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The information content of US stock market factors

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Received 7 October 2019
Revised 17 December 2019
Accepted 15 January 2020

Abstract

Purpose – The purpose of this paper is to consider the economic information content within several popular stock market factors and to the extent to which their movements are both explained by economic variables and can explain future output growth.

Design/methodology/approach – Using US stock portfolios from 1964 to 2019, the authors undertake three related exercises: whether a set of common factors contain independent predictive ability for stock returns, what economic and market variables explain movements in the factors and whether stock market factors have predictive power for future output growth.

Findings – The results show that several of the considered factors do not contain independent information for stock returns. Further, most of these factors are neither explained by economic conditions nor they provide any predictive power for future output growth. Thus, they appear to contain very little economic content. However, the results suggest that the impact of these factors is more prominent with higher macroeconomic risk (contractionary regime).

Research limitations/implications – The stock market factors are more likely to reflect existing market conditions and exhibit a weaker relation with economic conditions and do not act as a window on future behavior.

Practical implications – Fama and French three-factor model still have better explanations for stock returns and economic information more than any other models.

Originality/value – This paper contributes to the literature by examining whether a selection of factors provides unique information when modelling stock returns data. It also investigates what variables can predict movements in the stock market factors. Third, it examines whether the factors exhibit a link with subsequent economic output. This should establish whether the stock market factors contain useful information for stock returns and the macroeconomy or whether the significance of the factor is a result of chance. The results in this paper should advance our understanding of asset price movement and the links

JEL classification – C22, G12

Dr Moahmmed M. Elgammal is in a sabbatical leave from Monufia University, Egypt.

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The authors gratefully acknowledge financial assistance from the Qatar National Research Fund (QNRF), project number NPRP8-601-5-074.

between the macroeconomy and financial markets and, thus, be of interest to academics, investors and policy-makers.

Keywords Stock market factors, GDP growth, Predictability, Asset pricing, Macroeconomic risk

Paper type Research paper

1. Introduction

In understanding asset price behavior, current research typically forms portfolios based on some firm characteristic, measure of value or past stock returns. This often includes, to provide a few examples, defining a portfolio according to size (such as large and small firms), book-to-market ratio (such as value and growth firms) or by past performance (such as winners and losers). These portfolios are then regressed against factors that are defined as the difference between such portfolios, for example, small minus large firms, value minus growth firms and winners minus losers. Where a factor is identified as statistically significant, it is then regarded as a risk factor that helps explain the cross-sectional variation in (expected) returns. See, for example, Fama and French (1993), Carhart (1997), Liew and Vassalou (2000), Vassalou and Xing (2004), Bollerslev *et al.* (2016), Cederburg and O'Doherty (2016), Chai *et al.* (2017), Detzel and Strauss (2017) and Nartea *et al.* (2017).

Currently, the number of identified factors is vast; Harvey *et al.* (2016) note over 300 factors within the academic literature, although preference for the simpler capital asset pricing model (CAPM) often remains, as the gains from larger factor models are unclear. A drawback with this approach is that it provides little guidance for investors or policy-makers in selecting factors to use when seeking to predict movements in stock returns or the wider economy. No model could reasonably include all the factors suggested in the literature. Thus, an obvious question arises as to the information content of each factor. Specifically, beyond statistical significance, do the factors contain independent information and to what extent are they related to movements in economic variables, that is, do they contain economic significance. Therefore, in seeking to understand these factors and their relevance for asset price movement and the economy, we consider several aspects of their behavior. First, as highlighted by the extensive number of identified factors, there must be some clarity regarding whether any given factor contains unique information that can be used to aid our understanding of asset price movements. Second, as argued by Cochrane (2011), it is the factors themselves that we wish to estimate and understand. It is the stock market factors that govern movement in expected returns and asset prices, and hence, it is these factors that hold the key to understanding movements in asset valuations. As such, we would expect movement in these factors to arise from economic risk variables. Third, the factors should contain information that correlates with the underlying economic state variable that drives asset price movement. As such, factors should exhibit a causal relation with the macroeconomy. Without any given factor exhibiting independent information for stock returns and a relation with economic variables, it is unlikely to retain its importance in future samples and does not add to our knowledge of the relation between financial and real markets.

Our work contributes to the literature by considering whether a (relatively) small set of factors exhibit independent information for stock returns and whether these factors are linked with the macroeconomy. We do this through a series of empirical approaches. First, we seek to examine the extent to which a selection of factors provides both common and unique information when modelling stock returns data. Second, we consider what variables can predict movements in the stock market factors. Notably, we wish to consider variables that capture macroeconomic risk; this includes output growth, inflation and the term structure of interest rates (10-year bond minus 3-month bill). Third, we examine whether the factors exhibit a link with subsequent economic output. This should establish whether the stock market factors considered within this paper contain useful information for stock returns and the macroeconomy or whether the significance of the factor is potentially a result of chance. The results in this paper should, therefore, advance our understanding of asset price movement and the links between the macroeconomy and financial markets and, thus, be of interest to academics, investors and policy-makers.

Our findings suggest that several factors do indeed carry similar information content. Namely, the profit and quality factors contain similar information for stock returns movement. A similar effect is revealed in which the change in the Q-ratio is rendered insignificant by the inclusion of the market factor. Our findings support the size and value factors, but there is no evidence of a consistent momentum or reversal effect, while the investment and quality factors do not provide consistency in the sign of the relation with stock returns. In linking the stock market factors with macroeconomic variables, we find both only limited evidence that the risk factors can be explained by economic variables and that the factors exhibit any predictive power for subsequent economic growth. Our findings do reveal that the change in the Q-ratio has predictive power for economic growth; however, other factors have limited predictability power, although this is enhanced when examining contractionary periods in isolation. Nonetheless, this casts doubt on the economic content of these stock market factors.

The rest of the paper is organized as follows. Section 2 summarizes the current state of the literature and the motivation of the paper. The third section explains the methodological framework. Section 4 discusses the empirical results, and finally, Section 5 concludes the paper with summary for the implications of the work.

2. Literature review

As noted above, there exists a large literature that identifies stock market factors as predictors of stock returns. This line of work largely began with the three-factor model of Fama and French (1993) and has continued with research that subsequently uncovers a wide range of factors that can seemingly explain stock returns. This led to the work of Harvey *et al.* (2016), who note over 300 factors have been introduced and argue that conventional statistical significance levels should not be used when evaluating the ability of factors. This is particularly relevant given the large number of studies that search for alternate factors but are based on the same set of data.

Together with the work of Harvey *et al.* (2016), the recent work of Cochrane (2011), Lewellen (2015) and Dickson (2016) has questioned the line of empirical finance research that seeks to find (an ever-increasing number of) factors thought to explain cross-sectional differences between stock returns. Lewellen (2015) considers whether adding additional factors to a model of expected returns improves the model fit and, thus, the ability to generate a profitable investment strategy. Dickson (2016) continues this approach and examines whether a range of factors can be used to build an investment strategy. In a slightly different tact, Cochrane (2011) argues that the apparent race for factors misses the key point that lies behind the use of factors in asset price valuation. Cochrane (2011) refers to the explosion in factors as a "factor zoo." It is clear from this developing line of work that the search for factors is moving the research agenda down a path that does not necessarily enhance our understanding of stock market behavior and its link with the macroeconomy.

In seeking to compare the ability of factors to explain stock returns, one recently introduced approach is to consider the value of the intercept (alpha) terms in the asset-pricing model. For example, Fama and French (2015, 2016), Hou *et al.* (2015, 2017) and Stambaugh and Yuan (2016) compare the performance of different asset pricing models using the average absolute alpha or the Gibbons *et al.* (1989) F-statistic for a zero-alpha restriction. The argument here is that the model with the smallest (and ideally a zero) alpha is preferred. In contrast, Barillas and Shanken (2017) claim that this (alpha test) framework can be misleading in identifying the preferred model. Notably, Barillas and Shanken (2017) argue that a relevant factor should price both asset returns and the factors of alternative models. In other words, to understand whether factors contain independent information for stock returns, we should regress the different factors on each other and consider as important any that exhibits a non-zero alpha[1]. In an example of this approach, Fama and French (2016) highlight that the value factor (HML) is explained by the other factors in the five-factor model and, thus, maybe redundant. Notwithstanding this, Barillas and Shanken (2017) argue that potentially irrelevant test assets may still be required in the construction of non-traded factors. This, therefore, invites us to consider further approaches to investigate the information content of factors as we do here[2].

Although the CAPM has been widely used in many financial applications, empirical research has shown many cases of mispricing, including significant unexplained risk factors that vary in a cross-sectional manner with firm characteristics and business conditions. This invite researchers to adopt arbitrage pricing theory (APT) introduced by Ross in 1976 (Ross, 2013) who suggested that an asset's returns can be predicted using a number of macroeconomic variables that capture systematic risk. The linear factor model structure of the APT is used as the basis for many of the multiple risk factors models in the literature and even the practical risk systems used by asset managers (Roll and Ross, 1984 and French, 2017). The APT theory is more flexible compared to the CAPM, as the former allows to include many risk factors assuming that these factors capture systematic risk elements and can be linked to macroeconomic factors. However, the APT imposes certain criteria in selecting risk factors; first, they should empirically explain the unexpected movements in assets prices and this relation can be theoretically justified by economic explanation, and second, they should capture systematic risk and have available timely and accurate information.

We adopt the APT in building our framework in both selecting investigated risk factors macroeconomic variables and in testing the relationship between risk factors and macroeconomic variables. The paper considers a selection of factors that are commonly used within the literature and have some theoretical base and economic explanation for their inclusion. Our first selected set of variables is Fama and French five-factor model, which is dominating the current literature. The risk factors in this model are market factor (supported by CAPM theory); small minus big firms (SMB), high minus low book-to-market (HML), high profit firms minus low profit firms (PMU) and low investing minus high investing firms (CMA) (Novy-Marx, 2013 and Fama and French, 2015). Fama and French (1993) explain the economic rationale behind the HML and SMB by suggesting that proxy for state variables that describe time variation in the investment opportunity set. This risk-based explanation finds its roots in Merton's (1973) intertemporal capital asset pricing model (ICAPM) which allows to incorporate multistate state variables that capture the investors decisions to hedge against shortfalls in consumption or against changes in the future investment opportunity set. This economic rationality for HML and SMB has been confirmed by empirical research, which linked these factors to macroeconomic variables and business cycle fluctuations. For example, Liew and Vassalou (2000), Lettau and Ludvigson (2001), Vassalou (2003), Elgammal and McMillan (2014), Elgammal *et al.* (2016) and Hammerschmid and Lohre (2017) show links between the FF factors and gross domestic product (GDP) growth among other macroeconomic variables which is consistent with the ICAPM explanation that the investment opportunity set are summarized by changes in future GDP growth. However, Campbell (1996) argues that empirical implementations of the

ICAPM should include factors which can be linked to innovations in state variables that forecast future investment opportunities. This explanation is supported by Petkova (2006), who relates the HML and SMB factors to innovations in state variables. Therefore, the HML and SMB factors can be considered as compensation for a single common risk in the context of a one-state variable ICAPM or a two-factor APT.

The two remaining factors in Fama-French five-factor model are profit and investment factors (these two factors have been suggested also by Hou *et al.*, 2015, 2017). Fama and French (2015) found the theoretical ground for his 5Fmodel using a theoretical framework of the dividend discount model of Modigliani and Miller (1958) and relate the five factors to state variables of expected stock returns. Fama and French (2015) use the dividend discounted model to show a positive relationship between higher book-to-market and profitability of the firm from one side and its expected stock returns from other side, while the model shows a negative relationship between investment and stock return. On the other hand, Hou *et al.* (2015) build their model based on the investment-based asset pricing theory which is, in turn, derived from the neoclassical q-theory of investment. Hou *et al.* (2015) justify the ability of investment and profitability factors to predict returns because high costs of capital reflect low net present values of new capital and low investment where high expected profitability relative to low investment must imply high discount rates.

We also consider the momentum factor suggested by Carhart (1997) motivated by the work of Jegadeesh and Titman (1993). The momentum factor is well documented in the literature as a risk factor (Fama and French, 2012; Asness *et al.*, 2019). Barillas and Shanken (2018) find that the recent models of Hou *et al.* (2015, 2017) and Fama and French (2015, 2016) are both dominated by a variety of models that include a momentum factor, along with value and profitability factors. Johnson (2002) introduces a theoretical rational explanation for the momentum by showing that firm cash-flows discounted by an ordinary pricing kernel can deliver a strong positive correlation between past realized returns and current expected returns. The crucial element in Johnson's (2002) theory is the stochastic expected growth rates in equity, which affect returns in a highly non-linear way with extreme curvature with convex log. This convex log means that growth rate risk rises with growth rates, and if the exposure to this risk conveys a price increase, then expected returns rise with growth rates. In Johnson's (2002) words:

> [. . .] firms that have recently had large positive price moves are more likely to have had positive growth rate shocks than other firms, with negative growth shocks more likely among poor performers.

Motivated by the theoretical work of Johnson (2002), Sagi and Seasholes (2007) and Liu and Zhang (2008) find a high loading from the past winner on the growth rate of industrial production compared to lower loading by past losers which suggest that momentum profits reflect temporary increases in growth-related risk for winner-minus-loser portfolios. Daniel and Moskowitz (2016) explain equity momentum by assuming that a share of common stock is a call option on the underlying firm's assets when there is debt in the capital structure (Merton, 1974) . In distressed periods, the underlying firm values of the past losers suffered severely; this may bring them to a level in which the option convexity is strong.

Berk *et al.* (1999) suggest another explanation for HML, SMB, MOM, LTR and STR by introducing a model to show that investment decisions affect the firm growth opportunities, which in turn affect the systematic risk of the firm and its expected returns. If the firm takes investment with lower systematic risk, this will increase the firm value although it will reduce its systematic risk and reduce expected return. The expected returns in a given period are positively associated with lagged expected returns because the systematic risk of firm's assets are persistence and negatively correlated for realized returns which create the momentum and STR and LTR effects. In the same context, the reversal of stocks over the short-run STR (Jegadeesh, 1990) has been theoretically explained by the investor's overreaction to the past information and a correction of that reaction after a short time horizon. Nagel (2012) introduces different interpretation by arguing that STR is a proxy for the returns from liquidity provision and shows that reversal anomaly returns closely track the returns earned by liquidity providers. The reversals are induced by inventory imbalances by market makers and that the contrarian profits are compensation for bearing inventory risks. On the other hand, long-run reversal LTR, documented by De Bondt and Thaler (1985), can be explained by delayed understanding of the structural changes in an industry by investors which consequently yield a reversal in its returns (Blackburn and Cakici, 2017; Jegadeesh and Titman, 1993; Daniel *et al.*, 1998; Barberis *et al.*, 1998 and Hong and Stein, 1999).

Harney and Tower (2003) showed that Tobin Q ratio, advocated by Smithers and Wright (2000), is able to explain variation in stock returns. They imply that stock prices should demonstrate a fundamental relationship to the ability of firms to generate profits in terms of earnings. There should be a fundamental relationship between stock market valuations and underlying corporate assets; more simply, firms in the long run should be valued at their current cost of creation, so q should theoretically hover around 1.0 under rational expectations. Robertson and Wright (1998) demonstrate that q mean-reverts through changes in stock market values (the numerator) rather than through changes in corporate investment (the denominator).

Our last considered risk factor is the quality minus junk factor (QMJ) introduced by Asness *et al.* (2019), who show that high-quality stocks in terms of profits, growth, low risk and payout surprisingly make higher returns compared to lower-quality stocks. They explain this premium by suggesting that investors may have other criteria of quality stocks rather than aforementioned four criteria. Investors may assume that high-quality stocks are efficiently priced, which results in a bias toward junk stocks because of their perceived low price.

The current paper also builds on the earlier work of Liew and Vassalou (2000), who consider whether stock market factors have any predictive ability for output. Specifically, if stock market factors indeed act as (proxies for) risk factors, then they will contain information for the future performance of the macroeconomy. That is, movements in stock markets reflect expected changes in future economic performance, which will ultimately be reflected by movements in macroeconomic variables. Thus, factors that are believed to affect stock returns should also affect output growth. Huang and Kracaw (1984), Chen *et al.* (1986), Asprem (1989), Chen (1991) and Serletis (1993), among others, find a positive relation between stock prices and economic growth. Barillas (2017) argues that the asset prices should reveal aggregate macroeconomic risk and that stocks returns vary countercyclically. This paper considers the relation between economic and return risk factors and seeks to provide clarity with respect to the nature of information contained within a range of stock market factors.

3. Data and methodology

3.1 Data

We begin by selecting nine factors, in addition to the market portfolio. As noted in the work of Harvey *et al.* (2016), there are a (very) large number of factors that could be selected. However, it will be difficult for any research to consider all suggested factors. Therefore, we apply selection criteria, and in particular, our choice is motivated by a selection of factors that are commonly used within the literature and have some theoretical base and economic explanation for their inclusion.

The factors we include are: SMB (Fama and French, 1993); HML (Fama and French, 1993); stock price continuation or MOM (Carhart, 1997); the reversal of stocks over the short run (previous month, Jegadeesh, 1990) and the long run (between one and five years and sometimes referred to as the overreaction effect, De Bondt and Thaler, 1985); PMU (Novy-Marx, 2013; Fama and French, 2015); CMA (Fama and French, 2015); QMJ (Asness *et al.*, 2019); and Tobin's Q ratio (Harney and Tower, 2003)[3]. These factors are chosen for several reasons. The factors include the Fama-French five-factor model, which is arguably the current state-of-the-art model. They also include the momentum and reversal factors, for which a long history of supportive research exists, while we also include the quality factor as a representative of a newer factor and the Q-ratio as an alternative measure that is considered in the time-series predictability literature but not the stock market factor literature. Thus, the selected factors represent a range of alternative factors available from the literature[4].

The portfolio stock return is obtained at the quarterly frequency from the data library of Ken French[5]. This is also true for the factors data, except the quality factor, which is obtained from the AQR website[6]. Data on GDP, interest rates and inflation is obtained from the St Louis Federal Reserve. The sample period is 1964Q1-2019Q2 and all the data is for the US market.

3.2 Do factors contain independent information for stock returns?

In the first empirical exercise, we consider a standard regression approach of the type popularized by Fama and French (1993) in which different portfolio types are regressed against the above factors. Hence, we estimate:

$$r_t = \alpha + \sum_i \beta_i x_{i,t} + \varepsilon_t \tag{1}$$

where r_t is returns in an excess of a three-month treasury bill, $x_{i,t}$ is the explanatory factor outlined above and ε_t is a random error term. We include all factors simultaneously to examine whether they each contain relevant explanatory information. To test the predictive ability of the factors, we report results based on Fama-French size and book-to-market sorted portfolio returns[7]. Our interest here lies in whether this set of factors has explanatory information for the different stock return portfolios. Moreover, we are interested in whether each factor has an individually statistically significant effect on stock returns and, thus, provides independent information not contained within the other factors.

As noted in the literature review, one approach to examining whether the factors contain independent information is to conduct a sequence of regressions of the factors themselves. Indeed, Barillas and Shanken (2017) argue that using asset returns themselves is not required as an examination of the relations between the factors themselves is sufficient. Therefore, we estimate a sequence of regressions with each factor in turn considered as the dependent variable, regressed against all the other factors. Here, we are primarily interested in whether the intercept term in each of these regressions is statistically significant, which suggests that the factor does contain independent information.

3.3 Principal components analysis

Building upon the above exercises, we consider a principal components analysis to examine the degree of common information within the factors. Principal component analysis allows us to extract common factors (components) from a group of data series. The components are ordered according to how much of the variation across the series they can account for and are orthogonal to each other, thus representing independent information. Hence, the principal components approach allows a number of factors to be expressed by a small number of components should the factors share common information. Therefore, in considering whether the stock market factors contain independent information, we can examine whether the number of principle components that account for the majority of variation in the data is less than the number of factors.

3.4 What explains the factors?

In the previous section, we describe the usual modelling approach in which the factors, x, are used to explain movements in stock returns, r. Here, however, we also wish to consider what can explain the factors themselves. Thus, we estimate the following regression:

$$x_t = \alpha + \sum_i \beta_i z_{i,t-1} + \varepsilon_t \tag{2}$$

where $z_{i,t-1}$ represents the lagged values of the explanatory variables for the stock market factors.

The factors themselves are believed to proxy for movements in expected returns. Therefore, in choosing explanatory variables, we consider those that will be linked to measures of macroeconomic conditions and risk. While inevitably there could be a large number of possible variables, we take direction from the discussion in Section 2. As a measure of macroeconomic conditions, we include GDP growth, inflation and the term structure of interest rates (10-year bond minus 3-month bill). These variables provide information about the state of the economy, for example, a strong economic environment will be characterized by increasing inflation, positive output growth and an upward sloping term structure, while a weak economy will be characterized by subdued inflation, low positive or negative GDP growth and a flat or even downward sloping term structure.

3.5 Do factors explain gross domestic product?

Ultimately, the factors that we use to predict stock returns must also have some predictive power for output as the underlying economic state variable. Movement in stock returns reflects expectations regarding future output and risk. Thus, for factors to explain movement in stock returns, they must also proxy for the same movements in future economic behavior. Hence, we consider a predictive relation similar to that in equation (1) for the growth rate of output (GDP). The earlier analysis by Liew and Vassalou (2000) reports that size and book-to-market factors do have predictive power for economic growth but that momentum does not. We regress the following model:

$$\Delta y_{t+k} = \alpha + \beta_i x_{i,t} + \varepsilon_{t+k} \tag{3}$$

Thus, the regression model is like equation (1) but differs in two ways. First, we examine whether the stock market factors have predictive power for future economic growth, Δy_{t+k}, where Δy_t refers to the change in output, y_t, and k refers to the number of periods ahead that the factors seek to predict output growth. Second, we include each factor separately into the regression to consider which, if any, of the factors can explain future output movements and, thus, contain economic information regarding stock returns.

4. Empirical results

4.1 Factor regressions: do they contain unique information

Table I presents the empirical results for equation (1) where the excess returns for the Fama-French size and book-to-market portfolios are regressed against the market factors we consider here. Several pertinent results can be taken from this table. Several factors are significant across the majority of the four different portfolios, but there are notable exceptions to this. More specifically, for the Fama-French five-factor model (market, size, value, profit and investment), there is strong evidence of significance for four of these factors across three portfolios; the profit factor is insignificant for all portfolios except the large growth portfolio, for which the investment factor is not significant. The quality minus junk (QMJ) factor is also significant for each of the four portfolios (albeit at the 10 per cent level for the small growth portfolio). Of the remaining factors, short-term reversals are significant for the small value portfolio at the 5 per cent level and the small growth and large value portfolios at the 10 per cent level. The momentum factor is only significant at the 10 per cent level for the small growth portfolio, while long-term reversals and the (change in the) Q-ratio are insignificant across all portfolios. These results suggest that across these ten factors, only five report statistical significance for the majority of the portfolios. For the other factors, while they may indicate some significance, this occurs for different portfolios. The profit factor is only significant for one portfolio. The lack of significance in these latter factors suggest that they contain little information for stock returns[8]. Thus, in terms of the Fama and French (2015) five-factor model, there is little support even across these key portfolios.

Regarding the results in more depth, we can see that the size factor (SMB) loads positively on small stocks and negatively on large stocks as expected (albeit only at the 10 per cent significance level for large value stocks) as we would expect given the nature of the factor. Equally consistent, the value factor (HML) loads positively on value stocks and negatively on growth stocks. The investment factor (CMA), which is significant for three portfolios (although at the 6 per cent level for small value stocks), exhibits no consistency in the coefficient sign. Notably, it is positive for the small value portfolio and negative

Factors	SH	SL	BH	BL
Constant	0.333 (5.15)	0.490 (6.58)	0.544 (6.39)	0.387 (5.26)
Mkt	1.013 (63.83)	1.024 (51.54)	1.028 (33.66)	1.017 (44.34)
SMB	0.869 (51.24)	0.949 (32.43)	−0.058 (−1.66)	−0.138 (−6.36)
HML	0.528 (17.48)	−0.376 (−9.71)	0.842 (17.22)	−0.254 (−10.12)
PMU	0.038 (1.11)	−0.055 (−0.98)	−0.007 (−0.08)	0.086 (2.09)
CMA	0.075 (1.95)	−0.089 (−2.39)	−0.236 (−4.51)	−0.072 (−1.58)
MOM	−0.016 (−1.09)	−0.029 (−1.70)	−0.036 (−1.55)	−0.022 (1.08)
ST Reversals	0.048 (3.22)	−0.048 (−1.80)	−0.071 (−1.81)	0.026 (1.23)
LT Reversals	0.002 (0.06)	−0.016 (−0.55)	−0.002 (−0.05)	0.015 (0.45)
QMJ	0.102 (2.49)	−0.206 (−3.02)	−0.151 (−1.84)	0.157 (3.23)
D(Q Ratio)	−0.088 (−0.19)	−0.086 (1.10)	−0.086 (−0.95)	−0.093 (−0.16)

Notes: Coefficient and Newey–West *t*-statistics from equation (1). $r_t = \alpha + \Sigma_i \beta_i x_{i,t} + \varepsilon_t$. The dependent variable is the return on sorted portfolios based on size and book to market ratio. S = small firms; L = large firms; H = high book-to-market firms; and L = low book-to-market firms. The returns are those in excess of a three-month treasury bill. The independent variables are: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER); and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU); high-quality minus low-quality (junk) firms (QMJ); and the change in Tobin's Q ratio (D(Q Ratio))

Table I. Factor models for selected portfolios sorted based on the size and book to market ratio, 1964Q1-2019Q2 elsewhere. Both the short-term (ST) reversal and quality minus junk (QMJ) factors exhibit a positive relation for small value and large growth portfolios and negative for the small growth and large value factors. Thus, again, there is no consistency in the nature (coefficient sign) of the results. This suggests that while the investment, short-term reversal and quality factors exhibit statistical significance, they lack a consistent economic message.

Regarding the factors that exhibit less significance, the profit (PMU) factor is only significant for the large growth portfolio and changes sign in an inconsistent manner across the different portfolios. The momentum (MOM) factor loads negatively across all portfolios, while it is only statistically significant at the 10 per cent level for the small growth portfolio. The long-term (LT) reversals factor is not statistically significant for any portfolio. The same is true for the (change in) Q-ratio, which exhibits a negative coefficient sign across all portfolios.

The results in Table I suggest that of the ten factors considered (including the market portfolio), only five exhibit statistical significance across the majority of the returns portfolios. Notably, the profit, momentum, two reversion and Q-ratio factors are not significant across the majority of the portfolios. Moreover, for some factors that do demonstrate significance, the coefficient signs do not present a consistent picture, notably for the investment and quality factors. However, as reported in the Introduction, research has indicated that these factors have demonstrated significance in previous studies. We, therefore, examine this further by considering whether these factors are individually significant and if so, which other factor, when included in the regression model, results in their insignificance.

More specifically, we re-estimate equation (1) but include the profit, momentum, reversal and Q-ratio factors individually. This will allow us to consider whether these factors exhibit any significant effect on stock returns. Assuming these factors do exhibit a significant effect, then we add, in an alternating individual manner, the five significant factors identified from Table I (the market portfolio, the size, value, investment and quality factors). This will allow an examination of whether the inclusion of another factor causes the insignificance of the profit, momentum, reversal or Q-ratio factors. This would indicate that these factors contain similar information for stock return behavior.

These results are reported in Table II. Examining the top panel, this reports the coefficient results of including these factors individually within the stock return regression. Here, we can see that with the exception of the Q-ratio, none of the factors demonstrate significance across the full range of portfolios. The profit factor is significant for the two small portfolios, while the reversal factors demonstrate some significance for the value portfolios, but at a strict 5 per cent significance level, this only occurs for long-term reversals on the small value portfolio. For the momentum factor, significance is only reported for the large value portfolio. Looking at the profit and Q-ratio factors more closely, as they exhibited greater significance, for the profit factor, the coefficient on the two small portfolios is negative, this suggests that greater profitability is associated with lower risk and lower (expected) returns. For the Q-ratio, the positive coefficient suggests that an increase in this ratio suggests an increase in risk and returns. The results support previous findings in the literature that these factors do have a predictive effect for stock returns but equally suggests that their information content may vary with the time period examined.

To further examine this latter point, we now include in our regression, individually, the additional variables noted as significant in Table I. These are reported in the lower panels of Table II, first for the profit factor and then for the Q-ratio[9]. Specifically, under the heading PMU, the coefficient results are for the profit factor when also including into the regression the factor listed in the first column. For example, the row Mkt presents the result for the profit factor of including both the market and profit factors in the regression of equation (1). The results for the profit factor reveal that it remains significant for the two small portfolios

Factors	SH	SL	BH	BL
Panel A: *Examining insignificant factors in equation (1) individually*				
PMU	−0.772 (−3.53)	−1.220 (−4.62)	−0.452 (−1.14)	−0.256 (−1.10)
MOM	−0.141 (−0.82)	0.020 (0.07)	−0.273 (−2.10)	−0.065 (−0.48)
ST REVER	0.399 (1.93)	0.263 (0.90)	0.328 (1.90)	0.266 (1.81)
LT REVER	0.496 (2.21)	0.175 (0.53)	0.370 (1.82)	−0.095 (−0.57)
D(Q Ratio)	0.199 (3.81)	0.270 (5.41)	0.176 (3.75)	0.211 (7.01)
Panel B: *Including individually variables noted as significant in Table I in the PMU regression*				
Mkt	−0.283 (−2.75)	−0.623 (−2.15)	0.009 (0.03)	0.239 (3.88)
SMB	−0.237 (−0.77)	−0.533 (−1.80)	−0.384 (−1.04)	−0.173 (−0.62)
HML	−0.783 (−3.60)	−1.106 (−4.82)	−0.503 (−1.61)	−0.179 (−0.62)
CMA	−0.802 (−3.35)	−1.322 (−7.13)	−0.406 (−1.11)	−0.329 (−1.32)
QMJ	0.635 (2.92)	0.211 (0.40)	0.841 (2.76)	0.578 (2.29)
Panel C: *Including individually variables noted as significant in Table I in the (Q Ratio) regression*				
Mkt	−0.021 (−0.70)	−0.001 (−0.030	−0.027 (−1.12)	0.006 (0.61)
SMB	0.168 (4.77)	0.227 (7.03)	0.171 (3.81)	0.207 (7.02)
HML	0.208 (3.97)	0.227 (3.80)	0.203 (5.19)	0.185 (5.73)
CMA	0.191 (3.49)	0.219 (3.60)	0.176 (3.78)	0.173 (4.71)
QMJ	0.111 (2.78)	0.166 (3.99)	0.106 (2.83)	0.177 (5.55)

Notes: Coefficient and Newey–West *t*-statistics from re-estimating equation (1) $rt = \alpha + \Sigma i\ \beta i\ xi,t + \varepsilon t$. The dependent variable is the return on sorted portfolios based on size and book to market ratio. S = small firms; L = large firms; H = high book-to-market firms; and L = low book-to-market firms. The returns are those in excess of a three-month treasury bill. The independent variables are: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER) and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU); high-quality minus low-quality (junk) firms (QMJ); and the change in Tobin's Q ratio (D(Q Ratio))

Table II. Which factors hinder insignificant factors, 1964Q1-2019Q2

when including the market, value, investment and, for one portfolio, the quality minus junk factors. This implies that the profit factor is capturing different information to these factors. However, the inclusion of the size factor renders the profit factor statistically insignificant at the 5 per cent level for all the portfolios considered.

The results for the change (denoted D in the table) in the Q-ratio are even clearer in terms of its conclusion. The inclusion of the market portfolio renders the Q-ratio statistically insignificant across all portfolios. However, the inclusion of the other factors (size, value, investment and quality) does not impact the statistical significance of the Q-ratio. Together, these results suggest that the information content of each factor may not be unique, with information in the profit factor also captured by the size factor and the market capturing information in the Q-ratio. Indeed, Harney and Tower (2003) argue that the Q-ratio is a predictor of market-level returns.

These results suggest that the influence on stock returns of several factors are captured by other factors within the regression. We can observe this directly when we introduce additional variables into each regression as shown in Table II. Barillas and Shanken (2017) highlight an alternative way to consider the same issue. They show that a significant intercept (alpha) in a regression of one factor against the other factors indicates that factor contains independent information for stock returns. Table III, thus, presents the results of each factor regressed against all other factors in turn. Focusing on the alpha terms, we can see that largely the same variables as reported above exhibit a significant alpha and, hence, contain information for stock returns. Specifically, the market, size, investment and quality

Table III.
Factor to other factor regressions, 1964Q1-2019Q2

Risk factors	MKT	SMB	HML	PMU	CMA	MOM	ST Rever	LT Rever	QMJ	D(Q Ratio)
Alpha	0.743 (3.18)	0.722 (3.29)	0.209 (1.36)	0.010 (0.08)	0.184 (1.70)	1.271 (3.95)	0.756 (3.29)	0.037 (0.20)	0.339 (3.48)	0.007 (1.41)
MKT	–	−0.067 (−0.92)	−0.041 (−0.86)	0.098 (2.08)	−0.121 (−3.29)	0.095 (0.73)	0.058 (0.62)	0.057 (0.82)	−0.191 (−7.30)	0.010 (4.48)
SMB	−0.091 (0.96)	–	−0.093 (−1.35)	0.015 (0.29)	−0.056 (−1.15)	0.220 (1.58)	−0.013 (−0.19)	0.142 (2.12)	−0.151 (−5.02)	−0.002 (−0.81)
HML	−0.120 (−0.84)	−0.200 (−1.28)	–	0.264 (2.63)	0.448 (8.83)	−0.427 (−1.95)	0.071 (0.48)	0.262 (2.31)	−0.170 (−3.78)	−0.008 (−1.98)
PMU	0.469 (2.19)	0.052 (0.29)	0.435 (3.01)	–	−0.135 (−1.80)	−0.136 (0.48)	0.242 (0.85)	−0.372 (−2.27)	0.556 (11.80)	0.003 (0.50)
CMA	−0.622 (−3.32)	−0.215 (−1.20)	0.794 (8.77)	−0.145 (−1.93)	–	0.295 (1.00)	−0.160 (−0.79)	0.285 (1.82)	−0.037 (−0.65)	0.001 (0.12)
MOM	0.064 (0.72)	0.109 (1.61)	−0.099 (−1.95)	−0.019 (−0.48)	0.039 (1.01)	–	−0.187 (−2.05)	0.032 (0.56)	0.056 (2.21)	−0.003 (−0.96)
ST REVER	0.060 (0.61)	−0.010 (−0.19)	0.025 (0.46)	0.053 (0.90)	−0.032 (−0.75)	−0.289 (−1.84)	–	0.067 (0.91)	−0.044 (−1.25)	0.003 (0.09)
LT REVER	0.116 (0.83)	0.215 (1.98)	0.185 (2.42)	−0.159 (−2.05)	0.114 (1.86)	0.097 (0.55)	0.133 (1.01)	–	0.046 (0.94)	0.005 (1.33)
QMJ	−1.295 (−5.95)	−0.759 (−4.57)	−0.399 (−3.53)	0.789 (8.62)	−0.049 (−0.65)	0.565 (2.14)	−0.286 (−1.09)	−0.153 (0.92)	–	−0.005 (−0.97)
D(Q RATIO)	10.768 (4.06)	−1.879 (−0.86)	−2.864 (2.08)	0.628 (0.50)	0.193 (0.12)	−4.313 (−0.95)	0.338 (0.09)	2.625 (1.47)	−0.885 (−0.93)	–

Notes: Coefficients and Newey–West *t*-statistics of a regression of each factor against all other factors. The independent variables are: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER) and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU); high-quality minus low-quality (junk) firms (QMJ); and the change in Tobin's Q ratio (D(Q Ratio)) factors all report a statistically significant intercept. Of interest, the value factor does not exhibit a significant alpha, while the momentum and short-term reversal factors do. The profit, long-term reversal and Q-ratio factors exhibit a statistically insignificant alpha. These results are further evidence that across even a relatively small set of factors, the individual information content is limited, and factors are indeed capturing similar information.

Of further interest, we can see that several factors exhibit significance in the regressions. Using a strict 5 per cent significance level, we can see that in the market factor regression, profit, investment, quality and the Q-ratio are significant. For the size factor, the long-term reversal and quality factors are significant; these factors are also significant for the value factor, together with profit, investment and the Q-ratio. For the profit and investment factors, the market and value factors are significant in their respective regressions, while the long-term reversal and the quality factors are also significant for the former series. In the momentum regression, only the quality factor is significant, while only momentum is significant in the short-term reversal regression. For the long-term reversal regression, the size, value and profit factors are all significant, while for the quality regression, the market, size, value, profit and momentum factors are significant. For the Q-ratio, the market and value factors are significant. These results highlight the interrelated nature of the factors and again suggest that they exhibit similar information content.

Continuing the examination of whether each factor provides unique information, Table IV presents the correlations and principal components analysis for the set of factors. We first examine the correlations in the lower panel of the table. Here, we can see noticeably large positive correlations between the profit and quality factors, the investment and value factors, the market factor and the change in the Q-ratio and between long-term reversals and the value factor. In addition to the results above, this helps explain the lack of significance for these factors. We can also observe high negative correlations between the quality factor and the market, size and Q-ratio factors, which in turn may explain the relatively mixed nature of the results for the quality factor reported in Table I. There is also a high negative correlation between the market and investment factor, while other sizeable correlations occur between the market and size, value and profit factors, the size and profit factor, the quality and reversal factors and investment and long-term reversal factors. Again, these support the view that the factors contain similar information, and these correlations may explain the mixed set of results across the factors reported above.

Considering the principal components, the first component explains 27 per cent of the variance of the factors, while the first two components account for nearly 50 per cent of the variance of the factors. Further, the first four components account for over 70 per cent of the variation, while the first six account for 85 per cent of the variation. In determining the preferred number of components, both the scree plot and the eigenvalue cumulative proportion (which are available upon request) suggest that three components are required to capture the movement in stock returns. Overall, these results reveal that there is indeed common information across the ten factors, supporting the above view that each factor does not contain unique information for stock return movement.

Looking at the principal components, we can see that for the first component, the profit and quality factor (and to a lesser extent the investment factor) have a large negative loading, again highlighting the above result that they contain very similar information. In terms of positive loading, the market, size and Q-ratio factors are broadly similar. The second component appears to be (positively) heavily weighted with the value, investment and long-term reversal factors, with notably the value and investment factors very similar. There is some negative weightings for the profit, momentum and quality factors. Momentum (negatively) and short-

Table IV. Principal components and correlations, 1964Q1-2019Q2

No. of components	Value	Difference	Proportion	Cumulative value	Cumulative proportion
1	2.7243	0.5353	0.2724	2.7243	0.2724
2	2.1890	0.7664	0.2189	4.9133	0.4913
3	1.4225	0.5598	0.1423	6.3358	0.6336
4	0.8628	0.0970	0.0863	7.1986	0.7199
5	0.7658	0.1713	0.0766	7.9643	0.7964
6	0.5945	0.0308	0.0594	8.5588	0.8559
7	0.5637	0.0848	0.0564	9.1225	0.9123
8	0.4789	0.2399	0.0479	9.6014	0.9601
9	0.2390	0.0794	0.0239	9.8404	0.9840
10	0.1596	–	0.0160	10.0000	1.0000
Eigenvectors (loadings)					
Variable	PC 1	PC 2	PC 3	PC 4	PC 5
MKT	0.4556	−0.1549	0.1892	0.2425	0.0568
SMB	0.3530	−0.0145	−0.3577	−0.4086	0.2128
HML	−0.1557	0.5615	0.1374	0.0961	0.0025
RMW	−0.4053	−0.1904	0.3338	0.1012	0.3437
CMA	−0.1732	0.5626	−0.1035	0.1648	−0.0321
MOM	−0.0953	−0.2121	−0.5764	0.2065	0.5059
STR	0.1739	0.1149	0.5157	−0.4661	0.5319
LTR	0.1742	0.4368	−0.1612	0.2167	0.4695
QMJ*100	−0.5085	−0.2121	0.0558	0.0837	0.2510
D(Q_RATIO)	0.3479	−0.1171	0.2606	0.6433	0.0997

Correlations

	MKT	SMB	HML	RMW	CMA	MOM	STR	LTR	QMJ*100	D(Q_RATIO)
MKT	1.0000									
SMB	0.2482	1.0000								
HML	−0.2449	−0.1863	1.0000							
RMW	−0.2367	−0.3638	0.0864	1.0000						
CMA	−0.3707	−0.1558	0.7005	−0.0764	1.0000					
MOM	−0.0843	0.1033	−0.2489	0.0156	−0.0675	1.0000				
STR	0.2002	0.0361	0.0930	−0.0119	−0.0426	−0.3007	1.0000			
LTR	0.0544	0.1833	0.3391	−0.3227	0.3668	−0.0455	0.1050	1.0000		
QMJ*100	−0.5385	−0.4452	−0.0688	0.6883	−0.0305	0.2033	−0.2058	−0.2846	1.0000	
D(Q_RATIO)	0.4986	0.1077	−0.1975	−0.1512	−0.2158	−0.1236	0.1337	0.0836	−0.3063	1.0000

Notes: Entries are based on the principle components and correlations. Top panel contains the eigenvalues of the ten components and explains how much of the variability of the data each component captures. The second panel reveals the relation (loading) between each factor and component. The bottom panel presents the correlation matrix term reversals (positively) have the highest loadings in the third component, while size (negatively) and profit and the Q-ratio (positively) also exhibit a reasonable weighting.

The nature of the results presented in this section strongly support the view that even in the modest number of factors considered here (in comparison to the 300 factors noted by Harvey *et al.*, 2016), they do not all contain unique information that aids in explaining stock returns. Notably, the market, size and value factors appear to dominate in both economic and statistical significance. The investment factor is typically statistically significant, but its coefficient value is noticeably smaller than for size and value. The quality factor is also statistically significant, but its coefficient signs are not consistent. Other factors are either not significant or lose their significance with the inclusion of multiple factors. Equally, in terms of the correlation and components analysis, the results show high correlations among several factors, while the principal components analysis selects a number of components that is less than half the number of factors.

4.2 Explaining the factors

A key to understanding asset price movement is in understanding the variables that affect movement in the factors themselves. As noted by Cochrane (2011), movement in the factors themselves is really the variables that require explanation. Notably, it is the factors that provide information about movement in unobservable expected returns. Table V presents the results of this analysis, based on equation (2)[10].

Taking the results as a whole, it is obvious that there is very little significance and, thus, little in the way of a predictive relation running from key macroeconomic variables to stock market factors. For inflation, this exhibits a negative and statistically significant relation with the quality factor, while it only exhibits a positive relation at the 10 per cent significance level with short-term reversals. This perhaps indicates that higher inflation is a risk factor such that investors would move into higher-quality stocks (thus depressing their return over less quality stocks). GDP growth has a negative predictive relation with the size and Q-ratio factors. This indicates that higher growth reduces subsequent risk and, thus, the magnitude of the size risk premium. Equally, the lower change in the Q-ratio reflects the view that higher economic

Risk factors	Inflation	GDP	TS
SMB	−0.041 (−0.67)	−0.153 (−2.17)	0.073 (0.48)
HML	0.048 (0.59)	0.014 (0.24)	0.005 (0.03)
PMU	0.002 (0.05)	0.012 (0.25)	0.226 (2.37)
CMA	0.058 (0.83)	−0.001 (−0.01)	−0.046 (−0.38)
MOM	−0.034 (−0.36)	0.143 (1.23)	−0.081 (−0.37)
STR	0.120 (1.88)	−0.029 (−0.32)	−0.014 (−0.09)
LTR	−0.024 (−0.43)	−0.90 (−1.56)	−0.092 (−0.80)
QMJ	0.012 (0.24)	−0.039 (−0.64)	0.118 (1.10)
Q Ratio	−0.452 (−2.19)	−0.445 (−2.33)	0.071 (0.13)

Notes: Coefficient and Newey–West *t*-statistics from equation (2) $x_t = \alpha + \Sigma_i \beta_i z_{i,t-1} + \varepsilon_t$ where x_t represents risk factors: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER) and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU); high-quality minus low-quality (junk) firms (QMJ); and the change in Tobin's Q ratio (Q Ratio). $z_{i,t-1}$ represents the lagged values of the explanatory variables including inflation, GDP growth, the term structure (TS; the difference between 10-year treasury bonds and 3-month bills)

Table V. Do macroeconomic variables explain stock risk factors, 1964Q1-2019Q2?

growth leads to higher market values and lower subsequent returns. The term structure exhibits a positive and significant relation with the profit factor. A higher (steeper) term structure is an indicator that investors expect improving future economic conditions and, thus, higher profitability. This is also reflected in a positive coefficient on the profit factor from the GDP growth variable, although it is not statistically significant.

4.3 Do stock market factors explain future output growth?

As discussed above, what remains key in understanding the movement of asset prices is whether the factors that we believe govern movement in stock returns also contain information for future movements in output. Movement in stock returns occurs as investors change their perception of expected future returns. Expected returns, in turn, change as investors' views of future economic conditions change, altering perceptions of macroeconomic risk and future cash flows. Changes in stock returns, thus, reflect changes in expected future output. However, stock returns themselves are often too noisy to reveal this relation. Therefore, we consider whether the stock market factors, as proxies for expected returns, are able to predict future output growth[11].

Following previous research, notably Liew and Vassalou (2000), we consider the predictive ability of the stock market factors over a range of time horizons for output growth as shown in equation (3). Results in Table VI show that only the change in the Q-ratio has a consistent and significant predictive effect on output growth. Here, the coefficient is positive and significant at all horizons, albeit only at the 10 per cent level for the two-year horizon. Recalling, the definition of the Q-ratio is the ratio of the market value to accounting value of the company and its assets and liabilities. Thus, an increase in the current market valuation is consistent with a future increase in economic activity and improving economic conditions. This is consistent with our view that market valuations increase when expected future economic performance increases with a resulting rise in expected cash flows and an expected fall in the risk premium. Of the other factors, only the quality factor exhibits any kind of a statistical relation, being negative and statistically significant at the 10 per cent level for the one- and two-quarter horizons.

The results presented here differ from those of Liew and Vassalou (2000), who argue that both the size and value factor have significant predictive power for future economic growth[12]. To consider why there may be a difference between the results here and those with Liew and Vassalou, we examine whether the strength of any relation, through the coefficients, exhibits time variation. To this end, we run recursive regressions of equation (3) with an initial sample of 10-years for the SMB, HML, Q-ratio and QMJ factors. These plots are presented in Figure 1, from where we can see that each predictive coefficient shows time variation over the sample period.

The sample used in Liew and Vassalou covers the time period from 1978 to 1996; examining the factors used in their analysis (SMB and HML), we can see that the coefficient for SMB declines toward zero from the beginning of our sample period. Moreover, there is a noticeable reduction in the coefficient, and accompanying statistical significance, around 1990 and, thus, toward the end of the Liew and Vassalou sample. Indeed, the coefficient switches from being positive in value to negative around 1990 and then back to positive as the coefficient increases in value near the end of our sample period, since around 2010. For the HML time-varying coefficient, while this is insignificant throughout the sample, again, the coefficient appears to move toward zero over the period under examination and since 1990. Again, we see a potential change in the nature of the relation at the end of the sample period, where the coefficient becomes positive for the first time. For the change in the Q-ratio, which does have significant predictive power for GDP growth, we can also see that the magnitude of the coefficient declines over the sample period, and notably from 2010, but remains statistically significant throughout.

Table VI. Do the factors predict gross domestic product growth in 1964Q1-2019Q2?

GDP Gr	SMB	HML	PMU	CMA	MOM	STR	LTR	QMJ	Q-Ratio
$k = 1$	−0.003 (−0.12)	0.005 (0.15)	0.047 (1.25)	−0.006 (−0.10)	−0.004 (−0.17)	0.025 (1.13)	−0.038 (−0.99)	−0.074 (−1.66)	0.008 (1.98)
$k = 2$	−0.008 (−0.22)	−0.014 (−0.28)	0.064 (0.92)	−0.054 (−0.60)	−0.008 (−0.30)	0.031 (0.78)	−0.080 (−1.47)	−0.137 (−1.90)	0.020 (2.14)
$k = 4$	−0.003 (−0.04)	−0.054 (−0.58)	0.141 (1.12)	−0.064 (−0.50)	−0.022 (−0.48)	0.084 (1.26)	−0.044 (−0.64)	−0.146 (−1.05)	0.039 (2.41)
$k = 8$	0.081 (0.70)	−0.131 (−0.99)	0.305 (1.74)	0.216 (1.04)	−0.054 (−0.73)	0.059 (0.67)	0.011 (0.12)	−0.182 (−0.95)	0.039 (1.84)

Notes: Coefficient and Newey–West *t*-statistics from equation (3): $\Delta y_{t+k} = \alpha + \beta_i x_{i,t} + \varepsilon_{t+k}$. The dependent variable is GDP growth measured over k quarters. The independent variables are: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER) and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU), high-quality minus low-quality (junk) firms (QMJ); the change in Tobin's Q ratio (Q Ratio)

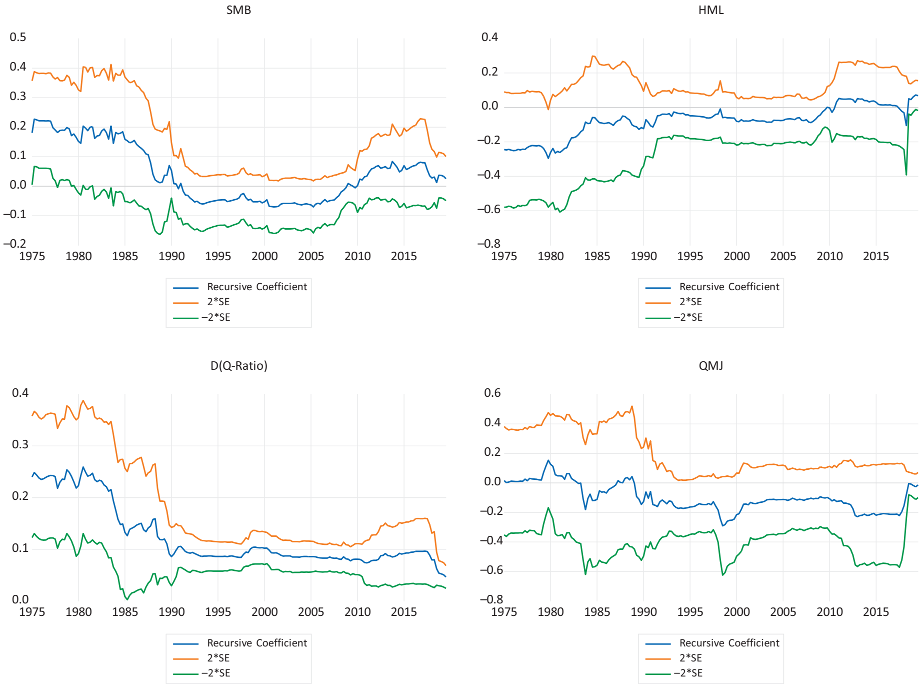

Figure 1.
Recursive coefficients for predicting gross domestic product growth

Notes: The above plots trace the recursive regression coefficients for equation (3), $\Delta_{yt+k} = \alpha + \beta_i x_{i,t} + \varepsilon_{t+k}$ where $k = 4$. The two times standard error bands are also included

For the newer, QMJ, factor, we can see that this coefficient remains more stable over the sample period, although statistical significance is at best marginal through a part of the sample. These results suggest that the nature of the predictive relation between the factors and GDP growth varies over time and those factors can gain or lose significance over time. Notwithstanding this, the Q-ratio is consistently significant.

To further understand whether factors have any predictive power for future output growth, we reconsider the regression in equation (3) but separate the analysis between periods of negative output growth (contractionary periods) and periods of positive output growth (expansionary periods). Such expansionary and contractionary periods will be marked by different degrees of economic risk, and thus, the underlying (economic) nature of the stock market factors will differ. As such, examining the behavior of the factors over the full business cycle may mask how these factors interact with future movements in GDP growth.

The results of this exercise are presented in Table VII. Here, we can see differences across the phases of the business cycle as well as some greater evidence of interaction between movement in these factors and subsequent output growth, particularly in the contractionary phase. However, the general view remains that only the Q-ratio exhibits robust evidence of predictability for future output growth. Examining the results, we can see that two factors (value and investment) continue to have no predictive effect (at the 5 per cent significance level) for output growth across any of the time horizons. Several factors only exhibit a significance effect during a contraction; this includes the size (k = 2, 4), profit (k = 2, 4, 8), momentum (k = 4, 8) and short-term reversal

Table VII. Do the factors predict gross domestic product growth? Separating contractionary and expansionary periods1964Q1-2019Q2

GDP Gr.	SMB	HML	PMU	CMA	MOM	ST Rever	LT Rever	QMJ	D(Q-Ratio)
Panel A Contraction									
$k = 1$	−0.102 (−0.80)	−0.257 (−1.41)	0.241 (1.35)	0.122 (0.60)	−0.033 (−0.42)	−0.010 (−0.16)	0.267 (2.16)	−0.247 (−2.16)	0.046 (2.96)
$k = 2$	−0.378 (−2.52)	−0.272 (−1.62)	0.460 (2.48)	−0.234 (−1.16)	0.130 (1.44)	0.159 (2.24)	0.288 (2.14)	−0.551 (−4.55)	0.077 (2.62)
$k = 4$	−0.743 (−3.15)	0.064 (0.25)	0.959 (2.52)	−0.471 (−1.42)	0.447 (3.66)	0.571 (2.46)	0.335 (1.88)	−1.048 (−4.12)	0.098 (2.84)
$k = 8$	−0.409 (−0.70)	0.063 (0.13)	1.667 (2.56)	0.555 (0.94)	0.556 (2.32)	0.345 (0.64)	0.920 (3.21)	−1.134 (−2.32)	0.034 (1.88)
Panel B Expansion									
$k = 1$	−0.002 (−0.06)	0.004 (−0.13)	0.020 (0.46)	0.032 (0.61)	0.002 (0.08)	0.036 (1.34)	−0.071 (−1.97)	−0.066 (−1.20)	0.006 (1.98)
$k = 2$	−0.004 (−0.11)	−0.002 (−0.04)	0.012 (0.16)	−0.004 (−0.05)	−0.010 (−0.33)	0.045 (0.95)	−0.122 (−2.38)	−0.125 (−1.51)	0.014 (2.01)
$k = 4$	0.001 (0.01)	−0.052 (−0.53)	0.114 (0.79)	−0.054 (−0.42)	−0.040 (−0.76)	0.077 (1.06)	−0.070 (−0.92)	−0.14 (−0.96)	0.030 (2.24)
$k = 8$	0.081 (0.70)	−0.151 (−1.06)	0.330 (1.74)	0.138 (0.62)	−0.103 (−1.28)	0.038 (0.46)	−0.005 (−0.04)	−0.210 (−1.16)	0.030 (2.18)

Notes: As Table V: Coefficient and Newey–West t-statistics from equation (3): $\Delta y_{t+k} = \alpha + \beta_i\, x_{i,t} + \varepsilon_{t+k}$ k. The dependent variable is GDP growth measured over k quarters. The independent variables are: small minus big firms (SMB); high minus low book-to-market (HML); stock price continuation or momentum effect (MOM); the reversal of stocks over the short run (previous month, ST REVER) and the long run (between one and five years and sometimes referred to as the overreaction effect, LT REVER); high profit firms minus low profit firms (PMU); high-quality minus low-quality (junk) firms (QMJ); and the change in Tobin's Q ratio (Q Ratio). The sample is separated between periods of negative GDP growth (Contraction) in Panel A and positive GDP growth (Expansion) in Panel B

(k = 1) and long-term reversal (k = 1, 2, 8) factors, while the quality factor is significant at all horizons in the contractionary regime. Conversely, only the long-term reversal factor is significant in the expansionary regime (for k = 1, 2).

The change in the Q-ratio exhibits significance across both phases of the business cycle and at all horizons (albeit at the 10 per cent level for k = 8 in the contractionary regime). Moreover, we can also observe that the strength of the coefficient is greater in the contractionary regime than in the expansionary regime (indeed, this holds across all factors), while there is also consistency in the sign of the coefficients across the different horizons. Thus, we can again conclude that the change in the Q-ratio has economic content that the other stock market factors appear not to exhibit. Nonetheless, the results do suggest that the impact of these factors as measures of stock market risk is more prominent with higher macroeconomic risk (contractionary regime), with greater statistical significance and coefficient magnitude.

5. Summary and conclusion

In this paper, we seek to examine the information content within several popular stock market factors. This includes examining whether the factors have independent explanatory power for stock returns, exploring the drivers of the movement in the stock market factors and considering whether the factors have explanatory power for future output growth. Current research highlights a multitude of factors that can explain movements in stock market returns. However, this raises the question as to whether each of these factors provides unique information and whether these factors exhibit any economic content or whether their significance in any given sample occurs by chance.

To consider these issues, we undertake three related exercises. First, we consider whether a set of popular factors contains independent predictive ability for stock return portfolios. We do this by conducting a series of multivariate regressions to consider whether each factor retains statistical power. Further, we conduct a principal components exercise to examine whether there is commonality in the movements of these factors. Second, we examine whether economic and market variables can explain movements in the factors themselves. For the factors to contain any economic meaning, they must be linked to economic state variables. Equally, in the third exercise, we consider whether stock market factors have predictive power for future output growth. Where the stock market is regarded as a window to future economic conditions, we would expect those factors that can predict stock returns should also be able to predict movements in the economy.

Our results suggest that when considering a range of factors for predicting stock market movement, several factors do indeed carry similar information. Of note, the profit factor is insignificant in the multivariate regressions although it exhibits some significance when included individually, while further investigation reveals it is highly correlated with the quality factor. Thus, both factors contain similar information for stock returns movement. A similar effect is revealed in which the change in the Q-ratio is rendered insignificant by the inclusion of the market factor. Elsewhere, while we find supportive evidence for the size, value and investment factors, although the coefficient value of the latter is noticeably smaller than that of the former variables. There is no evidence of the reversal effect, while the quality factor is significant but does not exhibit a consistent coefficient sign. These results are further supported by regressions of the factors against each other and an examination of whether the intercept term is significant, which indicates independent information.

In building upon this analysis, we also consider a principal components analysis, the aim of which is to examine whether movement in the different factors are in fact driven by a common component. The results demonstrate that the first four components account for over 70 per cent of the movement across the ten factors, while testing supports that three components are sufficient. Again, we can see that the profit and quality factors have similar loadings in the first component, consistent with the previous results, which suggest that these two series have very similar impacts on stock returns.

For the stock market factors to have any economic meaning, they must exhibit some relation with economic variables. We consider this by examining which macroeconomic variables explain the movement in factors. The results reveal very limited evidence of significance with inflation, GDP growth and the term structure being significant for at most two factors each. Furthermore, we would expect the stock market factors to predict subsequent output growth. Specifically, movements in stock prices reflect expectations regarding future movements in economic conditions. Hence, stock returns should have predictive power for future output growth. However, while stock returns themselves may be too noisy (as expectations are revised and as investors trade for non-fundamental reasons), we would expect the factors to exhibit the same predictive relation. Results show that the change in the Q-ratio has predictive power across all time horizons considered. For the remaining factors, there is little evidence of a predictive effect for economic growth; although when separating contractionary and expansionary periods, there is greater evidence of predictability in the investment factor during a contraction. Overall, this casts doubt on the economic content of these stock market factors.

In sum, the key implication arising from this paper concerns the nature of stock market factors in terms of their ability to provide information content. While many such factors are suggested, this exercise supports the view that they do not necessarily contain independent information for stock returns. Further, most of these factors do not provide any predictive power for future output growth and, thus, do not appear to contain any information with regard to economic behavior.

Notes

1. The origin of this framework appears in the work of Fama (1998) and Asness and Frazzini (2013).
2. In another paper, Barillas and Shanken (2018) use a Bayesian asset-pricing framework to compare alternative sets of pricing models. They argue that the models of Hou *et al.* (2015, 2017) and Fama and French (2015, 2016) are both dominated by a variety of models that include a momentum factor, along with value and profitability factors.
3. Strictly speaking, we use the change in the Q-ratio to ensure stationarity.
4. An element of data availability also determines the choice of factors.
5. mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
6. The quality factor is obtained from https://www.aqr.com/library/data-sets/quality-minus-junk-factors-monthly
7. We consider a wider range of portfolios and style indices with the key results qualitatively similar to those reported in the text.
8. As noted in Table III, there exists a degree of correlation between the explanatory variables, which may affect the statistical significance of the coefficients. As a check, we examine the coefficient variance inflation factors, all of which are below the value of ten and so considered to be safe. An interesting discussion surrounding variance inflation factors is given by O'Brien (2007).
9. As the remaining factors exhibited little significance in the top panel of Table II, we do not include them in this analysis.
10. Again, there exists the possibility of multicollinearity between the explanatory variance, notably, the three stock market return series. An analysis of the variance inflation factors does suggest that the significance of these variables may be understated. However, there equivalent analysis

for the macroeconomic series, which are arguably the key variables of interest, suggest no multicollinearity issue.

11. These regressions were estimated for each explanatory variable separately, and thus, there is no issue of multicollinearity here.
12. But it should be borne in mind that their conclusion is for a range of markets and the evidence for the USA is mixed when compared across different model specifications.

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