Correlations, Value Factor Returns, and Growth Options*

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Abstract

This paper documents that the average equity market correlation is informative about the value of growth options and the correlation dynamics of growth and value stocks and, in turn, forecasts changes in growth options and the returns on the value factor. Consistently, a production-based asset-pricing model shows that correlations are homogeneous among stocks with similar growth characteristics and increasing in the value of growth options. Therefore, the expected average equity correlation serves as a leading procyclical state variable and drives the value premium. Correlations extracted from an equity value index improve the predictability of value-related factors in-sample and out-of-sample.

Keywords: option-implied correlations, value premium, present value of growth options, production model, 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 equity market correlation (market-wide correlation) serves as an important state variable measuring the diversification benefits in financial markets. It predicts market returns and risks, and is, therefore, a variable of interest for investors. The correlation dynamics among stocks stems from a variety of sources, depending on other variables on the economic regime and 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. Market-wide correlations increase not only in market downturns, as documented in previous research, but also in anticipation of a good state due to an increase in individual growth options[1] and, hence, are related to the business cycle. The difference in returns between growth and value portfolios, namely, the returns on the value factor (the value premium) is known to be strongly associated to growth options. Consequently, growth and value portfolios differ not only in their average return but also in their time-varying correlation dynamics among themselves, which can be linked to the business cycle.

The interplay of market-wide correlations and growth options is also connected to returns on the value factor and market returns: Expected market-wide correlations and future valuations are positively related. Hence, when firms accumulate growth options, growth stocks comove more strongly with each other. Due to the accumulation of growth options, growth stocks will gain in value. The higher valuation of growth stocks compared to value stocks will result in a negative return on the value factor.[2]

My main results can be summarized as follows: i) An extension of the production-based asset-pricing model by Kogan and Papanikolaou (2014) shows that stock correlations are increasing in the firm's present value of growth options (PVGO), and, therefore, the average correlation among growth stocks and the average correlation among value stocks display a

[1]Growth options describe the opportunity to undertake positive net present value projects in the future.

[2]The high market capitalization among low book-to-market (B/M) stocks (growth stocks) contributes positively to this effect on a market level, and as another consequence, market returns will increase.

time-varying pattern in which the former exceeds the latter most of the time. Stock correlations are not only linked to the firms PVGO but also to firm-specific idiosyncratic components and, therefore, to the business cycle. The theory is consistent with the explored empirical evidence. ii) In the model, stock correlations are increasing in the firm's PVGO, and, therefore, empirically, expected market-wide correlations are related to growth characteristics and therefore predict the future changes in the market-wide PVGO positively. iii) The theoretical model and prior empirical results establish the value return predictability by expected market-wide correlations and provide an additional explanation of the already established market return predictability by expected market-wide correlations. iv) Market-wide correlations also predict other Fama and French (2015) value factors (such as CMA and RMW). Exploiting the more specific information content in expected correlations extracted for the S&P 500 Value Index improves the predictability results among value factors.

To obtain the aforementioned results, I proceed as follows. The main theoretical motivation for the paper is the structural model developed by Kogan and Papanikolaou (2014), in which investment-specific technology shocks (IST) affect 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. While Kogan and Papanikolaou (2014) focus on the cross-section, I build on their framework and formally 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 theory, I empirically document that the correlation of growth stocks is on average higher than that of value stocks and that the difference between the two quantities is time-varying and moves with the state of the economy.

While the prior result purely investigates the correlation dynamics, the theoretical finding that the correlation between stocks is a function of the firm's PVGO motivates the relation between expected market-wide correlations and (future) changes in the economies growth characteristics, that is, changes in the market-wide PVGO. The anticipation of a future increase in individual firm PVGOs is reflected in an increase in the expected market-wide correlation extracted from a large index such as the S&P 500, estimated from option data.

The explored link between (firm) characteristics and market-wide correlations 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 is natural that the ability to predict the associated value factor returns inherits.

Empirically, I document the predictive power of expected market-wide correlations with respect to the value factor. In univariate regressions, expected market-wide correlations, extracted from options data, predict future returns for horizons of up to one year. The regression coefficient is significantly negative, 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.[3] By analyzing the individual long and short legs of the HML factor, it turns out that the predictive power of expected market-wide correlations is stronger for returns on growth stocks (L). In the last step, since the HML factor also considers the size of the firm, I emphasize the predictability of returns on growth and value stocks considering only the firm's B/M. 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 market-wide correlations is concentrated among growth stocks.

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 expected market-wide correlation outperforms realized market-wide

[3]In order to verify that the return predictability of the value factor 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 significantly negative.

correlation in terms of R^2s, confirming the information advantage of an option-implied variable over its realized equivalent.

The model-implied idiosyncratic variance allows me to investigate the influence of idiosyncratic growth components on the correlation between stocks. In the model, the correlation between stocks serves as the connection between the firms' systematic and idiosyncratic growth components. The gathered theoretical insights and the empirical evidence connecting market-wide correlations to the dynamics of growth options, and systematic and idiosyncratic risks, indicate that expected correlation serves as a leading procyclical state variable.

Expected market-wide 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, is extended, considering the expected market-wide correlation for the S&P 500, and expected correlations extracted for the S&P 500 Value Index, in-sample and out-of-sample.[4] Interestingly, even though the S&P 500 Value Index contains only about half the stocks as the S&P 500 parent index, the predictability results for the value factors are similar (or sometimes even superior), as if considering expected market-wide correlations extracted for the whole S&P 500. Therefore, it seems important 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, that value firms are less flexible in cutting capital, causing them to be riskier than growth firms. According to Garleanu, Kogan, and Panageas (2012), growth firms offer a hedge against displacement risk, which describes the process of innovation capturing that the young benefit more from innovative activity than the old. Berk, Green, and Naik (1999) provide a theoretical model showing that stock returns are related to the market value and to book-to-

[4]One can find the S&P 500 Value Index under the ticker "SVX" or "IVE" (iShares S&P 500 Value ETF).

market, serving as a state variable summarizing the firms' risk. 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. 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.

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 the value premium 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.

This paper also adds the role of market-wide correlation to the strands of literature dealing with idiosyncratic risk, which is known to be connected to the market risk premium, the value premium, growth options, and the business cycle. 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. 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 in-sample 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 correlations, which can be extracted backward-looking from historical returns (realized correlations), or forward-looking via option data (expected correlations or implied correlations). In Pollet and Wilson (2010), long-term market returns, that is, quarterly stock market excess returns, are predicted by realized correlations. Several studies within the field of option-implied information deal with implied correlations, which quantify the expected diversification benefits. Driessen, Maenhout, and Vilkov (2005) and Driessen, Maenhout, and Vilkov (2009) demonstrate that implied correlations predict market returns for horizons up to 12 months. In Buss, Schoenleber, and Vilkov (2018), the authors decompose implied correlation in its option-implied parts (market variance, average idiosyncratic variance, and cross-sectional dispersion of market betas) 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&P 500, S&P 100, or the DJ 30) and not on factors related to growth, value, or the value premium.

The rest of this paper is organized as follows: Section III states the production model. Section IV shows how to construct the correlation measures. Section V empirically tests the models main implications. Section VI emphasizes the role of implied correlation as a procyclical state variable. In Section VII, the value predictability is extended to other factors, out-of-sample, and regarding 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 returns of growth firms, which benefit the most from positive IST shocks, have higher exposure to IST shocks, and, therefore, on average a lower return.

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 firms 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 Internet Appendix C.

A. Model Setup

The state variables capturing firm-specific (ε_{ft}), project-specific (u_{jt}), economy-wide shocks (x_t), and the cost of capital (z_t) evolve according to

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

$$du_{jt} = -\theta_u(u_{jt} - 1)dt + \sigma_u\sqrt{u_{ft}}dB_{jt}, \tag{2}$$

$$dx_t = \mu_x x_t dt + \sigma_x x_t dB_{xt}, \tag{3}$$

$$dz_t = \mu_z z_t dt + \sigma_z z_t dB_{zt}, \tag{4}$$

where the Brownian motions dB_{ft}, dB_{jt}, dB_{xt}, and dB_{zt} are pairwise independent. The stochastic discount factor prices the risk associated with x and z,

$$\frac{d\pi_t}{\pi_t} = -rdt - \gamma_x dB_{xt} - \gamma_z dB_{zt}. \tag{5}$$

B. Assets in Place, Investment, and Valuation

Each firm f owns a finite number of individual projects J_t^f, which they create over time through investment. Given the projects' chosen physical capital K_j, the output of an individual project j equals

$$y_{fjt} = \varepsilon_{ft} u_{jt} x_t K_j^{\alpha}, \tag{6}$$

where K_j denotes the chosen project physical capital.

Firms acquire new projects according to a Poisson process with firm-specific arrival rate $\lambda_{ft} = \lambda_f \tilde{\lambda}_{ft}$, thereby $\tilde{\lambda}_{ft}$ follows a two-state Markov process where a firm is either high growth λ_H or low growth λ_L.[5] 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 is equal to the expected present value of its cash flows.[6]

The value of the firm (V) can be composed as the present value of cash flows generated by existing project (VAP) and the expected discounted NPV of future investments (PVGO) (see (C1), (C3), (C4) for details),

$$VAP_{ft} = \sum_{j \in J_t^f} p(\varepsilon_{ft}, u_{jt}, x_t, K_j) = x_t \sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^{\alpha} =: x_t \sum_j A_{ft}, \tag{7}$$

[5] The distribution of mean project arrival rates $\mathrm{E}[\lambda_{ft}] = \lambda_f = \mu_\lambda \delta - \sigma_\lambda \delta \log(X_f)$, where $X_f \sim U[0, 1]$.

[6] The firm chose K^* such that it maximizes the NPV, which is the difference between the present value of its cash flows and the associated costs of capital $z_t^{-1} x_t K_j$ (see (C2)).

$$PVGO_{ft} = z_t^{\frac{\alpha}{1-\alpha}} x_t G(\varepsilon_{ft}, \lambda_{ft}) =: z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}, \tag{8}$$

$$V_{ft} = VAP_{ft} + PVGO_{ft} = x_t \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}. \tag{9}$$

C. Risk and Risk Premia

The expected excess return of firm f is (see (C12))

$$\frac{1}{dt} E[R_{ft}] - r_f = \gamma_x \sigma_x + \frac{\alpha}{1-\alpha} \gamma_z \sigma_z \frac{PVGO_{ft}}{V_{ft}}. \tag{10}$$

Kogan and Papanikolaou (2014) 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.[7] This serves as an explanation for the outperformance of value firms compared to growth firms 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) firms are more strongly linked to the correction in returns.

To obtain expressions for the aggregate (expected) market return, the results for the individual firms are exploited. Value-weighting (10) across its constituents results in the expected market excess return and is given by (see (C13))

$$\frac{1}{dt} E[R_{Mt}] - r_f = \gamma_x \sigma_x + \frac{\alpha}{1-\alpha} \gamma_z \sigma_z \frac{PVGO_{Mt}}{V_{Mt}}, \tag{11}$$

where $\frac{PVGO_{Mt}}{V_{Mt}}$ denotes the market-cap-weighted averaged individual firm ratios $\frac{PVGO_{ft}}{V_{ft}}$.[8]

[7] Empirically, the authors use the relative stock returns of the investment and consumption good producers to create a factor-mimicking portfolio (IMC) for the IST shock, which 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.

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

D. Firm Return Dynamics

In order to analyze higher moments of firms, and between firms, the firms instantaneous return dynamics are derive first, which can be expressed as (see (C15) and (C17))

$$dR_{ft} = \frac{dV_{ft}}{V_{ft}} = \mathrm{E}[R_{ft}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha}\frac{PVGO_{ft}}{V_{ft}}\sigma_z dB_{zt} + \frac{dIdio_f}{V_{ft}}, \tag{12}$$

where $dIdio_f$ denotes the dynamics associated to A_{ft} (as a function of ε_{ft}, u_{jt}, and K_j^α) and G_{ft} (as a function of ε_{ft}, and λ_{ft}). The covariance and the variance of the returns can be calculated as (see (C18) and (C19))

$$dR_{kt}dR_{lt} = \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2\frac{PVGO_{kt}}{V_{kt}}\frac{PVGO_{lt}}{V_{lt}}dt, \tag{13}$$

$$\sigma^2(dR_{ft}) = dR_{ft}dR_{ft} = \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{ft}}{V_{ft}})^2 dt + (\frac{dIdio_f}{V_{ft}})^2. \tag{14}$$

Idiosyncratic terms are uncorrelated, and, hence, the covariance is increasing in the PVGO, depending on α and the volatility of the cost of capital process σ_z. To calculate the correlation, one normalizes the covariance by the standard deviations of the respective processes (C20),

$$Corr(dR_{kt}, dR_{lt}) = \frac{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2\frac{PVGO_{kt}}{V_{kt}}\frac{PVGO_{lt}}{V_{lt}}dt}{\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{kt}}{V_{kt}})^2 dt + (\frac{dIdio_k}{V_{kt}})^2}\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2\sigma_z^2(\frac{PVGO_{lt}}{V_{lt}})^2 dt + (\frac{dIdio_l}{V_{lt}})^2}}. \tag{15}$$

Therefore, the correlation among firms captures the individual PVGOs such as the idiosyncratic dynamics of the firms. In Figure 2 the correlation (15) is depicted as a function of the firms' PVGOs and for different idiosyncratic levels (Panel A – Panel D). As visible, the correlation between two firms is an increasing function of the firms individual PVGO. This is why, for any given level of idiosyncratic risk (Figure 2 Panel A to Panel D), the correlation among growth firms exceeds the correlation among value firms. This can be inferred immediately from comparing the boundaries of the plots, that is, for individual PVGOs close to 1 (growth firms) or close to 0 (value firms).

The level of correlation between any two firms is decreasing in the firms idiosyncratic growth components. To further improve the understanding of the result, the idiosyncratic component dynamics of the firm (C16),

$$dIdio_f = x_t d \sum_{j \in J_t^f} A(\varepsilon_{ft}, u_{jt}) K_j^{\alpha} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG(\varepsilon_{ft}, \lambda_{ft}), \tag{16}$$

are analyzed next. The first part corresponds to changes 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 (change) of assets in place (see (C1) and (C5)). For the second part, as inferable from (C4), $G(\varepsilon_{ft}, \lambda_{ft})$ is a function of the returns to scale at the project level α, the firm-specific component ε_{ft} (such as managerial skill, that is, the "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. Taking the two expressions together, 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.

Contrasting the expression for $PVGO_{ft}$ (8), and as just outlined, the idiosyncratic component $dIdio_{ft}$ (16), there are several differences immediately visible. First, the expression for the project-specific component u_{jt} is not part of the expression for $PVGO_{ft}$. Second, $PVGO_{ft}$ is a function of G_{ft}, whose level is heavily determined by the two growth states of the firm ($\tilde{\lambda}_{ft} \in [\lambda_H, \lambda_L]$). In contrast, $dIdio_{ft}$ as a function of the changes in G_{ft} (dG_{ft}), does not rely heavily on the state itself.

Overall, the correlation between firms is effected by the proportion of systematic growth as opposed to idiosyncratic growth, where the two main drivers are identified to be the project-specific component u_{jt}, and the systematic growth component of the firm $\tilde{\lambda}_{ft}$. In Section VI market-wide correlation will be connected to state variables know or be associated with systematic and idiosyncratic risk, and in a next step to growth options, market returns and the value premium.

To conclude this section, the main predictions of the model, which will later be tested empirically, are restated: i) The correlation among growth firms exceeds the correlation among value firms. These dynamics are time-varying. ii) Correlation is a function of the firms PVGO and, therefore, expected correlations should be related to future movements in PVGO measures. iii) An average market-wide increase in PVGO gives rise to the value premium (10) and reduces the expected market returns (11). Therefore, variables linked to PVGO should predict returns on the value factor and market returns.

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 market-wide correlations, that is, 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 $\sigma_i^2(t), i = 1 \ldots N$, and the index weights $w_i(t)$, the equicorrelation $\rho_{ij}(t) = \rho(t)$ is calculated as

$$\rho(t) = \frac{\sigma_I^2(t) - \sum_{i=1}^{N} w_i(t)^2 \sigma_i^2(t)}{\sum_{i=1}^{N} \sum_{j \neq i} w_i(t) w_j(t) \sigma_i(t) \sigma_j(t)}. \tag{17}$$

When using risk-neutral implied (realized) variances and volatilities in (17), one calculates then implied (realized) correlations — IC (RC). The composition of all the indices is obtained from Compustat, while the data on returns and market capitalization is received from CRSP.[9]

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.[10] Option-implied second moments are computed as simple variance swaps following Martin (2013). The options for the S&P 500 are available from January 1996 through December 2017, while for the S&P 500 Value Index the availability starts

[9] 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).

[10] 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.

in August 2006.[11] In Table I the summary statistics for realized and implied correlations are presented while the time series are displayed in Figure 1.

The portfolio return data is available over the whole sample period on Kenneth French's website. The market-neutral version of the Fama and French factor is 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

$$HML_{t-21\to t} = \alpha + \beta_{MKTRF} MKTRF_{t-21\to t} + \varepsilon_t. \tag{18}$$

$\alpha + \varepsilon_t$ are then considered as the market-neutral return of the factor (called HML^*). Table II Panel A, 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 B, 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 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. Several variables associated with the present value of growth options are constructed, as in Cao, Simin, and Zhao (2008) on the firm level: i) The Market-to-Book Ratio (M/B) proxies for corporate growth options due the incorporation of the market value of assets ii) Tobin's Q is the ratio between the physical asset market value and its replacement value. iii) The Debt to Equity ratio (DTE) represents growth options, since firms with significant growth opportunities may have lower financial leverage (lower DTE).[12] iv) $CAPEX$ acts as a proxy for growth options since capital expenditures

[11] The traded continuum of index options on the SVX, i.e., the S&P 500 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 five trading days.

[12] From the perspective of the 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.

lead to new investment opportunities. In the empirical tests, I follow insights from Cao, Simin, and Zhao (2008) to obtain the value-weighted firm averages for M/B, Q, DTE, and $CAPEX$. Details on the calculation can be found in Appendix A. The summary statistics for the value of growth options proxies are displayed in Table III.

A number of realized portfolio risk measures 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 factor model[13]).[14] The residuals from the just outlined regressions are considered for the calculation of the sum of squared residuals (SSR) at each point in time.[15] 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.

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

V. Testing Model Predictions

In this section the theoretical insights provided in Section III are investigated in an empirical setting, where the focus will lie on correlations, and the summary state variable of the model, which is PVGO. The difference in correlation among growth stocks and among value stocks, the predictive interplay of expected market-wide correlations and PVGO proxies, so as the prediction of portfolios sorted on these PVGO proxies by expected market-wide correlations, can be seen as the major insights in this empirical analysis. In this section, new empirical

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

[14]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.

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

observations, which are in line with the theory, are investigated and documented first. In a next step, new theoretical insights are getting connected to known empirically documented results (such as the market return predictability).

A. New Empirical Results in line with the Theory

A major hypothesis testable from the model is that the correlation between stocks (15) is an increasing function in the firms' PVGO, or in other words, that growth stocks comove more strongly among themselves compared to value stocks. First, the average correlation among growth and value stocks based on the B/M characteristic starting in 1965 is investigated.[16] 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.[17] Figure 3, Panel A, displays the time-varying average correlation dynamics of the two portfolios and its difference (called Correlation Delta). As depicted in the plot, the 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 where peaks in the Correlation Delta are mostly associated with periods before a recession. Immediately recognizable, the largest Correlation Delta peak happened during the build up of 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. Overall, the empirical evidence confirms that the comovement among growth and value stocks differs, and, depending on the economic conditions, they display different dynamics over time.

In the next part of this empirical analysis the theoretical insights from the model, concerning the correlation dynamics between two stocks, are tested and embedded in an aggregated market-wide setting. Since time series predictions are formulated, the information content inherited in implied correlations, as a forward-looking measure for the market-wide correlation, is exploited.

[16] A helpful Python code replicating the B/M sorted decile portfolios can be found on WRDS.
[17] For growth (value) stocks I consider stocks belonging to the lowest (highest) B/M sorted decile.

The second hypothesis states that, since the correlation between stocks is an increasing function of PVGO, implied correlation should predict changes in PVGO. The main results for the in-sample predictability of changes in the aggregate PVGO proxies by IC, can be inferred from Table IV, where the following predictive regressions is performed:

$$\Delta_{log} PVGO_{t \to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{19}$$

thereby PVGO equals M/B, Q, DTE, or $CAPEX$. As displayed in Table IV, M/B, Q, and $CAPEX$ are positively related to IC with highly significant coefficients and with increasing R^2s for longer predictive horizons, while future changes in DTE are, as expected, negatively related to IC. 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.

PVGO is identified as the models central state variable for the explanation of the value premium, that is, the outperformance of value stocks over growth stocks (see (10)). Since changes in PVGO proxies are predicted by IC, it is expected that the predictive power of IC is inherited when predicting future returns on the value factor or B/M sorted portfolios. In order to illustrate the predictive relation of implied correlations and value factor returns, the following specification is performed:

$$r^F_{t \to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{20}$$

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).[18] The results for the in-sample return predictability are presented Table V Panel A and visually displayed in Figure 4 Panel A. IC predicts HML with a significant negative coefficient for all maturities, with increasing R^2s ranging from over 2% to almost 23% for a yearly return predictability. To better understand the source of prediction, the predictability of the long and short legs of the value factor returns (Table V Panel B and Figure 4 Panel B) are analyzed next. It turns out that IC does not predict value stocks (H) but rather the

[18]For non-overlapping observations is controlled in the Robustness Section VIII.

returns of growth stocks (L) with positive regression coefficient and, therefore, its difference HML (and HML^*) with a negative coefficient. In line, when predicting the 10 B/M portfolios, the significance and R^2s of the regression coefficients show a monotonic pattern, where the significance is increasing in portfolio deciles containing more and more growth stocks (see Table VI and Figure 5). Overall, the return predictability draws a clear picture: Implied correlation predicts future value factor returns negatively. The predictiveness is primarily through the positive prediction of the short leg (L) and the low B/M portfolios, which are characterized through a higher amount of growth stocks.

To summarize, this section showed that the correlation dynamics among growth and value stocks differ and are time-varying. Expected market-wide correlation, as function of the PVGO, predicts not only changes in the PVGO, but also returns of portfolios sorted on one of the PVGO representatives (B/M).

B. Existing Empirical Results in Line with the Theory

In this section new theoretical insights are getting connected to known empirically documented results, such as the market return predictability by expected market-wide correlations. 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 $PVGO_M$ reduces the expected market return (11).

First, as reported by Cao, Simin, and Zhao (2008), the interplay of idiosyncratic variance, $PVGO_M$, and future market returns is in line with the new theoretical insights, since 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, Pollet and Wilson (2010), Driessen, Maenhout, and Vilkov (2005), and Buss, Schoenleber, and Vilkov (2018) document that market-wide correlations (realized or implied) predict market returns positively for horizons up to one year. The contemporaneous (time series) correlation between IC (RC) and the proxies for PVGO are displayed in Table VII, and behave 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).[19] The results are robust (but weaker) considering the differences in the growth options proxies (see Panel B). In line with the equation for expected market returns (11), low IC corresponds to a high level in $PVGO_M$ (contemporaneously), and, therefore, to a reduction of the future market return.

An additional way of connecting these two variables of interest is obtained when the contemporaneous time series correlation for the yearly IC (with 365 days maturity) and the (yearly) market-to-book value of the 10 decile portfolios is calculated. The time series correlation in Figure 6 displays a clear increasing monotonic pattern with the lowest (highest) value for the lowest (highest) B/M sorted portfolio (-0.5 vs. 0.2). Hence, the characteristics of low B/M portfolios (growth firms), are comoving negatively with an increase in IC, while the opposite is true, but less pronounced, for high B/M portfolios (value firms). As visible in Figure 7, the high market capitalization among low B/M stocks (growth stocks) contributes positively to this effect on a market level. As shown in the previous section, IC predicts the return on growth stocks (rather than the return on value stocks).

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

VI. Correlation as a State Variable

As showed in the model section, the correlation between stocks inherits both, the firms systematic and the idiosyncratic growth dynamics, where the interplay of the two determine the

[19] 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.

shape and the level it. Not surprisingly, there are two main strands of literature connecting systematic and idiosyncratic risk to growth options, the market risk premium, the value premium, and finally to the business cycle. The empirical link between the various risk measures and (implied) correlations is investigated, and placed in the wider context. In Figure 8 an overview of the predictive (Panel A) and contemporaneous (Panel B) interplay between (implied) correlations, systematic and idiosyncratic risk, market- and value factor returns (and their respective long and short legs), and the PVGO is displayed. In both figures the blue-dashed dotted (red-dashed) line indicates a positive (negative) connection between two edges. Overall, correlation does not only predict the value factor and market returns 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 PVGO. The sign of prediction is in line and consistent with prior literature and the new empirical observations.

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

$$Risk_{t\rightarrow t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \varepsilon_t, \tag{21}$$

where $Risk_{t\rightarrow t+\tau_r}$ denotes the realized risk measure for a period from t to τ_r. The set of risk measures consist 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 $VWIV$). The results are presented in Table VIII.

Confirming the results of Buss, Schoenleber, and Vilkov (2018), 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.

IC is loading negatively on the future average idiosyncratic risk, proxied by the equal ($EWIV$)–or value ($VWIV$)–weighted SSR. In line with the intuition, increasing correlation lowers the prevalent idiosyncratic risk in the market. 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. IC predicts future idiosyncratic stock market volatility, and is, therefore, indirectly related to the future US value premium.

For value and growth betas, the signs are in line with the results by Petkova and Zhang (2005), and IC 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 cross-sectional return dispersion (RD), 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, it is negatively related with the market return and positively related with the value premium.

Overall, the model theoretical insights, and the predictive relation of market-wide correlations to various risk measures, known to be associated with growth options, the value premium, and market returns, allows to draw the conclusion that IC serves as a leading procyclical state variable.

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. At the end I conduct the return prediction out-of-sample.

A. *Predicting Value Factors with Correlations Constructed for the S&P 500*

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 B/M ratio of the company and, therefore, to the value premium; for a motivation, see Hou, Xue, and Zhang (2015), or Fama and French (2006).

In the first step of this additional investigation, the predictability and inheritable features of IC, w.r.t, other value strategies are analyzed. The main results can be summarized as follows: i) IC (extracted for the S&P 500) also predicts alternative value factor returns 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 IX Panel A and visualized in Figure 9 (Panel A and Panel C), CMA (RMW) is also 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 IX Panel B and Figure 9 (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 B/M 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 B/M 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" firms (W).

B. Predicting Value with Correlations Constructed for the S&P 500 Value Index

In most studies, implied correlations are constructed for either broad major indices, such as the S&P 500, S&P 100, DJ 30, or the nine economic sectors of the S&P 500; 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 an value or growth equity index.

The S&P 500 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&P 500 parent index.[20] Index options are available starting from August 2006.[21] As shown in Table I Panel C, the mean of the expected correlation for the S&P 500 Value Index is on average larger and, in addition, more volatile, as recognizable in Figure 10. The 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 information content of two different implied correlations, namely for the S&P 500 and the S&P 500 Value Index, will be compared in terms of predictability across the three value factors HML, CMA, and RMW.

As visible in Table X, when running the in-sample predictive regressions starting from 2006, the value premia are predicted with a positive sign. The potential reason is that the correlation between market returns and HML is positive (0.33) starting from 2007, and, therefore, the value factor no longer displays a countercyclical behavior.

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

[21] Implied correlations for the S&P 500 Growth Index are not constructed due to the late availability for the S&P 500 Growth Index Option data starting in 2012.

Figure 11 displays the in-sample R^2s for both predictors. Considering IC_{IVE} (instead of IC) increases the coefficient of determination by almost 33% (from 15% to 20%) at a yearly horizon when predicting HML. For CMA, both implied correlations predict similar. For the RMW growth factor, IC still outperforms IC_{IVE}.

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 is to decompose IC_{IVE} into its part explained by IC, and the additional information content represented by the residuals $\varepsilon_{IC_{IVE}}$,

$$IC_{IVE} = \alpha + \beta_{IC} IC + \varepsilon_{IC_{IVE}}. \tag{22}$$

In the next step, future factor returns ($MKTRF$, HML, CMA, and RMW) are regressed on (IC) and the residuals $\varepsilon_{IC_{IVE}}$

$$r^F_{t \to t+\tau_r} = \gamma + \beta_{IC} IC(t, t+\tau_r) + \beta_{\varepsilon_{IC_{IVE}}} \varepsilon_{IC_{IVE}} + \varepsilon_t, \tag{23}$$

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 often matter when predicting value factor returns, indicating that the there is significant additional information content in IC_{IVE} over IC.[22]

C. Out-of-Sample Predictability

In this section the out-of-sample performance of the value factor returns for the two implied correlation measures IC and IC_{IVE} is compared and documented.

As in most studies, the forecasting performance of a specific model s is compared with the performance of a model based on the historical mean of the respective factor return ($s = 0$).

[22] 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.

Therefore the out-of-sample R^2 is calculated as

$$R^2_{s,\tau_r} = 1 - \frac{MSE_{s,\tau_r}}{MSE_{0,\tau_r}}, \tag{24}$$

where $MSE_{s,\tau_r} = \frac{1}{N}\sum^N e^2_{s,\tau_r}$ denotes the mean-squared error of model s computed from the prediction errors e_{s,τ_r} for horizon τ. A particular model, s, outperforms the benchmark model $s = 0$ based on the average historical return if the out-of-sample R^2_{s,τ_r} is significantly positive. Because of the limited availability of options data for the value index, the sample period only spans about 10 years. Consequently, asymptotic standard errors may not be accurate, so I resort to the moving-block bootstrap procedure of Künsch (1989).[23]

Out-of-sample predictions are based on rolling or expanding window estimations of the predictive in-sample regression (20) (with the addition of a time-specific intercept). The estimated coeffcient $\beta_{IC,t}$ together with the time-t value of IC_t then forms the out-of-sample return forecast $r^F_{t\to t+\tau_r}$. Note that, at date t, one uses only observations from the past to avoid any look-ahead bias.

Figure 12 and Figure 13 display the out-of-sample R^2 for univariate predictions using a rolling or expanding-window based on a five-year estimation period. The out-of-sample results are qualitatively similar to the in-sample results and not much affected by the selected estimation window (rolling vs. expanding). Important to notice, the predictability applying IC_{IVE} as predictor works as well as considering IC.

VIII. Robustness

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

[23]Technically, I draw $10,000$ random samples (with replacement) of 200 blocks, with blocks of 12 observations (i.e., one-year blocks), to preserve the autocorrelation in the data. Using the bootstrapped distribution, the p-value for the null hypothesis: $R^2 = 0$ are computed.

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 B1, the average R^2 for the growth option proxy predictability for each maturity is displayed. The non-overlapping sampling does not harm the R^2 when considering IC as an independent variable. The same procedure is applied to the factor returns' predictability and displayed in Figure B2. The monotonic increasing R^2's are not caused by overlapping return observations.

B. Predictions with Controls

In this subsection the in-sample predictions from Section V are extended to control for (implied) market volatility (IV) and for a market-wide idiosyncratic risk proxy ($VWIV$); see Table B2 for growth option predictions and Table B3 for return predictions. For both types of predictions, IV does not show much of a significance. 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 C5 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 C6 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).[24] 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;

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

B/M 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.

C. Full Sample, Expansion, and Contraction

In Table C7, the predictive growth options regressions as stated in (19) are repeated for RC over the full sample (1983). RC predicts changes in future growth option proxies for a horizon up to a quarter.

In Table C8, the return predictability is repeated starting from 1965, using RC as a predictor. The signs for the return predictions are consistent with the the usage of IC (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 C9, for RC (starting in 1965) and Table C10 for IC (starting in 1996). For RC significance is not ensured even though the coefficients display mostly the correct positive sign. Noticeably, the information content of IC 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 C4, for RC (starting in 1965) and Figure C5 for IC (starting in 1996). The regressions considering RC reveal stronger predictive power in contraction states, especially for the market neutral 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 C5, 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.

D. *PVGO across Industry Sectors*

The exposure for the value of growth options proxies across different industry sectors is displayed in Figure C6. Not surprisingly the exposure for M/B, Q, and $CAPEX$ is the highest within the technology and health sector and the lowest in the utilities and materials sector. To summarize, the PVGO across different economic sectors do not show any extreme behavior or capture any industry effect.

IX. Conclusion

This paper relates, theoretically and empirically, market-wide correlation and its dynamics to growth options, growth stocks, and the value premium. An increase in expected market-wide correlation happens due to an increase in expectations of economic growth. When firms accumulate growth options, growth stocks gain in value simultaneously, thus showing higher correlation. The higher valuation of growth stocks leads to decreasing returns on the value factor and increasing market returns.

New insights provided by the production model confirm that the correlation between firms is an increasing function of the firms PVGO. As it turns out, not only the return of value and growth stocks differ but also their correlation dynamics; that is, the correlation among growth stocks exceeds the correlation among value stocks. The correlation among growth and value portfolios is time-varying and its difference can be connected to the prevailing economic regime.

Empirically validated, the comovement among growth stocks is indeed stronger, compared to the comovement among value stocks, and expected market-wide correlations are able to predict future changes in growth options proxies with a positive sign. Since correlation predicts changes in the state variable which drives the value premium (PVGO), it is an immediate consequence that correlation significantly predicts future returns on the value factor for horizons up to one year with a negative sign. The predictiveness can be attributed to the ability of expected market-wide correlations predicting returns on stocks with low B/M ratios (growth stocks).

Expected correlations extracted for the S&P 500 Value Index improve the predictability results in-sample and out-of-sample and further motivate the use of implied correlations beyond the large major indices.

The model relates the correlation between firms to the firms' systematic and idiosyncratic growth components. The insights, therefore, support existing and new empirical findings that relate market-wide correlations and idiosyncratic variances, via growth options, to aggregate market returns, the value premium, and the business cycle. Taking the results into consideration, it affirms the hypotheses that correlation serves as a leading procyclical state variable.

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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 (17) for the S&P 500 Index and for the S&P 500 Value Index, for five different maturities of 30, 91, 182, 273, and 365 calendar days. The sample period for realized correlations (RC) is ranging from 01/1965 to 12/2017, for implied correlations extracted for the S&P 500 (IC) from 01/1996 to 12/2017, and for implied correlations for the S&P 500 Value Index (IC_{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_{IVE} – from 2006

	$IC_{IVE}30$	$IC_{IVE}91$	$IC_{IVE}182$	$IC_{IVE}273$	$IC_{IVE}365$
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 Factor Return Overview

This table contains the time series correlation of the respective factor returns (sampled monthly), i.e, their long and short legs, and the B/M sorted portfolios as displayed in Panel A and in Panel B. The market neutral returns are estimated applying (18). The data is obtained from Kenneth French's website and ranges from 1965 to the end of 2018.

Panel A: 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 B: Monthly B/M 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 III PVGO Proxies and Correlation Measures

This table displays the summary statistics for the value of growth options. 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 from 1983 to 2018. For further details, see Appendix A.

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

Table IV 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 for RC and IC ranges 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 PVGO proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix A. 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 V 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&P 500 Index, computed by applying (17) 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, sampled at daily frequency. The market neutral returns are estimated applying (18) 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 VI Predictive: B/M Sorted Portfolio Returns

The table shows the slope and the R^2s of the regressions of the Fama and French B/M sorted decile portfolio over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) for the S&P 500 Index, computed by applying (17) 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, 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 VII PVGO Proxies and Correlation Measures

This table displays 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 and for the S&P 500. The sample period for RC ranges from 01/1965 to 12/2017, and for IC 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 PVGO proxies is obtained from Compustat and available on a monthly frequency from 1983 to 2018. For further details see Appendix A.

Panel A: 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 B: 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 VIII 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 (IC) for horizons of 30, 91, 182, 273, and 365 calendar days, calculated by applying (17) for the S&P 500 Index over the sample period ranging from 01/1996 to 12/2017. 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 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 B/M sorted portfolios returns. 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 IX 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, and RMW^*) and their legs (C, A, R, and W) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) for the S&P 500 Index, computed by applying (17) to model-free implied variances ($MFIV$) using out-of-the money options with the respective maturity. The sample period for IC ranges from 01/1996 to 12/2018, sampled at daily frequency. The market-neutral returns are estimated applying (18) 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 X 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, CMA, and RMW) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) on the S&P 500, and implied correlation (IC) on the S&P 500 Value Index (IVE), computed by applying (17) 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, 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	-	0.153	-	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
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
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

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

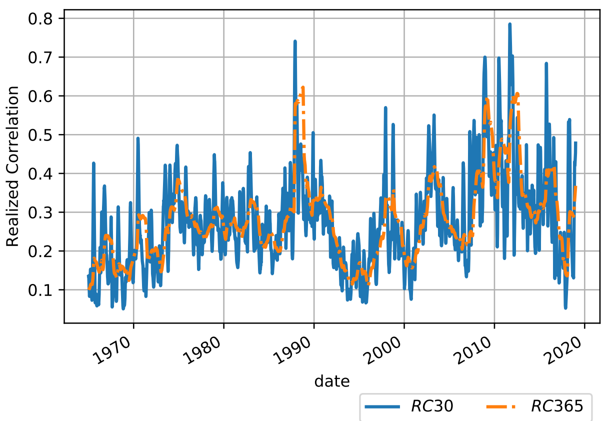
The table shows the slope and the R^2s of the regressions of the value factor returns ($MKTRF$, HML, CMA, and RMW) realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlation (IC) on the S&P 500, and the residuals ($Res_{IC_{IVE}}$) obtained from (22) regressing IC_{IVE} on implied correlation (IC) and a constant. ICs are computed by applying (17) 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, 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

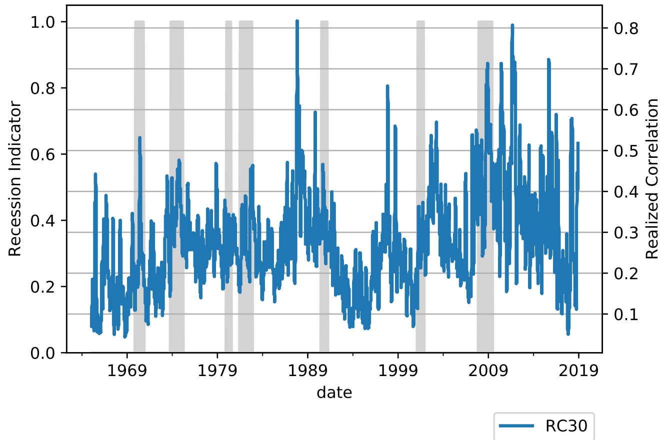
Figure 1. Realized and Implied Correlations

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, RC and IC with a maturity of 30 days are displayed together with the NBER Recession Indicator (see Appendix **??**), which equals 1 if the economy is in recession and 0 elsewhere (expansion). RC and IC are calculated as equicorrelations applying)17) for the S&P 500 Index for five different maturities of 30, and 365 calendar days. The sample period for RC is ranges from 01/1965 to 12/2017 and for IC extracted for the S&P 500 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. In the plots the 30 days moving average is depicted.

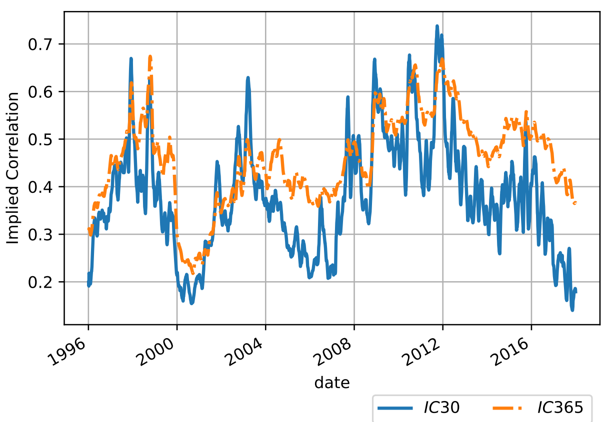
A: $RC30$ and $RC365$



B: $RC30$ and Recession Indicator



C: $IC30$ and $IC365$



D: $IC30$ and Recession Indicator

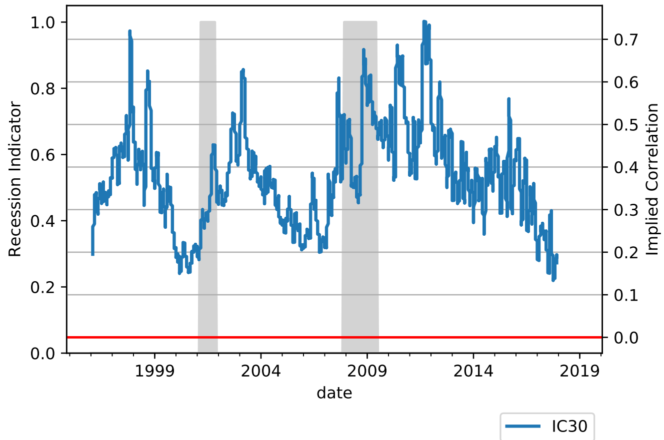
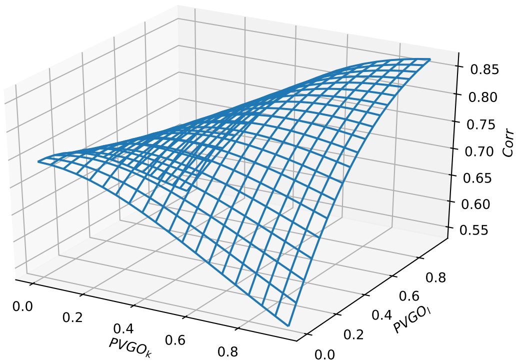


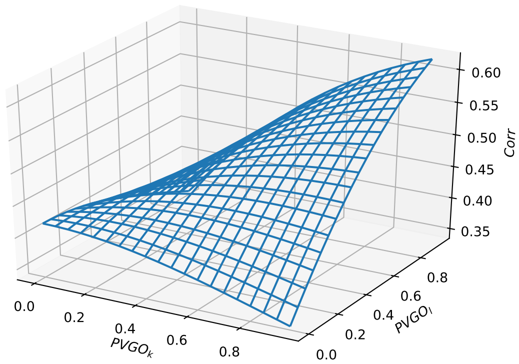
Figure 2. Model Correlation between Two Stocks

The figure displays the correlation between two stocks as calculated in equation (15) for different idiosyncratic levels. Therefore, $\sigma_x = 0.17$, $\alpha = 0.85$, $\sigma_z = 0.035$, and $V_k = V_l = 1$ normalized to one. The function is evaluated for $PVGO_k$ and $PVGO_l$ between 0 and 1.

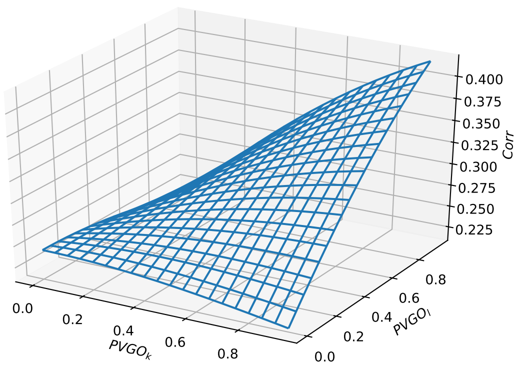
A: Stock Correlation - Idiosyncratic = 0.1



B: Stock Correlation - Idiosyncratic = 0.2



C: Stock Correlation - Idiosyncratic = 0.3



D: Stock Correlation - Idiosyncratic = 0.4

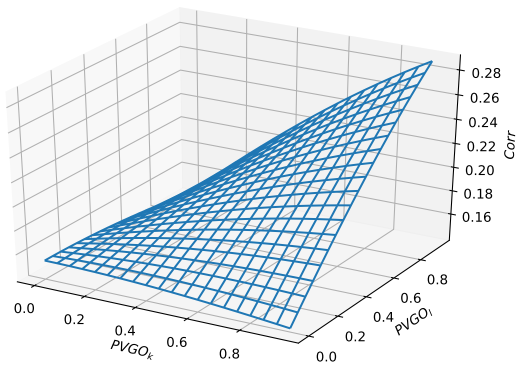


Figure 3. Average Correlation in B/M Sorted Portfolios

The figure shows the time series plots of the average correlation in growth portfolios (ρ(Lo10 BM)) and the average correlation in value portfolios (ρ(Hi10 BM)), and its difference, called Correlation Delta (ρ(Lo10 BM) $-$ ρ(Hi10 BM)). 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 ranges from 01/1965 to 12/2017. In Panel B the Correlation Delta is displayed together with the NBER Recession Indicator (see Appendix **??**), which equals 1 if the economy is in recession and 0 elsewhere (expansion).

A: Correlation Delta *B: Correlation Delta and Recession Indicator*

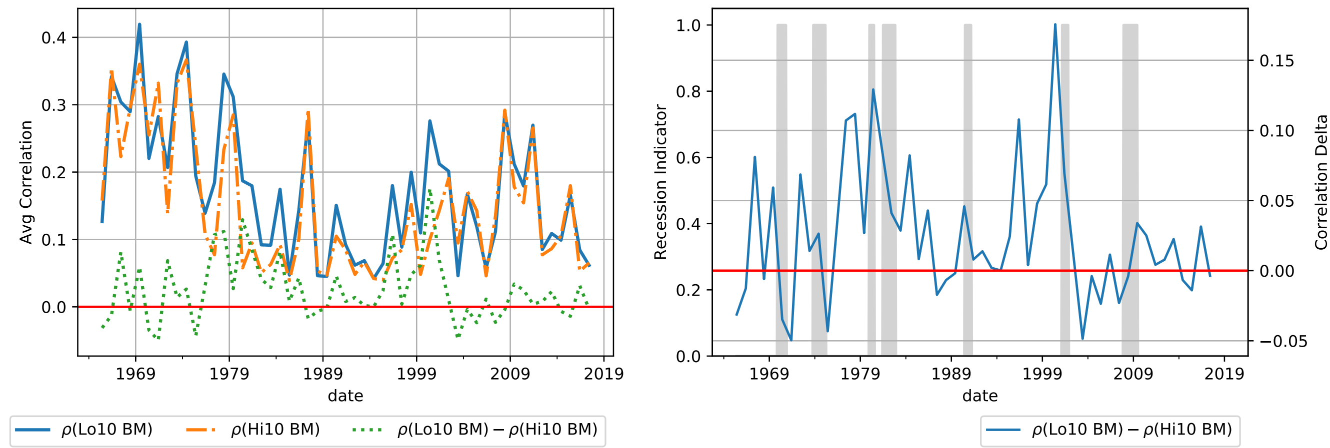


Figure 4. Predictive: Factor Returns

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 (18) to the factor data, which is obtained from Kenneth French's website.

A: R^2 – Factors *B: R^2 – Legs of the Factors*

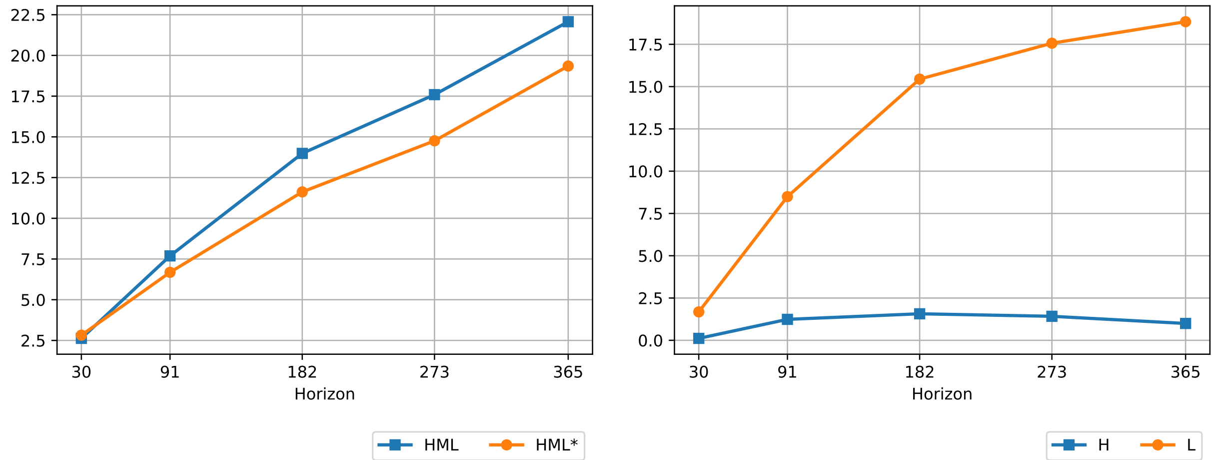


Figure 5. Predictive: B/M Sorted Decile Portfolios

The figure shows the R^2s (Panel A) and the p-values (Panel B) of the regressions of the Fama and French B/M 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*

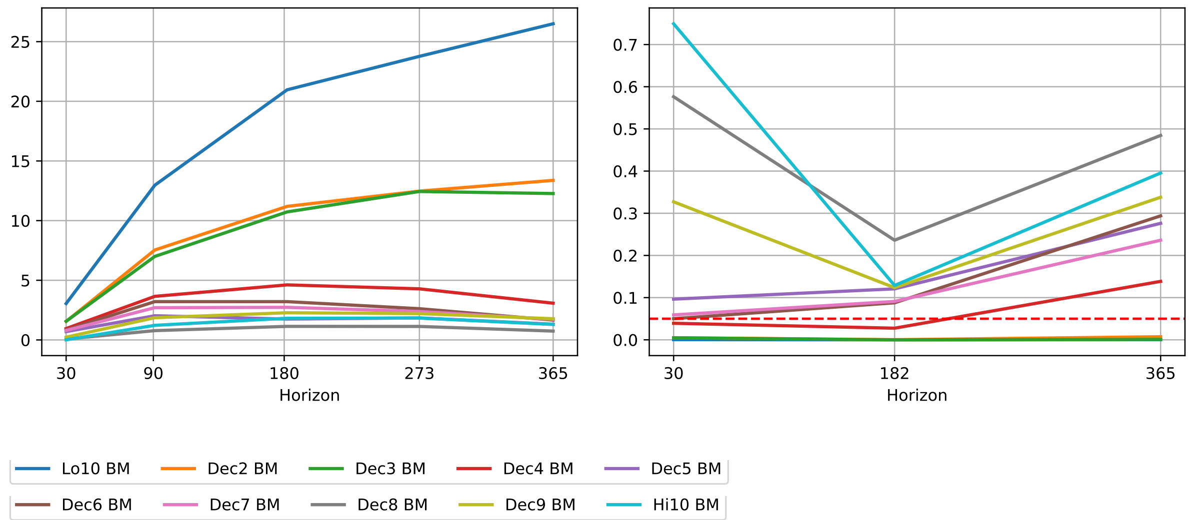
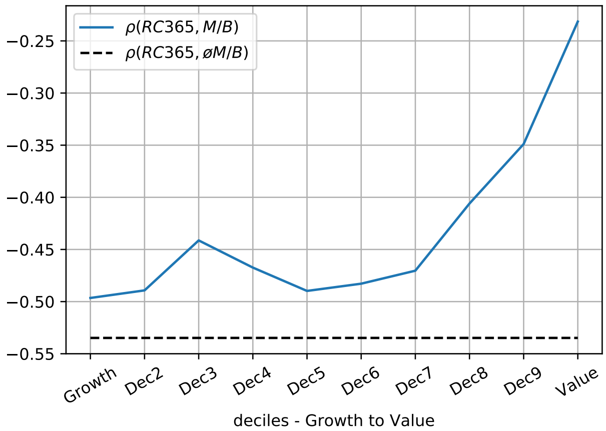


Figure 6. Contemporaneous: Correlations and M/B Characteristics

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 10 book-to-market sorted portfolios. The market-to-book characteristics for year t are available at Kenneth French's website. Therefore, 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 B/M is calculated in December of $t-1$, RC and IC are sampled at the end of December in $t-1$ (Panel A and Panel B). The sample period for RC ranges from 01/1965 to 12/2017 and for IC extracted for the S&P 500 from 01/1996 to 12/2017. The sample period for the M/B 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 M/B characteristic across all deciles.

A: Correlation – $RC_{Dec,t-1}$



B: Correlation – $IC_{Dec,t-1}$

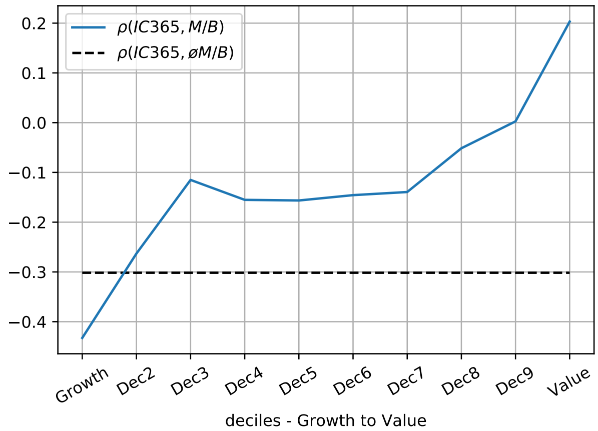


Figure 7. Market Capitalization of B/M Sorted Decile Portfolios

The figure shows the relative market capitalization of 10 B/M sorted portfolios, calculated as number of firms multiplied by the average firm size, in the respective deciles. 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. In the plots, the 12 month moving average is depicted.

A: Market Capitalization – B/M Sorted Deciles

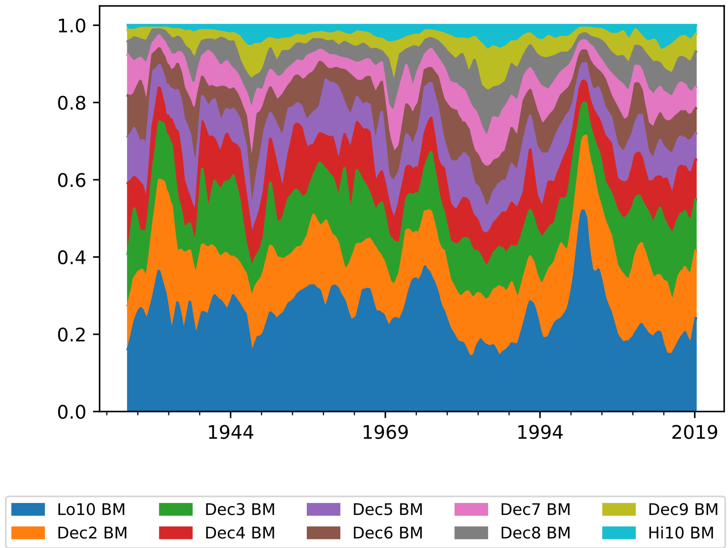
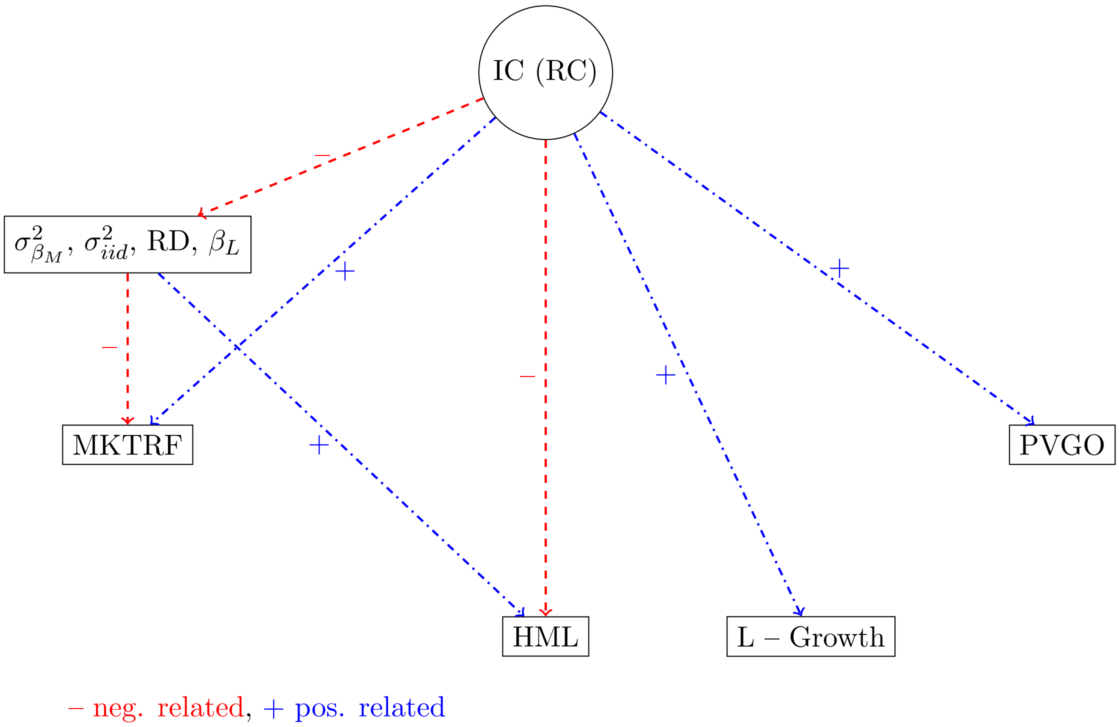


Figure 8. Correlation as a State Variable – Interplay with Risks, *PVGO*, and Returns

The figure displays the relation between *IC* (at time t) and future risk variables, the *PVGO*, 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 Market-Wide Correlations, Risks, Growth Options, and Returns



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

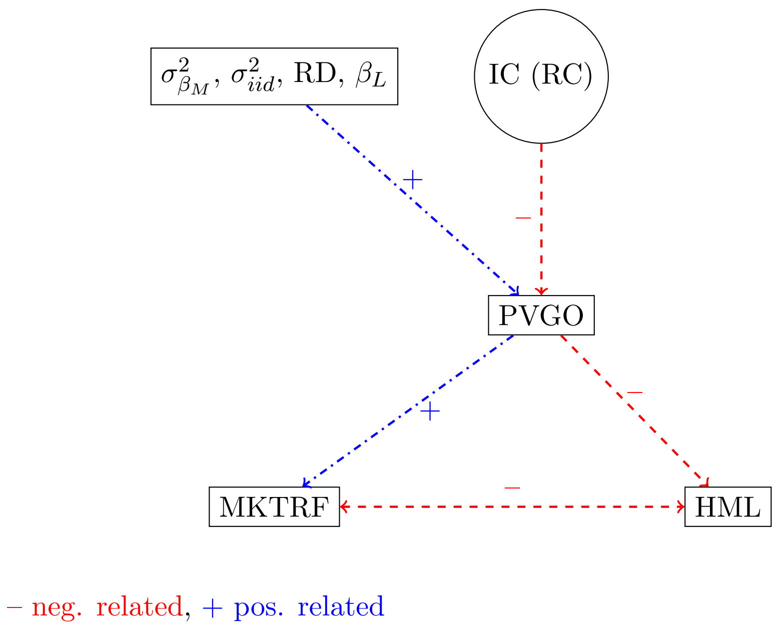


Figure 9. Predictive: Factor Returns – CMA and RMW

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 daily. The market-neutral returns are estimated applying (18) to the factor data, which is obtained from Kenneth French's website.

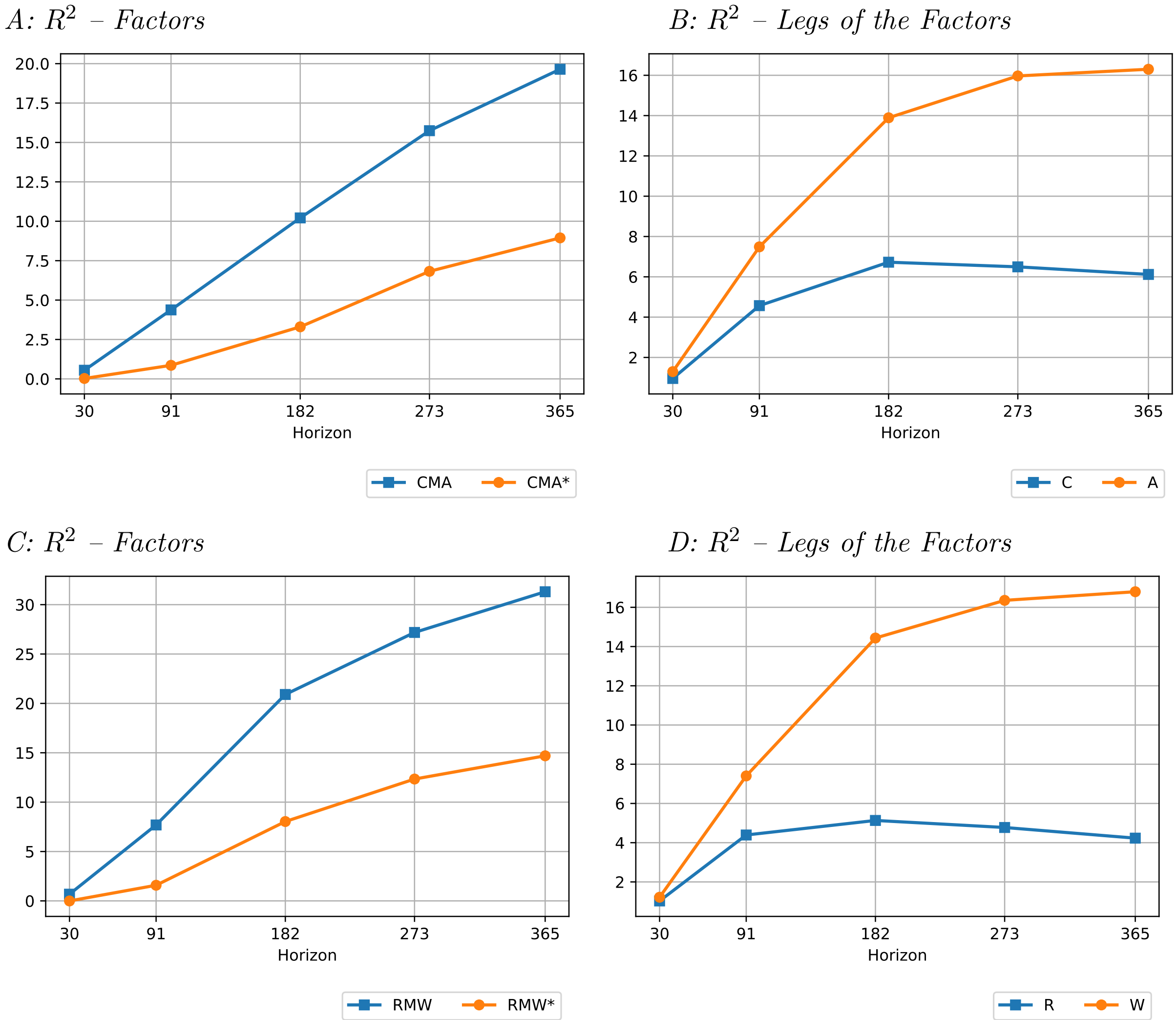
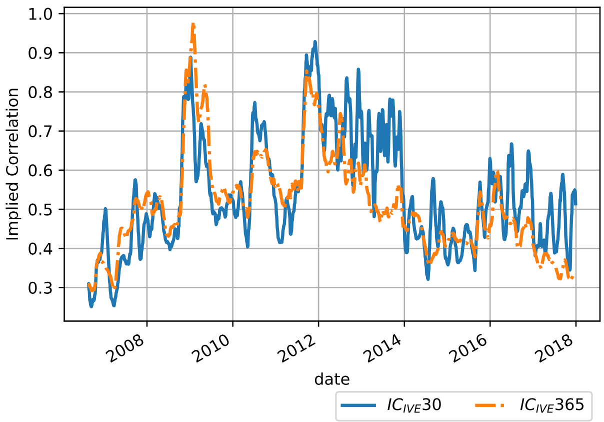


Figure 10. Implied Correlations – S&P 500 Value Index vs. S&P500

The figure shows the time series plots for implied correlations, which are calculated as equicorrelations applying (17) for the S&P 500 Index (IC) and for the S&P 500 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. In the plots the 30 days moving average is depicted.

A: IC_{IVE}



B: IC *vs.* IC_{IVE}

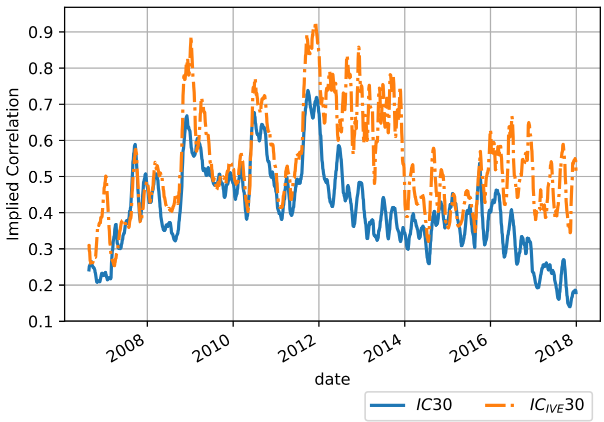


Figure 11. Predictive: Factor Returns – IC vs. IC_{IVE}

The figure shows the R^2s of the regressions of the value factor returns (HML, CMA, RMW), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations for the S&P 500 Index (IC) and on implied correlations for the S&P 500 Value Index (IC_{IVE}) from matching-maturity options. The sample period ranges from 08/2006 to 12/2017, and the variables are sampled daily. The market-neutral returns are estimated applying (18) to the factor data, which is obtained from Kenneth French's website.

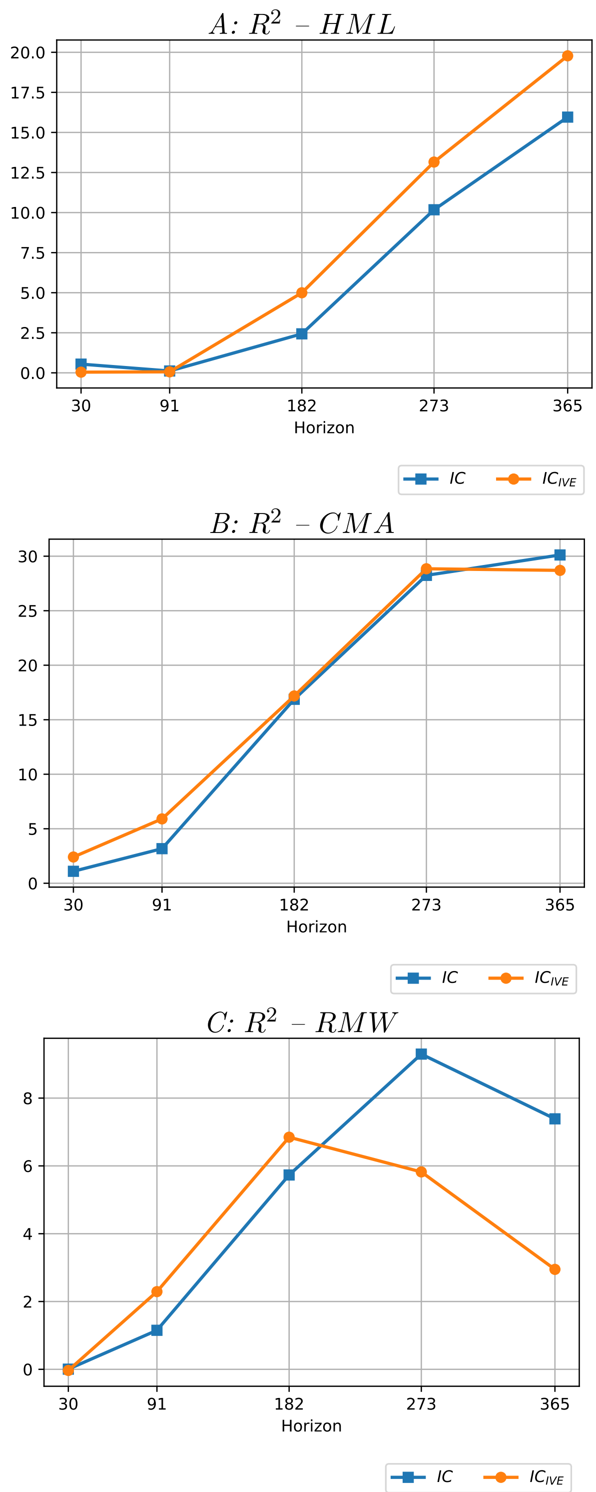
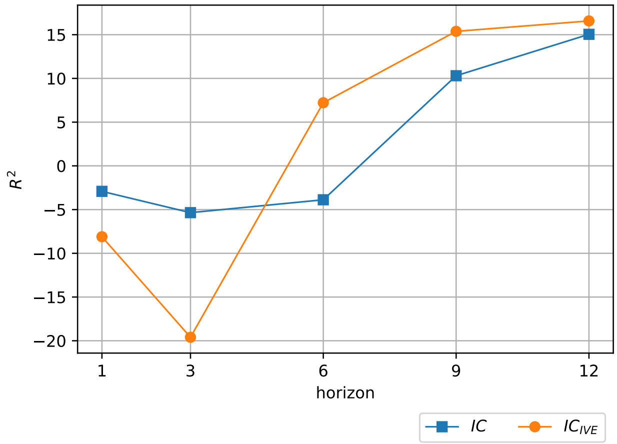


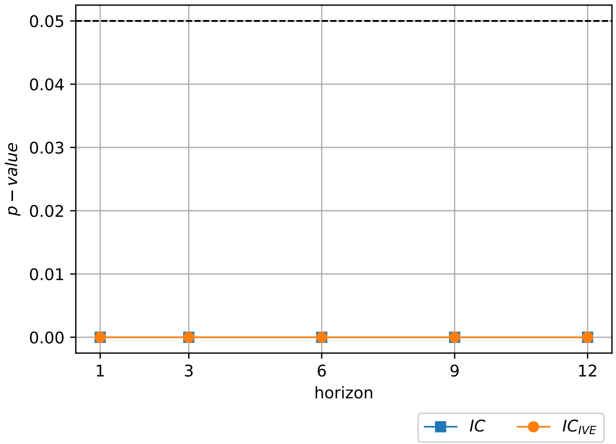
Figure 12. Predictive: Out-of-Sample – Rolling-Window: Factor Returns – IC vs. IC_{IVE}

The figure displays the out-of-sample R^2 (as defined in (24)) and its p-value for predictions based on a long (5-year) rolling estimation window. p-values are computed from bootstrapped distributions, and the dotted lines indicate 5% significance bounds. Implied correlations are constructed for the S&P 500 Index (IC), and for the S&P 500 Value Index (IC_{IVE}) from matching-maturity options. Predictions are made at a monthly frequency from 08/2006 to 12/2017.

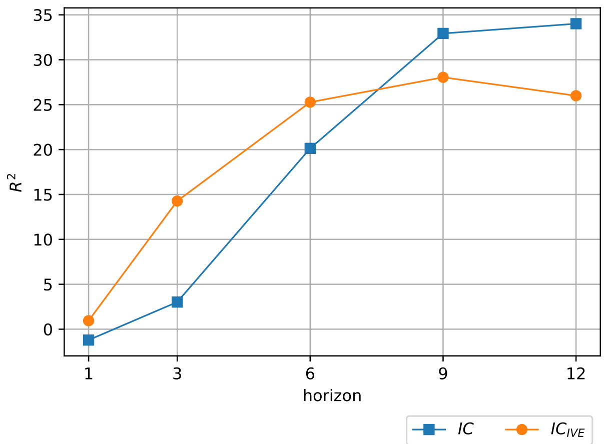
A: R^2 – HML



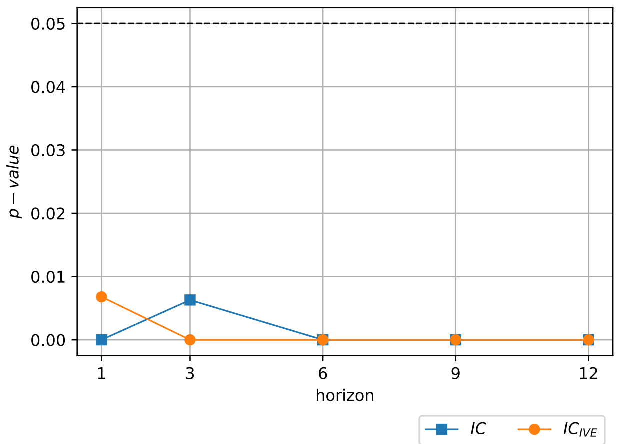
B: p-values – HML



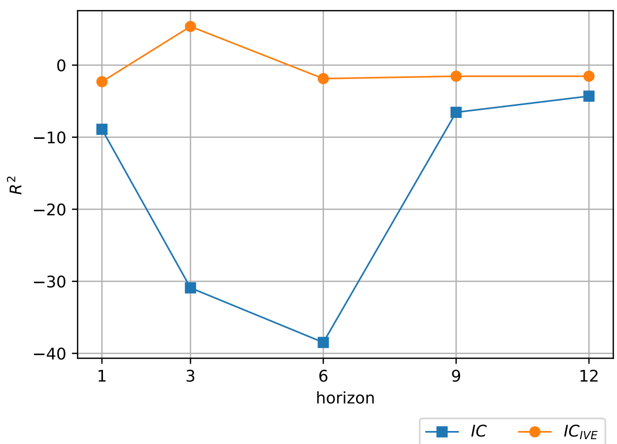
C: R^2 – CMA



D: p-values – CMA



E: R^2 – RMW



F: p-values – RMW

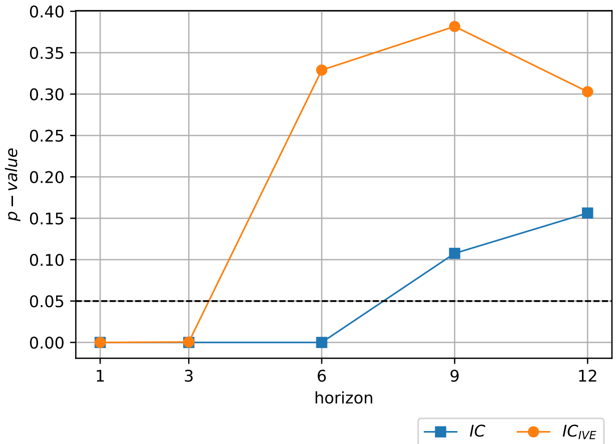
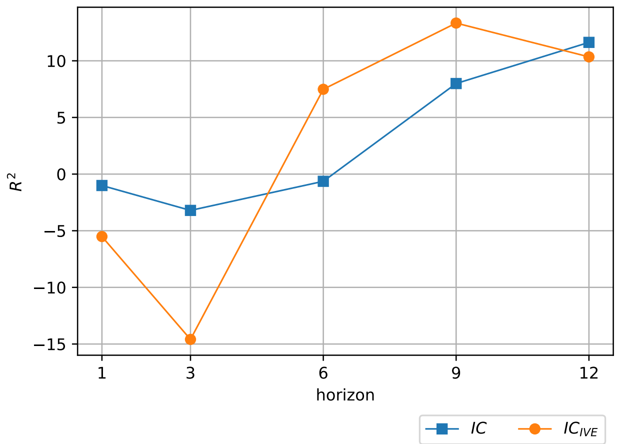


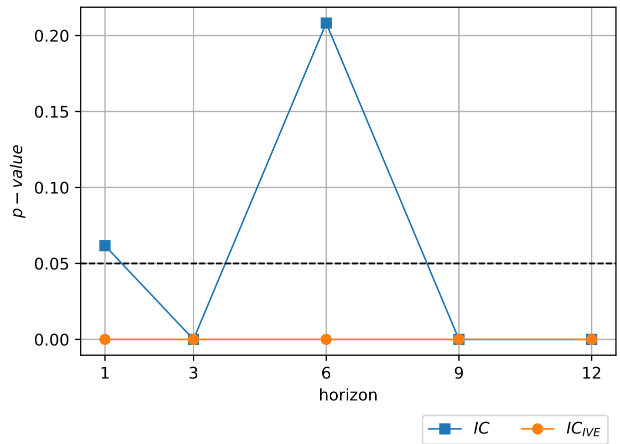
Figure 13. Predictive: Out-of-Sample – Expanding-Window: Factor Returns – IC vs. IC_{IVE}

The figure displays the out-of-sample R^2 (as defined in (24)) and its p-value for predictions based on a long (5-year) expanding estimation window. p-values are computed from bootstrapped distributions and the dotted lines indicate 5% significance bounds. Implied correlations are constructed for the S&P 500 Index (IC), and for the S&P 500 Value Index (IC_{IVE}) from matching-maturity options. Predictions are made at a monthly frequency from 08/2006 to 12/2017.

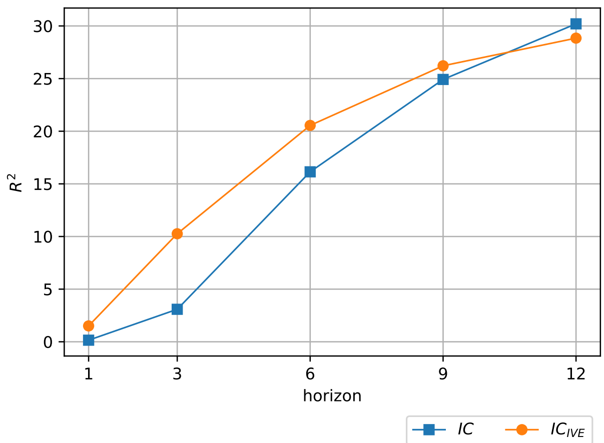
A: R^2 – HML



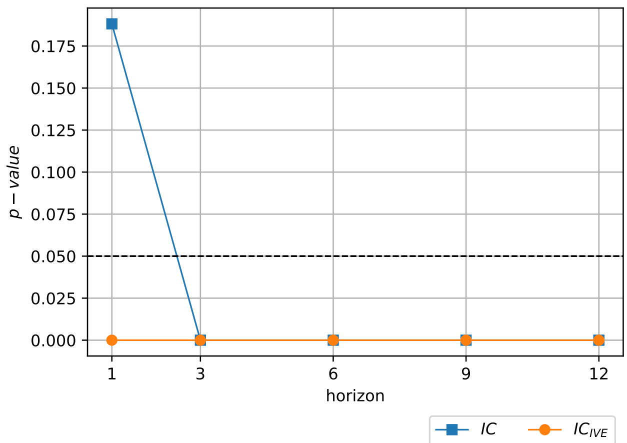
B: p-values – HML



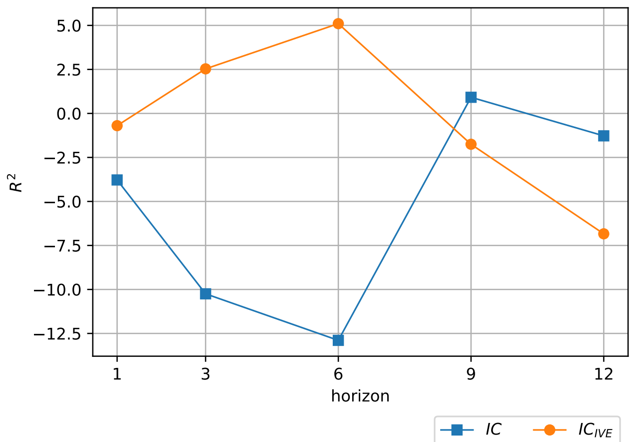
C: R^2 – CMA



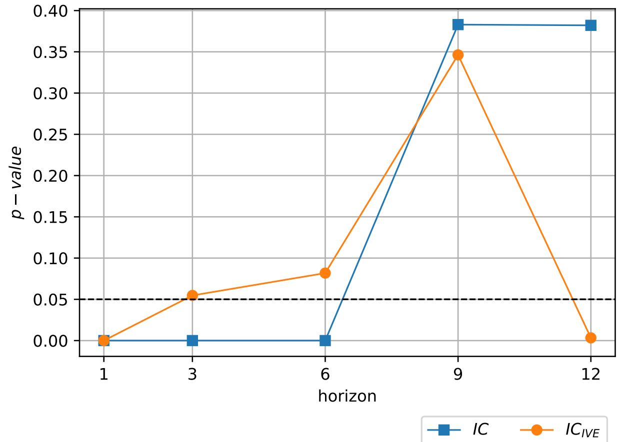
D: p-values – CMA



E: R^2 – RMW



F: p-values – RMW



Appendix

Appendix A. Proxies for PVGO

I follow Cao, Simin, and Zhao (2008) to calculate the proxies for the growth options: 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 ($CAPEX$).

$$M/B = (ATQ - CEQQ + PRCCQ \times CSHOQ)/ATQ \tag{A1}$$

$$Q = (PRCCQ \times CSHOQ + PSTKQ + LCTQ - ACTQ + DLTTQ)/ATQ \tag{A2}$$

$$DTE = (DLCQ + DLTTQ + PSTKQ)/(PRCCQ \times CSHOQ) \tag{A3}$$

$$CAPEX = CAPXY/PPENTQ \tag{A4}$$

Table A1 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 million US$ and financials (sic code between 6000 and 6999). I include only common stocks (CRSP share code in 10 or 11).

Appendix B. Robustness

Figure B1. Predictive: PVGO Proxies – Changes – Non-overlapping

This figure reports the average R^2s and the t-statistics of the univariate predictive regressions of future (log) changes of common proxies for the present value of growth options (PVGO) over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) from matching-maturity options calculated for the S&P 500. The sample period ranges from 01/1996 to 12/2017. The data is sampled on 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 A.

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

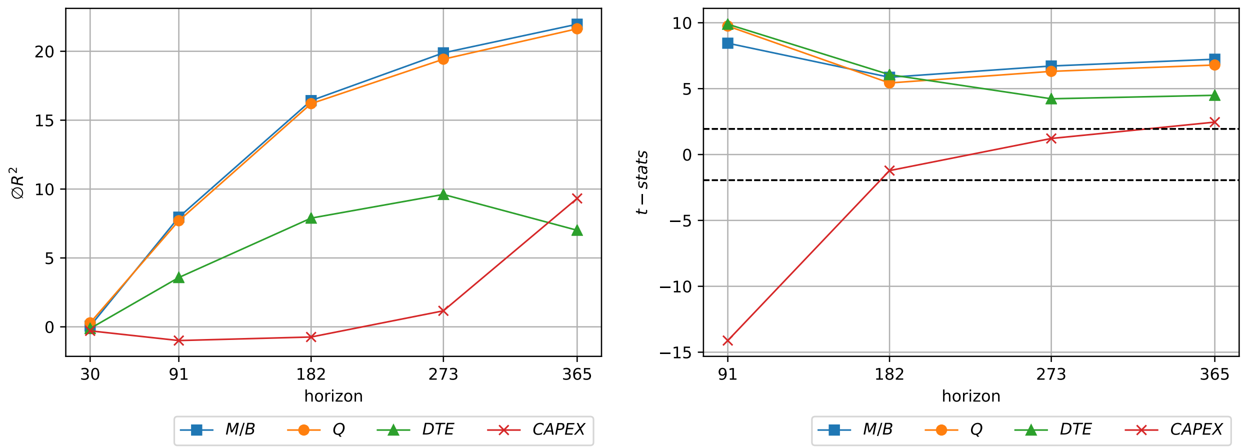
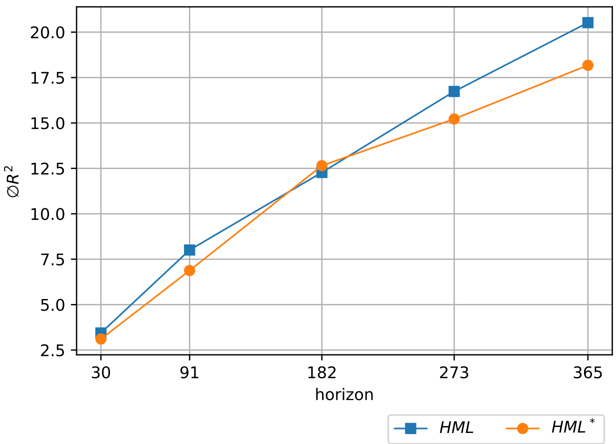


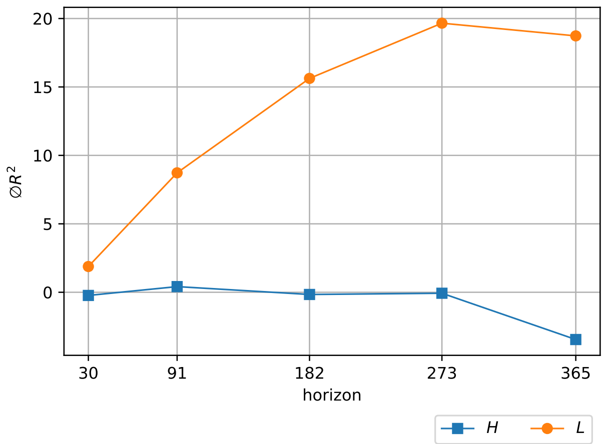
Figure B2. Predictive: Factor Returns – Non-overlapping

The figure shows the average R^2s of the regressions of the value factor returns (HML, HML^*, CMA, CMA^*, RMW, and RMW^*), realized over a future horizon of 30, 91, 182, 273, and 365 calendar days on implied correlations (IC) for the S&P 500 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 (18) to the factor data, which is obtained from Kenneth French's website.

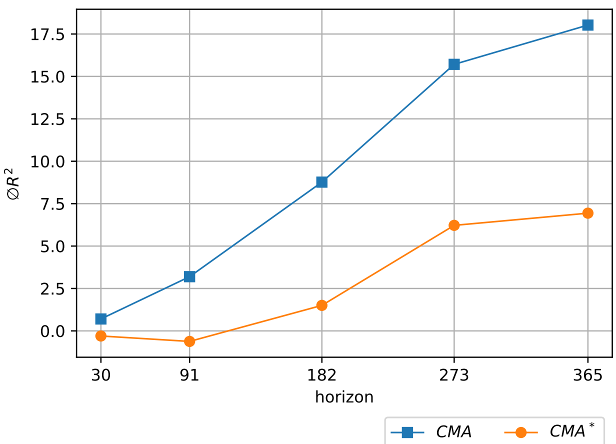
A: R^2 – HML and HML^*



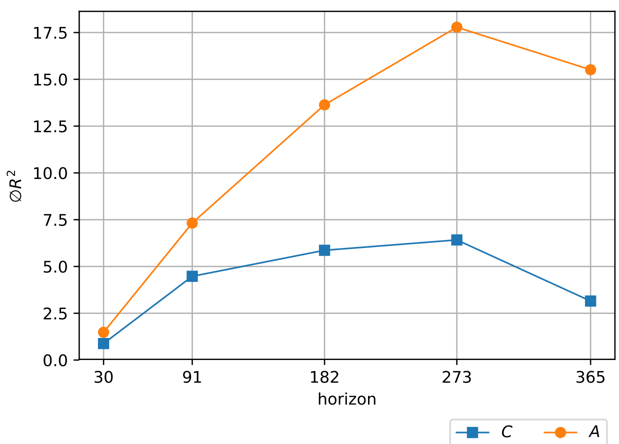
B: R^2 – H and L



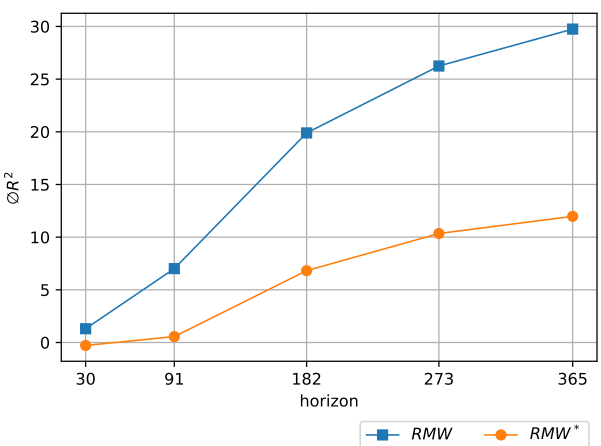
C: R^2 – CMA and CMA^*



D: R^2 – C and A



E: R^2 – RMW and RMW^*



F: R^2 – R and W

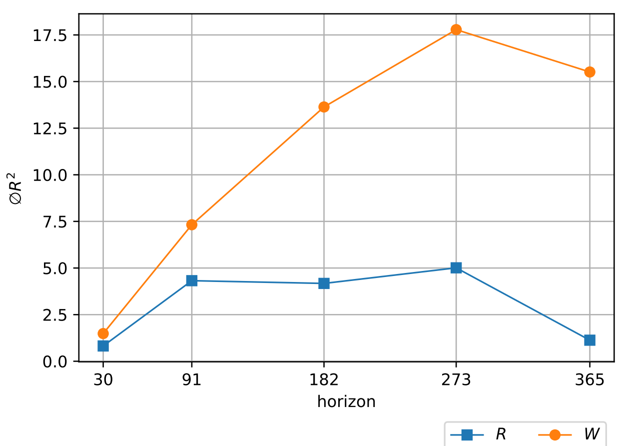


Table B2 Predictive: PVGO Proxies – Changes – with Volatility Controls

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 calculated for the S&P 500. As a proxy for idiosyncratic risk, the value-weighted sum of squared residuals ($VWIV$) is calculated from a factor model for the whole CRSP universe. The sample period ranges from 01/1996 to 12/2017. The data is sampled on 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 A.

	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 B3 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 calculated for the S&P 500. As a proxy for idiosyncratic risk the value-weighted sum of squared residuals ($VWIV$) is calculated from a factor model for the whole CRSP universe. The sample period is from 01/1996 to 12/2017, and the variables are sampled on daily frequency. The market neutral returns are estimated applying equation (18) 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

Appendix C. Internet Appendix

Appendix C.1. The Model

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

Appendix C.1.1. 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,

$$p(\varepsilon_{ft}, u_{jt}, x_t, K_j) = \mathrm{E}_t[\int_t^\infty e^{-\delta(s-t)}\frac{\pi_s}{\pi_t} y_{fjs} ds] = \mathrm{E}_t[\int_t^\infty e^{-\delta(s-t)}\frac{\pi_s}{\pi_t}\varepsilon_{fs} u_{js} x_s K_j^\alpha ds] = A(\varepsilon_{ft}, u_{jt}) x_t K_j^\alpha, \tag{C1}$$

where

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

Appendix C.1.2. Optimal Investment

The optimal investment K_j of firm f in project j at time t is given by $K_f = (z_t \alpha A(\epsilon_{f_t}, 1))^{\frac{1}{1-\alpha}}$. K_f is the solution to the problem

$$\max_{K_f} A(\epsilon_{f_t}, 1) x_t K_f^\alpha - z_t^{-1} x_t K_f. \tag{C2}$$

Rearranging the the first-order condition leads to the optimal solution

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

Appendix C.1.3. 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

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

The present value of growth options can then be written as

$$\begin{aligned} PVGO_{ft} &= \mathrm{E}_t^{\mathbb{Q}}[\int_t^{\infty} e^{-r(s-t)} \lambda_{fs} C z_t^{\frac{\alpha}{1-\alpha}} x_t A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}} ds] \\ &= C z_t^{\frac{\alpha}{1-\alpha}} x_t \mathrm{E}_t[\int_t^{\infty} e^{-\rho(s-t)} \lambda_{fs} A(\epsilon_{f_t}, 1)^{\frac{1}{1-\alpha}} ds] \\ &= C z_t^{\frac{\alpha}{1-\alpha}} x_t G(\varepsilon_{ft}, \lambda_{ft}), \end{aligned} \tag{C3}$$

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

$$\begin{aligned} G_{ft} := G(\varepsilon_{ft}, \lambda_{ft}) &= C \cdot \mathrm{E}_t[\int_t^{\infty} e^{-\rho(s-t)} \lambda_{fs} A(\varepsilon_{fs})^{\frac{1}{1-\alpha}} ds] \\ &= \begin{cases} \lambda_f(G_1(\varepsilon_{ft}) + \frac{\mu_L}{\mu_L+\mu_H}(\lambda_H - \lambda_L) G_2(\varepsilon_{ft})) & \bar{\lambda}_{ft} = \lambda_H \\ \lambda_f(G_1(\varepsilon_{ft}) - \frac{\mu_H}{\mu_L+\mu_H}(\lambda_H - \lambda_L) G_2(\varepsilon_{ft})) & \bar{\lambda}_{ft} = \lambda_L, \end{cases} \end{aligned} \tag{C4}$$

with $\rho = r + \gamma_x\sigma_x - \mu_x - \frac{\alpha}{1-\alpha}(\mu_z - \gamma_z\sigma_z + \frac{1}{2}\sigma_z^2) - \frac{\alpha^2\sigma_z^2}{2(1-\alpha)^2}$, and $C = \alpha^{\frac{1}{1-\alpha}}(\alpha^{-1} - 1)$. An application of the Feynman–Kac formula states that $G_1(\varepsilon)$ and $G_2(\varepsilon)$ solve the following ODE:

$$a(\varepsilon)z' - b(\varepsilon)z - \rho_i y + c(\varepsilon) = 0,$$

where $a(\varepsilon) = \frac{1}{2}\sigma_\varepsilon^2\varepsilon, b(\varepsilon) = \theta_\varepsilon(\varepsilon - 1), c(\varepsilon) = CA(\varepsilon, 1)^{\frac{1}{1-\alpha}}, y = G, z = G'$, and $\rho_1 = \rho, \rho_2 = \rho + \mu_H + \mu_L$. For further details, see Kogan and Papanikolaou (2014).

Appendix C.1.4. Value and Growth Dynamics

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

$$dVAP_{ft} = dx_t \sum_j A_{ft} + x_t d\sum_j A_{ft} + dx_t d\sum_j A_{ft} = dx_t \sum_j A_{ft} + x_t d\sum_j A_{ft}, \tag{C5}$$

and, therefore,

$$\frac{dVAP_{ft}}{VAP_{ft}} = \frac{dx_t}{x_t}\frac{\sum_j A_{ft}}{\sum_j A_{ft}} + \frac{x_t}{x_t}\frac{d\sum_j A_{ft}}{\sum_j A_{ft}} = \frac{dx_t}{x_t} + \frac{d\sum_j A_{ft}}{\sum_j A_{ft}}. \tag{C6}$$

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

$$dPVGO_{ft} = d(z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}) = d(z_t^{\frac{\alpha}{1-\alpha}} x_t)G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} + d(z_t^{\frac{\alpha}{1-\alpha}} x_t) dG_{ft}. \tag{C7}$$

First, calculate

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

and, therefore,

$$dPVGO_{ft} = (z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + x_t R(z_t) dt) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}. \tag{C8}$$

In relative terms, one obtains

$$\begin{aligned} \frac{dPVGO_{ft}}{PVGO_{ft}} &= \frac{z_t^{\frac{\alpha}{1-\alpha}} dx_t}{z_t^{\frac{\alpha}{1-\alpha}} x_t} + \frac{x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t}{z_t^{\frac{\alpha}{1-\alpha}} x_t} + \frac{R(z_t)dt}{z_t^{\frac{\alpha}{1-\alpha}}} + \frac{z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft}}{z_t^{\frac{\alpha}{1-\alpha}} x_t G_{ft}} \\ &= \frac{dx_t}{x_t} + \frac{\alpha}{1-\alpha}\frac{dz_t}{z_t} + \frac{R(z_t)dt}{z_t^{\frac{\alpha}{1-\alpha}}} + \frac{dG_{ft}}{G_{ft}}. \end{aligned} \tag{C9}$$

Appendix C.1.5. Expected Returns Dynamics

The risk premium on VAP and $PVGO$ is given by the covariance of the pricing kernel $\frac{d\pi_t}{\pi_t} = -rdt - \gamma_x dB_{xt} - \gamma_z dB_{zt}$ and the respective expressions (C6) and (C9),

$$\mathrm{E}_t[R_{ft}^{VAP}] - r_f = -cov(\frac{dVAP_{ft}}{VAP_{ft}}, \frac{d\pi_t}{\pi_t}) = -cov(\frac{dx_t}{x_t}, \frac{d\pi_t}{\pi_t}) = \sigma_x\gamma_x dt, \tag{C10}$$

and

$$\mathrm{E}_t[R_{ft}^{GO}] - r_f = -cov(\frac{dPVGO_{ft}}{PVGO_{ft}}, \frac{d\pi_t}{\pi_t}) = -cov(\frac{dx_t}{x_t} + \frac{\alpha}{1-\alpha}\frac{dz_t}{z_t}, \frac{d\pi_t}{\pi_t}) = \sigma_x\gamma_x dt + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z dt. \tag{C11}$$

Hence,

$$\begin{aligned}
\mathrm{E}_t[R_{ft}] - r_f &= \frac{VAP_{ft}}{V_t}(\mathrm{E}_t[R_{ft}^{VAP}] - r_f) + \frac{PVGO_{ft}}{V_t}(\mathrm{E}_t[R_{ft}^{GO}] - r_f) \\
&= \frac{VAP_{ft}}{V_t}(\sigma_x\gamma_x) + \frac{PVGO_{ft}}{V_t}(\sigma_x\gamma_x + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z) \\
&= \sigma_x\gamma_x + \frac{\alpha}{1-\alpha}\sigma_z\gamma_z\frac{PVGO_{ft}}{V_t}.
\end{aligned} \tag{C12}$$

Appendix C.1.6. Market Return Dynamics

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

$$\sum_f \frac{1}{dt}\frac{V_{ft}}{V_{Mt}}E[R_{ft}] - r_f = \sum_f \frac{V_{ft}}{V_{Mt}}\gamma_x\sigma_x + \frac{\alpha}{1-\alpha}\gamma_z\sigma_z\sum_f \frac{V_{ft}}{V_{Mt}}\frac{PVGO_{ft}}{V_{ft}} = \gamma_x\sigma_x + \frac{\alpha}{1-\alpha}\gamma_z\sigma_z\frac{PVGO_{Mt}}{V_{Mt}}, \tag{C13}$$

where $PVGO_M := \sum_f PVGO_f$. The market return variance can be written as

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

$$= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{Mt}}{V_{Mt}})^2 dt, \tag{C14}$$

where the last step follows with $\sum_k \sum_l \frac{V_{kt}}{V_{Mt}} \frac{V_{lt}}{V_{Mt}} = 1$, and $PVGO_M^2 := (\sum_k PVGO_k)^2 = \sum_k \sum_l PVGO_k PVGO_l$.

Appendix C.1.7. Firm Return Dynamics

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

$$\begin{aligned}
dV_{ft} &= dVAP_{ft} + dPVGO_{ft} \\
&= \sum_j A_{ft} dx_t + x_t d \sum_j A_{ft} + (z_t^{\frac{\alpha}{1-\alpha}} dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} dz_t + R(z_t)dt) G_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} \\
&= R(z_t) G_{ft} dt + (\sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} G_{ft}) dx_t + x_t \frac{\alpha}{1-\alpha} z_t^{\frac{\alpha}{1-\alpha}-1} G_{ft} dz_t + x_t d \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} \\
&= \bar{R}(z_t) dt + \sigma_x dB_{xt} (x_t \sum_j A_{ft} + x_t z_t^{\frac{\alpha}{1-\alpha}} G_{ft}) + x_t z_t^{\frac{\alpha}{1-\alpha}} G_{ft} \frac{\alpha}{1-\alpha} \sigma_z dB_{zt} + dIdio_f \\
&= \bar{R}(z_t) dt + \sigma_x dB_{xt} V_{ft} + \frac{\alpha}{1-\alpha} PVGO_{ft} \sigma_z dB_{zt} + dIdio_f,
\end{aligned} \tag{C15}$$

where

$$dIdio_f = x_t d \sum_j A_{ft} + z_t^{\frac{\alpha}{1-\alpha}} x_t dG_{ft} \tag{C16}$$

denotes the dynamics associated with A_{ft} (as a function of $\varepsilon_{ft}, u_{jt}, K_j^\alpha$) and G_{ft}. The return dynamic of the firm can be written as

$$dR_{ft} = \frac{dV_{ft}}{V_{ft}} = \mathrm{E}[R_{ft}]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \frac{PVGO_{ft}}{V_{ft}} \sigma_z dB_{zt} + \frac{dIdio_f}{V_{ft}}. \tag{C17}$$

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

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

$$= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 \frac{PVGO_{kt}}{V_{kt}} \frac{PVGO_{lt}}{V_{lt}} dt. \tag{C18}$$

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

$$dR_{ft} dR_{ft} = (\mathrm{E}[R_f]dt + \sigma_x dB_{xt} + \frac{\alpha}{1-\alpha} \sigma_z \frac{PVGO_{ft}}{V_{ft}} dB_{zt} + \frac{dIdio_f}{V_f})^2$$

$$= \sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{ft}}{V_{ft}})^2 dt + (\frac{dIdio_f}{V_{ft}})^2. \tag{C19}$$

Therefore, the correlation can be calculated as

$$Corr(dR_{kt}, dR_{lt}) = \frac{dR_{kt} dR_{lt}}{\sqrt{\sigma^2(dR_{kt})}\sqrt{\sigma^2(dR_{lt})}}$$

$$= \frac{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 \frac{PVGO_{kt}}{V_{kt}} \frac{PVGO_{lt}}{V_{lt}} dt}{\sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{kt}}{V_{kt}})^2 dt + (\frac{dIdio_k}{V_{kt}})^2} \sqrt{\sigma_x^2 dt + (\frac{\alpha}{1-\alpha})^2 \sigma_z^2 (\frac{PVGO_{lt}}{V_{lt}})^2 dt + (\frac{dIdio_l}{V_{lt}})^2}}. \tag{C20}$$

Appendix C.2. NBER Recession Indicator - Contraction and Expansion

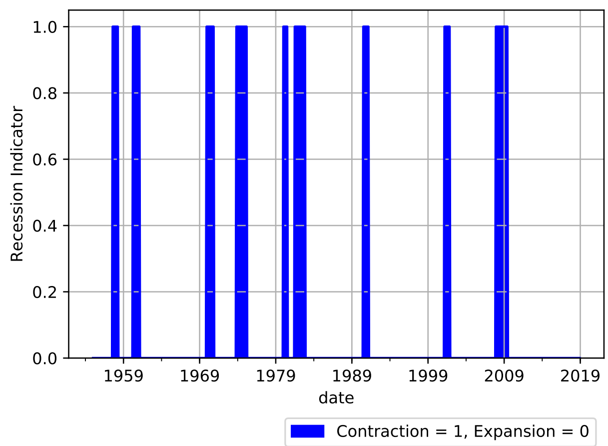
The time series is composed of dummy variables that represent periods recession (1) and expansion (0). The recession begins on the first day of the period following a peak and ends on the last day of the period of the trough. The NBER defines the contraction periods (peak to trough) as displayed in the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

Table C4 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 C3. 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.



Appendix C.3. Additional Tables and Figures

Table C5 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&P 500 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 A. The sample period is from 01/1996 to 12/2017, and the variables are sampled monthly. The market-neutral returns are estimated applying equation (18) 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 C6 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&P 500 Index. The sample period is from 01/1996 to 12/2017, and the variables are sampled monthly. 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 (18) 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

Table C7 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 ranges 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 A. 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 C8 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&P 500 Index. Realized correlations are obtained via (17) and calculated from daily realized returns over a respective backward-looking window, corresponding to the predictive horizon. The sample period for RC ranges from 01/1965 to 12/2018. The variables are sampled at daily frequency. The market-neutral returns are estimated applying (18) 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 C9 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 RC ranges 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 A. 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 **??**. 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 C10 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 and for the S&P 500. The sample period for RC ranges from 01/1965 to 12/2017 and for IC 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 A. 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 **??**. 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

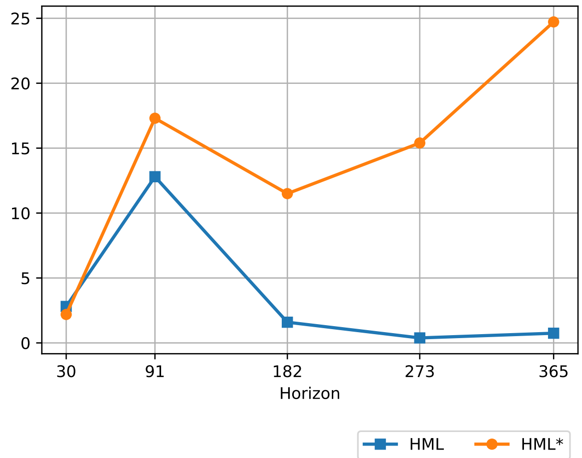
Panel B: Expansion

	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

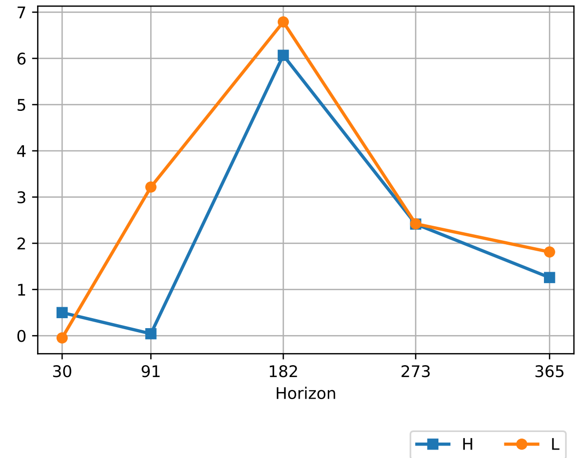
Figure C4. Predictive: Factor Returns – RC – Expansion and Contraction

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 realized correlations (RC) for the S&P 500, obtained via (17) 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 is defined based on the NBER based Recession Indicator. The market-neutral returns are estimated applying (18) to the factor data, which is obtained from Kenneth French's website.

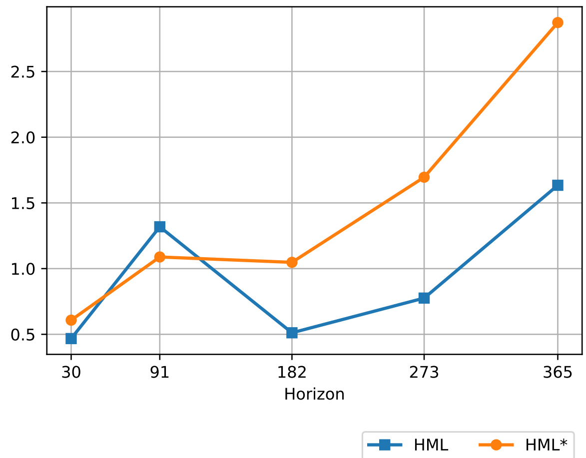
A: R^2 – Factors - Contraction



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



C: R^2 – Factors - Expansion



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

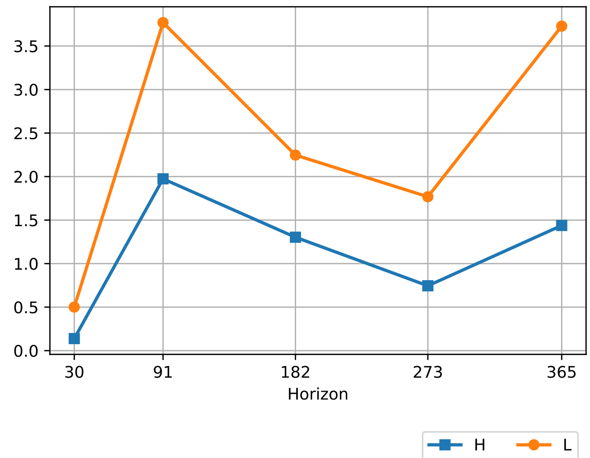
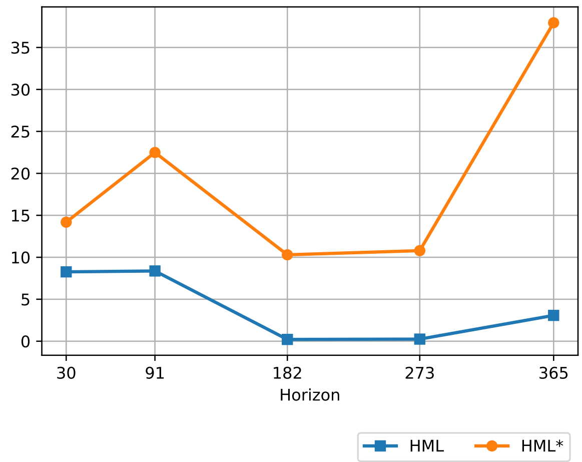


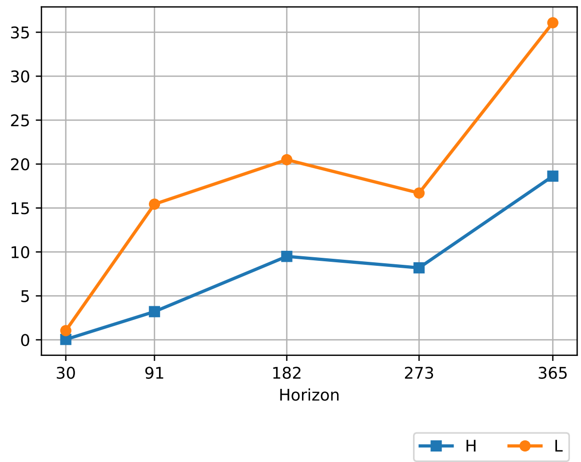
Figure C5. Predictive: Factor Returns – IC – Expansion and Contraction

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&P 500 Index from matching-maturity options. The sample period is from 01/1996 to 12/2017, and the variables are sampled daily. The relevant data for contraction and expansion are defined based on the NBER based Recession Indicator. The market-neutral returns are estimated applying (18) to the factor data, which is obtained from Kenneth French's website.

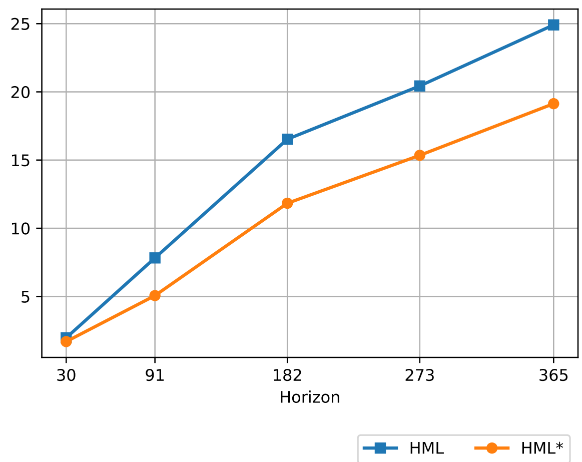
A: R^2 – Factors – Contraction



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



C: R^2 – Factors – Expansion



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

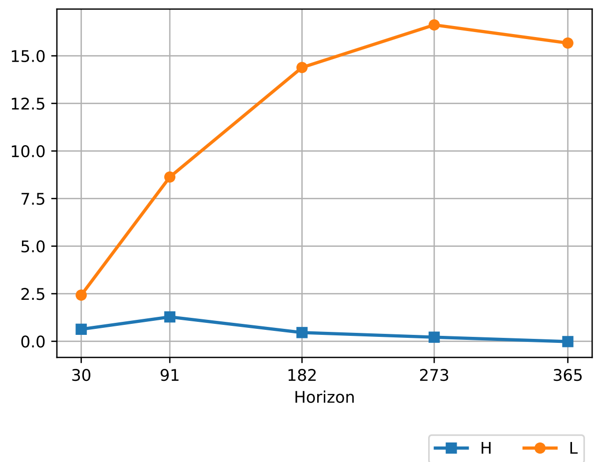


Figure C6. PVGO Proxies: Sector Exposure

The figure shows the exposure of common proxies for the value of growth options. The sample period ranges from 01/1984 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 growth options are classified via the sector information based on GICS codes and weighted according to the market capitalization of the respective company. The data for the calculation of the PVGO proxies is obtained from Compustat and available on a monthly frequency. For further details see Appendix A. In the plots the twelve months moving average is depicted.