	0,3930***	0,4025***	0,3928***	0,3930***	0,4027***	0,3930***	0,3933***	0,4029***	0,3931***
	36,53	*37,65*	*36,51*	*36,52*	*37,66*	*36,25*	*36,55*	*37,68*	*36,53*
Market Cap. (t-1) (ln)	0,0130***	0,0020***	0,0130***	0,0130***	0,0020***	0,0130***	0,0130***	0,0020***	0,0131***
	6,02	*3,68*	*6,08*	*6,08*	*3,65*	*6,08*	*6,05*	*3,57*	*6,09*
Book-to-Market (t-3)	0,0139***	0,0012	0,0139***	0,0138***	0,0012	0,0139***	0,0139***	0,0011	0,0139***
	3,50	*0,62*	*3,60*	*3,57*	*0,60*	*3,60*	*3,49*	*0,57*	*3,59*
Trading Volume (t-1) scaled	-0,0232	-0,0266		-0,0197	-0,0233		-0,0225	-0,0257	
	-0,98	*-1,21*		*-0,84*	*-1,07*		*-0,91*	*-1,10*	
Constant	-0,2507***	-0,0071	-0,2519***	-0,2512***	-0,0066	-0,2516***	-0,2521***	-0,0055	-0,2524***
	-5,20	*-0,58*	*-5,26*	*-5,25*	*-0,55*	*-5,26*	*-5,22*	*-0,46*	*-5,27*
R^2 (within firm)	0,1567	0,1538	0,1567	0,1566	0,1580	0,1565	0,1565	0,1535	0,1564
Observations	7724	7724	7724	7724	7724	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes

Table E: Lagged Repurchase Intensity (TV) and Contemporaneous Repurchase Intensity (TV) as independent variables

*This table shows the effect of different Repurchase measures and control variables on R-squared. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity (TV) results in a 0.0526 change in the standard deviation of R-squared. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

Dependent variable:	Market Correlation								
Method:	OLS	GLS	OLS	OLS	OLS	OLS	OLS	GLS	OLS
Repurchase Intensity (t-1)	-0,0265	-0,1118	-0,2677	-0,3280	-0,0534	-0,2709			
	-0,03	*-0,12*	*-0,35*	*-0,42*	*-0,06*	*-0,35*			
Repurchase Intensity (t)							0,2762	0,2289	0,0546
							0,33	*0,27*	*0,07*
|Market Correlation| (t-1)	0,2288***	0,2399***	0,2291***	0,2330***	0,2316***	0,2288***	0,2288***	0,2399***	0,2288***
	20,34	*21,42*	*20,56*	*20,71*	*20,79*	*20,33*	*20,34*	*21,42*	*20,33*
Market Cap. (t-1) (ln)	0,0199***	0,0015*	0,0104***			0,0199***	0,0199***	0,0015*	0,0199***
	5,75	*1,74*	*4,39*			*5,75*	*5,76*	*1,74*	*5,76*
Book-to-Market (t-3)	0,0224***	0,0027		-0,0025		0,0224***	0,0223***	0,0028	0,0225***
	3,58	*0,87*		*-0,56*		*3,59*	*3,58*	*0,88*	*3,60*
Trading Volume (t-1) scaled	-0,0204	-0,0234			-0,0191		-0,0265	-0,0310	
	-0,45	*-0,54*			*-0,42*		*-0,65*	*-0,80*	
Constant	-0,2925***	0,1127***	-0,0737	0,1507***	0,1489***	-0,2926***	-0,2927***	0,1126***	-0,2931***
	-3,79	*5,73*	*-1,45*	*34,92*	*53,97*	*-3,79*	*-3,79*	*5,73*	*-3,80*
R^2 (within firm)	0,0572	0,0536	0,0549	0,0531	0,0526	0,0571	0,0572	0,0536	0,0571
Observations	7724	7724	7852	7724	7852	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes

Table F: Lagged Repurchase Intensity and Contemporaneous Repurchase Intensity as independent variables

*This table shows the effect of different Repurchase measures and control variables on Market Correlation. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity results in a -0.0265 change in the standard deviation of Market Correlation. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

Dependent variable:	Market Correlation								
Method:	OLS	GLS	OLS	OLS	GLS	OLS	OLS	GLS	OLS
Repurchase Intensity (TV) (t-1)	0,1129**	0,1208**	0,1027**						
	2,24	*2,44*	*2,08*						
Repurchase Intensity (TV) (t)				0,0695	0,0795*	0,0630			
				1,39	*1,62*	*1,28*			
Remaining Volume (t)							0,0511	0,0630	0,0206
							0,39	*0,52*	*0,17*
|Market Correlation| (t-1)	0,2284***	0,2394***	0,2284***	0,2287***	0,2397***	0,2286***	0,2288***	0,2399***	0,2288***
	20,31	*21,38*	*20,30*	*20,33*	*21,41*	*20,32*	*20,34*	*21,42*	*20,33*
Market Cap. (t-1) (ln)	0,0199***	0,0017*	0,0199***	0,0199***	0,0016*	0,0199***	0,0199***	0,0015*	0,0199***
	5,77	*1,87*	*5,78*	*5,77*	*1,82*	*5,77*	*5,77*	*1,73*	*5,76*
Book-to-Market (t-3)	0,0224***	0,003	0,0226***	0,0224***	0,0029	0,0225***	0,0223***	0,0028	0,0225***
	3,58	*0,95*	*3,61*	*3,58*	*0,92*	*3,61*	*3,58*	*0,88*	*3,60*
Trading Volume (t-1) scaled	-0,0383	-0,0448		-0,0299	-0,0367		-0,0267	-0,0341	
	-1,01	*-1,26*		*-0,79*	*-1,04*		*-0,67*	*-0,90*	
Constant	-0,2943***	0,1094***	-0,2950***	-0,2936***	0,1106***	-0,2942***	-0,2941***	0,1127***	-0,2938***
	-3,82	*5,56*	*-3,82*	*-3,81*	*5,62*	*-3,81*	*-3,81*	*5,74*	*-3,80*
R^2 (within firm)	0,0578	0,0543	0,0577	0,0574	0,0539	0,0573	0,0572	0,0536	0,0571
Observations	7724	7724	7724	7724	7724	7724	7724	7724	7724
Firm FE	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Month FE	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes

Table G: Lagged Repurchase Intensity and Contemporaneous Repurchase Intensity as independent variables

*This table shows the effect of different Repurchase measures and control variables on Market Correlation. The effects are reported in a change in a standard deviation, so a change of one in the standard deviation of the lagged Repurchase Intensity (TV) results in a 0.1129 change in the standard deviation of Market Correlation. The stars give the level of significance, * is significant at a 10% level, ** is significant at a 5% level and *** is significant at an 1% level. The number in the second row of each variable is the t-statistic. Furthermore, the R-squared (within firm) shows the explanatory power of the model, Observations shows the numbers of observations and the use of firm-fixed and monthly-fixed effects is shown.*

1.3 Appendix C

Description of variables

Variables short-term announcement part:

Name:	*Definition:*	*Source:*
Observed rate of return	Percentual difference of the closing price of a firm between day t and day t-1	Compustat Global
Expected rate of return	Percentual difference of the closing price of the market between day t and day t-1	Bloomberg
Abnormal return	Difference between the daily return of a firm and the daily return of the market	Compustat Global /Bloomberg
Cumulative abnormal return	Summation of the differences in daily returns between a firm and the market for a certain time period	Compustat Global /Bloomberg

Variables long-term announcement part:

Name:	*Definition:*	*Source:*
Observed rate of return	Percentual difference of the closing price of a firm between day t and day t-1	Compustat Global
Expected rate of return	Percentual difference of the closing price of the market between day t and day t-1	Bloomberg
Abnormal return	Difference between the daily return of a firm and the daily return of the market	Compustat Global /Bloomberg
Buy-and-hold abnormal return	Difference in return between a firm and the market when both items are held for a one-year period	Compustat Global /Bloomberg
Book-to-Market ratio	Book value of equity of a firm divided by the market capitalization of a firm	Compustat Global

Variables actual buyback (price efficiency) part:

Name:	*Definition:*	*Source:*
Delay	Measure for price efficiency, calculated by doing one minus the ratio of the estimated r-squared of the base model and the estimated r-squared of the extended market model	Compustat Global /Bloomberg
R-squared	The estimated r-squared of the base market model	Compustat Global /Bloomberg
Market correlation	Correlation between the daily return of a firm and the daily return of the market	Compustat Global /Bloomberg

Repurchase intensity	The number of shares repurchased in a month, divided by the number of shares outstanding at the end of the previous month	Website of the firm
Remaining volume	The number of shares that still can be bought under the current program at the beginning of month t scaled by shares outstanding at the beginning of the program	Website of the firm
Repurchase intensity (TV)	The number of shares repurchased during the month divided by the number of shares traded over the current month	Website of the firm
Repurchase volume	The volume of shares repurchased during the month in euros	Website of the firm
Program size	Maximum number of shares that may be bought back under a particular program scaled by the number of shares outstanding	Website of the firm
Program month	The number of calendar months since the announcement of the repurchase program	Website of the firm
Book-to-Market ratio	Book value of equity of a firm divided by the market capitalization of the firm, winsorized at a 1% level	Compustat Global
Cash to assets	Cash and short-term investments scaled by assets	Compustat Global
Dividends to assets	Total dividends scaled by assets	Compustat Global
EBITDA to assets	Operating income before depreciation scaled by assets	Compustat Global
Leverage	(Total assets - the book value of equity) / (total assets - book value of equity + market capitalization)	Compustat Global
Market capitalization	The natural logarithm of the monthly average of the daily market capitalization	Compustat Global
Return	Monthly stock return	Compustat Global
Total assets	The natural logarithm of the total assets	Compustat Global
Trading volume	The total monthly trading volume excluding the repurchased scaled by the shares outstanding	Compustat Global

Turnover	Trading volume scaled by the market capitalization	Compustat Global
Volatility	The natural logarithm of the standard deviation of daily returns over one month	Compustat Global