Value and Interest Rates

Are rates to blame for value's torments?

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May 2020

Abstract

Value stocks sharply underperformed growth stocks from 2017 to early 2020, exacerbating a longer period of lackluster performance that dates back to the Global Financial Crisis for some value factors. Some have blamed the interest rate environment – the low level of interest rates, falling bond yields or the flattening yield curve. We examine these claims. Theory suggests the link between value and interest rates is ambiguous and complicated. Empirically, we find fairly modest links that change for different specifications. Evidence of a mild relationship between interest rate variables and value's performance is found for some specifications, but not others. Despite some eye-catching patterns in recent data, particularly those related to changes in bond yields or the yield curve slope, the economic significance of any relationship is small and not robust in other samples. We conclude that the performance of value is not easily assessed based on the interest rate environment, and that factor timing strategies based on interest rate-related signals are likely to perform poorly.

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1. Introduction

The value premium, often measured by the performance of the Fama-French U.S. HML book-to-market equity factor, has experienced very poor performance over the last decade. From its peak at the end of 2006 through the end of 2019, the current drawdown was not the deepest in value's history (deeper ones occurred in the 1930s and the late 1990s), but it was the longest.[1] Negative performance over the last decade and cumulative flat performance for nearly two decades have prompted many to search for what might have driven value's poor showing.[2] Further losses in early 2020 have intensified this scrutiny, which we analyze separately toward the end of the paper.

A popular hypothesis for value's recent travails relates to the interest rate environment. The 2010s being a decade of low interest rates, and (especially in the second half of the decade) low bond yields, too, has prompted many to wonder if the interest rate environment is a possible culprit. Of course, good science (and good investing) should be wary of inferring a causal relationship from a single observation of two market phenomena that happen to coincide. However, an existing literature suggests a longer-term link between stock market anomalies, including value, and interest rates, though the picture emerging from this body of research is complex. For example, Dechow, Sloan, and Soliman (2004), Lettau and Wachter (2007), and Gormsen and Lazarus (2019) characterize value stocks as low-duration assets with near-term cash flows and growth stocks as high-duration assets, such that a long/short value strategy is a negative duration asset that is sensitive to falling interest rates. This story implies that falling bond yields from 2010 to 2019 provided a strong tailwind for growth stocks and a headwind for value stocks, driving value-tilted portfolio returns lower. Empirically, Maio and Santa Clara (2017) find that value stocks are *more* sensitive to changes in short-term interest rates and suggest this may be due to their poorer financial position and sensitivity to financing costs. U.S. short-term interest rates also rose during 2017 and 2018 as value suffered, feeding this story an anecdote as well. This combination of opposite sensitivities to short- and long-term rates implies sensitivity to the *slope* of the yield curve. Several studies have noted a pattern in the data consistent with this notion (Mezrich, Wei, and Gould (2019) and Harvey (2019)), where some versions of value have outperformed when the yield curve steepens and following yield curve

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[1] Further losses in Q1 2020 made this drawdown the longest *and* deepest in HML's history. There are many ways to construct a systematic value factor, and many approaches to value investing. Not all have been suffering for so long. For example, an HML variant using unlagged prices, an industry-neutral variant, and a variant based on earnings-to-price ratios saw their last peaks in 2010, 2016, and 2016, respectively. But the three years from 2017 to 2019 saw negative returns for all value factors, and the 2010s was generally a disappointing decade for value investors of all types.

[2] For a statistical analysis of value's underperformance, see Fama and French (2020). For a discussion of whether the economics of value investing have changed, see Israel, Laursen and Richardson (2020). Both studies conclude that value has not changed dramatically in terms of its statistical or economic support.

inversions. Mezrich et al. attribute this finding to differing debt characteristics of value and growth companies, suggesting value firms have more shorter-dated debt and are therefore more vulnerable to rises in short rates, while growth firms have more longer-dated debt and benefit more from falling long rates.

We explore and investigate the link between equity value factors and the interest rate environment, including the hypotheses above. We begin by examining theory, noting that the theoretical relationship between the value factor and interest rates is complex and ambiguous. We then explore the relationship between value and interest rates empirically, analyzing various aspects of the yield curve (levels and changes in short- and long-term rates, as well as the slope of the yield curve) applied to different measures and implementations of the value factor. We also examine different periods in history, as well as global evidence in addition to the U.S. evidence. These varying choices serve to provide a broad and robust view of the relationship between value and interest rates.

We find, however, that the relationship between value factor returns and the interest rate environment is not very robust. Different choices for interest rate variables, different measurements and implementations of value, and different samples through time and across markets deliver varying results. Thus, despite the apparent strong coincidence between recent interest rate trends and the classic value premium measured by Fama and French's HML factor, the potential connection between the interest rate environment and value returns is suspect. The strongest and most statistically reliable result we find is between changes in the slope of the yield curve and value returns. However, the economic significance of this relationship is weak. During the period 2017 to 2019, when we witnessed a steep value drawdown coinciding with a flattening yield curve slope, this connection can only explain a small part of value's losses, leaving the majority unconnected to interest rate changes.

Finally, while the main analysis focuses on contemporaneous relationships between value and interest rates as a potential explanation for why value has suffered, we also explore predictive relationships. This analysis addresses whether the interest rate environment has any tactical timing information for the value factor. We find that the predictive relationships are even weaker than the contemporaneous ones, suggesting that a value timing strategy based on interest rate signals is likely to yield poor out-of-sample performance.

Our findings help clarify the relationship between value investing strategies and interest rates, with a focus on the practical implications for investors. We conclude that the interest rate regime offers little insight into value's prospects.

The rest of the paper is organized as follows. Section 2 presents the theoretical links between interest rates and value and growth stocks. Section 3 explores empirical contemporaneous relations between value strategies and interest rates across a whole host of specification choices, variables, sample periods, and markets, and interprets the results in the context of the theories in Section 2. Section 4 examines the predictive relationships between the interest rate environment and value factors relevant to factor timing strategies. Section 5 analyzes relationships observed during the volatile first quarter of 2020 as a brief out-of-sample test. Section 6 concludes with implications for practical investing.

2. Theoretical Links Between Interest Rates and Returns

To understand the theoretical links between interest rates and the relative performance of value and growth stocks, we begin by examining the link between interest rates and asset prices in general. The present value formula for any asset states that the asset's price is the sum of expected nominal cash flows discounted to their present value.

$$\boldsymbol{P_0} = \frac{E[\boldsymbol{D_1}]}{(1+\boldsymbol{r_1})^1} + \frac{E[\boldsymbol{D_2}]}{(1+\boldsymbol{r_2})^2} + \cdots + \frac{E[\boldsymbol{D_n}]}{(1+\boldsymbol{r_n})^n}$$

where $\boldsymbol{P_0}$ is the price today at time 0, $E[\boldsymbol{D_n}]$ is the expected cash flow (for a stock, the expected dividend per share) at time *n*, and $\boldsymbol{r_n}$ is the discount rate from the present to time *n*, i.e., the required rate of return. The discount rate $\boldsymbol{r}$ is the sum of the real risk-free rate $\boldsymbol{R}$, expected inflation $E[\boldsymbol{inf}]$, and a risk premium $\boldsymbol{P}$ that reflects the riskiness of the expected cash flows, where all three components have their own term structure:

$$\boldsymbol{r_n} = \boldsymbol{R_n} + E[\boldsymbol{inf_n}] + \boldsymbol{P_n}$$

As the risk-free interest rate is one component of the discount rate, when interest rates go up, the discount rate increases and the asset price falls – *if* everything else stays constant. Hence, if expected cash flows are unchanged and if the risk premium associated with those cash flows is unchanged (where the risk premium is determined by both the amount of risk exposure the cash flows have and the price of aggregate risk to those exposures in the economy), then the formula tells us how prices will change when riskless interest rates change. However, in the case of stocks, these other components rarely stay constant. Changes in real or nominal interest rates are often accompanied by (or are often a response to) changes in expected inflation and/or changes in expected economic growth, and hence expected cashflows are often changing as well. There may also be a change in the required risk premium which is the other (and often larger) component of the discount rate. All of these components have their own dynamics and are likely simultaneously being affected by macroeconomic conditions in possibly different ways. These confounding effects make it extremely difficult to identify what impact interest rates should have on value and growth portfolios.

For example, monetary policy changes are often a response to the economic environment, which are linked to both cash flows and risk appetite (and hence risk premia) in the economy. Much research shows that variation in stock prices is largely driven by cash flow shocks or risk premium shocks (Campbell and Shiller (1988), Vuolteenaho (2003)), while very little can be attributed to interest rate shocks, although as the above simple framework illustrates, disentangling each component's effect is challenging if these variables are moving around simultaneously. The overall effect from monetary policy shifts is therefore difficult to predict and depends on how these pieces interact. For example, over the past two decades stock and bond returns have been negatively correlated, suggesting that changes in expected cashflows and risk premia have offset changes in the risk-free rate as drivers of stock prices, at least at the market level.[3]

If the relationship between interest rates and a single stock price is complex, any relationship with a long/short factor such as value-minus-growth is even more complex. A requirement for such a relationship to exist is that value and growth stock prices respond *differently* to changes in the discount rate, and that this difference in response is not overwhelmed by the other moving parts. One such theory is that growth stocks' expected cash flows are further in the future, implying they have higher cash flow duration.[4] Under this theory, growth stock prices should benefit more than value stock prices from falling riskless rates, assuming the other moving parts – cash flows and risk premia – are not offsetting these effects. Similarly, a fall in long-term yields versus short-term yields (i.e., a flattening of the yield curve) could benefit growth stock prices more than value stocks if the duration hypothesis holds, ceteris paribus. In reality, the assumption that all else is equal is routinely violated. For instance, it is likely that expected cash flows for growth and value stocks also exhibit different degrees of uncertainty and respond differently to economic shocks, and interest rate changes are merely a symptom of those economic movements. In other words, interest rate changes reflect economic conditions which almost surely are reflected in cash flows and risk premia, too, and the combined effect from these changes may dominate the duration effect.

[3] There is an extensive literature on stock-bond comovement, typically examining interactions between real rates, expected cash flow growth and expected inflation. See for example David and Veronesi (2016) and references therein.

[4] Dechow, Sloan and Soliman (2004), Lettau and Wachter (2007), Gormsen and Lazarus (2019).

A less direct theory for the value factor's potential sensitivity to interest rates posits that value and growth companies have different debt characteristics. Differences in the amount or average maturity of debt could lead to different responses to changes in borrowing costs, which interest rates affect. This theory is about leverage rather than valuation, however, and thus is best tested by directly looking at leverage and debt-related factors not value measures per se. Nevertheless, if value is a proxy for debt characteristics of the firm, this theory could explain why value appears sensitive to interest rates. A related theory suggests value firms are more likely to be financially distressed, and hence more sensitive to interest rate changes. This theory, too, is not about value per se, but rather about value being associated with financial distress. A more direct way to test this theory would be to look at default probabilities or other financial distress indicators of firms and test their relationships with valuation and with rates. However, under this theory it is unclear *a priori* whether rising or falling rates would be good or bad for value companies if rising borrowing costs are also a function of economic conditions, which in turn may affect cash flows and risk premia.

Finally, there are other macro theories about sensitivities of the value factor to macroeconomic conditions – for example due to cyclical variations in required risk premia or the cyclical industry exposures of simple academic value factors – of which changing interest rates are one symptom. However, these theories tend to be only indirectly related to interest rates and just like the above theories, it is not clear that interest rates alone are changing. Expected cash flows and risk premia are likely changing too, and particularly so for these macroeconomic theories.

Given the complexity of these theoretical considerations, and the ambiguity of their predictions, we turn to an empirical evaluation of value's sensitivity to interest rates. The data informs us of the net impact of all the interacting variables associated with interest rate regimes and value returns. The downside is that associating the results with any particular theory is challenging since multiple effects are likely at play. In assessing the relation between interest rates and value, we consider a wide array of specifications, including multiple measures and implementations of value factors, different aspects of information in the yield curve, and various time periods and markets to identify any robust patterns in the data.

3. Empirical Relationships with Interest Rate Levels and Contemporaneous Changes

We study the empirical relationship between interest rates and value by examining various aspects of the yield curve and a variety of value measures. We begin by describing our data and factor construction and then proceed to analyze the contemporaneous relationships between levels and changes in the yield curve and value factors.

a. Data and factor construction

Our main empirical analysis focuses on U.S. equity markets and U.S. interest rates, but we also examine international markets in the U.K., Germany, and Japan.

i. U.S. interest rates

We use the 3-month Treasury Bill yield to represent short-term interest rates, and the 10-year constant maturity Treasury Bond yield to represent long-term rates. Daily data from the FRED data library are used to derive month-end and quarter-end series from January 1954 to December 2019 (daily data do not exist for 10-year yields from 1954 to 1961 so we use month-average data as a proxy for month-end values, but the results do not change if we drop these seven years). The yield curve slope is defined as the 10-year yield minus the 3-month yield. For each of these series we consider both their levels (defined as the level at the start of period t) and their changes (defined as level at end of period t minus the level at start of period t) and examine their contemporaneous relation with value returns over period t.

ii. U.S. value factors

We test the sensitivities of four different U.S. value equity factors. The first, 'HML FF', is the classic HML factor from Fama and French (1993, 1996, 2020), obtained from the Ken French data library. This factor portfolio is long the top 30% of stocks sorted on ratios of book value of equity to market value of equity (BE/ME) and short the bottom 30% of stocks ranked on BE/ME. The portfolio is rebalanced in June of each year based on BE/ME sorts, where book values are taken from the prior fiscal year-end with an additional six-month lag and divided by the market value of the equity at that time, which uses price information from at least six to as much as 18 months in the past.[5]

The second value factor, 'HML Devil', follows the same procedure as Fama and French (1993), but updates BE/ME ratios using more timely price information as described in Asness and Frazzini (2013). Instead of dividing book values by stale market values from the same time as the book values, Asness and Frazzini (2013) use the most recent market value information, which they show has some desirable

[5] Stocks are also sorted separately among the largest stocks (based on NYSE market capitalization median) and among the smallest stocks (below the NYSE size median) and an equal-weighted average of the top and bottom 30% of stocks based on BE/ME are computed from the large and small stock universes. The value-weighted returns of the top and bottom 30% of high and low BE/ME stocks are then computed each day and month over the following year from July to June to create the time-series of daily and monthly HML returns.

properties, like being more negatively related to momentum. This factor is obtained from the publicly available AQR data library.

The third value factor we examine, 'HML Devil Intra', is an alternative construction designed to be industry-neutral, where instead of ranking all firms in the market as in HML Devil, we compute ranks within each of the 30 industries of Fama and French (1997), construct long/short portfolios for each industry as described above, then aggregate all industry portfolios with industry market capitalization weights. This construction is designed to make more meaningful comparisons across firms since book values and accounting statements provide different information across industries. Cohen and Polk (2000) and Asness, Porter, and Stephens (2000) show that making industry adjustments to value portfolios has a meaningful impact on performance and provides a cleaner measure of value not tainted by accounting differences across industries.

Finally, we compute a 'Value Composite' factor, which uses multiple measures of value in addition to BE/ME to sort stocks. Specifically, stocks are ranked on each of five measures: BE/ME, earnings-to-price, forecast earnings-to-price, cash flow-to-price, and sales-to-enterprise value. The ranks are done based on each measure relative to the industry median, so that the resulting view portfolios are industry neutral. The Value Composite is an equal risk-weighted combination of the resulting long/short portfolios, constructed to be beta-neutral and dollar-neutral and to target a constant volatility using the Barra Developed Equity Risk Model, and rebalanced monthly. The Value Composite factor is only available since 1980 due to data availability.

iii. International data

For robustness, we also examine international data. We use monthly 3-month and 10-year yields (and the resulting yield curve slope) for Japan, Germany, and the U.K., obtained from Global Financial Data starting in 1988. We construct 'HML Devil' and HML Devil Intra' equity value factors in each of these markets as described above, using stock return and accounting data from Compustat/Xpressfeed. The international data offer out of sample evidence for interest rate sensitivity, and the possibility of a cross-sectional analysis, though a shorter history is available.

b. Statistical relationships

We examine the contemporaneous relation between the equity value factors and interest rates in each market, looking at both levels and changes in interest rate variables.

i. Levels of short and long rates and slope

We run a time-series regression of the value factor's returns on two explanatory variables: the equity market excess return, to control for general market exposure, and one of the interest rate variables. As mentioned above the interest rate variables we examine are the level of the 3-month short rate, the 10-year long-term rate, and the slope of the yield curve (10-year yield minus 3-month yield). The regressions are run such that the period *t* return to the value factor is regressed on the value of the interest rate variable at the start of that period. Testing other specifications, such as omitting the market factor and/or including two or more rates factors together, using period-average levels, and using different data frequencies other than monthly, yielded similar results that lead to the same conclusions. Hence, we omit those results for brevity.

Exhibit 1 reports the coefficients and *t*-statistics for the interest rate variable from each estimated regression over the full sample period (we omit the constant and the coefficient on the market for brevity). Panel A reports results for the three U.S. value factors available since 1954 – HML FF, HML Devil, and HML Devil Intra. As the first three columns show, there are no significant value sensitivities to the levels of short- or long-term rates, and no significant exposure to the yield curve slope either. The *t*-statistics on the interest level variables are all well below 2, indicating the associated coefficients on the level and slope of rates are indistinguishable from zero. These (lack of) results indicate that neither the level of interest rates at the long or short end, nor the slope of the yield curve, has much import for the performance of value strategies. The clear implication is that the low-yield environment that pervaded the last decade and continues in 2020 says very little about the past performance or future prospects of value investing.

ii. Contemporaneous changes in short and long rates and in slope

The last three columns of Panel A of Exhibit 1 report regression results for value returns on contemporaneous *changes* in the interest rate variables. Here, we find some significant sensitivities of value factors to contemporaneous interest rate changes in the short and long rates, and also to changes in the slope of the yield curve. Specifically, value factors underperform when short rates contemporaneously increase. This result seems to contradict the duration hypothesis that declining interest rates are bad for value investing. It could be consistent with value being a proxy for financially distressed firms, but this interpretation is complicated by the fact that short rates tend to rise during benign economic environments when distressed firms are unlikely to suffer disproportionately. In addition, the effect is weaker for the industry-neutral version of value, which indicates that part of the sensitivity to short rates is coming from industry exposure.

For long-rate changes, we find a positive coefficient, which indicates that declining (rising) long rates are bad (good) for value. The sign of this relationship is consistent with the duration theory for value. However, for the classic measure of value, HML FF, the coefficient is insignificant. Likewise, we do not find a significant effect for HML Devil either. It is only when we examine the industry-neutral value factor that a significant positive coefficient emerges on long-rate changes. So, in addition to finding opposite-signed exposures to changes in short rates versus long rates, we also find that industry-neutralizing value reduces the exposure to short rates but *increases* the exposure to long rates. None of the theories explains this result. Even if one might argue that short rates matter for financial distress and long rates capture the duration effect, which might explain their opposite-signed exposures, that argument would also have to explain why financial distress matters more across industries but duration matters more within industries.. Absent a coherent story, these results could simply be driven by chance.

Finally, the last column of Panel A looks at changes in the slope of the yield curve. The coefficients are all positive and statistically significant (even meeting the higher significance threshold that accounts for multiple tests using the Bonferroni correction). However, the significance of these results seems to be mostly driven by the negative exposure to changes in the short rate, except for the industry-neutral version of value, where it is both the negative impact of changes in the short rate and positive impact from long rates. These results are consistent with other findings in the literature (Maio and Santa Clara (2017), Mezrich, Wei, and Gould (2019) and Harvey (2019)), but are hard to reconcile with any of the theories from Section 2, since most of the effect is coming from the short rate exposure.[6]

iii. Robustness tests: Other value measures, other markets, and other time periods

Panel B of Exhibit 1 shows results for the shorter time period beginning in 1980, and adds the Value Composite factor, which is comprised of more value indicators besides BE/ME. The results for the first three value factors are similar to the longer sample: negative exposures to short rates and positive exposures to long rates, with the effect on short rates muted by industry neutralization and the effect on long rates exacerbated by it. Comparing Panel B to Panel A, in the more recent period the magnitudes of the coefficients on short rates are smaller, but the magnitude on long rates are larger. Thus, value's

[6] We also separately tested sensitivities to changes in real bond yields and expected inflation, but do not find conclusive evidence as to which component of nominal yields is the source of the sensitivity.

sensitivity to long rates has increased over time, while its sensitivity to short rates has declined. Looking at the multi-measure Value Composite, which uses other measures of value in addition to BE/ME, we find slightly stronger sensitivities to levels (but still not meeting the multiple tests statistical threshold), and much weaker sensitivities to changes in both short and long rates. In fact, the coefficients on both short and long rate changes are statistically insignificant. Even for the changes in slope regression, the coefficient for the Value Composite is marginally significant and does not pass the statistical threshold for significance for the multiple tests being made. The size of the coefficient is also significantly smaller,[7] suggesting a weaker economic effect as well. In the last row of Exhibit 1 Panel B we report results for a version of the Value Composite that excludes BE/ME, with equal weights across the other value metrics, and here the sensitivities to rates changes are even weaker (this version is omitted from later exhibits as it is 0.99 correlated to the Value Composite). The much weaker results for these Value Composites indicate that other credible and reasonable measures of value do not show reliable sensitivity to interest rate changes. This evidence casts doubt on theories for value's relation to interest rate environments. Absent a compelling economic story for why some measures of value, namely BE/ME, are sensitive to interest rate changes, and others (such as CF/P, E/P, or sales-to-enterprise value) are not, the results indicate a lack of robustness. The interest rate sensitivities of BE/ME may be due to some complex and unreliable interaction of factors, rather than a robust general sensitivity of value factors. Of course, it is also possible that the lack of robustness indicates a spurious relation between value returns and interest rates.

For further robustness tests, Panel C reports results for international markets. Since the data start in 1988, we also report the U.S. results over this same time period for comparison. The first and fifth rows of Panel C report that the U.S. results are consistent with the longer period results from Panels A and B. Looking at the other markets, the relationship between value returns and interest rates are much milder in Japan and the U.K. (though with some similar patterns) and non-existent in Germany. The results are weaker outside of the U.S., consistent with possible overfitting of the U.S. sample and inconsistent with an economic reason for value to be impacted by interest rate regimes.

We also show results of a cross-sectional regression to test whether relative interest rate patterns are associated with relative value returns across countries. We find mild evidence that cross-country value outperformance has been associated with *lower* levels of rates, which is the opposite sign of what the

[7] The size of the coefficient depends on both the correlation and the relative factor volatilities. The risk-targeted Value Composite has a slightly lower volatility than the other value factors but even after accounting for this, the coefficient is lower.

interest rate stories claim and clearly inconsistent with the notion that value cannot work when rates are low. As a strong case in point: Japan has by far the highest average value return during the sample period, and the lowest interest rates. We also find a mild relationship with relative rises in long rates, but it is not significant.

As another robustness test, we also look at out of sample data from 1926 to 1953, using quarterly as opposed to monthly returns due to rates data availability. Exhibit A1 in the appendix shows the results, which are weaker in the 1926 to 1953 out-of-sample period, though coefficients on changes in rates have broadly the same signs as in the later period.[8]

iv. Time variation

Finally, some commentary (e.g., Mezrich et al. (2019)) has asserted that the exceptional interest rate environment since the Global Financial Crisis (GFC) has caused the sensitivities of equity factors to become elevated. Exhibit 2 shows time variation of sensitivities to two variables that have received attention recently – changes in the long rate and changes in the yield curve slope. The exhibit plots the rolling 10-year *t*-statistics from regressing various value factors on these two interest rate variables (the market factor is also included in the regression, but this coefficient and the intercept are not reported for brevity). Value does show a stronger link to these interest rate variables in the most recent decade, even for different factor constructions and countries (though the peak is much lower for the Value Composite).

However, the last decade is not the only peak in the relationships between value and interest rates. The yield curve slope relationship was just as strong in the 1970s, which was certainly not a period of low interest rates. This finding challenges the narrative that the post-GFC low rates environment is responsible for the stronger recent relationship. In addition, the relationships between value and interest rates are reversed in some periods, such as the 1990s. These results give us less confidence in the recent positive relationships being meaningful and suggests that they may be chance events. This illustrates one of the dangers in drawing inferences from short samples such as the past decade.[9]

v. Direct tests for cash flow duration, debt characteristics, and financial distress

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[8] For the curious reader, Exhibit A2 in the appendix shows sensitivities of other U.S. equity factors: the market, the Fama and French (1993) SMB small-minus-big stock factor, the UMD momentum factor from Ken French's data library, and the BAB betting-against-beta factor from Frazzini and Pedersen (2013). The market has mild sensitivities to levels of short rates (negative) and slope (positive), and to changes in long rates. SMB has similar sensitivities as HML, while UMD has opposite sensitivities. BAB has some bond-like sensitivities which are much weaker in industry-neutral variants (not shown).

[9] It is also possible that investor belief in such a relationship over this period strengthened it during recent episodes (such as during a period of high factor volatility in September 2019), as a self-fulfilling prophecy. But random variation is likely to be the main source of the strengthening.

As discussed in Section 2, some have suggested that cash flow duration, debt amount and maturity, or financial distress may make value portfolios sensitive to interest rates. To test these hypotheses directly, rather than focus on value, we focus instead on the cash flow duration, debt, and financial distress characteristics of firms. In Exhibits 3 and 4 we directly test the sensitivities of U.S. industry-neutral factors constructed on each of these characteristics.

We first compare the book-to-price factor from our industry-neutral Value Composite to a similarly-constructed dividend-to-price factor, as the latter is more directly related to cash flow duration. While both have some long-term sensitivity to slope changes, BE/ME has the stronger sensitivity to changes in bond yields, which does not seem supportive of the cash flow duration theory since dividend yields are more closely related to cash flow duration than book values.

Second, we test total indebtedness (debt-to-assets). Specifically, we examine a book-to-price factor constructed to have no debt-to-asset exposure, and then do the reverse exercise of constructing a debt-to-asset factor with no value exposure to see if the interest rate sensitivity is any different. If the debt story is true, then once we strip out debt exposure from the value factor, we should see no interest rate sensitivity. Conversely, the debt factor that is value-neutral should exhibit even stronger interest rate sensitivity, as it is a pure debt measure devoid of any confounding influence from value. Examining the evidence in Exhibit 3, the debt factors exhibit no sensitivities to interest rates over our longer sample (Panel A), while over the recent decade (Panel B) they show a negative loading on changes in short term rates. These results for the hedged factors confirm that debt levels do not seem responsible for value's sensitivities to long rate changes and slope changes. Moreover, Exhibit 4 shows that although value firms have tended to be more indebted over the long term, they were not so over the past decade, which is when we see the mild sensitivity to changes in short rates. All of this evidence suggests that debt exposure of value portfolios during low interest rate environments is not the driving force behind the recent poor performance of value.

Third, we test whether more shorter-term debt or financial distress associated with value stocks could be contributing to interest rate exposure of the value factor. We use short-term debt as a proportion of total debt as a measure of debt maturity, and use the default probability of Bharath and Shumway (2008) as a direct measure of financial distress. We find no evidence that companies with a higher proportion of short-term debt tend to be value firms or exhibit any sensitivity to rates factors. Thus, we find little support for the theory that shorter debt duration explains value's sensitivity to changes in yield curve slope. Value firms *have* tended to be more distressed over the long term (Exhibit 4), but less so during the past decade when performance really suffered. If poor returns to financially distressed firms contributed to value's underperformance in a meaningful way, we would have expected a much larger exposure to distress over the recent decade.

Finally, we find that the past decade's increases in sensitivities to changes in yields and slope are led primarily by book-to-price factors, and not any of these other factors directly associated with debt, duration, or financial distress, which casts serious doubts on the popular narrative that the value factor's debt characteristics are responsible for these recent trends.

c. Economic significance

In the previous section we found most relationships between value factors and interest rates to be statistically insignificant (especially those relating to levels of rates). We also found some relationships (changes in slope) that are moderately significant, and fairly robust across some dimensions but not others. Given we have a century of data, we do not believe our tests lack power. However, another way to assess the link between value returns and interest rates is to examine the economic significance of any relationship.

Specifically, we take the strongest relationship we find in the data, which is the relation between value returns and changes in the slope of the yield curve. The results from Exhibit 1 suggest that a flattening of the yield curve is associated with poorer value returns. Given those results and the estimated coefficients, we ask, how much of value's performance could yield curve slope changes explain? Exhibit 5 shows the worst five drawdowns for each value factor, and, using the long-term regression coefficients from Exhibit 1, calculates the portion explained by changes in yield curve slope during these periods. Slope changes are not a major driver of any of the drawdowns, and in several cases the curve *steepened* during the drawdown, implying a positive contribution to value during these events. Hence, the economic significance of any relation between value and yield curve slope changes is weak and explains very little of historical drawdowns to value, including the very recent one. Thus, despite the yield curve having flattened in recent years, and value simultaneously performing poorly, there is only a mild connection between the two.

Another way to measure the economic significance of the empirical relationships is to estimate the value premium conditional on a shock to interest rates. Exhibit 6 shows the long-term unconditional annualized premium for each U.S. value factor, and plots alongside it estimates of the value premium conditional on -1SD and -2SD events for the contemporaneous 12-month change in yield curve slope. These events correspond to -119 and -238 basis point flattening events, respectively (the last 12-month event of the latter magnitude was during 2004 to 2005). For a moderate flattening event, the premium remains positive for all four variations of the value factor. For the more extreme -2SD events, one factor turns negative (the HML Devil factor), while the other premia are reduced by varying amounts. The Value Composite factor sees little impact. For sophisticated quantitative investors, this supports the case for strategic value exposure regardless of the current or predicted interest rate environment. The bottom line is that even during extreme changes to the slope of the yield curve, we see very little variation in composite value factor returns.

The evidence in favor of a link between interest rate environments and value returns is limited. We do find some statistically significant relationships between value factor returns and changes in the slope of the yield curve. However, these relationships are not very robust and have modest economic consequences. Our findings are inconsistent with a duration-based story for the value factor and suggest that all else is not equal – that is, when rates and yield curve change, so do the other components of the present value formula, cash flows and risk premia, which makes the link between value investing and the interest rate environment murky. For other theories, such as value proxying for financial distress and debt characteristics of the firm, our findings provide very limited supporting evidence.

4. Predictive Relationships and Factor Timing

While the contemporaneous relationship between interest rates and value's performance is modest at best and cannot explain the recent drawdown for value, investors may wonder whether it is a good or bad time to be a value investor. More specifically, despite the weak contemporaneous relationship between rates and value returns, there may be a predictive relationship between rates and returns that is valuable to investors. Interest rates may not explain much of value's performance through time, but if even a small amount of time variation in value's premium can be predicted by information in the yield curve, this could be valuable to investors. In this section we examine the predictive relationship between interest rates and value returns and assess whether investors may be able to exploit it through timing.

Exhibit 7 shows results from the same regressions as in Exhibit 1, but where we lag changes in interest rates to test for predictive relationships. We test the prior 1-month change and the prior 12-month change in each rates variable. The predictive relationships in Exhibit 7 are even weaker than the contemporaneous ones from Exhibit 1. Moreover, we find negative sensitivities to lagged changes in long-term rates, which is the opposite sign to the contemporaneous relationship we found for long-term rates, contradicting the duration-based theory. However, none of the lagged coefficients meet the threshold for statistical significance adjusting for multiple tests. The international results for changes in the yield curve slope vary in sign across countries, suggesting that despite changes in slope being our most consistent contemporaneous finding, its predictive relationship to value returns is insignificant and varied.

Timing signals are notorious for data mining and hindsight biases, where under- or overweighting one or two events can make a substantial difference to backtest performance.[10] For this reason, long data sets are helpful for more reliable testing of tactical strategies. Ilmanen et al. (2019) construct a multi-asset factor premia data set over a century and examine a wide range of timing indicators, including some of the interest rate variables we examine. Across a variety of different timing methods and signals, they find little evidence for predictability based on the interest rate environment. Consistent with their results, we find little evidence of predictive relationships useful for tactical timing of the value premium. Exhibit 8 plots time variation in the predictive relationship between the U.S. HML Devil factor and changes in the yield curve and long rate. For comparison, we also plot the contemporaneous relationship between the variables over time (from Exhibit 2). As Exhibit 8 shows, while contemporaneous sensitivities to changes in 10-year yields and changes in yield curve slope are heightened over the last decade, predictive relationships are not. Hence, even if one had predicted after the GFC that a stronger relationship would emerge in the ensuing decade, that information would not have proven useful in timing the value factor.

Contemporaneous relations are not useful for timing. Even if you believe a strong relationship exists between value and rates changes, forecasting when and in what way rates will change is notoriously difficult. Moreover, if one could predict rates changes, a better strategy would be to trade instruments more tightly connected to the yield curve such as fixed income instruments or interest rate derivatives. A long-short equity factor such as value is an indirect way of using that information, and, as it turns out, is not tightly linked to the interest rate environment empirically or theoretically.

5. An Out-of-Sample Test During the Coronavirus Pandemic

Our analysis examined data through December 2019, and was motivated by value's poor performance during the 2010s and especially the last few years of that decade. However, in the first quarter (January 1

[10] See for example Asness, Ilmanen and Maloney (2017) on market timing, and Asness, Chandra, Ilmanen and Israel (2017) on factor timing.

to March 31) of 2020, during the outbreak of the Coronavirus pandemic, value suffered even more sharply. We use this short and extreme time period to analyze the predictions of our findings out-of-sample.

During this time, monetary and fiscal policies were changing rapidly in response to the crisis, providing variation in interest rate news that we can compare to value's performance. Exhibit 9 Panel A shows attributions based on net changes in the interest rate variables over the quarter, using the long-term regression coefficients estimated earlier. The yield curve steepened by around 20 basis points during this time, so value's mild *positive* long-term relationship with slope changes cannot explain any of value's deep losses over this period. Treasury yields fell by around 120 basis points over this time, but based on our long-term estimates of the relationship between value and Treasury rates, this can only explain a tiny portion of the losses. By contrast, value's long-term exposure to credit risk explains a substantial portion of Q1 2020 losses. Indeed, both credit portfolios and value portfolios suffered during this period and the two are significantly positively correlated.

Finally, Exhibit 9 Panel B shows the relationships between daily returns of our Value Composite and contemporaneous daily rates changes during this volatile quarter. The daily data provides high frequency changes capturing news to rates and value returns that offer another perhaps more powerful test of their relationship during this time. For both long rate changes and slope changes, there is a mild negative relationship over this period, with value's worst losses tending to occur on days when yields went up and/or the yield curve steepened. These results are the *opposite* sign to the average relationships observed over the previous decade. This test further supports our skepticism that interest rates are to blame for value's poor performance.

6. Conclusion

The relationship between the value premium and the interest rate environment is theoretically complex and empirically we find inconsistent results. Value factors vary considerably in their exposure to levels and changes in rates and slopes of the yield curve, and different implementations of value yield different results. We find modest evidence of a positive relationship between value factors and contemporaneous changes in long-term bond yields, which matches recent research that characterizes value stocks as lower duration assets than growth stocks. While this relationship has been stronger than average in the recent decade, our analysis suggests this is more likely due to random variation than low interest rates. In fact, we find the opposite relationship over the first out of sample value drawdown during the Coronavirus pandemic.

We also find mild evidence of a *negative* relationship between value premia and changes in short-term interest rates, though our more direct analysis of debt and financial distress factors does not support the theory that value firms' poorer financial position is responsible for its performance. Combining these two patterns produces statistically stronger sensitivities to changes in the yield curve slope. Hence, the flattening of the yield curve from 2017 to 2019 may have applied a mild headwind to value, coinciding with its poor performance. However, this effect is of small economic significance, and the relationship varies for different value measures, implementations, time periods, and markets, questioning its robustness. In particular, value strategies commonly used in practice that are based on multiple valuation metrics exhibit milder sensitivities than simple academic factors based on book-to-price ratios.

We find no evidence that links the size of the value premium to the *level* of interest rates, and therefore our results do not support assertions that a change in interest rate environment is a necessary condition for value's recovery from the last decade. Neither do our results support assertions that interest rates or the yield curve have been a major driver of value underperformance during the sharp drawdown from 2017 to 2019 or over the past decade. Rather, the right explanation is often the simplest one (albeit less satisfying perhaps) – large drawdowns are simply an unwanted feature of factor premia such as value (and the market premium, too). The paucity of evidence that these drawdowns can reliably be explained or predicted by observable variables – despite narratives with the benefit of hindsight – may be precisely why these factors are risky and therefore why they provide long-term positive return premia that are not easily arbitraged away.

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EXHIBIT 1: Sensitivities of Value Factors to Interest Rates (Levels and Changes)

The tables show regression coefficients with *t*-statistics in parentheses. Asterisks denote relationships significant at the 95% confidence level, without (single) and with (double) Bonferroni adjustment for multiple tests. Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (coefficient not shown), and one interest rate variable. The value factor variants are described in the text. International value factors are regressed on their own market and interest rate variables. The international sample starts in July 1988 for U.S., Japan and U.K., and July 1990 for Germany.

Panel A: U.S. Long Sample 1954-2019

	Starting Levels of Rates			**Contemporaneous Changes in Rates**		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	0.04 (1.3)	0.05 (1.5)	0.00 (0.1)	-0.70 (-3.3) **	0.20 (0.6)	1.07 (4.4) **
HML Devil	0.04 (1.0)	0.05 (1.2)	0.05 (0.5)	-1.13 (-4.4) **	0.46 (1.2)	1.83 (6.2) **
HML Devil Intra	0.04 (1.1)	0.06 (1.7)	0.10 (1.1)	-0.57 (-2.5) *	1.52 (4.6) **	1.77 (6.7) **

Panel B: U.S. Recent Sample 1980-2019

	Starting Levels of Rates			**Contemporaneous Changes in Rates**		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	0.06 (1.7)	0.07 (1.8)	0.01 (0.1)	-0.46 (-1.6)	0.30 (0.8)	0.85 (2.6) *
HML Devil	0.03 (0.7)	0.04 (0.9)	0.08 (0.6)	-0.97 (-2.7) **	0.61 (1.3)	1.78 (4.4) **
HML Devil Intra	0.01 (0.3)	0.03 (0.8)	0.15 (1.3)	-0.19 (-0.6)	1.73 (4.7) **	1.66 (5.0) **
Value Composite	0.06 (2.0) *	0.09 (2.7) *	0.15 (1.6)	-0.15 (-0.6)	0.50 (1.6)	0.60 (2.1) *
Composite ex B/P	*0.07 (2.1) **	*0.09 (2.8) **	*0.13 (1.4)*	*-0.15 (-0.6)*	*0.36 (1.2)*	*0.50 (1.8)*

Panel C: International Sample 1988-2019

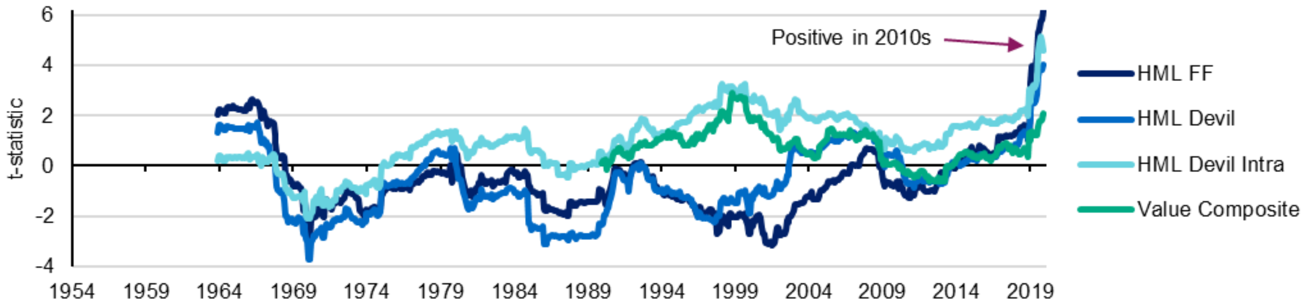
	Starting Levels of Rates			**Contemporaneous Changes in Rates**		
Country	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML Devil						
U.S.	-0.08 (-1.1)	-0.06 (-0.7)	0.20 (1.2)	-1.46 (-1.7)	1.74 (2.5) *	2.30 (3.6) **
Japan	0.08 (0.9)	0.10 (1.2)	0.10 (0.5)	-0.07 (-0.1)	2.43 (2.5) *	2.17 (2.4) *
Germany	0.16 (1.8)	0.15 (1.6)	-0.21 (-0.8)	-0.73 (-0.6)	-1.19 (-1.0)	-0.50 (-0.5)
U.K.	-0.01 (-0.1)	-0.01 (-0.1)	0.01 (0.1)	-1.05 (-1.5)	1.14 (1.6)	1.70 (2.7) *
Cross-section	-0.23 (-1.2)	-0.17 (-2.3) *	-0.11 (-1.0)	0.80 (0.4)	3.29 (2.2) *	1.5 (1.9)
HML Devil Intra						
U.S.	-0.11 (-1.7)	-0.09 (-1.2)	0.21 (1.5)	-0.36 (-0.5)	3.19 (5.5) **	2.93 (5.4) **
Japan	0.08 (0.9)	0.09 (0.9)	-0.04 (-0.2)	0.14 (0.1)	1.08 (1.0)	0.84 (0.9)
Germany	-0.04 (-0.6)	-0.04 (-0.5)	0.05 (0.2)	0.89 (0.8)	-0.07 (-0.1)	-0.71 (-0.8)
U.K.	0.01 (0.2)	0.01 (0.2)	-0.01 (0.0)	-0.56 (-0.8)	2.03 (3.0) **	2.00 (3.4) **
Cross-section	-0.30 (-1.5)	-0.26 (-3.4) *	0.06 (0.3)	-0.26 (-0.1)	3.50 (2.9) *	0.69 (0.9)

EXHIBIT 2: Time variation in contemporaneous rates sensitivities – rolling 10-year t-statistics

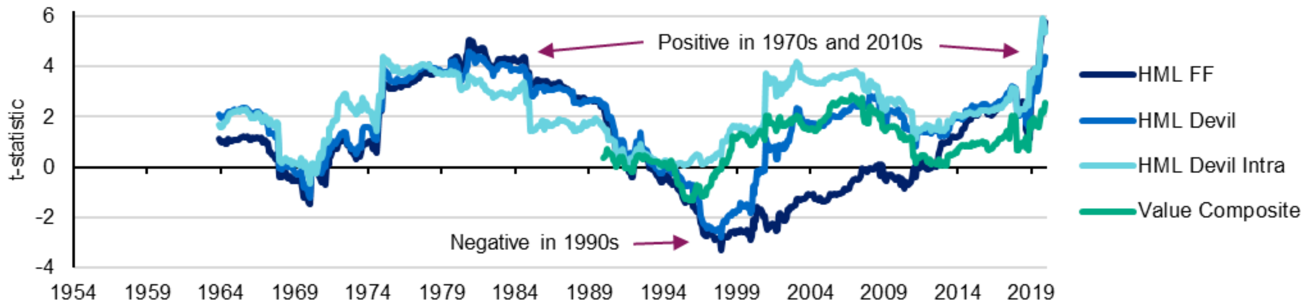
Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (t-statistic not shown) and one rates variable. The LHS value factor variants are described in the text.

Panel A: U.S. Factors 1954-2019

i. Sensitivity to 10-Year Yield Changes

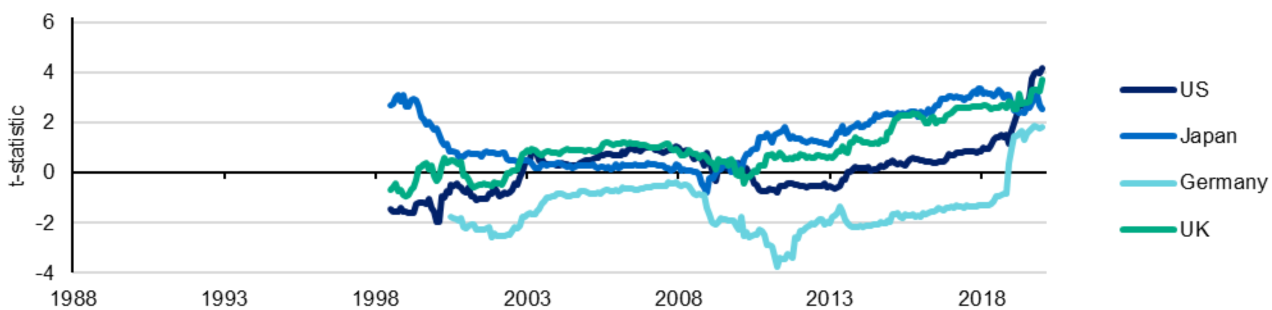


ii. Sensitivity to Yield Curve Slope Changes



Panel B: Global Value Factors 1988-2019 (all HML Devil)

i. Sensitivity to 10-Year Yield Changes



ii. Sensitivity to Yield Curve Slope Changes

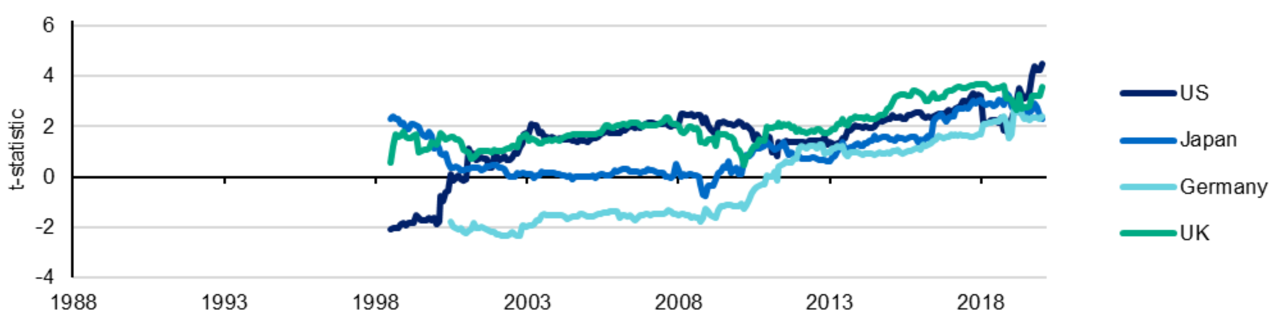


EXHIBIT 3: Average sensitivities of cash flow, debt and distress factors to interest rate factors

The tables show regression coefficients with t-statistics in parentheses. Asterisks denote relationships significant at the 95% confidence level, without (single) and with (double) Bonferroni adjustment for multiple tests. Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (coefficient not shown), and one interest rate variable. Debt and distress factors are constructed to go long companies that are more indebted, have a higher proportion of short-term debt, or have higher default probability. Hedged B/P and D/A factors are ranked on the first characteristic and constructed to have zero exposure to the second characteristic using a generalized least squares hedge.

Panel A: Full Sample 1980-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
	3-Month Rate	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML Devil	0.03 (0.7)	0.04 (0.9)	0.08 (0.6)	-0.97 (-2.7) *	0.61 (1.3)	1.78 (4.4) **
Value Composite	0.06 (2.0) *	0.09 (2.7) *	0.15 (1.6)	-0.15 (-0.6)	0.50 (1.6)	0.60 (2.1) *
- Book-to-Price	0.02 (0.8)	0.05 (1.5)	0.15 (1.7)	-0.11 (-0.5)	0.63 (2.2) *	0.66 (2.5) *
- Dividend-to-Price	0.05 (1.7)	0.05 (1.7)	-0.02 (-0.2)	-0.29 (-1.4)	0.25 (0.9)	0.59 (2.4) *
Debt/Assets (D/A)	0.00 (0.0)	0.00 (-0.1)	-0.01 (-0.2)	0.01 (0.0)	0.41 (1.4)	0.32 (1.2)
B/P hedging D/A	0.03 (1.2)	0.06 (1.9)	0.16 (2.0) *	-0.13 (-0.6)	0.47 (1.8)	0.56 (2.3) *
D/A hedging B/P	-0.01 (-0.5)	-0.03 (-0.9)	-0.09 (-1.1)	-0.05 (-0.2)	0.23 (0.8)	0.25 (1.0)
ST Debt / Total	0.04 (1.4)	0.04 (1.3)	-0.04 (-0.5)	0.11 (0.5)	-0.15 (-0.5)	-0.27 (-1.1)
Default Prob.	-0.12 (-3.3)	-0.14 (-3.9) **	-0.10 (-1.1)	0.59 (1.4)	0.68 (2.0) *	0.29 (0.9)

Panel B: Recent Decade 2010-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
	3-Month Rate	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML Devil	-0.28 (-1.0)	-0.43 (-1.1)	0.05 (0.2)	-1.45 (-0.5)	4.63 (4.1) **	5.06 (4.4) **
Value Composite	-0.68 (-2.5) *	-0.73 (-1.9)	0.23 (1)	-2.83 (-0.9)	2.44 (2.1) *	3 (2.6) *
- Book-to-Price	-0.37 (-1.7)	-0.71 (-2.3) *	0.01 (0.0)	-2.52 (-1.0)	2.29 (2.4) *	2.79 (2.9) *
- Dividend-to-Price	0.14 (0.6)	-0.11 (-0.3)	-0.14 (-0.7)	0.74 (0.3)	0.71 (0.7)	0.63 (0.6)
Debt / Assets	0.12 (0.5)	-0.65 (-1.8)	-0.33 (-1.5)	-6.22 (-2.2) *	-0.66 (-0.6)	0.30 (0.3)
B/P hedging D/A	-0.39 (-1.8)	-0.51 (-1.6)	0.09 (0.5)	-2.19 (-0.9)	2.40 (2.6) *	2.86 (3.1) *
D/A hedging B/P	0.09 (0.4)	-0.63 (-1.8)	-0.30 (-1.4)	-5.65 (-2.0) *	-0.95 (-0.9)	-0.09 (-0.1)
ST Debt / Total	0.40 (1.6)	0.05 (0.1)	-0.27 (-1.3)	2.23 (0.8)	0.19 (0.2)	-0.16 (-0.1)
Default Prob.	0.15 (0.7)	-0.46 (-1.5)	-0.28 (-1.5)	-3.7 (-1.6)	0.7 (0.7)	1.32 (1.4)

EXHIBIT 4: Value spreads of debt and distress factors 1980-2019

For each factor the chart shows the ratio of view-weighted valuations of long and short sides, with valuation measured using the multi-metric Value Composite. A ratio of greater than 1 indicates longs are cheaper than shorts.

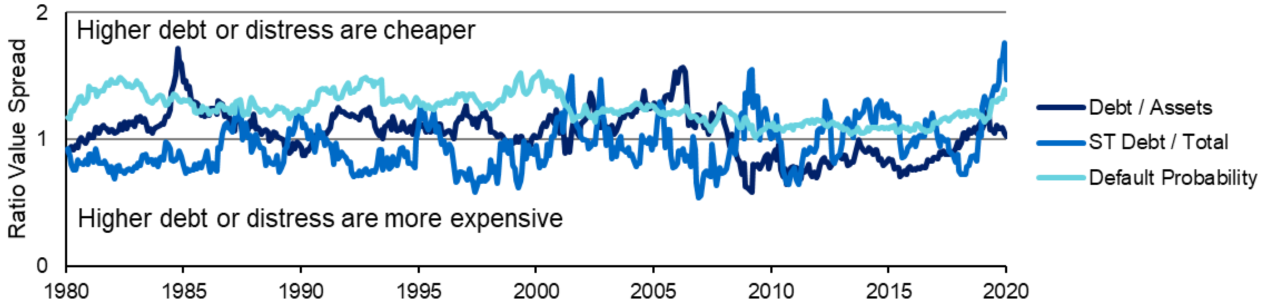


EXHIBIT 5: Attribution of Worst Value Drawdowns to Slope Change

Each column chart shows the worst five peak-to-trough drawdowns for one value factor 1954-2019 (1980-2019 for Value Composite factor). For each drawdown, an attribution to yield curve slope change is calculated by multiplying slope change during the drawdown by the regression coefficient from Exhibit 1 Panel A (Panel B for Value Composite factor). Drawdowns are based on arithmetic cumulative returns. Labels show dates of peak and trough.

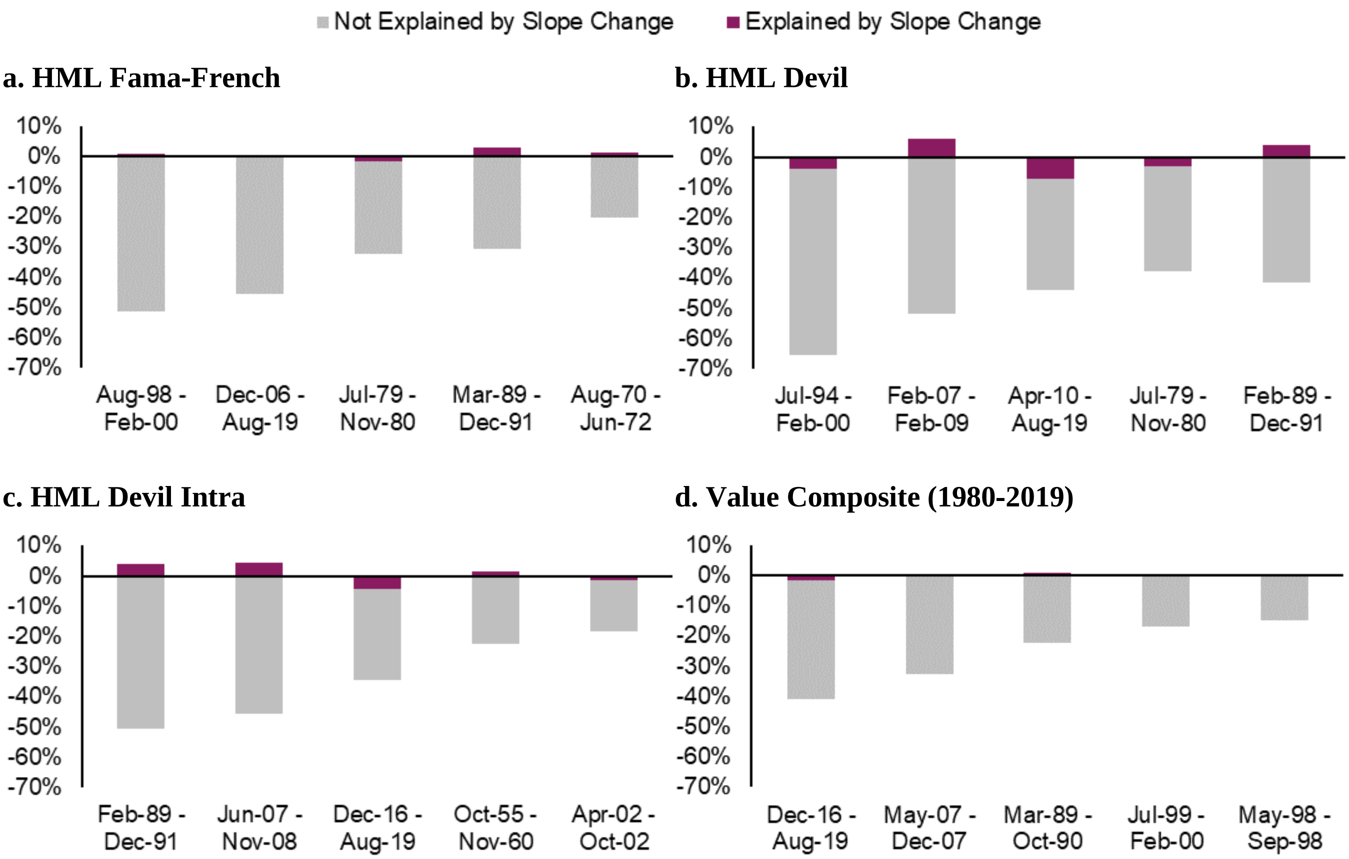


EXHIBIT 6: Value Premium Conditional on Shock to Yield Curve Slope

Unconditional premium is long-term average annualized return 1954-2019 (1980-2019 for Value Composite). Slope change events are based on rolling 12-month slope changes 1954-2019. Impact of yield curve slope change event is based on regression coefficient from Exhibit 1 Panel A (Panel B for Value Composite factor).

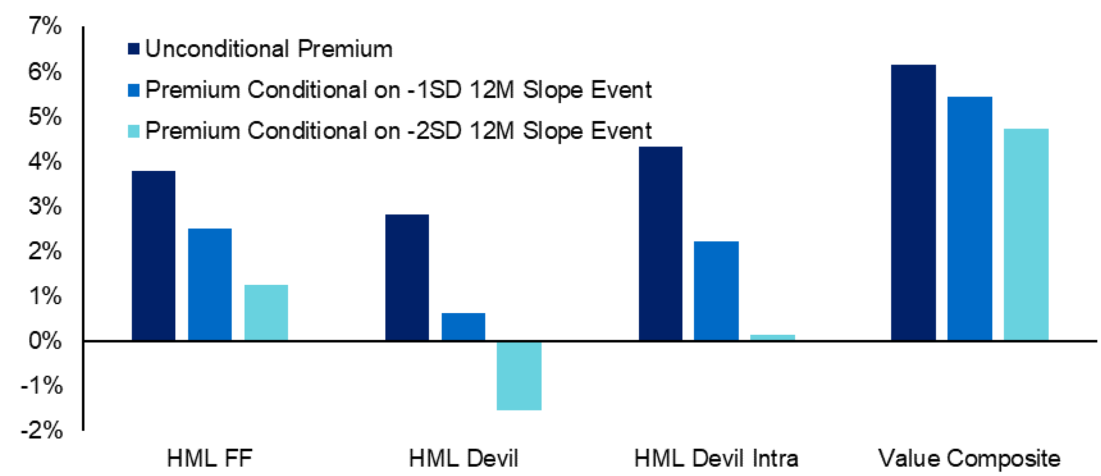


EXHIBIT 7: Average sensitivities of value factors to interest rate factors (lagged changes)
The tables show regression coefficients with t-statistics in parentheses. Asterisks denote relationships significant at the 95% confidence level, without (single) and with (double) Bonferroni adjustment for multiple tests. Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (coefficient not shown), and one interest rate variable. The value factor variants are described in the text. International value factors are regressed on their own market and interest rate variables. The international sample starts in July 1988 for U.S., Japan and U.K., and July 1990 for Germany.

Panel A: U.S. Long Sample 1954-2019

	Lagged 1-Month Changes			Lagged 12-Month Changes		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	-0.08 (-0.4)	-0.60 (-2.0) *	-0.28 (-1.1)	0.05 (0.9)	-0.02 (-0.2)	-0.10 (-1.3)
HML Devil	-0.06 (-0.2)	-0.97 (-2.6) *	-0.55 (-1.8)	0.05 (0.7)	-0.04 (-0.3)	-0.12 (-1.2)
HML Devil Intra	-0.17 (-0.7)	-0.84 (-2.5) *	-0.33 (-1.2)	-0.04 (-0.7)	-0.03 (-0.3)	0.05 (0.6)

Panel B: U.S. Recent Sample 1980-2019

	Lagged 1-Month Changes			Lagged 12-Month Changes		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	-0.17 (-0.6)	-0.45 (-1.2)	-0.14 (-0.4)	0.08 (1.0)	-0.02 (-0.2)	-0.15 (-1.5)
HML Devil	-0.19 (-0.5)	-0.77 (-1.7)	-0.36 (-0.9)	0.11 (1.1)	-0.02 (-0.2)	-0.21 (-1.6)
HML Devil Intra	-0.29 (-1.0)	-0.65 (-1.7)	-0.14 (-0.4)	-0.01 (-0.1)	-0.02 (-0.1)	-0.01 (-0.1)
Value Composite	-0.12 (-0.5)	-0.55 (-1.7)	-0.28 (-1.0)	-0.04 (-0.5)	-0.02 (-0.3)	0.04 (0.4)

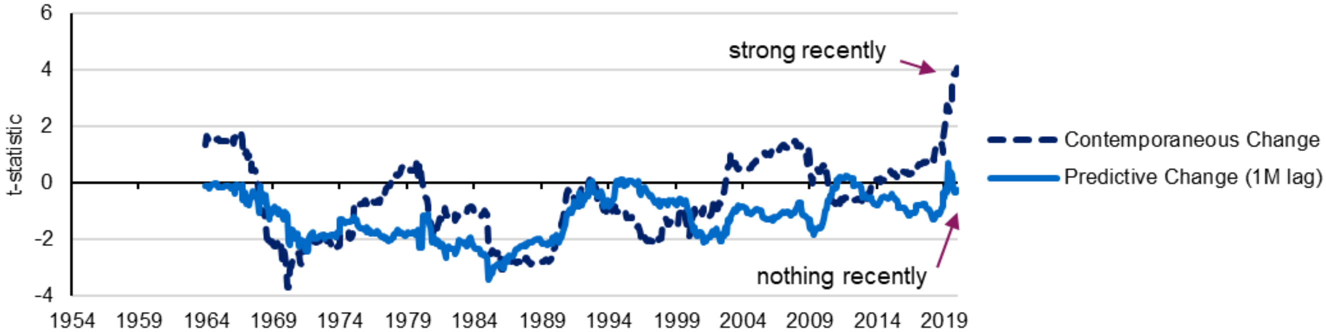
Panel C: International Sample 1988-2019

	Lagged 1-Month Changes			Lagged 12-Month Changes		
Country	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML Devil						
U.S.	-0.39 (-0.4)	-1.30 (-1.8)	-0.89 (-1.4)	-0.04 (-0.3)	-0.34 (-1.5)	-0.12 (-0.8)
Japan	-0.49 (-0.5)	-0.24 (-0.3)	0.16 (0.2)	-0.10 (-0.5)	-0.17 (-0.6)	0.02 (0.1)
Germany	-3.64 (-3.0) *	-0.24 (-0.2)	2.60 (2.5) *	-0.32 (-1.4)	-0.62 (-2.1) *	-0.06 (-0.2)
U.K.	-0.48 (-0.7)	-0.97 (-1.4)	-0.31 (-0.5)	-0.25 (-2.1) *	-0.24 (-1.1)	0.24 (1.7)
Cross-section	1.17 (0.6)	2.04 (1.0)	-0.25 (-0.3)	-2.55 (-0.7)	5.77 (1.7)	5.79 (1.5)
HML Devil Intra						
U.S.	-0.09 (-0.1)	-0.71 (-1.2)	-0.56 (-1.0)	-0.11 (-0.9)	-0.20 (-1.0)	0.04 (0.3)
Japan	-0.36 (-0.3)	-0.21 (-0.2)	0.08 (0.1)	-0.03 (-0.1)	-0.09 (-0.3)	-0.04 (-0.1)
Germany	-2.80 (-2.7) *	-0.07 (-0.1)	2.09 (2.3) *	-0.49 (-2.5) *	-0.43 (-1.7)	0.33 (1.4)
U.K.	0.34 (0.5)	-0.51 (-0.8)	-0.67 (-1.2)	-0.32 (-2.9) *	-0.23 (-1.1)	0.34 (2.6) *
Cross-section	-1.08 (-0.6)	0.30 (0.2)	0.07 (0.1)	0.15 (0.3)	0.81 (2.5) *	0.52 (1.7)

EXHIBIT 8: Time variation in predictive rates sensitivities – rolling 10-year t-statistics

Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (t-statistic not shown) and one rates variable. Time period is January 1954 to December 2019.

Panel A: Sensitivity of U.S. HML Devil to 10-Year Yield Changes



Panel B: Sensitivity of U.S. HML Devil to Yield Curve Slope Changes

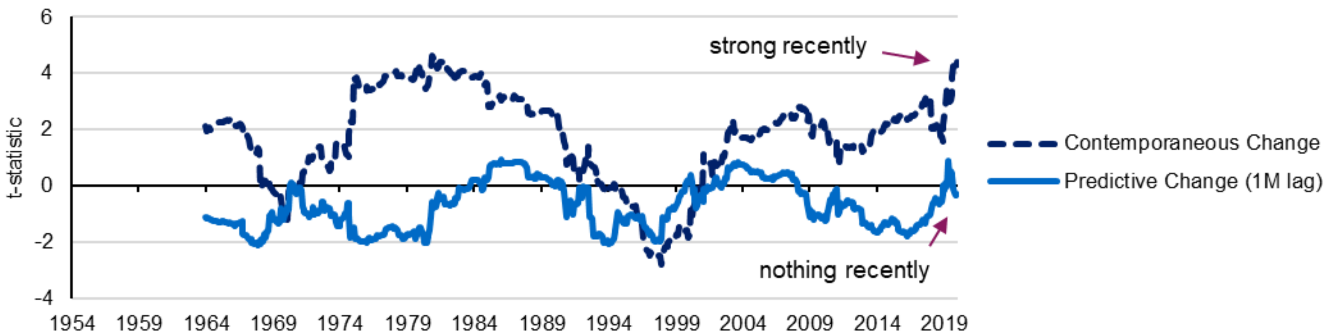
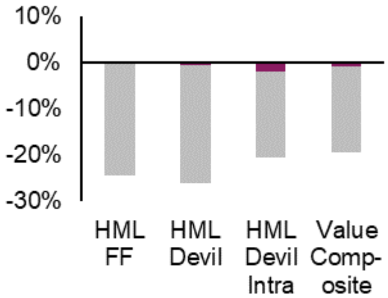


EXHIBIT 9: Analysis of Q1 2020

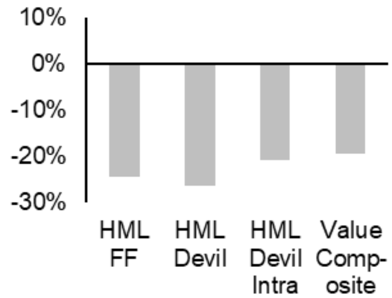
In Panel A, attributions to 10Y rate change and 10Y-3M slope change are calculated by multiplying net change during the period by the regression coefficient from Exhibit 1 Panel A (Panel B for Value Composite factor). Attribution to credit excess return is based on coefficients estimated over the same periods. Credit return data is Asvanunt and Richardson data set from AQR data library from 1954-1988, and Barclays U.S. Corporate Excess Return Index from 1988-2020. Value factor variants are described in the text. In Panel B, dotted lines are linear least squares fits. All charts in this exhibit are based on the period January 1, 2020 to March 31, 2020.

Panel A: Attribution of Cumulative Q1 2020 Value Returns to Rates and Credit Factors

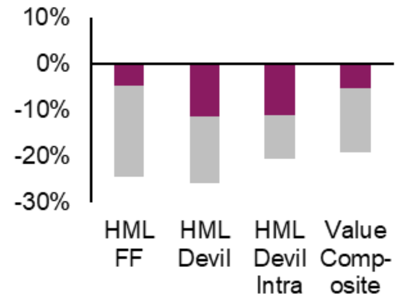
i. Change in 10Y rate



ii. Change in 10Y-3M slope

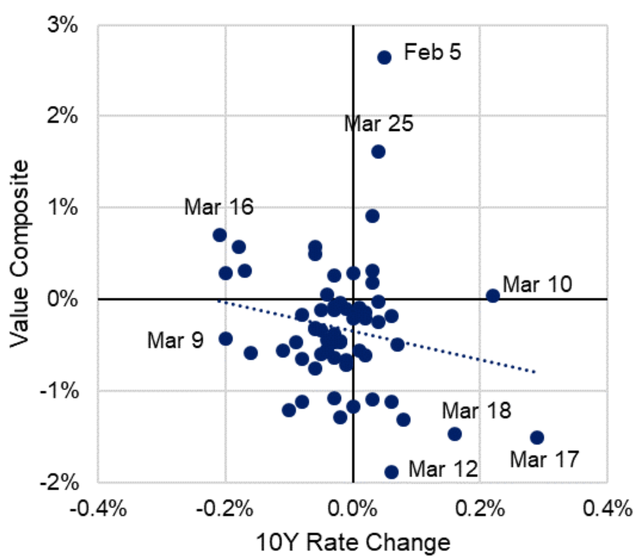


iii. Corporate credit excess return

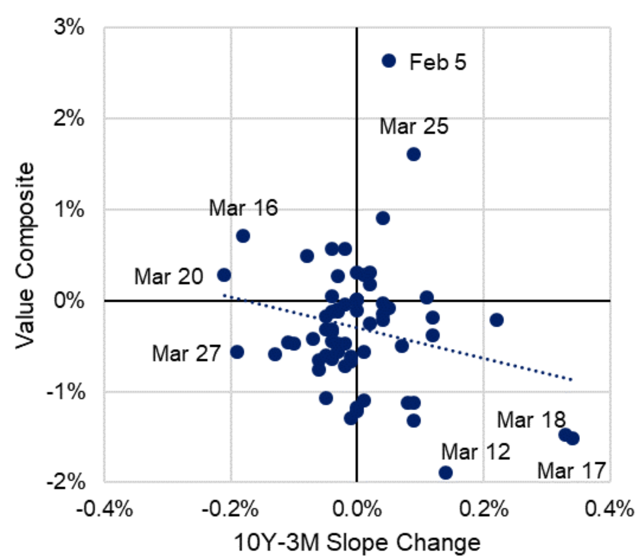


Panel B: Daily Changes in Interest Rates vs. Value Composite Returns, Q1 2020

i. Changes in 10Y rate



ii. Changes in 10Y-3M slope



APPENDIX

EXHIBIT A1: Average sensitivities 1926 to 1953 with quarterly data

The tables show regression coefficients with t-statistics in parentheses. Asterisks denote relationships significant at the 95% confidence level, without (single) and with (double) Bonferroni adjustment for multiple tests. Regressions are based on quarterly non-overlapping data and each includes two RHS variables: the market as a control variable (coefficient not shown), and one interest rate variable. The value factor variants are described in the text.

Panel A: U.S. Early Sample 1926-1953 (month-average data)

	Starting Levels of Rates			Contemporaneous Changes in Rates		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	-0.25 (-0.4)	0.27 (0.2)	0.44 (0.6)	-4.41 (-2.2) *	10.21 (1.0)	5.08 (2.5) *
HML Devil	-0.73 (-1.1)	1.75 (0.9)	1.49 (1.8)	-5.63 (-2.4) *	1.84 (0.1)	6.07 (2.5) *
HML Devil Intra	-1.30 (-2.0) *	1.88 (1.0)	2.39 (3.0) *	-4.79 (-2.1) *	3.50 (0.3)	5.23 (2.2) *

Panel B: U.S. Long Sample 1954-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	0.12 (1.2)	0.15 (1.3)	0.08 (0.3)	-0.66 (-1.8)	0.1 (0.2)	1.17 (2.5) *
HML Devil	0.11 (0.9)	0.16 (1.2)	0.22 (0.7)	-0.97 (-2.3) *	0.82 (1.3)	2.26 (4.2) **
HML Devil Intra	0.13 (1.1)	0.19 (1.5)	0.28 (0.9)	-0.41 (-1.0)	1.86 (3.2) **	2.12 (4.2) **

Panel C: U.S. Recent Sample 1980-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
Value Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
HML FF	0.18 (1.4)	0.22 (1.6)	0.09 (0.2)	-0.51 (-1.1)	0.2 (0.3)	1.01 (1.7)
HML Devil	0.08 (0.5)	0.13 (0.8)	0.3 (0.7)	-0.77 (-1.4)	1.07 (1.4)	2.19 (3.1) **
HML Devil Intra	0.04 (0.3)	0.09 (0.7)	0.39 (1.0)	-0.09 (-0.2)	2.08 (3.1) **	1.92 (3.1) **
Value Composite	0.18 (1.6)	0.27 (2.3) *	0.54 (1.6)	0.05 (0.1)	0.85 (1.5)	0.65 (1.2)

EXHIBIT A2: Average sensitivities of other equity factors to interest rate factors

The tables show regression coefficients with t-statistics in parentheses. Asterisks denote relationships significant at the 95% confidence level, without (single) and with (double) Bonferroni adjustment for multiple tests. Regressions are based on monthly data and each includes two RHS variables: the market as a control variable (except where Mkt-RF is the LHS variable), and one interest rate variable. Mkt-RF and SMB are market and size factors from the Ken French data library. UMD and BAB are momentum and low beta factors from the AQR data library.

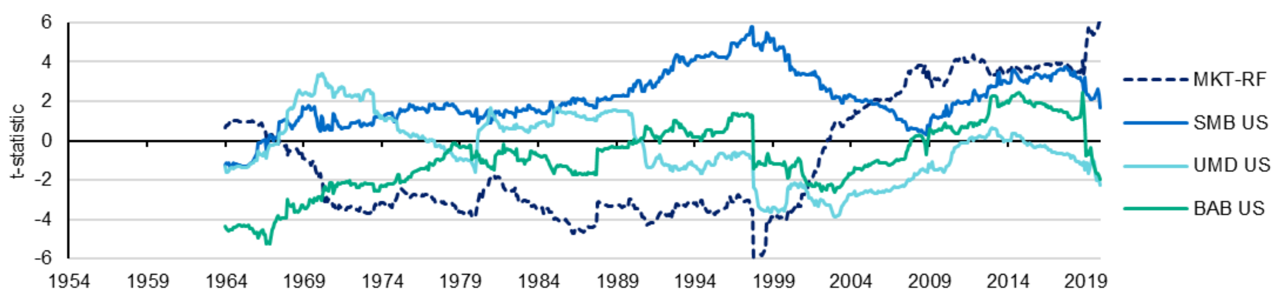
Panel A: U.S. Long Sample 1954-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
Equity Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
Mkt-RF	-0.13 (-2.6) *	-0.1 (-1.8)	0.29 (2.2) *	-0.39 (-1.1)	-1.37 (-2.8) *	-0.38 (-1.0)
SMB	-0.01 (-0.4)	0.00 (0.0)	0.09 (1.1)	0.04 (0.2)	1.4 (4.9) **	0.86 (3.7) **
UMD	0.06 (1.3)	0.07 (1.4)	0.01 (0.0)	0.84 (2.7) *	-1.26 (-2.8) *	-1.96 (-5.5) **
BAB	0.00 (0.1)	0.07 (1.8)	0.38 (4.1) **	-0.27 (-1.1)	-1.16 (-3.3) **	-0.40 (-1.4)

Panel B: U.S. Recent Sample 1980-2019

	Starting Levels of Rates			Contemporaneous Changes in Rates		
Equity Factor	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**	**3-Month Rate**	**10-Year Rate**	**10Y-3M Slope**
Mkt-RF	-0.07 (-1.2)	-0.06 (-1.1)	0.1 (0.6)	0.08 (0.2)	-0.62 (-1.1)	-0.61 (-1.2)
SMB	-0.04 (-1.1)	-0.01 (-0.4)	0.21 (2.1)	0.35 (1.4)	1.61 (5.0) **	0.84 (2.9) *
UMD	0.07 (1.3)	0.09 (1.5)	0.05 (0.3)	0.97 (2.2) *	-1.54 (-2.8) *	-2.54 (-5.2) **
BAB	0.03 (0.6)	0.07 (1.4)	0.32 (2.4) *	0.01 (0.0)	-0.84 (-1.9)	-0.71 (-1.7)

Panel C: Rolling 10-year t-statistic for change in 10Y rate



Panel D: Rolling 10-year t-statistic for change in 10Y-3M slope