What Explains the Asset Growth Effect in Stock Returns?

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Abstract

We consider the expanding evidence for a negative correlation between firm asset growth and subsequent stock returns with respect to risk-based and costly-arbitrage-based explanations. We test for return effect interactions with received risk-based proxies and costly arbitrage proxies. We find that firm idiosyncratic volatility, which we use as a measure of the cost an extended position in the stock, explains substantial variation in the asset growth effect both in the cross section and time series. Our findings highlight the magnitude of the impact of costly arbitrage on stock returns.

1. Introduction

Suppose that on June 30th of each year from 1968 to 2006 an investor sorted U.S. stocks based on the past year's percentage change in the firm's total assets into five equal portfolios. If the investor bought an equal-weighting in the top asset growth quintile, the mean portfolio return would have been 7.0%, just over the average Treasury Bill rate for this same period which was 6.0%. If, alternatively, the investor bought an equal-weighting in the bottom asset growth quintile, the mean portfolio return would have been 22.5%. This 15.5% mean difference in returns is large and highly persistent (the lowest annual difference between low and high growth rate firms over the 39 year period is -0.5%). Cooper, Gulen, and Schill (2008) refer to this empirical fact as the "asset growth effect." A number of papers observe a similar negative relationship between various measures of firm asset growth and subsequent stock returns (see Fairfield, Whisenant, and Yohn, 2003; Titman, Wei, and Xie, 2004; and Broussard, Michayluk, and Neely, 2005).[1]

There is a growing literature that provides theoretical support for a negative correlation between the growth in firm assets and subsequent returns (see Cochrane, 1991,1996; Berk, Green, and Naik 1999; Gomes, Kogan, and Zhang, 2003; and Li, Livdan, Zhang, 2008). One argument is that firms maintain a mix of growth options and assets in place, and growth options are inherently more risky than assets in place. As firms exercise growth options, the asset mix of the firm becomes less risky as assets in place displace growth options. The systematic reduction in risk following the exercise of growth options induces a negative correlation between investment and subsequent returns

[1] One might also reference the relationship between subsequent returns and measures of firm asset growth events including acquisitions (Asquith (1983), Agrawal Jaffe, and Mandelker (1992), Loughran and Vijh (1997), Rau and Vermaelen (1998)), public equity offerings (Ibbotson (1975), Loughran and Ritter (1995)), public debt offerings (Spiess and Affleck-Graves (1999)), bank loan initiations (Billet, Flannery, and Garfinkel (2006)), and broadly defined external financing (Pontiff and Woodgate (2006) and Richardson and Sloan (2003)), as well as firm asset contraction events such as spinoffs (Cusatis, Miles, and Woolridge (1993), McConnell and Ovtchinnikov (2004)), share repurchases (Lakonishok and Vermaelen (1990), Ikenberry, Lakonishok, and Vermaelen (1995)), debt prepayments (Affleck-Graves and Miller (2003)), and dividend initiations (Michaely, Thaler, and Womack (1995)).

Another theoretical argument for the growth-return relationship arises if firms experience adjustment costs to investment (as an example, John Cochrane refers to the difficulty in producing research when your computer is being replaced). If one models the marginal cost of investment as $MC(I_t/K_t)$ where I_t is the incremental investment at time t and K_t is the stock in capital at time t, then the firm invests up to the point where the marginal cost of investing equals the discounted marginal benefits of the investment, or

$$MC(I_t/K_t) = MB(K_{t+1}) / (1+R) \qquad (1)$$

where R is the relevant discount rate and $MB(K_{t+1})$ is the marginal benefit of the invested capital at time $t+1$. Solving for the discount factor we obtain the relationship,

$$(1+R) = MB(Kt+1) / MC(It/Kt) \qquad (2)$$

Since the values of *MB()* and *MC()* are strictly positive, the relationship between the discount rate and the investment rate (I_t/K_t) is negative.

Both theoretical explanations maintain that the relationship between returns and asset growth rates should disappear once proper risk adjustments are made, but presupposes that such risk adjustments may be empirically difficult. With this theoretical foundation, there is expanding empirical support for risk-based explanations. Lyandres, Sun, and Zhang (2008) create an investment factor (long in low-investment stocks and short in high-investment stocks) and use that factor to explain the abnormal returns to firms expanding due to stock and equity issuance. They conclude that their evidence lends support to the theoretical predictions of the risk-based theories. Li, Li, and Zhang (2008) use proxies for the cost of external finance to find that the asset growth and other effects are larger for firms with greater costs of external finance consistent with risk-based theories of asset growth effects. Anderson and Garcia-Feijoo (2006) show that after controlling for growth in capital expenditures, the book-to-market effect is substantially diminished. Their interpretation of this result, consistent with theoretical work by Berk, Green and Naik (1999), is that the book-to-market effect is driven by changes in risk. In particular, firms with high book-to-market ratios are making investments in relatively low risk projects, and this change in asset composition implies a reduction in risk and, therefore, lower future returns.

The researcher is left to decide whether these risk-based explanations can justify the 15.5 percentage point risk premium cited at the beginning of this paper. An alternative explanation for the asset growth effect is costly arbitrage (see Shiller, 1984; DeLong, Shleifer, Summer, and Waldman, 1990; Shleifer and Vishny, 1990, 1997; Tuckman and Vila, 1992; and Pontiff, 1996). The costly arbitrage explanation employs the standard arbitrage logic that in a frictionless world if a security is undervalued (overvalued) then arbitrage traders costlessly buy (sell) the undervalued (overvalued) security and costlessly sell (buy) a fair-priced security that is perfectly correlated with the fundamental value of the mispriced security. Arbitrage traders costlessly hold the position until prices reflect fundamental values. The standard finance conclusion is that such arbitrage trade pressure eliminates mispricing. In a world of trading frictions, however, the incentive to eliminate mispricing may be diminished because the expected cost of initiating, holding, and terminating the position may exceed the expected benefits. Pontiff (2006) separates such arbitrage costs into two types, transactions costs and holding costs. Transaction costs are defined as those costs that are proportional to acts of initiating and terminating arbitrage positions. Transaction costs may include such trading frictions as bid-ask spreads, market impact, and commissions. Holding costs are defined as those costs that are proportional to the amount of time the arbitrage position is held. Holding costs may include such frictions as interest on margin requirements, short sale costs (e.g., the haircut on short sale rebate rate) and the difficulty in finding a good hedging security. If firm expansion (contraction) tends to systematically coincide with above (below) value stock prices, asset growth effects can persist in equilibrium due to costly arbitrage.

A number of papers provide empirical support for the effects of costly arbitrage in explaining the subsequent returns of firms following asset expansion and contraction events (see Baker and Savasogul, 2002 (corporate mergers); Pontiff and Schill, 2004 (equity offerings); Mashruwala, Rajgopal, and Shevlin, 2006 (accruals)). In each of these papers, the role of holding costs as proxied by idiosyncratic risk exposure is of particular importance. The idiosyncratic risk exposure of the mispriced security is important to arbitrageurs because positions in that security are difficult to hedge. In particular, Pontiff (1996) argues that arbitrageurs trade off the degree to which they profit from predictable return patterns against the degree of risk they incur to do so – and that risk is increasing in the magnitude of firm specific idiosyncratic risk.[2]

In this paper we test these competing explanations with a series of tests. First, if the asset growth effect arises from an underlying relation to asset changes, then the asset growth effect should displace the book-to-market effect when both are acknowledged together as suggested by Anderson and Garcia-Feijoo (2006). Second, if the asset growth effect arises because these measures capture expected future *changes* in risk, we should subsequently observe the predicted changes in risk factor loadings. And third, the mispricing and risk factor explanations differ in the expected effect of arbitrage costs – only mispricing would lead to effects that are limited largely to stocks with high arbitrage costs. In our tests, we focus on the idiosyncratic volatility of firm returns as a proxy for arbitrage costs.

We find that asset growth explains very little of the book-to-market effect.[3] Specifically, in bi-variate sorts on book-to-market against investment measures (the asset growth rate used by Cooper, Gulen, and Schill (2008) and the investment rate used by Lyandres, Sun, and Zhang (2008)), the book-to-market effect is little changed and in Fama-MacBeth multiple regressions the coefficient on book-to-market is still significant and only slightly diminished in magnitude. The fact that a direct measure of the extent of asset changes does not seem to diminish the book-to-market effect provides one piece of evidence that the book-to-market effect is not a manifestation of a change in asset structure. In effect, our results suggest these are two distinct phenomena.

We find that the asset growth effects are limited to stocks with high idiosyncratic volatility. Specifically, we find that when idiosyncratic risk is low, there are no reliable differences in returns across extreme portfolios sorted by asset growth. As idiosyncratic risk

[2] It is true that forming portfolios to trade on these patterns mitigates idiosyncratic risk, but the portfolios are not sufficiently large that idiosyncratic risk is entirely eliminated. In fact, we find that the risk of portfolios sorted on firm level idiosyncratic risk is increasing in the average idiosyncratic risk of constituent firms.

[3] Furthermore, we find that the capital expenditure effect specifically examined by Anderson and Garcia-Feijoo is notably subsumed under the asset growth effect. In bi-variate sorts, only two of five asset growth portfolios exhibit an expenditure growth effect and in the Fama-MacBeth regressions, expenditure growth is dramatically reduced in significance (though still significant at conventional levels) and in magnitude. Our evidence, therefore, suggests two very distinct effects – one associated with book-to-market ratios and one associated with investment activity. For the remainder of our analysis, therefore, we examine both book-to-market and asset growth.

increases, the returns to high growth portfolios decline, the returns to low growth portfolios increase, and the differences become statistically reliable. This result suggests a simple specification for examining this issue in a multivariate setting. Specifically, the product of an arbitrage cost measure and asset growth, would reflect the degree to which arbitrage costs are necessary for the relation to hold. In this manner, we determine whether high arbitrage costs are, in fact, a necessary condition for these effects to hold. We find this to be the case for asset growth effects.

We extend our multivariate analysis, which addresses only return predictability, to consider whether these effects are priced risk factors (whether they have risk premia) following the approach of Fama and MacBeth (1973).[4] In particular, a first stage regression estimates risk factor betas from the time-series of portfolio returns and a second stage cross-sectional regression estimates the risk premium associated with the factor betas. We document that both the asset growth and investment-to-assets ratio maintains a risk premium. We partition factor loadings by idiosyncratic volatility and include both high and low idiosyncratic loadings in our analysis. We find significant risk premia only for the high idiosyncratic portfolio. Thus, as with our analysis of return predicatability, the effects seem to be associated only with portfolios with high arbitrage costs.

Looking at the time-series of asset pricing models, we find notable reversals in alphas. For example, for high asset growth firms, alphas are rising in the past and falling in the future. This is consistent with mispricing – the rising alpha reflects overly high prices and the declining alpha reflects the unwinding of the mispricing. Once again and more importantly, we find this pattern to be prevalent only for stocks with high idiosyncratic volatility. As for changes in risk factor loadings predicted by the risk-based theories that tie return predictability to change in asset characteristics and, therefore, to changes in underlying risk, we find no patterns consistent with these theories.

Our research is closely related to a number of other papers. Anderson and Garcia-Feijoo (2006) show that firms with relatively large increases in capital expenditures have lower

[4]One needs to establish that the risk factor explains cross-sectional variation in returns. In effect, the factors must also have risk premium. Recent uses include the Jagannathan and Wang (1996) test of the conditional CAPM, the Brennan, Wang and Xia (2004) test of the intertemporal CAPM, the Canokbekk and Vuolteenaho (2004) test of the two-beta model, and the Core, Guay, Verdi (2006) analysis of an information risk factor measured by accruals.

subsequent returns and that after controlling for this expenditure growth effect, the book-to-market effect is substantially diminished. We find little diminution in the book-to-market effect from inclusion of asset growth.[5] In addition to documenting the asset growth effect, Cooper, Gulen and Schill (2007) provide some evidence consistent with mispricing. They look at characteristics of high growth firms and patterns in the time series of returns for indications of mispricing - we look at asset pricing tests directly and examine a direct measure of arbitrage costs. Daniel, Hirshleifer and Subramanyam (2001) note that a positive risk premium might still be observed when the return patterns are generated by miss-pricing. Our contribution is to partition factor loadings by indiosyncratic volatility and include both high and low idiosynchratic loadings in our analysis.

Ultimately the reader is left to decide whether the risk-based or costly-arbitrage-based explanations can justify the 15.5 percentage point risk premium cited at the beginning of this paper. In the paper, section 2 describes the data, section 3 provides empirical results, and section 4 provides concluding remarks.

2. Data

Our sample is composed of all nonfinancial firms (one-digit SIC code not equal to 6) with data available on Compustat annual industrial files and CRSP monthly files. To mitigate backfilling biases, a firm must be listed on Compustat for two years before it is included in the data set (Fama and French, 1993). As in Fama and French (1992), we consider returns from July of year *t* through June of year *t+1*, using Compustat annual financial statement information from fiscal year end *t-1*. The asset growth rate is defined as in Cooper, Gulen, and Schill (2008). It is the one year percentage change in total assets (Data6) for the firm. The investment-to-asset ratio follows Lyandres, Sun, and Zhang (2008) and is defined as the annual change in firm gross PPE (Data7) and inventories (Data3) divided by the lagged value of total assets (Data6).

We sort the data into five portfolios based on the asset growth rate (Panel A) and investment-to-asset ratio (Panel B) and report summary statistics (means of annual median

[5] We also look at expenditure growth (their measure of asset changes – which is essentially the change in the rate of growth) and still find a strong book-to-market effect.

values) for these portfolios in Table 1. For the asset growth rate sort, the asset growth rate varies from -14.9% for the low growth group to 57.4% for the high growth group. For the investment-to-asset ratio sort, the investment-to-asset ratio varies from -6.2% for the low growth group to 30.7% for the high growth group. Since the change in gross PPE and inventories is a subset of the change in total assets, the two measures are expected to be correlated. There is some indication of this in the values reported in the table.

To provide further detail on the characteristics of the firms within each of the five portfolios, we report the average size and book-to-market ratio across the groups. For firm capitalization, we use the market value of the firm's equity from CRSP at the end of June of year t. For price scaled book-to-market (BM), we use price or market value from December of year *t-1*. Year *t* is set from 1968 to 2006. Book value of equity is as defined in Davis, Fama, and French (2000) where book equity (BE) is the stockholders' book equity (Data216), plus balance sheet deferred taxes and investment tax credit (Data35), minus book value of preferred stock (in the following order: Data56 or Data10 or Data130). The low growth group tend to be fairly small (asset growth rate sort: $30.1 million; investment-to-asset ratio sort: $41.1 million) and have high book-to-market ratios (both sorts: 0.99). For both sorts, the size peaks in portfolio 4 (asset growth rate sort: $167.2 million; investment-to-asset ratio sort: $143.2 million) and the book-to-market ratio is lowest in portfolio 5 (asset growth rate sort: 0.45; investment-to-asset ratio sort: 0.53). It appears clear that firm asset expansion is correlated with the book-to-market ratio as suggested by Anderson and Garcia-Feijoo (2006).

We also present summary statistics for various proxies for arbitrage cost. Following Pontiff (1996), our measure of holding costs, idiosyncratic volatility (*IVOL*), is defined as the standard deviation of the residuals from a regression of daily returns on an equal-weighted market index over a minimum of 100 days starting on July 1st of year *t*-1 and ending on June 30 of year *t*. We measure transaction costs with two common measures of stock market liquidity. We use the illiquidity measure proposed in Amihud (2002) that is calculated as the ratio of the absolute value of the daily stock return to its daily dollar trading volume. Since volume on Nasdaq is known to be overstated as a result of trades between dealers, we divide volume on Nasdaq-listed firms by 2 (see Atkins and Dyl (1997)). We annualize the measure by simply taking the simple average of the daily measure. We denote this measure *AMIHUD*. Since

AMIHUD is the daily price response associated with one dollar of trading volume, it serves as an indicator of price impact (See Hasbrouk, 2006). We also use the Gibbs sampler estimate of the Roll (1984) trading cost measure proposed in Hasbrouck (2006), based on daily stock returns. The Roll measure estimates bid-ask spreads from the time series of daily price changes based on the magnitude of the negative serial correlation returns. Since returns are often positively correlated, implying a negative spread, Hasbrouck (2006) proposes a Gibbs sampler estimate of the Roll measure that minimizes this problem. Using direct measures of spread as benchmarks, Hasbrouck finds that the Gibbs sampler estimate of the Roll model is the best measure of effective trading costs. We generate annual spread measures by taking simple annual averages of daily values of the Gibbs estimate supplied by Joel Hasbrouk. We denote this measure *GIBBS*. We do not use measures of quoted or effective spreads because of the lack of necessary high frequency data which are available for a relatively short time series. The indirect measures we use are available for a significantly longer period and allow us to analyze a more comprehensive sample. Note that our measures are inverse measures of liquidity (essentially measures of trading costs or illiquidity).[6]

From Table 1 we observe that both extreme asset expansion portfolios tend to maintain higher arbitrage costs, but particularly the low expansion firms. Idiosyncratic volatility ranges from 67.3% for the low asset growth group to 36.2% for the middle growth group to 50.8% for the high growth group. The *AMIHUD* price impact measure ranges from a high 4.2 for the low asset growth group to 0.3 for the middle growth group to 0.4 for the high growth group. The *GIBBS* measure ranges from a high 1.5% spread for the low asset growth group to a 0.5% spread

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[6] Include? The average (median) book-to-market is 1.32 (0.67), average (median) firm annual asset growth is 19% (8%), and average (median) firm size as measured by equity capitalization is 0.6 million dollars (0.07). Each of these measures is significantly rightly skewed, as suggested by the differences between means and medians. For this reason, when estimating correlation coefficients or performing regression analyses we use the log of these variables. Because book to market and asset growth values are likely to be close to zero or even negative we add one to the variable before taking the logs. The correlation between book-to-market and asset growth variables is not excessively high, the correlation coefficient is -0.22. The correlation coefficient between size and book to market is -0.31 while that between size and asset growth is 0.15. Larger firms tend to be more stable, and liquid, this is reflected in our sample's correlation coefficients. Size is strongly negatively related to Idiosyncratic risk, and our two measures of illiquidity (Illiquid and Gibbs), the coefficients are between -0.39 and -0.57. Volatile firms are known to be less liquid, consistently, we find that idiosyncratic volatility is strongly correlated with Gibbs and Illiquid, 0.74 and 0.54 respectively. As would be expected of two measures of the same concept – liquidity – Gibbs and Illiquid are strongly correlated with a coefficient of 0.71.

for the middle growth group to a 0.7% spread for the high growth group. Similar relationships are found for the investment-to-asset ratio sort groups.

Table 1 also reports the associated mean portfolio returns for the groups over the year subsequent to the June 30^{th} sorting date (July to June of the next year). The return values monotonically decline with the increase in firm expansion. For the asset growth rate sort, the mean returns range from 22.5% for the low growth group to 7.0% for the high growth group. For the investment-to-asset ratio sort, the mean returns range from 20.0% for the low growth group to 8.3% for the high growth group. These 15.5% and 11.7% differences, respectively, in gross returns for the asset growth rate and investment-to-asset ratio sorts are highly statistically significant. The only arbitrage cost measure that we can directly compare with returns is the GIBB measure. If we add the two mean GIBB values for the extreme portfolios we obtain 2.2% for the asset growth rate sort and 2.0% for the investment-to-asset ratio sort. These sums represent the mean round-trip bid-ask spread cost from buying and selling a position in portfolios 1 and 5 and rebalancing the entire position every June 30th. Unlike such return effects as momentum (see Lesmond, Schill, and Zhou, 2004), the estimates of the spread seem to be far from explaining the magnitude of the returns that were generated from a long position in portfolio 1 and a short position in portfolio 5.

3. Results

3.1 The relationship between investment and book-to market effects

We start by studying the relations between the book-to-market, asset growth and size effects. Berk, Green and Naik (1999) suggest that the book-to-market and size effects are driven by changes in risk caused by changes in the firm's investment opportunities set. In their model, firms realize investment opportunities as they invest, and because growth opportunities are riskier than assets in place, risk declines as firms invest and transform growth opportunities into assets in place. Assuming high investment firms have low book-to-market ratios, i.e., high investment opportunities, and are smaller, then the book-to-market and size effects documented in Fama and French (1992) should be explained by this asset growth effect. Anderson and Garcia-Feijoo (2006) conclude that the book to market and asset growth effects are the same, and therefore the book-to-market effect can be explained by the theoretical framework of Berk, Green and Naik.

In order to investigate to the independence of these effects we compute portfolio returns for portfolios of firms sorted independently into quintiles based on the lagged book-to-market and size measures with respect to our asset growth rate and investment-to-asset ratio quintiles. We compute monthly portfolio returns from July of the sorting year through June of the following year. The mean portfolio returns are reported in Table 2 for asset growth rate (Panel A) and investment-to-asset ratio (Panel B). To observe the interactions of the effects, we focus our attention on the difference in returns between the extreme portfolios, controlling for the alternative characteristic. If the correlation of the effects subsume each other, as suggested by some risk-based models, we expect the difference in returns across book-to-market ratio or size quintiles to disappear once these values are conditioned on asset expansion quintile. In results inconsistent with Anderson and Garcia-Feijoo, we find that this is not the case.[7] Controlling for all levels of asset growth rate or investment-to-asset ratio, the difference in returns is highly significant across extreme quintiles for both the book-to-market ratio and firm size. In Panel A, the difference in monthly returns between the high and low book-to-market ratio quintiles varies from 1.0%, 1.0%, 0.7%, 0.7%, and 1.2% across asset growth rate quintiles 1 through 5, respectively. There is no evidence that the book-to-market disappears once firm investment policy is considered. Firms with high book-to-market ratio stocks generate 1.2% higher monthly returns than low book-to-market ratio stocks, even among of sample of firms that are growing

[7]We repeat our tests using an alternative measure of asset growth the 2 year growth in capital expenditures, the main measure used in Anderson and Garcia-Feijoo, though do not tabulate this analysis. Even though the asset growth effect is much stronger than the capital expenditure growth effect (1% vs. 0.5%) we keep it for comparison purposes with the previous literature. As before we find that the capital expenditures growth arbitrage portfolios yield positive and statistically significant returns, across all book-to-market quintiles, and the same is true for the book-to-market portfolios conditioning on capital expenditures growth. We find that portfolio returns decline monotonically with asset growth quintiles keeping expenditure growth constant, and the corresponding arbitrage portfolios are significant at the 1% level across all expenditure growth quintiles. On the other hand, when conditioning on asset growth we find that returns for the various expenditure growth portfolios do not vary monotonically, and the corresponding arbitrage portfolios are significant for only two of the five portfolios. Our results indicate that while the asset growth effect cannot be explained by expenditure growth, the expenditure growth effect is largely subdued by the asset growth. Overall, our results indicate that the asset growth effect is much stronger than the expenditure growth effect.

assets at an average rate of 57% (see Table 1). Moreover, the asset growth effect is also robust controlling for size and book-to-market levels. The difference in returns between extreme asset growth rate portfolios is almost identical across the five book-to-market quintiles. We do observe a relationship with size (the asset growth effect is smaller among larger firms) as already observed by Cooper, Gulen, and Schill (2008) and Fama and French (2008), but in both cases the difference in returns across asset growth groups is still significant among the largest quintile stocks.

Given that size can also be considered as a proxy for arbitrage costs, we replace size with two of our arbitrage costs measures: *IVOL* and *AMIHUD*. In Panel C, we recompute the difference in returns between asset growth quintiles controlling for *IVOL* and *AMIHUD*. We observe little relationship with *AMIHUD*, but a strong relationship with *IVOL*. It appears that the asset growth effect is particularly strong among high *IVOL* stocks and nonexistent among low *IVOL* stocks.[8]

3.2. Fama-MacBreth tests with monthly returns

So far our analysis has been based on bivariate sorts, we now investigate these firm characteristics' ability to explain returns in a multivariate setting. We run Fama and McBeth (1973) type regressions explaining cross-sectional variation in monthly returns, to obtain monthly regression coefficients. We then report the average of those coefficients, and inference is based on the t-tests of the average. Results are tabulated in Table 3. In our baseline regression, we regress returns on log of size, and log of 1+ book-to-market. We find, consistent with previous work, that size is generally negatively related to returns, and book-to-market is positively related.

We now add the log of 1+asset growth in regression 2 and log 1+investment-to-asset ratio in regression 3. We find that both measures of asset growth are negatively related to returns with large t-statistics of -9.47 and -8.24. When we add the asset growth variables to our baseline specification, the coefficient on book-to-market declines somewhat from 0.0030 (t-statistic=4.24)

[8] Add GIBB, Also, do 3 way test with size to respond to Fama-French

(baseline coefficient) to 0.0022 (t-statistic=3.28) with asset growth rate and 0.0025 (t-statistic=3.64) with investment-to-asset ratio. Again, our results provide evidence that book-to-market and asset growth are mostly independent effects.

We know that the asset growth rate and the investment-to-asset ratio are highly correlated. To provide some understanding of the independent explanatory power of the asset growth rate and the investment-to-asset ratio we include both variables on the right-hand side of regression 4. For this regression the t-statistic is -6.93 for the asset growth rate and -1.05 for the investment-to-asset ratio. The estimates clearly suggest that the asset growth rate dominates the investment-to-asset ratio in explaining the cross-section of returns. Given this result, we focus only on the asset growth rate for the remainder of the regressions reported in table 3.

In the next regressions we add various measures of arbitrage costs and interactions of these costs with asset growth rates to identify whether these measures provide explanatory power in the cross section. If that is so, then we would expect the relation between asset growth and returns to strengthen with holding costs. This type of analysis suggests an interaction between these two variables and holding costs. Thus in the fourth regression specification we build on regression specifications by adding 3 additional variables: holding costs, an interaction between holding costs and book-to-market, and one other interaction between asset growth and holding costs. We find that the interaction coefficients with *IVOL* is statistically significant. The coefficient on the interaction with is -0.26 [t-statistic=-3.97]. Thus, our results suggest that the asset growth effects increase significantly with holding cost. Most interestingly, the coefficients on the asset growth variable become insignificant -0.001 [t-statistic=-0.42], suggesting that these two effects per se are non-existing in the absence of holding costs. The coefficient on idiosyncratic volatility is insignificant, suggesting that idiosyncratic volatility is not independently priced.

As we showed in table 1, holding costs (idiosyncratic risk) are correlated with implementation costs (measures of liquidity). Thus it could be that holding costs are capturing implementation cost effects. In order to distinguish between which cost-types are impeding price adjustments we also add to this specification the Amihud's measure of illiquidity, illiquid and illiquid interacted with each book to market and asset growth. We find the interaction terms with illiquid to be insignificant, and the term on illiquid to be positive and significant, reflecting the previously found effect that illiquidity predicts positive returns. Most importantly, the interaction terms with holding costs continue to be strongly significant and of the same sign as in equation 5. For robustness, in specification 6 we substitute the variable *AMIHUD* for our other measure of liquidity, and *GIBBS* in specification 7. We obtain the same results.

These results are consistent with those in Ali et. al. (2003) who establish a similar relation for the book-to-market effect. Our results suggest that the asset growth effect, like the book-market effect is explained in the cross section by estimates of holding cost (such as *IVOL*) and not so much by measures of transaction cost. These results cannot be explained by portfolio formation costs. Finally, our results suggest again that the asset growth and book-to-market effects are independent effects.

3.3. Risk premiums and idiosyncratic risk

Fama and French suggest that the difference between small and big portfolio returns (SMB) and high minus low book to market portfolio returns (*HML*) are risk factors along with market returns, and Carhart introduces one other factor, the momentum factor (*MOM*). There are several papers suggesting reasons for why that would be the case, and research typically includes these four factors to better capture portfolio risk. Similarly, Lyandres, Sun, and Zhang (2008) propose a factor based on the investment-to-asset ratio. Although Lyandres et al. argue that their factor is theoretically motivated by Zhang (2005) and Carlson, Fisher, and Geimmarino (2006) they recognize that it is also consistent with a simple measure of systematic mispricing.

In this spirit, we construct a similar asset growth factor (*GRO*). Regardless of whether the factor captures systematic risk or mispricing, we might expect that cross-sectional loadings on the factor should be correlated with higher returns. For example, if we sort portfolios on book-to-market, high book-to-market firms will have a higher factor loading on the *HML* portfolio, and low book-to-market firms will have a lower factors loading. It is known that high book to market firms yield higher future returns, and the low book to market firms yield lower future returns. If the factor loadings on book to market are positively correlated with this portfolio characteristic, the factor loadings will then, similarly to returns from book to market portfolio sorts, produce a positive relation between factor loadings and returns, which would be interpreted as a risk premium. If these premiums are compensation for trading on mispricing opportunities (arbitrage premiums), rather than compensation for risk (risk premiums), then we would expect them to exist only in mispriced portfolios.

We test this assertion by partitioning the GRO factor into low, medium and high idiosyncratic risk factors. We then estimate the risk premiums following the standard two stage procedure, where we first compute the factor loadings, and then estimate the risk premiums. If what has been previously interpreted as a risk premium is indeed a result of miss-pricing, then we would expect those premiums to only be generated in the mispriced portfolios, those with high idiosyncratic risk.

We present results in table 4. We get the return factors RMRF, SMB, HML and MOM from Ken French's website. We form the GRO factor by first sorting portfolios into growth terciles, and then taking the weighted average of monthly returns from July to June. Portfolios are resorted every year. We also compute the GRO factor mimicking portfolios for three levels of idiosyncratic risk. Specifically, we sort firms independently on asset growth terciles and idiosyncratic risk terciles. We then form the low growth minus the high growth portfolios within each of the idiosyncratic risk terciles.

In panel A we present summary statistics. Specifically, we present the time series means of each factor portfolio, and respective t-statistics. We also present the correlation matrix. All factor mimicking portfolios are positive and statistically significant, except for the HML Low IVOL portfolios. The portfolios that are also sorted on idiosyncratic risk yield returns that increase monotonically with idiosyncratic risk, for example the returns for the GRO portfolios are 0.4%, 0.6% and 1.0% for the low, medium and high idiosyncratic risk portfolios. The standard deviation of the portfolio return also increases with IVOL from 3.2% to 4.7%. This suggests that the overall volatility of the portfolio increases with IVOL.

The correlation coefficient between the GRO and the HML returns is very high, 0.7. The HML portfolio return is not that strongly correlated with the GRO portfolio return with a correlation coefficient of 0.14. The GRO portfolio is most correlated with the GRO high IVOL portfolio, and much less so with the GRO low IVOL portfolio (correlation coefficient of 0.84 vs. 0.57). Finally the GRO low IVOL portfolio is only modestly correlated to the GRO high IVOL, with a coefficient of 0.36. This is noteworthy, given that they are both sorted on asset growth rates. The low correlation coefficient is consistent with the high IVOL portfolio having mispricing component that are different from systematic variations in the factor mimicking portfolios.

We now turn to studying how these factor mimicking portfolios are priced. To generate sufficient cross-section variation we follow Chung, Johnson, and Schill (2006) and sort stocks into 50 asset growth portfolios and compute equal-weighted monthly returns for each of these portfolios. For each of these portfolios we estimate portfolio factor loadings in rolling 10 year periods (120 months). It is important to estimate factor loadings over a long time period because high IVOL portfolios have, by construction, more volatility, and a longer period increases the reliability of the estimates. We estimate risk premiums, as in Fama-MacBeth, by running for each month cross-sectional regressions of the 50 portfolio returns on the factor loadings estimations ending two months before. Table 4 Panel B tabulates the time-series means, and t-statistics for the means, of these estimates.

In panel C we estimate the risk premium on our 5 factor model, including the asset growth factor *GRO*. To do this, we run monthly Fama-MacBeth regressions of the cross-section of portfolio returns on the contemporaneous factor loadings. Our choice of forming portfolios based on asset growth rate is to strengthen the cross-sectional variation across the key variable. We find that the loadings on GRO are indeed correlated with high returns. The coefficient on the GRO loading is 0.005 with a t-statistic of 2.98.

We now substitute the three partitioned GRO factors for the overall GRO factor. The implication we hope to test is the expectation that a risk-based explanation entails no expectation on variation in explanatory power across the partitioned factors. A costly arbitrage model, however, maintains strong predictions that it is the high IVOL portfolio that should be generating the premium. If the previously estimated premiums were compensation for risk, then we would expect to find the premium to be significant in the low IVOL group, the factor portfolio that is the least sensitive to mispricing. If they are a reflection of mispricing, then we would expect to find them in the high IVOL factor portfolio, as this factor is the most sensitive to mispricing. Our results are again consistent with the costly arbitrage explanation. We find that there is not a reliable premium for the low IV factor loading. In both specifications, the correlation between the low IVOL GRO loading and returns is insignificant. In contrast, there is a large and statistically significant correlation between the high IVOL GRO loading and returns. Our results suggest that the theoretically suggested premium on the GRO factor, that we document empirically in this paper, is more consistent with costly arbitrage than with compensation for risk.

3.4. Time-series tests

As a last set of tests we examine the time-series characteristics of the asset growth portfolio returns in over the five years prior and subsequent to the sorting year. In Figure 1 we plot the intercept and 3-factor model loadings using the returns for the respective event year. We also plot the difference between the low and high asset growth quintiles. We observe a substantial reversal pattern in the intercept consistent with Cooper, Gulen, and Schill (2008). The magnitude of the intercept over several years after the sorting year suggest that our crude dynamic risk adjustment model does little to diminish the magnitude of the raw return differential discussed in the introduction to this paper. If time-varying loadings are to explain the abnormal returns, we might expect the difference in loadings on the market, SMB, and HML to increase after the sorting year. We find no evidence of an increase in the difference in the market or the SMB loading. There is however some evidence that the difference in the HML loading does increase.

To further investigate this result, we partition the asset growth quintiles by idiosyncratic risk quintiles as in the analysis reported in Table 2. We repeat the estimation procedure for across the sorting event window for the 25 portfolios. In Figure 2, we plot the difference in coefficients between the low asset growth quintile and the high asset growth quintile for each of the two extreme IVOL quintiles. In Table 5 we report the numbers and t-statistics for the data. Examining the plot of the intercept, we observe that the time-series reversal in the abnormal return is concentrated among the high IVOL stocks. The subsequent intercept for the low IVOL groups is small and marginally statistically different from zero with intercepts of 0.1% (t-stat 0.96), 0.1% (t-stat 0.76), and 0.3% (t-stat 2.18) in Years 1, 2, and 3, respectively. The subsequent intercept for the high IVOL groups is massive and highly statistically different from zero with intercepts of 2.2% (t-stat 10.60), 1.2% (t-stat 5.68), and 0.7% (t-stat 3.86) in Years 1, 2, and 3, respectively. Furthermore, we observe that the increase in loading on the HML factor observed in Figure 1, is primarily associated with an increase in HML loading among the high IVOL stocks, although the HML loading increase is statistically significant for both IVOL and low IVOL stocks.

4. Summary and conclusions

Determining whether patterns in returns are the result of variation in risk or mispricing is a central and ongoing question in asset pricing. Violations of market efficiency that may be implied by mispricing would challenge the fundamental function of markets. Of course, mispricing need not violate market efficiency if the mispricing exists within reasonable arbitrage bounds. Exactly what constitutes those bounds and what they can tell us about return patterns is the focus of this paper. In particular, we look at arbitrage costs and the return patterns for the asset growth effect.

We conclude that arbitrage costs are a necessary condition for the existence of the return patterns we examine. In particular, large holding costs that we model with estimates of idiosyncratic volatility create frictions to exploiting these patterns. Our results suggest that the return patterns in asset growth are most consistent with costly arbitrage.

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Table 1. Summary Statistics

Summary statistics for five equal equal-weighted portfolios of stocks formed at the end of June from 1968 through 2006. Panel A presents portfolios formed based on asset growth rate defined as the annual change in total assets divided by the lagged value of total assets. Panel B presents portfolios formed based on the investment-to-asset ratio defined as the annual change in gross PPE and inventories divided by the lagged value of total assets. Size is the market value of equity as of June 31st of the sorting year. The book-to-market ratio (BM) is defined as defined in Davis, Fama, and French (2000) where the market value is of December of year before sorting and the book value of equity is the stockholders' book equity (Compustat data 216), plus balance sheet deferred taxes and investment tax credit (Compustat data35), minus book value of preferred stock (in the following order: Compustat data56 or data10 or data130). Idiosyncratic volatility (IVOL) is defined as the standard deviation of the residuals of a market model regression of firm returns over the twelve months prior to sorting. In this table we annualize the IVOL value by multiplying RVOL by the square root of 252 trading days. The Amihud illiquidity measure (AMIHUD) is the Amihud (2002) measure of illiquidity calculated using stock returns and trading volume over the prior twelve months. To facilitate reporting, in this table we multiply AMIHUD by 10000. The Gibbs illiquidity measure (GIBBS) is the Gibbs sampler estimate of the Roll (1984) model over the calendar year prior to the sorting year. The annual return measures are the annual raw returns for the twelve months prior to and subsequent to the sorting June 30th sorting date. To minimize the effect of outliers, we winsorize the data at the 1% and 99% levels except returns. This table reports means of annual median values expect for the annual return values which are means of annual portfolio returns.

Panel A. Asset growth rate

	Asset growth rate				
	1(low)	2	3	4	5 (high)
Asset growth rate	-14.9%	0.5%	7.9%	18.3%	57.4%
Investment rate	-2.1%	3.3%	7.3%	12.3%	26.4%
Size ($ millions)	30.1	90.2	152.4	167.2	122.8
Book-to-market ratio (BM)	0.99	0.99	0.82	0.63	0.45
Annualized idiosyncratic volatility (IVOL)	67.3%	42.0%	36.2%	40.5%	50.8%
Amihud illiquidity measure (AMIHUD)	4.2	0.8	0.3	0.3	0.4
Gibbs illiquidity measure (GIBBS)	1.5%	0.7%	0.5%	0.6%	0.7%
Annual return prior to sorting					
Annual return subsequent to sorting	22.5%	18.7%	16.2%	14.1%	7.0%

Panel B. Investment-to-asset ratio

	Investment-to-asset ratio				
	1(low)	2	3	4	5 (high)
Investment rate	-6.2%	2.3%	6.7%	12.8%	30.7%
Asset growth rate	-7.6%	1.5%	6.6%	13.5%	40.5%
Size ($ millions)	41.1	82.4	131.8	143.2	123.4
Book-to-market ratio (BM)	0.99	0.86	0.77	0.67	0.53
Annualized idiosyncratic volatility (IVOL)	58.8%	45.8%	40.4%	41.7%	48.6%
Amihud illiquidity measure (AMIHUD)	2.9	0.8	0.3	0.3	0.4
Gibbs illiquidity measure (GIBBS)	1.3%	0.8%	0.6%	0.6%	0.7%
Raw contemporaneous annual return					
Raw subsequent annual return	20.0%	18.6%	16.4%	14.3%	8.3%

Table 2. Portfolio returns based on independent sorts

This table reports equal-weighted mean monthly portfolio returns for portfolios of stocks formed at the end of June from 1968 through 2006. Panel A presents portfolios formed based on asset growth rate defined as the annual change in total assets divided by the lagged value of total assets. Panel B presents portfolios formed based on investment-to-asset ratio defined as the annual change in gross PPE and inventories divided by the lagged value of total assets. Size is the market value of equity as of June 31st of the sorting year. The book-to-market ratio (BM) is defined as defined in Davis, Fama, and French (2000). The table presents results for two-way independent sorts based on these variables into quintiles. Portfolios are rebalanced annually. Portfolios returns are from the beginning of July of the sorting year through the end of June of the following year. We also report statistics on "high-low" and "small-large" difference portfolio returns. For each month, we take the difference in portfolio return for the extreme quintiles. Over the sample period there are 468 monthly observations (12 months x 39 years of data). The t-statistics for the extreme quintile spreads are reported in brackets with ** denoting significance at the 1% level, and * at the 5% level.

Panel A. Asset growth rate

		Asset growth rate						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
Book -to-market ratio	1(low)	0.012	0.010	0.009	0.008	0.002	0.010	[4.22**]
	2	0.017	0.013	0.012	0.012	0.006	0.010	[5.60**]
	3	0.018	0.014	0.013	0.012	0.008	0.010	[5.66**]
	4	0.021	0.015	0.015	0.013	0.011	0.010	[5.60**]
	5 (high)	0.022	0.020	0.016	0.015	0.013	0.009	[4.85**]
	High-low	0.010	0.010	0.007	0.007	0.012		
	[t-stat]	[4.73**]	[4.81**]	[4.18**]	[3.63**]	[4.95**]		

		Asset growth rate						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
Size	1(small)	0.027	0.022	0.018	0.017	0.013	0.013	[7.13**]
	2	0.015	0.015	0.015	0.011	0.005	0.010	[6.57**]
	3	0.013	0.014	0.014	0.011	0.004	0.009	[6.17**]
	4	0.011	0.013	0.013	0.011	0.005	0.006	[4.12**]
	5 (large)	0.013	0.012	0.011	0.010	0.006	0.007	[3.90**]
	Small-large	0.014	0.010	0.007	0.007	0.008		
	[t-stat]	[4.17**	[3.95**]	[2.82**]	[2.62*]	[2.57*]		

Table 2. Portfolio returns based on independent sorts (Continued)

Panel B. Investment-to-asset ratio

		Investment rate						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
Book-to-market ratio	1(low)	0.009	0.010	0.009	0.008	0.002	0.007	[3.68**]
	2	0.015	0.013	0.012	0.011	0.007	0.007	[5.16**]
	3	0.016	0.015	0.013	0.012	0.008	0.008	[6.05**]
	4	0.017	0.017	0.015	0.014	0.011	0.006	[4.41**]
	5 (high)	0.021	0.019	0.018	0.016	0.014	0.007	[5.11**]
	High-low	0.011	0.010	0.009	0.009	0.012		
	[t-stat]	[5.35**]	[5.15**]	[4.34**]	[4.15**]	[5.35**]		

		Investment-to-asset ratio						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
Size	1(low)	0.023	0.024	0.021	0.019	0.014	0.010	[6.50**]
	2	0.014	0.015	0.014	0.012	0.007	0.007	[5.25**]
	3	0.013	0.013	0.013	0.011	0.004	0.008	[6.25**]
	4	0.012	0.013	0.012	0.011	0.006	0.006	[4.66**]
	5 (high)	0.013	0.012	0.011	0.010	0.007	0.006	[4.22**]
	Small-large	0.011	0.013	0.010	0.009	0.006		
	[t-stat]	[3.63**]	[4.35**]	[3.81**]	[3.40**]	[2.37*]		

Table 2. Portfolio returns based on independent sorts (Continued)

Panel C. Asset growth rate and arbitrage costs

		Asset growth rate						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
	1(low)	1.25%	1.29%	1.21%	1.13%	1.13%	0.12%	[1.02]
	2	1.44%	1.31%	1.29%	1.15%	0.84%	0.61%	[4.48**]
IVOL	3	1.59%	1.55%	1.46%	1.21%	0.61%	0.98%	[6.67**]
	4	1.58%	1.60%	1.42%	1.13%	0.36%	1.22%	[7.72**]
	5 (high)	2.26%	1.93%	1.55%	1.33%	0.58%	1.68%	[7.47**]

		Asset growth rate						
		1(low)	2	3	4	5 (high)	Low-high	[t-stat]
	1(low)	1.28%	1.16%	1.08%	0.96%	0.36%	0.93%	[4.76**]
	2	1.11%	1.38%	1.23%	1.01%	0.42%	0.68%	[4.10**]
AMIHUD	3	1.34%	1.38%	1.24%	1.10%	0.45%	0.89%	[4.99**]
	4	1.77%	1.60%	1.49%	1.21%	0.55%	1.21%	[7.32**]
	5 (high)	2.47%	2.08%	1.83%	1.77%	1.34%	1.13%	[5.90**]

Table 3. Fama-Macbeth regressions predicting returns

This table reports monthly cross-sectional regressions of monthly returns on various firm characteristics of US stocks over the period 1968 to 2006. The independent variables are: size, the log of market value of equity as of June 31st of year t; book-to-market, the log of 1+book-to-market as of year *t-1*; Asset growth, the log of 1+percentage change in assets from year t-2 to year *t-1*; the investment-to-asset ratio, the log of 1+the investment-to-asset ratio; Holding costs, the idiosyncratic volatility over July of year t-1 through June of year t; Illiquid, the Amihud measure of illiquidity, for each firm, the time-series mean over July of year t-1 through June of year t; Gibbs the Gibbs sampler estimate of the Roll (1984) model over the calendar year t-1; and interactions between holding and trading costs, and book-to-market and asset growth. Beta estimates are time series averages of cross-sectional regression betas, obtained from monthly cross-sectional regressions. In brackets are t-statistics, and ** denote significance at the 1% level, * at the 5% level.

	1	2	3	4	5	6	7
Intercept	0.0199	0.0205	0.020554	0.0204	0.0183	0.0181	0.0171
	[4.68]	[4.86]	[4.85]	[4.85]	[7.92]	[7.37]	[6.30]
Size	-0.0013	-0.0017	-0.0012	-0.00115	-0.0009	-0.0007	-0.0007
	[-2.54*]	[-2.26*]	[-2.34*]	[-2.23*]	[-2.59*]	[-1.95]	[-1.66]
BM	0.003	0.0022	0.0025	0.0022	0.0029	0.0024	0.0023
	[4.24**]	[3.28**]	[3.64**]	[3.25**]	[4.6**8]	[3.95**]	[3.41**]
Asset growth		-0.01196		-0.0107	-0.001	-0.0012	0.2195
		[-9.47**]		[-6.93**]	[-0.42]	[-0.47]	[1.55]
Investment-to-asset ratio			-0.014	-0.0119			
			[-8.24**]	[-1.05]			
IVOL					-0.0057	-0.0567	-0.0672
					[-0.09]	[-0.80]	[-0.79]
*IVOL*Asset growth*					-0.264	-0.2805	-0.4155
					[-3.97**]	[-3.56**]	[-4.03**]
AMIHUD						312.76	
						[3.09**]	
*AMIHUD*Asset growth*						479.97	
						[1.67]	
GIBBS							0.0898
							[1.03]
*GIBBS*Asset growth*							0.2195
							[1.55]

Table 4. Fama-MacBeth regressions - risk premium estimates

The sample consists of monthly returns of 50 equal-sized portfolios. For each month, we estimate risk premiums by running cross-sectional regressions of portfolio returns on various factor loadings. These loadings are computed by regressing portfolio returns over the past ten years on an identical set of factor portfolios. SMB represents the return on a portfolio of small stocks less the return on a portfolio of large stocks while HML represents the return on a portfolio of high book-to-market-value stocks less the return on a portfolio of low book-to-market-value stocks. GRO represents the return on a portfolio of high asset growth stocks less the return on a portfolio of low asset growth stocks. MOM represents the return on a momentum strategy. We also compute HML and GRO for stocks with low, medium and high idiosyncratic volatility. Panel A contains the summary statistics and correlation coefficients on the factor portfolios. In panels B and C the mean risk premium estimates across the sample period are reported with their *t*-statistics. In Panel B the portfolios are sorted by beginning-of-period book-to-market ratio and contain all CRSP listed ordinary common equities from 1968 to 2006. In Panel C, the portfolios are sorted by beginning-of-period asset growth.

Panel A. Factor portfolio means and correlation matrix

	RMRF	SMB	HML	MOM	GRO	GRO Low RVOL	GRO Med RVOL	GRO High RVOL
Mean	0.0046	0.0015	0.0047	0.0080	0.0055	0.0036	0.0062	0.0101
Std. dev.	0.045	0.033	0.030	0.041	0.031	0.032	0.036	0.047
[t-stat]	[2.18]	[0.99]	[3.35]	[4.19]	[3.81]	[2.43]	[3.75]	[4.64]
RMRF		0.292	-0.081	-0.434	-0.331	-0.483	-0.477	-0.287
SMB			-0.009	-0.299	0.102	-0.191	-0.059	0.121
HML				-0.105	0.142	-0.041	0.140	0.253
MOM					0.370	0.553	0.547	0.279
GRO						0.569	0.799	0.839
GRO-Low							0.591	0.357
GRO-Med								0.630

Table 4. Fama-MacBeth regressions - risk premium estimates (Continued)

Panel B. 50 Portfolios sorted on asset growth

Model	Intercept	RMRF	SMB	MOM	HML	GRO	GRO Low IV	GRO Mid IV	GRO High IV
(1)	0.0158	-0.0090	0.0004	-0.0043	0.0053	0.0050			
	[4.23]	[-2.26]	[0.19]	[-1.58]	[2.91]	[2.98]			
(2)	0.0145	-0.0075	0.0013	-0.0035	0.0061		0.0027		0.0121
	[4.03]	[-1.94]	[0.58]	[-1.31]	[3.35]		[1.53]		[3.41]
(3)	0.0139	-0.0071	0.0014	-0.0042	0.0050		0.0020	0.0116	0.0098
	[3.90]	[-1.84]	[0.65]	[-1.49]	[2.69]		[1.14]	[3.88]	[2.81]

Table 5. Returns and coefficients in event time sorted by IVOL

We sort firms at the end of each calendar year (event year 0) on asset growth and idiosyncratic volatility quintiles, and get monthly portfolio returns for 12 months starting in July of each of the 11 years centered around the year of the sort. We run a 3 factor model on each of the asset growth/idiosyncratic volatility portfolios for each event year. We report the difference in each of the regression coefficients for the 4 permutations of the highest and lowest asset growth and the highest and lowest idiosyncratic volatility portfolios. The difference assumes a long position in the lowest asset growth quintile portfolios and a short position in the highest asset growth quintile portfolios for low and high idiosyncratic volatility quintiles.

	Year										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
Alpha											
Low-High growth (Low	-0.006	-0.007	-0.009	-0.012	-0.011	-0.009	0.001	0.001	0.003	0.002	0.001
t-stat	-5.07	-5.50	-7.78	-9.47	-9.98	-8.50	0.96	0.76	2.18	1.53	0.83
Low-High growth (High	0.001	-0.001	-0.008	-0.023	-0.044	-0.026	0.022	0.012	0.007	0.005	0.003
t-stat	0.37	-0.64	-4.04	-11.64	-22.32	-11.68	10.60	5.68	3.86	2.34	1.78
MKTRF											
Low-High growth (Low	-0.03	-0.04	-0.07	-0.10	-0.11	-0.14	-0.09	-0.10	-0.11	-0.17	-0.09
t-stat	-0.95	-1.36	-2.42	-3.28	-4.14	-5.70	-3.53	-3.56	-3.74	-5.18	-2.62
Low-High growth (High	0.05	0.16	0.14	0.02	-0.10	-0.10	-0.10	-0.21	-0.13	-0.20	-0.10
t-stat	0.96	3.60	3.05	0.41	-2.07	-1.75	-1.90	-3.92	-2.77	-4.07	-2.33
HML											
Low-High growth (Low	0.17	0.21	0.10	0.08	0.17	0.11	0.15	0.26	0.03	0.03	0.14
t-stat	3.69	4.42	2.28	1.78	4.27	3.08	3.78	6.11	0.76	0.69	2.72
Low-High growth (High	-0.13	0.12	-0.01	0.13	0.30	0.42	0.45	0.29	-0.02	-0.06	0.00
t-stat	-1.80	1.80	-0.17	1.81	4.20	5.10	6.03	3.72	-0.25	-0.90	0.02
SMB											
Low-High growth (Low	0.04	0.14	0.05	0.19	0.10	0.06	0.01	0.03	-0.03	-0.08	-0.02
t-stat	0.89	3.21	1.27	4.80	2.92	1.79	0.37	0.86	-0.75	-1.92	-0.50
Low-High growth (High	0.10	-0.02	-0.04	0.10	0.17	-0.15	0.38	0.39	0.16	0.08	0.01
t-stat	1.64	-0.37	-0.60	1.61	2.75	-2.13	5.85	5.66	2.66	1.34	0.09

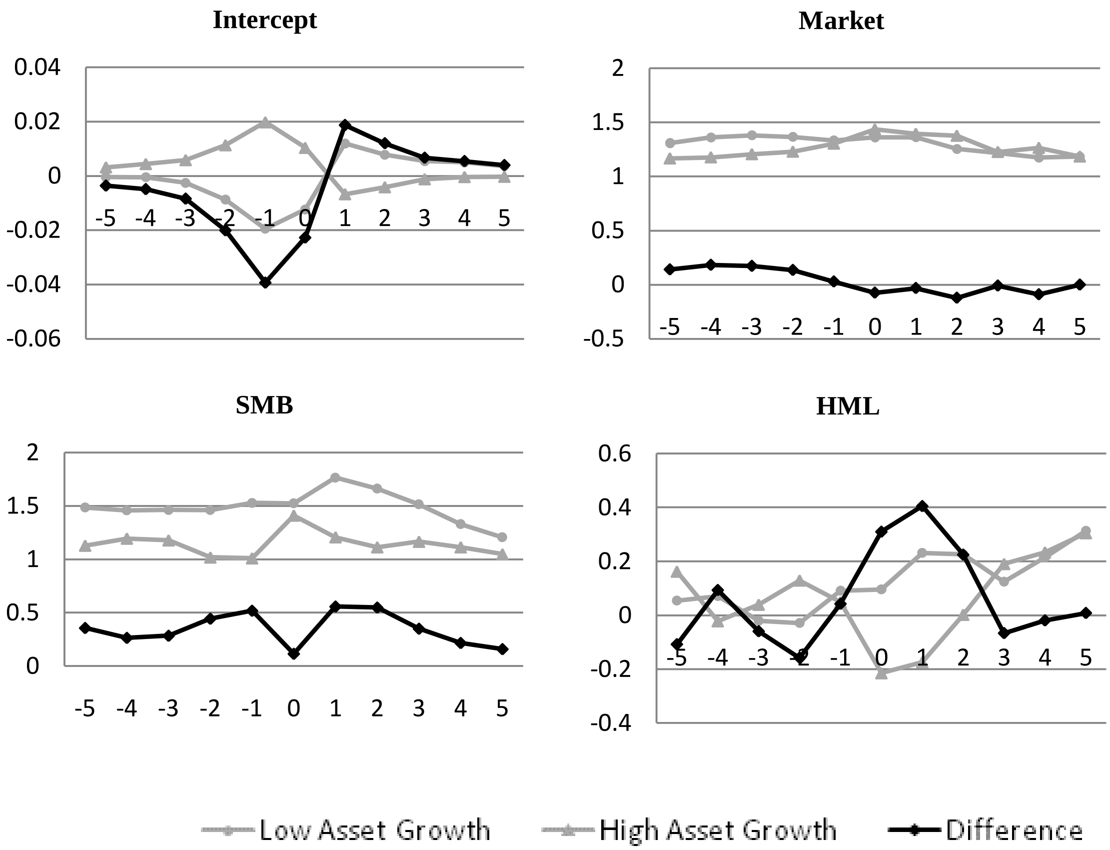

Figure 1. Asset growth portfolio return regression coefficients in event time
We sort firms at the end of each calendar year (event year 0) on asset growth quintiles, and get monthly portfolio returns for 12 months starting in July of each of the 11 years centered around the year of the sort. We run a 3 factor model on each asset growth portfolio for each event year. We plot each of the regression coefficients for the highest and lowest asset growth portfolios and for the arbitrage portfolio that takes a long position in the lowest asset growth quintile portfolio and a short position in the highest asset growth quintile portfolio.

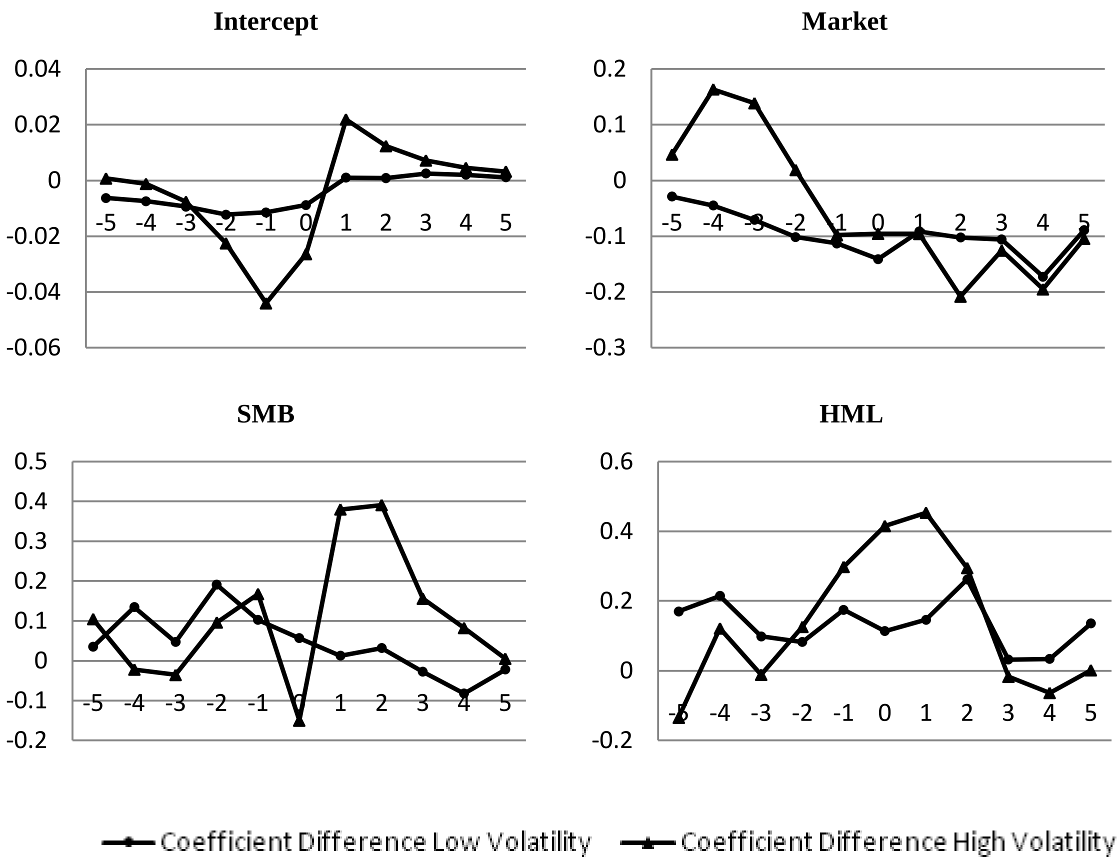

Figure 2. Asset growth return regression coefficients – Volatility sorted
We sort firms at the end of each calendar year (event year 0) on asset growth and idiosyncratic volatility quintiles, and get monthly portfolio returns for 12 months starting in July of each of the 11 years centered around the year of the sort. We run a 3 factor model on each of the asset growth/idiosyncratic volatility portfolios for each event year. We plot each of the regression coefficients for the 4 permutations of the highest and lowest asset growth and the highest and lowest idiosyncratic volatility portfolios (first two figures). The remaining figures plot the asset growth arbitrage portfolios that take a long position in the lowest asset growth quintile portfolios and a short position in the highest asset growth quintile portfolios for low and high idiosyncratic volatility quintiles.