Correlations, Value Factor Returns, and Growth Options*

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Abstract

Ex ante (expected) average equity market correlation is linked to the differential correlation dynamics of growth and value firms, as well as the value premium. It predicts returns on the value factor, returns of growth firms, and the changes in growth options within an economy for horizons up to one year. A production-based asset-pricing model supports the existence of a homogeneous correlation among stocks with similar growth characteristics, increasing in the value of growth options, and depending on the prevailing idiosyncratic firm variance. As a result, the model connects average equity correlations to the value premium. Due to its link to growth options and the value premium, implied correlation serves as a leading procyclical state variable. Value Index–based implied correlations improve the predictability of value-related factors.

Keywords: option-implied correlations, production model, value premium, present value of growth options, factor return predictability, option-implied information, trading strategy, diversification, factor risk

JEL: G11, G12, G13, G17

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I. Introduction

It has long been recognized that the average correlation among stocks serves as an important state variable measuring the diversification benefits in the market. It predicts market returns and risks, and is therefore a variable of interest for investors. The correlation among stocks stems from a variety of sources, depending on other variables on the business cycle. The difference in returns between growth and value portfolios, namely, the value premium is known to be strongly associated with economic growth through its tight link to the business cycle.

This paper introduces theoretically motivated empirical evidence that market-wide correlations are related to one of the most fundamental drivers of the economy, namely economic growth. Correlations increase not only in market downturns, as documented in previous research, but also in anticipation of a good state of nature due to an increase in individual growth options and, hence, are related to the business cycle, the equity risk premium, and the value premium. Consequently, growth and value portfolios differ not only in their average return (the value premium) but also in their time-varying correlation dynamics, which can be linked to the business cycle.

The interplay of market-wide correlations and growth opportunities is also connected to market returns and returns on the value factor: Expected correlations and future valuations are positively related. Hence, when firms accumulate growth options, growth stocks comove stronger with each other. Due to the accumulation of growth options, growth stocks will gain in value, reflected in an increase in market returns, and due to their higher valuation compared to value stocks in a negative return on the value factor.

My main results can be summarized as follows: i) The extension of the production-based asset-pricing model by Kogan and Papanikolaou (2014) shows that correlations are increasing in the present value of growth options (PVGO), and, therefore, the average correlation among growth stocks and the average correlation among value stocks display a time-varying pattern, in which the former exceeds the latter most of the time. The difference in correlation is linked to the market cycle and market-wide correlations. The theory is consistent with the explored empirical evidence. ii) In the model, correlation is an increasing function of PVGO, and, therefore, explains future movements of it. Empirically, expected correlations are related to growth and value portfolio characteristics and predict the future changes in the market-wide PVGO positively. iii) The implications from the theoretical model can be utilized to provide an additional explanation of the already established market return predictability results, and to motivate the value return predictability by market-wide correlations. iv) Other Fama and French (2015) value factors are also predicted by expected correlations. Exploiting the more specific information content in implied correlations extracted for the S&P500 Value Index improves the predictability results among value factors and their value and growth components.

To obtain the aforementioned results, I proceed as follows.

First, the application of the structural model by Kogan and Papanikolaou (2014) allows me to work out economic mechanisms to explicitly study the expression for the correlation among stocks as a function of growth characteristics. The model confirms a stronger comovement among growth stocks compared to value stocks. In line with the model, I empirically document that the correlation of growth stocks is on average higher than of value stocks (resulting in a positive "correlation delta").

The expressions for the model-implied idiosyncratic variance (and market variance) allows me to investigate the correlation dynamics in more detail and for different economic regimes. Empirically, the contemporaneous relationship between the correlation delta and market-wide correlations is on average negative, and, therefore, when markets are expanding (low market-wide correlation), the market rally leads to a stronger comovement among growth stocks (compared to value stocks). The high market capitalization among low book-to-market (B/M) stocks (growth stocks) contributes positively to this effect on a market level.

While the prior result was purely investigating the correlation dynamics, the theoretical finding that correlation is a function of the PVGO motivates the relation between expected market-wide correlations and the changes in the economies characteristics, that is, changes in the PVGO. The anticipation of a future increase in individual PVGOs is reflected in an increase in expected correlation extracted from a large index such as the S&P500, estimated from option data.

The main theoretical motivation for this paper is the structural model developed by Kogan and Papanikolaou (2014), in which the effect of investment-specific technology shocks (IST) is related to the value of assets in place (VAP) and the PVGO. As a result, the firms' PVGO can be treated as a systematic component affecting the expected stock return negatively and, therefore, giving rise to the value premium. The model however focuses on the cross-section, and not the prediction of stock returns. Therefore the extension of the model allow me to work out detailed economic mechanisms related to the interplay of correlation, that is, its dynamics, growth, and various risk premia.

The explored link between (firm) characteristics and correlation leads to the question of whether these insights can be applied to explain portfolio returns based on growth and value characteristics. The theoretical model motivates me to analyze the closed-form expressions for the firms expected returns, which are negatively related to the PVGO, giving rise to the value premium. Therefore, if expected market-wide correlations can predict changes in one of the models' state variable (PVGO), it seems natural that the ability to predict the associated value factor returns is inherited.

Empirically, I document the in-sample predictive power of correlations with respect to the value factor. In univariate regressions, expected correlations, extracted from options data, predict future factor returns for horizons of up to one year. The regression coefficient is highly significant and negative (for both the original factor and its market-neutral version), and its predictive power, measured in terms of R^2, is increasing from about 2.6% at the monthly horizon to around 22% on a yearly horizon.

By analyzing the individual long and short legs of the HML factor, both legs are predicted positively, which implies that the predictive power of expected correlations is stronger for returns on growth stocks (L). In order to verify that the return predictability of the value premium is not driven by the market return predictability, I construct a market-neutral version of the HML factor (HML*), where the "pure" value premium is also predicted negatively.

In the last step I emphasize the predictability of returns on growth and value stocks considering only the firms' B/M.[1] Predictive regressions for each decile portfolio sorted on B/M from growth (low B/M) to value (high B/M) show that with increasing decile, the R^2s are decreasing, confirming that the predictive power of expected correlations is concentrated among growth stocks. For the market-neutral B/M sorted portfolios, the relation is the opposite (predictive power is increasing in B/M), which indicates that implied correlations also measure the presence of "pure" value in the economy.

Overall, the empirical results are robust to various specifications including the usage of realized correlations over longer time horizons, non-overlapping sampling, the sample split according to the NBER recession indicator, and controlling for other known predictor variables. It is worth mentioning that implied correlation outperforms realized correlation in terms of R^2s, confirming the information advantage of an option-implied variable over its realized equivalent.

The gathered empirical evidence connecting market-wide correlations to the various dynamics of growth and value portfolios, and its associated risks, indicates that (expected) correlation serves as a leading procyclical state variable.

Correlation predicts the returns of the value factor (HML) and its components. The prediction of the additional Fama and French (2015) value factors, such as CMA and RMW, and their respective long and short components, is extended, considering the regular S&P500 implied correlation and, implied correlations extracted for the S&P500 Value Index.[2] Interestingly, even though the S&P500 Value Index contains only about half of the stocks as the S&P500 parent index, the predictability results for the value factors are similar (or sometimes even superior), as if considering implied correlations extracted for the whole S&P500. Hence, it seems important

[1] The HML factor also considers the size of the firm.

[2] One can find the S&P500 Value Index under the ticker "SVX" or "IVE" (iShares S&P500 Value ETF).

to compute the correlation of the stocks of interest, instead of considering as many stocks as possible.

II. Literature Review

This work is related to the literature dealing with theoretical models explaining the returns on the value premium and other asset pricing "anomalies." Zhang (2005) shows, due to costly reversibility and the countercyclical price of risk, that value firms are less flexible in cutting capital, causing them to be riskier than growth firms, especially in bad times, when the price of risk is high. According to Garleanu, Kogan, and Panageas (2012), growth firms offer a hedge against "displacement risk," which describes the process of innovation that creates a systematic risk factor, capturing that the young benefit more from innovative activity than the old. Kogan and Papanikolaou (2013) argue that firm characteristics are likely correlated within firms' exposure to the same common risk factor, which is not captured by the market. Kogan and Papanikolaou (2014) investigate the impact of investment-specific technology (IST) shocks, reflecting technological advances embodied in new capital goods, on the cross section of stock returns. They are able to show that firms with similar growth opportunities comove with each other, giving rise to the value factor in stock returns. Berk, Green, and Naik (1999) provide a theoretical model showing that stock returns are related to the market value and to book-to-market, serving as a state variable summarizing the firms' risk. Gomes, Kogan, and Zhang (2003) develop a general equilibrium model that links expected stock returns to firm characteristics, such as size, book value, investment, and productivity.

This paper also adds the role of correlation to the strands of literature dealing with systematic risk and idiosyncratic risk, which are known to be connected to the market risk premium, the value premium, growth options, and the business cycle.

Growth options have different risk characteristics than assets in place, and, therefore, also different exposure to systematic risk, measured by the firms' market beta. In the model of Santos and Veronesi (2004), the equity risk premium is low when the dispersion in systematic risk is high. Within their model they fully characterize conditional betas as a function of fundamentals and the aggregate market premium. Petkova and Zhang (2005) decompose market betas into value and growth betas, and find that H (L) carries a positive (negative) beta premium. They further claim that HML displays a countercyclical pattern of risk and that value (growth) betas tend to covary positively (negatively) with the future market risk premium. Closely related to the market beta dispersion is the cross-sectional return dispersion (RD). In Stivers and Sun (2010) and Angelidis, Sakkas, and Tessaromatis (2015), the authors find, that RD is positively related to the subsequent value premium and negatively related to the aggregated equity premium. Therefore, RD serves as a leading countercyclical state variable, hence a quantity that tends to increase when the overall economy is slowing down. Both papers confirm a countercyclical variation in the value premium.

Campbell, Lettau, Malkiel, and Xu (2001) and Irvine and Pontiff (2009) show empirically an increase in firm-level volatility relative to the market volatility accompanied by a lower average correlation. The latter paper claims that increased competition between firms induces a lower correlation between firms' performance and cash flows, and, therefore, more idiosyncratic risk. Guo and Savickas (2008) argue that changes in average idiosyncratic volatility provides a proxy for changes in the investment opportunity set, which is closely related to the book-to-market factor. An investigation of idiosyncratic market-wide risk and the connection to growth options can be found in Cao, Simin, and Zhao (2008), in which the authors establish a positive relation between the two variables.

Since this paper is also about predictability, I contribute to a strand of literature that uses several macro- and market-based variables to predict returns. Gulen, Xing, and Zhang (2010) study the time-variations of the value premium using a two-state Markov switching frame with time-varying transition probabilities. They connect the sensitivity of expected excess returns of value stocks to high-volatility states, while the expected excess returns of growth stocks are less sensitive to worsening aggregate economic conditions. Asness, Friedman, and Liew (2000) predict annual value strategy returns formed by incorporating and composing three accounting ratios, such as earnings, book value, and sales, via their corresponding spreads. Bollerslev, Todorov, and Xu (2015) predict the value premium insample via their left risk-neutral jump tail variation measure, in which the maximal R^2 is obtained around a four month predictive horizon.

This paper exploits the information content of market-wide equity correlations, which can be extracted backward-looking from historical returns (realized correlations, RC), or forward-looking via option data (implied correlations, IC). In Pollet and Wilson (2010), long-term market return predictability, that is, quarterly stock market excess returns, are predicted by RC. Several studies within the field of option-implied information deal with IC, which quantify the expected diversification benefits, while the correlation risk premium (CRP) quantifies the compensation required by agents for being exposed to the risk of losing diversification benefits. Driessen, Maenhout, and Vilkov (2005) and Driessen, Maenhout, and Vilkov (2009) demonstrate that IC predicts market returns for horizons up to 12 months.In Buss, Schoenleber, and Vilkov (2018), the authors decompose IC in its option-implied parts (market variance, cross-sectional dispersion of market betas, average idiosyncratic variance) and analyze the different information content and predictability horizons of these in the scope of market and risk predictability. A good overview about the option-implied predictive literature can be found in Christoffersen, Jacobs, and Chang (2011). To my knowledge, all of these studies explore the relation of market-wide correlations and the return predictability of stock returns on an aggregate market level (S&P500, S&P100, or the DJ30) and not on factors related to growth, value, or the value premium.

The link between correlation and other variables, as summarized in the literature review, are depicted in Figure 1. An overview of the predictive (Panel A) and contemporaneous (Panel B) interplay between (implied) correlations, systematic and idiosyncratic risk, market- and factor returns (and their respective long and short legs), the value premium, and the $PVGO$ is displayed. In both figures the blue-dashed dotted (red-dashed) line indicates a positive (negative) connection between two edges.

The rest of this paper is organized as follows: Section III states and derives the production model. Section IV shows how to construct the various correlation measures from the (options) data. Section V empirically tests the models main implications. Section VI connects implied correlation to risk measures known to be associated with growth options and the value premium. In Section VII, the value predictability is extended to other factors and other implied correlation measures. Section VIII provides robustness tests. Section IX concludes.

III. The Model

The production model by Kogan and Papanikolaou (2014) explains the effect of investment-specific technology shocks (IST) on the cross-sectional differences in risk premia, that is, to the firms value of assets in place (VAP) and the value of growth opportunities ($PVGO$). Their major theoretical insight is that the stock returns of growth firms, which benefit the most from positive IST shocks, have higher exposure to IST shocks. In the model, realized returns will have a two-factor structure, and as a result the conditional CAPM fails to price the cross section of stock returns.

While taking the general setting such as the quantity and the form of the state variables as given, in this presented extension, new interesting elements of the model that are in line with the data are studied. The explicit expression of the correlation between two stocks is connected to $PVGO$ and differentiated from the index variance through the model-implied idiosyncratic variance. The model implications further support the empirical results associated with the interplay between market returns, the value premium, and market-wide correlations, presented later in the paper.

Within the next sections the main equations of the model are stated and derived; for details, see the original paper or the Appendix I.E.

A. Assets in Place

Each firm f owns a finite number of individual projects J_t^f, which they create over time through investment. The output of an individual project j equals

$$y_{fjt} = \varepsilon_{ft} u_{jt} x_t K_j^{\alpha} \tag{1}$$

thereby K_j denotes the chosen project physical capital, u_{jt} is a project-specific component of productivity, ε_{ft} is the firm-specific component of productivity (skills), and x_t is a productivity shock affecting the output of the whole economy.

The three state variables capturing firm-specific, project-specific, and economy-wide specific shocks and evolve according to

$$d\varepsilon_{ft} = -\theta_{\varepsilon}(\varepsilon_{ft} - 1)dt + \sigma_{\varepsilon}\sqrt{\varepsilon_{ft}}dB_{ft}, \tag{2}$$

$$du_{jt} = -\theta_u(u_{jt} - 1)dt + \sigma_u\sqrt{u_{ft}}dB_{jt}, \tag{3}$$

$$dx_t = \mu_x x_t dt + \sigma_x x_t dB_{xt}, \tag{4}$$

where ε_f and u_j are CIR processes and x follows a Geometric Brownian motion (generating long-run growth). The Brownian motions dB_{ft}, dB_{jt}, and dB_{xt} are pairwise independent.

B. Investment

Firms acquire new projects according to a Poisson process with firm-specific arrival rate

$$\lambda_{ft} = \lambda_f \tilde{\lambda}_{ft}. \tag{5}$$

Thereby $\tilde{\lambda}_{ft}$ follows a two-state Markov process. The two states are either that a firm is high growth λ_H or low growth λ_L. It is assumed that u_{jt} is at its long-run mean of 1 at the time of investment.

If a firm decides to invest in a project at time t, it chooses the amount of capital K_j and pays the investment costs $z_t^{-1} x_t K_j$, where z_t denotes the cost of capital and follows a Geometric Brownian motion,

$$dz_t = \mu_z z_t dt + \sigma_z z_t dB_{zt}, \tag{6}$$

unrelated to its current level of average productivity x_t.

C. Valuation

The stochastic discount factor prices the risk associated with x and z

$$\frac{d\pi_t}{\pi_t} = -rdt - \gamma_x dB_{xt} - \gamma_z dB_{zt}. \tag{7}$$

Firms' investment decisions are affected by the trade-off between the market value of a new project and the cost of physical capital associated with it. Hence, the firms' market value of an existing project j at time t is equal to the present value of its cash flows,

$$p(\varepsilon_{ft}, u_{jt}, x_t, K_j) = \mathrm{E}_t[\int_t^\infty e^{-\delta(s-t)} \frac{\pi_s}{\pi_t} y_{fjs} ds]. \tag{8}$$

The firm chose K^* such that it maximizes the NPV, which is the difference between the present value of its cash flows $p(\varepsilon_{ft}, u_{jt}, x_t, K_j)$ and the associated costs of capital $z_t^{-1} x_t K_j$.

The value of the firm at time t can be composed as the market value of its existing project (VAP) and the present value of its growth options ($PVGO$). Thereby the present value of cash flows generated by existing projects can, therefore, be written as (see A9)

$$VAP_{ft} = \sum_{j \in J_t^f} p(\varepsilon_{ft}, u_{jt}, x_t, K_j) = x_t \sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^\alpha =: x_t \sum_j A_{ft}, \tag{9}$$

while the value of growth opportunities for firm f is given by the expected discounted NPV of future investments (see A16),

$$PVGO_{ft} = z_t^{\frac{\alpha}{1-\alpha}} x_t G(\varepsilon_{ft}, \lambda_{ft}) =: z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}, \tag{10}$$

where G_{ft} is restated in the appendix of Kogan and Papanikolaou (2014) or in Appendix I.E. Bringing together equation (9) and equation (10), the value of the firm equals

$$V_{ft} = VAP_{ft} + PVGO_{ft} = x_t \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}. \tag{11}$$

D. Risk and Risk Premia

The expected excess return of firm f is (see A30)

$$\frac{1}{dt}E[R_{ft}] - r_f = \gamma_x \sigma_x + \frac{\alpha}{1-\alpha}\gamma_z \sigma_z \frac{PVGO_{ft}}{V_{ft}}. \tag{12}$$

In Kogan and Papanikolaou (2014) the authors argue that the price of risk for disembodied technology shocks γ_x is positive, while the price of risk for IST shock γ_z is negative.[3] This serves as a explanation for the outperformance of value stocks compared to growth stocks and introduces an additional systematic factor in the firms' return structure. Since market-to-book ratios are positively (negatively) correlated with the share of growth opportunities to firm value ($PVGO/V$), growth (value) stocks are more strongly linked to the correction in returns and, hence, display a stronger comovement among themselves.

E. Firm Return Dynamics

The dynamics of value of assets in place (VAP) and the present value of growth options ($PVGO$) can be expressed as

$$dVAP_{ft} = dx_t \sum_j A_{ft} + x_t d \sum_j A_{ft}, \tag{13}$$

$$dPVGO_{ft} = (z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + x_t R(z_t) dt) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}. \tag{14}$$

Therefore, the firms' price follows (see A31):

$$dV_{ft} = dVAP_{ft} + dPVGO_{ft} \tag{15}$$

$$= \bar{R}(z_t)dt + \sigma_x dB_{xt} V_{ft} + \frac{\alpha}{1-\alpha} PVGO_{ft} \sigma_z dB_{zt} + dIdio_f. \tag{16}$$

Hence, the return dynamic of the firm can be written as (see A33)

$$dR_{ft} = \frac{dV_{ft}}{V_{ft}} = \mathrm{E}[R_{ft}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha}\frac{PVGO_{ft}}{V_{ft}}\sigma_z dB_{zt} + \frac{dIdio_f}{V_{ft}}, \tag{17}$$

[3] Empirically, the authors use the relative stock returns of the investment and consumption good producers to create a factor-mimicking portfolio for the IST shock. The IMC portfolio is long the investment sector and short the consumption sector. Sorting firms on their IST betas results in a declining profile of average stock returns and an increasing profile of market betas. Hence, IST shocks carry a negative risk premium. Papanikolaou (2011) provides a theoretical explanation for the negative price of risk of IST.

where $dIdio_f$ denotes the dynamics associated to A_{ft} (as a function of ε_{ft}, u_{jt}, K_j^α) and G_{ft} (as a function of ε_{ft}, λ_{ft}). Since idiosyncratic terms are uncorrelated, one can calculate the covariance between two returns as (see A34)

$$dR_{kt}dR_{lt} = \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 \frac{PVGO_{kt}}{V_{kt}} \frac{PVGO_{lt}}{V_{lt}} dt, \tag{18}$$

and, hence, the covariance is increasing in the $PVGO$, depending on α and the volatility of the cost of capital process σ_z. In order to calculate the correlation, one normalizes the covariance by the standard deviations of the respective processes,

$$\sigma^2(dR_{ft}) = dR_{ft}dR_{ft} = \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{ft}}{V_{ft}})^2 dt + (\frac{dIdio_f}{V_{ft}})^2. \tag{19}$$

Therefore, the correlation can be calculates as

$$\begin{aligned} Corr(dR_{kt}, dR_{lt}) &= \frac{dR_{kt}dR_{lt}}{\sqrt{\sigma^2(dR_{kt})}\sqrt{\sigma^2(dR_{lt})}} \\ &= \frac{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 \frac{PVGO_{kt}}{V_{kt}} \frac{PVGO_{lt}}{V_{lt}} dt}{\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{kt}}{V_{kt}})^2 dt + (\frac{dIdio_k}{V_{kt}})^2}\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{lt}}{V_{lt}})^2 dt + (\frac{dIdio_l}{V_{lt}})^2}}. \end{aligned} \tag{20}$$

Figure 9 provides a plot for the correlation between two stocks for different idiosyncratic levels, confirming the positive relationship between average correlation and the individual $PVGOs$ of the firms. The average correlation among two stocks is lower if the idiosyncratic component of the individual firms is higher and vice versa.

F. Market Return Dynamics

In order to obtain some expressions for the aggregate (expected) market return, the results for the individual firms are exploited. Value-weighting equation (12) across its constituents results in the expected market excess return and is given by (see A37)

$$\frac{1}{dt} E[R_{Mt}] - r_f = \gamma_x \sigma_x + \frac{\alpha}{1-\alpha} \gamma_z \sigma_z \frac{PVGO_{Mt}}{V_{Mt}}, \tag{21}$$

where $\frac{PVGO_{Mt}}{V_{Mt}}$ denotes the market-cap-weighted averaged individual firm ratios $\frac{PVGO_{ft}}{V_{ft}}$.[4]

With the principle of diversification, the market variance can be written similarly to equation (18) as (see A38)

$$\sigma^2(dR_{Mt}) = \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{Mt}}{V_{Mt}})^2 dt, \tag{22}$$

indicating that the market variance is an increasing function of $PVGO_M$. Figure 10 a provides a plot for the market volatility as a function of the market-wide average of the present value of growth options ($PVGO_M$).

The main difference between the market variance equation (22) and the correlation among stocks (equation (20)) is captured in the idiosyncratic dynamics of the firm (see A32):

$$dIdio_f = x_t d \sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^\alpha + z_t^{\frac{\alpha}{1-\alpha}} x_t dG(\varepsilon_{ft}, \lambda_{ft}). \tag{23}$$

In order to better understand the idiosyncratic component of the firm, both parts of $dIdio_f$ are analyzed next.

Since $d\sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^\alpha = \sum_{j \in J_t^f} dA(\varepsilon_{ft}, u_{jt}) K_j^\alpha$, the object of interest is the change in $A(\varepsilon_{ft}, u_{jt})$, which is a function of the firm-specific component ε_{ft}, and the project-specific component u_{jt} and is, therefore, directly associated with the value of assets in place (see A9). As follows from equation (13), the change in VAP can be decomposed into the change of the economic-wide growth variable x_t and the change of the project-specific components $dA(\varepsilon_{ft}, u_{jt})$. As inferable from A17, $G(\varepsilon_{ft}, \lambda_{ft})$ is a function of the returns to scale at the project level α, the firm-specific component ε_{ft} (such as managerial skill, i.e., a "success rate" of the project), and the individual firms' arrival rate of the project λ_{ft}. $G(\varepsilon_{ft}, \lambda_{ft})$, therefore, combines the success of the project with the average project arrival rate of the firm. Overall, a high level of idiosyncratic variance corresponds to positive changes in the project-specific components, a high success of the project, and a high project arrival rate. Such economic environments are typically characterized by an economic expansion.

[4]It is assumed that γ_x, σ_x, α and γ_z are equal for each firm.

In order to distinguish the variables of interest, namely the market variance, the correlation among stocks, and idiosyncratic components, their dynamics are further investigated in a comparative statics setting.

The market volatility is monotonically increasing in the market-wide level of $PVGO_M$ (Figure 10). Correlation dynamics are richer and can be interpreted as the division of the market variance by the idiosyncratic variance. In Figure 9 the correlation (equation 20) is depicted as a function of the firms' $PVGO$s and for different idiosyncratic levels (Panel A – Panel D). Comparing the different plots for the correlation between two stocks, it appears that for a low idiosyncratic level (Panel A), the correlation is on average higher whenever the stocks' $PVGO$s are similar (hence, for $PVGO$s, close to 1 or close to 0). The level of correlation among growth (value) stocks is 0.85 (0.75), while the lowest correlation attainable is about 0.55 (if two firms are maximally heterogeneous in their $PVGO$ characteristics). For a high idiosyncratic level (Panel D), the correlation is lower and determined by the absolute level of the $PVGO$s rather than the homogeneity among them. Overall, a higher idiosyncratic variance leads to a lower absolute correlation but with the correlation concentrated among the growth stocks. The level of correlation among growth (value) stocks is 0.26 (0.15), while the lowest correlation attainable is about 0.15. In relative terms, the difference in correlation among growth and value stocks is higher (lower) in a low (high) correlation environment (high (low) idiosyncratic variance).

To conclude this section the main predictions of the model, which will later be tested empirically, are restated: i) An average market-wide increase in $PVGO_M$ reduces the expected market returns (equation 21), and, therefore, variables contemporaneously linked to $PVGO_M$ should predict market returns and the value premium. ii) The correlation among growth stocks exceeds the correlation among value stocks. iii) The difference in correlation is linked to the market-wide correlations. iv) Correlation is a function of $PVGO$ and, therefore, expected correlation should predict future movements in $PVGO$.

Before the empirical testing of the model implications is conducted, availability, preparation, and the construction of the variables is explained in the next section.

IV. Data and Preparation of Variables

Expected correlations are estimated by comparing the variance of the index with the variance of the portfolio of its components. The composition of all the indices is obtained from Compustat, while the data on returns and market capitalization are received from CRSP.[5] As a proxy for index weights on each day, the relative market cap of each stock in an index from the previous day is considered.

Computing the option-based variables relies on the Surface File from OptionMetrics, selecting for each underlying options with 30, 91, 182, 273 and 365 days to maturity and (absolute) delta lower or equal to 0.5. The surface proved to be a valuable source of information that can be used in generating asset-pricing tests (e.g., DeMiguel, Plyakha, Uppal, and Vilkov (2013) and Driessen, Maenhout, and Vilkov (2005), among others).[6]

Option-implied second moments are computed as simple variance swaps following Martin (2013). The options for the S&P500 are available from January 1996 through December 2017 while for the S&P500 Value Index the availability starts in August 2006.[7]

Option-implied equicorrelations are estimated, following Driessen, Maenhout, and Vilkov (2005), from the restriction that the variance of the index I has to be equal to the variance of the portfolio of its constituents (which holds under both—objective and risk-neutral—measures). Given the variances of the index $\sigma_I^2(t)$, its components $\sigma_i^2(t), i = 1 \dots N$, and the index weights $w_i(t)$, the equicorrelation $\rho_{ij}(t) = \rho\,(t)$ is calculated as

$$\rho\,(t) = \frac{\sigma_I^2\,(t) - \sum\limits_{i=1}^{N} w_i(t)^2 \sigma_i^2\,(t)}{\sum\limits_{i=1}^{N} \sum_{j \neq i} w_i(t) w_j(t) \sigma_i\,(t) \sigma_j\,(t)}. \tag{24}$$

[5] Merging CRSP with Compustat is done via the CCM Linking Table using GVKEY and IID to link to PERMNO, following the second-best method from Dobelman, Kang, and Park (2014).

[6] Matching the historical data with options happens through the historical CUSIP link provided by OptionMetrics. PERMNO is used as the main identifier in the merged database.

[7] The traded continuum of index options on the SVX, i.e., the S&P500 Value Index, is sometimes limited, and the change in the associated implied index variance can be quite large. To overcome the fluctuation, the simple variance swaps are averaged over a rolling window of 5 trading days.

When using risk-neutral implied (realized) variances and volatilities in equation (24), one calculates implied (realized) correlations — IC (RC). In Table I the summary statistics for realized and implied correlations are presented. The time series are displayed in Figure 2 Panels A and C.

A number of realized portfolio risk measures computed for each time t over a particular future horizon of 30, 91, 182, 273, and 365 days are prepared: The cross-sectional dispersion of market betas ($\sigma^2(\beta_M)$) for the available CRSP universe, quantifying portfolio risks — calculated as the cross-sectional variance of the market betas (which are obtained for each stock in the sample over the required future period from a six-factor model[8]).[9] The residuals from the just outlined regressions are considered for the calculation of the sum of squared residuals (SSR) at each point in time.[10] Value and growth betas are calculated as in Petkova and Zhang (2005), where value and growth portfolio excess returns ($H - r_f$ and $L - r_f$) are regressed on the market excess return ($MKTRF$). The return dispersion (RD) is obtained following Stivers and Sun (2010), by simply calculating the daily cross-sectional standard deviation of 100 size and book-to-market sorted portfolios returns.

To analyze the correlation dynamics, CRSP stocks are getting classified into growth and value by considering their book-to-market value.[11] Knowing which stock belongs into which decile allows calculating the average correlation within the portfolio, whenever the portfolio was formed.

The US Business Cycle Expansion and Contraction indicator is provided by NBER. The reference dates and business cycle lengths are stated in Appendix I.D.

The return data for the factors and the portfolios are available over the whole sample period and are available in daily and monthly frequency on Kenneth French's website.[12] The market-

[8]Considering $MKTRF$, SMB, HML, MOM, RMW, and CMA.

[9]For the stock to be included in the beta computation for a given period t to $t + \Delta t$, it must have more than 30% of valid returns available.

[10]The SSR are either averaged equally; ($EWIV$) or market-cap-weighted ($VWIV$) across firms.

[11]A helpful Python code replicating HML and the B/M sorted decile portfolios can be found on WRDS.

[12]A more detailed definition and construction of the individual factors can be found in Fama and French (1993) for $MKTRF$, SMB, and HML, in Jegadeesh and Titman (1993) and Carhart (1997) for MOM, and for RMW and CMA in Fama and French (2015). A high-level value factor overview is provided in Appendix I.A.

neutral versions of the Fama and French factors are obtained by regressing, for each point in time, the considered value factor on a constant and the market return over a window of 21 business days, as follows

$$HML_{t-21\to t} = \alpha + \beta_{MKTRF} MKTRF_{t-21\to t} + \varepsilon_t. \tag{25}$$

$\varepsilon_t + \alpha$ are then considered the market-neutral return of the factor at the given date.

The present value of growth options is defined as the present value of dividends from all firms' projects to be adopted in the future and can be calculated as the difference between the aggregate market value and the value of assets in place.

As a first approach measuring the average value of growth options in the economy the market-to-book characteristics for the 10 Fama and French book-to-market sorted portfolios are considered. The data are available on a yearly frequency on Kenneth French's website and covers the period from 1965 to 2017.

To obtain data on a higher frequency and different from Fama and French's book-to-market, several variables associated with the present value of growth options are constructed, as in Cao, Simin, and Zhao (2008): The Market Value to Book Value ratio (M/B) proxies for corporate growth options due the incorporation of the market value of assets (only the book value does not). Tobin's Q is the ratio between the physical asset market value and its replacement value. The Debt to Equity ratio (DTE) represents growth options, since firms with significant growth opportunities may have lower financial leverage (lower DTE). From the perspective of trade-off theory, growth firms should use less debt because growth opportunities are intangible assets which cannot be used as collateral in the event of bankruptcy. $CAPEX$ acts as a proxy for growth options since capital expenditures lead to new investment opportunities. In the empirical tests, I follow insights from Cao, Simin, and Zhao (2008) and Long, Wald, and Jingfeng (2002) to obtain the value-weighted averages for M/B, Q, DTE, and $CAPEX$. Details on the calculation can be found in Appendix I.C. The summary statistics for the value of growth options proxies are displayed in Panel A of Table II.

V. Testing Model Predictions

In this section the theoretical insights provided in Section III are now investigated in an empirical setting. Throughout this section, the focus will lie on correlation, and the summary state variable of the model, which is the present value of growth options. The new theoretical insights are getting first connected to known empirically documented results, such as the return predictability by idiosyncratic variances or market-wide correlations. In a next step, new empirical observations, which are in line with the theory, are investigated and documented, the difference in correlation among growth stocks and among value stocks, and the predictive interplay of market-wide correlations and $PVGO$ can be seen as the major insights in this analysis.

The discussion starts with two empirical results that have been documented in the past in the scope of market return prediction that support the theory that an average market-wide increase in $PVGO_{Mt}$ reduces the expected market return, that is, are in line with equation (21)

$$\frac{1}{dt}E[R_{Mt}] - r_f = \gamma_x \sigma_x + \frac{\alpha}{1-\alpha}\gamma_z \sigma_z \frac{PVGO_{Mt}}{V_{Mt}},$$

where $\gamma_x(\gamma_z)$ is positive (negative).

First, the interplay of idiosyncratic variance, $PVGO_M$, and future market returns is in line with the new theoretical insights, that is, equation (21). As reported by Cao, Simin, and Zhao (2008), aggregate idiosyncratic volatility is (contemporaneously) positively related to $PVGO_M$. Guo and Savickas (2008) argue that the value-weighted idiosyncratic volatility measure is negatively related to the future equity premium (controlling for the market volatility).

Second, it is shown that market-wide correlations (realized or implied) predict market returns positively for horizons up to 1 year see Pollet and Wilson (2010), Driessen, Maenhout, and Vilkov (2005), and Buss, Schoenleber, and Vilkov (2018). A potential explanation is given by equation (21). The contemporaneous correlation between IC (RC) and the proxies for the absolute level of growth options are displayed in Table II. In Panel B the interplay is presented and behaves as expected: A high market correlation is associated with a low absolute level of growth options in the economy, and therefore the sign is negative (positive) for growth option proxies positively (negatively) related to growth options (M/B, Q, and $CAPEX$ vs. DTE).[13] The results are robust (but weaker) considering the differences in the growth options proxies and (expected) correlations see Panel C. In line with the equation for expected market returns, a low implied correlation corresponds to a high level in $PVGO_M$ (contemporaneously), and, therefore, to a reduction of the future market return.

Overall, the previously outlined connections motivate from a theoretical point of view the empirical finding that correlation (idiosyncratic volatility) positively (negatively) predicts future market returns.

An additional way of connecting correlations to $PVGO$ is obtained when investigating the different value characteristics among growth and value stocks. As a first approach connecting market-wide correlations and the value of growth options, the contemporaneous time series correlation for the yearly implied correlations (with 365 days maturity) and the (yearly) market-to-book value of the 10 decile portfolios is calculated. The time series correlation in Figure 5 displays a clear increasing monotonic pattern with the lowest (highest) value for the lowest (highest) book-to-market sorted portfolio (-0.5 vs. 0.2). Hence, the characteristics of low B/M portfolios (growth firms), are comoving negatively with an increase in implied correlations, while the opposite is true, but less pronounced, for high B/M portfolios (value firms). As shown in the later return predictability, (expected) correlation predicts the return on growth stocks (rather than the return on value stocks).

Not only existing theories fit to the explored theoretical insights, also new predictions of the theory are in line with new empirics. A major hypothesis testable from the model is that correlation is an increasing function in the $PVGO$ of the stocks (equation (20)), or in other words, that growth stocks comove more strongly among themselves (compared to value stocks).

[13]Even though the contemporaneous relationship is on average negative, on a yearly rolling basis it displays time-varying patterns with high absolute correlations between -0.75 to 0.75.

First, the average correlation among growth and value stocks based on the B/M characteristic starting in 1965 is investigated. For each yearly formation date t (June), all stocks in the corresponding decile are selected and the realized average correlation within the actual holding period from t to $t+1$ is calculated. Figure 3, Panel A, displays the time-varying correlation dynamics of the two portfolios and its difference (called correlation delta). As depicted in the plot, the average correlation delta fluctuates around zero, with a time series average of around 2.5%. In Figure 3, Panel B, the correlation delta and the recession indicator are displayed together. Peaks in the correlation delta are associated with the recession indicator being equal to 1 (recession). Immediately recognizable, the largest correlation delta peak happened during the dot-com tech bubble where especially companies adapting new internet services experienced a huge market turmoil. In the 90s era such companies were the flagship growth stocks per se.

A second hypothesis testable from the model is the negative relationship between the correlation delta and the market-wide correlation. As emphasized in the model section: The relative difference among the correlation of growth stocks and the correlation of value stocks is higher (lower) in a low (high) correlation environment.

In Figure 4 the correlation delta is plotted against market-wide realized (Panel A) and implied correlations (Panel B). For realized (implied) correlations and the correlation delta the time series correlation is on average negative, about -0.14 (-0.44), affirming that if market conditions are temporarily good (low correlations), growth stocks comove more strongly with each other (compared to value stocks). Overall, the empirical evidence confirms that the comovement among growth and value stocks differs, and, depending on the economic conditions, they display different correlation dynamics over time. As visible in Figure 6, the high market capitalization among low book-to-market stocks (growth stocks) contributes positively to this effect on a market level.

Investigating the correlation dynamics of the model (equation 20), the hypothesis can be formed that market-wide correlation (as a function of $PVGO$) can predict future changes in the proxies for the absolute level of the present value of growth options.

The main results for the insample predictability of changes in the aggregate present value of growth options can be inferred from Table III, where the the following predictive regressions is performed

$$\Delta_{log} PVGO_{t \to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{26}$$

where $PVGO$ equals M/B, Q, DTE, or $CAPEX$ in the respective regressions. As displayed in Table III, M/B, Q, and $CAPEX$ are positively related to IC with highly significant coefficients for all horizons (30–365 days) and with increasing R^2s for longer predictive horizons, while future changes in DTE are, as expected, negatively related to implied correlations.[14] For the market variance, the idiosyncratic risk, and other variables is controlled in the Robustness Section VIII.

Equation (12) relates the outperformance of value stocks (over growth stocks) to the present value of growth options. Since proxies for the future present value of growth options are predicted by market-wide correlations, it is expected that the predictive power of correlation is inherited when predicting future returns on B/M sorted portfolios or the value premium. Before getting to the main empirical results, some summary statistics will be provided.

The annualized portfolio statistics (returns, standard deviations, and Sharpe ratios) for the horizon from 1965 to 2018 of the factors are presented in Table V, Panel A. Panel B, displays the correlation of the value factors from 1965 to 2018 sampled on a monthly frequency. The value factor is negatively correlated with the market (-0.26), in contrast, the corresponding legs of the factor are highly positively correlated with the market (0.89 for H and 0.95 for L). For the market-neutral value factor HML^* the correlation with the market displays lower values (per construction). In Panel C, the correlation between the market (value factors), and the B/M sorted decile portfolios is displayed, which is higher (lower) for low B/M portfolios.

The return predictability will be performed on HML, and HML^*, and its legs (H, L). In order to illustrate the relation of market-wide correlations and value factor returns, the

[14] As pointed out by Cao, Simin, and Zhao (2008), M/B, Q, and $CAPEX$ are positively related to the absolute average level of growth options, while DTE is negatively related.

following specification is performed:

$$r^F_{t\to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{27}$$

where $r^F_{t\to t+\tau_r}$ denotes the factor return for a period from t to τ_r. Standard errors are corrected to account for autocorrelation introduced by overlapping return observations, see Newey and West (1987). For non-overlapping observations is controlled in the Robustness Section VIII.

The results for the insample return predictability are presented Table VI Panel A. Expected correlation predicts the value premium with a negative and significant coefficient for all maturities, with increasing R^2s ranging from over 2% to almost 23% for a yearly return predictability. The performance of IC predicting the value premium is displayed in Figure 7, Panel A.

To better understand the source of prediction, the predictability of the long and short legs of the value factor returns are analyzed next. In Table VI Panel B the results for the insample predictability of the individual legs of the considered value strategy by IC is presented. It turns out that market-wide correlation does not predict value stocks (H) but rather the returns of growth stocks (L) with positive regression coefficient and, therefore, its difference HML (and HML^*) with a negative coefficient. The performance of IC predicting the different factors is displayed in Figure 7, Panel B.

To further investigate whether IC predicts the return on growth or value firms, predictive regressions on the ten B/M sorted Fama and French decile portfolios are performed. The results are presented in Table VII and visualized in Figure 8, Panel A, and Panel B. The significance and R^2s of the univariate regression coefficients shows a monotonic pattern: Starting with high significance for B/M, the statistics are decreasing considering portfolio deciles containing more and more value stocks, and by no later than the fourth decile all significance is gone.

Overall, the return predictability draws a clear picture: Correlation negatively predicts future value factor returns. When considering HML, the predictiveness is primarily through the positive prediction of the short leg (L), which is characterized through a higher amount of growth stocks.

VI. Risk Predictability

There are two main strands of literature connecting systematic and idiosyncratic risk to the market risk premium, the value premium, growth options, and to the business cycle. In this section the empirical link between the various risk measures and correlations is investigated, and placed in the wider context (see Figure 1).

In order to explore the existing risk channel predictive regressions for various risk measures on implied correlations are performed,

$$Risk_{t \to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{28}$$

where $Risk_{t \to t+\tau_r}$ denotes the realized risk measure for a period from t to τ_r. The set of risk measures consist on an overall market risk level, of the dispersion of market betas $\sigma^2(\beta_M)$, value and growth betas (β_H, β_L), the cross-sectional return dispersion (RD), and the average idiosyncratic risk proxied by the equally and value-weighted sum of squared residuals ($EWIV$ and $VWIV$) estimated via a Fama and French six-factor model.

The results for the dispersion of market betas are presented in Table IV and confirm parts of the the results in Buss, Schoenleber, and Vilkov (2018). On an aggregated market level, IC predicts the dispersion of market betas for all horizons with a negative significant coefficient and R^2s ranging from 2% to 25%. An increase in market-wide correlation translates to a concentration of the market betas around their mean, decreasing the diversification possibilities. The results are in line with the findings of Santos and Veronesi (2004), that is, the dispersion of market betas is positively related to growth opportunities, which, in turn, are negatively related to the equity risk premium.

For value and growth betas, the signs are in line with the results by Petkova and Zhang (2005), and market-wide correlations positively (negatively) predict future value (growth) betas, and are, therefore, directionally correctly comoving with the expected market risk premium.

IC loads negatively on the future return dispersion, estimated as the cross-sectional return dispersion (RD) from the 100 book-to-market and size sorted portfolios, again indicating that the market moves intensified in one direction during times of turmoil. As Stivers and Sun (2010) argue: RD increases when the economy is slowing down (leading countercyclical state variable); that is, it is negatively related with the market return and positively related with the value premium. Since IC is negatively related to the future return dispersion and the value premium, and positively related to the future market excess return, IC serves as a leading procyclical state variable.

Market-wide correlations are loading negatively on the future average idiosyncratic risk, proxied by the equal ($EWIV$)–or value ($VWIV$)–weighted SSR (the sum of squared residuals estimated via a six-factor model). In line with the intuition, increasing correlation lowers the prevalent idiosyncratic risk in the market. The R^2s for regressions predicting the value-weighted implied volatility exceeds the R^2s for regressions predicting the equally weighted implied volatility by far. Guo and Savickas (2008) finds that idiosyncratic volatility is negatively related to the future US equity premium (controlling for the market volatility), positively related to the future US value premium, and contemporaneously negative related to the aggregate B/M ratio.[15] IC predicts future idiosyncratic stock market volatility with a negative sign, and is therefore indirectly related to the future US value premium. The

Overall, correlation does not only predict the value factor by itself (as shown in the previous section) but also risk measures, which are known to be associated with the value premium, the market equity premium, and the present value of growth options.

VII. Additional Evidence

In this section I investigate whether implied correlations also predict other Fama and French (2015) value factors. In a next step the predictability is repeated, exploiting the more specific information content for implied correlations extracted for the S&P Value Index.

[15]See Guo and Savickas (2008) Table 5 and Table 7.

A. *Predicting Value Factors with Correlations constructed for the S&P500*

Closely related to the book-to-market concept are factors considering the investment expenses or the individual operating profitability of the company. Such factors deliver an excess return by investing in companies with conservative versus aggressive investments expenses (CMA, Conservative Minus Aggressive) or by investing in companies with higher operating probability (RMW, Robust Minus Weak). The latter two portfolios can theoretically be linked to the book-to-market ratio of the company and, therefore, to the value premium; for a motivation, see Hou, Xue, and Zhang (2015), Fama and French (2006), or the short recap in Appendix I.B.

In the first step of this additional investigation, the predictability and inheritable features of implied correlations, w.r.t, other value strategies are analyzed. The main result can be summarized as follows: i) Option-implied correlations extracted from a large index, such as the S&P500, are able to predict the factor returns related to the value premium for horizons up to one year; ii) The predicting channel is evolving through the short legs of the considered value factors (A and W).

As shown in Table VIII Panel A and visualized in Figure 11 (Panel A and Panel C), CMA (RMW) is predicted negatively with an R^2 of about 20% (32%) for the yearly horizon. While CMA is always on the edge of being significant at the 5% level, RMW displays a strong significance across predictive horizons larger than one month.

When investigating the predictability of the individual legs of the factors, see Table VIII Panel B and Figure 11 (Panel B and Panel D), it turns out that IC positively predicts the short leg, that is, predicting returns on companies with aggressive investment behavior (A) and companies with low operating profitability (W), where the R^2s reach around 16% for the respective legs for a yearly horizon.

Since growth firms (low book-to-market ratio) tend to invest more, the results are in line with the economic theory around the linkage of operating profitability and investment expenditures to growth and value stocks provided by Fama and French (2006) and Zhang (2005).

As discussed in Novy-Marx (2010), the profitability factor always merits some discussion. More profitable firms earn significantly higher average returns than unprofitable firms. They do so despite having, on average, lower book-to-markets and higher market capitalization. Therefore the profitability factor is considered a growth strategy rather than a value strategy. In terms of the author, IC predicts the returns on "bad value" (W) firms.

For each strategy, IC significantly predicts both legs positively. The R^2s for predicting the short legs (W and A) are much higher than their long antagonists (R and C), and as a result, IC loads negatively on their differences, RMW and CMA.

B. Predicting Value with Correlations Constructed for the S&P500 Value Index

In most studies, expected correlations are constructed for large major indices, such as the S&P500, S&P100, and DJ30, or the nine economic sectors of the S&P500; see Driessen, Maenhout, and Vilkov (2005), Buss, Schoenleber, and Vilkov (2016), and Buss, Schoenleber, and Vilkov (2018).

This paper is about value and growth, and, therefore, it seems natural to construct implied correlations for a value or growth index. The S&P500 Value Index (IVE) consists of value stocks, which are selected based on three characteristics: the ratios of book value, earnings, and sales to price. The index is rebalanced quarterly and its constituents are drawn from the S&P500 parent index.[16] Index options are available starting from August 2006.[17]

As shown in Table I Panel C, the mean of the expected correlation for the S&P500 Value Index is on average larger and, in addition, more volatile, as recognizable in Figure 12. The

[16] S&P style Indices divide the complete market capitalization of each parent index into growth and value segments.

[17] Implied correlations for the S&P500 Growth Index are not constructed due to the late availability for the S&P500 Growth Index Option data starting in 2012.

correlation between the regular IC and the IC_{IVE} ranges from 0.48 (for 30 days maturity) to 0.75 (for 365 days maturity).

In the following analysis, the predictive information of two different expected correlations, namely for the S&P500 and the S&P500 Value Index, will be compared in terms of predictability across the three value factors HML, CMA, RMW, including their long and short legs.

As visible in Table IX, when running the insample predictive regressions starting from 2006, the various value premia are predicted with a positive sign. One potential reason, as visible in Figure 4, is that the difference in correlation of growth stocks with the correlation of value stocks comoves positively, with implied correlation starting from around 2007. Additionally, when investigating the individual legs of the value strategies (see Table X), it turns out that the predicitveness of the long legs is on average stronger, and, consequentially, the premium prediction is positive.

Figure 13 displays the insample R^2s for both predictors. Exploiting the expected correlation for the value index increases the coefficient of determination by almost 33% (from 15% to 20%) at a yearly horizon when predicting HML. For CMA, both expected correlations predict similar. For the RMW growth factor, the market-wide IC still outperforms the value IC_{IVE}. The superior information content of expected correlations extracted for the S&P Value Index only inherits partially to the long and short legs of the individual factors. For H and L, Figure 14, it turns out that the regular IC delivers on average slightly better prediction results. For the individual legs of CMA and RMW, IC_{IVE} slightly outperforms the regular IC.

The coefficient of determination is not the only way to ascertain whether there is a differential information content in IC_{IVE} over IC. Another approach would be to first run

$$IC_{IVE} = \alpha + \beta_{IC} IC + \varepsilon_{IC_{IVE}}, \tag{29}$$

and, hence, to decompose IC_{IVE} into its part explained by IC, and the additional information content represented by the residuals $\varepsilon_{IC_{IVE}}$. In the next step, future factor returns ($MKTRF$, HML, CMA, and RMW) are regressed on market-wide correlations (IC) and the residuals

$\varepsilon_{IC_{IVE}}$

$$r^F_{t\to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \beta_{\varepsilon_{IC_{IVE}}} \varepsilon_{IC_{IVE}} + \varepsilon_t, \tag{30}$$

where $r^F_{t\to t+\tau_r}$ denotes the factor return for a period from t to τ_r.

The results of the described regression procedure are presented in Table XI. While the residuals ($Res_{IC_{IVE}} := \varepsilon_{IC_{IVE}}$) are not significant when predicting $MKTRF$, they indeed matter when predicting value factor returns with results similar, as presented in Table IX, indicating that the there is significant additional information content in IC_{IVE} over IC.[18]

VIII. Robustness

To verify the robustness results of the analysis to various specifications, a series of tests are carried out and reported in Appendix AI1.A. In each subsection the robustness tests are roughly divided into the predictability of growth option proxies and factor returns. Overall, the results in the main part of the paper are robust.

A. Non-Overlapping Predictions

Due to the autocorrelation introduced by overlapping changes in growth option proxies and factor returns, the variables of interest are sampled in a non-overlapping fashion. In Figure AI1 the average R^2 for the growth option proxy predictability for each maturity are displayed. The non-overlapping sampling does not harm the R^2 when considering IC as a regress or. The same procedure is applied to the factor returns predictability and displayed in Figure AI2. The monotone increasing R^2's are not caused by overlapping return observations.

[18]Decomposing IC into IC_{IVE} and residuals (ε_{IC}), and then predicting $r^F_{t\to t+\tau_r} = \gamma + \beta_{IC_{IVE}} IC_{IVE}(t, t+\tau_r) + \beta_{\varepsilon_{IC}} \varepsilon_{IC} + \varepsilon_t$ leads to the same qualitative result. The beta coefficient for the residual ($\beta_{\varepsilon_{IC}}$) is not significance.

B. Predictions with Controls

In this subsection the insample predictions from Section V are extended to control for (implied) market volatility (IV) and for a market-wide idiosyncratic risk proxy ($VWIV$), see Table AI101 for growth option predictions and Table AI102 for return predictions.

For both types of predictions, implied volatility does not show much of a significance in the regressions. In line with the intuition, the idiosyncratic risk measure loads negatively on future growth options, and positively on future value factor returns. Significance is rarely given and only at the 10% confidence.

In table AI103 controls for the growth option proxies are incorporated when predicting future factor returns. For longer predictive horizons M/B predicts value factor returns positively. Together with IC, other growth options proxies (Q, DTE, and $CAPEX$) do not contribute significantly in predicting factor returns.

Table AI104 presents the return predictability results when controlling for a larger set of common predictors. Specifically, the Earnings Price Ratio (EP), the Term Spread (TMS), the Default Yield Spread (DFY), the Book-to-Market Ratio (B/M), and the Net Equity Expansion (NTIS) are included in the regressions. These variables are constructed from the data following the procedures from the study of Goyal and Welch (2008).[19] EP is defined as the log ratio of earnings to prices; TMS is the difference between the long-term yield on government bonds and the Treasury bill; DFY is the difference between BAA- and AAA-rated corporate bond yields; BTM is the ratio of book value to market value for the Dow Jones Industrial Average and NTIS is the ratio of 12-month moving sums of net issues by NYSE listed stocks divided by the total end-of-year market capitalization of NYSE stocks.

[19]I am grateful to the authors for providing the data on their website.

C. Full Sample, Expansion and Contraction

The predictive growth options regressions are repeated, that is, equation (26), for realized correlations over the full sample (1983), Table AI105. Realized correlations predict changes in future growth option proxies for a horizon up to a quarter.

In Table AI106, the return predictability is repeated starting from 1965, using realized correlations as a predictor. The signs for the market return and the value premium predictions are consistent with the the usage of expected correlations (Panel A). The value factor returns HML are predicted for horizons up to a quarter while returns on HML^* and growth stocks (L) (Panel B) are predicted for horizons up to one year.

The predictive growth options regressions are repeated over the respective subsample divided by the NBER recession indicator, Table AI107, for realized correlations (starting in 1965) and Table AI108 for implied correlations (starting in 1996). The predictive power of realized correlations is clearly superior in contraction states. For realized measures significance is not ensured even though the coefficients display mostly the correct positive sign. Noticeably the information content of implied correlations stays comparable, regardless of the economic state of the world.

In the same fashion, the return predictability regressions are repeated over the respective subsample divided by the NBER recession indicator, Figure AI3, for realized correlations (starting in 1965) and Figure AI4 for implied correlations (starting in 1996).

The regressions considering realized correlations reveals stronger predictive power in contraction states, especially for the pure value premium HML^*, with R^2s ranging from 2% to 24% and the five predictive horizons. The signs of the coefficients are consistently negative within the two subsamples, even though significance is sometimes missing. As displayed in Table AI4, Panel A and Panel B, within the contraction phases, IC predicts HML, the pure value premium HML^* and growth stocks (L). When considering expansion states, Panel C and Panel D, the results w.r.t IC are similar to the ones without the division into contraction and expansion.

IX. Conclusion

Value strategies follow the approach of buying securities that are undervalued (value stocks) and selling securities that are overvalued (growth stocks), based on its "value" fundamentals, such as a firms book-to-market ratio. As it turns out, not only the return of value and growth firms differ, but also their correlation dynamics. This paper relates, theoretically and empirically, market-wide expected correlation and its dynamics to growth options, growth stocks, and the value premium. An increase in expected correlation happens due to an increase in expectations of economic growth. When firms accumulate growth options, they gain in value simultaneously, thus showing higher correlation. The higher valuation of growth stocks leads to increasing returns on the market and a decreasing value premium.

New insights provided by the production model confirm that correlation is a function of the present value of growth options and that the correlation among growth stocks is on average larger than the correlation among value stocks. The theoretical model also supports existing empirical findings that relate market-wide correlations and idiosyncratic variances, via growth options, to aggregate market returns and the value premium. Theoretically, firm-specific idiosyncratic variance affects correlation and serves as the connector between the market variance and the correlation dynamics.

Empirically validated, correlations are able to predict future changes in growth options with a positive sign, and the comovement among growth stocks is indeed stronger, compared to the comovement among value stocks. Correlation significantly predicts future value factor returns for horizons up to one year with a negative sign. The predictiveness can be attributed to the ability of correlations predicting returns on stocks with low B/M ratios (growth stocks). In addition to the new economic mechanism, the predictability results could potentially be utilized for a value factor timing strategy in a portfolio management context. Correlations extracted for the S&P500 Value Index improve the predictability results and further motivate the use of implied correlations beyond the large major indices.

Overall, the findings are in line with several papers that connect idiosyncratic and systematic risk to growth options, the value premium, market returns, and the business cycle. Taking together the results, it affirms the hypotheses that correlation serves as a leading procyclical state variable.

References

Angelidis, T., A. Sakkas, and N. Tessaromatis, 2015, "Stock market dispersion, the business cycle and expected factor returns," *Journal of Banking & Finance*, 59, 265–279.

Asness, C. S., J. A. Friedman, and J. M. Liew, 2000, "Style Timing: Values versus Growth," *The Journal of Portfolio Management*, 26(3).

Berk, J. B., R. C. Green, and V. Naik, 1999, "Optimal Investment, Growth Options and Security Returns," *The Journal of Finance*, LIV(5), 1553–1606.

Bollerslev, T., V. Todorov, and L. Xu, 2015, "Tail risk premia and return predictability," *Journal of Financial Economics*, 118(1), 113–134.

Buss, A., L. Schoenleber, and G. Vilkov, 2016, "Option-Implied Correlations, Factor Models, and Market Risk," .

——— , 2018, "Expected Correlation and Future Market Returns," Working Paper, FSFM.

Campbell, J. Y., M. Lettau, B. G. Malkiel, and Y. Xu, 2001, "Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk," *The Journal of Finance*, 56(1), 1–43.

Cao, C., T. Simin, and J. Zhao, 2008, "Can Growth Options Explain the Trend in Idiosyncratic Risk?," *Review of Financial Studies*, 21(6).

Carhart, M. M., 1997, "On Persistence in Mutual Fund Performance," *Journal of Finance*, 52(1), 57–82.

Christoffersen, P., K. Jacobs, and B. Y. Chang, 2011, "Forecasting with Option Implied Information," CREATES Research Papers 2011-46, School of Economics and Management, University of Aarhus.

DeMiguel, V., Y. Plyakha, R. Uppal, and G. Vilkov, 2013, "Improving Portfiolio Selection using Option-Implied Volatility and Skewness," *Journal of Financial and Quantitative Analysis*, 48(06), 1813–1845.

Dobelman, J., H. Kang, and S. Park, 2014, "WRDS Index Data Extraction Methodology," Technical Report TR-2014-01, Rice University, Department of Statistics.

Driessen, J., P. Maenhout, and G. Vilkov, 2005, "Option-Implied Correlations and the Price of Correlation Risk," Working paper, INSEAD.

——— , 2009, "The Price of Correlation Risk: Evidence from Equity Options," *Journal of Finance*, 64(3), 1375–1404.

Fama, E. F., and K. R. French, 1993, "Common Risk Factors in the Returns on Stock and Bonds," *Journal of Financial Economics*, 33(1), 3–56.

——— , 2006, "Profitability, investment and average returns," *Journal of Financial Economics*, 82, 491–518.

——— , 2008, "Dissecting Anomalies," *Journal of Finance*, 63(4), 1653–1678.

——— , 2015, "A five-factor asset pricing model," *Journal of Financial Economics*, 116(1), 1–22.

Garleanu, N., L. Kogan, and S. Panageas, 2012, "Displacement risk and asset returns," *Journal of Financial Economics*, 105, 491–510.

Gomes, J., L. Kogan, and L. Zhang, 2003, "Equilibrium Cross Section of Returns," *Journal of Political Economy*, 111(4), 693–732.

Goyal, A., and I. Welch, 2008, "A Comprehensive Look at The Empirical Performance of Equity Premium Prediction," *Review of Financial Studies*, 21(4), 1455–1508.

Gulen, H., Y. Xing, and L. Zhang, 2010, "Value versus Growth: Time-Varying Expected Stock Returns," NATIONAL BUREAU OF ECONOMIC RESEARCH.

Guo, H., and R. Savickas, 2008, "Average idiosyncratic volatility in G7 countries," *Review of Financial Studies*, 21(3), 1259–1296.

Hou, K., C. Xue, and L. Zhang, 2015, "Digesting Anomalies: An Investment Approach," *The Review of Financial Studies*, 28(3), 650–705.

Irvine, P. J., and J. Pontiff, 2009, "Idiosyncratic Return Volatility, Cash Flows, and Product Market Competition," *The Review of Financial Studies*, 22(3).

Jegadeesh, N., and S. Titman, 1993, "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," *Journal of Finance*, 48, 65–91.

Kogan, L., and D. Papanikolaou, 2013, "Firm Chractersitics and Stock Returns: The Role of Investment-Specific Shocks," *The Review of Financial Studies*, (11), 2718–2759.

——— , 2014, "Growth Opportunities, Technology Shocks, and Asset Prices," *The Journal of Finance*, 69(2), 675–718.

Long, M., J. Wald, and Z. Jingfeng, 2002, "A Cross-sectional Analysis of Firm Growth Options," .

Martin, I., 2013, "Simple Variance Swaps," NBER Working Paper 16884.

Newey, W. K., and K. D. West, 1987, "A Simple, Positive-semidefinite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 55(3), 703–708.

Novy-Marx, R., 2010, "The other Side of Value: Good Growth and the Gross Profitability Premium," NBER Working Paper Series.

Papanikolaou, D., 2011, "Investment Shocks and Asset Prices," *Journal of Political Economy*, 119(4), 639–685.

Petkova, R., and L. Zhang, 2005, "Is value riskier than growth?," *Journal of Financial Economics*, 78, 187–202.

Pollet, J. M., and M. Wilson, 2010, "Average correlation and stock market returns," *Journal of Financial Economics*, 96(3), 364–380.

Santos, T., and P. Veronesi, 2004, "Conditional Betas," University of Chicago and NBER.

Stivers, C., and L. Sun, 2010, "Cross-Sectional Return Dispersion and Time Variation in Value and Momentum Premiums," *The Journal of Financial and Quantitative Analysis*, 45(4), 987–1014.

Zhang, L., 2005, "The Value Premium," *The Journal of Finance*, LX(1).

Table I Summary Statistics – Correlation Measures

The table reports the summary statistics (time-series mean, p-value for the mean, median, standard deviation, the 10% and 90% percentile) for realized and implied correlations, which are calculated as equicorrelations applying Eq.(24) for the S&P500 Index and for the S&P500 Value Index, for five different maturities of 30, 91, 182, 273, and 365 calendar days. The sample period for realized correlations is ranging from 01/1965 to 12/2017, for implied correlations extracted for the S&P500 from 01/1996 to 12/2017, and for implied correlations for the S&P500 Value Index (IVE) from 08/2006 to 12/2017. Second moments are calculated for the index and for all index components from daily realized returns over a respective window for realized variances and as model-free implied variances following Martin (2013) and are sampled on a daily frequency.

Panel A: Summary Statistics – RC – from 1965

	$RC30$	$RC91$	$RC182$	$RC273$	$RC365$
Mean	0.276	0.276	0.278	0.280	0.282
p-val	0.000	0.000	0.000	0.000	0.000
Std	0.133	0.117	0.111	0.109	0.107
Per 10	0.122	0.140	0.150	0.153	0.156
Median	0.256	0.267	0.268	0.271	0.267
Per 90	0.456	0.419	0.409	0.407	0.411

Panel B: Summary Statistics – IC – from 1996

	$IC30$	$IC91$	$IC182$	$IC273$	$IC365$
Mean	0.378	0.417	0.444	0.453	0.459
p-val	0.000	0.000	0.000	0.000	0.000
Std	0.129	0.114	0.105	0.102	0.097
Per 10	0.219	0.267	0.317	0.339	0.350
Median	0.367	0.416	0.450	0.460	0.462
Per 90	0.551	0.563	0.570	0.576	0.578

Panel C: Summary Statistics – IC for the S&P Value Index

	$IC30$	$IC91$	$IC182$	$IC273$	$IC365$
Mean	0.538	0.515	0.518	0.516	0.511
p-val	0.000	0.000	0.000	0.000	0.000
Std	0.181	0.130	0.116	0.125	0.135
Per 10	0.342	0.363	0.380	0.373	0.359
Median	0.491	0.500	0.504	0.497	0.492
Per 90	0.812	0.696	0.680	0.696	0.696

Table II PVGO Proxies and Correlation Measures

This table displays the summary statistics (Panel A) and the time series correlation of common proxies (and their changes) for the value of growth options with realized correlations (RC) calculated from daily realized returns over the respective window and implied correlations (IC) from matching-maturity options, both constructed for five different maturities of 30, 91, 182, 273, and 365 calendar days. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The sample period for the growth option proxies ranges from 1983 to 2018. The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C. The sample period for realized correlations is ranging from 01/1965 to 12/2017, and for implied correlations extracted for the S&P500 from 01/1996 to 12/2017.

Panel A: Summary Statistics – PVGO Proxies

	M/B	Q	DTE	CAPEX
Mean	2.903	2.394	0.276	0.154
Std	1.594	1.624	0.118	0.049
Per 10	1.811	1.302	0.144	0.096
Median	2.533	2.023	0.254	0.152
Per 90	3.933	3.512	0.454	0.209
Skew	4.678	4.483	1.152	0.811

Panel B: Contemporaneous Correlation – Levels on Levels

	$RC30$	$RC91$	$RC182$	$RC273$	$RC365$	$IC30$	$IC91$	$IC182$	$IC273$	$IC365$
M/B	-0.213	-0.264	-0.259	-0.266	-0.275	-0.440	-0.472	-0.512	-0.510	-0.508
Q	-0.210	-0.264	-0.261	-0.264	-0.273	-0.443	-0.471	-0.506	-0.503	-0.499
DTE	0.051	0.071	0.084	0.094	0.128	0.217	0.289	0.277	0.283	0.297
CAPEX	-0.183	-0.180	-0.190	-0.218	-0.243	-0.227	-0.276	-0.320	-0.331	-0.340

Panel C: Contemporaneous Correlation – Changes on Changes

	$RC30$	$RC91$	$RC182$	$RC273$	$RC365$	$IC30$	$IC91$	$IC182$	$IC273$	$IC365$
M/B	-0.016	-0.078	-0.080	-0.083	-0.076	-0.108	-0.118	-0.127	-0.090	-0.098
Q	-0.007	-0.079	-0.078	-0.077	-0.077	-0.137	-0.142	-0.142	-0.101	-0.106
DTE	0.069	0.040	0.076	0.079	0.074	-0.126	0.049	0.024	0.027	0.081
CAPEX	-0.046	-0.009	-0.027	-0.020	-0.013	0.023	-0.006	0.017	0.029	-0.018

Table III Predictive: PVGO Proxies – Changes

This table shows the slope and the R^2s of the univariate regressions of (log) changes of common proxies for the value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) from matching-maturity options over the respective window. The sample period ranges from 01/1996 to 12/2017 for realized and implied correlations. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the PVGO proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C. The $p-values$ are computed with Newey and West (1987) standard errors.

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
IC	0.140	0.191	0.050	0.362	0.002	7.114	0.796	0.001	14.818	1.099	0.005	17.956	1.507	0.005	21.525
Q															
IC	0.200	0.092	0.292	0.435	0.001	7.356	0.912	0.001	14.485	1.264	0.003	17.799	1.747	0.003	21.678
DTE															
IC	0.197	0.285	-0.121	-0.204	0.006	4.196	-0.450	0.000	9.337	-0.565	0.002	10.048	-0.655	0.010	9.879
$CAPEX$															
IC	-0.092	0.516	-0.290	-0.052	0.777	-0.361	-0.072	0.741	-0.352	0.292	0.192	0.096	0.600	0.022	8.873

Table IV Predictive: Risks – Market Level

This table reports the regression coefficients (with corresponding p-values) and the R^2s from regressions of various risk measures on implied correlations for horizons of 30 to 365 days. Thereby $\sigma^2(\beta_M)$ denotes the cross sectional dispersion of market betas, $EWIV$ ($VWIV$) the equally (value) weighted sum of squared residuals. The measures are calculated from a Fama and French five factor model for the whole CRSP universe. β_H (β_L) value (growth) betas, are calculated by regressing excess returns of value (growth) portfolios on market excess returns over a rolling window equal to the predictive horizon. Return Dispersion (RD) is calculated as the cross sectional dispersion of the 100 size and book-to-market sorted portfolios returns. Option-implied equicorrelations are calculated applying Eq.(24) for the S&P500 Index over the sample period ranging from 01/1996 to 12/2017, and for five different maturities of 30, 91, 182, 273, and 365 calendar days. The intercept is not shown. The p-values are computed with Newey and West (1987) standard errors.

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
$\sigma^2(\beta_M)$															
IC	-2.255	0.000	2.764	-0.709	0.000	8.411	-0.531	0.000	20.158	-0.408	0.000	25.843	-0.316	0.000	24.674
β_H															
IC	0.589	0.000	5.472	0.873	0.000	11.337	1.107	0.000	18.078	1.192	0.000	21.929	1.232	0.001	22.319
β_L															
IC	-0.321	0.000	9.238	-0.279	0.000	7.861	-0.216	0.002	5.422	-0.147	0.044	3.014	-0.141	0.079	2.999
$EWIV$															
IC	0.002	0.614	0.128	-0.026	0.235	1.855	-0.160	0.001	14.361	-0.282	0.000	19.523	-0.356	0.002	16.700
$VWIV$															
IC	-0.002	0.194	0.913	-0.030	0.034	6.945	-0.119	0.001	20.210	-0.205	0.000	24.323	-0.272	0.002	21.463
RD															
IC	-0.068	0.001	5.387	-0.138	0.002	11.931	-0.215	0.000	18.165	-0.259	0.001	18.506	-0.256	0.013	13.349

Table V Factor Return Overview

This table contains the annualized average return, standard deviation, and sharp ratio of the market- ($MKTRF$) and the value factor returns (HML, HML^*). The monthly timeseries correlation of the respective factors, i.e their long- and short legs, and the book-to-market sorted portfolios is displayed in Panel B and in Panel C. The market neutral returns are estimated applying Eq.(25). The data is obtained from Kenneth French's Website, and ranges from 1965 to the end of 2018.

Panel A: Factor Return Summary Statistics

	Ret	Std	Sr
MKTRF	0.048	0.158	0.302
HML	0.037	0.081	0.455
HML*	0.038	0.061	0.618

Panel B: Monthly Factor Return Correlation

	MKTRF	HML	H	L	HML*
MKTRF	1.000	-0.261	0.889	0.953	-0.046
HML	-0.261	1.000	0.120	-0.406	0.844
H	0.889	0.120	1.000	0.858	0.273
L	0.953	-0.406	0.858	1.000	-0.188
HML*	-0.046	0.844	0.273	-0.188	1.000

Panel C: Monthly Book-to-Market Portfolio Return Correlation

	MKTRF	HML	H	L
Lo10 BM	0.928	-0.487	0.728	0.923
Dec2 BM	0.954	-0.328	0.824	0.929
Dec3 BM	0.950	-0.227	0.856	0.905
Dec4 BM	0.927	-0.130	0.865	0.863
Dec5 BM	0.911	-0.047	0.867	0.822
Dec6 BM	0.889	0.014	0.880	0.802
Dec7 BM	0.874	0.079	0.896	0.782
Dec8 BM	0.868	0.154	0.954	0.799
Dec9 BM	0.869	0.138	0.958	0.809
Hi10 BM	0.823	0.169	0.943	0.779

Table VI Predictive: Factor Returns

The table shows the slope and the R^2s of the regressions of the excess market and value factor returns realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) for the S&P500 Index. Implied correlations are computed applying Eq.(24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 01/1996 to 12/2018 for both variables, sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

Panel A: Factors

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
MKTRF					
IC	0.057	0.234	0.480	0.668	0.860
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	2.355	10.936	19.177	22.178	22.690
HML					
IC	-0.041	-0.148	-0.330	-0.504	-0.720
	(0.007)	(0.005)	(0.019)	(0.035)	(0.033)
R^2	2.626	7.692	13.985	17.592	22.071
*HML**					
IC	-0.037	-0.130	-0.269	-0.396	-0.570
	(0.002)	(0.001)	(0.002)	(0.006)	(0.005)
R^2	2.824	6.682	11.619	14.756	19.349

Panel B: Legs

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
H					
IC	0.016	0.099	0.167	0.206	0.219
	(0.472)	(0.104)	(0.145)	(0.259)	(0.413)
R^2	0.114	1.239	1.568	1.420	0.995
L					
IC	0.057	0.247	0.494	0.677	0.875
	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	1.680	8.494	15.442	17.565	18.838

Table VII Predictive: Book-to-Market sorted Portfolio Returns

The table shows the slope and the R^2s of the regressions of the Fama and French book-to-market sorted decile portfolio over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) for the S&P500 Index. Implied correlations are computed applying Eq.(24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 01/1996 to 12/2017, and the variables are sampled at daily frequency. The factor data is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
Lo10 BM					
IC	0.069	0.275	0.550	0.756	1.009
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	3.041	12.947	20.930	23.140	24.737
Dec2 BM					
IC	0.045	0.186	0.349	0.477	0.630
	(0.004)	(0.000)	(0.000)	(0.001)	(0.004)
R^2	1.549	7.524	11.174	12.246	12.890
Dec3 BM					
IC	0.044	0.176	0.332	0.457	0.564
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	1.562	6.990	10.711	12.353	12.186
Dec4 BM					
IC	0.038	0.138	0.232	0.279	0.292
	(0.037)	(0.007)	(0.024)	(0.055)	(0.111)
R^2	0.951	3.642	4.606	4.236	3.069
Dec5 BM					
IC	0.032	0.104	0.147	0.190	0.204
	(0.090)	(0.047)	(0.119)	(0.144)	(0.250)
R^2	0.696	2.023	1.745	1.843	1.350
Dec6 BM					
IC	0.034	0.128	0.201	0.233	0.235
	(0.047)	(0.009)	(0.074)	(0.161)	(0.254)
R^2	0.841	3.200	3.205	2.616	1.758
Dec7 BM					
IC	0.037	0.134	0.214	0.260	0.293
	(0.052)	(0.018)	(0.075)	(0.131)	(0.191)
R^2	0.795	2.696	2.725	2.411	1.939
Dec8 BM					
IC	0.013	0.073	0.132	0.170	0.180
	(0.563)	(0.221)	(0.222)	(0.312)	(0.440)
R^2	0.072	0.777	1.133	1.142	0.810
Dec9 BM					
IC	0.022	0.119	0.201	0.260	0.312
	(0.318)	(0.047)	(0.103)	(0.197)	(0.299)
R^2	0.230	1.856	2.274	2.240	1.971
Hi10 BM					
IC	0.010	0.128	0.229	0.295	0.333
	(0.742)	(0.130)	(0.122)	(0.221)	(0.356)
R^2	0.011	1.221	1.816	1.865	1.464

Table VIII Predictive: Factor Returns – CMA and RMW

The table shows the slope and the R^2s of the regressions of the value factor returns (CMA, CMA^*, RMW, RMW^*) and their legs (C, A, R, W) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) for the S&P500 Index. Implied correlations are computed applying Eq.(24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 01/1996 to 12/2018 when considering implied correlations, and the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

Panel A: Factors

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
CMA					
IC	-0.013	-0.074	-0.186	-0.312	-0.457
	(0.169)	(0.052)	(0.068)	(0.065)	(0.060)
R^2	0.548	4.377	10.213	15.746	19.644
*CMA**					
IC	-0.003	-0.026	-0.083	-0.151	-0.218
	(0.688)	(0.298)	(0.192)	(0.143)	(0.128)
R^2	0.026	0.860	3.303	6.823	8.945
RMW					
IC	-0.018	-0.131	-0.360	-0.572	-0.793
	(0.200)	(0.004)	(0.000)	(0.001)	(0.002)
R^2	0.679	7.689	20.903	27.184	31.307
*RMW**					
IC	0.002	-0.048	-0.174	-0.287	-0.395
	(0.867)	(0.145)	(0.013)	(0.015)	(0.031)
R^2	-0.007	1.583	8.035	12.339	14.690

Panel B: Legs

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
C					
IC	0.041	0.175	0.322	0.408	0.492
	(0.040)	(0.001)	(0.000)	(0.001)	(0.007)
R^2	0.956	4.570	6.725	6.495	6.118
A					
IC	0.053	0.245	0.492	0.671	0.853
	(0.023)	(0.000)	(0.000)	(0.000)	(0.002)
R^2	1.295	7.487	13.892	15.968	16.300
R					
IC	0.039	0.150	0.238	0.289	0.342
	(0.029)	(0.001)	(0.003)	(0.013)	(0.044)
R^2	1.029	4.392	5.134	4.775	4.232
W					
IC	0.055	0.271	0.578	0.794	1.007
	(0.032)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	1.219	7.404	14.434	16.355	16.795

Table IX Predictive: Factor Returns – IC vs. IC_{IVE}

The table shows the slope and the R^2s of the regressions of the value factor returns ($MKTRF$, HML, HML^*, CMA, CMA^*, RMW, RMW^*) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) on the S&P500, and implied correlation (IC) on the S&P500 Value Index (IVE). Implied correlations are computed applying Eq. (24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 08/2006 to 12/2018, and the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
$MKTRF$										
IC	0.036	-	0.153	-	0.413	-	0.675	-	0.918	-
	(0.077)	-	(0.048)	-	(0.050)	-	(0.037)	-	(0.029)	-
IC_{IVE}	-	0.026	-	0.089	-	0.320	-	0.379	-	0.464
	-	(0.073)	-	(0.135)	-	(0.009)	-	(0.006)	-	(0.002)
R^2	0.998	0.925	3.923	1.970	9.158	9.532	13.097	9.535	14.456	12.155
HML										
IC	-0.017	-	-0.020	-	0.119	-	0.300	-	0.455	-
	(0.251)	-	(0.685)	-	(0.164)	-	(0.037)	-	(0.024)	-
IC_{IVE}	-	-0.005	-	-0.013	-	0.129	-	0.224	-	0.279
	-	(0.655)	-	(0.771)	-	(0.015)	-	(0.001)	-	(0.000)
R^2	0.544	0.043	0.116	0.063	2.433	4.996	10.175	13.152	15.956	19.780
$HML*$										
IC	-0.031	-	-0.098	-	-0.058	-	0.058	-	0.157	-
	(0.020)	-	(0.080)	-	(0.589)	-	(0.728)	-	(0.503)	-
IC_{IVE}	-	-0.011	-	-0.049	-	0.011	-	0.071	-	0.082
	-	(0.262)	-	(0.305)	-	(0.877)	-	(0.473)	-	(0.501)
R^2	1.992	0.402	3.280	1.209	0.496	0.001	0.329	1.222	1.883	1.687
CMA										
IC	0.011	-	0.048	-	0.187	-	0.319	-	0.422	-
	(0.108)	-	(0.053)	-	(0.000)	-	(0.000)	-	(0.000)	-
IC_{IVE}	-	0.012	-	0.053	-	0.143	-	0.212	-	0.227
	-	(0.003)	-	(0.007)	-	(0.000)	-	(0.000)	-	(0.000)
R^2	1.098	2.409	3.174	5.905	16.875	17.182	28.243	28.848	30.114	28.699
$CMA*$										
IC	0.009	-	0.036	-	0.154	-	0.271	-	0.375	-
	(0.247)	-	(0.166)	-	(0.004)	-	(0.005)	-	(0.009)	-
IC_{IVE}	-	0.013	-	0.048	-	0.128	-	0.188	-	0.197
	-	(0.002)	-	(0.022)	-	(0.001)	-	(0.001)	-	(0.007)
R^2	0.627	2.669	1.939	5.000	11.623	14.012	20.163	22.339	23.723	21.489
RMW										
IC	0.003	-	-0.033	-	-0.124	-	-0.218	-	-0.248	-
	(0.777)	-	(0.153)	-	(0.070)	-	(0.068)	-	(0.136)	-
IC_{IVE}	-	-0.000	-	-0.037	-	-0.102	-	-0.114	-	-0.087
	-	(0.944)	-	(0.062)	-	(0.025)	-	(0.044)	-	(0.128)
R^2	0.005	-0.033	1.151	2.292	5.732	6.846	9.298	5.822	7.388	2.948
$RMW*$										
IC	0.012	-	0.016	-	-0.009	-	-0.067	-	-0.062	-
	(0.144)	-	(0.411)	-	(0.870)	-	(0.554)	-	(0.710)	-
IC_{IVE}	-	0.005	-	-0.007	-	-0.022	-	-0.028	-	-0.005
	-	(0.366)	-	(0.713)	-	(0.619)	-	(0.663)	-	(0.943)
R^2	1.035	0.342	0.313	0.072	0.006	0.423	1.229	0.471	0.615	-0.023

Table X Predictive: Factor Returns – Legs – IC vs. IC_{IVE}

The table shows the slope and the R^2s of the regressions of the long- and short value factor returns (H, L, C, A, R, W) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) on the S&P500, and implied correlation (IC_{IVE}) on the S&P500 Value Index (IVE). Implied correlations are computed applying Eq. (24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 08/2006 to 12/2018, and the variables are sampled at daily frequency. The factor data is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
H										
IC	0.023	-	0.141	-	0.480	-	0.854	-	1.214	-
	(0.464)	-	(0.153)	-	(0.049)	-	(0.029)	-	(0.022)	-
IC_{IVE}	-	0.022	-	0.078	-	0.404	-	0.536	-	0.689
	-	(0.319)	-	(0.340)	-	(0.006)	-	(0.003)	-	(0.000)
R^2	0.180	0.322	1.773	0.802	7.397	9.090	12.692	11.535	15.174	16.063
L										
IC	0.041	-	0.164	-	0.369	-	0.543	-	0.710	-
	(0.061)	-	(0.046)	-	(0.111)	-	(0.128)	-	(0.113)	-
IC_{IVE}	-	0.027	-	0.091	-	0.278	-	0.310	-	0.393
	-	(0.078)	-	(0.134)	-	(0.045)	-	(0.072)	-	(0.036)
R^2	1.113	0.840	4.007	1.826	6.594	6.525	7.814	5.866	8.216	8.286
C										
IC	0.046	-	0.203	-	0.547	-	0.875	-	1.192	-
	(0.061)	-	(0.021)	-	(0.020)	-	(0.012)	-	(0.009)	-
IC_{IVE}	-	0.034	-	0.130	-	0.429	-	0.550	-	0.692
	-	(0.042)	-	(0.061)	-	(0.003)	-	(0.001)	-	(0.000)
R^2	1.196	1.187	4.984	3.041	11.771	12.596	16.385	14.964	18.292	20.299
A										
IC	0.034	-	0.148	-	0.334	-	0.517	-	0.710	-
	(0.164)	-	(0.093)	-	(0.173)	-	(0.172)	-	(0.144)	-
IC_{IVE}	-	0.022	-	0.071	-	0.269	-	0.311	-	0.426
	-	(0.213)	-	(0.271)	-	(0.072)	-	(0.105)	-	(0.056)
R^2	0.644	0.453	2.731	0.904	4.738	5.330	6.268	5.219	7.140	8.466
R										
IC	0.041	-	0.161	-	0.376	-	0.578	-	0.807	-
	(0.070)	-	(0.051)	-	(0.087)	-	(0.079)	-	(0.057)	-
IC_{IVE}	-	0.028	-	0.084	-	0.296	-	0.365	-	0.500
	-	(0.071)	-	(0.170)	-	(0.026)	-	(0.025)	-	(0.010)
R^2	1.092	0.893	3.864	1.534	7.265	7.779	9.581	8.845	11.170	14.131
W										
IC	0.038	-	0.185	-	0.477	-	0.758	-	1.004	-
	(0.159)	-	(0.048)	-	(0.071)	-	(0.062)	-	(0.058)	-
IC_{IVE}	-	0.028	-	0.117	-	0.385	-	0.468	-	0.575
	-	(0.140)	-	(0.111)	-	(0.018)	-	(0.019)	-	(0.006)
R^2	0.695	0.674	3.542	2.091	7.756	8.754	10.640	9.352	11.408	12.287

Table XI Predictive: Factor Returns – Residuals – IC vs. IC_{IVE}

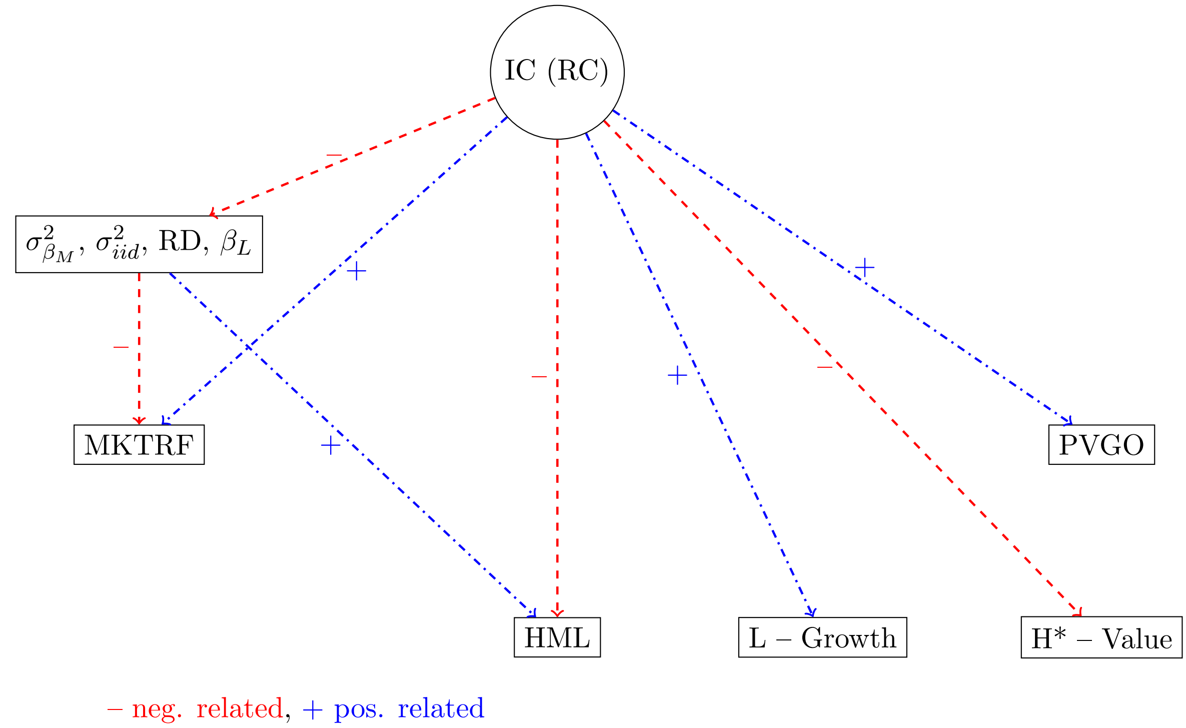
The table shows the slope and the R^2s of the regressions of the value factor returns ($MKTRF$, HML, CMA, and RMW) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) on the S&P500, and the residuals ($Res_{IC_{IVE}}$) obtained from Eq. (29) regressing IC_{IVE} on implied correlation (IC) and a constant. Implied correlations are computed applying Eq. (24) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period ranges from 08/2006 to 12/2018, and the variables are sampled at daily frequency. The factor data is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
MKTRF										
IC	0.036	0.036	0.153	0.153	0.413	0.413	0.675	0.675	0.918	0.918
	(0.077)	(0.077)	(0.048)	(0.048)	(0.050)	(0.052)	(0.037)	(0.039)	(0.029)	(0.030)
$Res_{IC_{IVE}}$	-	0.017	-	0.005	-	0.193	-	0.093	-	0.200
	-	(0.240)	-	(0.941)	-	(0.032)	-	(0.624)	-	(0.451)
R^2	0.998	1.258	3.923	3.892	9.158	10.513	13.097	13.302	14.456	15.460
HML										
IC	-0.017	-0.017	-0.020	-0.020	0.119	0.119	0.300	0.300	0.455	0.455
	(0.251)	(0.251)	(0.685)	(0.685)	(0.164)	(0.145)	(0.037)	(0.028)	(0.024)	(0.015)
$Res_{IC_{IVE}}$	-	0.002	-	-0.004	-	0.148	-	0.177	-	0.207
	-	(0.819)	-	(0.942)	-	(0.014)	-	(0.023)	-	(0.015)
R^2	0.544	0.524	0.116	0.085	2.433	5.030	10.175	13.526	15.956	20.887
CMA										
IC	0.011	0.011	0.048	0.048	0.187	0.187	0.319	0.319	0.422	0.422
	(0.108)	(0.103)	(0.053)	(0.052)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Res_{IC_{IVE}}$	-	0.011	-	0.050	-	0.083	-	0.124	-	0.122
	-	(0.014)	-	(0.014)	-	(0.128)	-	(0.087)	-	(0.080)
R^2	1.098	2.479	3.174	5.893	16.875	19.173	28.243	32.285	30.114	33.879
RMW										
IC	0.003	0.003	-0.033	-0.033	-0.124	-0.124	-0.218	-0.218	-0.248	-0.248
	(0.777)	(0.777)	(0.153)	(0.152)	(0.070)	(0.074)	(0.068)	(0.068)	(0.136)	(0.137)
$Res_{IC_{IVE}}$	-	-0.002	-	-0.036	-	-0.075	-	-0.009	-	0.031
	-	(0.740)	-	(0.157)	-	(0.111)	-	(0.896)	-	(0.695)
R^2	0.005	-0.001	1.151	2.260	5.732	7.156	9.298	9.279	7.388	7.526

Figure 1. The interplay of IC, Risks, PVGO, and Factor Returns

The figure displays the relation between implied correlations (at time t) and future- risk variables, the present value of growth options, and factor returns (Panel A). In Panel B the contemporaneous relation between implied correlations, risk variables, the present value of growth options, and factor returns is depicted. The network is collected from several empirical and theoretical research papers explained in Section II and complemented by the findings in this paper.

A: The Predictive Interplay of IC, Risks, Growth Options, and Factor Returns



B: The Contemporaneous Interplay of IC, Risks, Growth Options, and Factor Returns

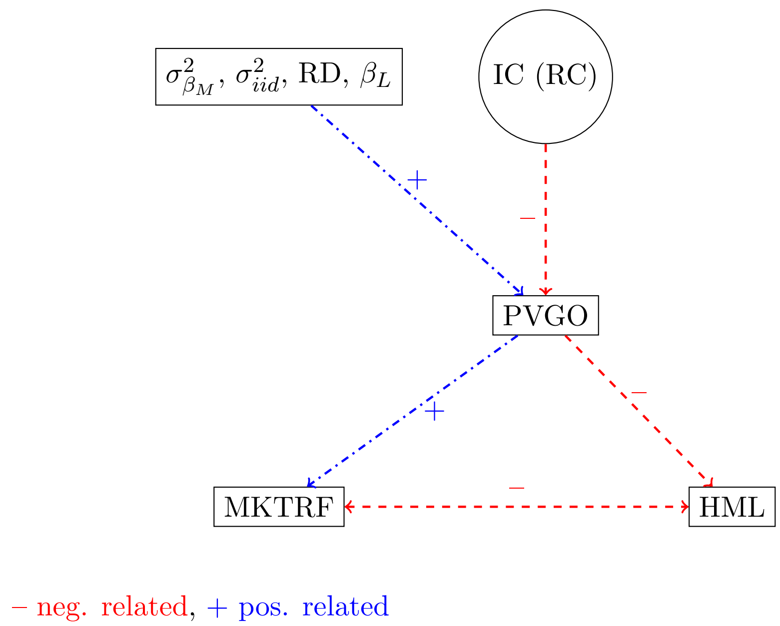


Figure 2. Realized and Implied Correlations

The figure shows the time series plot (i.e. the 21 days moving average) of realized correlation (RC) and implied correlation (IC) for a maturity of 30 and 365 calender days, in Panel A and Panel C. In Panel B and Panel D realized and implied correlations with a maturity of 30 days are displayed together with the NBER Recession Indicator (see Appendix I.D), which equals 1 if the economy is in recession and 0 elsewhere (expansion). Realized and implied correlations, are calculated as equicorrelations applying Eq.(24) for the S&P500 Index for five different maturities of 30, 91, 182, 273, and 365 calendar days. The sample period for realized correlations is ranging from 01/1965 to 12/2017 and for implied correlations extracted for the S&P500 from 01/1996 to 12/2017. Second moments are calculated for the index and for all index components from daily realized returns over a respective window for realized variances and as model-free implied variances following Martin (2013) and are sampled on a daily frequency.

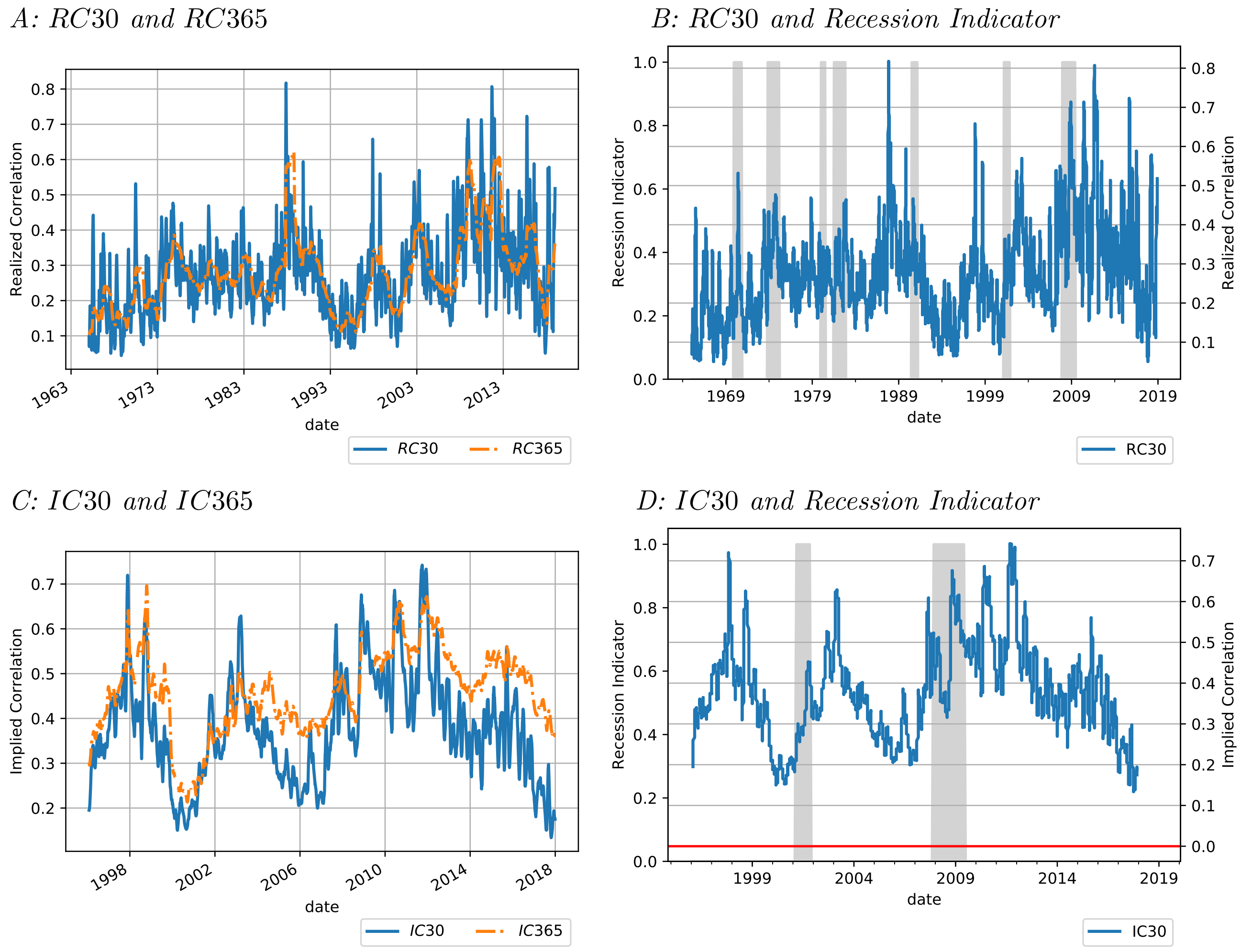


Figure 3. Average Correlation in B/M Sorted Portfolios

The figure shows the time series plots of the average correlation in growth ($G = Lo_{10}$) and value ($V = Hi_{10}$) portfolios and its difference, called Correlation Delta ($\Delta\rho := \rho(G) - \rho(V)$). The yearly average correlation among the various portfolios is calculated in forward looking manner from t to $t+1$, where t denotes the rebalancing month (June). The sample period for the measures is ranging from 01/1965 to 12/2017. In Panel B the Correlation Delta is displayed together with the NBER Recession Indicator (see Appendix I.D), which equals 1 if the economy is in recession and 0 elsewhere (expansion). The correlations are calculated using monthly data.

A: Forward-looking $\Delta\rho_{t,t+1}$ *B:* $\Delta\rho_{t,t+1}$ *and Recession Indicator*

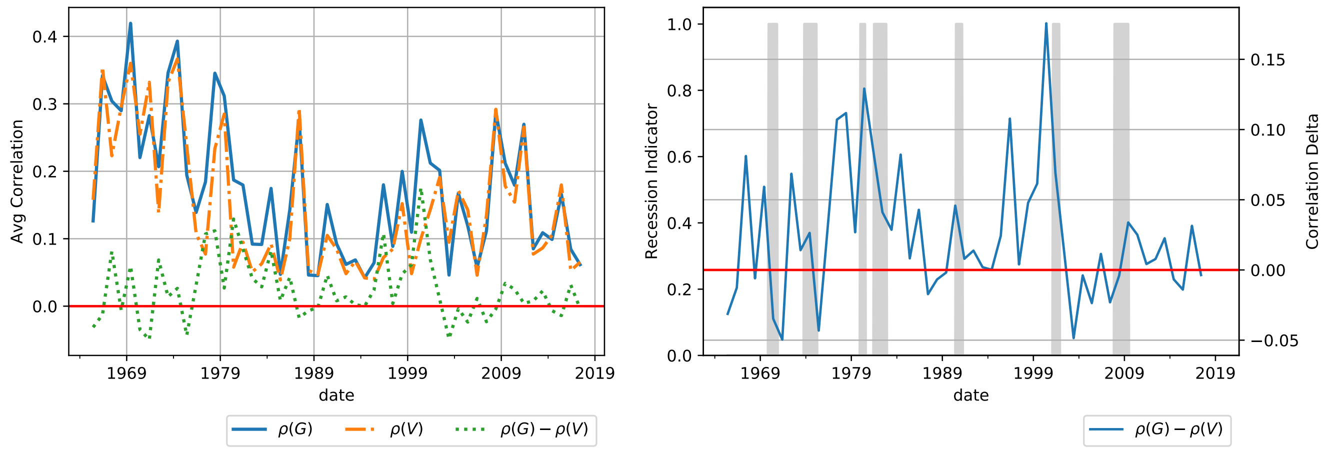


Figure 4. Growth-Value Correlation Delta – RC and IC

The figure displays the time series plots of the average Correlation Delta ($\Delta\rho := \rho(G) - \rho(V)$) together with realized correlations (Panel A) or implied correlations (Panel B). The yearly average Correlation Delta is calculated in a forward looking manner from t to $t+1$, where t denotes the rebalancing month (July). The sample period for the measures is ranging from 01/1965 to 12/2017 for realized correlations and for implied correlations extracted for the S&P500 from 01/1996 to 12/2017. Second moments are calculated for the index and for all index components from daily realized returns over a respective window for realized variances and as model-free implied variances following Martin (2013) and are sampled on a yearly frequency.

A: $\Delta\rho_{t,t+1}$ *and* $RC365_{t-1,t}$

B: $\Delta\rho_{t,t+1}$ *and* $IC365_{t,t+1}$

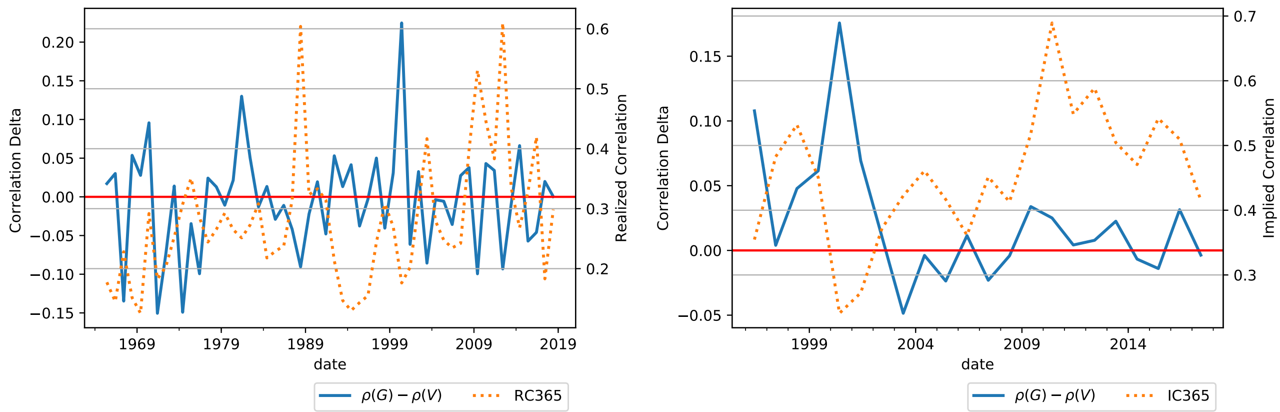


Figure 5. Contemporaneous: Correlations and Book-to-Market Characteristics

The figure shows the time series correlation of realized correlation (RC) and implied correlation (IC) for a maturity of 365 calender days and the value weighted market-to-book values of the ten book-to-market sorted portfolios. The market-to-book characteristics for year t are available at Kenneth French's website. Thereby the book value of year t is the book equity for the last fiscal year end in $t-1$ and the market value is price times shares outstanding at the end of December of $t-1$. Since book-to-market is calculated in December of $t-1$, RC and IC are sampled at end of December in $t-1$ (Panel A and Panel B). The sample period for realized correlations is ranging from 01/1965 to 12/2017 and for implied correlations extracted for the S&P500 from 01/1996 to 12/2017. The sample period for the market-to-book characteristics ranges from 01/1965 to 12/2017 and is available on a yearly frequency. The dashed line displays the time series correlation w.r.t the average value weighted market-to-book characteristic across all deciles.

A: Correlation – $RC_{Dec,t-1}$ *B: Correlation –* $IC_{Dec,t-1}$

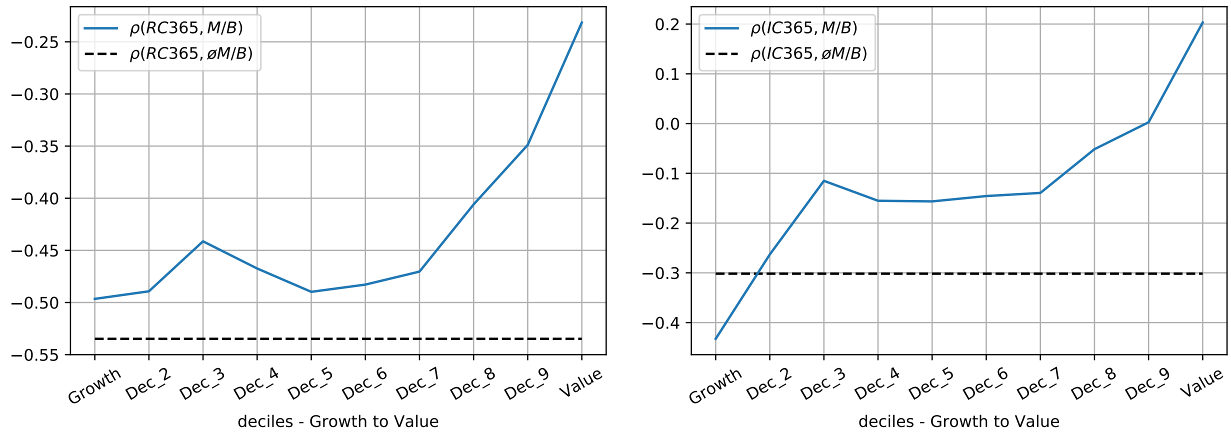


Figure 6. Market Capitalization of Book-to-Market sorted decile Portfolios

The figure shows the relative market capitalization of the ten book-to-market sorted portfolios, calculated as number of firms multiplied by the average firm size, in the respective decile. The sample period ranges from 01/1926 to 12/2017 and is available on a monthly frequency. The factor data, is obtained from Kenneth French's Website.

A: Market Capitalization – Book-to-Market sorted Deciles

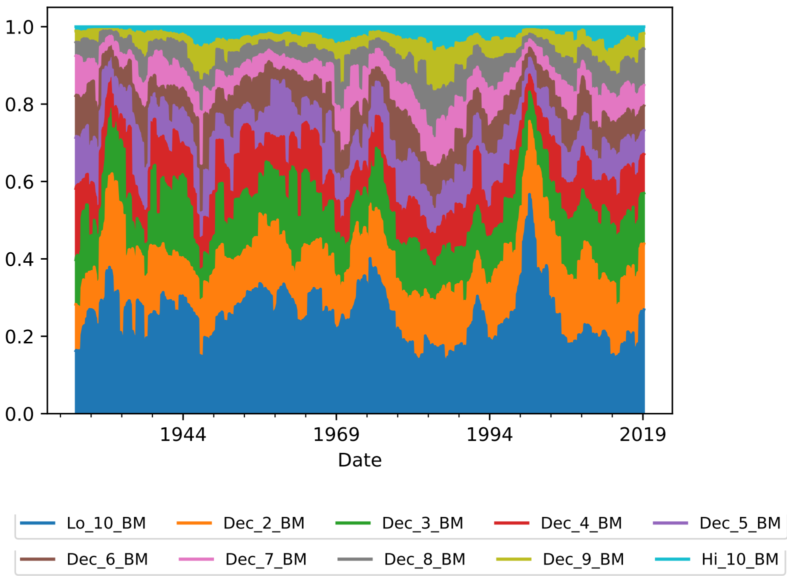


Figure 7. Predictive: Factor Returns

The figure shows the R^2s of the regressions of the value factor returns (HML, HML^*) and the individual long- and short legs returns of the factors (H, L), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 Index from matching-maturity options. The sample period is from 01/1996 to 12/2017, and the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

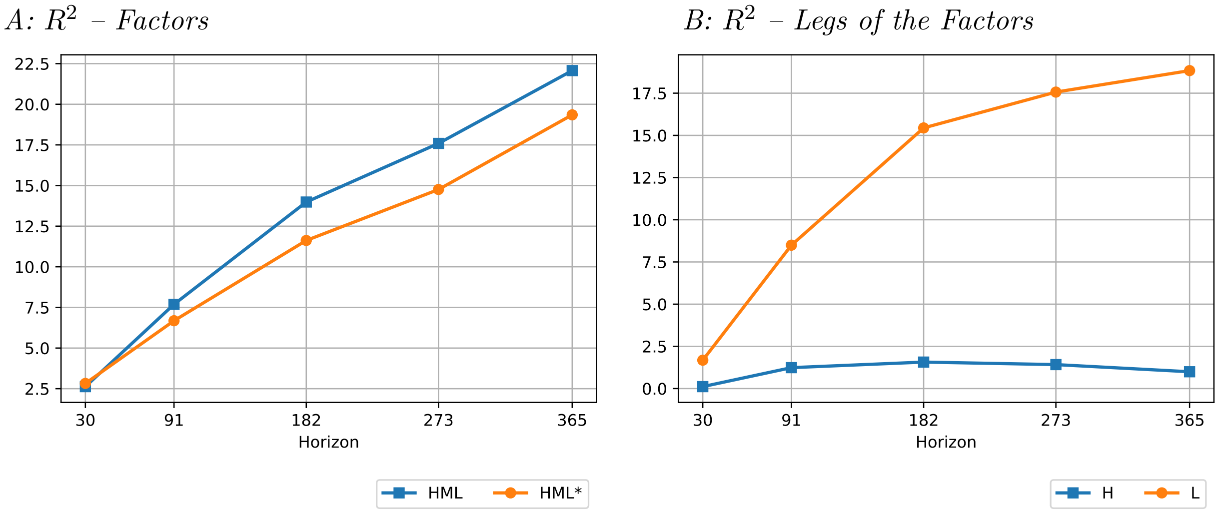


Figure 8. Predictive: Book-to-Market Sorted Decile Portfolios

The figure shows the R^2s (Panel A) and the p-values (Panel B) of the regressions of the Fama and French book-to-market sorted decile portfolios, realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 Index from matching-maturity options. The sample period is from 01/1996 to 12/2017, and the variables are sampled at monthly frequency. The factor data is obtained from Kenneth French's Website.

A: R^2 – Factors *B: p-values*

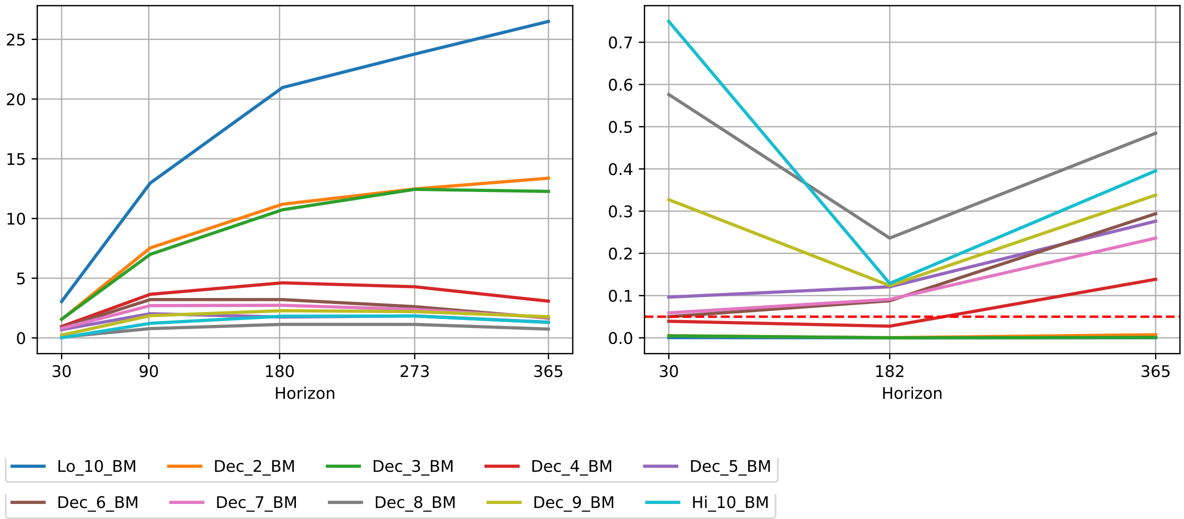
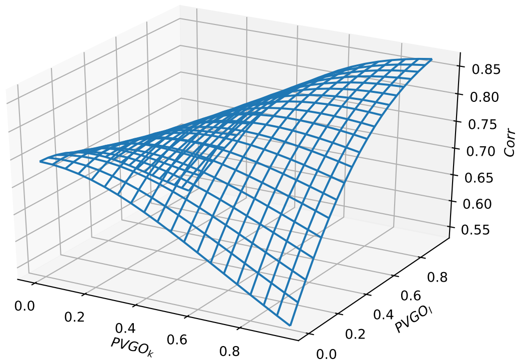


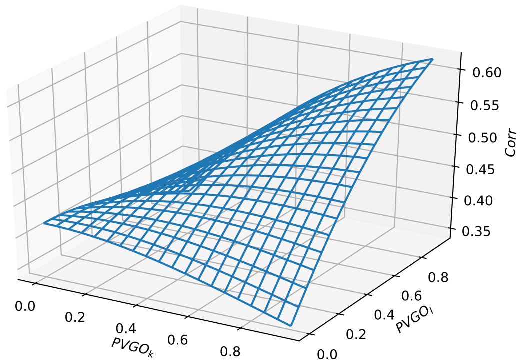
Figure 9. Model Correlation between two Stocks

The figure displays the correlation between two stocks as calculated in equation (20) for different idiosyncratic levels. Thereby $\sigma_x = 0.17$, $\alpha = 0.85$, $\sigma_z = 0.035$, and $V_k = V_l = 1$ normalized to one. The function is evaluated for $PVGO_k$ and $PVGO_l$ between 0 and 1.

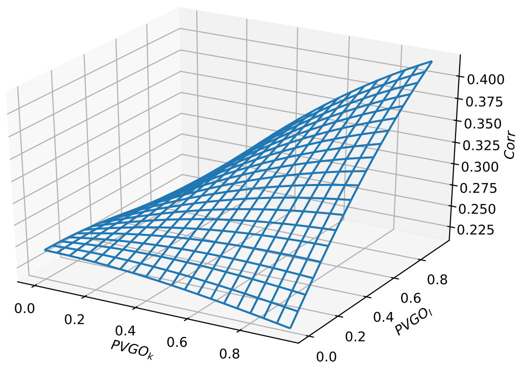
A: Stock Correlation - Idiosyncratic = 0.1



B: Stock Correlation - Idiosyncratic = 0.2



C: Stock Correlation - Idiosyncratic = 0.3



D: Stock Correlation - Idiosyncratic = 0.4

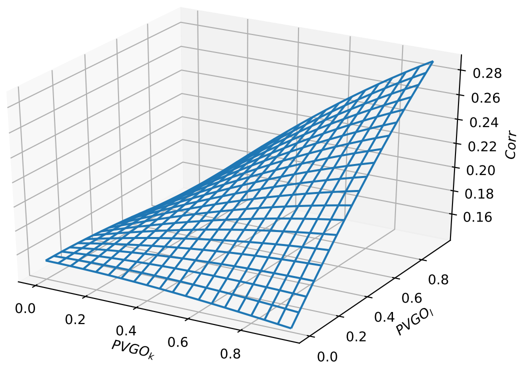


Figure 10. Market Volatility

The figure displays the market volatility as calculated in equation (22). Thereby $\sigma_x = 0.17$, $\alpha = 0.85$, $\sigma_z = 0.035$, and $V_M = 1$ normalized to one. The function is evaluated for $PVGO_M$ between 0 and 1.

A: Market Volatility

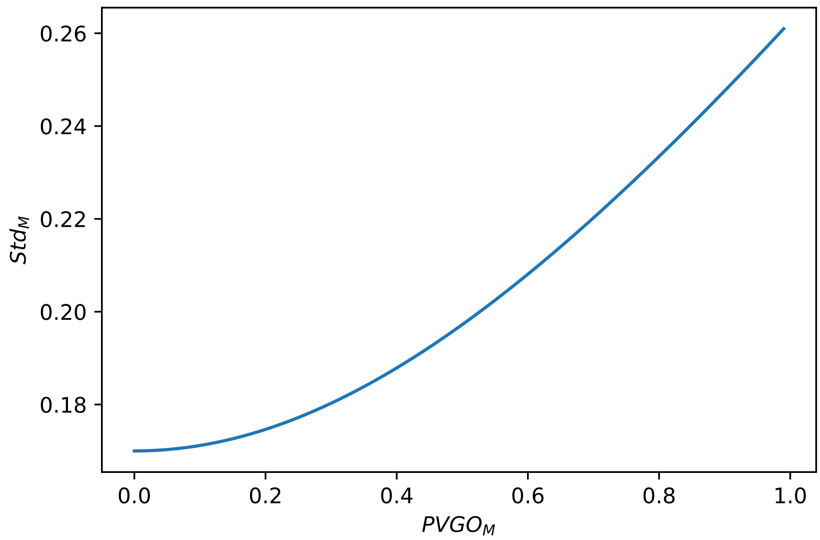
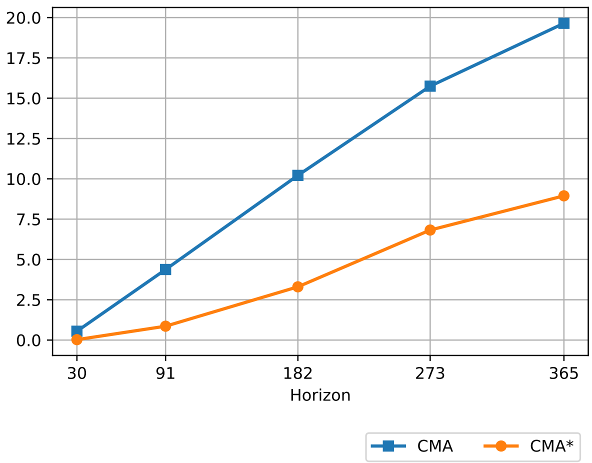


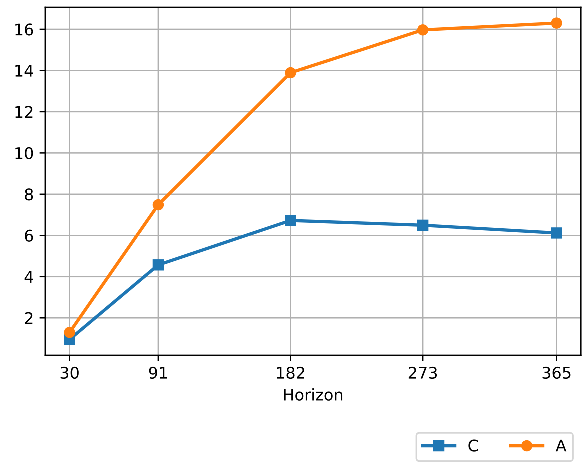
Figure 11. Predictive: Factor Returns – CMA and RMW

The figure shows the R^2s of the regressions of the value factor returns (CMA, CMA^*, RMW, RMW^*) and the individual long- and short legs returns of the factors (C, M, R, W), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 Index from matching-maturity options. The sample period is from 01/1996 to 12/2017, and the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

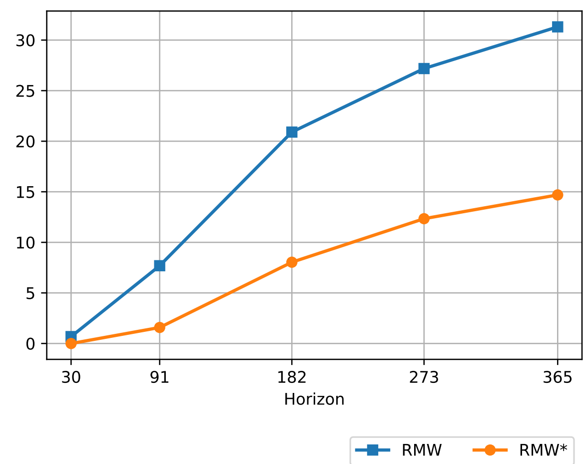
A: R^2 – Factors



B: R^2 – Legs of the Factors



C: R^2 – Factors



D: R^2 – Legs of the Factors

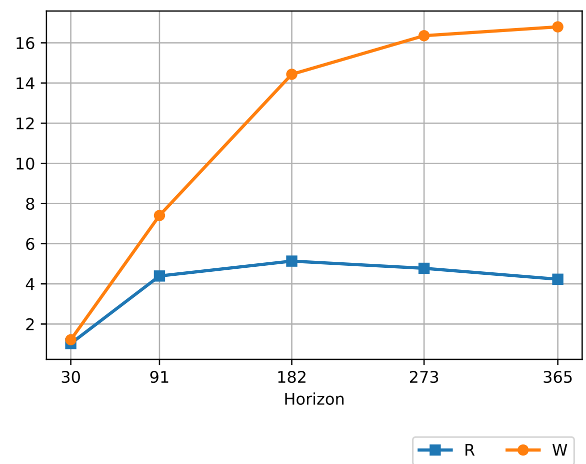


Figure 12. Implied Correlations – S&P500 Value Index vs. S&P500

The figure shows the time series plots for implied correlations, which are calculated as equicorrelations applying Eq. (24) for the S&P500 Index (IC) and for the S&P500 Value Index (IC_{IVE}), for 30 and 365 calendar days. The sample period for the implied correlations extracted ranges from 08/2006 to 12/2017. Second moments are calculated for the index and for all index components as model-free implied variances following Martin (2013) and are sampled on a daily frequency.

A: IC_{IVE} *B: IC vs. IC_{IVE}*

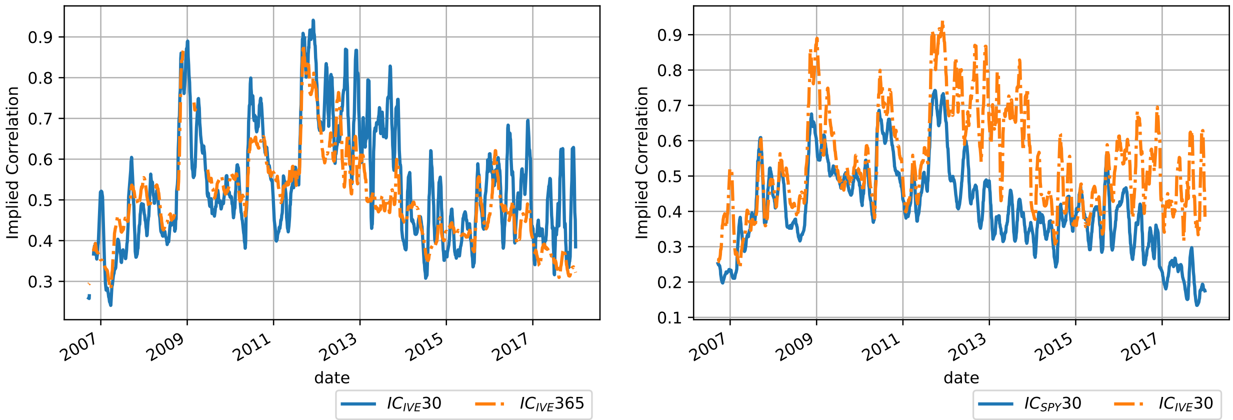


Figure 13. Predictive: Factor Returns – IC vs. IC_{IVE}

The figure shows the R^2s of the regressions of the value factor returns (HML, HML^*, CMA, CMA^*, RMW, RMW^*), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations for the S&P500 Index (IC), and on implied correlations for the S&P500 Value Index (IC_{IVE}) from matching-maturity options. The sample period ranges from 08/2006 to 12/2017, and the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

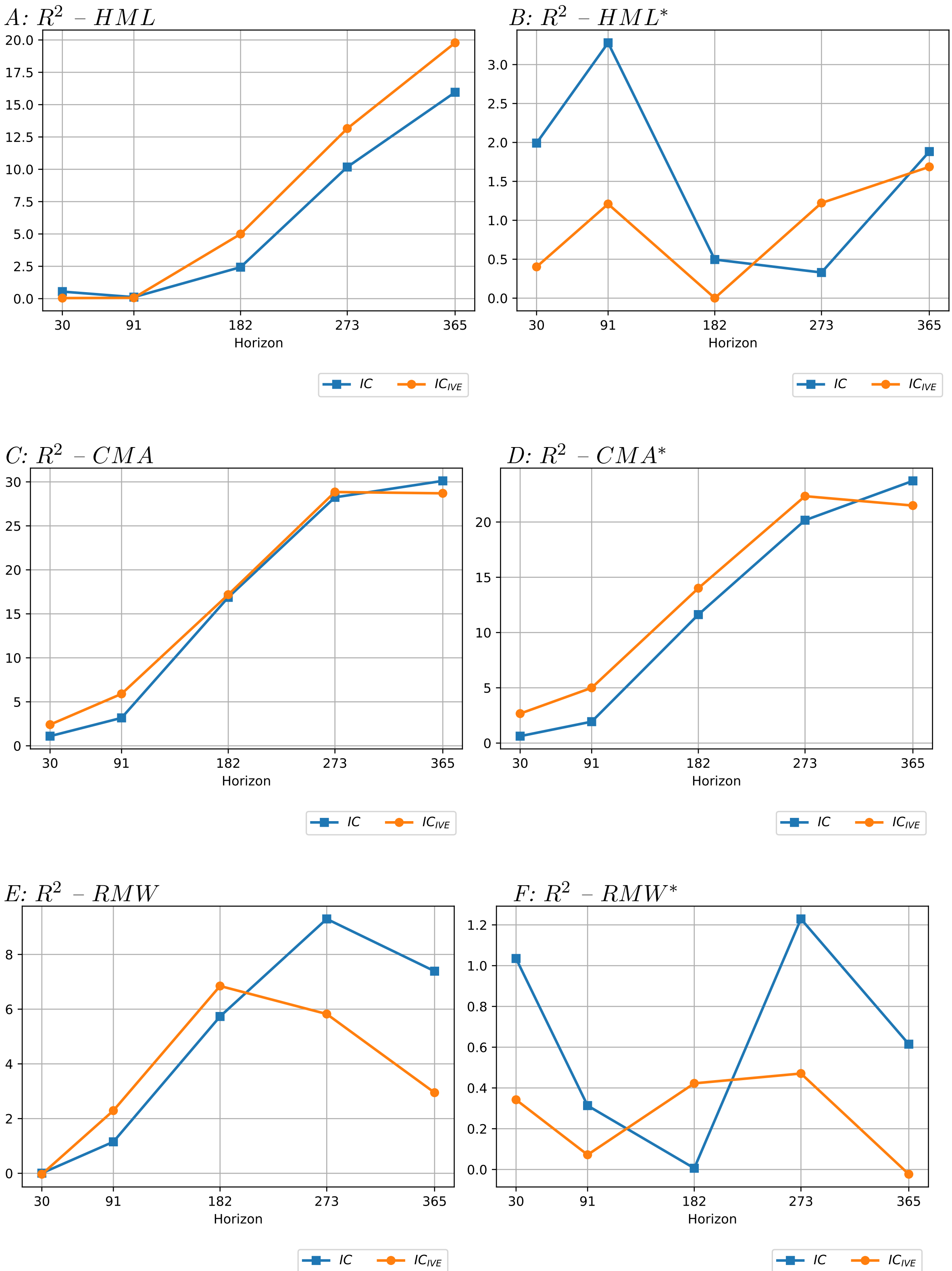
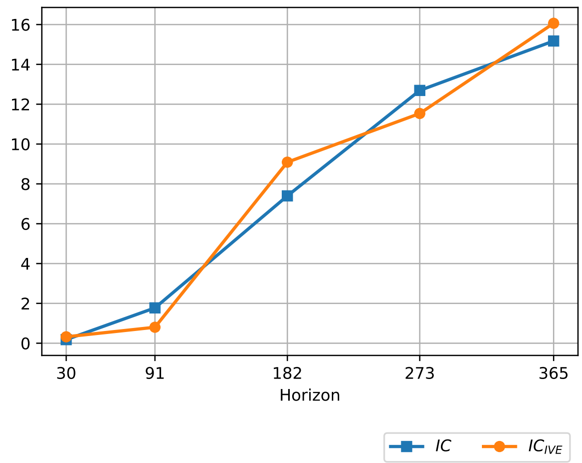


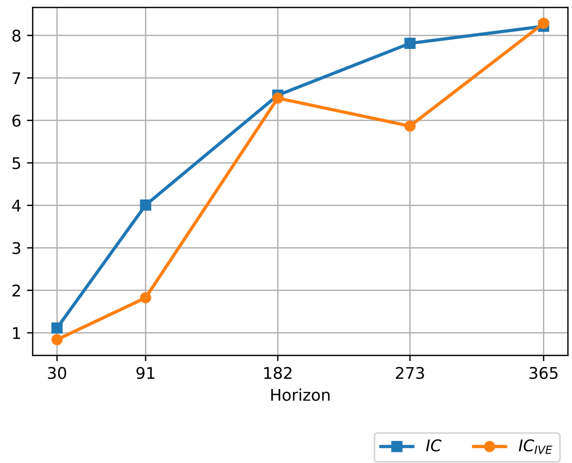
Figure 14. Predictive: Factor Returns – Legs – IC vs. IC_{IVE}

The figure shows the R^2s of the regressions of the value factor returns (H, L, C, A, R, W), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations for the S&P500 Index (IC), and on implied correlations for the S&P500 Value Index (IC_{IVE}) from matching-maturity options. The sample period ranges from 08/2006 to 12/2017, and the variables are sampled at daily frequency. The factor data is obtained from Kenneth French's Website.

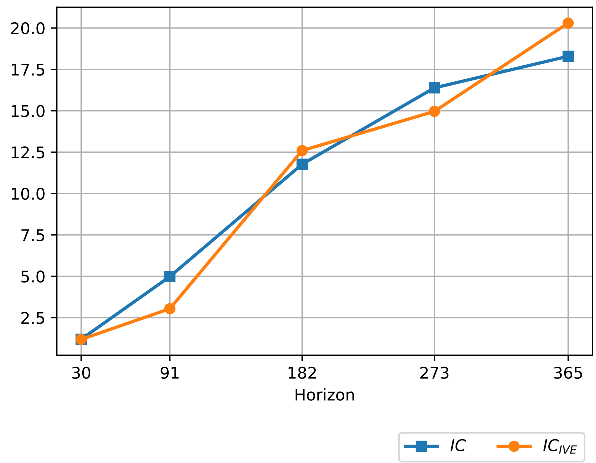
A: R^2 – H



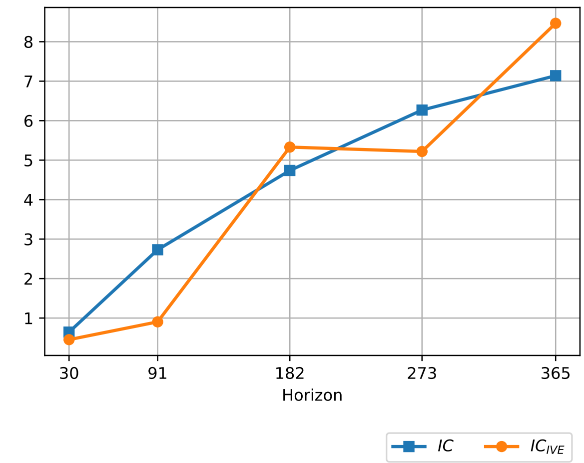
B: R^2 – L



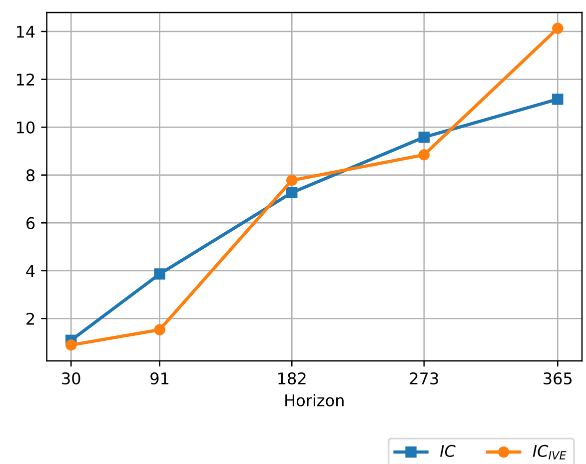
C: R^2 – C



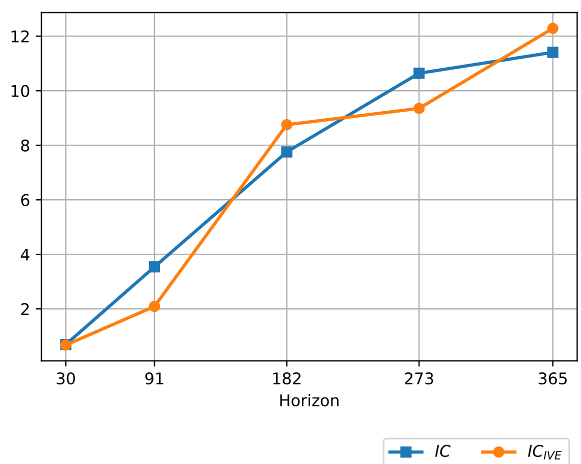
D: R^2 – A



E: R^2 – R



F: R^2 – W



I. Appendix

A. A Brief Description of the Fama-French Factors

$MKTRF$ denotes the excess return on the market, value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ that have a CRSP share code of 10 or 11 at the beginning of month t, good shares and price data at the beginning of t, and good return data for t minus the one-month Treasury bill rate (from Ibbotson Associates).

HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios. The portfolios are constructed at the end of June. The book-to-market ratio considers the book equity at the last fiscal year end of the prior calendar year divided by market equity at the end of December of the prior year.

RMW (Robust Minus Weak) is the average return on the two robust operating profitability (OP) portfolios minus the average return on the two weak operating profitability portfolios. In Fama and French OP is calculated as the annual revenues minus cost of goods sold, interest expense, and selling, general, and administrative expenses divided by book equity for the last fiscal year. Earnings per share can serve as an indicator of a company's profitability too.

CMA (Conservative Minus Aggressive) is the average return on the two conservative investment portfolios minus the average return on the two aggressive investment portfolios. The sorting criteria is the investment.

B. The connection between HML, RMW and CMA

The motivation follows closely Fama and French (2006) where the market value of a share of a firm's stock at time t, M_t, is given by the present value of its expected dividends $E[D_{t+\tau}]$.

$$M_t = \sum_{\tau=1}^{\infty} \frac{E[D_{t+\tau}]}{(1+r)^{\tau}} \tag{A1}$$

r denotes the internal rate of return on the expected dividends, which proxies the return of the stock. Theoretically the dividend should be the difference of the equity earnings per share (Y_t)

and the reinvestment, i.e the change in book equity per share ($dB_t = B_t - B_{t-1}$).

$$M_t = \sum_{\tau=1}^{\infty} \frac{E[Y_{t+\tau} - dB_{t+\tau}]}{(1+r)^{\tau}} \tag{A2}$$

Dividing both sides by the time t book equity leads to

$$\frac{M_t}{B_t} = \sum_{\tau=1}^{\infty} \frac{E[Y_{t+\tau} - dB_{t+\tau}]}{B_t(1+r)^{\tau}} \tag{A3}$$

Comparative statics of equation (A3) leads to the following implications, solving for r: i) A higher B/M ratio, and therefore a lower M/B ratio, needs to be offset with a higher value of r. ii) Keeping the left hand side fix, more profitable firms, i.e higher earnings Y relative to the book equity, indirectly increase the amplitude of r. iii) Taken B/M and Y as given, the stock return r is decreasing in the growth in equity due to reinvestment dB.

Overall the stylized model links the several components book-to-market, investment and operating profitability to each other and further motivates the HML, RMW and CMA investment factors.

C. Proxies for the Present Value of Growth Options – PVGO Proxies

In order to calculate the proxies for the growth options I follow Cao, Simin, and Zhao (2008). The ratio of the market value to book value of assets ($MABA$), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$).

$$MABA = (ATQ - CEQQ + PRCCQ \times CSHOQ)/ATQ \tag{A4}$$

$$Q = (PRCCQ \times CSHOQ + PSTKQ + LCTQ - ACTQ + DLTTQ)/ATQ \tag{A5}$$

$$DTE = (DLCQ + DLTTQ + PSTKQ)/(PRCCQ \times CSHOQ) \tag{A6}$$

$$CAPEX = CAPXY/PPENTQ \tag{A7}$$

$$\tag{A8}$$

Table XII Compustat Items - Calculation of Growth Option Proxies

Item #	Name	Description
5	*LCTQ*	Current Liabilities - Total
6	*ATQ*	Assets - Total
14	*PRCCQ*	Price
19	*DVPQ*	Dividends - Preferred
40	*ACTQ*	Current Assets - Total
42	*PPENTQ*	Property Plant and Equipment - Total (Net)
44	*ATQ*	Assets-Total
45	*DLCQ*	Debt in Current Liabilities
49	*LCTQ*	Current Liabilities - Total
51	*DLTTQ*	Long-Term Debt - Total
55	*PSTKQ*	Preferred/Preference Stock (Capital) - Total
59	*CEQQ*	Common/Ordinary Equity - Total
61	*CSHOQ*	Common Shares Outstanding
90	*CAPXY*	Capital Expenditures
308	*OANCFY*	Operating Cash Flow

To reduce outliers when calculating the dept to equity ratio I exclude stocks with market capitalization below 1 mio US$ and financials (sic code between 6000 and 6999). I include only common stocks (CRSP share code in 10 or 11).

D. NBER Recession Indicator - Contraction and Expansion

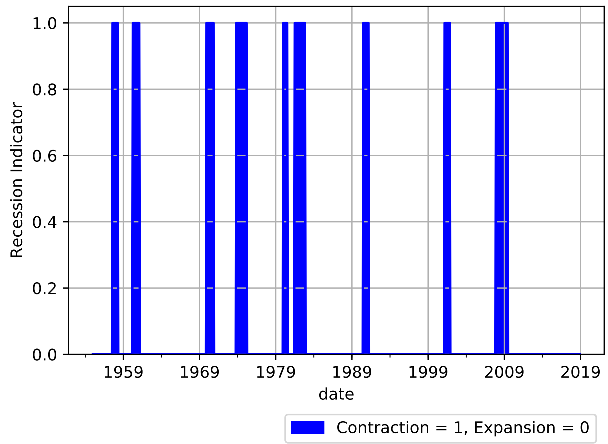
The time series is composed of dummy variables that represent periods recession (1) and expansion (0). The recession begins at the first day of the period following a peak and ends on the last day of the period of the trough. The NBER defines the contraction periods (peak to trough) as displayed in the table. The rest of the time is defined as expansion.

Table XIII NBER - Contraction and Expansion Periods

Peak	Trough	Lenght
1957-08	1958-04	8
1960-04	1961-02	10
1969-12	1970-11	11
1973-11	1975-03	16
1980-01	1980-07	6
1981-07	1982-11	16
1990-07	1991-03	8
2001-03	2001-11	8
2007-12	2009-06	18

Figure 15. Recession Indicator – Contraction and Expansion

The figure shows the Contraction and Expansion periods as defined by NBER from the period of 1957 to 2018. Contraction periods are characterized by the bars equal to 1. By definition, not being in contraction means that the economy is situated in expansion.



E. Appendix – Model

In this subsection some derivations and equations stated in the main text are derived and explained in more detail.

E.1. Assets in Place

The time-t market value of an existing project j, $p(\varepsilon_{ft}, u_{jt}, x_t, K_j)$ is equal to the present value of its cash flows

$$p(\varepsilon_{ft}, u_{jt}, x_t, K_j) = \mathrm{E}_t[\int_t^\infty e^{-\delta(s-t)}\frac{\pi_s}{\pi_t}y_{fjs}ds] = \mathrm{E}_t[\int_t^\infty e^{-\delta(s-t)}\frac{\pi_s}{\pi_t}\varepsilon_{fs}u_{js}x_sK_j^\alpha ds] = A(\varepsilon_{ft}, u_{jt})x_tK_j^\alpha, \tag{A9}$$

where

$$A(\varepsilon, u) = \frac{1}{r+\gamma_x\sigma_x+\delta-\mu_x} + \frac{1}{r+\gamma_x\sigma_x+\delta-\mu_x+\theta_\varepsilon}(\varepsilon-1) + \frac{1}{r+\gamma_x\sigma_x+\delta-\mu_x+\theta_u}(u-1)$$
$$+\frac{1}{r+\gamma_x\sigma_x+\delta-\mu_x+\theta_\varepsilon+\theta_u}(\varepsilon-1)(u-1). \tag{A10}$$

E.2. Optimal Investment

The optimal investment K_j of firm f in project j at time t is given by

$$K_f = (z_t \alpha A(\epsilon_{f_t}, 1))^{\frac{1}{1-\alpha}}. \tag{A11}$$

Proof: K_f is the solution to the problem

$$\max_{K_f} A(\epsilon_{f_t}, 1) x_t K_f^{\alpha} - z_t^{-1} x_t K_f \tag{A12}$$

The first order condition reads as

$$0 = \frac{\partial}{\partial K_f}[A(\epsilon_{f_t}, 1) x_t K_f^{\alpha} - z_t^{-1} x_t K_f] = \alpha A(\epsilon_{f_t}, 1) K_f^{\alpha-1} - z_t^{-1}, \tag{A13}$$

and hence

$$K_f^{\alpha-1} = z_t^{-1}(\alpha A(\epsilon_{f_t}, 1))^{-1} \quad \Rightarrow \quad K_f = (z_t \alpha A(\epsilon_{f_t}, 1))^{\frac{1}{1-\alpha}}. \tag{A14}$$

E.3. The Value of Growth Opportunities

The NPV of future projects determines the value of growth opportunities. The value added net of investment costs, when a project is financed is

$$K_f A(\epsilon_{f_t}, 1) x_t - \frac{K_f x_t}{z_t} = [\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}] z_t^{\frac{\alpha}{1-\alpha}} x_t A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}} = C z_t^{\frac{\alpha}{1-\alpha}} x_t A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}}. \tag{A15}$$

The present value of growth options can then be written as

$$\begin{aligned} PVGO_{ft} &= \mathrm{E}_t^{\mathbb{Q}}[\int_t^{\infty} e^{-r(s-t)} \lambda_{fs} C z_t^{\frac{\alpha}{1-\alpha}} x_t A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}} ds] \\ &= C z_t^{\frac{\alpha}{1-\alpha}} x_t \mathrm{E}_t[\int_t^{\infty} e^{-\rho(s-t)} \lambda_{fs} A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}} ds] \\ &= C z_t^{\frac{\alpha}{1-\alpha}} x_t G(\varepsilon_{ft}, \lambda_{ft}). \end{aligned} \tag{A16}$$

where E_t^Q denotes the expectations under the risk-neutral measure $\mathbb{Q}$.

$$\begin{aligned} G_{ft} := G(\varepsilon_{ft}, \lambda_{ft}) &= C \cdot \mathrm{E}_t[\int_t^{\infty} e^{-\rho(s-t)\lambda_{fs}} A(\varepsilon_{fs})^{\frac{1}{1-\alpha}} ds] \\ &= \begin{cases} \lambda_f (G_1(\varepsilon_{ft}) + \frac{\mu_L}{\mu_L+\mu_H}(\lambda_H - \lambda_L) G_2(\varepsilon_{ft})) & \bar{\lambda}_{ft} = \lambda_H \\ \lambda_f (G_1(\varepsilon_{ft}) - \frac{\mu_H}{\mu_L+\mu_H}(\lambda_H - \lambda_L) G_2(\varepsilon_{ft})) & \bar{\lambda}_{ft} = \lambda_L \end{cases} \end{aligned} \tag{A17}$$

with

$$\rho = r + \gamma_x \sigma_x - \mu_x - \frac{\alpha}{1-\alpha}(\mu_z - \gamma_z \sigma_z + \frac{1}{2}\sigma_z^2) - \frac{\alpha^2 \sigma_z^2}{2(1-\alpha)^2}, \tag{A18}$$

$$C = \alpha^{\frac{1}{1-\alpha}}(\alpha^{-1} - 1). \tag{A19}$$

The functions $G_1(\varepsilon)$ and $G_2(\varepsilon)$ solve the following ODE

$$a(\varepsilon)z' - b(\varepsilon)z - \rho y + c(\varepsilon) = 0, \tag{A20}$$

where $a(\varepsilon) = \frac{1}{2}\sigma_\varepsilon^2 \varepsilon, b(\varepsilon) = \theta_\varepsilon(\varepsilon - 1), c(\varepsilon) = CA(\varepsilon, 1)^{\frac{1}{1-\alpha}}, y = G$, and $z = G'$.

For further details see Kogan and Papanikolaou (2014)

E.4. Value and Growth Dynamics

For notational convenience define $\sum_j A_{ft} := \sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^\alpha$ and $G_{ft} := G(\varepsilon_{ft}, \lambda_{ft})$. The dynamics of value of assets in place can be written as:

$$dVAP_{ft} = dx_t \sum_j A_{ft} + x_t d \sum_j A_{ft} + dx_t d \sum_j A_{ft} = dx_t \sum_j A_{ft} + x_t d \sum_j A_{ft}, \tag{A21}$$

and therefore

$$\frac{dVAP_{ft}}{VAP_{ft}} = \frac{dx_t}{x_t} \frac{\sum_j A_{ft}}{\sum_j A_{ft}} + \frac{x_t}{x_t} \frac{d \sum_j A_{ft}}{\sum_j A_{ft}} = \frac{dx_t}{x_t} + \frac{d \sum_j A_{ft}}{\sum_j A_{ft}}. \tag{A22}$$

The dynamics of the present value of growth options can be written as:

$$dPVGO_{ft} = d(z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}) = d(z_t^{\frac{\alpha}{1-\alpha}} x_t) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} + d(z_t^{\frac{\alpha}{1-\alpha}} x_t) dG_{ft}. \tag{A23}$$

First calculate

$$\begin{aligned} d(z_t^{\frac{\alpha}{1-\alpha}} x_t) &= z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t d(z_t^{\frac{\alpha}{1-\alpha}}) + d[x_t, z_t^{\frac{\alpha}{1-\alpha}}] \\ &= z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t d(z_t^{\frac{\alpha}{1-\alpha}}) \\ &= z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + x_t \frac{1}{2} \frac{\partial^2 z_t^{\frac{\alpha}{1-\alpha}}}{\partial z^2} \sigma_z^2 z_t^2 dt \\ &= z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + x_t R(z_t) dt, \end{aligned} \tag{A24}$$

and therefore

$$dPVGO_{ft} = (z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + x_t R(z_t) dt) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}. \tag{A25}$$

In relative terms one obtains

$$\begin{aligned}\frac{dPVGO_{ft}}{PVGO_{ft}} &= \frac{z_t^{\frac{\alpha}{1-\alpha}} dx_t}{z_t^{\frac{\alpha}{1-\alpha}} x_t} + \frac{x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t}{z_t^{\frac{\alpha}{1-\alpha}} x_t} + \frac{R(z_t)dt}{z_t^{\frac{\alpha}{1-\alpha}}} + \frac{z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}}{z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}} \\ &= \frac{dx_t}{x_t} + \frac{\alpha}{1-\alpha}\frac{dz_t}{z_t} + \frac{R(z_t)dt}{z_t^{\frac{\alpha}{1-\alpha}}} + \frac{dG_{ft}}{G_{ft}}. \end{aligned} \tag{A26}$$

E.5. Expected Returns Dynamics

The risk premium on assets in place (growth opportunities) can by calculated by the covariance with the pricing kernel

$$\frac{d\pi_t}{\pi_t} = -rdt - \gamma_x dB_{xt} - \gamma_z dB_{zt}. \tag{A27}$$

Therefore

$$\mathrm{E}_t[R_{ft}^{VAP}] - r_f = -cov(\frac{dVAP_{ft}}{VAP_{ft}}, \frac{d\pi_t}{\pi_t}) = -cov(\frac{dx_t}{x_t}, \frac{d\pi_t}{\pi_t}) = \sigma_x \gamma_x dt, \tag{A28}$$

and

$$\mathrm{E}_t[R_{ft}^{GO}] - r_f = -cov(\frac{dPVGO_{ft}}{PVGO_{ft}}, \frac{d\pi_t}{\pi_t}) = -cov(\frac{dx_t}{x_t} + \frac{\alpha}{1-\alpha}\frac{dz_t}{z_t}, \frac{d\pi_t}{\pi_t}) = \sigma_x\gamma_x dt + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z dt. \tag{A29}$$

And hence

$$\begin{aligned}\mathrm{E}_t[R_{ft}] - r_f &= \frac{VAP_{ft}}{V_t}(\mathrm{E}_t[R_{ft}^{VAP}] - r_f) + \frac{PVGO_{ft}}{V_t}(\mathrm{E}_t[R_{ft}^{GO}] - r_f) \\ &= \frac{VAP_{ft}}{V_t}(\sigma_x\gamma_x) + \frac{PVGO_{ft}}{V_t}(\sigma_x\gamma_x + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z) \\ &= \sigma_x\gamma_x + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z\frac{PVGO_{ft}}{V_t}. \end{aligned} \tag{A30}$$

E.6. Return Dynamics

The dynamics for the changes in firm value can be calculated as follows

$$
\begin{aligned}
dV_{ft} &= dVAP_{ft} + dPVGO_{ft} \\
&= \sum_j A_{ft} dx_t + x_t d \sum_j A_{ft} + (z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + R(z_t)dt) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} \\
&= R(z_t) G_{ft} dt + (\sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} G_{ft}) dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} G_{ft} dz_t + x_t d \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} \\
&= \bar{R}(z_t)dt + \sigma_x dB_{xt} (x_t \sum_j A_{ft} + x_t z_t^{\frac{\alpha}{1-\alpha}} G_{ft}) + x_t z_t^{\frac{\alpha}{1-\alpha}} G_{ft} \frac{\alpha}{1-\alpha} \sigma_z dB_{zt} + dIdio_f \\
&= \bar{R}(z_t)dt + \sigma_x dB_{xt} V_{ft} + \frac{\alpha}{1-\alpha} PVGO_{ft} \sigma_z dB_{zt} + dIdio_f, \qquad \text{(A31)}
\end{aligned}
$$

where $dIdio_f$ denotes the dynamics associated to A_{ft} (as a function of $\varepsilon_{ft}, u_{jt}, K_j^{\alpha}$) and G_{ft}.

$$
dIdio_f = x_t d \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}. \qquad \text{(A32)}
$$

The return dynamic of the firm can be written as

$$
dR_{ft} = \frac{dV_{ft}}{V_{ft}} = \mathrm{E}[R_{ft}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \frac{PVGO_{ft}}{V_{ft}} \sigma_z dB_{zt} + \frac{dIdio_f}{V_{ft}}. \qquad \text{(A33)}
$$

Since idiosyncratic terms are uncorrelated one can calculate the covariance between two returns as follows

$$
\begin{aligned}
dR_{kt} dR_{lt} &= (\mathrm{E}[R_{kt}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \sigma_z \frac{PVGO_{kt}}{V_{kt}} dB_{zt} + \frac{dIdio_k}{V_{kt}}) \\
&\quad \times (\mathrm{E}[R_{lt}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \sigma_z \frac{PVGO_{lt}}{V_{lt}} dB_{zt} + \frac{dIdio_l}{V_{lt}}) \\
&= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 \frac{PVGO_{kt}}{V_{kt}} \frac{PVGO_{lt}}{V_{lt}} dt. \qquad \text{(A34)}
\end{aligned}
$$

The variance of the return process ,$\sigma^2(dR_{ft})$, is given by

$$
\begin{aligned}
dR_{ft} dR_{ft} &= (\mathrm{E}[R_f]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \sigma_z \frac{PVGO_{ft}}{V_{ft}} dB_{zt} + \frac{dIdio_f}{V_f})^2 \\
&= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{ft}}{V_{ft}})^2 dt + (\frac{dIdio_f}{V_{ft}})^2. \qquad \text{(A35)}
\end{aligned}
$$

Therefore the correlation can be calculates as

$$\frac{dR_{kt}dR_{lt}}{\sqrt{\sigma^2(dR_{kt})}\sqrt{\sigma^2(dR_{lt})}} = \frac{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2 \frac{PVGO_{kt}}{V_{kt}}\frac{PVGO_{lt}}{V_{lt}}dt}{\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{kt}}{V_{kt}})^2 dt + dIdio_k^2}\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{lt}}{V_{lt}})^2 dt + dIdio_l^2}}. \tag{A36}$$

F. Market Return Dynamics

To aggregate the individual components into the market index, it is assumed that constituents are market cap weighted, hence $V_{it}/\sum V_{it} := V_{it}/V_{Mt}$. The market return can be written as

$$\begin{aligned}\sum_f \frac{1}{dt}\frac{V_{ft}}{V_{Mt}}E[R_{ft}] - r_f &= \sum_f \frac{V_{ft}}{V_{Mt}}\gamma_x\sigma_x + \frac{\alpha}{1-\alpha}\gamma_z\sigma_z\sum_f \frac{V_{ft}}{V_{Mt}}\frac{PVGO_{ft}}{V_{ft}} \\ &= \gamma_x\sigma_x + \frac{\alpha}{1-\alpha}\gamma_z\sigma_z\sum_f \frac{PVGO_{ft}}{V_{Mt}} \\ &= \gamma_x\sigma_x + \frac{\alpha}{1-\alpha}\gamma_z\sigma_z\frac{PVGO_{Mt}}{V_{Mt}}, \end{aligned} \tag{A37}$$

where $PVGO_M := \sum_f PVGO_f$.

The market return variance can be written as

$$\begin{aligned}\sum_k\sum_l w_k w_l dR_{kt}dR_{lt} &= \sum_k\sum_l \frac{V_{kt}}{V_{Mt}}\frac{V_{lt}}{V_{Mt}}\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2\sum_k\sum_l \frac{V_{kt}}{V_{Mt}}\frac{V_{lt}}{V_{Mt}}\frac{PVGO_{kt}}{V_{kt}}\frac{PVGO_{lt}}{V_{lt}}dt \\ &= \sum_k\sum_l \frac{V_{kt}}{V_{Mt}}\frac{V_{lt}}{V_{Mt}}\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2\sum_k\sum_l \frac{PVGO_{kt}}{V_{Mt}}\frac{PVGO_{lt}}{V_{Mt}}dt \\ &= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{Mt}}{V_{Mt}})^2 dt, \end{aligned} \tag{A38}$$

where the last step follows with $\sum_k\sum_l \frac{V_{kt}}{V_{Mt}}\frac{V_{lt}}{V_{Mt}} = 1$ and

$$PVGO_M^2 := (\sum_k PVGO_k)^2 = \sum_k\sum_l PVGO_k PVGO_l.$$

AI1. Robustness

A. Robustness – Non-Overlapping

Figure AI1. Predictive: PVGO Proxies – Changes – Non-overlapping

This figure reports the average R^2s and the$t$-statistic of the univariate predictive regressions of future (log) changes of common proxies for the present value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) from matching-maturity options. The sample period ranges from 01/1996 to 12/2017. The data is sampled at a frequency equal to the predictive horizon (i.e., non overlapping). The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C.

A: R^2 – GO Proxies *B: t-stats – GO Proxies*

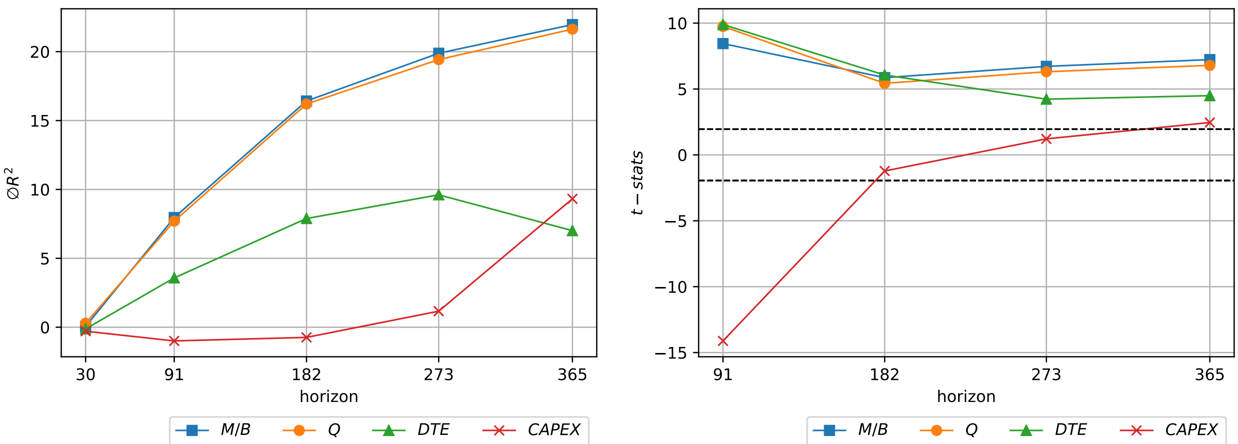
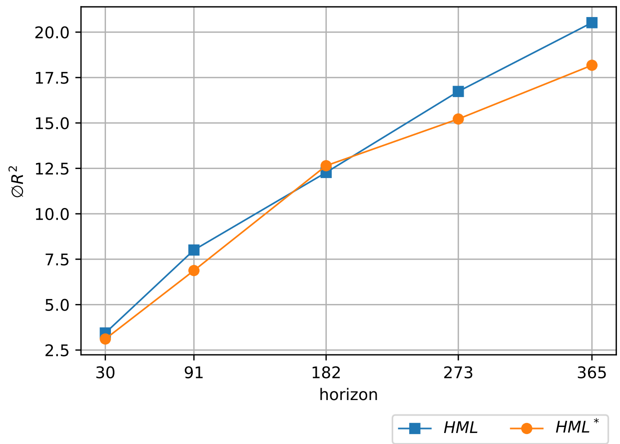


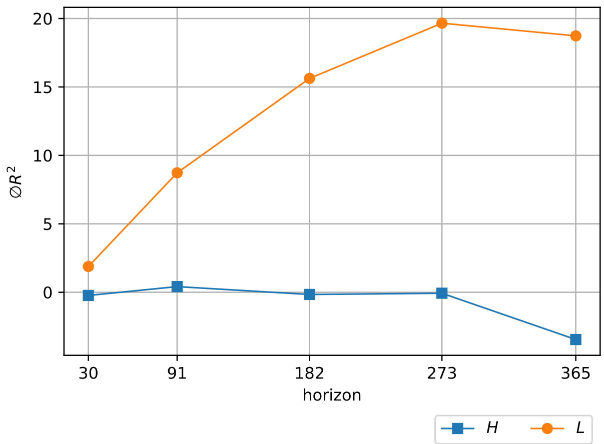
Figure AI2. Predictive: Factor Returns – Non-overlapping

The figure shows the average R^2s of the regressions of the value factor returns (HML, HML^*, CMA, CMA^*, RMW, RMW^*), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) and implied variance (IV) for the S&P500 Index from matching-maturity options. The sample period ranges from 01/1996 to 12/2017. The data is sampled at a frequency equal to the predictive horizon (i.e., non overlapping). The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

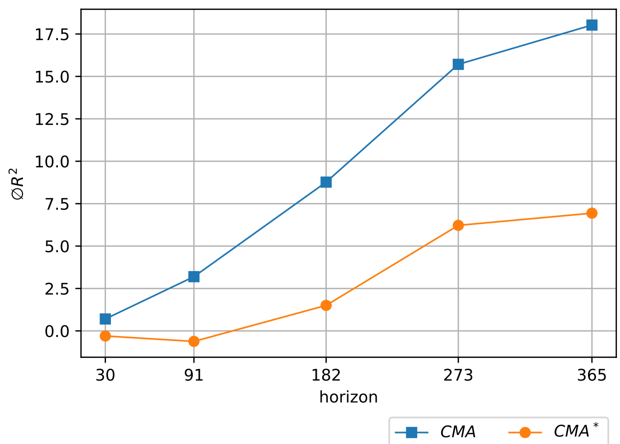
A: R^2 – HML and HML^*



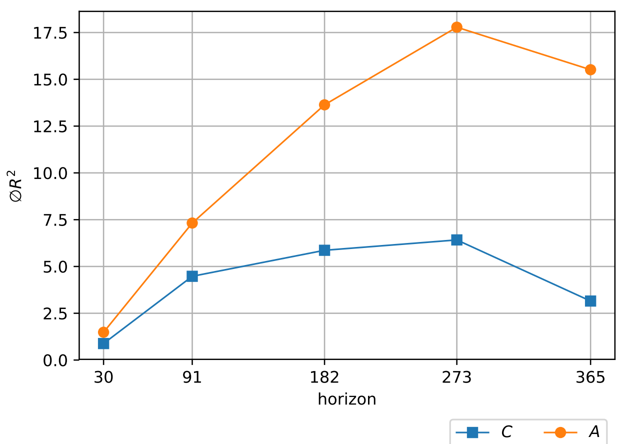
B: R^2 – H and L



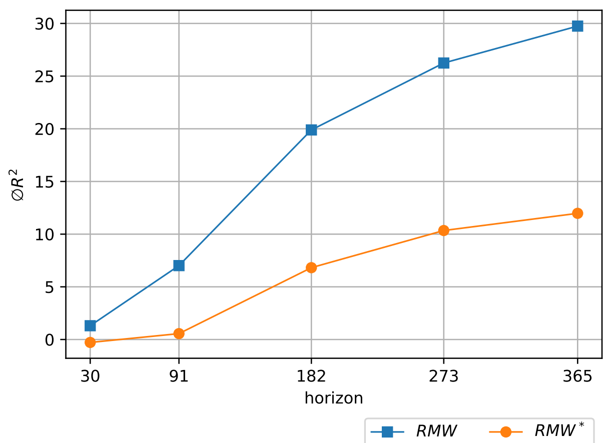
C: R^2 – CMA and CMA^*



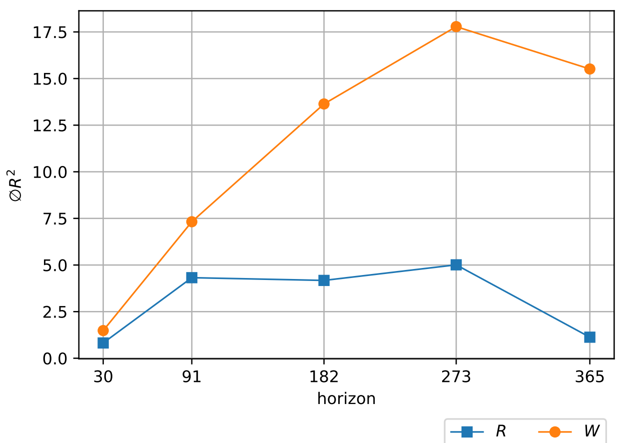
D: R^2 – C and A



E: R^2 – RMW and RMW^*



F: R^2 – R and W



B. Robustness – Controls

Table AI101 Predictive: PVGO Proxies – Changes – with Volatility Controls

The table reports the slopes and the R^2 of the predictive regressions of future (log) changes of common proxies for the present value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) and implied variance (IV) from matching-maturity options. As a proxy for idiosyncratic risk the value-weighted sum of squared residuals ($VWIV$) is calculated from a Fama and French five factor model for the while CRSP universe. The sample period ranges from 01/1996 to 12/2017. The data is sampled at a monthly frequency. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the PVGO proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C.

	30 days		91 days		182 days		273 days		365 days	
M/B										
IC	0.162	0.120	0.417	0.292	0.808	0.677	1.134	0.903	1.596	1.218
	(0.243)	(0.261)	(0.007)	(0.001)	(0.004)	(0.003)	(0.009)	(0.008)	(0.006)	(0.013)
IV	-0.138	-	-0.405	-	-0.140	-	-0.472	-	-1.150	-
	(0.723)	-	(0.375)	-	(0.863)	-	(0.726)	-	(0.525)	-
$VWIV$	-	-2.310	-	-2.356	-	-1.339	-	-1.138	-	-1.123
	-	(0.737)	-	(0.144)	-	(0.328)	-	(0.324)	-	(0.261)
R^2	-0.312	-0.358	7.239	10.235	14.516	17.628	17.810	21.613	21.874	25.501
Q										
IC	0.240	0.172	0.504	0.344	0.924	0.735	1.307	0.983	1.859	1.358
	(0.107)	(0.157)	(0.003)	(0.001)	(0.003)	(0.003)	(0.006)	(0.008)	(0.003)	(0.013)
IV	-0.248	-	-0.507	-	-0.127	-	-0.578	-	-1.449	-
	(0.545)	-	(0.333)	-	(0.888)	-	(0.698)	-	(0.471)	-
$VWIV$	-	-4.477	-	-3.072	-	-1.906	-	-1.600	-	-1.514
	-	(0.531)	-	(0.082)	-	(0.203)	-	(0.210)	-	(0.180)
R^2	-0.037	-0.024	7.539	11.207	14.172	18.473	17.674	22.722	22.152	26.936
DTE										
IC	0.313	0.131	-0.184	-0.169	-0.356	-0.348	-0.466	-0.388	-0.553	-0.405
	(0.188)	(0.481)	(0.053)	(0.025)	(0.020)	(0.013)	(0.035)	(0.076)	(0.080)	(0.172)
IV	-0.723	-	-0.152	-	-1.020	-	-1.320	-	-1.317	-
	(0.428)	-	(0.718)	-	(0.057)	-	(0.096)	-	(0.227)	-
$VWIV$	-	-16.120	-	1.858	-	1.257	-	1.131	-	1.078
	-	(0.084)	-	(0.187)	-	(0.279)	-	(0.224)	-	(0.163)
R^2	-0.326	0.349	3.958	8.554	11.576	14.344	12.545	16.470	11.645	17.894
$CAPEX$										
IC	-0.110	-0.100	0.000	-0.134	0.106	-0.254	0.400	0.182	0.758	0.495
	(0.530)	(0.488)	(0.999)	(0.504)	(0.644)	(0.283)	(0.087)	(0.458)	(0.002)	(0.068)
IV	0.112	-	-0.387	-	-1.938	-	-1.448	-	-2.032	-
	(0.866)	-	(0.616)	-	(0.040)	-	(0.102)	-	(0.096)	-
$VWIV$	-	-0.610	-	-2.042	-	-1.434	-	-0.630	-	-0.508
	-	(0.926)	-	(0.218)	-	(0.155)	-	(0.366)	-	(0.344)
R^2	-0.667	-0.662	-0.685	-0.379	0.360	-0.117	0.302	0.009	13.937	11.024

Table AI102 Predictive: Factor Returns with Volatility Controls

The table shows the slope and the R^2s of the regressions of the excess market- and value factor returns realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) and implied variance (IV) from matching-maturity options. As a proxy for idiosyncratic risk the value-weighted sum of squared residuals ($VWIV$) is calculated from a Fama and French five factor model for the while CRSP universe. The sample period is from 01/1996 to 12/2017, and the variables are sampled at daily frequency. The market neutral returns are estimated applying equation (25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The $p-values$ (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
MKTRF										
IC	0.090	0.054	0.309	0.199	0.522	0.332	0.722	0.438	0.901	0.481
	(0.002)	(0.032)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.005)	(0.000)	(0.014)
IV	-0.169	-	-0.357	-	0.045	-	0.325	-	0.017	-
	(0.230)	-	(0.360)	-	(0.920)	-	(0.623)	-	(0.985)	-
VWIV	-	-3.443	-	-2.135	-	-1.747	-	-1.574	-	-1.595
	-	(0.025)	-	(0.011)	-	(0.013)	-	(0.006)	-	(0.001)
R^2	3.825	7.929	15.073	24.377	22.580	36.569	26.947	42.341	25.484	47.041
HML										
IC	-0.040	-0.048	-0.144	-0.161	-0.363	-0.364	-0.570	-0.544	-0.843	-0.759
	(0.104)	(0.003)	(0.046)	(0.001)	(0.019)	(0.001)	(0.022)	(0.003)	(0.012)	(0.004)
IV	-0.055	-	-0.155	-	0.099	-	0.507	-	0.946	-
	(0.573)	-	(0.613)	-	(0.837)	-	(0.481)	-	(0.325)	-
VWIV	-	0.395	-	0.130	-	-0.083	-	-0.046	-	0.059
	-	(0.729)	-	(0.850)	-	(0.899)	-	(0.936)	-	(0.908)
R^2	3.516	3.394	9.791	9.383	15.720	15.701	21.087	20.186	28.093	26.137
*HML**										
IC	-0.027	-0.039	-0.103	-0.133	-0.262	-0.312	-0.400	-0.474	-0.582	-0.669
	(0.154)	(0.002)	(0.039)	(0.000)	(0.008)	(0.000)	(0.012)	(0.000)	(0.008)	(0.000)
IV	-0.089	-	-0.293	-	-0.504	-	-0.619	-	-0.633	-
	(0.236)	-	(0.093)	-	(0.138)	-	(0.218)	-	(0.346)	-
VWIV	-	0.665	-	0.326	-	-0.055	-	-0.162	-	-0.154
	-	(0.509)	-	(0.587)	-	(0.907)	-	(0.667)	-	(0.636)
R^2	3.922	3.527	9.911	8.448	16.625	14.447	20.801	19.256	25.366	24.502

Table AI103 Predictive: Factor Returns with PVGO Controls

The table shows the slope and the R^2s of the regressions of the excess market- and value factor returns realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 index controlling for PVGO proxies: the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C. The sample period is from 01/1996 to 12/2017, and the variables are sampled at monthly frequency. The market neutral returns are estimated applying equation (25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The $p-values$ (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
MKTRF										
IC	0.056	0.055	0.232	0.230	0.482	0.480	0.625	0.621	0.676	0.672
	(0.025)	(0.026)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
M/B	0.001	-	0.000	-	0.002	-	-0.001	-	-0.010	-
	(0.504)	-	(0.926)	-	(0.728)	-	(0.923)	-	(0.170)	-
Q	-	0.001	-	-0.000	-	0.001	-	-0.001	-	-0.010
	-	(0.532)	-	(0.963)	-	(0.778)	-	(0.845)	-	(0.145)
DTE	0.032	0.030	0.062	0.060	0.194	0.191	0.273	0.271	0.361	0.367
	(0.485)	(0.503)	(0.257)	(0.267)	(0.008)	(0.008)	(0.006)	(0.005)	(0.007)	(0.005)
CAPEX	-0.081	-0.080	-0.007	-0.002	0.073	0.076	-0.116	-0.110	-0.105	-0.099
	(0.217)	(0.222)	(0.943)	(0.984)	(0.565)	(0.546)	(0.488)	(0.510)	(0.563)	(0.582)
R^2	2.572	2.549	11.844	11.842	21.434	21.418	26.176	26.187	27.783	27.888
HML										
IC	-0.037	-0.037	-0.119	-0.122	-0.261	-0.272	-0.340	-0.353	-0.468	-0.484
	(0.009)	(0.008)	(0.005)	(0.004)	(0.010)	(0.008)	(0.038)	(0.032)	(0.044)	(0.039)
M/B	0.001	-	0.004	-	0.008	-	0.017	-	0.027	-
	(0.541)	-	(0.422)	-	(0.235)	-	(0.084)	-	(0.027)	-
Q	-	0.001	-	0.003	-	0.006	-	0.015	-	0.025
	-	(0.616)	-	(0.528)	-	(0.363)	-	(0.156)	-	(0.059)
DTE	-0.045	-0.047	0.016	0.011	0.069	0.057	0.139	0.120	0.203	0.175
	(0.148)	(0.131)	(0.727)	(0.811)	(0.315)	(0.394)	(0.118)	(0.169)	(0.101)	(0.146)
CAPEX	-0.023	-0.020	0.074	0.083	0.057	0.075	0.178	0.199	0.200	0.223
	(0.648)	(0.686)	(0.300)	(0.246)	(0.607)	(0.490)	(0.200)	(0.145)	(0.249)	(0.187)
R^2	3.992	3.896	9.512	9.205	15.622	14.999	22.774	21.887	32.068	31.069
*HML**										
IC	-0.033	-0.033	-0.114	-0.117	-0.246	-0.254	-0.329	-0.338	-0.457	-0.465
	(0.007)	(0.006)	(0.002)	(0.002)	(0.003)	(0.002)	(0.009)	(0.007)	(0.013)	(0.012)
M/B	0.000	-	0.000	-	0.003	-	0.006	-	0.009	-
	(0.857)	-	(0.902)	-	(0.533)	-	(0.375)	-	(0.299)	-
Q	-	0.000	-	-0.000	-	0.001	-	0.005	-	0.008
	-	(0.947)	-	(0.965)	-	(0.756)	-	(0.516)	-	(0.386)
DTE	-0.045	-0.046	-0.020	-0.022	-0.014	-0.019	0.011	0.002	0.045	0.034
	(0.064)	(0.056)	(0.634)	(0.592)	(0.837)	(0.766)	(0.902)	(0.983)	(0.685)	(0.759)
CAPEX	-0.013	-0.011	0.102	0.109	0.091	0.104	0.165	0.179	0.258	0.271
	(0.700)	(0.752)	(0.098)	(0.077)	(0.439)	(0.376)	(0.236)	(0.196)	(0.152)	(0.131)
R^2	3.602	3.575	7.671	7.658	13.225	13.069	17.297	17.005	23.033	22.736

Table AI104 Predictive: Factor Returns with Controls

The table shows the slope and the R^2s of the regressions of the excess market- and value factor returns realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 index. The sample period is from 01/1996 to 12/2017, and the variables are sampled at monthly frequency. The Earnings Price Ratio (EP), the Term Spread (TMS), the Default Yield Spread (DFY), the Book-to-Market Ratio (B/M), and the Net Equity Expansion (NTIS) are constructed from the data and the procedures from the study of Goyal and Welch (2008). The market neutral returns are estimated applying equation (25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The $p-values$ (under the slope) are computed with Newey and West (1987) standard errors.

	Return, 30 days		Return, 91 days		Return, 182 days		Return, 273 days		Return, 365 days	
MKTRF										
IC	0.087	0.051	0.329	0.215	0.629	0.398	0.802	0.539	0.845	0.629
	(0.001)	(0.030)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EP12	-0.006	-	-0.027	-	-0.051	-	-0.046	-	-0.007	-
	(0.547)	-	(0.227)	-	(0.160)	-	(0.331)	-	(0.903)	-
TMS	-0.148	-	-0.692	-	-1.258	-	-0.827	-	0.541	-
	(0.494)	-	(0.225)	-	(0.245)	-	(0.556)	-	(0.741)	-
DFY	-1.716	-	-4.066	-	-4.040	-	-2.189	-	0.534	-
	(0.112)	-	(0.145)	-	(0.306)	-	(0.667)	-	(0.925)	-
BM	-	0.042	-	0.112	-	0.319	-	0.519	-	0.734
	-	(0.342)	-	(0.237)	-	(0.038)	-	(0.016)	-	(0.014)
NTIS	-	0.221	-	0.814	-	1.724	-	2.320	-	2.822
	-	(0.268)	-	(0.154)	-	(0.086)	-	(0.100)	-	(0.091)
R^2	3.560	2.791	15.999	15.474	23.488	28.504	24.963	34.216	23.627	35.637
HML										
IC	-0.039	-0.040	-0.142	-0.130	-0.336	-0.311	-0.536	-0.512	-0.842	-0.751
	(0.014)	(0.009)	(0.004)	(0.008)	(0.014)	(0.020)	(0.017)	(0.031)	(0.006)	(0.025)
EP12	-0.009	-	-0.018	-	-0.008	-	0.007	-	0.031	-
	(0.205)	-	(0.315)	-	(0.817)	-	(0.891)	-	(0.612)	-
TMS	-0.046	-	-0.105	-	-0.379	-	-0.572	-	-0.201	-
	(0.779)	-	(0.811)	-	(0.680)	-	(0.688)	-	(0.909)	-
DFY	-0.600	-	-0.411	-	2.314	-	5.215	-	8.044	-
	(0.505)	-	(0.855)	-	(0.514)	-	(0.210)	-	(0.103)	-
BM	-	-0.042	-	-0.092	-	-0.063	-	0.037	-	0.072
	-	(0.188)	-	(0.235)	-	(0.700)	-	(0.870)	-	(0.795)
NTIS	-	-0.093	-	-0.213	-	-0.305	-	-0.135	-	0.046
	-	(0.432)	-	(0.518)	-	(0.593)	-	(0.859)	-	(0.958)
R^2	3.126	3.496	8.616	9.104	14.674	14.024	19.005	16.909	25.195	22.178
*HML**										
IC	-0.027	-0.032	-0.109	-0.107	-0.268	-0.245	-0.406	-0.386	-0.616	-0.576
	(0.047)	(0.011)	(0.010)	(0.003)	(0.006)	(0.010)	(0.004)	(0.016)	(0.001)	(0.009)
EP12	0.000	-	0.006	-	0.023	-	0.042	-	0.064	-
	(0.959)	-	(0.698)	-	(0.413)	-	(0.320)	-	(0.221)	-
TMS	-0.080	-	-0.229	-	-0.317	-	-0.472	-	-0.193	-
	(0.534)	-	(0.548)	-	(0.699)	-	(0.700)	-	(0.901)	-
DFY	-0.715	-	-1.121	-	-1.016	-	-0.319	-	0.580	-
	(0.258)	-	(0.476)	-	(0.727)	-	(0.929)	-	(0.894)	-
BM	-	-0.036	-	-0.108	-	-0.123	-	-0.051	-	0.017
	-	(0.159)	-	(0.119)	-	(0.434)	-	(0.818)	-	(0.949)
NTIS	-	-0.038	-	-0.148	-	-0.105	-	0.218	-	0.711
	-	(0.757)	-	(0.670)	-	(0.847)	-	(0.762)	-	(0.364)
R^2	3.367	3.066	8.173	8.391	14.933	13.505	18.633	15.965	23.367	21.255

C. *Robustness – Full Sample, Expansion and Contraction*

Table AI105 Predictive: PVGO Proxies – Changes – RC – Full Sample

This table shows the slope and the R^2s of the univariate regressions of (log) changes of common proxies for the present value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on realized correlations (RC) calculated from daily realized returns over the respective window. The sample period for realized correlations is ranging from 01/1965 to 12/2017. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The sample period for the PVGO proxies ranges from 1983 to 2018. The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix I.C. The $p-values$ are computed with Newey and West (1987) standard errors.

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
RC	-0.060	0.392	-0.129	0.178	0.008	2.382	0.132	0.267	0.482	0.200	0.250	0.907	0.294	0.217	1.492
Q															
RC	-0.073	0.364	-0.111	0.213	0.006	2.312	0.180	0.189	0.703	0.236	0.241	0.893	0.346	0.210	1.484
DTE															
RC	0.114	0.401	-0.119	-0.101	0.067	0.680	-0.041	0.729	-0.151	-0.008	0.960	-0.239	-0.130	0.438	0.330
$CAPEX$															
RC	0.019	0.855	-0.233	-0.024	0.890	-0.234	-0.268	0.111	0.250	-0.101	0.477	-0.167	-0.061	0.684	-0.096

Table AI106 Predictive: Factor Returns – RC – Full Sample

The table shows the slope and the R^2s of the regressions of the excess market and value factor returns realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on realized correlations (RC) for the S&P500 Index. Realized correlation are obtained via Eq. (24) and calculated from daily realized returns over a respective backward-looking window, corresponding to the predictive horizon. The sample period ranges from 01/1965 to 12/2018 for realized correlations, the variables are sampled at daily frequency. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website. The intercept is not shown. The p-values (under the slope) are computed with Newey and West (1987) standard errors.

Panel A: Factors

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
MKTRF					
RC	0.023	0.128	0.223	0.262	0.381
	(0.050)	(0.000)	(0.002)	(0.016)	(0.005)
R^2	0.444	3.525	4.517	3.942	6.168
HML					
RC	-0.017	-0.070	-0.062	-0.092	-0.154
	(0.023)	(0.010)	(0.228)	(0.268)	(0.171)
R^2	0.624	2.158	0.670	0.853	1.660
*HML**					
RC	-0.016	-0.066	-0.094	-0.145	-0.218
	(0.014)	(0.005)	(0.059)	(0.070)	(0.042)
R^2	0.761	2.339	1.986	2.889	4.437

Panel B: Legs

	Return, 30 days	Return, 91 days	Return, 182 days	Return, 273 days	Return, 365 days
H					
RC	0.002	0.088	0.180	0.169	0.237
	(0.894)	(0.069)	(0.050)	(0.219)	(0.162)
R^2	-0.005	1.146	2.014	1.144	1.653
L					
RC	0.019	0.155	0.235	0.248	0.372
	(0.162)	(0.000)	(0.005)	(0.047)	(0.014)
R^2	0.202	3.119	3.076	2.186	3.689

Table AI107 Predictive: PVGO Proxies – RC – Contraction and Expansion

This table shows the slope and the R^2s of the univariate regressions of (log) changes of common proxies for the present value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on realized correlations (RC) calculated from daily realized returns over the respective window. The sample period for realized correlations is ranging from 01/1965 to 12/2017. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see I.C. The sample period for the PVGO proxies ranges from 1983 to 2018. The sample is divided into contraction and expansion according to the manifestation of the NBER Recession Indicator, see Appendix I.D. The $p-values$ are computed with Newey and West (1987) standard errors.

Panel A: Contraction

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
RC	-0.388	0.102	0.825	0.109	0.552	-1.913	0.392	0.018	3.111	0.273	0.369	-0.492	0.520	0.023	3.829
Q															
RC	-0.473	0.081	1.559	0.134	0.587	-2.048	0.503	0.021	2.755	0.352	0.373	-0.607	0.644	0.031	3.276
DTE															
RC	-0.008	0.989	-2.857	-0.207	0.461	-1.147	-0.684	0.009	6.393	-0.716	0.115	5.125	-1.016	0.012	11.622
$CAPEX$															
RC	-0.142	0.665	-2.663	-0.587	0.309	-0.205	-0.452	0.350	-1.548	-0.065	0.884	-2.828	0.133	0.720	-1.832

Panel B: Expansion

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
RC	-0.032	0.664	-0.229	0.203	0.004	2.974	0.137	0.275	0.471	0.242	0.198	1.299	0.323	0.201	1.719
Q															
RC	-0.039	0.653	-0.226	0.243	0.002	2.964	0.188	0.192	0.729	0.285	0.182	1.325	0.381	0.188	1.745
DTE															
RC	0.129	0.370	-0.107	-0.105	0.050	0.781	0.016	0.883	-0.248	0.056	0.684	-0.114	-0.052	0.729	-0.167
$CAPEX$															
RC	0.036	0.755	-0.245	0.049	0.781	-0.241	-0.208	0.250	0.016	-0.028	0.839	-0.260	0.026	0.823	-0.242

Table AI108 Predictive: PVGO Proxies – IC – Contraction and Expansion

This table shows the slope and the R^2s of the univariate regressions of (log) changes of common proxies for the present value of growth options over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) from matching-maturity options and realized correlations (RC) calculated from daily realized returns over the respective window. The sample period for realized correlations is ranging from 01/1965 to 12/2017, and for implied correlations extracted for the S&P500 from 01/1996 to 12/2017. The proxies for PVGO include the ratio of the market value to book value of assets (M/B), an estimate of Tobin's Q (Q), the debt to equity ratio (DTE), and the ratio of capital expenditures to fixed assets ($CAPEX$). The data for the calculation of the proxies is obtained from Compustat and available on a monthly frequency. For further details see I.C. The sample period for the PVGO proxies ranges from 1983 to 2018. The sample is divided into contraction and expansion according to the manifestation of the NBER Recession Indicator, see Appendix I.D. The $p-values$ are computed with Newey and West (1987) standard errors.

Panel A: Contraction

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
IC	0.141	0.689	-3.500	0.439	0.044	8.775	0.703	0.086	12.220	0.608	0.278	8.085	0.946	0.057	25.623
Q															
IC	0.203	0.588	-3.289	0.547	0.055	7.827	0.912	0.091	11.848	0.792	0.283	7.758	1.182	0.075	23.832
DTE															
IC	0.147	0.850	-3.756	-0.634	0.054	11.590	-1.218	0.039	20.981	-1.152	0.189	14.105	-1.499	0.088	25.457
$CAPEX$															
IC	-0.763	0.268	0.526	-0.642	0.367	-0.969	-0.368	0.511	-3.156	0.172	0.734	-3.683	0.460	0.104	8.976

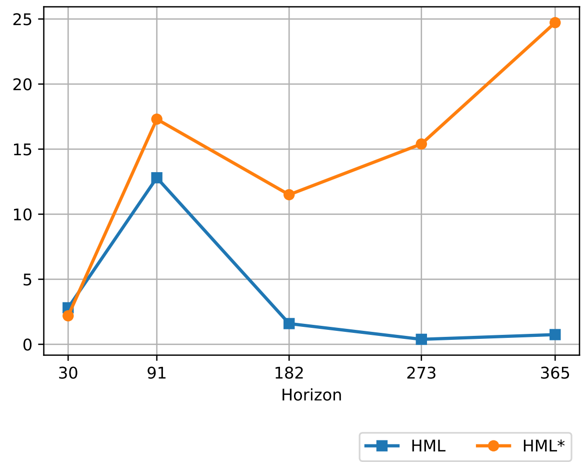
Panel B: Expansion

	30 days			91 days			182 days			273 days			365 days		
	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2	β	$p-val$	R^2
M/B															
IC	0.147	0.191	0.055	0.361	0.004	6.966	0.793	0.005	14.523	1.134	0.016	18.247	1.560	0.016	21.322
Q															
IC	0.210	0.094	0.327	0.432	0.002	7.303	0.895	0.004	14.158	1.287	0.014	18.069	1.791	0.013	21.414
DTE															
IC	0.203	0.292	-0.139	-0.170	0.025	3.494	-0.355	0.010	7.512	-0.466	0.037	8.659	-0.505	0.113	6.859
$CAPEX$															
IC	-0.037	0.795	-0.412	0.008	0.968	-0.427	-0.051	0.840	-0.412	0.269	0.297	-0.016	0.568	0.025	8.560

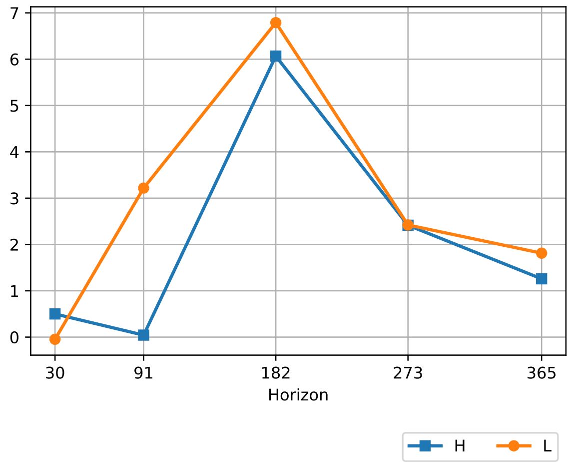
Figure AI3. Predictive: Factor Returns – RC – Expansion and Contraction

The figure shows the $R^2 s$ of the regressions of the value factor returns (HML, HML^*) and the individual long- and short legs returns of the factors (H, L) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on realized correlations (RC). Realized correlation RC is obtained via Eq. (24) and calculated from daily realized returns over a respective window, corresponding to the predictive horizon. The sample period is from 01/1965 to 12/2017, and the variables are sampled at daily frequency. The relevant data for contraction and expansion are defined based on the NBER based Recession Indicator. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

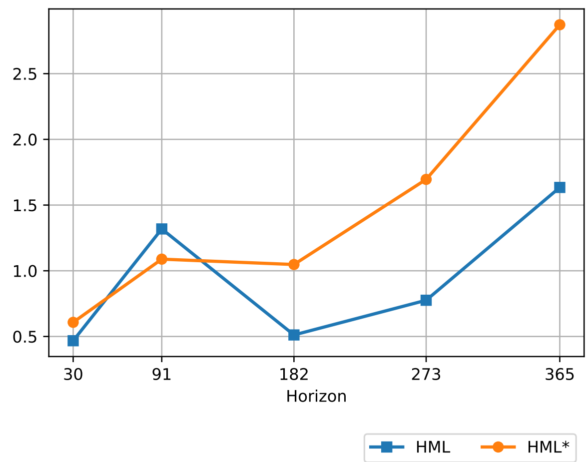
A: R^2 – Factors - Contraction



B: R^2 – Legs of the Factors - Contraction



C: R^2 – Factors - Expansion



D: R^2 – Legs of the Factors – Expansion

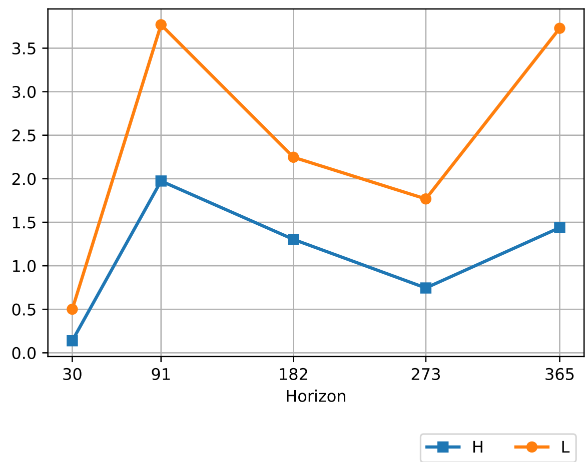
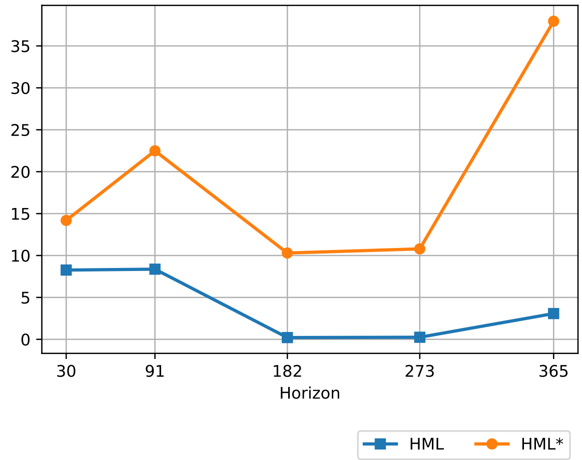


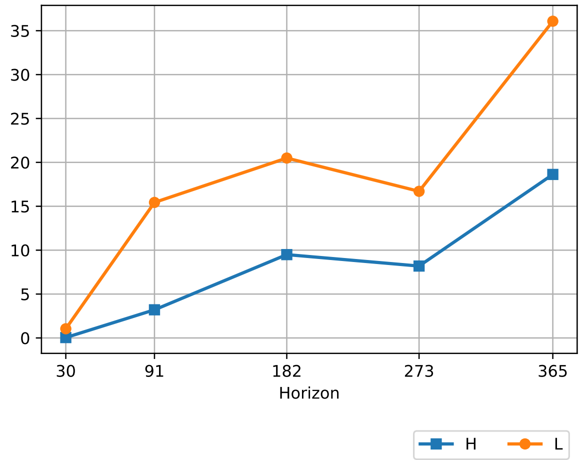
Figure AI4. Predictive: Factor Returns – IC – Expansion and Contraction

The figure shows the R^2s of the regressions of the value factor returns (HML, HML^*) and the individual long- and short legs returns of the factors (H, L) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P500 index from matching-maturity options. The sample period is from 01/1996 to 12/2017, and the variables are sampled at daily frequency. The relevant data for contraction and expansion are defined based on the NBER based Recession Indicator. The market neutral returns are estimated applying Eq.(25) to the factor data, which is obtained from Kenneth French's Website.

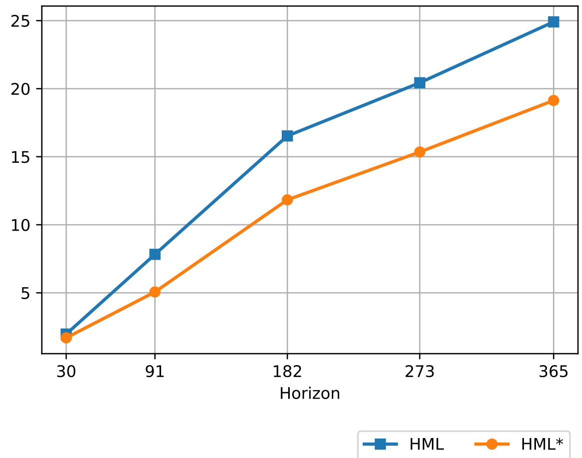
A: R^2 – Factors – Contraction



B: R^2 – Legs of the Factors – Contraction



C: R^2 – Factors – Expansion



D: R^2 – Legs of the Factors – Expansion