# Betting Against Beta

Andrea Frazzini and Lasse H. Pedersen*

This draft: September 13, 2010

**Abstract.**

We present a model in which some investors are prohibited from using leverage and other investors' leverage is limited by margin requirements. The former investors bid up high-beta assets while the latter agents trade to profit from this, but must de-lever when they hit their margin constraints. We test the model's predictions within U.S. equities, across 20 global equity markets, for Treasury bonds, corporate bonds, and futures. Consistent with the model, we find in each asset class that a betting-against-beta (BAB) factor which is long a leveraged portfolio of low-beta assets and short a portfolio of high-beta assets produces significant risk-adjusted returns. When funding constraints tighten, betas are compressed towards one, and the return of the BAB factor is low.

* Andrea Frazzini is at AQR Capital Management, Two Greenwich Plaza, Greenwich, CT 06830, e-mail: andrea.frazzini@aqr.com. Lasse H. Pedersen is at New York University, NBER, and CEPR, 44 West Fourth Street, NY 10012-1126; e-mail: lpederse@stern.nyu.edu; web: http://www.stern.nyu.edu/~lpederse/. We thank Cliff Asness, Nicolae Garleanu. Matt Richardson, Robert Whitelaw, Michael Mendelson, Michael Katz, Aaron Brown and Gene Fama for helpful comments and discussions as well as seminar participants at Columbia University, New York University, Yale University, Emory University, and the 2010 Annual Management Conference at University of Chicago Booth School of Business.

A basic premise of the capital asset pricing model (CAPM) is that all agents invest in the portfolio with the highest expected excess return per unit of risk (Sharpe ratio), and lever or de-lever it to suit their risk preferences. However, many investors – such as individuals, pension funds, and mutual funds – are constrained in the leverage they can take, and therefore over-weight risky securities instead of using leverage. For instance, many mutual fund families offer balanced funds where the "normal" fund may invest 40% in long-term bonds and 60% in stocks, whereas as the "aggressive" fund invests 10% in bonds and 90% in stocks. If the "normal" fund is efficient, then an investor could leverage it and achieve the same expected return at a lower volatility rather than tilting to a large 90% allocation to stocks. The demand for exchange-traded funds (ETFs) with leverage built in presents further evidence that many investors cannot use leverage directly.

This behavior of tilting towards high-beta assets suggests that risky high-beta assets require lower risk-adjusted returns than low-beta assets, which require leverage. Consistently, the security market line for U.S. stocks is too flat relative to the CAPM (Black, Jensen, and Scholes (1972)) and is better explained by the CAPM with restricted borrowing than the standard CAPM (Black (1972, 1993), Brennan (1971), see Mehrling (2005) for an excellent historical perspective). Several additional questions arise: how can an unconstrained arbitrageur exploit this effect – i.e., how do you bet against beta – and what is the magnitude of this anomaly relative to the size, value, and momentum effects? Is betting against beta rewarded in other asset classes? How does the return premium vary over time and in the cross section? Which investors bet against beta?

We address these questions by considering a dynamic model of leverage constraints and by presenting consistent empirical evidence from 20 global stock markets, Treasury bond markets, credit markets, and futures markets.

Our model features several types of agents. Some agents cannot use leverage and, therefore, over-weight high-beta assets, causing those assets to offer lower returns. Other agents can use leverage, but face margin constraints. They under-weight (or short-sell) high-beta assets and buy low-beta assets that they lever up. The model implies a flatter security market line (as in Black (1972)), where the slope depends on the tightness (i.e., Lagrange multiplier) of the funding constraints on average across agents.

One way to illustrate the asset pricing effect of the funding friction is to consider the returns on market-neutral betting against beta (BAB) factors. A BAB factor is long a portfolio of low-beta assets, leveraged to a beta of 1, and short a portfolio of high-beta assets, de-leveraged to a beta of 1. For instance, the BAB factor for U.S. stocks achieves a zero beta by being long $1.5 of low-beta stocks, short $0.7 of high-beta stocks, with offsetting positions in the risk-free asset to make it zero-cost.[1] Our model predicts that BAB factors have positive average return, and that the return is increasing in the ex ante tightness of constraints and in the spread in betas between high- and low-beta securities.

When the leveraged agents hit their margin constraint, they must de-lever, and, therefore, the model predicts that the BAB factor has negative returns during times of tightening funding liquidity constraints. Further, the model predicts that the betas of securities in the cross section are compressed towards 1 when funding liquidity risk rises. Our model thus extends Black (1972)'s central insight by considering a broader set of constraints and deriving the dynamic time-series and cross-sectional properties arising from the equilibrium interaction between agents with different constraints.

Consistent with the model's prediction, we find significant returns to betting against beta within each of the major asset classes globally. We show that betting-against-beta factors produce negative returns when credit constraints are more likely to be bindings and we also document the model-implied beta compression during times of illiquidity.

To perform these empirical tests, we first consider portfolios sorted by beta within each asset class. We find that alphas and Sharpe ratios are almost monotonically declining in beta in each asset class. This provides broad evidence that the flatness of the security market line is not isolated to the U.S. stock market,

[1] While we consider a variety of BAB factors within a number of markets, one notable example is the zero-covariance portfolio introduced by Black (1972), and studied for U.S. stocks by Black, Jensen, and Scholes (1972), Kandel (1984), Shanken (1985), Polk, Thompson, and Vuolteenaho (2006), and others.

but a pervasive global phenomenon. Hence, this pattern of required returns is likely driven by a common economic cause, and our funding-constraint model provides one such unified explanation.

We first consider the BAB factor within the U.S. stock market, and within each of the 19 other developed MSCI stock markets. The U.S. BAB factor realizes a Sharpe ratio of 0.75 between 1926 and 2009. To put this factor return in perspective, note that this is about twice the Sharpe ratio of the value effect over the same period and 40% higher than the Sharpe ratio of momentum. It has a highly significant risk-adjusted returns accounting for its realized exposure to market, value, size, momentum, and liquidity factors (i.e., significant 1, 3, 4, and 5-factor alphas), and realizes a significant positive return in each of the four 20-year sub-periods between 1926 and 2009. We find similar results in our sample of global equities: combining stocks in each of the non-US countries produces a BAB factor with returns about as strong as the U.S. BAB factor.

We show that BAB returns are consistent across countries, time, within deciles sorted by size, within deciles sorted by idiosyncratic risk, and robust to a number of specifications.. These consistent results suggest that coincidence or data-mining are unlikely explanations. However, if leverage aversion is the underlying driver and is a general phenomenon as in our model, then the effect should also exist in other markets.

We examine BAB factors in other major asset classes. For U.S. Treasuries, the BAB factor is long a leveraged portfolio of low-beta – that is, short maturity – bonds, and short a de-leveraged portfolio of long-dated bonds. This portfolio produces highly significant risk-adjusted returns with a Sharpe ratio of 0.85. This profitability of shorting long-term bonds may seem in contrast to the most well-known "term premium" in fixed income markets. There is no paradox, however. The term premium means that investors are compensated on average for holding long-term bonds rather than T-bills due to the need for maturity transformation. The term premium exits at all horizons, though: Investors are compensated for holding 1-year bonds over T-bills as well as they are compensated for holding 10-year bonds. Our finding is that the compensation per unit of risk is in fact larger for the 1-year bond than for the 10-year bond. Hence, a portfolio that has a leveraged long position in 1-year (and other short term) bonds, and a short position in long-term bonds produces positive returns. This is consistent with our model in which some investors are leverage constrained in their bond exposure and, therefore, require lower risk-adjusted returns for long-term bonds that give more "bang for the buck". Indeed, short-term bonds require a tremendous leverage to achieve similar risk or return as long-term bonds. These results complement those of Fama (1986) and Duffee (2010), who also consider Sharpe ratios across maturities implied by standard term structure models.

We find similar evidence in credit markets: a leveraged portfolio of high-rated corporate bonds outperforms a de-leveraged portfolio of low-rated bonds. Similarly, using a BAB factor based on corporate bond indices by maturity produces high risk-adjusted returns.

We test the model's prediction that the cross-sectional dispersion of betas is lower during times of high funding liquidity risk, which we proxy by the TED spread empirically. Consistent with the beta-compression prediction, we find that the dispersion of betas is significantly lower when the TED spread is high, and this result holds across a number of specifications. Further, we also find evidence consistent with the model's prediction that the BAB factor realizes a positive market beta when liquidity risk is high.

Lastly, we test the model's time-series predictions that the BAB factor should realize a high return when lagged illiquidity is high, when contemporaneous liquidity improves, and when there is a large spread between the ex ante beta of the long side of the portfolio and the short side of the portfolio. Consistent with the model, we find that high contemporaneous TED spreads predicts BAB returns negatively, and the ex ante beta spread predicts BAB returns positively. The lagged TED spread predicts returns negatively which is inconsistent with the model if a high TED spread means a high tightness of investors' funding constraints. It could be consistent with the model if a high TED spread means that investors funding constraints are tightening, perhaps as their banks diminish credit availability over time.

Our results shed new light on the relation between risk and expected returns. This central issue in financial economics has naturally received much attention. The standard CAPM beta cannot explain the cross-section of unconditional stock returns (Fama and French (1992)) or conditional stock returns (Lewellen and Nagel (2006)). Stocks with high beta have been found to deliver low risk-adjusted returns (Black, Jensen, and Scholes (1972), Baker, Bradley, and Wurgler (2010)) so the constrained-borrowing CAPM has a better fit (Gibbons (1982), Kandel (1984), Shanken (1985)). Stocks with high idiosyncratic volatility have realized low returns (Ang, Hodrick, Xing, Zhang (2006, 2009)),[2] but we find that the beta effect holds even controlling for idiosyncratic risk. Theoretically, asset pricing models with benchmarked managers (Brennan (1993)) or constraints imply more general CAPM-like relations (Hindy (1995), Cuoco (1997)), in particular the margin-CAPM implies that high-margin assets have higher required returns, especially during times of funding illiquidity (Garleanu and Pedersen (2009), Ashcraft, Garleanu, and Pedersen (2010)). Garleanu and Pedersen (2009) find empirically that deviations of the Law of One Price arises when high-margin assets become cheaper than low-margin assets, and Ashcraft, Garleanu, and Pedersen (2010) find the prices increase when central bank lending facilities lower margins. Further, funding liquidity risk is linked to market liquidity risk (Gromb and Vayanos (2002), Brunnermeier and Pedersen (2010)), which also affects required returns (Acharya and Pedersen (2005)). We complement the literature by deriving new cross-sectional and time-series predictions in a simple dynamic model that captures both leverage and margin constraints, and by testing its implications across broad cross-section of securities across all the major asset classes.

The rest of the paper is organized as follows. Section I lays out the theory, Section II describes our data and empirical methodology, Sections III-V test the theory's cross-sectional and time series predictions across asset classes, and Section VI concludes. Appendix A contains all proofs and Appendix B provides a number of additional empirical results and robustness tests.

---

[2] This effect disappears when controlling for the maximum daily return over the past month (Bali, Cakici, and Whitelaw (2010)) and other measures of idiosyncratic volatility (Fu (2009)).

## I. Theory

We consider an overlapping-generations (OLG) economy in which agents $i=1,...,I$ are born each period and live for two periods. Agents trade securities $s=1,...,S$, where security $s$ has $x^{*i}$ shares outstanding. Each time period $t$, young agents choose a portfolio of shares $x=(x^1,...,x^S)'$, investing the rest of their wealth $W^i$ at the risk-free return $r^f$, to maximize their utility:

$$\max x'(E_t(P_{t+1})-(1+r^f)P_t)-\frac{\gamma^i}{2}x'\Omega_t x \tag{1}$$

where $P_t$ is the vector of prices at time $t$, $\Omega_t$ is the variance-covariance matrix of $P_{t+1}$, and $\gamma^i$ is agent $i$'s risk aversion. Agent $i$ is subject to the following portfolio constraint:

$$m_t^i\sum_s x^s P_t^s \leq W_t^i \tag{2}$$

This constraint says that some multiple $m^i$ of the total dollars invested – the sum of the number of shares $x^s$ times their prices $P^s$ – must be less than the agent's wealth.

The investment constraint depends on the agent $i$. For instance, some agents simply cannot use leverage, which is captured by $m^i=1$ (as Black (1972) assumes). Other agents may not only be precluded from using leverage, but also need to have some of their wealth in cash, which is captured by $m^i$ greater than 1. For instance, $m^i = 1/(1\text{-}0.20)$=1.25 represents an agent who must hold 20% of her wealth in cash.

Other agents yet may be able to use leverage, but face margin constraints. For instance, if an agent faces a margin requirement of 50%, then his $m^i$ is 0.50 since this means that he can invest at most in assets worth twice his wealth. A smaller margin requirement $m^i$ naturally means that the agent can take larger positions. We note that our formulation assumes for simplicity that all securities have the same margin requirement. This may be true when comparing securities within the same asset class (e.g. stocks) as we do empirically. Garleanu and Pedersen (2009) and Ashcraft, Garleanu, and Pedersen (2010) consider assets with different margin requirements and show theoretically and empirically that higher margin requirements are associated with higher required returns (Margin CAPM).

We are interested in the properties of the competitive equilibrium in which the total demand equals the supply:

$$\sum_i x^i = x^* \tag{3}$$

To derive equilibrium, consider the first order condition for agent *i*:

$$0 = E_t\left(P_{t+1}\right) - (1+r^f)P_t - \gamma^i \Omega x^i - \psi_t^i P_t \tag{4}$$

where $\psi^i$ is the Lagrange multiplier of the portfolio constraint. This gives the optimal position

$$x^i = \frac{1}{\gamma^i}\Omega^{-1}\left(E_t\left(P_{t+1}\right) - \left(1 + r^f + \psi_t^i\right)P_t\right) \tag{5}$$

The equilibrium condition now follows from summing over these positions:

$$x^* = \frac{1}{\gamma}\Omega^{-1}\left(E_t\left(P_{t+1}\right) - \left(1 + r^f + \psi_t\right)P_t\right) \tag{6}$$

where the aggregate risk aversion $\gamma$ is defined by $1/\gamma = \Sigma_i\, 1/\gamma^i$, and $\psi_t = \sum_i \frac{\gamma}{\gamma^i}\psi_t^i$ is the weighted average Lagrange multiplier. (The coefficients $\frac{\gamma}{\gamma^i}$ sum to 1 by definition of the aggregate risk aversion $\gamma$.) This gives the equilibrium price:

$$P_t = \frac{E_t\left(P_{t+1}\right) - \gamma\Omega x^*}{1 + r^f + \psi_t} \tag{7}$$

Translating this into the return of any security $r_{t+1}^i = P_{t+1}^i / P_t^i - 1$, the return on the market $r_{t+1}^M$, and using the usual expression for beta, $\beta_t^s = \text{cov}_t\left(r_{t+1}^s, r_{t+1}^M\right) / \text{var}_t\left(r_{t+1}^M\right)$, we get the following results. (All proofs are in Appendix A.)

**Proposition 1.**

(i) *The equilibrium required return for any security s is:*

$$E_t\left(r_{t+1}^s\right) = r^f + \psi_t + \beta_t^s \lambda_t \tag{8}$$

*where the risk premium is* $\lambda_t = E_t\left(r_{t+1}^M\right) - r^f - \psi_t$, *and* $\psi_t$ *is the average Lagrange multiplier, measuring the tightness of funding constraints.*

(ii) *A security's alpha with respect to the market is* $\alpha_t^s = \psi_t (1 - \beta_t^s)$. *Alpha decreases in the security's market beta,* $\beta_t^s$.

(iii) *For a diversified efficient portfolio, the Sharpe ratio is highest for an efficient portfolio with beta less than 1 and decreases in* $\beta_t^s$ *for higher betas and increases for lower betas.*

As in Black's CAPM with restricted borrowing (in which $m^i = 1$ for all agents), the required return is a constant plus beta times a risk premium. Our expression shows explicitly how risk premia are affected by the tightness of agents' portfolio constraints, as measured by the average Lagrange multiplier $\psi_t$. Indeed, tighter portfolio constraints (i.e., a larger $\psi_t$) flatten the security market line by increasing the intercept and decreasing the slope $\lambda_t$.

Whereas the standard CAPM implies that the intercept of the security market line is $r^f$, here the intercept is increased by the weighted average of the agents' Lagrange multipliers. You may wonder why zero-beta assets require returns in excess of the risk free rate? The reason is that tying up your capital in such assets prevents you from making profitable trades that you would like to pursue but cannot if you are constrained. Further, if unconstrained agents buy a lot of these securities, then, from their perspective, this risk is no longer idiosyncratic since additional exposure to such assets would increase the risk of their portfolio. Hence, in equilibrium even zero-beta risky assets must offer higher returns than the risk-free rate. (Assets that have zero covariance to Markowitz's (1952) "tangency portfolio" held by an unconstrained agents do earn the risk free rate, on the other hand, but the tangency portfolio is not the market portfolio in this equilibrium.)

The portfolio constraints further imply a lower slope $\lambda_t$ .of the security market line, that is, a lower compensation for a marginal increase in systematic risk. This is because constrained agents need this access to high un-leveraged returns and therefore are willing to accept less high returns for high-beta assets.

We next consider the properties of a factor that goes long low-beta assets and short high-beta assets. For this, let $w_L$ be the relative portfolio weights a portfolio of low-beta assets with return $r_{t+1}^L = w_L' r_{t+1}$ and consider similarly a portfolio of high-beta assets with return $r_{t+1}^H$. The betas of these portfolios are denoted $\beta_t^L$ and $\beta_t^H$, where $\beta_t^L < \beta_t^H$. We then construct a betting-against-beta (BAB) factor as:

$$r_{t+1}^{BAB} = \frac{1}{\beta_t^L}\left(r_{t+1}^L - r^f\right) - \frac{1}{\beta_t^H}\left(r_{t+1}^H - r^f\right) \tag{9}$$

This portfolio is market neutral, that is, has a beta of zero: the long side has been leveraged to a beta of 1, and the short side has been de-leveraged to a beta of 1. Further, the BAB factor provides the excess return on a zero-cost portfolio like HML and SMB, since it is a difference between excess returns. The difference is that BAB is not dollar neutral in terms of only the risky securities since this would not produce a beta of zero.[3] The model has several predictions regarding the BAB factor:

[3] A natural BAB factor is the zero-covariance portfolio of Black (1972) and Black, Jensen, and

**Proposition 2.**

(i) *The expected excess return of the zero-cost BAB factor is positive:*

$$E_t\left(r_{t+1}^{BAB}\right)=\frac{\beta_t^H-\beta_t^L}{\beta_t^L\beta_t^H}\psi_t \geq 0 \tag{10}$$

*and increasing in the beta spread* $\frac{\beta_t^H-\beta_t^L}{\beta_t^L\beta_t^H}$ *and the funding tightness* $\psi_t$ *.*

(ii) *A tighter portfolio constraint, that is, an increase in* $m_t^k$ *for some of k, leads to a contemporaneous loss for the BAB factor*

$$\frac{\partial r_t^{BAB}}{\partial m_t^k}\leq 0 \tag{11}$$

*and an increase in its future required return:*

$$\frac{\partial E_t\left(r_{t+1}^{BAB}\right)}{\partial m_t^k}\geq 0 \tag{12}$$

The first part of the proposition says that a market-neutral portfolio that is long leveraged low-beta securities and short higher-beta securities should earn a positive expected return on average. The size of the expected return depends on the spread in betas and the how binding portfolio constraints are in the market, as captured by the average of the Lagrange multipliers, $\psi_t$.

The second part of the proposition considers the effect of a shock to the portfolio constraints (or margin requirements), $m^k$, which can be interpreted as a

---

Scholes (1972). We consider a broader class of BAB portfolios since we empirically consider a variety of BAB portfolios within various asset classes that are subsets of all securities (e.g., stocks in a particular size group). Therefore, our construction achieves market neutrality by leveraging (and de-leveraging) the long and short sides rather than adding the market itself as Black, Jensen, and Scholes (1972) do.

worsening of funding liquidity, a liquidity crisis in the extreme. Such a funding liquidity shock results in losses for the BAB factor as its required return increases. This happens as agents may need to de-lever their bets against beta or stretch even further to buy the high-beta assets. This shows that the BAB factor is exposed to funding liquidity risk – it loses when portfolio constraints become more binding.

Further, the market return tends to be low during such liquidity crises. Indeed, a higher $m^k$ increases the required return of the market and reduces the contemporaneous market return. Hence, while the BAB factor is market neutral on average, liquidity shocks can lead to correlation between BAB and the market. Another way of saying this is that low-beta securities fare poorly during times of increased illiquidity relative to their betas, while high-beta securities fare less poorly than their betas would suggest ("beta compression"):[4]

**Proposition 3.**

*The percentage price sensitivity with respect to funding shocks* $\frac{\partial P_t^s}{P_t^s} / \partial \psi_t$ *is the same for all securities s. A higher independent variance of funding shocks compresses betas of all securities towards 1, and the beta of the BAB factor increases if this is unanticipated.*

In addition to the asset-pricing predictions that we have derived, funding constraints naturally also affect agents' portfolio choices. In particular, the more constrained investors tilt towards riskier securities in equilibrium, whereas less constrained agents tilt towards safer securities with higher reward per unit of risk. To see this, we write next period's security values as

$$P_{t+1} = E_t\left(P_{t+1}\right) + b\left(P_{t+1}^M - E_t\left(P_{t+1}^M\right)\right) + e \qquad (13)$$

[4] Garleanu and Pedersen (2009) finds a complementary result, studying securities with identical fundamental risk, but different margin requirements. They find theoretically and empirically that such assets have similar betas when liquidity is good, but, when funding liquidity risk rises, the high-margin securities have larger betas as their high margins make them more funding sensitive. Here, we study securities with different fundamental risk, but the same margin requirements so, in this case, higher funding liquidity risk means that betas are compressed towards one.

where $b$ is a vector of market exposures and $e$ is a vector of noise that is uncorrelated with the market. With this, we have the following natural result for the agents' positions:

**Proposition 4.**

*Unconstrained agents hold risk free securities and a portfolio of risky securities that has a beta less than 1; constrained agents hold portfolios of securities with higher betas. If securities s and k are identical expect that s has a larger market exposure than k,* $b^s > b^k$*, then any constrained agent j with greater than average Lagrange multiplier,* $\psi_t^j > \psi_t$*, holds more shares of s than k, while the reverse is true for any agent with* $\psi_t^j < \psi_t$*.*

We next turn to the empirical evidence for Propositions 1-3. We leave a formal test of Proposition 4 for future research, although we discuss some suggestive evidence in the conclusion.

## II. Data and Methodology

The data in this study are collected from several sources. The sample of U.S. and global stocks includes 50,826 stocks covering 20 countries, and the summary statistics for stocks are reported in Table I. Stock return data are from the union of the CRSP tape and the Xpressfeed Global database. Our U.S. equity data include all available common stocks on CRSP between January 1926 and December 2009. Betas are computed with respect to the CRSP value weighted market index. The global equity data include all available common stocks on the Xpressfeed Global daily security file for 19 markets belonging to the MSCI developed universe between January 1984 and December 2009. We assign individual issues to their corresponding markets based on the location of the primary exchange. Betas are computed with respect to the corresponding MSCI local market index[5]. All returns are in USD and excess returns are above the US Treasury bill rate. We consider alphas with respect to the market and US factor returns based on size (SMB), book-to-market (HML), momentum (UMD), and liquidity risk.[6]

We also consider a variety of other assets and Table II contains the list instruments and the corresponding data availability ranges. We obtain U.S. Treasury bond data from the CRSP US Treasury Database. Our analysis focuses on monthly returns (in excess of the 1-month Treasury bill) on the Fama Bond portfolios for maturities ranging from 1 to 10 years between January 1952 and December 2009. Returns are an equal-weighted average of the unadjusted holding period return for each bond in the portfolios. Only non-callable, non-flower notes and bonds are included in the portfolios. Betas are computed with respect to an equally weighted portfolio of all bonds in the database.

We collect aggregate corporate bond index returns from Barclays Capital's Bond.Hub database.[7] Our analysis focused on monthly returns (in excess of the 1-month Treasury bill) on 4 aggregate US credit indices with maturity ranging from one to ten years and nine investment grade and high yield corporate bond portfolios with credit risk ranging from AAA to Ca-D and "Distressed"[8]. The data cover the period between January 1973 and December 2009 although the data availability varies depending on the individual bond series. Betas are computed with respect to an equally weighted portfolio of all bonds in the database.

We also study futures and forwards on country equity indexes, country bond indexes, foreign exchange, and commodities. Return data are drawn from the internal pricing data maintained by AQR Capital Management LLC. The data is collected from a variety of sources and contains daily returns on futures, forwards or swaps contracts in excess of the relevant financing rate. The type of contract for each asset depends on availability or the relative liquidity of different instruments. Prior to expiration positions are rolled over into next most liquid contract. The

---

[5] Our results are robust to the choice of benchmark (local vs. global). We report these tests in the Appendix.

[6] SMB, HML, UMD are from Ken French's website and the liquidity risk factor is from WRDS.

[7] The data can be downloaded at https://live.barcap.com

[8] The distress index was provided to us by Credit Suisse.

rolling date's convention differs across contracts and depends on the relative liquidity of different maturities. The data cover the period between 1963 and 2009, although the data availability varies depending on the asset class. For more details on the computation of returns and data sources see Moskowitz, Ooi, and Pedersen (2010), Appendix A. For equity indexes, country bonds and currencies, betas are computed with respect to a GDP-weighted portfolio, and, for commodities, betas are computed with respect to a diversified portfolio that gives equal risk weight across commodities.

Finally, we use the TED spread as a proxy for time periods where credit constraint are more likely to be binding (as Garleanu and Pedersen (2009) and others). The TED spread is defined as the difference between the three-month EuroDollar LIBOR rate on the three-month U.S. Treasuries rate. Our TED data run from December 1984 to December 2009.

*Estimating Betas*

We estimate pre-ranking betas from rolling regressions of excess returns on excess market returns. Whenever possible we use daily data rather than monthly since the accuracy of covariance estimation improves with the sample frequency (see Merton (1980)). If daily data is available we use 1-year rolling windows and require at least 200 observations. If we only have access to monthly data we use rolling 3-year windows and require at least 12 observations[9]. Following Dimson (1979) and Fama and French (1992) we estimate betas as the sum of the slopes in a regression of the asset's excess return of the current and prior market excess returns:

$$\begin{aligned} r_t - r_t^f &= \hat{\alpha} + \sum_{k=0}^{K} \hat{\beta}_k \left( r_{t-k}^M - r_{t-k}^f \right) + \hat{\varepsilon} \\ \hat{\beta}^{TS} &= \sum_{k=0}^{K} \hat{\beta}_k \end{aligned} \tag{14}$$

The additional lagged terms capture the effects of non-synchronous trading. We

[9] Daily returns are not available for our sample of US Treasury bonds, US corporate bonds and US credit indices.

include lags up to $K = 5$ trading days. When the sample frequency is monthly, we include a single lag. Finally, in order to reduce the influence of outliers, we follow Vasicek (1973) and Elton, Gruber, Brown, and Goetzmann (2003) and shrink the beta estimated using the time-series ($\beta_i^{TS}$) towards the cross-sectional mean ($\beta^{XS}$)

$$\hat{\beta}_i = w_i \hat{\beta}_i^{TS} + (1 - w_i)\hat{\beta}^{XS} \quad (15)$$

For simplicity, rather than having asset-specific and time-varying shrinkage factors as in Vasicek (1973), we set $w = 0.5$ and $\beta^{XS} = 1$ for all periods and across all assets, but our results are very similar either way.[10]

We note that our choice of the shrinkage factor does not affect how securities are sorted into portfolios since the common shrinkage does not change the ranks of security betas.[11] The amount of shrinkage does affect the choice of the hedge ratio in constructing zero-beta portfolios since it determines the relative size of the long and the short side necessary to keep the hedge portfolios beta-neutral at formation. To account for the fact that hedge ratios can be noisy, our inference is focused on realized abnormal returns so that any mismatch between ex ante and realized betas is picked up by the realized loadings in the factor regression. Our results are robust to alternative beta estimation procedures as we report in the Appendix.

*Constructing Betting-Against-Beta Factors*

We construct simple portfolios that are long low beta securities and short high beta securities, hereafter "BAB" factors. To construct each BAB factor, all securities in an asset class (or within a country for global equities) are ranked in ascending order on the basis of their estimated beta. The ranked stocks are assigned

[10] The Vasicek (1973) Bayesian shrinkage factor is given by $w_i = 1 - \sigma_{i,TS}^2 / (\sigma_{i,TS}^2 + \sigma_{XS}^2)$ where $\sigma_{i,TS}^2$ is the variance of the estimated beta for security *i*, and $\sigma_{XS}^2$ is the cross-sectional variance of betas. This estimator places more weight on the historical times series estimate when the estimate has a lower variance or there is large dispersion of betas in the cross section. Pooling across all stocks, in our US equity data, the shrinkage factor $w$ has a mean (median) of 0.51 (0.49).

[11] Using alternative rolling window, lag length or different shrinkage factors does not alter our main results. We report robustness checks in the Appendix.

to one of two portfolios: low beta and high beta. Securities are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of one at portfolio formation. The BAB is the zero-cost zero-beta portfolio (9) that is long the low-beta portfolio and shorts the high-beta portfolio. For example, on average the U.S. stock BAB factor is long $1.5 worth of low-beta stocks (financed by shorting $1.5 of risk free securities) and short $0.7 worth of high-beta stocks (with $0.7 earning the risk-free rate).

## III. Betting Against Beta in Each Asset Class

*Cross section of stock returns*

We now test how the required premium varies in the cross-section of beta-sorted securities (Proposition 1) and the hypothesis that long/short BAB factors have positive average returns (Proposition 2). Table III reports our tests for U.S. stocks. We consider 10 beta-sorted portfolios and report their average returns, alphas, market betas, volatilities, and Sharpe ratios. The average returns of the different beta portfolios are similar, which is the well-known flat security market line. Hence, consistent with Proposition 1 and with Black (1972), alphas decline almost monotonically from low-beta to high-beta portfolios. Indeed, alphas decline both when estimated relative to a 1-, 3-, 4-, and 5-factor model. Also, Sharpe ratios decline monotonically from low-beta to high-beta portfolios. As we discuss in detail below, declining alphas and Sharpe ratios across beta sorted portfolios is a general phenomenon across asset classes. As a overview of these results, the Sharpe ratios of all the beta-sorted portfolios considered in this paper are plotted in Figure B1 in the Appendix.

The rightmost column of Table III reports returns of the betting-against-beta (BAB) factor of Equation (9), that is, a portfolio that is long a levered basket of low-beta stocks and short a de-levered basket of high-beta stocks such as to keep the portfolio beta-neutral. Consistent with Proposition 2, the BAB factor delivers a high average return and a high alpha. Specifically, the BAB factor has Fama and French (1993) abnormal returns of 0.69% per month (t-statistic = 6.55). Additionally adjusting returns for Carhart's (1997) momentum-factor, the BAB portfolio earns abnormal returns of 0.55% per month (t-statistic = 5.12). Last, we adjust returns using a 5-factor model by adding the traded liquidity factor by Pastor and Stambaugh (2003), yielding an abnormal BAB return of 0.46% per month (t-statistic = 2.93) [12]. We note that while the alpha of the long-short portfolio is consistent across regressions, the choice of risk adjustment influences the relative alpha contribution of the long and short sides of the portfolio. Figure B2 in the Appendix plots the annual abnormal returns of the BAB stock portfolio.

We next consider beta-sorted portfolios for global stocks. We use all 19 MSCI developed countries except the U.S. (to keep the results separate from the U.S. results above), and we do this in two ways: We consider global portfolios where all global stocks are pooled together (Table IV), and we consider results separately for each country (Table V). The global portfolio is country neutral that is stocks are assignee to low (high) beta basket within each country.[13]

The results for our pooled sample of global equities in Table IV mimic the U.S. results: Alphas and Sharpe ratios of the beta-sorted portfolios decline (although not perfectly monotonically) with betas, and the BAB factor earns risk-adjusted returns between 0.42% and 0.71% per month depending on the choice of risk adjustment with t-statistics ranging from 2.22 to 3.72.

Table V shows the performance of the BAB factor within each individual country. The BAB delivers positive Sharpe ratios in 18 of the 19 MSCI developed countries and positive 4-factor alphas in 16 out of 19, displaying a strikingly consistent pattern across equity markets. The BAB returns are statistically significantly positive in 9 countries. Of course, the small number of stocks in our sample in many of the countries (with some countries having only a few dozen securities traded) makes it difficult to reject the null hypothesis of zero return in each individual factor. Figure B3 in the Appendix plots the annual abnormal returns of the BAB global portfolio.

---

[12] Note that Pastor and Stambaugh (2003) liquidity factor is available on WRDS only between 1968 and 2008 thus cutting about 50% of our observations.

[13] We keep the global portfolio country neutral since we report results for equity indices BAB separately in table IX.

Tables B1 and B2 in the Appendix report factors loadings. On average, the U.S. BAB factor invests $1.52 long ($1.58 for Global BAB) and $0.71 short ($0.84 for Global BAB). The larger long investment is meant to make the BAB factor market neutral since the long stocks have smaller betas. The U.S. BAB factor realizes a small positive market loading, indicating that our ex-ante beta are measured with noise. The other factor loadings indicates that, relative to high-beta stocks, low-beta stocks are likely to be smaller, have higher book-to-market ratios, and have higher return over the prior 12 months, although none of the loadings can explain the large and significant abnormal returns.

The Appendix reports further tests and additional robustness checks. We split the sample by size and time periods. We control for idiosyncratic volatility (both level and changes) and report results for alternative definition of betas. All the results tell a consistent story: equity beta-neutral portfolios that bet against betas earn significant risk-adjusted returns.

*Treasury Bonds*

Table VI reports results for US Treasury bonds. As before, we report average excess returns of bond portfolios formed by sorting on beta in the previous month. In the cross section of Treasury bonds, ranking on betas with respect to an aggregate Treasury bond index is empirically equivalent to ranking on duration or maturity. Therefore, in Table VI one can think of the term "beta," "duration," or "maturity" in an interchangeable fashion. The rightmost column reports returns of the BAB factor. Abnormal returns are computed with respect to a one-factor model: alpha is the intercept in a regression of monthly excess return on an equally weighted Treasury bond excess market return.

The results show that the phenomenon of a flat security market line is not limited to the cross section of stock returns. Indeed, consistent with Proposition 1, alphas decline monotonically with beta. Likewise, Sharpe ratios decline monotonically from 0.73 for low-beta (short maturity) bonds to 0.27 for high-beta (long maturity) bonds. Further, the bond BAB portfolio delivers abnormal returns of

0.16% per month (t-statistic = 6.37) with a large annual Sharpe ratio of 0.85. Figure B4 in the Appendix plots the annual time series of returns.

Since the idea that funding constraints have a significant effect on the term structure of interest may be surprising, let us illustrate the economic mechanism that may be at work. Suppose an agent, e.g., a pension fund, has $1 to allocate to Treasuries with a target excess return on 1.65% per year. One way to achieve this return target is to invest $1 in a portfolio of 10-year bonds as seen in Table VI. If instead the agent invests in 1-year Treasuries then he would need to invest $4.76 if all maturities had the same Sharpe ratio. This is because 10-year Treasures are 4.76 times more volatile than 1-year Treasuries. Hence, the agent would need to borrow an additional $3.76 to lever his investment in 1-year bonds. If the agent has leverage limits (or prefers lower leverage), then he would strictly prefer the 10-year Treasuries in this case.

According to our theory, the 1-year Treasuries therefore must offer higher returns and higher Sharpe ratios, flattening the security market line for bonds. This is the case empirically. Empirically, the return target can be achieved with by investing $2.7 in 1-year bonds. While a constrained investor may still prefer an un-leveraged investment in 10-year bonds, unconstrained investors now prefer the leveraged low-beta bonds, and the market can clear.

While the severity of leverage constraints varies across market participants, it appears plausible that a 2.7 to 1 leverage (on this part of the portfolio) makes a difference for some large investors such as pension funds.

*Credit*

We next test our model using several credit portfolios. In Table VII, the test assets are monthly excess returns of corporate bond indexes with maturity ranging from 1 to 10 years. Table VII panel A shows that the credit BAB portfolio delivers abnormal returns of 0.13% per month (t-statistic = 4.91) with a large annual Sharpe ratio of 0.88. Further, alphas and Sharpe ratios decline monotonically, with Sharpe ratios ranging from 0.79 to 0.64 from low beta (short maturity) to high beta (long maturity bonds).

Panel B of Table VII reports results for portfolio of US credit indices where we try to isolate the credit component by hedging away the interest rate risk. Given the results on Treasuries in Table VI we are interested in testing a pure credit version of the BAB portfolio. Each calendar month we run 1-year rolling regressions of excess bond returns on excess return on Barclay's US government bond index. We construct test assets by going long the corporate bond index and hedging this position by shorting the appropriate amount of the government bond index: $r_t^{CDS} - r_t^f = (r_t - r_t^f) - \hat{\theta}_{t-1}(r_t^{USGOV} - r_t^f)$, where $\hat{\theta}_{t-1}$ is the slope coefficient estimated in an expanding regression using data up to month *t-1*. One interpretation of this returns series is that it approximately mimics the returns on a Credit Default Swap (CDS). We compute market returns by taking equally weighted average of these hedged returns, and compute betas and BAB portfolios as before. Abnormal returns are computed with respect to a two factor model: alpha is the intercept in a regression of monthly excess return on the equally weighted average pseudo-CDS excess return and the monthly return on the (un-hedged) BAB factor for US credit indices in the rightmost column of Table VII panel B. The addition of the un-hedged BAB factor on the right hand side is an extra check to test a pure credit version of the BAB portfolio.

The results in Panel B of Table VII tell the same story as Panel A: the CDS BAB portfolio delivers significant returns of 0.08% per month (t-statistics = 3.65) and Sharpe ratios decline monotonically from low beta to high beta assets. Figure B5 in the Appendix plots the annual time series of returns.

Last, in Table VIII we report results where the test assets are credit indexes sorted by rating, ranging from AAA to Ca-D and Distressed. Consistent with all our previous results, we find large abnormal returns of the BAB portfolios (0.56% per month with a t-statistics = 4.02), and declining alphas and Sharpe ratios across beta sorted portfolios. Figure B6 in the Appendix plots the annual time series of returns.

*Equity indexes, country bond indexes, foreign exchange and commodities*

Table IX reports results for equity indexes, country bond indexes, foreign exchange and commodities. The BAB portfolio delivers positive return in each of the four asset classes, with annualized Sharpe ratio ranging from 0.22 to 0.51. The magnitude of returns is large, but the BAB portfolios in these assets are much more volatile and, as a result, we are only able to reject the null hypothesis of zero average return for global equity indexes. We can, however, reject the null hypothesis of zero returns for combination portfolios than include all or some combination of the four asset classes, taking advantage of diversification. We construct a simple equally weighted BAB portfolio. To account for different volatility across the four asset classes, in month $t$ we rescale each return series to 10% annualized volatility using rolling 3-year estimate up to moth $t$-$1$ and then equally weight the return series and their respective market benchmark. This corresponds to a simple implementable portfolio that targets 10% BAB volatility in each asset classes. We report results for an *All futures* combo including all four asset classes and a *Country Selection* combo including only Equity indices, Country Bonds and Foreign Exchange. The BAB *All Futures* and *Country Selection* deliver abnormal return of 0.52% and 0.71% per month (t-statistics = 4.50 and 4.42). Figure B7 in the Appendix plots the annual time series of returns.

To summarize, the results in Table III—IX strongly support the predictions that alphas decline with beta and BAB factors earn positive excess returns in each asset class. Figure A1 illustrate the remarkably consistent pattern of declining Sharpe ratios in each asset class. Clearly, the flat security market line, documented by Black, Jensen, Scholes (1972) for U.S. stocks, is a pervasive phenomenon that we find across markets and asset classes. Putting all the BAB factors together produces a large and significant abnormal return of 0.77% per month (t-statistics of 8.8) as seen in Table IX panel B.

This evidence is consistent with of a model in which some investors are prohibited from using leverage and other investors' leverage is limited by margin requirements, generating positive average return of factors that are long a leveraged portfolio of low-beta assets and short a portfolio of high-beta assets. To further examine this explanation of what appears to be a pervasive phenomenon, we next turn to tests the cross-sectional time-series predictions of the model.

## IV. Beta Compression

In this section, we tests Proposition 3 that betas are compressed towards 1 during times with shocks to funding constraints. This model prediction generates two testable hypotheses. The first is a direct prediction on the cross-sectional of betas: the cross-sectional dispersion in betas should be lower when individual credit constraints are more likely to be binding. The second is a prediction on the conditional market betas of BAB portfolios: although beta neutral at portfolio formation (and on average), a BAB factor should tend to realize positive market exposure when individual credit constraints are more likely to be binding. We present results for both predictions in Table X.

We use the TED spread as a proxy of funding liquidity conditions. Our tests rely on the assumption that high levels of TED spread (or, similarly, high levels of TED spread volatility) correspond to times when investors are more likely to face shocks to their funding conditions. Since we expect that funding shocks affect the overall market return, we confirm that the monthly correlation between the TED spread (either level or 1-month changes) and the CRSP value weighted index is negative, around -25%.

We test the model's predictions about the dispersion in betas using our samples of US and Global equities which have the largest cross sections of securities. The sample runs from December 1984 (the first available date for the TED spread) to 2009.

Table X, Panel A shows the cross-sectional dispersion in betas in different time periods sorted by likelihood of binding credit constraints for U.S. stocks. Panel B shows the same for global stocks. Each calendar month we compute cross-sectional standard deviation, mean absolute deviation and inter-quintile range in betas for all stocks in the universe. We assign the TED spread into three groups (low, medium, and high) based on full sample breakpoints (top and bottom 1/3) and regress the times series of the cross-sectional dispersion measure on the full set of dummies (without intercept). Table X shows that, consistent with Proposition 3, the cross-sectional dispersion in betas is lower when credit constraints are more likely to be biding. The average cross-sectional standard deviation of US equity betas in periods of low spreads is 0.47 while the dispersion shrinks to 0.35 in tight credit environment and the difference is highly statistical significant (t-statistics = -10.72). The tests based on the other dispersion measures and the global data all tell a consistent story: the cross-sectional dispersion in beta shrink at times where credit is more likely to be rationed.

Panel C and D reports conditional market betas of the BAB portfolios based on the credit environment for, respectively, U.S. and global stocks. We run factor regression and allow loadings on the market portfolio to vary as function of the realized TED spread. The dependent variable is the monthly return of the BAB portfolio. The explanatory variables are the monthly returns of the market portfolio, Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Market betas are allowed to vary across TED spread regimes (low, neutral and high) using the full set of TED dummies. We are interested in testing the hypothesis that $\hat{\beta}_{high}^{MKT} > \hat{\beta}_{low}^{MKT}$ where $\hat{\beta}_{high}^{MKT}$ ( $\hat{\beta}_{low}^{MKT}$ ) is the conditional market beta in times when credit constraints are more (less) likely to be binding. Panel B reports loading on the market factor corresponding to different time periods sorted by the credit environment. We include the full set of explanatory variables in the regression but only report the market loading. The results are consistent with Proposition 3: although the BAB factor is both ex ante and ex post market neutral on average, the conditional market loading on the BAB factor is function of the credit environment. Indeed, recall from Table III that the realized average market loading is an insignificant 0.03, while Table X shows that when credit is more likely to be rationed, the BAB-factor beta rises to 0.30. The rightmost column shows that variation in realized between tight and relaxed credit environment is large (0.51), and we are safely able to reject the null that $\hat{\beta}_{high}^{MKT} = \hat{\beta}_{low}^{MKT}$ (t-statistics 3.64). Controlling for 3 or 4 factors does not alter the results, although loadings on the other factors absorb some the difference. The results for our sample of global equities are similar as shown and panel D.

To summarize, the results in Table X support the prediction of our model that there is beta compression in times of funding liquidity risk. This can be understood in two ways. First, more discount-rate volatility that affects all securities the same way compresses beta. A deeper explanation is that, as funding conditions get worse, all prices tend to go down, but high-beta assets do not drop as much as their ex-ante beta suggests because the securities market line flattens at such times, providing support for high-beta assets. Conversely, the flattening of the security market line makes low-beta assets drop more than their ex-ante betas suggest.

## V. Time Series Tests

In this section, we test Proposition 2's predictions for the time-series of the BAB returns. When funding constraints become more binding (e.g., because margin requirements rise), the required BAB premium increases and the realized BAB returns becomes negative.

We take this prediction to the data using the TED spread as a proxy of funding conditions as in Section IV. Figure 2 shows the realized return on the U.S. BAB factor and the (negated) TED spread. We plot 3-years rolling average of both variables. The figure shows that the BAB returns tend to be lower in periods of high TED spread, consistent with Proposition 2.

We next test the hypothesis in a regression framework for each of the BAB factors across asset classes, as reported in Table XI. The first column simply regresses the U.S. BAB factor on the contemporaneous level of the TED spread. Consistent with Proposition 2, we find a negative and significant relation, confirming the relation that is visually clear in Figure 2. Column (2) has a similar result when controlling for a number of control variables.

The control variables are the market returns, the 1-month lagged BAB return, the ex ante *Beta Spread*, and the *Short Volatility Returns*. The *Beta Spread* is equal to $(\beta_S - \beta_L) / \beta_S \beta_L$ and measures the beta difference between the long and short side of the BAB portfolios. The *Short Volatility Returns* is the return on a portfolio that is short closest-to-the-money, next-to-expire straddles on the S&P500 index, and measures short to aggregate volatility.

In columns (3) and (4), we decompose the TED spread into its level and change: The *Change in TED Spread* is equal to TED in month $t$ minus the median spread over the past 3 years while *Lagged TED Spread* is the median spread over the past 3 years. We see that both the lagged level and contemporaneous change in the TED spread are negatively related to the BAB returns. If the TED spread measures that agents' funding constraint (given by $\psi$ in the model) are tight, then the model predicts a negative coefficient for the change in TED and a positive coefficient for the lagged level. Hence, the coefficient for the lagged level is not consistent with the model under this interpretation of the TED spread. If, instead, a high TED spread indicates that agents' funding constraints are *worsening*, then the results could be consistent with the model. Under this interpretation, a high TED spread could indicate that banks are credit constrained and that banks over time tighten other investors' credit constraints, thus leading to a deterioration of BAB returns over time, if this is not fully priced in.

Columns (5)-(8) of Table XI reports panel regressions for global stock BAB factors, and columns (9)-(12) for all the BAB factors. These regressions include fixed effect and standard errors are clustered by date. We consistently find a negative relationship between BAB returns and the TED spread.

In addition to the TED spread, the ex ante *Beta Spread,* $(\beta_S - \beta_L)/\beta_S\beta_L$, is of interest since Proposition 2 predicts that the ex ante beta spread should predict BAB returns positively. Consistent with the model, Table XI shows that the estimated coefficient for the *Beta Spread* is positive in all six regressions where it is included, and statistically significant in three regressions that control for the lagged TED spread.

To ensure that these panel-regression estimates are not driven by a few asset classes, we also run a separate regression for each BAB factor on the TED spread. Figure 3 plots the t-statistics of the slope estimate on the TED spread. Although we are not always able to reject the null of no effect for each individual factor, the slopes estimates display a consistent pattern: we find negative coefficients in 16 out of the 19 asset classes, with *Credit* and *Treasuries* being the exceptions. Obviously the exceptions could be just noise, but positive returns to BAB portfolios during liquidity crises (i.e., high TED periods) could possibly be related to "flight to quality" in which some investors switch towards assets that are closer to money-market instruments, or related to central banks cutting short-term yields to counteract liquidity crises. Table A7 in the Appendix provides more details on the BAB returns in different environments.

## VI. Conclusion

All real-world investors face funding constraints such as leverage constraints and margin requirements, and these constraints influence investors' required returns across securities and over time. Consistent with the idea that investors prefer un-leveraged risky assets to leveraged safe assets, which goes back to Black (1972), we find empirically that portfolios of high-beta assets have lower alphas and Sharpe ratios than low-beta assets. The security market line is not only flat for U.S. equities (as reported by Black, Jensen, and Scholes (1972)), but we also find this flatness for 18 of 19 global equity markets, in Treasury markets, for corporate bonds sorted by maturity and by rating, and in futures markets. We show how this deviation from the standard CAPM can be captured using betting-against-beta factors, which may also be useful as control variables in future research. The return of the BAB factor rivals that of standard asset pricing factors such as value, momentum, and size in terms of economic magnitude, statistical significance, and robustness across time periods, sub-samples of stocks, and global asset classes.

Extending the Black (1972) model, we consider the implications of funding constraints for cross-sectional and time-series asset returns: We show that increased funding liquidity risk compresses betas in the cross section of securities towards 1, leading to an increased beta for the BAB factor, and we find consistent evidence empirically. In the time series, we show that increased funding illiquidity should lead to losses for the BAB factor, and we find consistent evidence in all the asset classes that we study except Treasuries and credit.

Our model also has implications for agents' portfolio selection (Proposition 4). While we leave rigorous tests of these predictions for future research, we conclude with some suggestive ideas consistent with the model's predictions. Our model predicts that agents with access to leverage buy low-beta securities and lever them up. One such group of agents is private equity (PE) funds involved in leveraged buyouts (LBOs). Our model predicts that the stocks bought by PE firms have a lower beta than 1 before they buy them. Further, when the private equity firm sells the firm back to the public, the model predicts that the beta has increased. Also, banks have relatively easy access to leverage (e.g., through their depositors) so the model predicts that banks own leveraged positions in securities with low-beta. Indeed, anecdotal evidence suggests that banks hold leveraged portfolios of high-rated bonds, e.g. mortgage bonds. Further, shadow banks such as special investment vehicles (SIVs) had in some cases infinitely leveraged portfolios of short-dated high-rated fixed-income securities. Conversely, the model predicts that investors that are particularly restricted by constraints buy high-beta assets. For instance, mutual funds may be biased to holding high-beta stocks because of their limited leveraged (Karceski (2002)).

## References

Acharya, V. V., and L. H. Pedersen (2005), "Asset Pricing with Liquidity Risk," Journal of Financial Economics, 77, 375-410.

Ang, A., R. Hodrick, Y. Xing, X. Zhang (2006), "The Cross-Section of Volatility and Expected Returns," Journal of Finance, 61, pp. 259-299.

– (2009), "High Idiosyncratic Volatility and Low Returns: International and Further U.S. Evidence," Journal of Financial Economics, 91, pp. 1-23.

Ashcraft, A., N. Garleanu, and L.H. Pedersen (2010), "Two Monetary Tools: Interest Rates and Haircuts," NBER Macroeconomics Annual, forthcoming.

Baker, M., B. Bradley, and J. Wurgler (2010), "Benchmarks as Limits to Arbitrage: Understanding the Low Volatility Anomaly," working paper, Harvard.

Black, F. (1972), "Capital market equilibrium with restricted borrowing," Journal of business, 45, 3, pp. 444-455.

– (1992), "Beta and Return," The Journal of Portfolio Management, 20, pp. 8-18.

Black, F., M.C. Jensen, and M. Scholes (1972), "The Capital Asset Pricing Model: Some Empirical Tests." In Michael C. Jensen (ed.), Studies in the Theory of Capital Markets, New York, pp. 79-121.

Brennan, M.J., (1971), "Capital market equilibrium with divergent borrowing and lending rates." Journal of Financial and Quantitative Analysis 6, 1197-1205.

Brennan, M.J. (1993), "Agency and Asset Pricing." University of California, Los Angeles, working paper.

Brunnermeier, M. and L.H. Pedersen (2009), “Market Liquidity and Funding Liquidity,” The Review of Financial Studies, 22, 2201-2238.

Carhart, M. (1997), "On persistence in mutual fund performance", Journal of Finance 52, 57–82.

Cuoco, D. (1997), “Optimal consumption and equilibrium prices with portfolio constraints and stochastic income," Journal of Economic Theory, 72(1), 33-73.

Dimson, E. (1979), “Risk Measurement when Shares are Subject to Infrequent Trading,” Journal of Financial Economics, 7, 197–226.

Duffee, G. (2010), “Sharpe Ratios in Term Structure Models,” Johns Hopkins University, working paper.

Elton, E.G., M.J. Gruber, S. J. Brown and W. Goetzmannn: "Modern Portfolio Theory and Investment", Wiley: New jersey.

Fama, E.F. (1984), “The Information in the Term Structure,” Journal of Financial Economics, 13, 509-528.

Fama, E.F. (1986), “Term Premiums and Default Premiums in Money Markets,” Journal of Financial Economics, 17, 175-196.

Fama, E.F. and French, K.R. (1992), “The cross-section of expected stock returns,” Journal of Finance, 47, 2, pp. 427-465.

Fama, E.F. and French, K.R. (1993), "Common risk factors in the returns on stocks and bonds", Journal of Financial Economics 33, 3–56.

Fu, F. (2009), "Idiosyncratic risk and the cross-section of expected stock returns," Journal of Financial Economics, vol. 91:1, 24-37.

Garleanu, N., and L. H. Pedersen (2009), "Margin-Based Asset Pricing and Deviations from the Law of One Price," UC Berkeley and NYU, working paper.

Gibbons, M. (1982), "Multivariate tests of financial models: A new approach," Journal of Financial Economics, 10, 3-27.

Gromb, D. and D. Vayanos (2002), "Equilibrium and Welfare in Markets with Financially Constrained Arbitrageurs," Journal of Financial Economics, 66, 361–407.

Hindy, A. (1995), "Viable Prices in Financial Markets with Solvency Constraints," Journal of Mathematical Economics, 24(2), 105-135.

Kandel, S. (1984), "The likelihood ratio test statistic of mean-variance efficiency without a riskless asset," Journal of Financial Economics, 13, pp. 575-592.

Karceski, J. (2002), "Returns-Chasing Behavior, Mutual Funds, and Beta's Death," Journal of Financial and Quantitative Analysis, 37:4, 559-594.

Lewellen, J. and Nagel, S. (2006), "The conditional CAPM does not explain asset-pricing anomalies," Journal of Financial Economics, 82(2), pp. 289—314.

Markowitz, H.M. (1952), "Portfolio Selection," The Journal of Finance, 7, 77-91.

Mehrling, P. (2005), "Fischer Black and the Revolutionary Idea of Finance," Wiley: New Jersey.

Merton R. C. (1980), "On estimating the expected return on the market: An exploratory investigation" , Journal of Financial Economics 8, 323{361.

Moskowitz, T., Y.H. Ooi, and L.H. Pedersen (2010), “Time Series Momentum,” University of Chicago and NYU working paper.

Pastor, L , and R. Stambaugh. (2003), "Liquidity risk and expected stock returns", Journal of Political Economy 111, 642–685.

Polk, C., S. Thompson, and T. Vuolteenaho (2006), “Cross-sectional forecasts of the equity premium,” Journal of Financial Economics, 81, 101-141.

Shanken, J. (1985), “Multivariate tests of the zero-beta CAPM,” Journal of Financial Economics, 14,. 327-348.

Vasicek, O. A. (1973), “A Note on using Cross-sectional Information in Bayesian Estimation on Security Beta’s,” The Journal of Finance, 28(5), 1233–1239.

## Appendix A: Proofs

**Proof of Proposition 1.** Rearranging the equilibrium-price Equation (7) yields

$$\begin{aligned} E_t\left(r_{t+1}^s\right) &= r^f + \psi_t + \gamma \frac{1}{P_t^s} e_s{}'\Omega x^* \\ &= r^f + \psi_t + \gamma \frac{1}{P_t^s} \operatorname{cov}_t\left(P_{t+1}^s, P_{t+1}{}'x^*\right) \\ &= r^f + \psi_t + \gamma \operatorname{cov}_t\left(r_{t+1}^s, r_{t+1}^M\right) P_t{}'x^* \end{aligned} \tag{A1}$$

where $e_s$ is a vector with a 1 in row $s$ and zeros elsewhere. Multiplying this equation by the market portfolio weights $w^s = x^{*i} P_t^s / \sum_j x^{*j} P_t^j$ and summing over $s$ gives

$$E_t\left(r_{t+1}^M\right) = r^f + \psi_t + \gamma \operatorname{var}_t\left(r_{t+1}^M\right) P_t{}'x^* \tag{A2}$$

that is,

$$\gamma P_t{}'x^* = \frac{\lambda_t}{\operatorname{var}_t\left(r_{t+1}^M\right)} \tag{A3}$$

Inserting this into (A1) gives the first result in the proposition. The second result follows from writing the expected return as:

$$E_t\left(r_{t+1}^s\right) - r^f = \psi_t\left(1 - \beta_t^s\right) + \beta_t^s\left(E_t\left(r_{t+1}^M\right) - r^f\right) \tag{A4}$$

and noting that the first term is (Jensen's) alpha. Turning to the third result regarding efficient portfolios, the Sharpe ratio increases in beta until the tangency portfolio is reached, and decreases thereafter. Hence, the last result follows from the fact that the tangency portfolio has a beta less than 1. This is true because the market portfolio is an average of the tangency portfolio (held by unconstrained agents) and riskier portfolios (held by constrained agents) so the market portfolio is riskier than the tangency portfolio. Hence, the tangency portfolio must have a lower expected return and beta (strictly lower iff some agents are constrained).□

**Proof of Proposition 2.** The expected return of the BAB factor is:

$$\begin{aligned} E_t\left(r_{t+1}^{BAB}\right) &= \frac{1}{\beta_t^L}\left(E_t\left(r_{t+1}^L\right)-r^f\right)-\frac{1}{\beta_t^H}\left(E_t\left(r_{t+1}^H\right)-r^f\right) \\ &= \frac{1}{\beta_t^L}\left(\psi_t+\beta_t^L\lambda_t\right)-\frac{1}{\beta_t^H}\left(\psi_t+\beta_t^H\lambda_t\right) \\ &= \frac{\beta_t^H-\beta_t^L}{\beta_t^L\beta_t^H}\psi_t \end{aligned} \tag{A5}$$

Consider next a change in $m_t^k$. Note first that this does not change the betas. This is because Equation (7) shows that the change in Lagrange multipliers scale all the prices (up or down) by the same proportion. Hence, Equation (12) in the proposition follows if we can show that $\psi_t$ increases in $m^k$ since this lead to:

$$\frac{\partial E_t\left(r_{t+1}^{BAB}\right)}{\partial m_t^k} = \frac{\beta_t^H-\beta_t^L}{\beta_t^L\beta_t^H}\frac{\partial \psi_t}{\partial m_t^k} > 0 \tag{A6}$$

Further, since prices move opposite required returns, Equation (11) then follows. To see that an increase in $m_t^k$ increases $\psi_t$ , we first note that the constrained agents' asset expenditure decreases with a higher $m_t^k$. Indeed, summing the portfolio constraint across constrained agents (where is holds with equality) gives

$$\sum_{i\text{ constrained}}\sum_s x^{i,s}P_t^s = \sum_{i\text{ constrained}}\frac{1}{m^i}W_t^i \tag{A7}$$

Since increasing $m^k$ decreases the right-hand side, the left-hand side must also decrease. That is, the total market value of shares owned by constrained agents decreases.

Next, the constrained agents' expenditure is decreasing in $\psi$ so $\psi$ must increase:

$$\frac{\partial}{\partial \psi} \sum_{i \text{ constrained}} P_t' x^i = \sum_{i \text{ constrained}} \left( \frac{\partial P_t}{\partial \psi}' x^i + P_t' \frac{\partial x^i}{\partial \psi} \right) < 0 \tag{A8}$$

To see the last inequality, note first that clearly $\frac{\partial P_t}{\partial \psi}' x^i < 0$ since all the prices decrease by the same proportion (seen in Equation (7)) and the initial expenditure is positive. The second term is also negative since

$$\begin{aligned}
\sum_{i \text{ constrained}} P_t' \frac{\partial}{\partial \psi} x^i &= \sum_{i \text{ constrained}} \left( \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \right)' \frac{\partial}{\partial \psi} \frac{1}{\gamma^i} \Omega^{-1} \left( E_t\left(P_{t+1}\right) - \left(1 + r^f + \psi_t^i\right) \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \right) \\
&= -\left( \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \right)' \frac{\partial}{\partial \psi} \Omega^{-1} \sum_{i \text{ constrained}} \frac{1}{\gamma^i} \left(1 + r^f + \psi_t^i\right) \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \\
&= -\left( \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \right)' \frac{\partial}{\partial \psi} \Omega^{-1} \frac{1}{\gamma} \left( q\left(1 + r^f\right) + \psi \right) \frac{E_t\left(P_{t+1}\right) - \gamma \Omega x^*}{1 + r^f + \psi} \\
&= -\frac{1}{1 + r^f + \psi} \frac{1}{\gamma} \frac{\partial}{\partial \psi} \frac{q\left(1 + r^f\right) + \psi}{1 + r^f + \psi} \left( E_t\left(P_{t+1}\right) - \gamma \Omega x^* \right)' \Omega^{-1} \left( E_t\left(P_{t+1}\right) - \gamma \Omega x^* \right) \\
&< 0
\end{aligned}$$

where we have defined $q = \sum_{i \text{ constrained}} \frac{\gamma}{\gamma^i} < 1$ and used that $\sum_{i \text{ constrained}} \frac{\gamma}{\gamma^i} \psi^i = \sum_i \frac{\gamma}{\gamma^i} \psi^i = \psi$ since $\psi^i = 0$ for unconstrained agents. This completes the proof.□

**Proof of Proposition 3.** Using the Equation (7) for the price, the sensitivity of with respect to funding shocks can be calculated as

$$\frac{\partial P_t^s}{P_t^s} / \partial \psi_t = -\frac{1}{1 + r^f + \psi_t} \tag{A9}$$

which is the same for all securities *s*.

Intuitively, shocks that affect all securities the same way compress betas towards one. This is seen most easily using long returns:

$$\begin{aligned} r_t^{s,\log} &= \log P_t^s - \log P_{t-1}^s \\ &= \log\left(E_t\left(P_{t+1}^s\right) - \gamma\Omega x^*\right) - \log\left(1 + r^f + \psi_t\right) - \log P_{t-1}^s \end{aligned} \tag{A10}$$

Hence, a higher variance of $\log\left(1 + r^f + \psi_t\right)$ increases all co-variances and variances by the same amount, thus pushing betas – the ratio of covariance to market variance – towards one.

The result is seen as follows when returns are computed as ratios:

$$r_t^i = \frac{P_t^i}{P_{t-1}^i} - 1 = \frac{1}{1 + r^f + \psi_t} \frac{E_t\left(P_{t+1}^i\right) - \gamma\Omega_t^i x^*}{P_{t-1}^i} - 1 \tag{A11}$$

First, we decompose returns into two parts:

$$r_t^i = x_t z_t^i - 1 \tag{A12}$$

where

$$\begin{aligned} x_t &= \frac{1}{1 + r^f + \psi_t} \Big/ E_{t-1}\left(\frac{1}{1 + r^f + \psi_t}\right) \\ z_t^i &= E_{t-1}\left(\frac{1}{1 + r^f + \psi_t}\right) \frac{E_t\left(P_{t+1}^i\right) - \gamma\Omega_t^i x^*}{P_{t-1}^i} \end{aligned} \tag{A13}$$

When $x$ is independent of $z$, the covariance between and security $i$ and the market $M$ can be written as:

$$\begin{aligned} \operatorname{cov}_{t-1}(r_t^i, r_t^M) &= \operatorname{cov}_{t-1}(x\, z^i, x\, z^M) \\ &= E_{t-1}\left(x^2 z^i z^M\right) - E_{t-1}\left(x\, z^i\right) E_{t-1}\left(x\, z^M\right) \\ &= \left(\operatorname{var}_{t-1}(x) + E_{t-1}(x)^2\right) E_{t-1}\left(z^i z^M\right) - E_{t-1}(x)^2 E_{t-1}\left(z^i\right) E_{t-1}\left(z^M\right) \\ &= \operatorname{var}_{t-1}(x) E_{t-1}\left(z^i z^M\right) + \operatorname{cov}_{t-1}(z^i, z^M) \end{aligned} \tag{A14}$$

and, hence, beta is

$$\beta_{t-1}^{i}=\frac{\operatorname{cov}_{t-1}(r_t^i,r_t^M)}{\operatorname{var}_{t-1}(r_t^M)} \\ =\frac{\operatorname{var}_{t-1}(x)E_{t-1}\left(z^i z^M\right)+\operatorname{cov}_{t-1}(z^i,z^M)}{\operatorname{var}_{t-1}(x)E_{t-1}\left((z^M)^2\right)+\operatorname{var}_{t-1}(z^M)} \tag{A15}$$

A higher variance of $x$ pushes beta towards $E_{t-1}\left(z^i z^M\right)/E_{t-1}\left((z^M)^2\right)$ which is close to 1 since the $z$'s are effectively ratios of prices.

Lastly, if betas are compressed towards 1 after the formation of the BAB portfolio, then BAB will realize a positive beta as its long-side is more levered than its short side. □

**Proof of Proposition 4.** To see the first part of the proposition, we first note that an unconstrained investor holds the tangency portfolio, which has a beta less than 1 in equilibrium with funding constraints, and the constrained investors hold riskier portfolios of risky assets, as discussed in the proof of Proposition 1.

To see the second part of the proposition, note that given the equilibrium prices, the optimal portfolio is:

$$x^i=\frac{1}{\gamma^i}\Omega^{-1}\left(E_t\left(P_{t+1}\right)-\left(1+r^f+\psi_t^i\right)\frac{E_t\left(P_{t+1}\right)-\gamma\Omega x^*}{1+r^f+\psi_t}\right) \\ =\frac{\gamma}{\gamma^i}\frac{1+r^f+\psi_t^i}{1+r^f+\psi_t}x^*+\frac{\psi_t-\psi_t^i}{1+r^f+\psi_t}\frac{1}{\gamma^i}\Omega^{-1}E_t\left(P_{t+1}\right) \tag{A16}$$

The first term shows that each agent holds some (positive) weight in the market portfolio $x^*$ and the second term shows how he tilts his portfolio away from the market. The direction of the tilt depends on whether the agent's Lagrange multiplier $\psi_t^i$ is smaller or larger than the weighted average of all the agents' Lagrange multipliers $\psi_t$. A less constrained agent tilts towards the portfolio $\Omega^{-1}E_t\left(P_{t+1}\right)$ (measured in shares), while a more constrained agent tilts away from this portfolio.

Given the expression (13), we can write the variance-covariance matrix as

$$\Omega = \sigma_M^2 bb' + \Sigma \tag{A17}$$

where $\Sigma$=var$(e)$ and $\sigma_M^2 = \text{var}\left(P_{t+1}^M\right)$. Using the Matrix Inversion Lemma (the Sherman–Morrison–Woodbury formula), the tilt portfolio can be written as:

$$\begin{aligned}\Omega^{-1}E_t\left(P_{t+1}\right) &= \left(\Sigma^{-1} - \Sigma^{-1}bb'\Sigma^{-1}\frac{1}{\sigma_M^2 + b'\Sigma^{-1}b}\right)E_t\left(P_{t+1}\right) \\ &= \Sigma^{-1}E_t\left(P_{t+1}\right) - \Sigma^{-1}bb'\Sigma^{-1}E_t\left(P_{t+1}\right)\frac{1}{\sigma_M^2 + b'\Sigma^{-1}b} \\ &= \Sigma^{-1}E_t\left(P_{t+1}\right) - y\Sigma^{-1}b\end{aligned} \tag{A18}$$

where $y = b'\Sigma^{-1}E_t\left(P_{t+1}\right)/\left(\sigma_M^2 + b'\Sigma^{-1}b\right)$ is a scalar and $\left(\Sigma^{-1}b\right)_s > \left(\Sigma^{-1}b\right)_k$ since $b^s > b^k$ and $s$ and $k$ have the rows and columns in $\Sigma$ implying that $\left(\Sigma^{-1}\right)_{s,s} > \left(\Sigma^{-1}\right)_{s,k}$. So everything else equal, a higher $b$ leads to a lower weight in the tilt portfolio.

Finally, we note that security $s$ also has a higher return beta than $k$ since

$$\beta_t^i = \frac{P_t^M \text{cov}(P_{t+1}^i, P_{t+1}^M)}{P_t^i \text{ var}\left(P_{t+1}^M\right)} = \frac{P_t^M}{P_t^i}b^i \tag{A19}$$

and a higher $b^i$ means a lower price:

$$P_t^i = \frac{E_t\left(P_{t+1}^i\right) - \gamma\left(\Omega x^*\right)_i}{1 + r^f + \sum_i \frac{\gamma}{\gamma^i}\psi_t^i} = \frac{E_t\left(P_{t+1}^i\right) - \gamma\left(\Sigma x^*\right)_i - b^i b' x^* \gamma \sigma_M^2}{1 + r^f + \sum_i \frac{\gamma}{\gamma^i}\psi_t^i} \tag{A20}$$

□

## Appendix B: Additional Empirical Results and Robustness Tests

Tables B1 to B7 and Figures B1 to B7 contain additional empirical results and robustness tests.

- Table B1 reports returns of BAB portfolio in US and global equities using different window lengths and different benchmark to estimate betas.

- Table B2 reports returns and factor loadings of US and Global BAB portfolios

- Table B3 and B4 report returns of US and Global BAB portfolios controlling for idiosyncratic volatility. Idiosyncratic volatility is defined as the standard deviation of the residuals in the rolling regression used to estimated betas. We use conditional sorts: at the beginning of each calendar month stocks are ranked in ascending order on the basis of their idiosyncratic volatility and assigned to one of 10 groups from low to high volatility. Within each volatility deciles, we assign stocks to low and high beta portfolios and compute BAB returns. We report two sets of results: controlling for the level of idiosyncratic volatility and the 1-month change in the same measure.

- Table B5 reports returns of US and Global BAB portfolios controlling for size. Size is defined as the market value of equity (in USD). We use conditional sorts: at the beginning of each calendar month stocks are ranked in ascending order on the basis of their market value of equity and assigned to one of 10 groups from small to large based on NSYE breakpoints. Within each size deciles, we assign stocks to low and high beta portfolios and compute BAB returns.

- Table B6 reports returns of US and Global BAB portfolios in different sample periods

- Table B7 reports returns of BAB portfolios for all asset classes in different time periods sorted by likelihood of binding credit constraints. At the beginning of each calendar month, we rescale each return series to 10% annualized volatility using rolling 3-year estimate up to moth $t$-1. We assign the Ted spread into three groups (low, neutral and high) based on full sample breakpoints (top and bottom 1/3) and report returns for each time period.

- Figure B1 plot the Sharpe ratio (annualized) of beta-sorted portfolios for all the asset classes.

- Figures B2 to B7 reports calendar time returns of the BAB portfolios.

## Table B1
## US and Global equities. Robustness: Alternative Betas Estimation

This table shows calendar-time portfolio returns of BAB portfolios for different beta estimation methods. At the beginning of each calendar month within each country stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database, and all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. *$ Long (Short)* is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| Index | Universe | Estimation window (year) | Lagged terms | Excess Return | T-stat (Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CRSP - VW index | US | 1 | 1 Week | **0.71** | 6.76 | **0.55** | 5.12 | 0.71 | 1.52 | 11.5 | 0.75 |
| CRSP - VW index | US | 3 | 1 Week | **0.43** | 4.75 | **0.43** | 4.96 | 0.73 | 1.36 | 9.6 | 0.53 |
| CRSP - VW index | US | 5 | 1 Week | **0.37** | 4.04 | **0.42** | 5.01 | 0.76 | 1.29 | 9.8 | 0.46 |
| Local market index | GLOBAL | 1 | 1 Week | **0.72** | 3.79 | **0.45** | 2.47 | 0.86 | 1.51 | 10.9 | 0.79 |
| Global market index | GLOBAL | 1 | 1 Week | **1.06** | 4.08 | **0.59** | 2.40 | 0.87 | 1.78 | 15.5 | 0.82 |
| CRSP - VW index | GLOBAL | 1 | 1 Week | **0.81** | 3.07 | **0.39** | 1.57 | 0.98 | 1.81 | 15.3 | 0.64 |

**Table B2**
**US and Global equities. Factor Loadings**

This table shows calendar-time portfolio returns and factor loadings. At the beginning of each calendar month all stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database, and all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. Beta (ex ante) is the average estimated beta at portfolio formation. $ Long (Short) is the average dollar value of the long (short) position.

| | Excess Return | Alpha | MKT | SMB | HML | UMD | $ Short | $ Long |
|---|---|---|---|---|---|---|---|---|
| Panel A: US - all stocks | | | | | | | | |
| High Beta | **0.97** | 0.01 | **1.30** | **1.11** | **0.23** | **-0.23** | | |
| Low beta | **0.93** | **0.33** | **0.67** | **0.60** | **0.26** | **-0.05** | | |
| L/S | **0.71** | **0.55** | 0.02 | **0.13** | **0.10** | **0.11** | 0.71 | 1.52 |
| t-statistics | 3.03 | 0.09 | 86.35 | 47.40 | 10.25 | -13.47 | | |
| | 5.44 | 6.11 | 64.04 | 37.17 | 16.47 | -4.39 | | |
| | 6.76 | 5.12 | 1.13 | 3.99 | 3.14 | 4.39 | | |
| Panel B: US - above NYSE median ME | | | | | | | | |
| High Beta | **0.76** | **-0.15** | **1.41** | **0.62** | **0.05** | **-0.14** | | |
| Low beta | **0.65** | **0.14** | **0.69** | **0.17** | **0.15** | 0.02 | | |
| L/S | **0.30** | **0.28** | **-0.12** | **-0.20** | **0.13** | **0.13** | 0.73 | 1.35 |
| t-statistics | 2.59 | -2.15 | 105.40 | 29.85 | 2.34 | -8.83 | | |
| | 4.69 | 2.79 | 71.48 | 11.62 | 10.12 | 1.55 | | |
| | 2.78 | 2.69 | -6.03 | -6.47 | 4.29 | 5.63 | | |
| Panel C: Global- all stocks | | | | | | | | |
| High Beta | 0.19 | -0.26 | **1.02** | **0.37** | **0.20** | **-0.21** | | |
| Low beta | 0.47 | 0.05 | **0.61** | **0.28** | **0.36** | -0.01 | | |
| L/S | **0.90** | **0.59** | **0.18** | **0.13** | **0.38** | **0.17** | 0.84 | 1.58 |
| t-statistics | 0.44 | -0.91 | 15.05 | 4.17 | 2.06 | -3.59 | | |
| | 1.71 | 0.24 | 12.07 | 4.18 | 4.93 | -0.16 | | |
| | 4.39 | 3.00 | 4.00 | 2.23 | 5.74 | 4.38 | | |
| Panel D: Global, above 90% ME by country | | | | | | | | |
| High Beta | 0.34 | -0.21 | **1.10** | **0.31** | **0.23** | -0.11 | | |
| Low beta | 0.46 | 0.04 | **0.61** | **0.16** | **0.33** | 0.04 | | |
| L/S | **0.60** | **0.44** | -0.03 | -0.03 | **0.30** | **0.15** | 0.86 | 1.41 |
| t-statistics | 0.82 | -0.77 | 17.19 | 3.69 | 2.52 | -1.92 | | |
| | 1.80 | 0.21 | 12.56 | 2.55 | 4.76 | 0.94 | | |
| | 3.20 | 2.48 | -0.75 | -0.48 | 4.93 | 4.07 | | |

## Table B3
## US equities. Robustness: Idiosyncratic Volatility.

This table shows calendar-time portfolio returns of BAB portfolios with conditional sort on idiosyncratic volatility. At the beginning of each calendar month stocks are ranked in ascending order on the basis of their idiosyncratic volatility and assign to one of 10 groups. Idiosyncratic volatility is defined as the standard deviation of the residuals in the rolling regression used to estimated betas. Panel A reports results for conditional sorts based on the level of idiosyncratic volatility at portfolio formation. Panel B report results based on the 1-month changes in the same measure. At the beginning of each calendar month, within each volatility deciles stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database between 1926 and 2009. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. *$ Long (Short)* is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| Panel A: Control for Idiosyncratic volatility | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Low - volatility | **0.22** | 2.04 | **0.29** | 2.94 | 1.02 | 1.65 | 11.6 | 0.22 |
| P -2 | **0.37** | 3.60 | **0.38** | 3.82 | 0.91 | 1.51 | 11.3 | 0.40 |
| P -3 | **0.50** | 4.88 | **0.44** | 4.46 | 0.86 | 1.46 | 11.1 | 0.54 |
| P -4 | **0.40** | 3.66 | **0.32** | 3.07 | 0.82 | 1.42 | 11.9 | 0.40 |
| P -5 | **0.42** | 3.83 | **0.30** | 2.82 | 0.79 | 1.40 | 11.8 | 0.42 |
| P -6 | **0.48** | 4.45 | **0.35** | 3.30 | 0.76 | 1.39 | 11.8 | 0.49 |
| P -7 | **0.58** | 5.18 | **0.36** | 3.32 | 0.73 | 1.38 | 12.2 | 0.57 |
| P -8 | **0.74** | 5.49 | **0.41** | 3.41 | 0.70 | 1.37 | 14.6 | 0.61 |
| P -9 | **0.94** | 5.33 | **0.50** | 3.51 | 0.67 | 1.39 | 19.3 | 0.59 |
| High volatility | **1.81** | 5.25 | **1.16** | 3.98 | 0.63 | 1.61 | 37.6 | 0.58 |

| Panel B: Control for Idiosyncratic volatility changes | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Low - volatility | **0.46** | 3.99 | **0.41** | 3.64 | 0.75 | 1.52 | 12.6 | 0.44 |
| P -2 | **0.34** | 2.98 | **0.29** | 2.55 | 0.75 | 1.49 | 12.5 | 0.33 |
| P -3 | **0.48** | 4.22 | **0.40** | 3.43 | 0.74 | 1.48 | 12.5 | 0.47 |
| P -4 | **0.59** | 5.18 | **0.48** | 4.26 | 0.73 | 1.47 | 12.3 | 0.57 |
| P -5 | **0.54** | 4.63 | **0.46** | 3.89 | 0.72 | 1.47 | 12.6 | 0.51 |
| P -6 | **0.64** | 4.70 | **0.44** | 3.26 | 0.71 | 1.47 | 14.7 | 0.52 |
| P -7 | **0.60** | 4.72 | **0.47** | 3.56 | 0.70 | 1.49 | 13.8 | 0.52 |
| P -8 | **0.97** | 6.25 | **0.77** | 4.97 | 0.69 | 1.51 | 16.8 | 0.69 |
| P -9 | **1.16** | 5.82 | **0.93** | 4.80 | 0.68 | 1.60 | 21.7 | 0.64 |
| High volatility | 1.53 | 2.61 | 0.87 | 1.48 | 0.68 | 1.92 | 63.6 | 0.29 |

## Table B4
## Global equities. Robustness: Idiosyncratic Volatility.

This table shows calendar-time portfolio returns of BAB portfolios with conditional sort on idiosyncratic volatility. At the beginning of each calendar month stocks are ranked in ascending order on the basis of their idiosyncratic volatility and assign to one of 10 groups. Idiosyncratic volatility is defined as the standard deviation of the residuals in the rolling regression used to estimated betas. Panel A reports results for conditional sorts based on the level of idiosyncratic volatility at portfolio formation. Panel B report results based on the 1-month changes in the same measure. Within each volatility deciles stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database, and all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. *$ Long (Short)* is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| Panel A: Control for Idiosyncratic volatility | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Low - volatility | 0.30 | 1.85 | **0.31** | 2.16 | 1.06 | 1.56 | 8.7 | 0.41 |
| P -2 | **0.32** | 1.97 | 0.28 | 1.81 | 1.01 | 1.48 | 8.7 | 0.44 |
| P -3 | 0.17 | 1.03 | 0.11 | 0.70 | 0.98 | 1.45 | 8.6 | 0.23 |
| P -4 | **0.35** | 1.96 | 0.22 | 1.28 | 0.95 | 1.43 | 9.5 | 0.44 |
| P -5 | **0.38** | 2.21 | 0.33 | 1.92 | 0.92 | 1.41 | 9.1 | 0.49 |
| P -6 | 0.36 | 1.79 | 0.27 | 1.32 | 0.90 | 1.39 | 10.7 | 0.40 |
| P -7 | 0.24 | 1.10 | 0.07 | 0.32 | 0.87 | 1.37 | 11.9 | 0.25 |
| P -8 | 0.05 | 0.21 | -0.03 | -0.10 | 0.84 | 1.37 | 12.6 | 0.05 |
| P -9 | -0.07 | -0.23 | -0.22 | -0.78 | 0.81 | 1.36 | 15.1 | -0.05 |
| High volatility | -0.33 | -0.93 | -0.46 | -1.30 | 0.77 | 1.41 | 18.9 | -0.21 |

| Panel B: Control for Idiosyncratic volatility changes | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Low - volatility | **0.47** | 2.40 | 0.37 | 1.96 | 0.93 | 1.49 | 10.5 | 0.54 |
| P -2 | 0.22 | 1.03 | 0.06 | 0.29 | 0.92 | 1.48 | 11.3 | 0.23 |
| P -3 | **0.43** | 2.10 | **0.46** | 2.28 | 0.92 | 1.46 | 11.0 | 0.47 |
| P -4 | **0.45** | 2.21 | **0.42** | 2.07 | 0.91 | 1.45 | 10.9 | 0.50 |
| P -5 | **0.40** | 2.03 | 0.30 | 1.58 | 0.90 | 1.44 | 10.6 | 0.45 |
| P -6 | **0.60** | 2.96 | **0.45** | 2.30 | 0.89 | 1.44 | 10.8 | 0.66 |
| P -7 | **0.58** | 2.79 | 0.39 | 1.90 | 0.88 | 1.44 | 11.2 | 0.62 |
| P -8 | 0.44 | 1.77 | 0.22 | 0.90 | 0.87 | 1.44 | 13.2 | 0.40 |
| P -9 | **0.45** | 2.13 | 0.33 | 1.53 | 0.86 | 1.44 | 11.4 | 0.48 |
| High volatility | -0.02 | -0.06 | -0.09 | -0.31 | 0.84 | 1.46 | 14.2 | -0.01 |

## Table B5
## US and Global equities. Robustness: Size

This table shows calendar-time portfolio returns of BAB portfolios with conditional sort on size. At the beginning of each calendar month stocks are ranked in ascending order on the basis of their market value of equity (in USD) at the end of the previous month. Stocks are assigned to one of 10 groups based on NYSE breakpoints. Within each size deciles and within each country stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database, and all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. *$ Long (Short)* is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| Panel A: US | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Small - ME | **1.91** | 5.65 | **1.32** | 4.57 | 0.69 | 1.77 | 36.8 | 0.62 |
| ME -2 | **0.86** | 5.40 | **0.43** | 2.99 | 0.69 | 1.47 | 17.3 | 0.60 |
| ME -3 | **0.64** | 5.64 | **0.40** | 3.56 | 0.69 | 1.40 | 12.4 | 0.62 |
| ME -4 | **0.55** | 4.98 | **0.41** | 3.66 | 0.69 | 1.37 | 12.1 | 0.55 |
| ME -5 | **0.47** | 4.22 | **0.34** | 2.97 | 0.70 | 1.35 | 12.2 | 0.46 |
| ME -6 | **0.39** | 3.13 | **0.28** | 2.21 | 0.71 | 1.35 | 13.5 | 0.35 |
| ME -7 | **0.32** | 2.59 | **0.29** | 2.35 | 0.72 | 1.34 | 13.6 | 0.29 |
| ME -8 | **0.38** | 2.95 | **0.38** | 3.13 | 0.74 | 1.33 | 13.9 | 0.33 |
| ME -9 | **0.29** | 2.25 | **0.29** | 2.37 | 0.77 | 1.33 | 13.9 | 0.25 |
| Large-ME | 0.13 | 1.01 | 0.15 | 1.24 | 0.81 | 1.33 | 13.5 | 0.11 |

| Panel B: Global | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Small - ME | 0.98 | 0.92 | 0.70 | 0.64 | 0.88 | 1.64 | 32.1 | 0.03 |
| ME -2 | **0.92** | 2.19 | 0.69 | 1.60 | 0.90 | 1.54 | 24.0 | 0.46 |
| ME -3 | **0.74** | 2.84 | **0.61** | 2.29 | 0.90 | 1.52 | 14.9 | 0.60 |
| ME -4 | **0.63** | 2.84 | 0.40 | 1.82 | 0.89 | 1.49 | 12.6 | 0.60 |
| ME -5 | 0.45 | 1.95 | 0.22 | 0.97 | 0.90 | 1.45 | 13.2 | 0.41 |
| ME -6 | **0.73** | 3.35 | **0.48** | 2.25 | 0.90 | 1.45 | 12.5 | 0.71 |
| ME -7 | 0.26 | 1.09 | 0.14 | 0.60 | 0.90 | 1.43 | 13.4 | 0.23 |
| ME -8 | **0.62** | 2.83 | **0.45** | 2.05 | 0.88 | 1.36 | 12.5 | 0.60 |
| ME -9 | **0.49** | 2.18 | 0.34 | 1.55 | 0.89 | 1.36 | 12.9 | 0.46 |
| Large-ME | 0.35 | 1.64 | 0.27 | 1.38 | 0.88 | 1.29 | 12.0 | 0.34 |

## Table B6
## US and Global equities. Robustness: Sample Period

This table shows calendar-time portfolio returns of BAB portfolios. At the beginning of each calendar month within each country stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database, and all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. *$ Long (Short)* is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | Excess Return |
|---|---|---|---|---|---|---|---|---|
| Panel A: US | | | | | | | | |
| 1926 - 1945 | **0.55** | 2.36 | **0.49** | 2.18 | 0.72 | 1.29 | 12.0 | 0.55 |
| 1946 - 1965 | **0.56** | 5.43 | **0.56** | 4.88 | 0.79 | 1.35 | 5.6 | 1.22 |
| 1966 - 1985 | **0.80** | 5.02 | **0.57** | 3.73 | 0.72 | 1.31 | 8.6 | 1.12 |
| 1986 - 2009 | **0.90** | 3.26 | 0.33 | 1.39 | 0.69 | 1.42 | 16.1 | 0.67 |

| | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Panel B : Global | | | | | | | | |
| 1984 - 1994 | 0.62 | 1.67 | 0.40 | 1.08 | 0.87 | 1.27 | 12.5 | 0.59 |
| 1995 - 2000 | 0.41 | 1.59 | 0.36 | 1.24 | 0.89 | 1.44 | 7.6 | 0.65 |
| 2001 - 2009 | **1.03** | 3.24 | **0.81** | 2.93 | 0.86 | 1.49 | 11.3 | 1.09 |

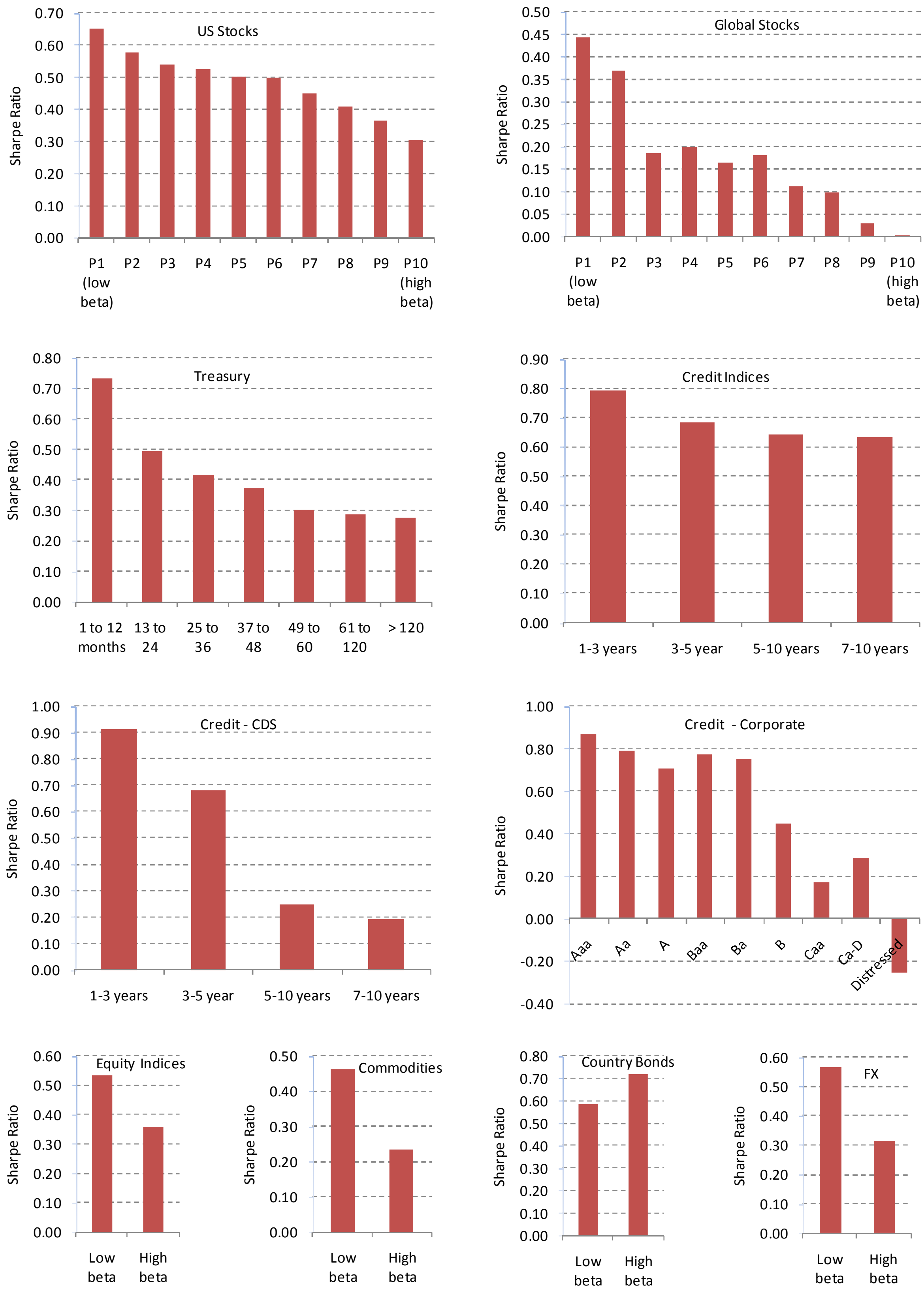
## Table B7
## BAB Returns and Ted Spread

This table shows calendar-time portfolio returns. The test assets are BAB factors, rescaled to 10% annual volatility. To construct the BAB factor, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. At the beginning of each calendar month, we rescale each return series to 10% annualized volatility using rolling 3-year estimate up to moth *t*-1. We assign the Ted spread into three groups (low, neutral and high) based on full sample breakpoints (top and bottom 1/3) and regress the times series of monthly returns on the full set of dummies (without intercept). Returns are in monthly percent.

| | P1<br>Low Ted | P2 | P2<br>High Ted | P3 - P1 | t-statistics |
|---|---|---|---|---|---|
| AUS | 1.19 | -0.14 | -0.78 | -1.97 | -2.77 |
| AUT | 0.10 | -0.07 | -0.93 | -1.03 | -1.44 |
| BEL | 0.56 | 0.03 | 0.53 | -0.02 | -0.03 |
| CAN | 2.35 | 0.72 | -0.18 | -2.53 | -3.59 |
| CHE | 0.91 | -0.24 | 0.21 | -0.70 | -1.09 |
| DEU | 0.52 | 0.23 | -0.51 | -1.02 | -1.64 |
| DNK | 1.35 | 0.15 | -1.33 | -2.68 | -4.48 |
| ESP | 1.27 | 0.79 | -0.19 | -1.46 | -2.23 |
| FIN | 0.60 | 0.16 | -0.77 | -1.37 | -1.96 |
| FRA | 1.06 | 0.42 | -0.75 | -1.81 | -2.73 |
| GBR | 1.33 | 0.34 | -2.26 | -3.59 | -4.76 |
| HKG | 0.74 | 0.54 | -0.44 | -1.17 | -1.65 |
| ITA | 0.84 | 1.12 | -0.51 | -1.35 | -2.25 |
| JPN | -0.34 | 0.22 | 0.00 | 0.35 | 0.54 |
| NLD | 1.73 | -0.05 | 0.00 | -1.73 | -2.76 |
| NOR | 0.22 | 0.49 | -0.32 | -0.53 | -0.85 |
| NZL | 1.35 | -0.04 | -0.05 | -1.40 | -2.07 |
| SGP | 1.06 | 0.91 | -0.67 | -1.72 | -2.68 |
| SWE | 0.88 | 1.34 | -0.95 | -1.83 | -2.90 |
| Commodities | 0.09 | -0.63 | 0.08 | -0.01 | -0.03 |
| Credit Indices | 1.17 | 1.16 | 0.96 | -0.20 | -0.38 |
| Credit - Corporate | -0.18 | 0.64 | 1.06 | 1.24 | 2.41 |
| Credit - CDS | 0.35 | 0.85 | 0.64 | 0.29 | 0.49 |
| Equity Indices | 0.57 | -0.18 | 0.17 | -0.40 | -0.70 |
| Country Bonds | -0.18 | 0.52 | 0.24 | 0.43 | 0.66 |
| FX | 0.37 | 0.01 | 0.02 | -0.35 | -0.66 |
| Global Stocks | 1.49 | 0.77 | -0.58 | -2.07 | -3.79 |
| Treasury | 0.78 | 0.85 | 1.01 | 0.23 | 0.44 |
| US Stocks | 2.30 | 0.56 | -0.73 | -3.03 | -5.44 |
| Pooled* | 0.84 | 0.40 | -0.11 | -0.95 | -8.29 |

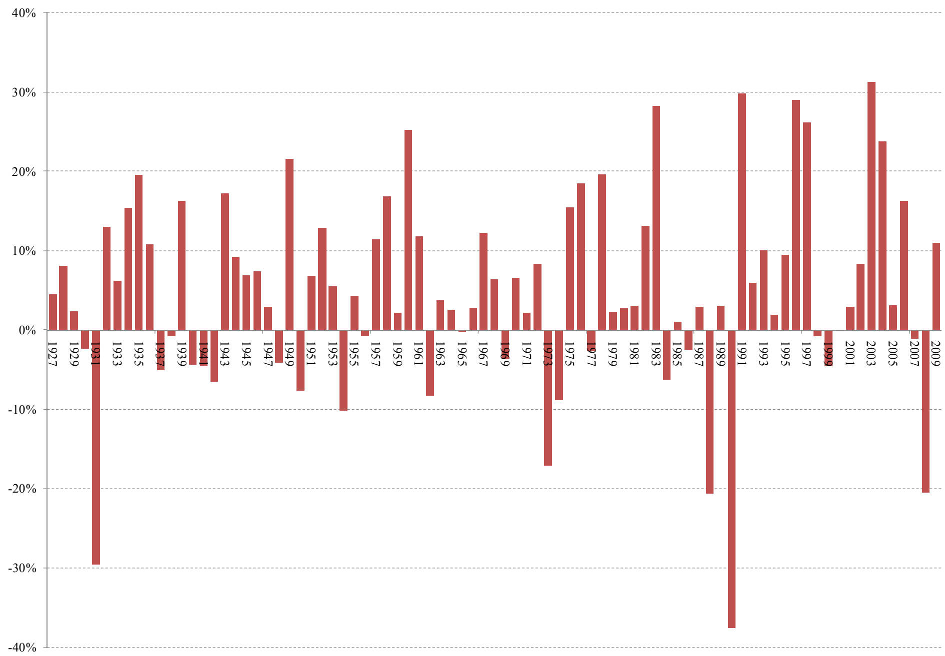
# Figure B1
# Sharpe Ratios of Beta-Sorted Portfolios

This figure shows annual Sharpe Rations returns. The test assets are beta-sorted portfolios. At the beginning of each calendar month instrument is ranked in ascending order on the basis of their estimated beta at the end of the previous month. The ranked stocks are assigned to beta-sorted portfolios. This figure plots Sharpe rations from low beta (left) to high beta (right). Sharpe ratios are annualized.



## Figure B2
## US Equities

This figures shows calendar-time annual abnormal returns. At the beginning of each calendar month all stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure plots the annualized intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. A separate factor regression is run for each calendar year. Alphas are annualized.



## Figure B3
## Global Equities

This figures shows calendar-time annual abnormal returns. At the beginning of each calendar month all stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure plots the annualized intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. A separate factor regression is run for each calendar year. Alphas are annualized.

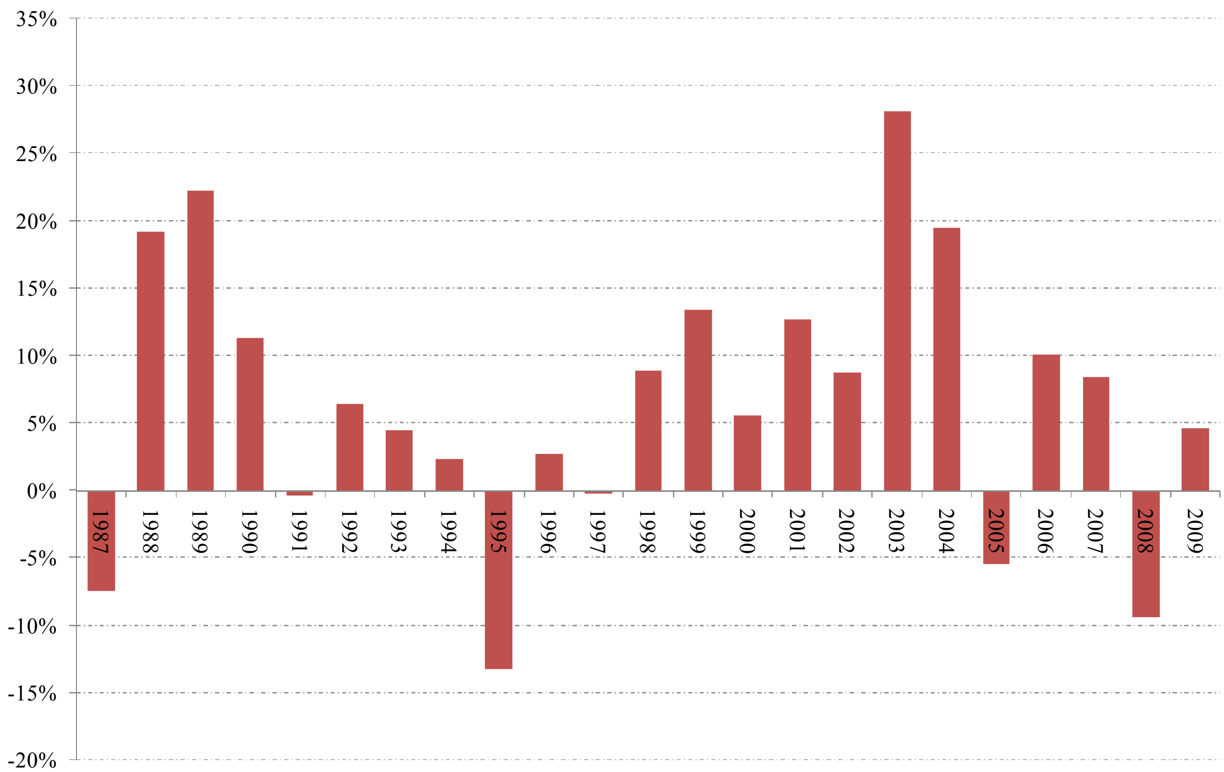


**Figure B4**
**US - Treasury Bonds**

This figures shows calendar-time portfolio returns. The test assets are CRSP Monthly Treasury - Fama Bond Portfolios. Only non-callable, non-flower notes and bonds are included in the portfolios. The portfolio returns are an equal weighted average of the unadjusted holding period return for each bond in the portfolios in excess of the risk free rate. To construct the zero-beta BAB factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure shows annual returns.

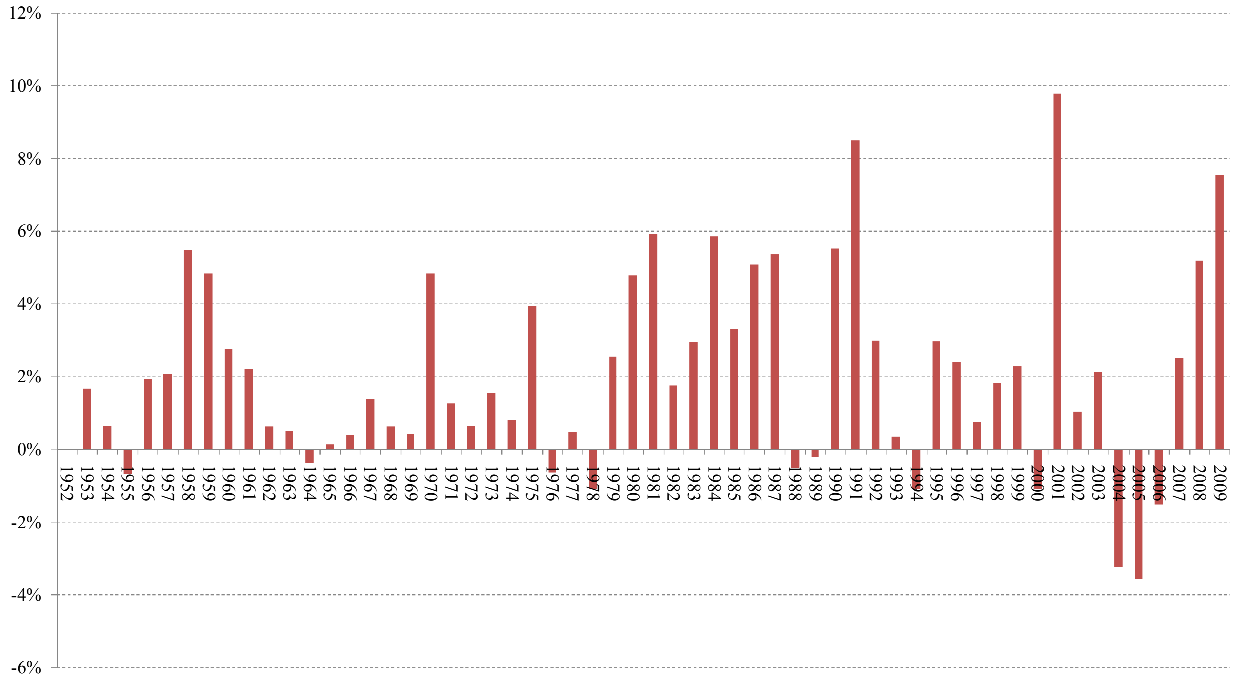
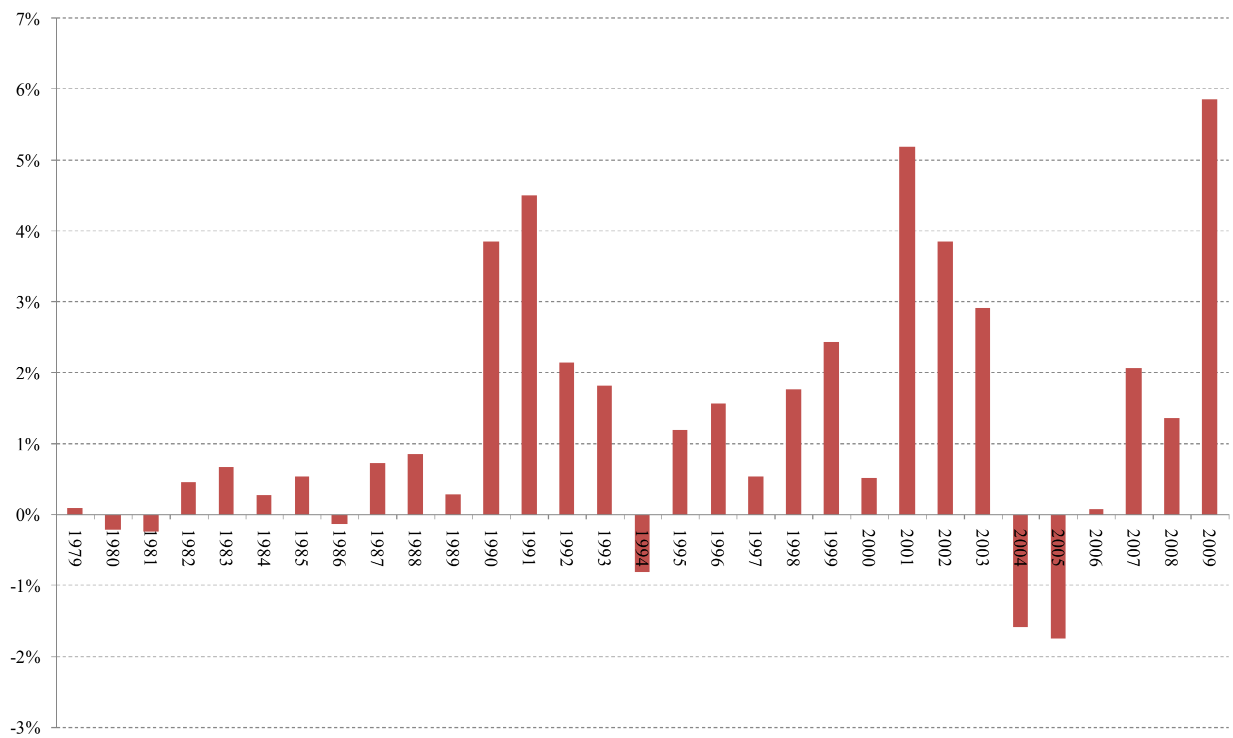


**Figure B5**
**US Credit indices**

This figure shows calendar-time portfolio returns. The test assets are monthly returns on corporate bond indices with maturity ranging from 1 to 10 years in excess of the risk free rate. To construct the zero-beta factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure shows annual returns.

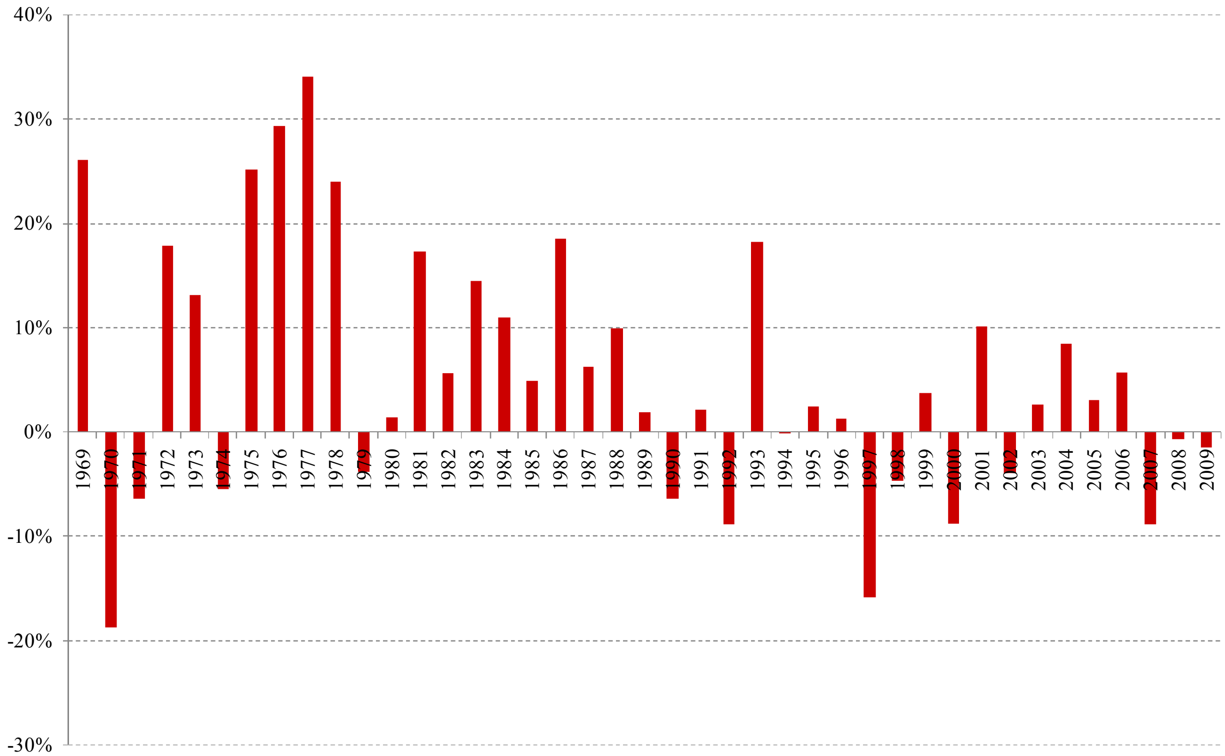


## Figure B6
## US Corporate Bonds

This figure shows calendar-time portfolio returns. The test assets are monthly returns on corporate bond indices in excess of the risk free rate. To construct the BAB factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure shows annual returns.

## Figure B7
## Equity indices, Country Bonds, Foreign Exchange and Commodities

This figures shows calendar-time portfolio returns. The test assets are futures, forwards or swap returns in excess of the relevant financing rate. To construct the BAB factor, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This figure shows annual returns of combo portfolios of all futures (Equity indices, Country Bonds, Foreign Exchange and Commodities) with equal risk in each individual BAB and 10% ex ante volatility. To construct combo portfolios, at the beginning of each calendar month, we rescale each return series to 10% annualized volatility using rolling 3-year estimate up to moth *t-1* and then equally weight the return series and their respective market benchmark



# Table I
## Summary Statistics: Equities

This table shows summary statistics as of June of each year. The sample include all commons stocks on the CRSP daily stock files ("shrcd" equal to 10 or 11) and Compustat Xpressfeed Global security files ("tcpi" equal to 0). "Mean ME" is the average firm's market value of equity, in billion USD. Means are pooled averages (firm-year) as of June of each year.

| Country | Local market index | Number of stocks - total | Number of stocks - mean | Mean ME (firm , Billion USD) | Mean ME (market , Billion USD) | Start Year | End Year |
|---|---|---|---|---|---|---|---|
| Australia | MSCI - Australia | 2,643 | 841 | 0.55 | 460 | 1984 | 2009 |
| Austria | MSCI - Austria | 197 | 84 | 0.72 | 60 | 1984 | 2009 |
| Belgium | MSCI - Belgium | 396 | 142 | 1.98 | 279 | 1984 | 2009 |
| Canada | MSCI - Canada | 4,592 | 1,591 | 0.49 | 566 | 1984 | 2009 |
| Denmark | MSCI - Denmark | 377 | 145 | 0.80 | 116 | 1984 | 2009 |
| Finland | MSCI - Finland | 256 | 111 | 1.39 | 154 | 1984 | 2009 |
| France | MSCI - France | 1,648 | 596 | 2.13 | 1,268 | 1984 | 2009 |
| Germany | MSCI - Germany | 1,893 | 701 | 2.39 | 1,673 | 1984 | 2009 |
| Hong Kong | MSCI - Hong Kong | 1,457 | 636 | 1.05 | 663 | 1984 | 2009 |
| Italy | MSCI - Italy | 563 | 234 | 2.12 | 496 | 1984 | 2009 |
| Japan | MSCI - Japan | 4,888 | 2,988 | 1.20 | 3,597 | 1984 | 2009 |
| Netherlands | MSCI - Netherlands | 384 | 185 | 3.27 | 602 | 1984 | 2009 |
| New Zealand | MSCI - New Zealand | 282 | 102 | 0.71 | 72 | 1984 | 2009 |
| Norway | MSCI - Norway | 587 | 162 | 0.73 | 117 | 1984 | 2009 |
| Singapore | MSCI - Singapore | 914 | 362 | 0.59 | 214 | 1984 | 2009 |
| Spain | MSCI - Spain | 371 | 152 | 2.62 | 398 | 1984 | 2009 |
| Sweden | MSCI - Sweden | 844 | 254 | 1.30 | 329 | 1984 | 2009 |
| Switzerland | MSCI - Switzerland | 508 | 218 | 2.89 | 627 | 1984 | 2009 |
| United Kingdom | MSCI - UK | 5,451 | 1,952 | 1.21 | 2,356 | 1984 | 2009 |
| United States | CRSP - VW index | 22,575 | 3,045 | 0.92 | 2,803 | 1926 | 2009 |

## Table II
## Summary Statistics: Asset classes

This table reports the list of instruments included in our datasets and the corresponding date range. *Freq* indicates the frequency (D = Daily, M = monthly)

| Asset class | instrument | Freq | Start Year | End Year |
|---|---|---|---|---|
| *Equity Indices* | Australia | D | 1977 | 2009 |
| | Germany | D | 1975 | 2009 |
| | Canada | D | 1975 | 2009 |
| | Spain | D | 1980 | 2009 |
| | France | D | 1975 | 2009 |
| | Hong Kong | D | 1980 | 2009 |
| | Italy | D | 1978 | 2009 |
| | Japan | D | 1976 | 2009 |
| | Netherlands | D | 1975 | 2009 |
| | Sweden | D | 1980 | 2009 |
| | Switzerland | D | 1975 | 2009 |
| | United Kingdom | D | 1975 | 2009 |
| | United States | D | 1965 | 2009 |
| *Country Bonds* | Australia | D | 1986 | 2009 |
| | Germany | D | 1980 | 2009 |
| | Canada | D | 1985 | 2009 |
| | Japan | D | 1982 | 2009 |
| | NW | D | 1989 | 2009 |
| | Sweden | D | 1987 | 2009 |
| | Switzerland | D | 1981 | 2009 |
| | United Kingdom | D | 1980 | 2009 |
| | United States | D | 1965 | 2009 |
| *Foreign Exchange* | Australia | D | 1977 | 2009 |
| | Germany | D | 1975 | 2009 |
| | Canada | D | 1975 | 2009 |
| | Japan | D | 1976 | 2009 |
| | Norway | D | 1989 | 2009 |
| | New Zealand | D | 1986 | 2009 |
| | Sweden | D | 1987 | 2009 |
| | Switzerland | D | 1975 | 2009 |
| | United Kingdom | D | 1975 | 2009 |
| *US - Treasury bonds* | 0-1 years | M | 1952 | 2009 |
| | 1-2 years | M | 1952 | 2009 |
| | 2-3 years | M | 1952 | 2009 |
| | 3-4 years | M | 1952 | 2009 |
| | 4-5 years | M | 1952 | 2009 |
| | 4-10 years | M | 1952 | 2009 |
| | > 10 years | M | 1952 | 2009 |

| Asset class | Freq | instrument | Start Year | End Year |
|---|---|---|---|---|
| *Credit indices* | M | 1-3 years | 1976 | 2009 |
| | M | 3-5 year | 1976 | 2009 |
| | M | 5-10 years | 1991 | 2009 |
| | M | 7-10 years | 1988 | 2009 |
| *Corporate bonds* | M | Aaa | 1973 | 2009 |
| | M | Aa | 1973 | 2009 |
| | M | A | 1973 | 2009 |
| | M | Baa | 1973 | 2009 |
| | M | Ba | 1983 | 2009 |
| | M | B | 1983 | 2009 |
| | M | Caa | 1983 | 2009 |
| | M | Ca-D | 1993 | 2009 |
| | M | CSFB | 1986 | 2009 |
| *Commodities* | D | Aluminum | 1989 | 2009 |
| | D | Brent Oil | 1989 | 2009 |
| | D | Cattle | 1989 | 2009 |
| | D | Cocoa | 1984 | 2009 |
| | D | Coffee | 1989 | 2009 |
| | D | Copper | 1989 | 2009 |
| | D | Corn | 1989 | 2009 |
| | D | Cotton | 1989 | 2009 |
| | D | Crude | 1989 | 2009 |
| | D | Feeder Cattle | 1989 | 2009 |
| | D | Gasoil | 1989 | 2009 |
| | D | Gold | 1989 | 2009 |
| | D | Heating Oil | 1989 | 2009 |
| | D | Hogs | 1989 | 2009 |
| | D | Lead | 1989 | 2009 |
| | D | Natural Gas | 1989 | 2009 |
| | D | Nickel | 1984 | 2009 |
| | D | Platinum | 1989 | 2009 |
| | D | Silver | 1989 | 2009 |
| | D | Soybeans | 1989 | 2009 |
| | D | Soy Meal | 1989 | 2009 |
| | D | Soy Oil | 1989 | 2009 |
| | D | Sugar | 1989 | 2009 |
| | D | Tin | 1989 | 2009 |
| | D | Unleaded | 1989 | 2009 |
| | D | Wheat | 1989 | 2009 |
| | D | Zinc | 1989 | 2009 |

## Table III
## US equities. Returns, 1926 - 2009

This table shows calendar-time portfolio returns. Column 1 to 10 report returns of beta-sorted portfolios: at the beginning of each calendar month stocks in each country are ranked in ascending order on the basis of their estimated beta at the end of the previous month. The ranked stocks are assigned to one of ten deciles portfolios based on NYSE breakpoints. All stocks are equally weighted within a given portfolio, and the portfolios are rebalanced every month to maintain equal weights. The rightmost column reports returns of the zero-beta BAB factor. To construct BAB factor, all stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the CRSP database between 1926 and 2009. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios, Carhart (1997) momentum factor and Pastor and Stambaugh (2003) liquidity factor. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. Beta (ex ante) is the average estimated beta at portfolio formation. Beta (realized) is the realized loading on the market portfolio. Volatilities and Sharpe ratios are annualized.

| | P1 (Low beta) | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 (high beta) | BAB Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Excess return | **0.99** | **0.90** | **0.92** | **0.98** | **1.04** | **1.12** | **1.07** | **1.07** | **1.03** | **1.02** | **0.71** |
| | (5.90) | (5.24) | (4.88) | (4.76) | (4.56) | (4.52) | (4.08) | (3.71) | (3.32) | (2.77) | (6.76) |
| CAPM alpha | **0.54** | **0.39** | **0.35** | **0.35** | **0.34** | **0.37** | **0.26** | 0.19 | 0.09 | -0.05 | **0.69** |
| | (5.22) | (4.70) | (4.23) | (4.00) | (3.55) | (3.41) | (2.45) | (1.54) | (0.65) | -(0.29) | (6.55) |
| 3-factor alpha | **0.38** | **0.25** | **0.19** | **0.18** | **0.15** | **0.14** | 0.04 | -0.07 | **-0.18** | **-0.36** | **0.66** |
| | (5.24) | (4.43) | (3.69) | (3.62) | (2.65) | (2.49) | (0.75) | -(1.06) | -(2.45) | -(3.10) | (6.28) |
| 4-factor alpha | **0.42** | **0.32** | **0.24** | **0.24** | **0.24** | **0.25** | **0.17** | **0.12** | 0.04 | -0.07 | **0.55** |
| | (5.66) | (5.67) | (4.55) | (4.63) | (4.20) | (4.58) | (3.00) | (1.98) | (0.61) | -(0.59) | (5.12) |
| 5-factor alpha* | **0.23** | **0.23** | **0.17** | **0.16** | **0.16** | **0.20** | **0.22** | 0.06 | 0.11 | 0.01 | **0.46** |
| | (2.37) | (3.00) | (2.28) | (2.13) | (2.08) | (2.76) | (2.86) | (0.69) | (1.08) | (0.07) | (2.93) |
| Beta (ex ante) | 0.57 | 0.75 | 0.84 | 0.92 | 0.99 | 1.06 | 1.14 | 1.23 | 1.36 | 1.64 | 0.00 |
| Beta (realized) | 0.75 | 0.86 | 0.97 | 1.07 | 1.18 | 1.28 | 1.37 | 1.50 | 1.60 | 1.82 | 0.03 |
| Volatility | 18.2 | 18.7 | 20.6 | 22.4 | 24.7 | 27.0 | 28.4 | 31.5 | 33.8 | 40.0 | 11.5 |
| Sharpe Ratio | 0.65 | 0.58 | 0.54 | 0.52 | 0.50 | 0.50 | 0.45 | 0.41 | 0.37 | 0.31 | 0.75 |

* Pastor and Stambaugh (2003) liquidity factor only available between 1968 and 2008.

# Table IV
## Global Equities. Returns, 1984 - 2009

This table shows calendar-time portfolio returns. Column 1 to 10 report returns of beta-sorted portfolios: at the beginning of each calendar month stocks are ranked in ascending order on the basis of their estimated beta at the end of the previous month. The ranked stocks are assigned to one of ten deciles portfolios. All stocks are equally weighted within a given portfolio, and the portfolios are rebalanced every month to maintain equal weights. The rightmost column reports returns of the zero-beta BAB factor. To construct the BAB factor, all stocks in each country are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the Compustat Xpressfeed Global database for the 19 markets listed table I. The sample period runs from 1984 to 2009. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios, Carhart (1997) momentum factor and Pastor and Stambaugh (2003) liquidity factor. All portfolios are computed from the perspective of a domestic US investor: returns are in USD and do not include any currency hedging. Risk free rates and risk factor returns are US-based. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold. Beta (ex ante) is the average estimated beta at portfolio formation. Beta (realized) is the realized loading on the market portfolio. Volatilities and Sharpe ratios are annualized.

| | P1 (Low beta) | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 (high beta) | BAB Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Excess return | **0.55** | 0.44 | 0.23 | 0.27 | 0.23 | 0.28 | 0.18 | 0.18 | 0.06 | 0.01 | **0.72** |
| | (2.13) | (1.77) | (0.89) | (0.95) | (0.79) | (0.86) | (0.53) | (0.48) | (0.14) | (0.01) | (3.79) |
| CAPM alpha | 0.33 | 0.19 | -0.04 | -0.02 | -0.09 | -0.08 | -0.20 | -0.23 | -0.41 | -0.55 | **0.71** |
| | (1.46) | (0.94) | -(0.21) | -(0.10) | -(0.37) | -(0.33) | -(0.74) | -(0.80) | -(1.21) | -(1.30) | (3.72) |
| 3-factor alpha | 0.16 | 0.08 | -0.17 | -0.16 | -0.21 | -0.20 | -0.31 | -0.34 | -0.49 | -0.61 | **0.60** |
| | (0.78) | (0.39) | -(0.83) | -(0.71) | -(0.92) | -(0.83) | -(1.17) | -(1.17) | -(1.49) | -(1.47) | (3.18) |
| 4-factor alpha | 0.10 | 0.08 | -0.15 | -0.15 | -0.19 | -0.18 | -0.23 | -0.25 | -0.38 | -0.37 | **0.45** |
| | (0.46) | (0.41) | -(0.76) | -(0.67) | -(0.84) | -(0.73) | -(0.86) | -(0.85) | -(1.12) | -(0.88) | (2.47) |
| 5-factor alpha | -0.03 | 0.00 | -0.32 | -0.32 | -0.39 | -0.40 | -0.47 | -0.53 | -0.71 | -0.77 | **0.42** |
| | -(0.13) | -(0.01) | -(1.57) | -(1.35) | -(1.67) | -(1.57) | -(1.70) | -(1.75) | -(2.05) | -(1.80) | (2.22) |
| Beta (ex ante) | 0.50 | 0.65 | 0.73 | 0.80 | 0.87 | 0.93 | 1.00 | 1.08 | 1.19 | 1.44 | 0.00 |
| Beta (realized) | 0.48 | 0.54 | 0.58 | 0.63 | 0.68 | 0.77 | 0.81 | 0.88 | 0.99 | 1.18 | 0.02 |
| Volatility | 14.9 | 14.4 | 14.9 | 16.4 | 16.9 | 18.7 | 19.9 | 21.7 | 24.8 | 30.3 | 10.9 |
| Sharpe Ratio | 0.44 | 0.37 | 0.19 | 0.20 | 0.17 | 0.18 | 0.11 | 0.10 | 0.03 | 0.00 | 0.79 |

* Pastor and Stambaugh (2003) liquidity factor only available between 1968 and 2008.

## Table V
## Global Equities. Returns by Country, 1984 - 2009

This table shows calendar-time portfolio returns. At the beginning of each calendar month all stocks in each country are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. This table includes all available common stocks on the Compustat Xpressfeed Global database for the 19 markets in listed table I. The sample period runs from 1984 to 2009. Alpha is the intercept in a regression of monthly excess return. The explanatory variables are the monthly returns from Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. All portfolios are computed from the perspective of a domestic US investor: returns are in USD and do not include any currency hedging. Risk free rates and factor returns are US-based. Returns and alphas are in monthly percent, and 5% statistical significance is indicated in bold. $ Long (Short) is the average dollar value of the long (short) position. Volatilities and Sharpe ratios are annualized.

| | Excess Return | T(Excess Return) | 4-factor alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|
| Australia | 0.79 | 0.66 | 0.15 | 0.12 | 0.80 | 1.62 | 63.8 | 0.15 |
| Austria | -0.26 | -0.58 | -0.17 | -0.37 | 0.96 | 1.61 | 22.8 | -0.14 |
| Belgium | 0.57 | 1.53 | 0.52 | 1.37 | 0.95 | 1.65 | 16.4 | 0.42 |
| Canada | **1.66** | 4.10 | **1.07** | 2.78 | 0.80 | 1.85 | 23.1 | 0.86 |
| Switzerland | 0.42 | 1.46 | 0.30 | 1.05 | 0.90 | 1.53 | 15.4 | 0.33 |
| Germany | 0.84 | 1.77 | 0.37 | 0.83 | 0.97 | 1.78 | 25.4 | 0.40 |
| Denmark | **0.95** | 2.65 | **0.79** | 2.18 | 0.87 | 1.50 | 19.3 | 0.59 |
| Spain | **0.99** | 3.08 | **0.76** | 2.41 | 0.87 | 1.52 | 17.1 | 0.70 |
| Finland | 0.65 | 1.07 | 0.46 | 0.79 | 0.96 | 1.56 | 31.6 | 0.25 |
| France | **0.98** | 2.55 | 0.66 | 1.82 | 0.90 | 1.66 | 20.5 | 0.57 |
| United Kingdom | 0.23 | 0.54 | -0.11 | -0.25 | 0.89 | 1.68 | 23.2 | 0.12 |
| Hong Kong | 0.68 | 1.96 | 0.33 | 0.95 | 0.89 | 1.46 | 17.9 | 0.45 |
| Italy | **0.88** | 3.14 | **0.68** | 2.42 | 0.87 | 1.43 | 15.0 | 0.70 |
| Japan | 0.03 | 0.12 | -0.03 | -0.09 | 0.82 | 1.41 | 14.1 | 0.03 |
| Netherlands | **1.09** | 3.72 | **0.94** | 3.23 | 0.86 | 1.54 | 15.7 | 0.83 |
| Norway | 0.27 | 0.69 | 0.08 | 0.20 | 0.82 | 1.37 | 20.6 | 0.15 |
| New Zealand | **1.06** | 2.54 | **0.85** | 1.98 | 1.06 | 1.66 | 21.1 | 0.60 |
| Singapore | **0.74** | 2.75 | 0.48 | 1.73 | 0.79 | 1.32 | 14.0 | 0.64 |
| Sweden | **1.11** | 2.71 | **0.85** | 2.06 | 0.92 | 1.51 | 22.0 | 0.61 |

## Table VI
## US Treasury Bonds. Returns, 1952 - 2009

This table shows calendar-time portfolio returns. The test assets are CRSP Monthly Treasury - Fama Bond Portfolios. Only non-callable, non-flower notes and bonds are included in the portfolios. The portfolio returns are an equal weighted average of the unadjusted holding period return for each bond in the portfolios in excess of the risk free rate. To construct the zero-beta BAB factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. Alpha is the intercept in a regression of monthly excess return. The explanatory variable is the monthly return of an equally weighted bond market portfolio. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates and 5% statistical significance is indicated in bold. Volatilities and Sharpe ratios are annualized.

| | P1 (low beta) | P2 | P3 | P4 | P5 | P6 | P7* (high beta) | BAB Factor |
|---|---|---|---|---|---|---|---|---|
| Maturity (months) | 1 to 12 | 13 to 24 | 25 to 36 | 37 to 48 | 49 to 60 | 61 to 120 | > 120 | |
| Excess return | **0.05** | **0.09** | **0.11** | **0.12** | **0.12** | **0.14** | 0.21 | **0.16** |
| | (5.57) | (3.77) | (3.17) | (2.82) | (2.30) | (2.17) | (1.90) | (6.37) |
| Alpha | **0.03** | **0.03** | **0.02** | 0.01 | -0.02 | **-0.03** | **-0.07** | **0.16** |
| | (5.87) | (3.42) | (2.21) | (1.10) | -(1.59) | -(2.66) | -(2.04) | (6.27) |
| Beta (ex ante) | 0.14 | 0.46 | 0.75 | 0.99 | 1.22 | 1.44 | 2.17 | 0.00 |
| Beta (realized) | 0.17 | 0.49 | 0.77 | 0.99 | 1.17 | 1.43 | 2.06 | 0.02 |
| Volatility | 0.83 | 2.11 | 3.23 | 4.04 | 4.76 | 5.80 | 9.12 | 2.32 |
| Sharpe ratio | 0.73 | 0.50 | 0.42 | 0.37 | 0.30 | 0.29 | 0.27 | 0.85 |

* Return missing from 196208 to 197112

**Table VII**
**US Credit indices. Returns, 1976 - 2009**

This table shows calendar-time portfolio returns. The test assets are monthly returns on corporate bond indices with maturity ranging from 1 to 10 years in excess of the risk free rate. To construct the zero-beta factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. Alpha is the intercept in a regression of monthly excess return. The explanatory variable is the monthly return of an equally weighted corporate bond market portfolio. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates and 5% statistical significance is indicated in bold. Volatilities and Sharpe ratios are annualized. Panel A shows results for unhedged returns. Panel B shows results for return obtained by hedging the interest rate exposure. Each calendar month we run 1-year rolling regressions of excess bond returns on excess return on Barclay's US government bond index. We construct test assets by going long the corporate bond index and hedging this position by shorting the appropriate amount of the government bond index. We compute market returns by taking equally weighted average hedged returns.

| | 1-3 years | 3-5 year | 5-10 years | 7-10 years | BAB Factor |
|---|---|---|---|---|---|
| Panel A: Unhedged Returns | | **0.21** | **0.32** | **0.33** | **0.12** |
| | (4.64) | (4.01) | (2.76) | (2.96) | (4.91) |
| Alpha | **0.04** | **0.01** | **-0.05** | **-0.07** | **0.13** |
| | (2.77) | (0.96) | -(4.01) | -(4.45) | (4.91) |
| Beta (ex ante) | 0.60 | 0.85 | 1.39 | 1.52 | 0.00 |
| Beta (realized) | 0.62 | 0.85 | 1.37 | 1.48 | -0.01 |
| Volatility | 2.73 | 3.66 | 5.91 | 6.13 | 1.70 |
| Sharpe ratio | 0.79 | 0.68 | 0.65 | 0.64 | 0.88 |
| Panel B: Hedged Returns | | **0.09** | **0.07** | **0.06** | 0.05 |
| | (2.61) | (2.25) | (0.97) | (0.82) | (1.77) |
| Alpha | **0.04** | **0.04** | **-0.03** | **-0.04** | **0.08** |
| | (3.62) | (3.23) | -(2.38) | -(2.16) | (3.33) |
| Beta (ex ante) | 0.70 | 0.78 | 1.14 | 1.38 | 0.00 |
| Beta (realized) | 0.58 | 0.72 | 1.34 | 1.37 | -0.34 |
| Volatility | 1.70 | 2.06 | 3.77 | 3.95 | 1.55 |
| Sharpe ratio | 0.62 | 0.53 | 0.23 | 0.19 | 0.42 |

# Table VIII
# US Corporate Bonds. Returns, 1973 - 2009

This table shows calendar-time portfolio returns. The test assets are monthly returns on corporate bond indices in excess of the risk free rate. To construct the BAB factor, all bonds are assigned to one of two portfolios: low beta and high beta. Bonds are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The zero-beta factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. Alpha is the intercept in a regression of monthly excess return. The explanatory variable is the monthly return of an equally weighted corporate bond market portfolio. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates and 5% statistical significance is indicated in bold. Volatilities and Sharpe ratios are annualized.

| | Aaa | Aa | A | Baa | Ba | B | Caa | Ca-D | CSFB Distressed | BAB Factor |
|---|---|---|---|---|---|---|---|---|---|---|
| Excess return | **0.26** | **0.27** | **0.27** | **0.31** | **0.43** | 0.33 | 0.21 | 0.70 | -0.51 | 0.33 |
| | (4.48) | (4.08) | (3.64) | (3.99) | (3.88) | (2.31) | (0.90) | (1.18) | -(1.23) | (1.74) |
| Alpha | **0.23** | **0.21** | **0.19** | **0.21** | **0.26** | 0.10 | -0.13 | 0.08 | **-1.10** | **0.56** |
| | (4.09) | (3.62) | (3.13) | (3.69) | (4.20) | (1.40) | -(0.95) | (0.26) | -(5.34) | (4.02) |
| Beta (ex ante) | 0.67 | 0.70 | 0.72 | 0.77 | 0.89 | 1.01 | 1.25 | 1.74 | 1.66 | 0.00 |
| Beta (realized) | 0.13 | 0.24 | 0.33 | 0.40 | 0.69 | 0.95 | 1.39 | 2.77 | 2.49 | -0.94 |
| Volatility | 3.62 | 4.11 | 4.63 | 4.84 | 6.79 | 8.93 | 14.26 | 29.15 | 24.16 | 11.47 |
| Sharpe ratio | 0.87 | 0.79 | 0.71 | 0.78 | 0.75 | 0.45 | 0.17 | 0.29 | -0.25 | 0.34 |

## Table IX
## Equity indices, Country Bonds, Foreign Exchange and Commodities. Return, 1965-2009

This table shows calendar-time portfolio returns. The test assets are futures, forwards or swap returns in excess of the relevant financing rate. To construct the BAB factor, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. Alpha is the intercept in a regression of monthly excess return. The explanatory variable is the monthly return of the relevant market portfolio. Panel A report results for equity indices, country bonds, foreign exchange and commodities. *All Futures* and *Country Selection* are combo portfolios with equal risk in each individual BAB and 10% ex ante volatility. To construct combo portfolios, at the beginning of each calendar month, we rescale each return series to 10% annualized volatility using rolling 3-year estimate up to moth *t-1* and then equally weight the return series and their respective market benchmark. Panel B reports results for all the assets listed in table I and II. *All Bonds and Credit* includes US treasury bonds, US corporate bonds, US credit indices (hedged and unhedged) and country bonds indices. *All Equities* included US stocks, all individual BAB country portfolios, a global stock BAB and equity indices. *All Assets* includes all the assets listed in table I and II. All portfolios in panel B have equal risk in each individual BAB and 10% ex ante volatility. Returns and alphas are in monthly percent, t-statistics are shown below the coefficient estimates and 5% statistical significance is indicated in bold. Volatilities and Sharpe ratios are annualized.

| Panel A: Equity indices, country Bonds, Foreign Exchange and Commodities | | Excess Return | T-stat Excess Return | Alpha | T(alpha) | $Short | $Long | Volatility | SR |
|---|---|---|---|---|---|---|---|---|---|
| Equity Indices | EI | **0.78** | 2.90 | **0.69** | 2.56 | 0.93 | 1.47 | 18.46 | 0.51 |
| Country Bonds | CB | 0.08 | 0.99 | 0.06 | 0.73 | 0.95 | 1.69 | 4.47 | 0.22 |
| Foreign Exchange | FX | 0.2 | 1.45 | 0.14 | 1.08 | 0.61 | 1.61 | 7.72 | 0.31 |
| Commodities | COM | 0.42 | 1.44 | 0.38 | 1.26 | 0.78 | 1.56 | 22.65 | 0.22 |
| All Futures* | EI + CB + FX + COM | **0.47** | 3.99 | **0.52** | 4.50 | | | 9.02 | 0.62 |
| Country Selection* | EI + CB + FX | **0.64** | 3.78 | **0.71** | 4.42 | | | 11.61 | 0.66 |
| **Panel B: All Assets** | | | | | | | | | |
| All Bonds and Credit* | | **0.73** | 6.00 | **0.72** | 5.88 | | | 11.06 | 0.79 |
| All Equities* | | **0.77** | 8.10 | **0.78** | 8.16 | | | 10.31 | 0.89 |
| All Assets* | | **0.71** | 8.60 | **0.73** | 8.84 | | | 8.95 | 0.95 |

* Equal risk, 10% ex ante volatility

## Table X
## Beta compression

This table report results of cross-sectional and time-series tests of beta compression. Panel a (B) reports the cross-sectional dispersion of betas in US (global) stocks. The data run from December 1984 (first available date for the TED spread) to December 2009. Each calendar month we compute cross sectional standard deviation, mean absolute deviation and inter-quintile range in betas for all stocks in the universe. *All* reports the simple means of the dispersion measures. *P1* to *P3* report coefficients on a regression of the dispersion measure on a series of TED spread dummies. We assign the TED spread into three groups (low, neutral and high) based on full sample breakpoints (top and bottom 1/3) and regress the times series of the cross sectional dispersion measure on the full set of dummies (without intercept). Panel C (D) reports conditional market betas of the BAB US (global) portfolio based on the TED spread level. The dependent variable is the monthly return of the BAB portfolios. The explanatory variables are the monthly returns of the market portfolio, Fama and French (1993) mimicking portfolios and Carhart (1997) momentum factor. Market betas are allowed to vary across TED spread regimes (low, neutral and high) using the full set of TED dummies. Panel B reports loading on the market factor corresponding to different TED spread regimes. All regressions include the full set of explanatory variables but only the market loading is reported. T-statistics are shown below the coefficient estimates, and 5% statistical significance is indicated in bold.

| | Panel A Cross-Sectional Beta Dispersion - US | | | Panel B Cross sectional Beta Dispersion - Global | | |
|---|---|---|---|---|---|---|
| | Standard deviation | Mean Absolute Deviation | Inter-quintile Range | Standard deviation | Mean Absolute Deviation | Inter-quintile Range |
| All | 0.42 | 0.33 | 0.67 | 0.27 | 0.21 | 0.44 |
| P1 (low TED) | 0.47 | 0.36 | 0.74 | 0.29 | 0.23 | 0.46 |
| P2 | 0.43 | 0.34 | 0.69 | 0.27 | 0.21 | 0.43 |
| P3 (high TED) | 0.35 | 0.28 | 0.58 | 0.25 | 0.20 | 0.42 |
| P3 minus P1 | **-0.11** | **-0.08** | **-0.16** | **-0.04** | **-0.03** | **-0.04** |
| t-statistics | **-10.72** | **-10.48** | **-10.04** | **-7.31** | **-6.59** | **-5.07** |

| | Panel C: Conditional Market Loading - US | | | | Panel D: Conditional Market Loading - Global | | | |
|---|---|---|---|---|---|---|---|---|
| | P1 (Low TED) | P2 | P3 (High TED) | P3 - P1 | P1 (Low TED) | P2 | P3 (High TED) | P3 - P1 |
| CAPM | -0.21 | 0.10 | **0.30** | **0.51** | **-0.33** | -0.01 | **0.19** | **0.51** |
| | -(1.77) | (1.04) | (3.99) | (3.64) | -(3.96) | -(0.17) | (3.33) | (5.15) |
| Control for 3 Factors | -0.07 | 0.38 | **0.33** | **0.41** | **-0.29** | 0.09 | **0.19** | **0.49** |
| | -(0.66) | (4.14) | (4.84) | (3.24) | -(3.57) | (1.09) | (3.46) | (5.00) |
| Control for 4 Factors | 0.06 | **0.42** | **0.36** | **0.31** | **-0.19** | 0.11 | **0.23** | **0.41** |
| | (0.50) | (4.55) | (5.34) | (2.46) | -(2.16) | (1.37) | (4.09) | (4.24) |

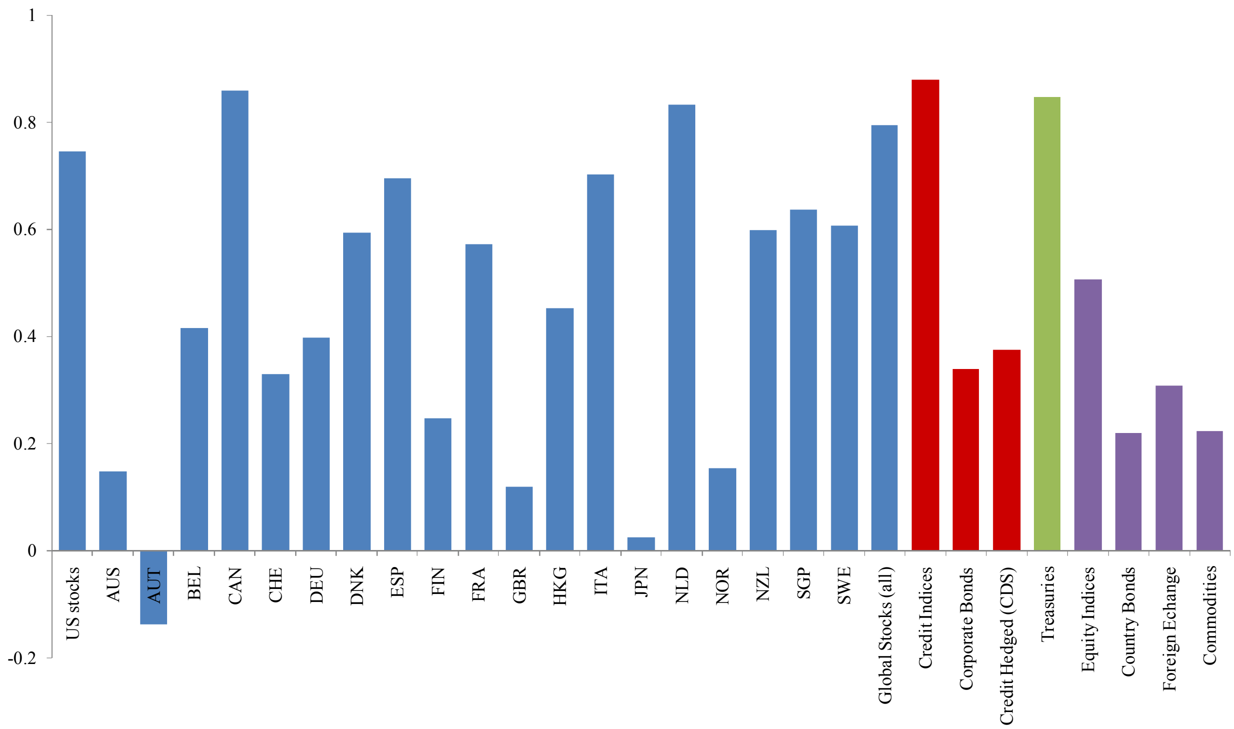
## Table XI
## Regression Results

This table shows results from time series (pooled) regressions. The left-hand side is the month t return on the BAB factors. To construct the BAB portfolios, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. The explanatory variables include the TED spread (level and changes) and a series of controls. *TED Spread* is the TED spread at the end of month t. "*Change in TED Spread*" is equal to Ted spread at the end of month t minus the median spread over the past 3 years. *"Lagged TED Spread" is* the median Ted spread over the past 3 years. "*Long Volatility Returns*" is the month t return on a portfolio that shorts at-the-money straddles on the S&P500 index. To construct the short volatility portfolio, on index options expiration dates we write the next-to-expire closest-to-maturity straddle on the S&P500 index and hold it to maturity. "*Beta Spread*" is defined as (*HBeta- LBeta*) / (*HBeta* LBeta*) where *HBeta (LBeta)* are the betas of the short (long) leg of the BAB portfolio at portfolio formation. "*Market Return*": is the monthly return of the relevant market portfolio. This table includes all the available BAB portfolios. The data run from December 1984 (first available date for the TED spread) to December 2009. Column 1 to 4 report results for US stocks. Columns 5 to 8 reports results for global equities. In these regressions we use each individual country BAB factors as well as a global sticks BAB factor. Columns 9 to 12 reports results for all assets in our data. Asset fixed effects are include where indicated, t-statistics are shown below the coefficient estimates and 5% statistical significance is indicated in bold. When multiple assets are included in the regressions standard errors are clustered by date.

| | US - Stocks | | | | Global Stocks - pooled | | | | All Assets pooled (Equities, Bonds and Futures) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| TED Spread | **-0.036** | **-0.023** | | | **-0.022** | **-0.017** | | | **-0.014** | **-0.012** | | |
| | -(6.17) | -(3.47) | | | -(5.02) | -(3.74) | | | -(5.30) | -(4.09) | | |
| Change in TED Spread | | | **-0.033** | **-0.019** | | | **-0.021** | **-0.017** | | | **-0.014** | **-0.011** |
| | | | -(5.23) | -(2.68) | | | -(4.84) | -(3.75) | | | -(5.04) | -(3.92) |
| Lagged TED Spread | | | **-0.046** | **-0.036** | | | **-0.030** | **-0.020** | | | **-0.018** | **-0.015** |
| | | | -(4.48) | -(3.40) | | | -(3.92) | -(2.21) | | | -(3.98) | -(3.14) |
| Short Volatility Returns | | 0.295 | | **0.300** | | -0.044 | | -0.044 | | -0.068 | | -0.069 |
| | | (0.29) | | (3.48) | | -(0.04) | | -(0.64) | | -(0.07) | | -(1.45) |
| Beta Spread | | 0.018 | | **0.020** | | 0.025 | | **0.024** | | 0.010 | | **0.009** |
| | | (0.02) | | (2.82) | | (0.02) | | (2.51) | | (0.01) | | (3.54) |
| Market return | | -0.027 | | -0.022 | | 0.009 | | 0.009 | | 0.001 | | 0.001 |
| | | -(0.03) | | -(0.36) | | (0.01) | | (0.22) | | (0.00) | | (0.04) |
| Lagged BAB return | | 0.186 | | **0.173** | | 0.060 | | 0.060 | | 0.073 | | 0.072 |
| | | (0.19) | | (2.86) | | (0.06) | | (1.14) | | (0.07) | | (1.50) |
| Asset Fixed Effects | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Num of observations | 295 | 295 | 295 | 295 | 4,393 | 4,393 | 4,393 | 4,393 | 7,271 | 7,271 | 7,271 | 7,271 |
| Adjusted R2 | 11.2% | 20.9% | 11.3% | 21.3% | 1.5% | 2.4% | 1.5% | 2.3% | 1.0% | 1.9% | 1.0% | 1.9% |

**Figure 1**
**BAB Sharpe Ratios by Asset Class**

This figures shows annualized Sharpe ratios of BAB factors across asset classes. To construct the BAB factor, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. Sharpe ratios are annualized.



# Figure 2
# US Stocks BAB and TED Spread

This figures shows annualized 3-year return of the US stocks BAB factor (left scale) and 3-year (negative) average rolling TED spread (right scale) . At the beginning of each calendar month all stocks are assigned to one of two portfolios: low beta and high beta. Stocks are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio.

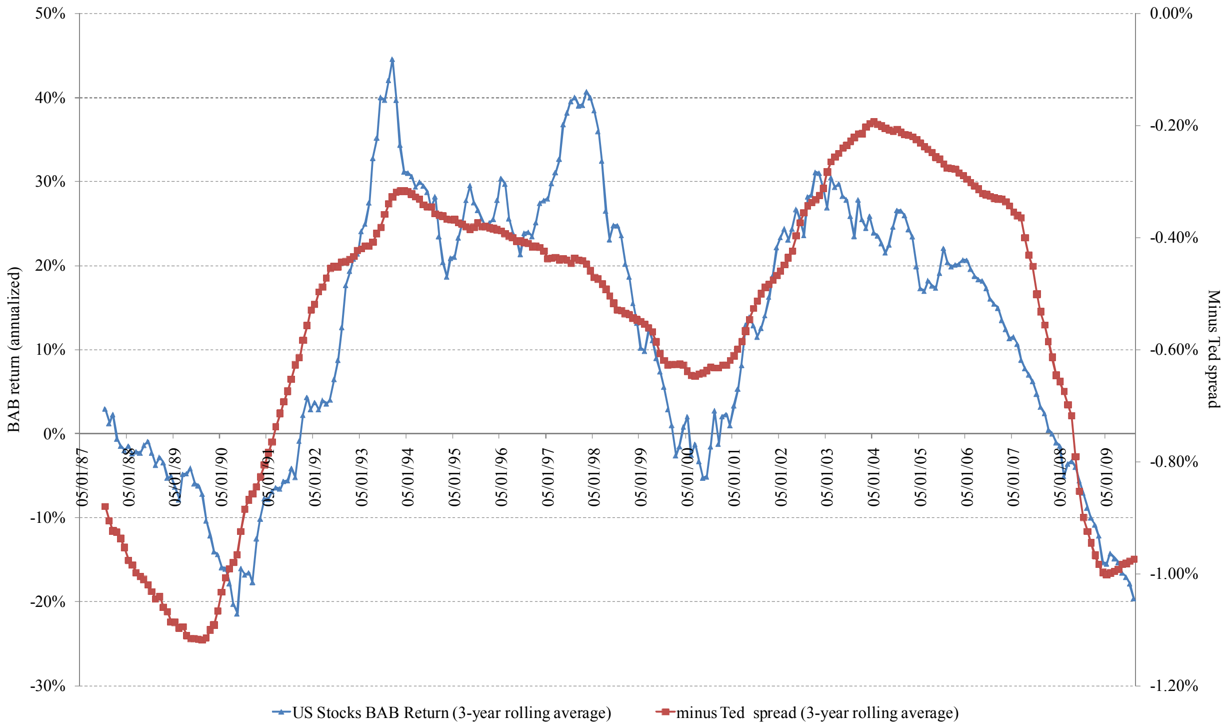


**Figure 3**
**Regression Results: BAB return on TED, T-statistics.**

This figure shows results from time series regressions. The left-hand side is the month t return on the BAB factors. To construct the BAB portfolios, all instruments are assigned to one of two portfolios: low beta and high beta. Instruments are weighted by the ranked betas and the portfolios are rebalanced every calendar month. Both portfolios are rescaled to have a beta of 1 at portfolio formation. The BAB factor is a zero-cost portfolio that is long the low-beta portfolio and shorts the high-beta portfolio. The explanatory variable is the Ted spread at the end of month t. A separate regression is run for each BAB portfolio. This figure report t-statistics for each regression