Leverage Change and Stock Returns: the Role of Intangible Capital

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March 25, 2025

Abstract

Firm leverage is known to affect stock returns, but the impact of intangible capital (IK) on this relationship remains understudied. The lower collateral value associated with IK suggests that firms with high IK exhibit a higher probability of default, likely affecting the relationship between leverage and stock returns. In this paper, we examine how this relationship is affected in the presence of IK and find that the stock returns of firms with higher IK are more sensitive to leverage changes. Through portfolio analysis, we demonstrate that stocks with the largest leverage decreases substantially outperform those with increases, particularly for high IK firms. We propose a new "Intangible Delta Leverage (IDL)" factor that is not explained by other commonly used factors and develop a profitable long-short equity strategy based on leverage changes and IK ratios. Our findings highlight the importance of intangible assets in the leverage-return dynamic and offer new insights for asset pricing and investment strategies.

Keywords: Stock returns, Leverage change, Intangible capital, Equity investment strategy

JEL classification: E22, G11, G12, G32

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We are grateful for the invaluable guidance and recommendations of Galina Hale, Grace Gu, Alonso Villacorta, Hikaru Saijo, Brenda Samaniego de La Parra, Chenyue Hu, Bhavyaa Sharma, and the UC Santa Cruz Macro Workshop participants. We also appreciate the crucial suggestions of Valentin Haddad and Andrea Eisfeldt at early stages of this work.

1 Introduction

The relationship between financial leverage and equity returns remains a central topic in corporate finance and asset pricing, driving significant attention from both academics and industry practitioners seeking to understand asset price dynamics and identify investment opportunities. Previous studies have yielded mixed results, with some finding a positive relationship between leverage and returns (Bhandari (1988)), others documenting a negative relationship (Penman et al. (2007)), and still others suggesting a more nuanced, non-linear relationship (Ait-Sahalia et al. (2013)). This paper contributes to this ongoing debate by exploring the dynamic relationship between leverage changes and subsequent stock returns in the US market. Crucially, we extend the existing literature by focusing on the heterogeneity of this relationship across firms with differing concentrations of intangible capital (such as patents, brand value, highly skilled employees, systems and operations, among others). Our novel approach allows us to investigate how the increasing importance of intangible assets in modern economies may be altering traditional frameworks in corporate finance and asset pricing.

We show that the composition of a firm's assets, particularly the ratio of intangible capital to total assets, significantly alters the relationship between leverage and stock returns. Specifically, we document that firms with a higher concentration of intangible capital exhibit, on average, a greater probability of default. This heightened risk can be attributed, in part, to the lower collateral value of intangible assets, which constrains these firms' borrowing capacity and financial flexibility (Döttling and Ratnovski (2023); Caggese and Pérez-Orive (2022); Rampini and Viswanathan (2013)).

As firms with a higher share of intangible capital are perceived as riskier, so are their loans (Andrei et al. (2019); Eisfeldt and Papanikolaou (2013); Ai et al. (2020)). Therefore, shareholders may view firms with more intangible capital as facing a higher risk of under-investment following increases in leverage. This mechanism explains part of the negative relationship between leverage levels and changes and subsequent stock returns (Choi and

Richardson (2016); Korteweg (2010); Cai and Zhang (2011)).

To further explore this mechanism, we employ Merton (1974) structural model of credit risk, following an approach similar to Doshi et al. (2019). We compute firms' default probabilities and show that firms with a higher concentration of intangible capital are typically more likely to default. We also examine whether firms with a higher probability of default comprise portfolios with higher expected returns.

Specifically, we create portfolios based on leverage change quintiles and intangible capital/assets ratio (IK/A) terciles. We find that the average returns of stocks at the bottom quintile of leverage change are significantly larger than those at the top quintile, especially so for high IK/A firms. We further split our sample into default probability quintiles, and argue that those in the top quintile are significantly more profitable than those at the bottom quintile, suggesting that default probability plays an important role in the higher returns of high IK/A portfolios.

We also analyze the proposed portfolios from a time-series perspective. Creating equal-weighted and value-weighted portfolios, we compute the alphas of standard asset pricing models for each leverage change quintile and the difference between the first and fifth quintiles. The models we apply are the CAPM, the Fama and French (1992) 3-factor, the Fama and French (2015) 5-factor, and the Fama and French (2018) 6-factor. We show that leverage change portfolios cannot be fully explained by these standard factors, in line with Cai and Zhang (2011), and further argue that firms with high IK/A exhibit stronger alphas from these regressions.

Based on the portfolio analysis, we introduce a novel factor, "Intangible Delta Leverage (IDL)," which demonstrates significant explanatory power for returns of portfolios sorted on book-to-market, leverage, and intangibility. The IDL factor is developed based on our empirical findings, which indicate that firms with a high intangible capital to assets ratio (IK/A) and low delta leverage tend to exhibit stronger stock returns compared to those with low IK/A and high delta leverage.

Consequently, we construct the factor by subtracting the value-weighted average returns of portfolios with low IK/A and high delta leverage from those with high IK/A and low delta leverage. We average each of these portfolios across value, neutral, and growth stocks, controlling for the book-to-market component. The reasoning for this averaging process is to isolate the effect of intangible capital and leverage from the well-documented value effect. By including stocks across the value-growth spectrum, we ensure that the IDL factor captures a broader cross-section of the market and is not unduly influenced by the value or growth characteristics of the stocks.

Relying on the portfolio analysis and the factor creation, we develop an investment strategy. We present a long-short equity strategy based on leverage changes, leverage levels, and the intangible-to-assets ratio. Our findings suggest that this leverage change strategy is more effective for firms with a high concentration of intangible capital, aligning with our empirical results.

Specifically, our findings reveal that firms with high leverage levels and high IK/A are more sensitive to the negative relationship between leverage change and subsequent stock returns. Based on these insights, we propose a strategy that goes long on stocks with low delta leverage and short on those with high delta leverage, further segmenting the sample by leverage levels and IK/A. Notably, firms with high leverage levels and high IK/A exhibit the most promising results, suggesting that the interplay between intangible assets and financial leverage is particularly significant for these companies. This heightened sensitivity may be attributed to the increased financial risk associated with high leverage, combined with the uncertainty and potential growth opportunities inherent in firms with a high concentration of intangible capital. These findings not only contribute to our understanding of the factors driving stock returns but also offer practical implications for portfolio management and risk assessment.

Our paper relates to the work of Eisfeldt and Papanikolaou (2013) and Eisfeldt et al. (2020), who explored how the increase in intangible capital has changed the relationship between firm fundamentals and stock returns. They used organization capital stocks to explain cross-sectional expected returns and incorporated intangible capital into the book-to-market ratio proposed by Fama and French (1992) and Fama and French (1993). We resort to Eisfeldt et al. (2020)'s intangible capital measure to classify firms into high and low IK/A, and show how these groups exhibit different sensitivity between leverage changes and stock returns.

We further extend the literature by showing that portfolios based on leverage changes and levels can be further enhanced by accounting for capital intangibility. Studies have related high leverage levels to debt overhang, and suggested that firms with higher leverage levels exhibit higher stock returns following a large deleveraging (Cai and Zhang (2011); George and Hwang (2010); Korteweg (2010); Dimitrov and Jain (2008)). We show that firms with high IK/A are more sensitive to this relationship, in particular those with high leverage levels. This finding aligns with recent studies highlighting the growing importance of intangible assets in firm valuation and performance (Peters and Taylor (2017); Crouzet and Eberly (2019); Crouzet et al. (2022)).

Furthermore, we contribute to the literature on asset pricing factors, building upon seminal works by Fama and French (1992), Fama and French (1993), and Fama and French (2015). These papers present the standard 3-factor and 5-factor Fama and French models, which have been used as benchmarks for a large number of asset pricing factors presented in the literature.

Our findings show that incorporating the IDL factor enhances the R^2 of Fama and MacBeth (1973) regressions of portfolio returns on factor loadings. This analysis extends the work of Hou et al. (2015) and Hou et al. (2019), who developed a q-factor model that performs comparably to or better than traditional factor models in explaining cross-sectional return anomalies.

Our work also builds on studies examining leverage-based equity trading strategies (Choi and Richardson (2016); Cai and Zhang (2011), D'Mello and Sivaprasad (2015), Muradoğlu and Sivaprasad (2012)). Muradoğlu and Sivaprasad (2012) focuses mostly on leverage levels to create portfolios and show that firms with low leverage earn higher returns in longer investment horizons. In D'Mello and Sivaprasad (2015), however, the authors argue that returns increase with leverage using Indian firms to develop their strategy. More specifically, our paper extends Cai and Zhang (2011) by creating long-short portfolios based not only on leverage change and levels, but also on capital intangibility, highlighting its role on leverage and stock returns.

The rest of this paper is organized as follows: Section 2 presents the data and the main specification, Section 3 presents multiple subsections where we create portfolios based on leverage change and levels, capital intangibility, and probability of default. Section 4 shows the proposal of the "Intangible Delta Leverage" (IDL) asset pricing factor, and in Section 5 we propose a new investment strategy based on leverage and capital intangibility. Section 6 concludes.

2 Benchmark methodology and results

This section describes the data and methodology used to identify how firms' capital intangibility can be used to better understand the relationship between leverage and stock returns, contributing to practical implementations of equity investment strategies. We use monthly stock returns from CRSP and quarterly balance sheet data from Compustat. The sample spans from 1975-12 to 2019-11, and the data cleaning follows the literature by excluding all financial and utility firms (banking, insurance, real estate, trading, and utilities industries as defined by Fama and French (1997))[1]. Only common stocks traded on NYSE, AMEX, and NASDAQ are included in our analysis.

Our main specification measures how stock returns are affected by firm leverage variation using a Fama and MacBeth (1973)-type regression as shown in equation 1.

[1]Firms with SIC between 4900-4999 and 6000-6999 are excluded.

$$ret_{i,t+1} = \alpha_t + \beta_1 \Delta Lev_{i,t} + \beta_2 \mathbf{X}_{t,i} + \epsilon_{i,t} \tag{1}$$

where $ret_{i,t+1}$ is the 1-month ahead return for firm i, $\Delta Lev_{i,t}$ is the change in firm i's leverage in the most recent quarter, and $\mathbf{X}_{t,i}$ is a vector of control variables including the leverage level, the Fama and French (1992) stock beta estimated with a 24-month rolling window, the log of the market value of equity, the book-to-market ratio, the return on equity (ROE), the prior one-year return, and the prior one-month return. Leverage is measured as the book value of total liabilities divided by the book value of total assets.

The book-to-market ratio is computed based on the literature that uses quarterly Compustat and monthly CRSP data (Hou et al. (2015), Hou et al. (2019), Hou et al. (2020)). We take the book value of equity (common equity, Compustat account CEQ) with a 3-month lag with respect to the quarter-end date to guarantee that it is known to the public at the current period. The market value of equity is computed in the current month by multiplying number of shares outstanding (CSHO) by shares' prices (PRC), and the book-to-market is the ratio of these two accounts.

The stock beta estimation uses monthly excess market returns from Kenneth French's website and stock returns from CRSP in excess of the risk-free rate, also obtained from Kenneth French's website. In addition to removing financial and utilities firms, we exclude those with non-positive book value of equity and negative total liabilities to prevent extreme leverage values. Details about the CRSP-Compustat merging procedure are provided in Appendix A.

Our clean dataset comprises 14,732 firms and 528 periods (monthly data from 1975-12 to 2019-11). Table 1 presents the summary statistics of the variables of interest.

Variable	Mean	Median	Standard Deviation
Market value of equity	2.33	0.13	15.14
Leverage	0.47	0.47	0.22
Leverage change	0.0034	-0.0000	0.0615
Book-to-Market Ratio	0.73	0.54	0.71
Log(assets)	5.13	4.98	2.15

Table 1: CRSP monthly and Compustat quarterly data from 1975-12 to 2019-11. Selected only common stocks traded on NYSE, AMEX, and NASDAQ, and excluded financial firms, utility firms, and those with non-positive book value of equity or negative values of total liabilities. Leverage is calculated as the firms' book value of total liabilities divided by the book value of total assets.

2.1 Main specification results

The results from the Fama and MacBeth (1973) regression 1 are presented in Table 2. We examine how leverage changes in the most recent quarter impact stock returns in the subsequent month. The first column shows the results for all stocks in our sample, the second column presents the results for firms with high leverage and high intangible capital as a proportion of total assets (IK/A), and the third column shows the results for firms with high leverage and low IK/A.

The intangible capital measure we use is developed by Eisfeldt et al. (2020) and can be obtained from Edward T. Kim's Github webpage. Leverage is defined as total liabilities over total assets, and leverage change is the variation in leverage with respect to the previous quarter. Our results suggest that leverage change in a given quarter is negatively associated with the following month's stock returns, in line with Cai and Zhang (2011), Penman et al. (2007), Korteweg (2004), and George and Hwang (2010). The latter three find that returns decrease in leverage, while Cai and Zhang (2011) argue that firms with high leverage levels exhibit an especially sensitive relationship between leverage change and subsequent stock returns, which we confirm in columns 2 and 3 of Table 2. We also show that firms with high IK/A and high leverage levels are particularly sensitive to leverage changes.

In column 2 of Table 2 (high leverage and high IK/A), the main coefficient's 95% confidence interval spans from -12.32 to -6.1, compared to -7.93 to -2.89 in the third column (firms with high leverage and low IK/A). Even with a much higher standard error, the confidence interval for column 2's coefficient does not overlap with that of column 1 (all stocks), suggesting a significantly stronger effect. On the other hand, there is a large overlap between the confidence intervals of the coefficients in columns 1 and 3, indicating that most of the difference between the leverage change coefficients can be explained by the concentration of intangible capital.

The comparison between columns 2 and 3 further corroborates this hypothesis. Column 2's results suggest that the stock returns of firms with high leverage and high IK/A are more sensitive to leverage changes than those of firms with high leverage and low IK/A. Despite large standard errors, the confidence intervals share a relatively small overlap, suggesting a stronger effect for firms with high leverage and high IK/A.

Our findings indicate that, among all firms, a 1% increase in leverage with respect to the previous quarter leads to a 3.4% decrease in monthly stock returns in the following month. The magnitude of this impact grows to 9.21% for firms with high leverage and high IK/A. These results confirm that understanding capital intangibility can enhance investment strategies based on leverage change, and better explain the cross-section of returns. In the following sections, we explore how to leverage these findings to create profitable equity portfolios and discuss the possible mechanisms behind this relationship.

3 Portfolios

This section develops several visualizations based on firms' leverage change, leverage level, and capital intangibility to explore how these characteristics can be used to form equity portfolios. We contribute to a vast literature that presents investment strategies based on firms' leverage (Choi and Richardson (2016), D'Mello and Sivaprasad (2015), Amin and Mollick (2022), Cai and Zhang (2011)) by incorporating capital intangibility into the portfolio formation process.

The first part of this section is dedicated to exploring the role of firms' default probability in understanding the impact of capital intangibility on stock returns. Literature suggests that firms with a high concentration of intangible capital tend to borrow less due to intangibles' low collateral value (Döttling and Ratnovski (2023), Caggese and Pérez-Orive (2022), Rampini and Viswanathan (2013)). Consequently, it is expected that firms with a high concentration of intangibles might be more likely to default on their debt. If this hypothesis holds, one could expect firms with high intangibles to be riskier and demand a higher return to compensate for the increased default risk.

To further explore this hypothesis, we employ Merton (1974)'s model to compute firms' probability of default. The following subsection presents the details of this model.

3.1 Probability of default: The Merton model

We employ a version of Merton (1974) structural model to estimate default probabilities for individual firms. Our approach is similar to the one outlined by Vassalou and Xing (2004), with slight modifications in the implementation. The Merton model views the equity of a firm as a call option on the firm's assets. The strike price of this option is the book value of the firm's liabilities. Following Merton (1974), we assume that the market value of a firm's underlying assets follows a geometric Brownian motion:

$$dV_A = \mu V_A \, dt + \sigma_A V_A \, dW \tag{2}$$

where V_A is the firm's asset value, μ is the instantaneous drift, σ_A is the instantaneous volatility of the firm's assets, and W is a standard Wiener process. The market value of equity, V_E, is given by the Black and Scholes (1973) formula for call options:

$$V_E = V_A N(d_1) - X e^{-rT} N(d_2) \tag{3}$$

where X is the book value of debt, r is the risk-free rate, T is the time horizon, $N()$ is the cumulative standard normal distribution function, and

$$d_1 = \frac{\ln\left(\frac{V_A}{X}\right) + \left(r + 0.5\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \tag{4}$$

$$d_2 = d_1 - \sigma_A\sqrt{T} \tag{5}$$

To estimate the unobservable parameters V_A and σ_A, we use an iterative procedure. We start with an initial guess for the asset volatility, σ_A, using the equity volatility, σ_E, scaled by the leverage ratio, as in equation 6. In this equation, V_E is the annualized monthly standard deviation of equity over 12 months for each firm, and V_E is the market value of equity.

$$\sigma_A = \sigma_E \cdot \left(\frac{V_E}{V_E + X}\right) \tag{6}$$

We then use the Black-Scholes formula to compute monthly values of V_A, with an initial guess of $V_A = V_E + X$ and the initial guess of σ_A as in equation 6. Through the iterative process, the standard deviation of these V_A values provides a new estimate of σ_A. This process is repeated until the values of V_A and σ_A from two consecutive iterations converge. Then, we calculate the distance to default (DD) as:

$$DD = \frac{\ln\left(\frac{V_A}{X}\right) + \left(\mu - 0.5\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \tag{7}$$

The default probability is then computed as:

$$P_{\mathrm{def}} = N(-DD) \tag{8}$$

In our implementation, we use monthly data and set the time horizon T to 40.56 (3.38 years), which is longer than the 1-year horizon used by Vassalou and Xing (2004), and in line with Doshi et al. (2019). The reasoning for this is to use a more recent average time to maturity of Compustat firms debt. We use the 1-month Treasury Bill rate from Kenneth

French's website as the risk-free rate. For the book value of debt, we use the book value of total liabilities, following Vassalou and Xing (2004)'s approach.

Our code includes additional safeguards to ensure numerical stability, such as preventing extreme values in the iterative process and handling potential convergence issues. We also compute equity volatility using a rolling 12-month window of returns, which allows for time-varying volatility estimates. This implementation of the Merton model provides us with monthly estimates of default probabilities and distances to default for each firm in our sample, allowing us to examine the relationship between default risk and equity returns.

In Figure 1, we present the average probability of default calculated according to this model. We use our full dataset, which spans from 1975-01 to 2020-12, slightly longer than the time span used in the portfolio formation of the following subsections. This extended period is due to data availability when creating quantiles for portfolio formation. The shaded regions in Figure 1 represent U.S. recessions as defined by the NBER. The average probability of default clearly captures significant economic events, including the dotcom bubble in the early 2000s, the Global Financial Crisis in 2007-2009, and the COVID-19 pandemic in 2020.

Figure 2 illustrates the relationship between the average probability of default from this model and the average intangible/assets ratio for each month/year in our sample. Each dot in the graph represents these averages for a specific time period. A positive correlation can be observed, suggesting that firms with a higher concentration of intangible capital tend to have a higher probability of default.

In the following subsections, we demonstrate how this probability of default can explain differences in portfolios based on leverage change and capital intangibility, shedding light on the type of risk factor captured by these portfolios.

3.2 Leverage change and intangibility-based portfolios

This subsection explores portfolio creation based on leverage change, intangible/assets ratio, and firms' probability of default. Our aim is to investigate whether portfolios of firms with

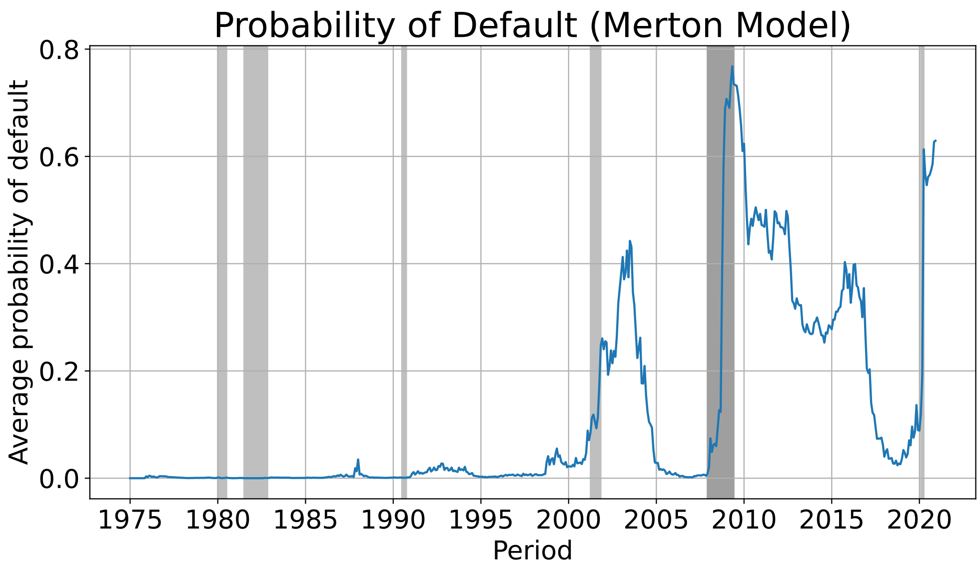

Figure 1: The average probability of default across firms calculated with the Merton model. Shaded areas represent recessions in the US as defined by the NBER.

higher default probability exhibit higher average returns.

Portfolio formation follows this procedure: we calculate equal-weighted and value-weighted returns 1 month and 2 months after the most recent quarterly leverage change. Firms are sorted into quintiles based on leverage change. We compute the difference between average stock returns for firms in the bottom quintile (Q1) and top quintile (Q5) of leverage change, denoted as (1-5). We calculate t-statistics, standard errors, and 95% confidence intervals for the time series of these differences. Additionally, we split firms into the lowest and highest terciles of intangible/assets ratio.

This process is performed for the entire sample and separately for subsamples of firms with high and low probability of default. Quintiles are computed for each time period, allowing firms to move between groups over time. To avoid misrepresentation, we require each portfolio to have at least 30 stocks, following Cai and Zhang (2011). Tables 7 - 9 present results for all stocks and for subgroups with high and low default probability, respectively.

In Table 7 (full sample), the return difference (1-5) is larger for firms with high intangible capital/assets (IK/A). For equal-weighted returns, the 95% confidence intervals for low and high IK/A stocks barely overlap (0.68 - 1.05% vs. 1.02 - 1.48%), indicating significantly

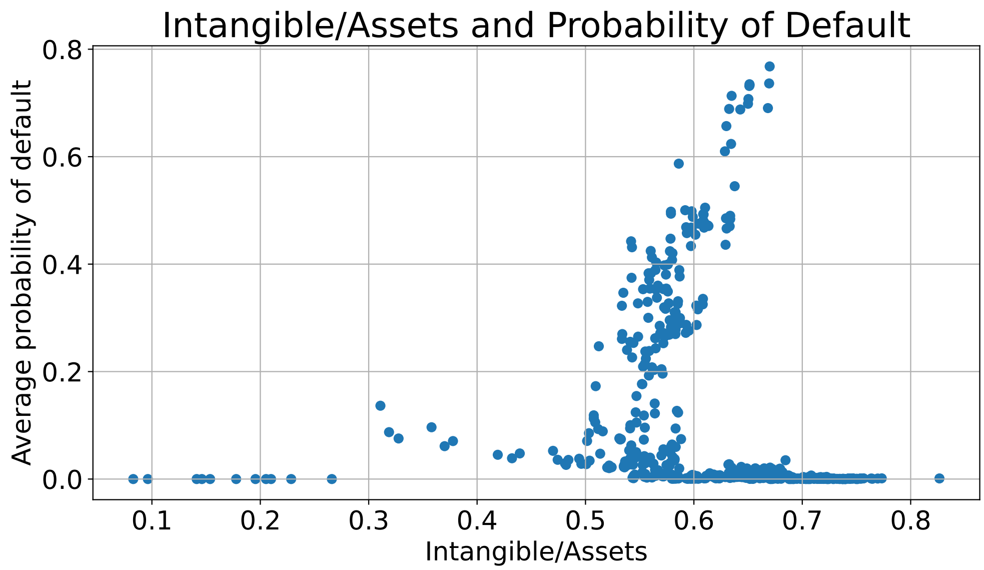

Figure 2: The relationship between the average probability of default from the Merton model and the weighted average intangible/assets across firms. Each dot represents one time period.

higher average returns for high IK/A firms. This trend persists in the 2nd month after the leverage change date.

In Table 8) (high default probability firms), value-weighted average returns are significantly higher than in the full sample. For firms in the top tercile of IK/A, the average (1-5) difference is 1.61%, compared to 0.58% in the full sample. Non-overlapping 95% confidence intervals (0.99 - 2.25% vs. 0.27 - 0.88%) indicate significantly stronger returns.

Finally, the results in Table 9) (low default probability firms) suggest that these firms exhibit lower average returns compared to high default probability firms. For high IK/A firms, the 95% confidence intervals for the (1-5) difference do not overlap between low and high default probability groups (0.05-0.91% vs. 1.15-2.06%), indicating lower average returns for lower default probability firms.

These results suggest that by categorizing firms according to their capital intangibility, we capture a risk factor associated with the probability of default. Building on this insight, we create new portfolios by grouping firms according to leverage change and leverage levels, then subsampling them based on their capital intangibility. This approach allows us to explore the higher probability of default expected from firms with high leverage levels. By focusing on firms with high IK/A, we aim to capture the risk factor associated with default probability.

3.3 Leverage Change and Leverage Level Portfolios by Intangibility

In this subsection, we construct portfolios based on leverage change, leverage level, and capital intangibility. We group stocks into quintiles of leverage change and quartiles of leverage level, applying these groupings to subsamples of firms with high or low intangible capital to assets ratio (IK/A) based on their terciles. We create equal-weighted and value-weighted portfolios using 1-month and 2-month ahead average returns with respect to Compustat's quarter-end. As in subsection 3.2, we only retain portfolios with at least 30 stocks to ensure robust representation.

Tables 10 - 12 present the results. For firms in the top quartile of leverage level, the (1-5) difference based on leverage change for equal-weighted portfolios is 1.94% for the full sample (Table 10), compared to 2.30% for the subsample of high IK/A stocks (Table 11). The 95% confidence intervals barely overlap (1.71% - 2.29% vs. 2.18% - 3.27%), suggesting significantly higher average returns for high IK/A stocks.

Comparing portfolios formed by stocks with low or high IK/A (Table 12 vs. Table 11), we find significantly higher average returns for the latter. With average estimates of 2.30% vs. 1.28%, the 95% confidence intervals (2.18% - 3.27% vs. 1.14% - 1.95%) indicate substantially higher average returns for high IK/A stocks.

We also present in Table 13 the leverage change for each of these portfolios. For firms with a high leverage level (top quartile), the leverage change for high IK/A stocks (Panel B) is slightly stronger than those of all stocks and low IK/A stocks (Panels A and C, respectively). For the bottom quintile of leverage change, the average change was -5.32% for high IK/A stocks, compared to -4.72% for all stocks and -4.85% for low IK/A stocks. For the top quintile, however, the numbers are very similar: 9.04% for high IK/A, compared to 8.59%

for all stocks and 8.93% for low IK/A ones. This suggests that the results from Tables 10 - 12 are mostly driven by the sensitivity of the relationship between leverage change and stock returns rather than by the leverage change itself. This goes in line with the results from Table 2.

These findings, together with those of subsections 2.1 and 3.2, suggest that the interaction of leverage change, leverage level, and capital intangibility can potentially serve as an asset pricing factor. To further explore this hypothesis, we present a time series analysis in the following section, comparing how standard asset pricing factors perform in explaining excess returns of portfolios based on these characteristics.

	Stock return (%)		
	All stocks	High leverage High IK/A	High leverage Low IK/A
Leverage Change	-3.40***	-9.21***	-5.41***
	(0.39)	(1.59)	(1.29)
	[-4.16, -2.64]	[-12.32, -6.10]	[-7.93, -2.89]
Leverage	0.12	-0.04	0.20
	(0.24)	(0.34)	(0.31)
	[-0.36, 0.60]	[-0.72, 0.63]	[-0.41, 0.81]
Beta	0.12	0.20	-0.09
	(0.09)	(0.12)	(0.10)
	[-0.05, 0.29]	[-0.04, 0.44]	[-0.28, 0.10]
Log Market Value of Equity	-0.11***	-0.18***	-0.05
	(0.04)	(0.06)	(0.04)
	[-0.19, -0.04]	[-0.30, -0.07]	[-0.13, 0.03]
Book-to-Market Ratio	1.32***	1.65***	1.23***
	(0.06)	(0.17)	(0.12)
	[1.19, 1.44]	[1.30, 1.99]	[0.99, 1.48]
Return on Equity	2.28***	1.59***	2.59***
	(0.17)	(0.26)	(0.33)
	[1.94, 2.61]	[1.08, 2.10]	[1.94, 3.24]
Previous one-year return	0.51***	0.06	0.79***
	(0.10)	(0.17)	(0.19)
	[0.32, 0.70]	[-0.27, 0.38]	[0.41, 1.16]
Previous month return	-5.05***	-5.41***	-3.22***
	(0.34)	(0.69)	(0.56)
	[-5.71, -4.39]	[-6.77, -4.05]	[-4.32, -2.11]
Observations	1441567	102536	153715
Number of Firms	13254	3828	3891
R^2	0.00833	0.00914	-0.00379

Table 2: Results of the specification $ret_{i,t+1} = \alpha_t + \beta_1 \Delta Lev_{i,t} + \beta_2 \mathbf{X}t, i + \epsilon_{i,t}$, where $ret_{i,t+1}$ is the 1-month ahead return for firm i, $\Delta Lev_{i,t}$ is the change in firm i's leverage in the most recent quarter, and $\mathbf{X}_{t,i}$ is a vector of control variables. Columns (2) and (3) give the results of high leverage (top quartile) and high (low) intangible capital to total assets ratio (IK/A) - top (bottom) tercile.

3.4 Portfolios from a time-series perspective

In this subsection, we create portfolios based on leverage change quintiles as before but analyze them from a time-series perspective by using standard asset pricing factors to explain excess returns. Specifically, we compute the monthly average portfolios' excess return with respect to the risk-free rate (1-month Treasury Bill rate from Kenneth French's website) and regress them on standard asset pricing factors.

The pricing factors, all from Kenneth French's website, include: the market excess return, the small-minus-big (SMB), the high-minus-low (HML), the momentum factor (UDM), the conservative-minus-aggressive (CMA), and the robust-minus-weak (RMW). Following the literature, we use models comprising these factors: CAPM (market excess return), the Fama and French (1992) 3-factor model (market excess return, SMB, and HML), the Fama and French (2015) 5-factor model (market excess return, SMB, HML, CMA, and RMW), and the Fama and French (2018) 6-factor model (5-factors plus UMD).

We create the time-series by averaging excess returns across all stocks within a given leverage change quintile for each time period. The series are created with equal-weighted and value-weighted averages (according to the market value of equity), and we run the following time-series regression on each portfolio:

$$r_{it} - r_{ft} = \alpha_i + \beta' F_t + \epsilon_{it}, \quad \text{for } i = 1 \text{ to } 5 \tag{9}$$

where r_{it} are the monthly portfolio returns (equal-weighted and value-weighted), r_{ft} is the risk-free rate, and F_t are the pricing factors as previously explained. The alphas represent the risk-adjusted returns of the portfolios. The alphas are not similar across leverage change portfolios, indicating that these asset pricing factors cannot fully explain their cross-sectional return patterns, in line with Cai and Zhang (2011) and Novy-Marx (2011), who argue that leverage adds information to the cross section of returns.

We further split the sample to create portfolios with high and low intangible capital/assets

(IK/A). From our previous findings, we learned that firms with high IK/A are more sensitive to the relationship between leverage change and stock returns. Therefore, we expect to find differing alphas for these portfolios depending on capital intangibility.

The results are shown in Tables 3 - 5. Besides the alphas of the 5 leverage change quintiles, we compute the alpha associated with the difference between Q1 and Q5 average returns (1-5). We find that alphas are overall strongly significant except for Q5, including those of the difference 1-5. Comparing the difference 1-5 alphas in Table 3 with those of Tables 4 and 5, we observe significantly stronger coefficients for high IK/A stocks. The differences are stable across all models, and the non-overlapping 95% confidence intervals suggest that high IK/A stocks exhibit higher unexplained excess returns compared to all stocks (1.22-1.77% vs. 0.85-1.17%). There is some overlap between the confidence intervals of the value-weighted portfolios, but the point estimate suggests somewhat different coefficients, in line with the equal-weighted results.

Based on these results and those of the previous subsections, there is evidence indicating that firms with high IK/A are more sensitive to the negative correlation between leverage change and stock returns. In the following section, we create portfolios based on leverage change, asset intangibility, and book-to-market to propose a new asset pricing factor, the Intangible Delta Leverage (IDL).

	Leverage change portfolio					
	1	2	3	4	5	Difference 1-5
Panel A: Equal-Weighted Portfolio						
CAPM	1.28***	1.19***	0.97***	0.70***	0.27	1.01***
	[0.26]	[0.24]	[0.24]	[0.25]	[0.29]	[0.08]
	(0.76, 1.80)	(0.71, 1.67)	(0.50, 1.44)	(0.21, 1.20)	(-0.30, 0.83)	(0.85, 1.17)
3-factor	1.30***	1.20***	0.98***	0.73***	0.28	1.02***
	[0.27]	[0.25]	[0.24]	[0.25]	[0.29]	[0.08]
	(0.77, 1.82)	(0.72, 1.68)	(0.50, 1.45)	(0.23, 1.23)	(-0.29, 0.85)	(0.85, 1.18)
5-factor	1.45***	1.31***	1.09***	0.88***	0.44	1.01***
	[0.28]	[0.25]	[0.25]	[0.26]	[0.30]	[0.09]
	(0.91, 1.99)	(0.81, 1.81)	(0.60, 1.58)	(0.36, 1.39)	(-0.15, 1.02)	(0.84, 1.18)
6-factor	1.49***	1.36***	1.15***	0.92***	0.48	1.01***
	[0.28]	[0.26]	[0.25]	[0.26]	[0.30]	[0.09]
	(0.95, 2.04)	(0.85, 1.86)	(0.65, 1.64)	(0.40, 1.44)	(-0.11, 1.07)	(0.84, 1.18)
Panel B: Value-Weighted Portfolio						
CAPM	0.81***	0.71***	0.70***	0.45**	0.42*	0.39***
	[0.22]	[0.20]	[0.19]	[0.20]	[0.22]	[0.10]
	(0.38, 1.24)	(0.31, 1.10)	(0.33, 1.08)	(0.06, 0.85)	(-0.01, 0.86)	(0.18, 0.59)
3-factor	0.84***	0.75***	0.74***	0.50**	0.45**	0.39***
	[0.22]	[0.20]	[0.19]	[0.20]	[0.22]	[0.11]
	(0.41, 1.27)	(0.35, 1.15)	(0.36, 1.12)	(0.10, 0.89)	(0.01, 0.89)	(0.18, 0.60)
5-factor	0.95***	0.83***	0.85***	0.60***	0.57**	0.39***
	[0.23]	[0.21]	[0.20]	[0.21]	[0.23]	[0.11]
	(0.51, 1.40)	(0.42, 1.24)	(0.46, 1.25)	(0.19, 1.01)	(0.11, 1.02)	(0.17, 0.60)
6-factor	0.99***	0.85***	0.87***	0.59***	0.60***	0.38***
	[0.23]	[0.21]	[0.20]	[0.21]	[0.23]	[0.11]
	(0.54, 1.44)	(0.43, 1.27)	(0.47, 1.27)	(0.18, 1.01)	(0.15, 1.06)	(0.16, 0.60)

Table 3: Results of the time-series regressions $r_{it} - r_{ft} = \alpha_i + \beta' F_t + \epsilon_{it}$, where r_{it} are the monthly portfolio returns (equal-weighted and value-weighted), r_{ft} is the risk-free rate, and F_t are the pricing factors as explained in the text. All stocks were included regardless of their intangible capital/assets (IK/A) ratio.

	Leverage change portfolio					
	1	2	3	4	5	Difference 1-5
Panel A: Equal-Weighted Portfolio						
CAPM	1.75***	1.44***	1.30***	1.07***	0.25	1.50***
	[0.29]	[0.26]	[0.27]	[0.28]	[0.33]	[0.14]
	(1.17, 2.32)	(0.93, 1.95)	(0.78, 1.83)	(0.53, 1.62)	(-0.40, 0.90)	(1.22, 1.77)
3-factor	1.78***	1.47***	1.32***	1.08***	0.27	1.51***
	[0.29]	[0.26]	[0.27]	[0.28]	[0.33]	[0.14]
	(1.20, 2.35)	(0.95, 1.98)	(0.79, 1.85)	(0.54, 1.63)	(-0.38, 0.92)	(1.22, 1.79)
5-factor	1.94***	1.60***	1.45***	1.29***	0.46	1.48***
	[0.30]	[0.27]	[0.28]	[0.29]	[0.34]	[0.15]
	(1.35, 2.53)	(1.07, 2.13)	(0.91, 2.00)	(0.73, 1.85)	(-0.21, 1.14)	(1.19, 1.77)
6-factor	1.97***	1.63***	1.50***	1.35***	0.49	1.48***
	[0.30]	[0.27]	[0.28]	[0.29]	[0.35]	[0.15]
	(1.37, 2.57)	(1.10, 2.17)	(0.95, 2.05)	(0.78, 1.91)	(-0.18, 1.17)	(1.18, 1.77)
Panel B: Value-Weighted Portfolio						
CAPM	1.14***	0.91***	0.66***	0.71***	0.43*	0.71***
	[0.24]	[0.23]	[0.22]	[0.23]	[0.25]	[0.18]
	(0.68, 1.60)	(0.46, 1.35)	(0.22, 1.09)	(0.27, 1.15)	(-0.07, 0.93)	(0.35, 1.07)
3-factor	1.19***	0.91***	0.68***	0.73***	0.45*	0.73***
	[0.24]	[0.23]	[0.22]	[0.23]	[0.26]	[0.19]
	(0.72, 1.65)	(0.46, 1.36)	(0.24, 1.12)	(0.28, 1.18)	(-0.05, 0.96)	(0.37, 1.10)
5-factor	1.28***	1.00***	0.77***	0.86***	0.63**	0.65***
	[0.25]	[0.24]	[0.23]	[0.23]	[0.26]	[0.19]
	(0.79, 1.76)	(0.54, 1.46)	(0.32, 1.23)	(0.40, 1.32)	(0.11, 1.14)	(0.27, 1.03)
6-factor	1.32***	1.08***	0.84***	0.90***	0.73***	0.58***
	[0.25]	[0.24]	[0.23]	[0.24]	[0.26]	[0.19]
	(0.83, 1.80)	(0.62, 1.55)	(0.38, 1.30)	(0.43, 1.37)	(0.21, 1.25)	(0.21, 0.96)

Table 4: Results of the time-series regressions $r_{it} - r_{ft} = \alpha_i + \beta' F_t + \epsilon_{it}$, where r_{it} are the monthly portfolio returns (equal-weighted and value-weighted), r_{ft} is the risk-free rate, and F_t are the pricing factors as explained in the text. Only stocks with a high intangible capital/assets (IK/A) ratio were included (top tercile).

	Leverage change portfolio					
	1	2	3	4	5	Difference 1-5
Panel A: Equal-Weighted Portfolio						
CAPM	0.98***	1.00***	0.83***	0.24	0.05	0.92***
	[0.29]	[0.26]	[0.24]	[0.27]	[0.30]	[0.12]
	(0.41, 1.55)	(0.50, 1.51)	(0.36, 1.30)	(-0.29, 0.77)	(-0.54, 0.65)	(0.69, 1.16)
3-factor	0.98***	1.01***	0.84***	0.27	0.05	0.92***
	[0.29]	[0.26]	[0.24]	[0.27]	[0.31]	[0.12]
	(0.40, 1.55)	(0.50, 1.52)	(0.36, 1.31)	(-0.26, 0.81)	(-0.55, 0.65)	(0.69, 1.16)
5-factor	1.14***	1.14***	0.93***	0.42	0.20	0.94***
	[0.30]	[0.27]	[0.25]	[0.28]	[0.32]	[0.13]
	(0.55, 1.73)	(0.61, 1.66)	(0.44, 1.43)	(-0.13, 0.97)	(-0.42, 0.82)	(0.69, 1.18)
6-factor	1.22***	1.21***	0.99***	0.44	0.28	0.94***
	[0.30]	[0.27]	[0.25]	[0.28]	[0.32]	[0.13]
	(0.63, 1.82)	(0.68, 1.73)	(0.49, 1.49)	(-0.11, 1.00)	(-0.34, 0.91)	(0.69, 1.19)
Panel B: Value-Weighted Portfolio						
CAPM	0.79***	0.60***	0.63***	0.06	0.32	0.47***
	[0.27]	[0.23]	[0.21]	[0.24]	[0.28]	[0.16]
	(0.25, 1.32)	(0.15, 1.05)	(0.22, 1.05)	(-0.41, 0.53)	(-0.23, 0.87)	(0.14, 0.79)
3-factor	0.82***	0.61***	0.66***	0.08	0.33	0.49***
	[0.27]	[0.23]	[0.21]	[0.24]	[0.28]	[0.17]
	(0.28, 1.36)	(0.15, 1.06)	(0.25, 1.08)	(-0.39, 0.55)	(-0.23, 0.88)	(0.17, 0.82)
5-factor	0.97***	0.70***	0.80***	0.20	0.51*	0.46***
	[0.28]	[0.24]	[0.22]	[0.25]	[0.29]	[0.17]
	(0.41, 1.52)	(0.23, 1.17)	(0.37, 1.23)	(-0.29, 0.69)	(-0.06, 1.08)	(0.12, 0.79)
6-factor	1.00***	0.73***	0.81***	0.20	0.55*	0.46***
	[0.29]	[0.24]	[0.22]	[0.25]	[0.29]	[0.17]
	(0.44, 1.56)	(0.25, 1.20)	(0.38, 1.24)	(-0.29, 0.70)	(-0.03, 1.12)	(0.11, 0.80)

Table 5: Results of the time-series regressions $r_{it} - r_{ft} = \alpha_i + \beta' F_t + \epsilon_{it}$, where r_{it} are the monthly portfolio returns (equal-weighted and value-weighted), r_{ft} is the risk-free rate, and F_t are the pricing factors as explained in the text. Only stocks with a low intangible capital/assets (IK/A) ratio were included (bottom tercile).

4 IDL asset pricing factor

In this section, we build on the results from Section 3 and create portfolios based on quintiles of leverage change, terciles of capital intangibility, and the NYSE 30th and 70th breakpoints of book-to-market, adapting Fama and French (1992)'s methodology to our quarterly Compustat database. Specifically, in line with the literature utilizing the quarterly Compustat database (Hou et al. (2019), Hou et al. (2015), Hou et al. (2020)), we create the IDL factor by sorting all stocks, at the beginning of each month, into three groups based on the NYSE breakpoints for the low 30%, middle 40%, and high 30% of book-to-market. Independently, we also split the sample into quintiles of delta leverage and terciles of IK/A.

In this way, we create 45 portfolios (5 X 3 X 3) for each time period, and propose a new asset pricing factor to explain the cross-section of excess returns, which we call the Intangible Delta Leverage factor (IDL). To generate this factor, we form two main groups of portfolios: high IK/A (top tercile) with low leverage change (bottom quintile), and low IK/A (bottom tercile) with high leverage change (top quintile). We also control for book-to-market in these portfolios based on the NYSE breakpoints each period. Formally, the IDL factor is the following:

$$IDL_t = \frac{(GHILL_t + NHILL_t + VHILL_t)}{3} - \frac{(GLIHL_t + NLIHL_t + VLIHL_t)}{3} \tag{10}$$

where $GHILL$, $NHILL$, and $VHILL$ represent the averages of growth, neutral, and value stock portfolios with high IK/A (top tercile) and low leverage change (bottom quintile), respectively. Analogously, $GLIHL$, $NLIHL$, and $VLIHL$ represent the growth, neutral, and value portfolios with low IK/A (bottom tercile) and high leverage change (top quintile).

We use this factor together with standard asset pricing factors to explain the cross-section of returns. The 45 portfolios are re-balanced every month based on the quantiles from the current 10-Q announcements reported in Compustat. We employ Fama and MacBeth (1973) regressions, which uses a two-stage approach.

In the first stage, we run time-series regressions to compute the betas of excess portfolio returns on the asset pricing factors. In this step, we use a 24-month rolling window to allow betas to vary over time and capture changing market conditions. Equation 11 shows the first-stage regressions:

$$r_{it} - r_{ft} = \alpha_{it} + \beta'_{it} F_t + \epsilon_{it} \tag{11}$$

where r_{it} are the average returns of each portfolio i in excess of the risk-free rate r_{ft}, and F_t are the asset pricing factors including the proposed IDL factor.

In the second stage, we apply the standard Fama and MacBeth (1973) framework, which consists of cross-sectional regressions of excess returns on the estimated betas (equation 12), followed by simple time averages of the factor risk premium and pricing errors (equation 13).

$$r_{it} - r_{ft} = \alpha_t + \hat{\beta}'_{it} \lambda_t \tag{12}$$

$$\hat{\lambda} = \frac{1}{T} \sum_{i=1}^{T} \hat{\lambda}_t \qquad \hat{\alpha} = \frac{1}{T} \sum_{i=1}^{T} \hat{\alpha}_t \tag{13}$$

Table 6 presents the results. The proposed factor, IDL, is significant in predicting returns regardless of which other factors we add to the regressions. Adding the factors from the standard CAPM, the Fama and French (1992) 3-factor, the Fama and French (2015) 5-factor, and the Fama and French (2018) 6-factor model, we show that the "IDL" factor exhibits a significant loading in all the specifications, and improves the R^2. The HML factor is also significant for all the regressions where it is included, capturing the component related to firms' book-to-market. The results suggest that the inclusion of the "IDL" factor adds explanatory power to the portfolio returns.

These results, along with our previous findings, provide evidence that incorporating capital intangibility and leverage change can enhance equity investment strategies. In the following section, we present an equity long-short strategy based on these insights.

	CAPM	CAPM+	FF3	FF3+	FF5	FF5+	FF6	FF6+
IDL		-0.49***		-0.47***		-0.38**		-0.39**
		(-2.87)		(-2.64)		(-2.10)		(-2.10)
Mkt-RF	-0.45**	-0.43**	-0.43**	-0.29	-0.25	-0.15	-0.11	0.01
	(-2.27)	(-2.10)	(-2.10)	(-1.51)	(-1.09)	(-0.66)	(-0.44)	(0.04)
HML			-0.52***	-0.53***	-0.88***	-0.90***	-0.95***	-0.98***
			(-5.19)	(-5.72)	(-6.32)	(-6.73)	(-6.70)	(-7.11)
SMB			-0.10	-0.15	-0.04	-0.09	0.05	-0.02
			(-0.71)	(-1.10)	(-0.24)	(-0.61)	(0.33)	(-0.16)
CMA					-0.45***	-0.41***	-0.44***	-0.39***
					(-4.60)	(-4.28)	(-4.52)	(-4.13)
RMW					-0.01	0.07	0.04	0.15
					(-0.12)	(0.59)	(0.36)	(1.30)
UMD							1.16***	1.28***
							(5.39)	(5.91)
Intercept	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(10.15)	(11.00)	(10.16)	(10.58)	(10.71)	(10.47)	(12.30)	(11.88)
Observations	22572	22572	22572	22572	22572	22572	22572	22572
Number of portfolios	45	45	45	45	45	45	45	45
R^2	0.02808	0.06189	0.21926	0.26919	0.39847	0.42576	0.6534	0.67601

Table 6: Results of Fama and MacBeth (1973) regressions 11 - 13. Portfolio returns are regressed on 24-month rolling window factor loadings. We create 45 portfolios based on quintiles of leverage change, terciles of intangibility, and the standard NYSE 30th and 70th breakpoints of book-to-market.

5 Investment strategy

Next, we use our empirical findings to develop an investment strategy based on leverage change and levels. As before, we sort stocks into quintiles of leverage change each month (repeating the change with respect to the previous quarter over each quarter), quartiles of leverage levels, and terciles of intangible capital/total assets (IK/A). Then, we apply a strategy that goes long on the stocks at the bottom quintile of leverage change and short on those at the top quintile.

We further split the sample into firms with high and low leverage level based on its quartiles. According to our empirical results, firms with a high leverage level are more sensitive to the negative relationship between leverage change and subsequent stock returns. Therefore, in our investment strategy, we expect to find stronger results for high leverage firms (based on leverage quartiles). Moreover, the results from Tables 10 - 12 suggest that high IK/A firms are even more sensitive to the relationship leverage change vs. stock returns. We apply this long-short strategy after excluding stocks with prices lower than $5 and those comprising the lowest 10% of market capitalization each period, following Fama and French (1992) and Asness et al. (2013), respectively.

To account for transaction costs in these strategies, we follow the literature by adjusting strategy returns downward by a certain number of basis points (Ehsani et al. (2023), De Nard et al. (2024), Idzorek (2023), Cabrol et al. (2024), Arnott et al. (2023)). Specifically, transaction costs are subtracted from stock returns based on each firm's market capitalization as follows: firms in the bottom decile (small caps) incur a 100 bps cost; those in the second to fifth deciles are assigned a 50 bps cost; those in the sixth to ninth deciles incur a 25 bps cost; and large-cap firms in the tenth decile are assigned a 10 bps cost.

The investment strategy results are in Figures 3 - 5. Each of these figures displays three graphs: the top left shows the log cumulative returns of high and low leverage level firms, the top right shows the annualized 12-month standard deviation of the strategies' returns, and the bottom shows the 5-year rolling window for both firms' groups. Figure 3 shows the results of the strategy applied to all stocks in the filtered database, regardless of capital intangibility. When compared to the results from Figure 4, the cumulative returns for high leverage firms is significantly stronger, achieving about 4 in logs, compared to about 3 from Figure 3. This means the strategy applied to all stocks multiplies the original investment from 1975-12 by about 20 times, while the same strategy applied to high IK/A firms multiplies the initial investment by about 54 times.

The return volatility of both high and low leverage firms exhibits a similar pattern. However, as shown in Figure 4, firms with high leverage and high IK/A display slightly higher standard deviation, particularly during the Global Financial Crisis. The 5-year rolling window Sharpe ratio are somewhat higher in Figure 4 as well, achieving 1.5 more frequently than in Figure 3. Figure 5, with low IK/A stocks, exhibits lower cumulative returns, higher average volatility, and naturally lower Sharpe ratio compared the other two groups. These results are in line with our empirical findings from the average returns shown in Tables 10 - 12.

Leverage Change Strategies - all stocks

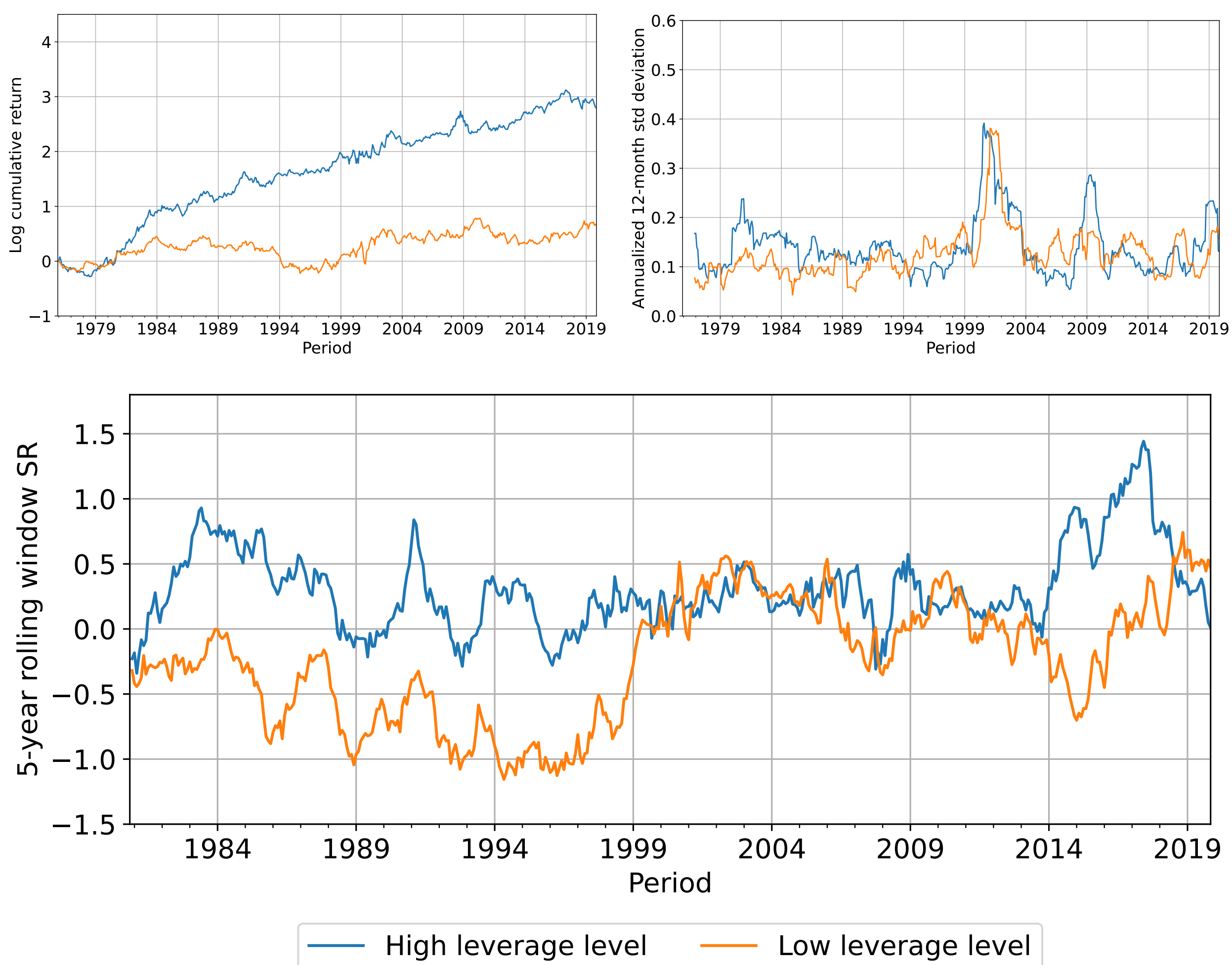

Figure 3: Top left: Log cumulative returns of investment strategies based on leverage change and level. Top right: Annualized 12-month rolling standard deviation. Bottom: 5-year rolling window Sharpe ratio. The strategies go long on the bottom quintile of firms with the lowest leverage change and short on those at the highest quintile. High (low) leverage level are firms at the top (bottom) leverage quartile. Stocks with prices lower than \$5 or that cumulatively comprise the bottom 10% of market capitalization are excluded.

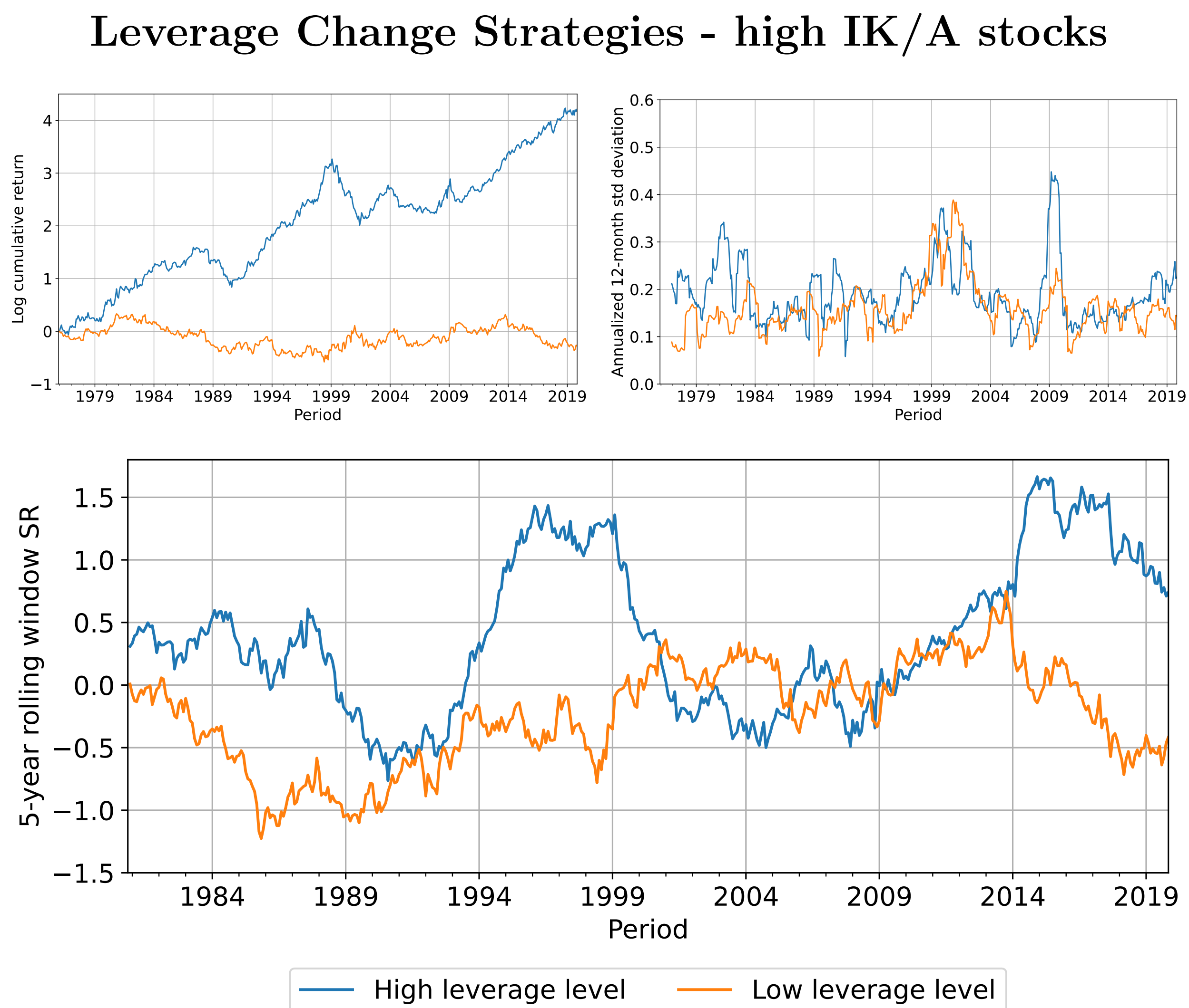

Figure 4: Top left: Log cumulative returns of investment strategies based on leverage change and level. Top right: Annualized 12-month rolling standard deviation. Bottom: 5-year rolling window Sharpe ratio. The strategies go long on the bottom quintile of firms with the lowest leverage change and short on those at the highest quintile. High (low) leverage level are firms at the top (bottom) leverage quartile. Stocks with prices lower than \$5 or that cumulatively comprise the bottom 10% of market capitalization are excluded. Only firms at the top tercile of IK/A are used.

Leverage Change Strategies - low IK/A stocks

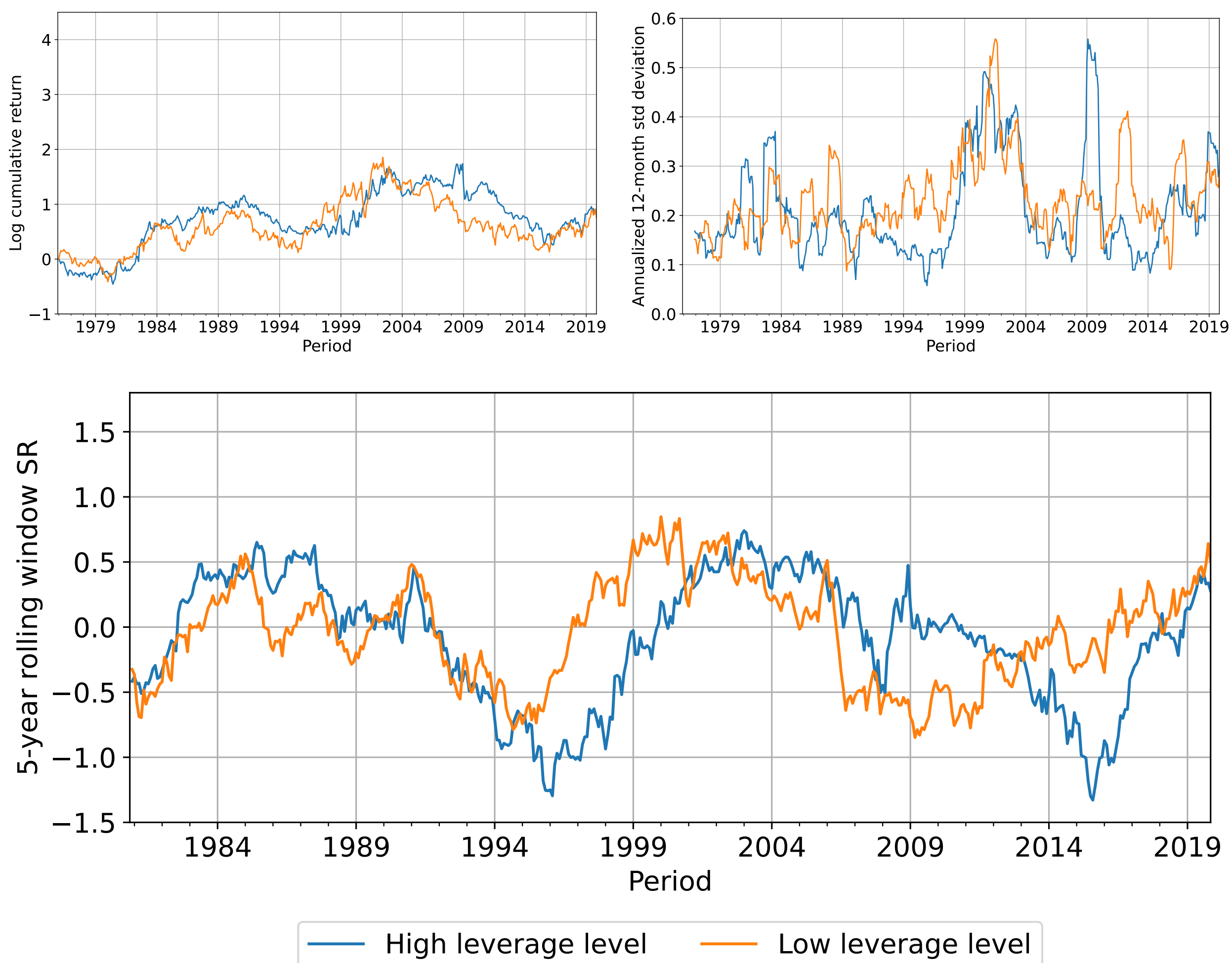

Figure 5: Top left: Log cumulative returns of investment strategies based on leverage change and level. Top right: Annualized 12-month rolling standard deviation. Bottom: 5-year rolling window Sharpe ratio. The strategies go long on the bottom quintile of firms with the lowest leverage change and short on those at the highest quintile. High (low) leverage level are firms at the top (bottom) leverage quartile. Stocks with prices lower than $5 or that cumulatively comprise the bottom 10% of market capitalization are excluded. Only firms at the bottom tercile of IK/A are used.

6 Conclusion

An overall conclusion of this study is that incorporating firm-level intangible capital concentration significantly enhances the prediction of future stock returns. Our analysis, based on portfolios constructed using the intangible capital to total assets ratio and leverage metrics, reveals a crucial insight: firms with higher intangible capital exhibit a more pronounced negative relationship between changes in leverage and subsequent stock returns, particularly when highly leveraged. This phenomenon is partially attributed to the increased default risk associated with firms having a high concentration of intangible capital, as these assets offer lower collateral value. Consequently, such firms are perceived as riskier, amplifying the negative impact of leverage changes on their stock returns.

These findings substantially improve our economic understanding of the relationship between leverage and stock returns. Based on this knowledge, we propose a new asset pricing factor, the "Intangible Delta Leverage" (IDL), and demonstrate its added explanatory power for portfolio returns. We also develop an equity long-short investment strategy focused on firms with high intangible capital concentration. This strategy yields superior cumulative returns while demonstrating lower volatility and higher risk-adjusted performance, as evidenced by improved Sharpe ratios compared to alternative approaches.

The bottom line of this paper is that the interaction between intangible capital concentration and leverage changes provides a powerful tool for predicting stock returns and crafting an effective asset pricing factor and investment strategies. This insight not only advances our theoretical understanding of asset pricing but also offers practical applications for investors seeking to optimize their portfolio performance in an increasingly intangible-driven economy.

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Appendix A. Data details

The CRSP monthly file and Compustat quarterly data are merged at the monthly frequency using the GVKEY-PERMNO link from WRDS. The monthly stock return date from CRSP is matched to the quarter-end date from Compustat, and a fill forward is applied to the appropriate Compustat columns to guarantee that firms with different quarter-end dates within each quarter are properly accounted for in the estimates.

In that way, after grouping by firm and computing leverage variation and a one-month lead of stock return, the leverage change information that is known to the public in the current month impacts the stock return in the following month.

The leverage ratios from quarter-end t are usually released in financial statements in quarter $t+1$. However, management may release this information to the market in quarter t if the leverage change is related to other corporate events (Cai and Zhang (2011)). Therefore, most of our portfolios are computed with stock returns after one and two months of the Compustat quarter-end, and the results are maintained.

Appendix B. Portfolio results

Leverage change portfolio	Intangible/assets portfolio: Equal-weighted 1 (Lowest)	Equal-weighted 3 (Highest)	Value-weighted 1 (Lowest)	Value-weighted 3 (Highest)
Panel A: 1-month ahead average returns				
1	1.46	2.15	1.17	1.47
2	1.52	1.89	0.97	1.25
3	1.23	1.79	1.01	1.15
4	0.83	1.60	0.69	1.20
5	0.59	0.90	0.84	0.89
1-5 Difference	0.87	1.25	0.33	0.58
(t-statistics)	(9.16)***	(10.71)***	(2.25)**	(3.75)***
(Std. Errors)	(0.09)	(0.12)	(0.15)	(0.15)
(95% CI)	[0.68, 1.05]	[1.02, 1.48]	[0.04, 0.62]	[0.27, 0.88]
Panel B: 2-months ahead average returns				
1	1.37	2.01	0.88	1.47
2	1.38	1.80	1.09	1.11
3	1.16	1.65	0.94	1.19
4	0.84	1.62	0.77	1.08
5	0.72	1.08	0.82	1.07
1-5 Difference	0.64	0.93	0.06	0.40
(t-statistics)	(6.49)***	(8.12)***	(0.38)	(2.67)***
(Std. Errors)	(0.10)	(0.11)	(0.15)	(0.15)
(95% CI)	[0.45, 0.84]	[0.71, 1.16]	[-0.24, 0.35]	[0.11, 0.70]

Table 7: Average portfolios based on 1- and 2-month-ahead returns relative to the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. All stocks were included regardless of their probability of default.

	Intangible/assets portfolio			
Leverage	Equal-weighted		Value-weighted	
change portfolio	1 (Lowest)	3 (Highest)	1 (Lowest)	3 (Highest)
Panel A: 1-month ahead average returns				
1	1.67	2.53	1.12	1.46
2	2.14	2.90	1.26	1.82
3	1.12	2.71	0.45	1.55
4	0.92	1.40	-0.25	0.00
5	0.41	0.92	-0.12	-0.15
1-5 Difference	1.26	1.61	1.24	1.61
(t-statistics)	(4.07)***	(6.99)***	(2.50)**	(5.05)***
(Std. Errors)	(0.28)	(0.23)	(0.43)	(0.32)
(95% CI)	[0.58, 1.66]	[1.15, 2.06]	[0.23, 1.91]	[0.99, 2.25]
Panel B: 2-months ahead average returns				
1	1.54	2.33	0.71	1.74
2	2.19	2.31	1.34	0.85
3	1.62	2.63	0.61	2.42
4	0.87	1.50	0.31	0.24
5	0.50	1.12	-0.06	0.47
1-5 Difference	1.04	1.20	0.77	1.27
(t-statistics)	(3.42)***	(4.80)***	(1.93)*	(3.92)***
(Std. Errors)	(0.27)	(0.25)	(0.43)	(0.32)
(95% CI)	[0.40, 1.47]	[0.70, 1.68]	[-0.02, 1.67]	[0.62, 1.88]

Table 8: Average portfolios based on 1- and 2-month-ahead returns relative to the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. Only stocks with a high probability of default were included (top quintile of firms with default probability from Merton (1974)).

	Intangible/assets portfolio			
Leverage	Equal-weighted		Value-weighted	
change portfolio	1 (Lowest)	3 (Highest)	1 (Lowest)	3 (Highest)
Panel A: 1-month ahead average returns				
1	1.40	1.46	1.08	1.43
2	1.02	1.13	0.88	1.19
3	1.18	1.20	1.14	1.07
4	0.88	1.12	0.93	1.43
5	1.30	0.74	1.57	0.92
1-5 Difference	0.11	0.72	-0.48	0.51
(t-statistics)	(3.00)***	(2.23)**	(0.23)	(0.47)
(Std. Errors)	(0.23)	(0.22)	(0.49)	(0.37)
(95% CI)	[0.24, 1.17]	[0.05, 0.91]	[-0.86, 1.08]	[-0.56, 0.91]
Panel B: 2-months ahead average returns				
1	1.31	1.45	0.98	1.51
2	1.19	1.24	1.14	1.13
3	1.20	1.19	1.08	1.25
4	0.83	1.16	0.73	1.27
5	1.30	0.94	1.29	1.22
1-5 Difference	0.01	0.51	-0.31	0.30
(t-statistics)	(2.13)**	(3.39)***	(0.44)	(0.68)
(Std. Errors)	(0.25)	(0.19)	(0.40)	(0.36)
(95% CI)	[0.04, 1.02]	[0.27, 1.02]	[-0.61, 0.96]	[-0.47, 0.96]

Table 9: Average portfolios based on 1- and 2-month-ahead returns relative to the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. Only stocks with a low probability of default were included (bottom quintile of firms with default probability from Merton (1974)).

	Leverage portfolio							
Leverage	Equal-weighted				Value-weighted			
change portfolio	1 (Lowest)	2	3	4 (Highest)	1 (Lowest)	2	3	4 (Highest)
Panel A: 1-month ahead average returns								
1	1.32	1.69	2.07	2.35	0.95	1.17	1.25	1.62
2	1.23	1.56	1.74	2.12	0.79	1.08	1.13	1.32
3	1.31	1.49	1.43	1.51	0.97	1.09	1.11	1.13
4	1.42	1.45	1.16	0.89	1.09	0.82	0.93	0.73
5	1.14	1.05	0.81	0.41	1.05	1.00	0.75	0.77
1-5 Difference	0.19	0.65	1.26	1.94	-0.10	0.17	0.49	0.85
(t-statistics)	(1.60)	(5.78)***	(11.16)***	(13.63)***	(-0.52)	(0.94)	(3.21)***	(5.31)***
(Std. Errors)	(0.12)	(0.11)	(0.11)	(0.15)	(0.19)	(0.17)	(0.15)	(0.16)
(95% CI)	[-0.04, 0.41]	[0.40, 0.81]	[1.04, 1.49]	[1.71, 2.29]	[-0.48, 0.28]	[-0.17, 0.48]	[0.19, 0.80]	[0.54, 1.18]
Panel B: 2-months ahead average returns								
1	1.33	1.64	1.85	2.14	0.89	1.02	1.30	1.42
2	1.25	1.47	1.56	1.93	1.11	1.08	1.01	1.32
3	1.29	1.41	1.35	1.38	1.20	0.96	1.04	1.07
4	1.35	1.43	1.14	1.06	0.95	0.91	1.00	0.77
5	1.09	1.19	0.94	0.66	0.78	1.02	0.85	1.00
1-5 Difference	0.24	0.46	0.91	1.49	0.11	-0.00	0.45	0.42
(t-statistics)	(2.10)**	(4.16)***	(8.05)***	(11.50)***	(0.57)	(0.03)	(2.86)***	(2.63)***
(Std. Errors)	(0.12)	(0.10)	(0.11)	(0.13)	(0.19)	(0.16)	(0.16)	(0.16)
(95% CI)	[0.02, 0.47]	[0.23, 0.63]	[0.69, 1.14]	[1.25, 1.77]	[-0.26, 0.48]	[-0.30, 0.31]	[0.14, 0.75]	[0.11, 0.74]

Table 10: Average portfolios based on 1- and 2-month-ahead returns relative the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. All stocks were included regardless of their intangible capital/assets (IK/A) ratio.

Leverage change portfolio	Leverage portfolio: Equal-weighted 1 (Lowest)	2	3	4 (Highest)	Value-weighted 1 (Lowest)	2	3	4 (Highest)
Panel A: 1-month ahead average returns								
1	1.52	2.03	2.39	2.81	0.75	1.54	1.57	1.51
2	1.36	1.73	2.15	2.26	0.88	1.22	1.40	1.55
3	1.65	1.77	1.69	1.62	1.29	1.21	1.19	1.17
4	1.54	1.59	1.53	1.23	1.02	0.88	1.53	1.08
5	1.06	1.09	0.74	0.51	1.01	0.89	0.97	0.95
1-5 Difference	0.46	0.94	1.64	2.30	-0.26	0.65	0.60	0.56
(t-statistics)	(1.92)*	(5.19)***	(8.98)***	(9.76)***	(-0.99)	(2.50)**	(2.36)**	(2.73)***
(Std. Errors)	(0.20)	(0.17)	(0.19)	(0.28)	(0.29)	(0.26)	(0.28)	(0.31)
(95% CI)	[-0.01, 0.79]	[0.55, 1.22]	[1.31, 2.04]	[2.18, 3.27]	[-0.87, 0.29]	[0.14, 1.15]	[0.11, 1.20]	[0.23, 1.44]
Panel B: 2-months ahead average returns								
1	1.57	1.95	2.18	2.83	0.85	1.59	1.73	1.62
2	1.46	1.65	1.86	2.31	1.05	1.11	1.35	1.54
3	1.61	1.71	1.69	1.56	1.10	1.20	1.25	1.35
4	1.58	1.66	1.48	1.42	0.97	1.18	1.28	0.87
5	1.02	1.28	1.10	0.74	0.98	0.99	1.30	1.03
1-5 Difference	0.55	0.67	1.08	2.10	-0.14	0.60	0.43	0.59
(t-statistics)	(2.56)**	(3.08)***	(5.59)***	(7.05)***	(-0.43)	(2.36)**	(1.68)*	(1.57)
(Std. Errors)	(0.20)	(0.18)	(0.20)	(0.28)	(0.25)	(0.23)	(0.27)	(0.29)
(95% CI)	[0.12, 0.89]	[0.20, 0.90]	[0.74, 1.54]	[1.45, 2.57]	[-0.61, 0.39]	[0.09, 0.98]	[-0.08, 1.00]	[-0.11, 1.01]

Table 11: Average portfolios based on 1- and 2-month-ahead returns relative the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. Only stocks with a high intangible capital/assets (IK/A) ratio were included (top tercile).

	Leverage portfolio							
Leverage	Equal-weighted				Value-weighted			
change portfolio	1 (Lowest)	2	3	4 (Highest)	1 (Lowest)	2	3	4 (Highest)
Panel A: 1-month ahead average returns								
1	0.95	1.17	1.50	1.47	0.85	1.25	1.15	1.30
2	1.05	1.29	1.41	1.86	0.45	0.81	1.09	1.20
3	1.04	1.16	1.27	1.33	0.88	0.90	1.06	1.02
4	1.00	0.82	0.71	0.65	0.98	0.73	0.67	0.71
5	0.86	0.53	0.39	0.19	0.73	0.73	0.54	0.57
1-5 Difference	0.09	0.65	1.11	1.28	0.12	0.52	0.61	0.73
(t-statistics)	(6.70)***	(7.54)***	(-0.32)	(3.23)***	(2.93)***	(3.14)***	(0.23)	(1.38)
(Std. Errors)	(0.27)	(0.19)	(0.17)	(0.21)	(0.38)	(0.30)	(0.26)	(0.25)
(95% CI)	[-0.61, 0.44]	[0.24, 0.97]	[0.82, 1.50]	[1.14, 1.95]	[-0.66, 0.83]	[-0.18, 1.00]	[0.25, 1.28]	[0.29, 1.28]
Panel B: 2-months ahead average returns								
1	1.01	1.12	1.38	1.51	0.76	0.84	0.84	1.13
2	1.06	1.20	1.20	1.63	0.89	0.97	1.04	1.27
3	1.10	1.18	1.18	1.26	1.25	0.90	0.99	1.00
4	0.80	1.14	0.67	0.82	0.65	1.12	0.69	0.89
5	1.12	0.75	0.59	0.40	0.65	0.81	0.60	0.77
1-5 Difference	-0.11	0.38	0.79	1.10	0.12	0.02	0.24	0.35
(t-statistics)	(4.22)***	(5.37)***	(0.71)	(1.39)	(0.88)	(0.94)	(1.42)	(0.12)
(Std. Errors)	(0.27)	(0.20)	(0.18)	(0.21)	(0.34)	(0.29)	(0.27)	(0.25)
(95% CI)	[-0.34, 0.73]	[-0.12, 0.68]	[0.41, 1.12]	[0.70, 1.51]	[-0.19, 1.16]	[-0.53, 0.60]	[-0.29, 0.77]	[-0.25, 0.71]

Table 12: Average portfolios based on 1- and 2-month-ahead returns relative the most recent quarter leverage change from Compustat. Each portfolio was required to contain at least 30 stocks. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. Only stocks with a low intangible capital/assets (IK/A) ratio were included (bottom tercile).

	Leverage levels							
	Equal-weighted				Value-weighted			
Leverage change	1 (Lowest)	2	3	4 (Highest)	1 (Lowest)	2	3	4 (Highest)
Panel A: Leverage change for all stocks								
1	-6.92	-6.01	-5.25	-4.72	-5.29	-4.61	-3.95	-3.94
2	-1.16	-1.18	-1.16	-1.13	-1.13	-1.14	-1.12	-1.09
3	0.02	0.01	-0.00	0.00	0.01	-0.01	-0.00	-0.00
4	1.38	1.40	1.38	1.37	1.31	1.34	1.34	1.30
5	5.12	6.67	7.52	8.59	4.52	5.60	5.76	6.97
Panel B: Leverage change for high IK/A stocks								
1	-6.86	-6.22	-5.84	-5.32	-4.99	-4.56	-4.17	-4.05
2	-1.19	-1.23	-1.24	-1.22	-1.17	-1.19	-1.23	-1.20
3	0.02	0.02	0.01	0.00	0.03	0.01	-0.01	0.01
4	1.44	1.46	1.47	1.50	1.40	1.40	1.44	1.42
5	5.12	6.55	7.57	9.04	4.45	5.21	5.79	6.52
Panel B: Leverage change for low IK/A stocks								
1	-8.13	-7.04	-5.55	-4.85	-6.70	-5.80	-4.29	-4.20
2	-1.19	-1.18	-1.15	-1.10	-1.19	-1.13	-1.11	-1.06
3	0.04	0.01	-0.00	0.01	0.03	-0.01	-0.01	-0.00
4	1.38	1.43	1.36	1.36	1.33	1.36	1.32	1.27
5	5.65	7.80	8.32	8.93	5.13	6.99	6.69	7.46

Table 13: Average leverage change in Compustat by leverage level. Financial and utility firms, as well as those with non-positive book value of equity and negative total liabilities, were excluded. High (low) intangible capital/assets (IK/A) ratio is comprised of firms at the top (bottom) tercile of IK/A.