

# Volatility and the Buyback Anomaly

Theodoros Evgeniou\*, Enric Junqué de Fortuny\*\*,

Nick Nassuphis\*\*\*, and Theo Vermaelen\*

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## Abstract

The buyback anomaly survives when using the five factor Fama and French (2015) and the four factor Stambaugh and Yuan (2016) models: buyback announcements are followed by positive long-term excess returns that are positively related to (idiosyncratic) volatility, inconsistent with the low volatility anomaly. The results are consistent with the market timing hypothesis: the option to take advantage of undervalued stock is more valuable when firm value is more uncertain or is more driven by company-specific information. Combining volatility with undervaluation indicators proposed by Peyer and Vermaelen (2009) improves the predictability of excess returns after buyback announcements.

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\*INSEAD, Bd de Constance, 77300 Fontainebleau, France, phone: +33(0)1 6072 4000, \*\*Rotterdam School of Management, Burgemeester Oudlaan 50, 3062 PA Rotterdam, The Netherlands, \*\*\*CQS, One Strand, London WC2N 5HR, United Kingdom, e-mail: theodoros.evgeniou@insead.edu, enric.junquedefortuny@insead.edu, nicknassuphis@gmail.com, and theo.vermaelen@insead.edu. Contact author: Theo Vermaelen, INSEAD, Bd de Constance, 77300 Fontainebleau, France, phone: +33(0)1 6072 4000, email: theo.vermaelen@insead.edu.

# 1 Introduction

In this paper we first test whether previously reported positive (negative) long-term excess returns following share buyback (equity issue) announcements<sup>1</sup> can be explained by the recently proposed five factor Fama and French (2015) or the four factor Stambaugh and Yuan (2016) models. Excess returns in previous research are calculated using different benchmarks such as firms with similar size and book-to-market ratio (Ikenberry et al., 1995), the Fama and French (1993) three-factor model or the Carhart (1997) 4-factor model (Peyer and Vermaelen, 2009). Fama and French (2015)<sup>2</sup> add investment and profitability factors to the Fama and French (1993) model. Note that these factors were considered anomalies before. Stambaugh and Yuan (2016) expand this approach and add two "mispricing" factors to the market and value ones. These factors are constructed by averaging rankings across a set of 11 prominent anomalies examined by Stambaugh, Yu, and Yuan (2015). Unlike Fama and French (2015) they don't argue that all their factors capture systematic risk: the mispricing factors can capture common sources of mispricing such as sentiment risk. Stambaugh and Yuan (2016) show that their model explains a wide range of the 73 anomalies listed by Hou et al. (2015).

It should be noted that this extensive list of 73 anomalies does not include the buyback anomaly we consider in this paper. The list includes the net issue anomaly which assumes that an equity issue is simply the opposite of a repurchase decision, a common assumption made in the asset pricing literature. For example, Fama and French (2016) calculate returns after net equity issues defined as funds spent on buybacks minus funds spent on equity issues. They assume investors buy after the completion of the buyback and the equity issue,

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<sup>1</sup>For evidence on long-term excess returns after buybacks see e.g., Ikenberry, Lakonishok, and Vermaelen (1995); Peyer and Vermaelen (2009); Manconi, Peyer, and Vermaelen (2015). For evidence on underperformance after equity issues see e.g., Loughran and Ritter (1995); Spiess and Affleck-Graves (1995); Eckbo, Masulis, and Norli (2000); Dittmar and Thakor (2007); Brav, Geczy, and Gompers (2000).

<sup>2</sup>Note that the q-factor model of Hou, Xue, and Zhang (2015) also combines market and size factors with investment and profitability factors. In this paper, their model generates similar results as that of Fama and French (2015). Results available upon request.

not around the announcement date of the buyback authorization as is done in previous research [e.g., Ikenberry et al. (1995)]. For buybacks this may be an issue as repurchases may be completed several years after the buyback authorization, or not completed at all (Stephens and Weisbach, 1998). A firm may announce a buyback today because it believes it is undervalued, but the market may become efficient before the firm has completed a significant fraction of the repurchase. In other words, the excess returns may be realized before the actual repurchase is completed. That's why the proper way to test this anomaly is to follow an event study approach that starts computing excess returns in the month after the buyback authorization.

Pooling buybacks and equity issues in a "net issues" measure ignores two other major differences between repurchases and equity issues which should have an effect on the ability and willingness to engage in market timing. First, an open market repurchase authorization creates an option to repurchase stock and the seller is not aware she is selling to the corporation, while in an equity issue the investor knows that the company is the issuer. Obviously this makes it easier to buy back undervalued shares than to issue overvalued shares. Second, issuing overvalued shares to new investors may hurt relations with these investors and make it more difficult to convince them to buy new shares in a follow up secondary offering.<sup>3</sup> On the other hand, repurchasing undervalued shares from investors who have decided to sell their shares anyway should not create an investor relations problem. So in order to test the buyback and equity issue anomalies one has to examine them separately, using an event study approach as we do in this paper.

We find that both the Fama and French (2015) and Stambaugh and Yuan (2016) models explain the equity issue anomaly, but not the buyback anomaly. Moreover, the Fama and French (2015) model does a better job than the Stambaugh and Yuan (2016) one: during the 48 months after the buyback announcement the four factor model produces (statistically significant at the 1% level) excess returns of 0.21% per month versus 0.31% per month

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<sup>3</sup>One of the arguments for IPO underpricing is that it creates a positive experience for investors making it easier to convince them to buy new shares in a follow up offering (Ibbotson, 1975).

with the four factor model. Unlike other anomalies that disappear over time (McLean and Pontiff, 2016), the buyback anomaly persists over time and does not decline in recent years. Peyer and Vermaelen (2009) show that long terms excess returns are negatively related to firm size, prior return and market to book ratio and summarize these characteristics in an undervaluation index (U-index). We also show that this conclusion holds for both factor models.

Having shown that the buyback anomaly survives the most recent factor models, we address the second major question in this paper: are excess returns related to volatility? Such a relation is plausible, considering past research on anomalies and volatility. Ang, Hodrick, Xing, and Zhang (2006) find that (idiosyncratic) volatility is negatively related to stock returns. However, Stambaugh et al. (2015) find that the relation between idiosyncratic volatility and future returns reverses and becomes positive for undervalued stocks, where undervaluation is measured by combining eleven major anomalies reported in the literature in a Mispricing Measure. They argue that their result is consistent with the costly arbitrage hypothesis: idiosyncratic volatility represents risk that deters arbitrage, hence among underpriced stocks, the stocks with the highest idiosyncratic volatility should be the most underpriced.<sup>4</sup> With the same reasoning they argue that for overpriced stocks there should be a negative relation between idiosyncratic volatility and future returns. If repurchasing firms are undervalued and equity issuers are overvalued, this theory predicts a positive (negative) relation between idiosyncratic volatility and future returns after firms announce a buyback (equity issue). Moreover, Stambaugh et al. (2015) also argue that because limits to arbitrage are higher among overvalued stocks (e.g., most investors are reluctant or unable to short stocks), the volatility effect among equity issuers should be stronger than the volatility

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<sup>4</sup>Note that the relation between volatility and arbitrage risk has been studied extensively over the last twenty years: volatility captures risk that prevents arbitrageurs from stepping in [e.g., De Long, Shleifer, Summers, and Waldmann (1990) and S. and Vishny (1997)]. For example, Pontiff (1996) finds that the closed end discount is stronger for high volatility stocks. Mendenhall (2004), Ali, Hwang, and Trombley (2003), Li and Zhang (2010) and Wang and Yuan (2013) report similar conclusions for, respectively the post-earnings drift anomaly, the value premium anomaly, the asset growth anomaly and the return on assets anomaly. Note, however, that none of these anomalies use the Fama and French (2015) model to estimate expected returns.

effect among repurchasing firms.

We find results inconsistent with the costly arbitrage hypothesis. First, as mentioned supra, on average long term excess returns are positive after buybacks but the negative equity issue anomaly disappears. Second, while the volatility effect for repurchasing firms is positive, as predicted, there is no significant *negative* relation between volatility and excess returns after equity issues.

We argue that the positive volatility effect after buybacks is consistent with the market timing hypothesis, the fundamental hypothesis behind the buyback anomaly.<sup>5</sup> According to this hypothesis the ability to time the market depends on the extent a stock can be mispriced. Ikenberry and Vermaelen (1996) point out that open market repurchase programs are options to buy undervalued stock, not firm commitments. The larger the volatility the larger the value of this option. While they show that short-term announcement returns are positively correlated with volatility, if markets underreact, this *option hypothesis* would also predict a positive relation between long-term returns and volatility. Note that as equity issues are underwritten firm commitments, not options to issue equity, no such volatility effect is predicted in that case. The market timing hypothesis also assumes that managers have superior knowledge about company-specific information, not the overall market. Hence the prediction of the *information advantage hypothesis* is that buyback announcements of firms with high standardized idiosyncratic volatility, namely  $(1-R^2)$  measuring to what extent the volatility of stock returns is explained by company specific (non-factor related) information [e.g., see Li, Rajgopal, and Venkatachalam (2014)], will generate higher long term excess returns, which is also what we find.

After documenting that volatility as well as standardized idiosyncratic volatility are positively related to long-term excess returns after buybacks we test whether these variables can improve our ability to predict long-term excess returns, above the predictive ability of

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<sup>5</sup>Note that the market timing hypothesis is different from the signalling hypothesis which assumes that the purpose of the buyback is to correct undervaluation [e.g., Vermaelen (1981), Bhattacharya and Jacobsen (2016)]. The market timing hypothesis requires that the market underreacts to the buyback allowing long-term investors (including insiders) to benefit at the expense of selling shareholders.

the undervaluation index (U-index) developed by Peyer and Vermaelen (2009). Combining total volatility and standardized idiosyncratic volatility with the Peyer and Vermaelen (2009) Undervaluation Index into an Enhanced Undervaluation Index (EU-Index) improves the predictability of excess returns. In particular, during the four years following the buyback announcement, the high EU-Index portfolio generates an excess return of 0.86% per month with the Calendar Time event study method. Using the IRATS method the cumulative excess return reaches 70.55% after 48 months. On the other hand, we show that the Mispricing Measure (MM) developed by Stambaugh et al. (2015) on the basis of 11 anomalies is not helpful in predicting long term excess returns after buyback authorization announcements. This again shows that the 11 anomaly indicators that may be relevant for average stocks don't apply to buyback stocks.

Summarizing, this paper makes four fundamental contributions. First we show that the buyback anomaly survives after using the most recent factor models developed by Fama and French (2015) and Stambaugh and Yuan (2016). We argue that this is a result of the fact that, unlike past research on anomalies in the asset pricing literature, we don't pool buybacks and equity issues in a "net issue" anomaly. Second, the fact that the buyback anomaly persists and the equity issuance anomaly disappears (i.e, we find no evidence that, on average, firms issue equity when they are overvalued) is inconsistent with the costly arbitrage hypothesis which predicts that anomalies that generate long-term negative excess returns are more difficult to arbitrage away than positive excess return anomalies. Third, we find evidence that long-term excess returns after buybacks are positively related with total volatility and standardized company specific volatility, which is consistent with the hypothesis that buybacks are driven by market timing. Indeed, the option hypothesis of Ikenberry and Vermaelen (1996) argues that an open market buyback authorization creates an option to take advantage of undervaluation and this option is more valuable for risky firms. The positive relation between idiosyncratic standardized volatility and long term excess returns is consistent with the hypothesis that the information advantage of managers is larger when

stock prices are less driven by common factors. Finally, we show that adding volatility and standardized idiosyncratic volatility to the factors proposed by previous research as undervaluation proxies and combining them in an Enhanced Undervaluation index improves our forecasting ability of excess returns after buyback authorization announcements. As a theoretical argument can be made that both measures are proxies for the competitive information advantage of managers-insiders, this strengthens the support for the undervaluation and market timing hypothesis. On the other hand, we show that the Mispricing Measure of Stambaugh et al. (2015) is not helpful in predicting excess returns after buyback authorization announcements, indicating that the anomaly indicators of Stambaugh et al. (2015) are not relevant in the case of buybacks.

So why does the buyback anomaly survive, unlike many of the 73 anomalies tested by Stambaugh and Yuan (2016)? First, it should be noted that the anomaly is more pronounced in small firms, which may explain why this anomaly has attracted little attention in the asset management industry. Second, unlike anomalies based on firm characteristics, research on the buyback anomaly is motivated by surveys of CFOs who claim that the anomaly exists (Brav, Graham, Harvey, and Michaely, 2005), i.e. they are able to time the market. Finally, firms that repurchase shares because of undervaluation don't look undervalued according to more general mispricing measures such as that of Stambaugh et al. (2015). As buyback stocks have negative momentum before the announcement, the momentum anomaly (Jegadeesh and Titman, 1993) predicts lower returns not higher returns. Similarly, Peyer and Vermaelen (2009) find that the most undervalued buyback stocks miss earnings forecast, which is the opposite of the Mendenhall (2004) earnings drift anomaly which predicts negative excess returns after missing earnings forecasts. In other words, an investor may be reluctant to buy stocks after a buyback announcement if there are other anomalies (such as, e.g., momentum) that suggest overvaluation.

The paper is organized as follows. In section 2 we describe our data. In section 3 we test whether the buyback and equity issue anomalies survive when we use the Fama and

French (2015) five-factor model and the Stambaugh and Yuan (2016) four factor model. In section 4 we test whether the buyback anomaly is robust across time and investment horizon. In section 5 we test whether (total) volatility as well as standardized idiosyncratic volatility ( $1 - R^2$ ) can improve the predictability of excess returns, relative to simply using the Undervaluation Index proposed by Peyer and Vermaelen (2009). Section 6 concludes.

## 2 Data

Our sample spans the period from January 1985 to December 2015. We start in 1985 as SDC's coverage is poor before that year. We stop in 2015, the last year all CRSP and Compustat data were available. We retrieved buyback authorization announcements and announcements of Secondary Equity Offerings (SEO's) from the Securities Data Corporation (SDC) database. Daily and monthly returns, pre-announcement daily closing prices and market capitalization data were taken from CRSP. Book value of equity (BE) was taken from Compustat. The Fama-French factors were obtained from Kenneth French's website. The Stambaugh and Yuan (2016) factors and the Mispricing Measure were obtained from Yu Yuan's website. All variables used in this paper are described in the Appendix.

For the buybacks we combined all open market repurchase announcements from both the SDC Repurchases data base and the SDC US mergers and acquisitions (*M&A*) data base. We ended up with a total of 24,501 repurchases events, out of which 12,205 were only from the SDC Repurchases database, 6,624 only from the SDC *M&A* database and 5,672 from both. Finally, we removed the following events: no CRSP returns or not all Compustat data available (6,687 events); the percent of shares authorized was larger than 50% (64 events), or the closing price was less than \$1 for events before 1995 or \$3 for the other (756 events), or the primary stock exchange was not the NYSE, the Nasdaq, or Amex (1,717 events). Finally, we removed all events from firms in the Financial and Utilities sectors (4,167 events).<sup>6</sup> At

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<sup>6</sup>We are using the industries from Kenneth French's Website. The Financial Sector consists of all firms with SIC code at the time of the buyback announcement that belonged in the "Banks" or "Fin" industries



the end we are left with 11,327 buyback events made by 3,982 firms. Table I summarizes the key data in this study. The average percent of shares authorized for these firms was 7.20% (median of 5.80%), the average Market Capitalization at announcement was \$6,205 Million (median of \$859.80 Million), while the BE/ME was on average 0.60 (median of 0.50).

For the issuers, we started with 13,072 events from SDC, filtered to exclude rights issues, pure secondary offerings where existing shareholders sell shares without generating proceeds for the company, issues made by non-U.S. firms or in non-U.S. markets, issues made by closed-end funds or unit investment trusts, as well as block trades, accelerated offers and best efforts. We removed all SDC events for which either the event date (1,923 events) or the CUSIP (2,355 events) was missing or where we found duplicate events with mismatching information (40 events), a total of 3,963 events - given the overlap between these cases. Finally, as for the buybacks, we removed the following events: no CRSP returns or not all Compustat data available (2,976 events); the percent of shares authorized was larger than 50% (45 events), or the closing price was less than \$1 for events before 1995 or \$3 for the other (304 events), or the stocks were not listed on the NYSE, Nasdaq or Amex (389 events). We again removed all events from firms in the Financial and Utilities sectors (887 events). Our final sample contains 4,021 events made by 2,895 firms. The average percent of shares issued (for the events for which this information was available) was 17.10% (median of 16%), the average Market Capitalization on the announcement day was \$1,117 Million (median of \$303 Million), while the BE/ME was on average 0.30 (median of 0.20). Note also from Table I that the average and median Mispricing Measure developed by Stambaugh et al. (2015) is higher for equity issuers than for buyback stocks, which is consistent with the hypothesis that equity issuers are more likely to be overvalued than share repurchasers.

Figure I shows the number of announcements per year in the sample period as well as the (standardized) level of the *S&P* 500. Buyback activity rises prior to stock market increases and tends to fall afterwards, especially during the financial crisis of 2008 when buyback

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(SIC codes 6000 to 6300 and 6700 to 6799). The Utilities Sector consists of all firms with SIC code 4900 to 4942.

announcements fell to a 15 year low. Note the structural decline in equity issues since 2000. A similar decline in IPOs is also observed by Gao, Ritter, and Zhu (2013).

### **3 Share Buybacks, Equity Issues and Abnormal Returns**

We start with revisiting past research but now using a longer and more recent time period and the five-factor model of Fama and French (2015) as well as the four-factor model of Stambaugh and Yuan (2016) to measure expected returns. In the tables below we refer to the first model as 5F and the second model as 4F. In particular, we test whether buyback (equity issue) announcements are followed by significant positive (negative) long term excess returns, and if so, whether the returns can be explained by proxies for undervaluation as proposed by Peyer and Vermaelen (2009).

Table II, Panel A, shows long-term cumulative excess returns for various holding periods after the announcement using the Ibbotson RATS (IRATS) event study method (Ibbotson, 1975). Each event month  $t$  we run cross-sectional regressions of stock returns against the factors. The intercept in the regression measures the average abnormal excess return in event month  $t$ . We then accumulate these excess returns over various time horizons (up to 48 months after the event). The advantage of this method is that each event gets the same weight and that factor betas are allowed to change in event time, something that may be important as capital structure changes may signal a change in risk. Grullon and Michaely (2004) argue that a repurchase signals a decline in growth opportunities. As growth opportunities are riskier than assets in place the overall risk of the firm should go down. If the market only slowly understands this, one will observe long-term positive excess returns. Moreover, Li, Livdan, and Zhang (2009) and Liu, Whited, and Zhang (2009) use Q-theory to argue that when a firm experiences an increase in its cost of capital, it should pay out cash. So, in contrast to Grullon and Michaely (2004) they argue that buybacks should be

associated with an increase rather than a decrease in risk. The IRATS procedure adjusts for event-induced risk changes.

The results in Table II, Panel A, show that using a five-factor the excess returns are statistically significantly positive over all investment horizons and reach 12.89% after 4 years ( $t=12.70$ ). The results with the 4 factor model are even stronger with excess returns of 20.44% ( $t=19.67$ ) after 4 years. In all the tables we also calculate cumulative excess returns in the 6 months prior to the buyback. Consistent with past research [see e.g., (Peyer and Vermaelen, 2009)] buyback authorization announcements are preceded by significant negative excess returns of around -6%. This is consistent with the hypothesis that the typical repurchase announcement is triggered by a stock price decline that insiders may feel is not justified given their long-term prospects about the company.

In order to test the market timing hypothesis in the buyback sample, we also test whether the “Undervaluation Index” (U-index) developed by Peyer and Vermaelen (2009) remains a robust indicator to separate companies that are buying back stock because they are undervalued from companies that repurchase shares for other reasons. We calculate the U-index as follows. Companies get a size score from 1 (large firms) to 5 (small firms) depending on the quintile of their market value of equity in the month prior to the buyback announcement. Then, we calculate the 11-months absolute returns of months -12 to -1 before announcement for all events and assign a score of 5 to the low returns firms and 1 to the high returns ones. Finally, companies get a book value to market value (BE/ME) score depending on the quintile of their BE/ME value of equity in the year prior to the buyback announcement, with a score of 1 to small BE/ME firms and 5 to large ones. Like Peyer and Vermaelen (2009) we use all CRSP companies to define the quintile thresholds each month.

We sum up these three scores for each firm and we then define as “high U-index” the firms with total score more than 10 and as “low U-index” those with total score less than 6. Note that unlike Peyer and Vermaelen (2009) we do not consider the stated reasons for the buyback in the press release, hence we define different thresholds for the high U-index and

low U-index buyback firms. We end up with 2,240 “high U-index” buyback stocks (19.78% of all buyback events), and 1,564 “low U-index” ones (13.81% of all buyback events). The distribution of the U-index of all buyback events is shown in Figure II.

Table II, Panel A, shows the five-factor as well as the four-factor IRATS for high U-index and low U-index firms. The interesting conclusion is that for all horizons starting 24 months after the buyback announcement, regardless of the factor model used, high U-index firms beat low U-index firms. For comparable horizons and u-index categories, the 4 factor model always produces larger excess returns. Consistent with Peyer and Vermaelen (2009) the low U-index buyback stocks earn significant positive excess returns as well. It is difficult to find a portfolio of buyback stocks that under-performs in the long run.

One critique of the IRATS method is that the result may be time-specific. Indeed, as every event is equally weighted the cumulative average abnormal returns are dominated by periods when there are a large number of events. However, as Loughran and Ritter (2000) point out, the fact that many firms decide to announce buybacks in a particular month may indicate that more firms believe markets are inefficient in that month. Giving equal weight to a calendar month with many buybacks and a calendar month with few buybacks may systematically bias excess returns downwards. So we also use the Calendar Time method where in each calendar month we form an equally-weighted portfolio of all firms that announced a buyback (or an equity issue) in the previous  $t$  months. We then run a time series regression of the portfolio returns against the factors. The intercept of the regression is the average monthly excess return in the  $t$  months after the event. The results are shown in Panel B of Table II.

The calendar time results confirm the IRATS results. Regardless of the factor model and the investment horizon (24 months and beyond) long-term excess returns are positive a statistically significant at the 1% level. As in Panel A, excess returns are larger when the Stambaugh-Yuan four factor model is used as a benchmark. Specifically, during the 48-month period after the buyback announcement firms earn excess returns of 0.31% ( $t=3.73$ )

and 0.53% ( $t=3.63$ ) in the case of high U-index firms. So we can conclude that the buyback anomaly and the relevance of the U-index survive the Fama and French (2015) and Stambaugh and Yuan (2016) models.

So far all our events are equally weighted. Mitchell and Stafford (2000) argue that events should be value weighted to test whether they represent an economically important anomaly. However, as pointed out by Loughran and Ritter (2000), small firms are more likely to be mispriced as they are less followed by analysts. Hence managers of small firms are better able to take advantage of mispricing than managers of large firms, which is the reason why firm size is one of the components of the U-index. So value weighting the events would simply bias the results toward zero. And indeed, when we value-weight the events (see Table III Panel A) long-term excess returns become statistically insignificantly different from zero when using the total sample of events. So the buyback anomaly is not economically important and does not challenge the basic premise that the market represented by a value-weighted index is priced correctly. Note, however, if we eliminate the firms with are in the top 25<sup>th</sup> market capitalization percentile (see Table III, Panel B) the results become again significant, especially for the high U-index firms. These firms had a market capitalization less than \$2,971 million in 2015. The fact that the buyback anomaly is a small cap anomaly makes it more likely that excess returns are evidence that managers (at least in these firms) time the market based on their information advantage relative to investors. It may also explain why the anomaly persists as the capacity of small cap funds (and therefore management fees) is smaller than the capacity of large cap funds.

Table IV, shows the results for all equity issues. Note that because there is no under-valuation index for equity issues we use the Mispricing Measure (MM) of Stambaugh et al. (2015) to measure overvaluation. Specifically, we define all issuers in the top 20<sup>th</sup> MM percentile as High MM firms and issuers in the bottom 20<sup>th</sup> MM percentile as low MM firms. Note that high values of MM correspond to more overvaluation. Table IV panel A shows the IRATS results while panel B shows the Calendar Time results. For the total sample,

the Fama-French five factor model fully explains the anomaly, regardless of the method to measure abnormal returns. However, using IRATS, the 4 factor model produces significant positive excess returns of 12.66% after 4 years ( $t=5.24$ ). With the calendar time method, the excess returns become less significant ( $t=1.81$ ) but have the same magnitude (0.27% per month or 12.96% after 48 months). When splitting up the sample according to MM, the Fama-French five factor model shows no significant long-term excess returns regardless of the investment horizon and the method to measure excess returns. A similar result is found when we use the Stambaugh et al. (2015) four factor model and the Calendar Time method.

Note also that equity issues are typically preceded by large positive excess returns of around 35.63% in the 6 months prior to the equity issue. However, the lack of post announcement *negative* excess returns shows that this was not reflecting "irrational exuberance" but rather that, for example, these firms possibly experienced a substantial increase in growth opportunities and issued equity to finance them. In summary, we find no robust evidence that firms issue stock because they are overvalued, irrespective of whether they are High or Low MM firms.

Overall our results show that when searching for anomalies, buybacks and equity issues should not be pooled in a "net issue" measure, a common practice in the asset pricing literature. Both events may be motivated by different reasons.

## 4 How robust is the buyback anomaly?

The results so far are based on a sample of all buyback and equity announcements over a thirty-year period. As the equity issue anomaly does not survive the Fama and French (2015) five-factor or the Stambaugh and Yuan (2016) four-factor model, this section focuses on better understanding the buyback anomaly and uses the five-factor model as a benchmark.<sup>7</sup> We use the five factor model as Table II shows that it better explains returns than the

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<sup>7</sup>All analyses below are also done for equity announcements. However, in agreement with the results in Section 3, we find no consistent/robust results for issuers. All issuers results are available upon request.

four-factor model. In other words, it is a more difficult benchmark to beat.<sup>8</sup> The purpose of this section is to test the robustness of this anomaly: has it become less important over time because markets have become more efficient? How sensitive is it to the length of the investment period?

## 4.1 Robustness across time periods and investment horizons

Table V shows excess returns, using both the IRATS and Calendar Time method for different time periods. We consider time periods, which overlap to some extent with past research [Ikenberry et al. (1995); Peyer and Vermaelen (2009); Manconi et al. (2015); and Fu and Huang (2016)]: 1985-1990; 1991-2000; 2001-2015 and 2008-2015. The last period was chosen to incorporate the financial crisis and to test whether indeed markets have become more efficient in recent years, or whether managers have for example been discouraged from market timing by the obvious mistakes that were made by buying back shares before a major financial crisis.

Table V shows that, regardless of the time period chosen or the method to calculate excess returns, the buyback anomaly remains economically and statistically significant and there is no clear time trend in the data that suggests that markets have become more efficient over time. There is one exception to the consistency between the IRATS and the Calendar Time results: in the period of 1991-2000, the IRATS method generates excess returns after 48 months of 20.56% ( $t=10.74$ ) but the Calendar Time method produces statistically insignificant excess returns of 0.16% per month. This result appears to also be inconsistent with Peyer and Vermaelen (2009). However, if one includes the financial sector firms or considers the three-factor model, as Peyer and Vermaelen (2009) do, the calendar method abnormal returns do become significant.<sup>9</sup> Note that the period 1991-2000 was a period characterized by a large number of buybacks near the end of the century (Figure 1). During the last two

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<sup>8</sup>We also repeated the whole analysis below with the Stambaugh and Yuan (2016) model but our main conclusions are essentially unchanged. Results are available upon request.

<sup>9</sup>Details available upon request.

years there were several months with an exceptionally large number of buybacks. High buyback concentration will produce significant differences between IRATS and Calendar Time results.

For comparison, we also tested the stability of the findings on equity issues in Table IV. The results (available on request), using IRATS, are time- and model-specific. When we use the 4 factor model, long-term (48 months) excess returns are significantly negative during the 1985-1990 period, but significantly positive during the 1991-2000 and 2001-2015 periods. With the 5 factor model only the 2001-2015 period shows significant positive long-term excess returns. However, for all horizons and both factor models, all long-term excess returns become statistically insignificantly different from zero when we use the Calendar Time Method.

## **4.2 Robustness with respect to estimation of factor betas**

Note that both event study methods measure alpha (excess return) and betas jointly. In other words, we do not use prior (to investing) information to estimate risk. An investor who wants to exploit the anomaly, however, may want to hedge market (and other) risk and would need to estimate betas using past data. If the buyback signals a change in risk (Grullon and Michaely, 2004; Li et al., 2009; Liu et al., 2009) it is not obvious that such a hedged strategy would work, which may make a buyback strategy impractical for investors who want to arbitrage the anomaly away.

To further study the robustness of the buyback anomaly, we simulate a portfolio investment strategy starting in 1985. The strategy uses past data to estimate the factor betas and measures the abnormal returns of buyback portfolios over different investment horizons. While this is not an accurate measure of the returns of a buyback fund - as we do not consider transaction costs, turnover issues, or other operational issues as discussed for example in Mitchell and Pulvino (2001) - it provides us with an estimate of what would have happened to an investor who starts investing in 1985 in an equally weighted portfolio of buyback



stocks and holds them over various horizons.

Specifically, we consider the following trading strategy: construct the first day of every month an equally weighted portfolio of all companies that announced buybacks during the previous  $N$  months, for a given holding period of length  $N$  (which can be chosen). Thus, once a company makes an announcement, it enters the portfolio on the first day of the following month and remains there for  $N$  months. Note that the portfolio is re-balanced (the first day of) each month. This “unhedged” strategy generates a time series of returns. Each month (when we re-balance the portfolio) we also use the previous 18 monthly returns of this time series to calculate the (portfolio level) time series betas of all five factors. This allows an investor to determine the betas for the factor risks using data available at the time of portfolio formation, and then hedge these factor risks (including the market) using these betas to get a “hedged” portfolio.

Despite using pre-portfolio formation data to estimate the betas, unlike both the IRATS and Calendar Time methods that use hindsight to estimate risk, the hedged portfolio indeed has very low betas with the five factors. For example for the  $N = 12$  months holding period, the betas for the five factors Market, SMB, HML, RMW, and CMA are respectively 0.01, 0.02, 0.01, 0.02 and -0.16. The corresponding betas for the “unhedged” strategy are 1.03, 0.56, 0.18, 0.19 and -0.08. This indicates that the returns of the hedged strategy are indeed close to “excess” returns, i.e. returns that have basically eliminated all factors risk. This is also consistent with the hypothesis that the buyback announcement itself does not materially change the risk of the repurchasing firms (in the short term).

We report the returns (unhedged strategy) and excess returns (hedged strategy) of such a portfolio strategy for different holding months  $N = 1, 3, 6, 12, 24, 36, 48$  in Figure III.<sup>10</sup> The basic conclusion is that the shorter the investment horizon the larger the excess returns. Specifically, at the end of 2015 the cumulative excess returns from the 1 month, 6 month, 12 month, 24 month, 36 month and 48 month holding periods are respectively equal to 287.30%,

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<sup>10</sup>Results for other holding periods, as in Figure III, are available upon request.

232.60%, 139.40%, 111.60%, 97.30%, 104.60% and 102.90%. This is not surprising as the Calendar Time results in Table II show that the monthly excess returns decline when the investment horizon becomes longer. However, Figure III also allows us to verify that the excess returns are not simply the result of outperformance during a particular time period.

## 5 Excess returns and volatility

Having established the robustness of the buyback anomaly we turn to the second question of this paper: are the buyback anomaly and the volatility anomaly related? One of the most puzzling findings in the large literature on volatility and stock returns<sup>11</sup> is the fact that total volatility and idiosyncratic volatility (measured by residual variance which is highly correlated with total volatility, e.g., 97.59% in this study) are negatively correlated with future abnormal returns, when expected returns are calculated using the 3-factor Fama and French (1993) model [see e.g., Ang et al. (2006) (Table VII)]. Fama and French (2016) find that this volatility anomaly also survives after using the Fama and French (2015) 5-factor model, at least for small firms. Perhaps the buyback and the volatility anomaly are related: are the buyback firms with the largest excess returns also firms with the smallest volatility? Or can we make arguments that the opposite is true, if we accept a key proposition of this paper, i.e. that excess returns are related to the fact that managers are on average successful in taking advantage of an undervalued stock price? In this paper we will consider a number of theories that predict relations between volatility and returns: first, the costly arbitrage hypothesis of Stambaugh et al. (2015) and second, two hypotheses predicted by market timing: the Ikenberry and Vermaelen (1996) options hypothesis and the information advantage hypothesis.

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<sup>11</sup>For the most recent overview of the literature and potential hypotheses, see Li, Sullivan, and Garcia-Feijoo (2016).

## 5.1 Costly arbitrage and volatility

Stambaugh et al. (2015) argue that anomalies are more likely to survive for stocks with higher idiosyncratic volatility as arbitraging the anomaly becomes costlier. Their theory predicts (1) a positive relation between idiosyncratic volatility and stock returns for undervaluation anomalies (such as the buyback anomaly) and (2) a negative relation between idiosyncratic volatility and stock returns for overvaluation anomalies (such as the equity issue anomaly). Their hypothesis also predicts that (3) overvaluation anomalies will persist longer than undervaluation anomalies as selling short is difficult and costly. Note that the results in Tables II and IV are inconsistent with the last hypothesis: the buyback anomaly persists but the equity anomaly does not.

Stambaugh et al. (2015) argue that idiosyncratic volatility, and not total volatility, should be positively related to future returns for undervalued stocks. However, the empirical fact is that their estimate of idiosyncratic volatility (residual variance) is highly correlated (97.59%) with total volatility. Their argument is that idiosyncratic volatility represents risk that deters arbitrage and therefore creates mispricing. Using a proxy for mispricing based on 11 anomalies they find indeed a positive relation between residual variance and future returns for undervalued stocks. But considering the very high correlation between residual variance and total variance, their prediction can also be tested by using total volatility.

For each event we measure the pre-announce returns volatility with the standard deviation of their daily stock returns over the 6 months prior to the buyback announcement. We define two types of events: “low volatility” and “high volatility” events, depending on whether volatility was in the top or bottom 20% of the volatilities of all CRSP companies before the event. In total we have 2,266 “high volatility” buybacks-events and 2,266 “low volatility” ones. In the smaller equity issue sample 804 events are classified as high and low volatility.

Starting with equity issues, Table VI shows that, using the IRATS methodology, there is a positive relation between volatility and returns: the issuers with the lowest volatility

tend be followed by significant negative returns and this result is independent of the factor model used. Issuers with high volatility are followed by significantly positive long-term excess returns, again independent of the factor model used. This is the opposite of the prediction of the costly arbitrage hypothesis. However, this result is not robust: when we move to the calendar time method the relation between volatility and returns disappears.

Moving on to buybacks, Table VI also shows a strong positive relation between volatility and excess returns independent of the factor model used. For example, using IRATS and the five factor model the cumulative average abnormal return is only 1.54% ( $t=1.06$ ) after 48 months in the low volatility sample and 38.56% ( $t=11.99$ ) in the high volatility sample. This time the calendar time method confirms the IRATS result: insignificant monthly excess returns of 0.09% ( $t=1.22$ ) in the low volatility sample versus significant positive monthly excess returns of 0.58% ( $t=3.22$ ) in the high volatility sample.

## 5.2 Market timing and volatility

In this paper we argue that the market timing hypothesis, the fundamental hypothesis behind the buyback anomaly, also predicts a positive relation between excess returns and volatility. The announcement of a buyback program is not a firm commitment, but an option to buy back stock. Ikenberry and Vermaelen (1996) model this flexibility as an exchange option in which the market price of the stock is exchanged for the true value of the stock. They predict that, as with all options, the value increases with the volatility. The intuition is that the larger the volatility, the larger the probability that the market price may deviate from the true value. This enhances the timing ability of the manager-insider. They show that this option can have large value, something that may not be realized at the time of the announcement of the buyback authorization. For example, the market may underestimate the maturity of the option if they do not realize that firms who are announcing a buyback authorization for say 2 years are likely to renew the authorization many times in the future. Hence the option hypothesis predicts that excess returns are positively correlated with volatility, which

is consistent with the results in Table VI.

Moreover, this market timing hypothesis assumes that that firms may have superior *company-specific* information. Such situations are more likely in industries or companies where the volatility is largely driven by company-specific volatility. So if buybacks are driven by market timing this superior information hypothesis predicts that there should be a positive relation between excess returns and the percentage of the volatility explained by company-specific factors, which we define as *standardized* idiosyncratic volatility, however not to be confused with residual variance. Unlike residual variance, this measure is little correlated with total volatility (24.20% in this study) and measures more precisely the fraction of total volatility explained by company-specific news.

This standardized volatility is defined as  $1 - R^2$ , where  $R^2$  is estimated with the five-factor regression using 6-months daily returns just before the event announcement.<sup>12</sup> We define two types of events: “low idiosyncratic” (high  $R^2$ ) and “high idiosyncratic” (low  $R^2$ ) events, depending on whether the five-factor regression  $R^2$  was in the top or bottom 20% of the  $R^2$  of all CRSP companies. The healthcare industry has the largest percentage of firms classified as “high idiosyncratic”, while cyclical industries such as steel, construction and chemicals contain a large number of “low idiosyncratic” firms.<sup>13</sup>

Table VII shows the IRATS and Calendar Time abnormal returns for high and low idiosyncratic risk events-companies, both for buybacks and equity issues. Focusing on buybacks and IRATS, after 48 months high idiosyncratic buyback stocks earn 30.43% ( $t = 11.07$ ) when we use the five factor model and 36.04% ( $t = 12.80$ ) when we use the four factor model. When we use the five factor model low idiosyncratic risk announcements are not followed by significant excess returns. Although the four factor model does show significant 48-month excess returns of 10.83% ( $t=5.67$ ) after low idiosyncratic risk events, the excess returns are more than 3 times smaller than for high idiosyncratic risk firms. The results

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<sup>12</sup>Using shorter time windows, e.g., 1 month, or the four factor regression leads to the same conclusions - results available upon request.

<sup>13</sup>Estimates of idiosyncratic volatility for a range of industries are available upon request.

using the Calendar Time method confirm these findings: only buybacks announced by firms with high idiosyncratic risk are followed by significant long-term excess returns, both for the five and four factor model. Hence the combined results of Table VI and VII are consistent with the hypothesis that market timing is driving long-term excess returns.

Turning to equity issues, we now find that firms with low idiosyncratic risk, i.e. firms largely driven by common factors, earn significant positive long-term excess returns and this conclusion holds for both the IRATs and the Calendar Time method, but only with the 4 factor model. Firms with high company specific risk earn no significant positive or negative long-run excess returns. While consistent with the view that managers in firms with higher idiosyncratic risk are better able to avoid selling undervalued stock, it does not correspond with the classic market timing story, i.e. that managers issue overvalued stock. In summary, throughout all equity issues results we only find significant negative long-term excess returns when low volatility companies issue equity, and only with the IRATS method (Table IV).

### **5.3 Measuring Mispricing for Buyback stocks: the Enhanced U-index**

Table VIII shows how the high/low U-index high/low idiosyncratic risk, high/low volatility, and high/low MM buyback events overlap, while Table IX shows the correlations between the idiosyncratic risk, volatility, MM, and U-index scores. Overall we see that although high U-index firms tend to have high standardized idiosyncratic risk and high volatility, while high idiosyncratic risk firms tend to also have high volatility, the overlap is not very high. For example from Table VIII we see that only 36.20% of the high volatility stocks that are classified as having either high or low standardized idiosyncratic risk - note that we only consider the 20% tails - have high standardized idiosyncratic risk. From Table IX we also infer that the correlation between standardized idiosyncratic risk and volatility scores is only 30.80%. We also see that the Mispricing Measure of Stambaugh et al. (2015) is not related to the other measures in the case of buybacks

Based on these results, a natural question is whether one can further enhance the Peyer and Vermaelen (2009) U-index by incorporating information about the firms’ pre-announce standardized idiosyncratic risk and volatility. We consider one such combination where we simply take an equal-weighted combination of the 4 criteria into one “Enhanced Undervaluation Index” (EU-index). Specifically, in the spirit of the U-index of Peyer and Vermaelen (2009), we calculate the EU-index simply as the sum of three numbers: high U-index firms get a score of 2, low get a 0; high idiosyncratic firms get a score of 2, low get a 0; and high volatility firms get a score of 2, low get a 0. Firms that get neither 0 nor 2 (hence are in the middle of the range) get a score of 1 for each of these 3 scores.

Figure IV shows the distribution of the EU-index. The index has a symmetric distribution with a mean of 3.06. Table X shows how the EU-index relates to a number of firm characteristics. Firm leverage, based on data the year before announcement, is defined as the ratio  $debt/(debt + equity)$ .<sup>14</sup> “ISS later” measures the percentage of firms that announced an equity issue within 48 months after the buyback announcement. Next, we measure the percentage of buybacks financed with cash (CASH) when the data is available (this data was available only for 7,858 of the events) and whether the reported purpose (available only for 8,366 events) included the term “Undervalued”, or “Enhance Shareholder Value” or “stock option plan”.

First there is a striking negative relation between the EU index and financial leverage. This makes sense according to the static trade-off theory of optimal capital structure: high risky firms have more financial distress and should have less debt. High EU index firms are also more likely to mention “undervaluation” as a motivation for the buyback and to use cash. This could of course be related to the fact that risky firms should have more cash

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<sup>14</sup>We use the definitions from [http://www.ivo-welch.info/professional/leverage.placebo/Ivo Welch’s website following http://www.ivo-welch.info/professional/leverage.placebo/r-sourcecode/mksane.R](http://www.ivo-welch.info/professional/leverage.placebo/IvoWelch%20website%20following%20http://www.ivo-welch.info/professional/leverage.placebo/r-sourcecode/mksane.R). Debt is the sum of the Compustat variables  $dlc + dltd$ , where  $dlc$  is “Debt in Current Liabilities” and  $dltd$  is “Long Term Debt - Total”. Equity is the Compustat variable  $seq$  which is “Total Parent Stockholders’ Equity”. We use the most recent data pre-announce, and make the winsorization and other adjustments as in the websites above. Note that we followed the same steps as in these websites to handle negative book value of equity (in the BE/ME calculations) and any other Compustat data issues.

holdings. They also tend to follow up more often with equity offerings after the buyback which suggests that they are more likely to be in the “market timing” business. Note that none of these firm characteristics has been used to define the EU-Index.

The table also shows a strong negative relation between market-to-book ratios and market capitalization and the EU index, which is not surprising as these are components of the index. It should be noted that the EU6 portfolio (consisting of all firms with EU index equal to 6) is composed of very small stocks with an average market capitalization of \$125.30 million. The average market capitalization of portfolios with long term (after 48 months) monthly excess return of larger than 0.5% (i.e. portfolios EU5 - EU6 in Table XII) is \$198.50 million (not indicated in the Table). So indeed the buyback anomaly is to large extent a small cap anomaly.

Tables XI and XII show respectively the IRATS and Calendar Time monthly abnormal returns for all values of the EU-index using the five factor model.<sup>15</sup> Focusing on IRATS, as the EU-index increases, the long term (48 months) abnormal returns increase (from 1.14% to 70.55%). Figure V show the same results over time for each EU-index. Long-term cumulative excess returns after 48 months are becoming statistically significantly positive at EU-index levels of 3 and higher, and then steadily increase from 6.59% to 70.55%. The Calendar Time results in Table XII are similar although they only show significance starting at EU-index levels of 5. Investing in the very high EU index firms (EU=6) generates alphas of 0.86% per month for 48 months.<sup>16</sup>

The bottom line is that combining volatility, standardized idiosyncratic risk and the U-index in one EU-index generates a more selective predictor of excess returns than each of the indicators separately.

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<sup>15</sup>The results using the four factor model are similar and are available upon request.

<sup>16</sup>We also calculated the returns of a hedged strategy similar to Figure III (Panel B). Starting in 1985 we form a portfolio of all stocks that announced a buyback during the previous  $N$  months and hold the stock for  $N$  months. The 12-month holding period high EU-index portfolio has average annual excess returns of 4.50%, while the low EU-index one earns only 2.50% annual excess returns. For the 48-month holding periods the high and low EU-index portfolio earn annual excess returns of respectively, 5.70% and 1.90%.



## 5.4 Robustness of the EU-index over Time

As volatility and standardized idiosyncratic risk are time dependent, the performance of the new EU-index may not be robust over time - e.g., relative to the U-index of Peyer and Vermaelen (2009). Tables XIII (IRATS) and XIV (Calendar Time method) show the relative performance of high and low EU-index repurchases. We define low EU-index firms to be those for which the EU-index is 0-3, and high for which it is 4-6 (the index takes values from 0 to 6). With this definition we have 7,471 low EU-index and 3,856 high EU-index firms in our sample.

Tables XIII and XIV indicate that the EU-index is robust over time, with the exception of the 1985-1990 period. However during this period our high EU index sample only contains 187 observations which results in statistically insignificant excess returns.

## 5.5 Mispricing measure versus EU-index

Both the EU index and the Mispricing Measure (MM) developed by Stambaugh et al. (2015) are measures of mispricing. The EU index is specific for firms that announce buybacks while the MM is developed for all firms. An interesting question is whether these two measures are substitutes in the case of firms that announce share repurchases. Specifically, will sorting buyback event firms on the basis of their MM also generate larger excess returns for low MM (undervalued) firms than high MM (overvalued) firms? And will this sort improve the EU-index classification? Note from Tables VIII and IX that the MM is not related to the other measures used as elements of the EU-index.

Table XV Panel A compares long-term excess returns for high and low EU firms and MM firms using the five factor model.<sup>17</sup> Low MM firms, which are undervalued based on that measure, earn smaller excess returns than high MM firms, which demonstrates that the Mispricing Measure may work well for the average firm but not for buyback stocks.

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<sup>17</sup>Results (available upon request) are similar for the four factor model.

It also may explain why investors fail to respond to buyback announcements if the stocks have characteristics that are normally associated with overvalued stocks (such as negative momentum). Panel B considers four samples: (1) low MM/low EU firms, (2) low MM/high EU firms, (3) high MM/low EU firms and finally (4) high MM/high EU firms. Comparing these samples with the samples in Panel A shows that adding the Mispricing Measure does not improve the predictability of the EU index in any consistent way. For example, while the high MM/low EU sample does worse (-1.50%) than the low EU sample by itself (5.10%), investing in low MM/high EU stocks generates lower long-term 48-month excess returns (20.73%) than simply buying high EU stocks (27.78%). The low MM/low EU sample generates basically the same excess returns (5.70%) as the low EU sample by itself (5.10%). So, adding the Mispricing Measure of Stambaugh et al. (2015) does not help forecasting long-term excess returns after buyback announcements.

## 6 Conclusion

The buyback anomaly first reported by Ikenberry et al. (1995) is still present and robust. Long term excess returns are large, highly statistically significant and robust even when we replace the Fama-French three-factor model with the Fama-French five-factor model and the Stambaugh-Yuan four factor model. However, both models eliminate the equity issue anomaly, i.e. the finding of Loughran and Ritter (1995) that equity issues are followed by long-term negative excess returns. Our results also show that pooling buybacks and equity issues in a "net issuance" anomaly can be strongly misleading. A buyback is not simply the inverse of an equity issue, especially in a world with asymmetric information. Managers who buy back undervalued stock from selling investors benefit their long-term shareholders at the expense of selling shareholders who are "leaving" the company. Issuing overvalued stock hurts new investors and therefore may not be in the interest of long-term shareholder value. Moreover buyback authorizations are options, not firm commitments such as equity issues.

Using net issues as a measure of (negative) buyback activity ignores the reality that an actual repurchase may occur several months, if not years after a buyback authorization. By the time the buyback is completed the firm may already have experienced significant excess returns. Finally, market timing is relatively easier in an open market repurchase setting as the seller is not aware that he is selling to the corporation.

We also find that both standardized idiosyncratic risk (small  $R^2$ ) and total risk are positively correlated with future returns. This result is consistent with the hypothesis that buybacks are driven by market timing: a buyback authorization creates an option to take advantage of an undervalued stock, and options on high volatility stocks are more valuable. Moreover, managers are more likely to have superior information when stock prices are driven by company-specific events. We combine these characteristics with the Undervaluation Index developed by Peyer and Vermaelen (2009) in a new measure of the likelihood that the buyback is driven by undervaluation: the EU index or Enhanced Undervaluation Index. Investing in very high EU index firms generates excess returns of 0.86% per month during the 48 months after the buyback announcement. However investing in high EU index firms implies investing in small caps and micro-caps, which may explain partially why the anomaly persists as these firms may not satisfy, for example, liquidity risk constraints of many funds. Finally, we find that the Misvaluation Measure of Stambaugh et al. (2015) is neither correlated with the buyback specific measures of undervaluation (e.g. the EU-index) nor can be used to better forecast post buyback announcement long term excess returns. This provides further evidence that the buyback anomaly may be different from the other anomalies.

## Appendix: Variable Definitions

**BE/ME:** Ratio of the book value of equity to the market value of equity. Book value of equity is calculated using the following CCM variables: SEQ, CEQ, PSTK, PSTKRV, TXDITC, PRBA, DLC, DLTT, AT, LT. We follow Fama and French (2001). Market value of equity is calculated as the price per share multiplied by the number of shares outstanding: CCM and CRSP Monthly Stocks.

**EU-index:** The EU-Index of a repurchase firm is the sum of 3 indicators measured using firms characteristics scores the month before the repurchase announcement: the U-index, plus a score of 0, 1, 2 for low, middle, and high firms in terms of their volatility and standardized idiosyncratic volatility ( $1 - R^2$ ) the month before the announcement.

**Mispricing Measure:** The Stambaugh et al. (2015) mispricing measure the month of the repurchase or SEO announcement, taken from [http://users.cla.umn.edu/~jianfeng/Misp\\_Score.csv](http://users.cla.umn.edu/~jianfeng/Misp_Score.csv). The higher the value, the greater the relative degree of overpricing of the firm.

**Leverage:** The ratio  $debt/(debt + equity)$ . Debt is the sum of the Compustat variables DLC+ DLTT. Equity is the Compustat variable SEQ. We make the winsorization and other data adjustments as in <http://www.ivo-welch.info/professional/leverage.placebo/>.

**Market Cap.:** Market value of equity, calculated as the price per share multiplied by the number of shares outstanding: CRSP Monthly Stocks.

**Percent Shares:** The percentage of shares authorized for repurchase in the case of buybacks, or issued for the case of issuers: SDC Database.

**Prior Returns:** Cumulative return for the previous 6 months: CRSP Daily Stocks.

**Standardized Idiosyncratic Vol. ( $1 - R^2$ ):** The  $R^2$  of the Fama and French (2015) five factor model using returns over the previous 6 months: CRSP Daily Stocks and Kenneth French's Website.

**U-index:** Based on Peyer and Vermaelen (2009), the U-Index of a repurchase firm is the sum

of 3 indicators measured using firms characteristics scores the month before the repurchase announcement: 0, 1, 2 for low, middle, and high firms in terms of their size (2 is for large firms, 0 for small, and 1 for others), BE/ME (2 is for large BE/ME), and returns over the 6 months before the announcement (2 is for low returns).

**Volatility:** Standard deviation of daily returns over the previous 6 months: CRSP Daily Stocks.

**Table I** Buyback and SEO announcements during 1985-2015: Descriptive Statistics

This table reports descriptive statistics of our samples. Panel A is for repurchases and Panel B for SEOs. All variables are described in the Appendix.

## Panel A: Buybacks

	Mean	Median	Standard Dev.	\$20 <sup>th</sup> \$ Percentile	\$80 <sup>th</sup> \$ Percentile
Market Cap.	6204.62	859.75	21306.61	157.89	4973.3
Prior Returns	-3.95	-0.9	29.68	-24.66	17.72
BE/ME	0.58	0.47	0.44	0.26	0.83
Volatility	2.82	2.44	1.47	1.63	3.81
\$(1-R^2)\$	0.24	0.21	0.17	0.08	0.39
U-index	8.26	8	2.5	6	10
EU-index	3.06	3	1.31	2	4
Mispricing Measure	45.28	44.38	12.71	34.45	55.79
Percent Shares	7.24	5.82	5.31	3.33	10.1
Leverage	0.48	0.48	0.22	0.26	0.68
Observations	11327	11327	11327	11327	11327

## Panel B: SEOs

	Mean	Median	Standard Dev.	\$20 <sup>th</sup> \$ Percentile	\$80 <sup>th</sup> \$ Percentile
Market Cap.	1117.14	303	7369.83	107.68	916.34
Prior Returns	47.82	41.21	47.4	14.02	77.75
BE/ME	0.33	0.24	0.38	0.1	0.47
Volatility	4.05	3.64	2	2.61	5.09
\$(1-R^2)\$	0.17	0.13	0.13	0.06	0.25
Mispricing Measure	53.15	53.23	13.07	41.8	64.2
Percent Shares	17.14	16.02	8.28	10.23	23.37
Leverage	0.48	0.48	0.25	0.23	0.7
Observations	4021	4021	4021	4021	4021

**Table II** Buyback announcements during 1985-2015

The table presents the abnormal returns for firms after open market repurchase announcements from the announcement date until  $t$  months after announcement. We include a version of the abnormal returns for the full sample and one for both companies with a high U-index and a low U-index. Panel A reports monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Stambaugh and Yuan (2016) four-factor model (4F) and the Fama and French (2015) five-factor model (5F) for the sample of firms that announced an open market share repurchase plus various subsamples. The following regressions are run each event month  $j$ :

$$\begin{aligned}(R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB'_t + d_jMGMT_t + e_tPERF_t + \epsilon_{i,t}, \\ (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},\end{aligned}$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the repurchase announcement.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively.  $SMB'_t$ ,  $MGMT_t$ ,  $PERF_t$  are the Stambaugh and Yuan (2016) factors Size, Management Related (MGMT), and Performance Related (PERF), respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. Panel B reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios using the Fama and French (2015) five-factor model. In this method, event firms that have announced an open market buyback in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of the Stambaugh and Yuan (2016) four factors (4F) or the Fama and French (2015) five factors (5F) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

**Panel A: IRATs Cumulative Abnormal Returns**

	All 4F		All 5F		High U-index 4F		Low U-index 4F		High U-index 5F		Low U-index 5F	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-5.65**	-18.85	-6.71**	-23.72	-25.89**	-35.32	20.05**	24.33	-27.57**	-40.55	20.11**	25.74
+12	5.03**	10.86	2.74**	6.13	4.66**	3.5	4.54**	4.4	2.72*	2.12	2.88**	2.88
+24	10.02**	14.26	6.47**	9.49	16.12**	7.8	8.41**	5.49	13.8**	6.86	4.33**	2.9
+36	15.52**	17.65	10.38**	12.11	24.48**	9.34	13.53**	7.1	22.26**	8.7	7.52**	4.04
+48	20.44**	19.67	12.89**	12.7	35.03**	11.19	19.69**	8.77	29.99**	9.76	10.7**	4.86
Observations	11327		11327		2240		1564		2240		1564	

**Panel B: Calendar Time Method Monthly Abnormal Returns**

	All 4F		All 5F		High U-index 4F		Low U-index 4F		High U-index 5F		Low U-index 5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	-0.81**	-8.23	-0.97**	-10.41	-4.18**	-17.08	3.22**	17.4	-4.5**	-18.95	3.13**	17.78
+12	0.36**	3.83	0.24**	2.73	0.3+	1.7	0.45**	3.7	0.22	1.38	0.36**	3.26
+24	0.33**	3.64	0.23**	2.89	0.4*	2.52	0.38**	3.56	0.34*	2.31	0.24*	2.47
+36	0.32**	3.74	0.22**	2.97	0.45**	3.08	0.34**	3.32	0.41**	3.01	0.22*	2.28
+48	0.31**	3.73	0.21**	2.85	0.53**	3.63	0.35**	3.36	0.46**	3.4	0.21*	2.21
Observations	11327		11327		2240		1564		2240		1564	

**Table III** Buyback announcements during 1985-2015: Value Weighted Portfolios

The table presents the abnormal returns for firms after open market repurchase announcements from the announcement date until  $t$  months after announcement. The table reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios using the Stambaugh and Yuan (2016) four-factor model (4F) and the Fama and French (2015) five-factor model (5F). In this method, event firms that have announced an open market buyback in the last calendar months form the basis of the calendar month value weighted portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of the Stambaugh and Yuan (2016) four factors (4F) or the Fama and French (2015) five factors (5F) as the independent variables. Panel B uses only firms which at the month prior to the repurchase announcement were in the bottom 75<sup>th</sup> percentile of all public firms reported in CRSP in terms of their market capitalization. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

**Panel A: Calendar Method Monthly Value Weighted Abnormal Returns**

	All 4F		All 5F		High U-index 4F		Low U-index 4F		High U-index 5F		Low U-index 5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	0.12	1.18	0.06	0.66	-4.28**	-15.76	2.11**	11.53	-4.65**	-17.5	2.18**	12.46
+12	0.23*	2.36	0.09	0.99	0.03	0.09	0.16	1.21	-0.06	-0.22	0.15	1.25
+24	0.13	1.52	0.01	0.16	0.33	1.33	0.13	1.1	0.19	0.8	0.06	0.62
+36	0.14 <sup>+</sup>	1.71	0.02	0.33	0.28	1.31	0.15	1.44	0.15	0.77	0.09	0.94
+48	0.11	1.41	0.01	0.09	0.31	1.59	0.13	1.31	0.18	0.97	0.07	0.76
Observations	11327		11327		2240		1564		2240		1564	

**Panel B: Calendar Method Monthly Value Weighted Abnormal Returns, No Large Firms**

	All 4F		All 5F		High U-index 4F		Low U-index 4F		High U-index 5F		Low U-index 5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	-1.18**	-7.17	-1.35**	-8.52	-5.89**	-13.12	3.09**	9.81	-6.33**	-14.33	3**	9.85
+12	0.25 <sup>+</sup>	1.9	0.17	1.39	0.35	0.96	0.68**	2.89	0.27	0.79	0.6**	2.68
+24	0.23 <sup>+</sup>	1.91	0.16	1.51	0.26	0.95	0.4 <sup>+</sup>	1.81	0.32	1.23	0.35 <sup>+</sup>	1.73
+36	0.24*	2.16	0.18 <sup>+</sup>	1.9	0.44 <sup>+</sup>	1.81	0.39 <sup>+</sup>	1.85	0.43 <sup>+</sup>	1.87	0.38 <sup>+</sup>	1.93
+48	0.26*	2.42	0.2*	2.07	0.54*	2.48	0.38 <sup>+</sup>	1.89	0.5*	2.42	0.33 <sup>+</sup>	1.78
Observations	5385		5385		663		939		663		939	



**Table IV** SEO announcements during 1985-2015

The table presents the abnormal returns for firms after issue announcements from the announcement date until  $t$  months after the announcement. We include a version of the abnormal returns for the full sample and one for both companies with high low Mispricing Measure (MM) before the announcement. Panel A reports monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Stambaugh and Yuan (2016) four-factor model (4F) and the Fama and French (2015) five-factor model (5F) for the sample of firms that announced equity issuance plus various subsamples. The following regressions are run each event month  $j$ :

$$\begin{aligned} (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB'_t + d_jMGMT_t + e_tPERF_t + \epsilon_{i,t}, \\ (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t}, \end{aligned}$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the equity issuance.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively.  $SMB'_t$ ,  $MGMT_t$ ,  $PERF_t$  are the Stambaugh and Yuan (2016) factors Size, Management Related (MGMT), and Performance Related (PERF), respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. Panel B reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios. In this method, event firms that have announced an equity issuance in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of the Stambaugh and Yuan (2016) four factors (4F) or the Fama and French (2015) five factors (5F) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

<b>Panel A: IRATs Cumulative Abnormal Returns</b>												
	All 4F		All 5F		Low MM 4F		Low MM 5F		High MM 4F		High MM 5F	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	35.63**	36.68	37.54**	40.37	47.9**	21.39	48.87**	23.29	23.4**	9.72	26.24**	11.26
+12	3.61**	3.44	2.12*	2.12	5.09*	2	3.8	1.58	1.78	0.62	1.37	0.5
+24	4.22**	2.75	-2.24	-1.53	11.51**	3.18	5.01	1.46	-1.52	-0.36	-4.01	-0.98
+36	5.62**	2.88	-4.4*	-2.36	13.99**	3.12	4.21	0.99	-0.51	-0.09	-7.93	-1.5
+48	12.66**	5.24	1.14	0.49	17.16**	3.21	5.75	1.13	13.28+	1.93	2.53	0.38
Observations	4021		4021		583		583		583		583	

<b>Panel B: Calendar Method Monthly Abnormal Returns</b>												
	All 4F		All 5F		Low MM 4F		Low MM 5F		High MM 4F		High MM 5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	5.47**	20.84	5.72**	24.16	2.51**	10.48	2.48**	11.19	10.04**	11.97	10.18**	13.1
+12	0.42*	2.39	0.25	1.5	0.2	0.94	0.12	0.61	0.05	0.1	-0.07	-0.16
+24	0.24+	1.67	-0.02	-0.11	0.1	0.58	-0.06	-0.41	-0.02	-0.06	-0.17	-0.46
+36	0.23	1.61	-0.03	-0.19	0.08	0.51	-0.1	-0.76	0.01	0.03	-0.01	-0.02
+48	0.27+	1.81	0.04	0.27	-0.01	-0.06	-0.18	-1.38	0.15	0.43	0.17	0.59
Observations	4021		4021		804		804		804		804	

**Table V** Buyback returns over different time periods

The table presents the long-run abnormal returns for firms after repurchase announcements for different time periods. Panel A reports monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Fama and French (2015) five-factor model for the sample of firms that announced an open market share repurchase plus various subsamples. The following regression is run each event month  $j$ :

$$(R_{i,t} - R_{f,t}) = a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the repurchase announcement.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. Panel B reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios using the Fama and French (2015) five-factor model. In this method, event firms that have announced an open market buyback in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of five factors as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

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**Panel A: IRATs Cumulative Abnormal Returns**


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	1985-1990		1991-2000		2001-2015		2008-2015	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-3.62**	-3.61	-11.58**	-22.63	-2.23**	-6	-2.42**	-4.99
+12	5.89**	3.93	4.25**	4.85	3.73**	7.15	4.95**	6.7
+24	6.8**	2.67	10.48**	7.9	7.84**	10.07	9.13**	8.6
+36	5.34+	1.76	17.01**	10.28	11.03**	11.18	13.17**	9.84
+48	12.02**	3.25	20.56**	10.74	13.45**	11.17	14.67**	8.99
Observations	809		4657		5861		2939	

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**Panel B: Calendar Method Monthly Abnormal Returns**


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	1985-1990		1991-2000		2001-2015		2008-2015	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	-0.86**	-3.99	-1.84**	-9.75	-0.4**	-3.6	-0.45**	-3.8
+12	0.29	1.65	0.24	1.24	0.39**	3.96	0.38**	3.04
+24	0.15	0.89	0.11	0.59	0.42**	4.14	0.4**	3.37
+36	0.07	0.49	0.22	1.46	0.42**	4.08	0.41**	3.6
+48	0.21+	1.78	0.16	1.13	0.39**	3.81	0.41**	3.59
Observations	809		4657		5861		2939	

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**Table VI** Buyback and SEOs for Low and High Volatility companies

This table presents the long-term abnormal return after open market repurchase (first 4 columns) and equity issuance (last 4 columns) announcements from the announcement date until  $t$  months after, for low and high volatility companies. Panel A reports monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Stambaugh and Yuan (2016) four-factor model (4F) and the Fama and French (2015) five-factor model (5F). The following regressions are run each event month  $j$ :

$$\begin{aligned} (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB'_t + d_jMGMT_t + e_tPERF_t + \epsilon_{i,t}, \\ (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t}, \end{aligned}$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the event (repurchase or equity issuance).  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively.  $SMB'_t$ ,  $MGMT_t$ ,  $PERF_t$  are the Stambaugh and Yuan (2016) factors Size, Management Related (MGMT), and Performance Related (PERF), respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. Panel B reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios. In this method, event firms that have announced a repurchase (first 4 columns) or an equity issuance (last 4 columns) in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of the Stambaugh and Yuan (2016) four factors (4F) or the Fama and French (2015) five factors (5F) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

**Panel A: IRATs Cumulative Abnormal Returns**

	Buyback: Low Vol. 4F		5F		High Vol. 4F		5F		SEOs: Low Vol. 4F		5F		High Vol. 4F		5F	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-1.01**	-3.02	-1.09**	-3.48	-10.67**	-10.34	-13.65**	-13.93	16**	16.83	16.05**	17.86	63.85**	17.95	62.89**	18.16
+12	0.37	0.62	-0.89	-1.6	12.19**	8.05	8.51**	5.83	0.22	0.14	-1.03	-0.72	4.91 <sup>+</sup>	1.73	3.64	1.31
+24	0.53	0.55	-1.11	-1.22	23.87**	10.53	19.25**	8.74	-4.01 <sup>+</sup>	-1.74	-8.12**	-3.8	15.44**	3.62	8.9*	2.15
+36	3.04*	2.46	-0.04	-0.03	36.6**	13.08	30.91**	11.32	-8.53**	-2.87	-14.6**	-5.26	19.91**	3.7	13.39*	2.56
+48	5.78**	3.8	1.54	1.06	46.42**	14.18	38.56**	11.99	-13.53**	-3.7	-20.38**	-5.96	35.07**	4.97	28.09**	4.09
Observations	2266		2266		2266		2266		804		804		804		804	

**Panel B: Calendar Method Monthly Abnormal Returns**

	Buyback: Low Vol. 4F		5F		High Vol. 4F		5F		SEOs: Low Vol. 4F		5F		High Vol. 4F		5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	-0.13	-1.22	-0.12	-1.37	-1.91**	-5.84	-2.26**	-7	2.51**	10.48	2.48**	11.19	10.04**	11.97	10.18**	13.1
+12	0.13	1.22	0.05	0.54	0.74**	3.21	0.62**	2.82	0.2	0.94	0.12	0.61	0.05	0.1	-0.07	-0.16
+24	0.11	1.06	0.04	0.52	0.64**	3.08	0.57**	2.99	0.1	0.58	-0.06	-0.41	-0.02	-0.06	-0.17	-0.46
+36	0.17 <sup>+</sup>	1.74	0.08	1.05	0.6**	3.06	0.54**	3.03	0.08	0.51	-0.1	-0.76	0.01	0.03	-0.01	-0.02
+48	0.19 <sup>+</sup>	1.92	0.09	1.22	0.65**	3.36	0.58**	3.22	-0.01	-0.06	-0.18	-1.38	0.15	0.43	0.17	0.59
Observations	2266		2266		2266		2266		804		804		804		804	

**Table VII** Buyback and SEOs for Low and High Idiosyncratic companies

This table presents the long-term abnormal return after open market repurchase (first 4 columns) and equity issuance (last 4 columns) announcements from the announcement date until  $t$  months after, for low and high idiosyncratic companies. Panel A reports monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Stambaugh and Yuan (2016) four-factor model (4F) and the Fama and French (2015) five-factor model (5F). The following regressions are run each event month  $j$ :

$$\begin{aligned}(R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB'_t + d_jMGMT_t + e_tPERF_t + \epsilon_{i,t}, \\ (R_{i,t} - R_{f,t}) &= a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},\end{aligned}$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the event (repurchase or equity issuance).  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively.  $SMB'_t$ ,  $MGMT_t$ ,  $PERF_t$  are the Stambaugh and Yuan (2016) factors Size, Management Related (MGMT), and Performance Related (PERF), respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. Panel B reports monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios. In this method, event firms that have announced a repurchase (first 4 columns) or an equity issuance (last 4 columns) in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of the Stambaugh and Yuan (2016) four factors (4F) or the Fama and French (2015) five factors (5F) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

**Panel A: IRATs Cumulative Abnormal Returns**

	Buyback: Low Id. 4F		5F		High Id. 4F		5F		SEOs: Low Id. 4F		5F		High Id. 4F		5F	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-1.26*	-2.22	-3.03**	-5.63	-8**	-9.78	-9.9**	-12.96	32.26**	17.59	33.31**	19.62	47.73**	16.85	46.81**	17.17
+12	4.19**	4.75	0.49	0.58	5.41**	4.3	4.75**	3.91	9.74**	4.42	5.64**	2.68	1.28	0.52	1.57	0.67
+24	7.41**	5.62	2.45+	1.93	14.42**	7.62	13.12**	7.14	17.81**	5.42	5.81+	1.85	-1.71	-0.48	-3.69	-1.09
+36	10.56**	6.43	3.92*	2.47	25.41**	10.62	22.57**	9.7	15.76**	3.86	-0.05	-0.01	1.06	0.23	-3.11	-0.69
+48	10.83**	5.67	2.26	1.22	36.04**	12.8	30.43**	11.07	20.27**	4.15	2.46	0.53	8.85	1.44	6	1.02
Observations	2266		2266		2266		2266		804		804		804		804	

**Panel B: Calendar Method Monthly Abnormal Returns**

	Buyback: Low Id. 4F		5F		High Id. 4F		5F		SEOs: Low Id. 4F		5F		High Id. 4F		5F	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	-0.12	-0.79	-0.38*	-2.38	-1.22**	-5.12	-1.49**	-6.62	4.15**	9.88	4.37**	11.53	7.55**	12.74	7.37**	12.9
+12	0.38*	2.49	0.15	0.98	0.26+	1.65	0.22	1.47	0.9**	2.91	0.59+	1.95	-0.1	-0.38	-0.09	-0.35
+24	0.3*	2.15	0.15	1.11	0.4**	2.73	0.35**	2.7	0.71**	2.94	0.35	1.44	-0.08	-0.38	-0.15	-0.73
+36	0.25*	2.07	0.12	1.01	0.46**	3.35	0.4**	3.2	0.53*	2.42	0.17	0.76	0.02	0.1	-0.08	-0.46
+48	0.19+	1.7	0.06	0.59	0.5**	3.72	0.42**	3.44	0.5*	2.26	0.14	0.64	0.07	0.41	0.04	0.26
Observations	2266		2266		2266		2266		804		804		804		804	

**Table VIII** Relations across firm characteristics for Buybacks

Relation between Under/Overvaluation, High/Low Idiosyncratic Risk, High/Low volatility for buybacks. Numbers indicate percentage of firms in the row that are also categorized as noted in the columns.

	H Idiosync.	L Idiosync.	H Vol.	L Vol.
<b>High U-index</b>	42.8	5.6	38	5.7
<b>Low U-index</b>	7.9	27.8	11.9	29.2
<b>High Idiosync.</b>	100	0	36.2	9.7
<b>Low Idiosync.</b>	0	100	11.3	35.6
<b>High Vol.</b>	36.2	11.3	100	0
<b>Low Vol.</b>	9.7	35.6	0	100
<b>High Mispr.</b>	21.5	15.8	29.3	9.1
<b>Low Mispr.</b>	15.8	24.9	10.2	32.7

**Table IX** Correlations of Buybacks Characteristics

Correlation between the three buybacks characteristics considered: Idiosyncratic score (percentile across all CRSP companies of firm's  $1 - R^2$ , 0 to 1), Volatility score (percentile across all CRSP companies, 0 to 1), U-index score (0 to 15), and the Mispricing measure of Stambaugh et al. (2015). All scores are defined using the universe of all CRSP companies at the time of the announcement with data up to the month before the announcement.

	Idiosyncratic Score	Volatility Score	U-Index Score	Mispricing Measure
<b>Idiosyncratic Score</b>	1	0.31	0.37	-0.12
<b>Volatility Score</b>	0.31	1	0.32	-0.06
<b>U-Index Score</b>	0.37	0.32	1	0.03
<b>Mispricing Measure</b>	-0.12	-0.06	0.03	1

**Table X** EU relations with Firm Characteristics

Firm characteristics for each of the 7 EU-index samples. Percentages indicated for all but the last 3 rows, and averages for the last 3 rows. We consider firm *leverage*, based on data the year before announcement, defined as the ratio  $debt/(debt + equity)$ . *ISS later* measures the percentage of firms that announced an equity issue within 48 months after the buyback announcement. Next, we measure the percentage of buybacks financed with cash (*CASH*) when the data is available and whether the reported purpose included the term *Undervalued*, *Enhance Shareholder Value* or *stock option plan*. Market Cap. is in millions, BE/ME Score is from 1, for firms below the 4<sup>th</sup> Fama-French BE/ME breakpoint, to 5 for firms above the 16<sup>th</sup>. Percentage Shares is the percentage shares authorized at announcement.

	EU0	EU1	EU2	EU3	EU4	EU5	EU6
<b>Low Leverage</b>	1.7	5.4	10.8	19.4	29.4	33.9	36
<b>High Leverage</b>	31.8	31.1	26.8	18.9	14.1	11.5	9.5
<b>ISS Later</b>	6.7	3.9	5.1	6	6.3	6.8	8.1
<b>Cash</b>	6.1	5.4	5.3	6.5	6.7	8.3	7.4
<b>Undervalued</b>	0	1.3	1.5	3.1	4.5	6	8.3
<b>Enhance Shareholder Value</b>	14	14.8	19.6	19.1	17.8	17.8	15.2
<b>Stock Option Plan</b>	2.8	3.1	2.9	2.9	3.9	3.2	3.1
<b>Market Cap.</b>	30001.3	20719.6	10652.2	3386.2	1084	330.4	125.3
<b>BE/ME Score</b>	0.2	0.4	0.4	0.4	0.5	0.6	0.7
<b>Percentage Shares</b>	4.9	5.6	5.9	6.2	6.8	7.6	7.4
<b>Mispricing Measure</b>	36.1	39.4	42.1	46	48.2	51.7	54.4

**Table XI** Buyback announcements IRATS for all EU-index Values

IRATS five factor cumulative abnormal returns after open market repurchase announcements for each Enhanced Undervaluation Index value from 0 to 6. We calculate the EU-index simply as the sum of three numbers: high Peyer and Vermaelen (2009) U-index terms get a score of 2, low get a 0; high idiosyncratic terms get a score of 2, low get a 0; and high volatility terms get a score of 2, low get a 0. Firms that get neither 0 nor 2 (hence are in the middle of the range) get a score of 1 for each of these 3 scores. For each EU-index value, we report the monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Fama and French (2015) five-factor model for the sample of firms that announced an open market share repurchase plus various subsamples. The following regression is run each event month  $j$ :

$$(R_{i,t} - R_{f,t}) = a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the repurchase announcement.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors.

	EU-index 0		EU-index 1		EU-index 2		EU-index 3	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	9.52**	9.41	4.11**	7.71	1.73**	3.84	-6**	-12.89
+12	1.73	0.96	0.56	0.62	-0.27	-0.38	2.3**	3.06
+24	2.14	0.75	0.46	0.34	0.58	0.54	3.58**	3.14
+36	3.24	0.87	1.81	1.07	2.35+	1.71	5.25**	3.7
+48	1.14	0.26	1.88	0.92	3.11+	1.9	6.59**	3.91
Observations	179		1089		2546		3657	
	EU-index 4		EU-index 5		EU-index 6			
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-12.13**	-15.51	-20.64**	-18.67	-31.84**	-16		
+12	4.12**	3.57	5.85**	3.38	8.09+	1.92		
+24	10.17**	5.65	15.46**	5.67	29.52**	4.84		
+36	14.52**	6.43	25.69**	7.37	54.37**	7.11		
+48	15.32**	5.7	37.88**	8.87	70.55**	8.02		
Observations	2195		1241		420			

**Table XII** Buyback announcements Calendar Time for all EU-index Values

IRATS five factor cumulative abnormal returns after open market repurchase announcements for each Enhanced Undervaluation Index value from 0 to 6. We calculate the EU-index simply as the sum of three numbers: high Peyer and Vermaelen (2009) U-index terms get a score of 2, low get a 0; high idiosyncratic terms get a score of 2, low get a 0; and high volatility terms get a score of 2, low get a 0. Firms that get neither 0 nor 2 (hence are in the middle of the range) get a score of 1 for each of these 3 scores. For each EU-index value, we report the monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios using the Fama and French (2015) five-factor model. In this method, event firms that have announced an open market buyback in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of five factors (the difference between the risk-free rate and the return on the equally weighted CRSP index, the monthly return on the size, book-to-market factor, profitability factor and investment factor in month) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

	EU-index 0		EU-index 1		EU-index 2		EU-index 3	
	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat
-6	1.49**	6.68	0.8**	6.4	0.24*	2.1	-0.96**	-7.35
+12	0.16	0.92	0.09	1.02	0.12	1.14	0.16	1.35
+24	0.12	0.76	0.02	0.23	0.1	1.04	0.12	1.16
+36	0.12	0.76	0.03	0.46	0.1	1.09	0.09	0.93
+48	0.09	0.65	0.02	0.33	0.08	0.92	0.07	0.83
Observations	179		1089		2546		3657	
	EU-index 4		EU-index 5		EU-index 6			
	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat		
-6	-1.98**	-9.2	-3.12**	-9.76	-5.21**	-10.23		
+12	0.23	1.38	0.51*	2.18	0.3	0.88		
+24	0.2	1.45	0.43*	2.32	0.72*	2.53		
+36	0.2 <sup>+</sup>	1.67	0.49**	2.77	0.85**	3.24		
+48	0.17	1.39	0.62**	3.42	0.86**	3.44		
Observations	2195		1241		420			

**Table XIII** Long-run IRATS abnormal returns after open market repurchase announcements for low and high EU-index companies over different time periods.

Long-run abnormal returns five factor monthly abnormal returns after open market repurchase announcements for low and high Enhanced Undervaluation (EU) Index companies over different time periods. We define low EU-index firms those for which the EU-index is 0-3, and high for which it is 4-6 (note that the index takes values from 0 to 6). IRATS five factor cumulative abnormal returns after open market repurchase announcements for each EU-index value from 0 to 6. We calculate the EU-index simply as the sum of three numbers: high Peyer and Vermaelen (2009) U-index terms get a score of 2, low get a 0; high idiosyncratic terms get a score of 2, low get a 0; and high volatility terms get a score of 2, low get a 0. Firms that get neither 0 nor 2 (hence are in the middle of the range) get a score of 1 for each of these 3 scores. For each EU-index value, we report the monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Fama and French (2015) five-factor model for the sample of firms that announced an open market share repurchase plus various subsamples. The following regression is run each event month  $j$ :

$$(R_{i,t} - R_{f,t}) = a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},$$

where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the repurchase announcement.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors.

	1985-1990: High-EU		Low-EU		1991-2000: High-EU		Low-EU	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-19.43**	-6.92	0.71	0.72	-22.02**	-22.33	-5.17**	-9.29
+12	6.61	1.59	5.73**	3.78	9.73**	5.49	0.83	0.91
+24	3.77	0.58	6.8*	2.5	23.6**	8.67	2.37+	1.75
+36	1.07	0.13	5.24+	1.67	36.1**	10.67	5.13**	3.01
+48	16.62	1.51	9.29*	2.57	45.46**	11.56	5.41**	2.72
Observations	187		622		1784		2873	
	2001-2015: High-EU		Low-EU		2008-2015: High-EU		Low-EU	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-10.37**	-12.01	1.7**	4.71	-10.78**	-9.1	1.53**	3.54
+12	4.61**	4.04	3.27**	5.95	5.46**	3.33	4.57**	5.98
+24	12.13**	7.07	5.77**	7.07	10.89**	4.48	7.93**	7.42
+36	17.22**	7.87	8.09**	7.79	17.62**	5.66	10.74**	8
+48	20.1**	7.52	10.41**	8.17	21.08**	5.45	11.73**	7.19
Observations	1885		3976		954		1985	



**Table XIV** Calendar method monthly abnormal returns after open market repurchase announcements for low and high EU-index companies over different time periods.

Long-term monthly abnormal returns after open market repurchase announcements for low and high Enhanced Undervaluation (EU) Index companies over different time periods. We define low EU-index firms those for which the EU-index is 0-3, and high for which it is 4-6 (note that the index takes values from 0 to 6). We calculate the EU-index simply as the sum of three numbers: high Peyer and Vermaelen (2009) U-index terms get a score of 2, low get a 0; high idiosyncratic terms get a score of 2, low get a 0; and high volatility terms get a score of 2, low get a 0. Firms that get neither 0 nor 2 (hence are in the middle of the range) get a score of 1 for each of these 3 scores. For each EU-index value, we report the monthly average abnormal returns (AR) of equally weighted Calendar Time portfolios using the Fama and French (2015) five-factor model. In this method, event firms that have announced an open market buyback in the last calendar months form the basis of the calendar month portfolio. A single time-series regression is run with the excess returns of the calendar portfolio as the dependent variable and the returns of five factors (the difference between the risk-free rate and the return on the equally weighted CRSP index, the monthly return on the size, book-to-market factor, profitability factor and investment factor in month) as the independent variables. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

	1985-1990: High-EU		Low-EU		1991-2000: High-EU		Low-EU	
	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat
-6	-2.71**	-4.23	-0.24	-1.1	-3.57**	-11.32	-0.87**	-4.3
+12	0.15	0.37	0.32	1.46	0.48	1.44	0.1	0.52
+24	-0.19	-0.49	0.26	1.38	0.39	1.39	-0.09	-0.46
+36	-0.06	-0.19	0.1	0.67	0.58*	2.24	-0.02	-0.11
+48	0.41	1.51	0.14	1.15	0.54*	2.22	-0.1	-0.68
Observations	187		622		1784		2873	

	2001-2015: High-EU		Low-EU		2008-2015: High-EU		Low-EU	
	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat	AR	<i>t</i> -stat
-6	-1.82**	-7.38	0.28**	2.65	-1.92**	-7.07	0.27**	2.85
+12	0.53**	3.5	0.33**	3.38	0.45*	2.23	0.34**	2.96
+24	0.61**	4.22	0.34**	3.32	0.49**	2.69	0.35**	3.14
+36	0.6**	4.35	0.33**	3.24	0.52**	3.06	0.35**	3.17
+48	0.56**	4.19	0.31**	3.01	0.53**	3.26	0.34**	3.07
Observations	1885		3976		954		1985	

**Table XV** Buyback for Low and High EU-index and for Low and High Mispricing measure companies

This table presents the long-term abnormal return after open market repurchase announcements from the announcement date until  $t$  months after, for low and high EU-index and for low and Mispricing measure (of Stambaugh et al. (2015)) companies. Monthly cumulative average abnormal returns (CAR) in percent using Ibbotson (1975) returns across time and security (IRATS) method combined with the Fama and French (2015) five-factor model for the sample of firms that announced an open market share repurchase are reported. The following regression is run each event month  $j$ :

$$(R_{i,t} - R_{f,t}) = a_j + b_j(R_{m,t} - R_{f,t}) + c_jSMB_t + d_jHML_t + e_tRMW_t + f_tCMA_t + \epsilon_{i,t},$$

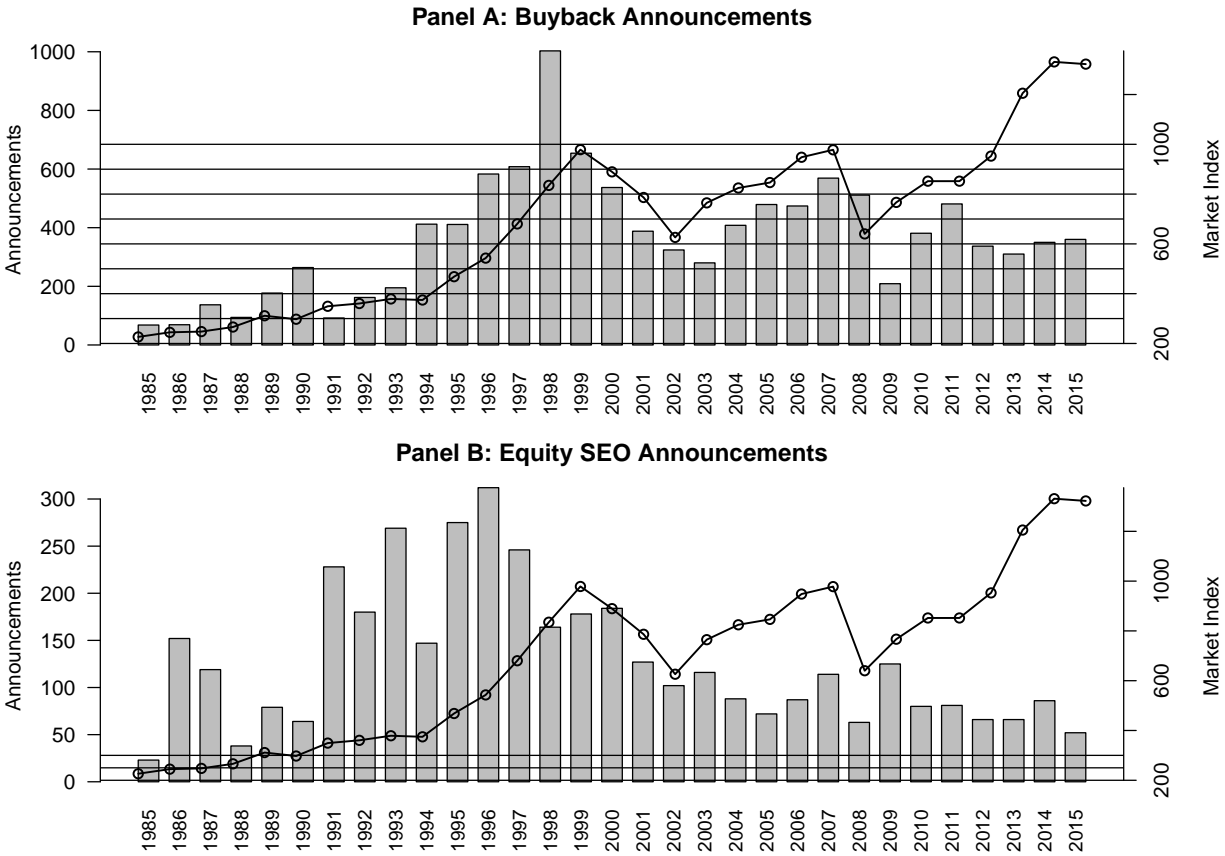
where  $R_{i,t}$  is the monthly return on security  $i$  in the calendar month  $t$  that corresponds to the event month  $j$ , with  $j = 0$  being the month of the repurchase announcement.  $R_{f,t}$  and  $R_{m,t}$  are the risk-free rate and the return on the equally weighted CRSP index, respectively.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ ,  $CMA_t$  are the monthly returns on the size, book-to-market factor, profitability factor and investment factor in month  $t$ , respectively. The numbers reported are sums of the intercepts of cross-sectional regressions over the relevant event-time-periods expressed in percentage terms. The standard error (denominator of the  $t$ -statistic) for a window is the square root of the sum of the squares of the monthly standard errors. The significance levels are indicated by +, \*, and \*\* and correspond to a significance level of 10%, 5%, and 1% respectively, using a two-tailed test.

**Panel A: IRATs Cumulative Abnormal Returns using single-sorting**

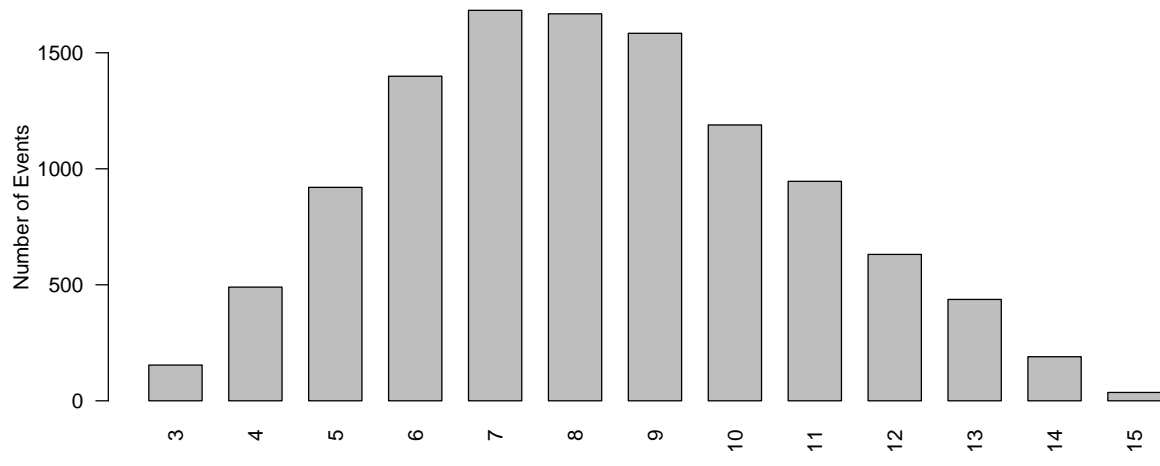
	Low EU		High EU		Low Mispr.		High Mispr.	
	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat	CAR	$t$ -stat
-6	-1.74**	-5.92	-17.02**	-27.9	3.92**	6.55	-17.81**	-21.96
+12	1.35**	2.87	5.08**	5.24	1.88*	2.16	0.42	0.33
+24	2.38**	3.34	13.94**	9.31	4.56**	3.47	5.68**	2.81
+36	4.08**	4.56	22.12**	11.71	8.33**	5.01	9.6**	3.83
+48	5.1**	4.8	27.78**	12.34	8.82**	4.54	12.18**	4.16
Observations	7292		3856		1918		1919	

**Panel B: IRATs Cumulative Abnormal Returns using double-sorting**

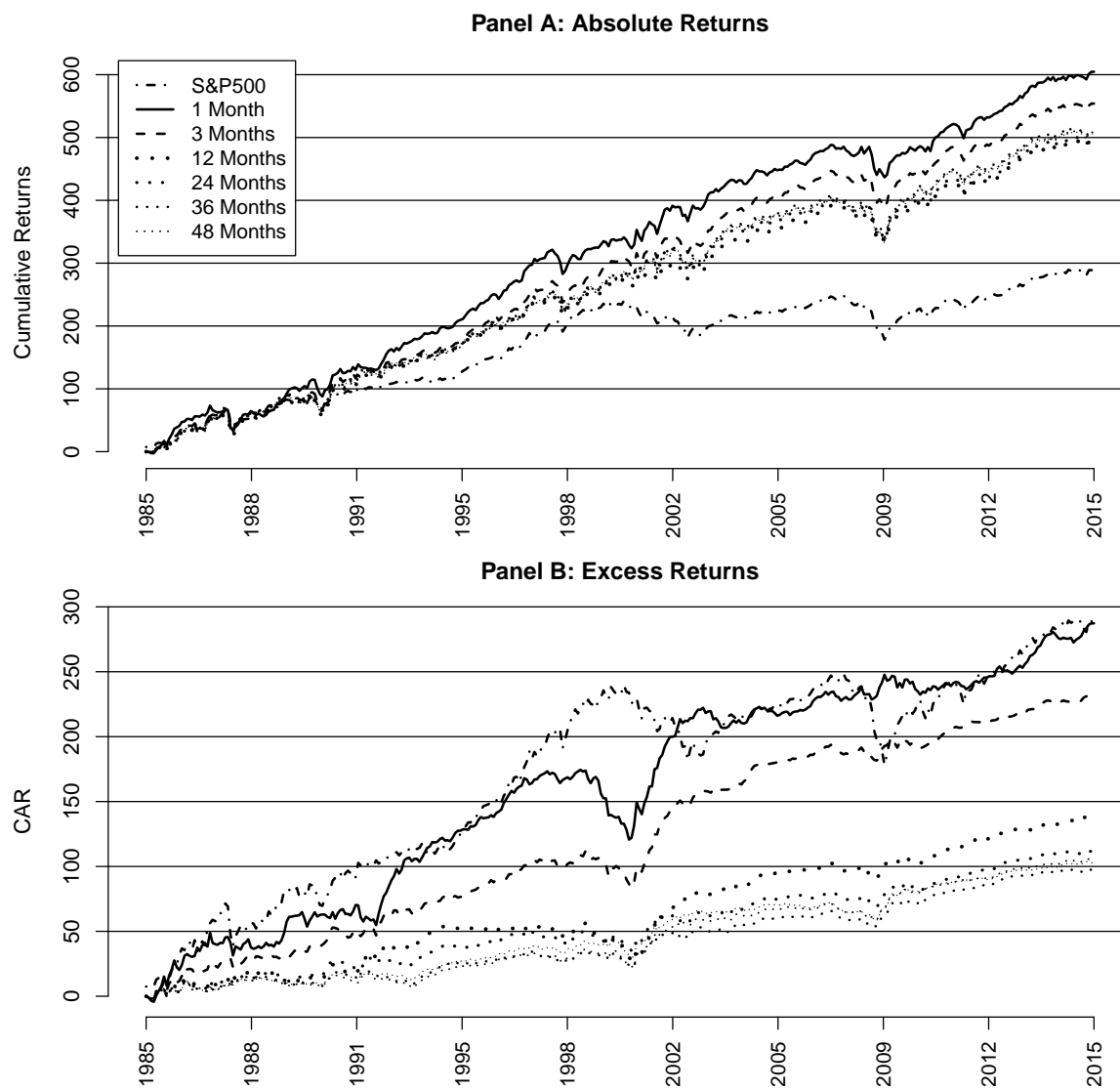
	Low Mispr./Low EU		Low Mispr./High EU		High Mispr./Low EU		High Mispr./High EU	
	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat	AR	$t$ -stat
-6	4.73**	7.42	-1.09	-0.61	-9.44**	-9.84	-27.24**	-20.44
+12	1.14	1.21	3.38	1.39	-2.25	-1.43	3.54 <sup>+</sup>	1.71
+24	1.55	1.12	13.95**	3.52	-1.24	-0.49	13.64**	4.19
+36	5.24**	2.98	20.03**	4.01	-2.31	-0.76	22.87**	5.57
+48	5.7**	2.74	20.73**	3.6	-1.5	-0.43	27.77**	5.69
Observations	1465		371		1002		909	



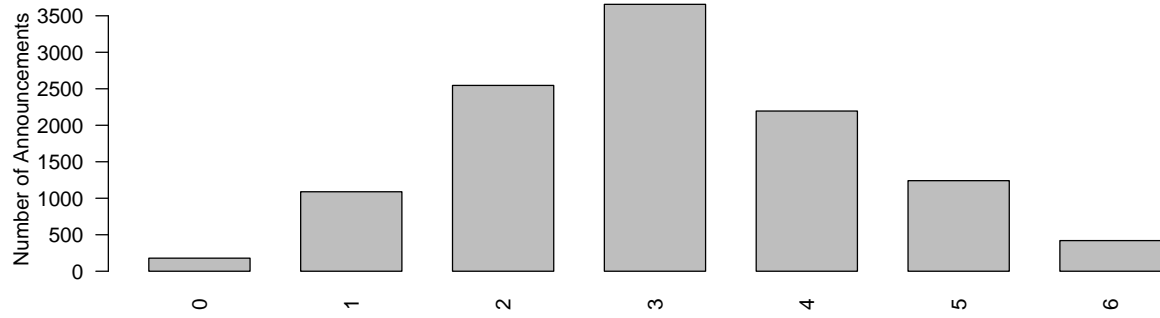
**Figure I** Buyback and equity announcements. Number of announcements per year. Panel A: Buyback announcements; Panel B: Equity SEO announcements. Solid line and right hand axis shows the *S&P* index at the end of each year, starting from 100 in January 1985. Buyback activity rises prior to stock market increases and tends to fall afterwards. Also note the structural decline in equity since 2000.



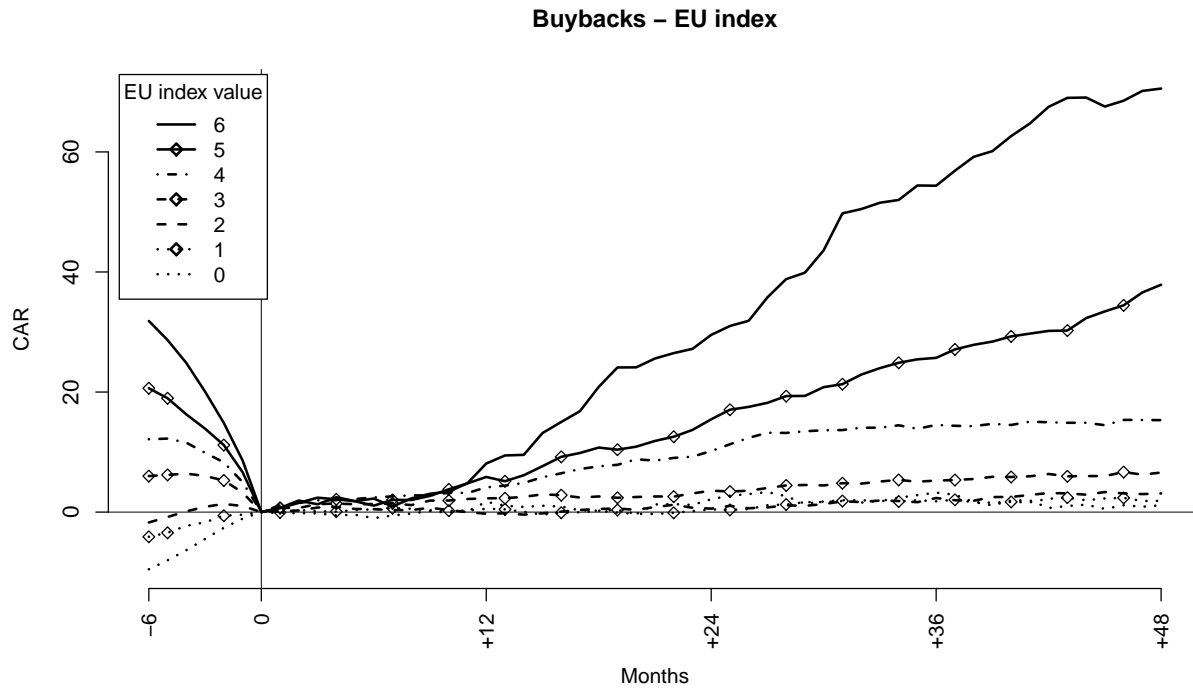
**Figure II** Distribution of the Undervaluation Index of all buyback events.



**Figure III** Cumulative returns of portfolios of all buybacks for different holding periods. Panel A: Absolute returns; Panel B: five-factor Rolling Hedged Abnormal returns using a rolling window of 18 months, lagging 1 month. Dotted-dashed line (e.g., lowest one in Panel A) is the cumulative returns of the *S&P* Index, for comparison; solid line is with 1-month holding period, dashed line is with 3 months holding period; dotted lines are, from the most to the least dark ones, for 6, 12, 24, and 48 months holding periods. Note that the last few lines overlap to a large extent (especially in Panel A). We assume we enter each position 1 day after the corresponding event announcement.



**Figure IV** EU-index. Distribution of the EU-index of all buyback events.



**Figure V** Long-run IRATS five factors cumulative abnormal returns of buybacks depending on the EU-index. From the highest to the lowest lines: solid line is for EU-index 6, solid with diamonds for EU index 5, dotted-dashed for EU index 4, dashed with diamonds for EU index 3, dashed for EU index 2, dotted with diamonds for EU index 1, and finally the lowest dotted line is for EU index 0. The x-axis indicates months from the date of the event announcement.

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