



Piotroski's FSCORE: international evidence

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Abstract

Almost 20 years after its publication, Piotroski's (J Account Res 38:1–41, 2000) FSCORE, the composite measure of the firm's fundamental strength remains a strong predictor of subsequent stock returns and future profitability in international markets over the 2000–2018 period. Across developed non-US countries as well as emerging countries, high-FSCORE firms significantly outperform low-FSCORE firms by about 10% per year. Furthermore, FSCORE preserves its return-predictive power in all size segments after controlling for established cross-sectional return determinants, such as firm size, book-to-market, momentum, operating profitability, and investment. The findings are consistent with the view that fundamental information is only gradually incorporated into prices by investors.

Keywords FSCORE · Fundamental analysis · Stock returns · Return predictability · International markets

Introduction

In his seminal work, Piotroski (2000) develops an accounting-based composite measure of the firm's fundamental strength, the FSCORE, which employs historical financial statement information to identify fundamentally weak and strong firms among value stocks. His results on the US market reveal a significantly positive FSCORE-return relation among firms with high book-to-market ratios that is robust to standard controls of that time.

Since then, the FSCORE has become particularly popular as a stock screening tool among US investors (Novy-Marx 2014) but also has been used for various purposes in the academic US literature. For instance, it has been applied for predicting future firm profitability (Fama and French 2006), institutional investor demand (Choi and Sias 2012), and as an instrument variable for testing how public fundamental information is incorporated into prices (Turtle and Wang 2017). In the latter vein, Piotroski and So (2012) and Ahmed and Safdar (2018) show that investors' expectation errors concerning the firm's fundamental strength, as proxied by FSCORE, cause the US value and momentum premiums and therefore help to explain these anomalies.

Besides, a recently growing strand of the literature also documents the usefulness of FSCORE in diverse applications outside the USA. Consistent with Piotroski and So (2012), Ng and Shen (2016) reveal that FSCORE helps to ex ante separate subsequent winners from losers among Asian value and growth firms. Walkshäusl (2017, 2019) finds supportive evidence that the FSCORE also adds to our understanding of the value and momentum effects in European stock returns that can be traced back to investors' expectation errors concerning firm fundamentals. Tikkanen and Äijö (2018) show that incorporating the information contained in FSCORE improves the performance of various long-only value investing strategies in Europe that are formed on valuation ratios other than book-to-market. Finally, Hyde (2018) and Ng and Shen (2019) provide evidence on the market-wide FSCORE-return relation in Australia and five Asian equity markets.

In this paper, we revisit the FSCORE and study its return-predictive ability in the broad cross section of international firms drawn from 20 developed non-US markets and 15 emerging markets in a unified framework of analysis over the post-publication period 2000–2018. We follow the path recently traveled by Hyde (2018) and Ng and Shen (2019) who also extend the scope of Piotroski (2000) by not just focusing on the application of FSCORE among value stocks but across all sample firms to shed light on its global economic importance as an average-return predictor.

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For readers who associate the FSCORE only with value investing, this may warrant some discussion. Though Piotroski (2000) initially has tested the FSCORE among value stocks because '[h]igh book-to-market firms offer a unique opportunity to investigate the ability of simple fundamental analysis heuristics to differentiate firms' (p. 2) due to their nature of being largely neglected by investors and thinly followed by analysts, the application of FSCORE may not be limited to firms with high book-to-market ratios. In fact, given that the FSCORE captures information about the firm's fundamental strength or fundamental quality, it represents a return-predictive device on its own that can be analyzed across all types of firms. Our approach is in line with Piotroski and So (2012) as well as prominent replication studies like Hou et al. (2018) who also investigate the FSCORE-return relation among all sample firms and not just among value stocks in the USA. By studying the pure FSCORE-return relation, we aim to provide a clearer and more general perspective on the genuine return-predictive power of FSCORE in international markets that is not influenced by another variable.

Our framework of analysis is inspired by Fama and French (2008) and employs the two most common techniques in studying variable-return relations: portfolio sorts and firm-level cross-sectional regressions in the manner of Fama and MacBeth (1973). The first approach gives a good impression of how average returns vary with FSCORE, while the second approach helps to assess the incremental power of FSCORE for predicting subsequent stock returns in the presence of established determinants of the cross section. We take into account the most recent developments in asset pricing that explicitly consider controls for the fundamental aspects of the firm based on operating profitability and investment behavior (Fama and French 2015, 2018). In further robustness tests, we additionally investigate whether our key findings hold when the controls of the q -factor model of Hou et al. (2015) are applied as an alternative way of risk-adjusting returns. Throughout our main return analysis, we also study the FSCORE-return relation in three different size segments (small-cap, mid-cap, and large-cap stocks) to evaluate its pervasiveness across firm size. This is important from a practical point of view to examine whether the excess returns associated with FSCORE are a market-wide phenomenon or mostly concentrated among low-capitalization stocks and therefore probably not realizable by international investors. Finally, we revisit the proposition that the return predictability of FSCORE arises due to its ability to forecast the firm's future profitability. Under the assumption that investors tend to underreact to changes in firm fundamentals (e.g., Lakonishok et al. 1994), FSCORE should possess unique information about subsequent fundamental

performance that governs the positive FSCORE-return relation.

The remainder of the paper is organized as follows. The next section reviews the existing literature in more detail and provides a synthesis of our contribution in comparison with previous works. After describing the data and variables used in this study, the subsequent section presents the empirical results with respect to (1) the FSCORE-return relation, (2) FSCORE's incremental cross-sectional return predictability, and (3) its ability to forecast future firm profitability. After that, further robustness tests are provided before the final section concludes the paper.

Literature review and synthesis of contribution

Before we present our empirical analysis, we review the existing research on FSCORE in investment strategies in more detail with the aim to synthesize the contribution of our study in comparison with previous works. For ease of assessment, Table 1 summarizes methodological aspects and performance-related findings of the literature.

The FSCORE in subsamples and in combination with other variables Though the FSCORE represents a return-predictive device on its own, it has previously been investigated largely in subsamples of firms (value stocks) or in combination with other variables, such as book-to-market and momentum. In the spirit of Piotroski's (2000) original study, Tikkanen and Äijö (2018) show that the performance of European long-only value investing strategies that employ valuation ratios other than book-to-market for the classification of value stocks, such as the earnings-to-price ratio, dividend yield, and enterprise multiple, can be significantly improved by incorporating the information contained in FSCORE.

Piotroski and So (2012), Ng and Shen (2016), and Walkshäusl (2017) document for the USA, seven Asia-Pacific markets, and Europe that there exists a strong performance-related interaction between FSCORE and the full spectrum of book-to-market ratios, i.e., value and growth stocks. They find that the positive value-growth returns are concentrated among value stocks with high FSCORES and growth stocks with low FSCORES, but absent among value stocks with low FSCORES and growth stocks with high FSCORES. Hence, consistent with a mispricing-based explanation, their results suggest that the value premium is the result of price corrections arising from the reversal of investors' expectation errors for those firms, where market-based performance expectations implied by the book-to-market ratio are incongruent with the actual fundamental strength of the firm as measured by FSCORE.



Table 1 Research on FSCORE in investment strategies

Study	Sample	Emphasis	Return measurement	FSCORE premium	Size segmentation	Risk adjustment	Significant
Piotroski (2000)	USA (value firms), 1976–1996	FSCORE among value firms	EW, MKT-Adj.	23.5% p.a. (EW), 23.0% p.a. (MKT-Adj.)	Yes	4F	Yes
Piotroski and So (2012)	USA, 1972–2010	Interaction between book-to-market and FSCORE	SZ-Adj.	10.03% p.a.	No	4F	Yes
Ng and Shen (2016)	7 Asia–Pacific markets, 2000–2015	Interaction between book-to-market/ firm size and FSCORE	VW, Risk-Adj.	0.83% p.m. (Risk-Adj.)*	Yes	4F	Yes
Turtle and Wang (2017)	USA, 1973–2014	FSCORE as an information instrument	EW	6.73% p.a.	Yes	6F	Yes
Walkshäusl (2017)	Europe, 1990–2013	Interaction between book-to-market and FSCORE	SZ-Adj.	0.84% p.m.	Yes	4F	Yes
Ahmed and Safdar (2018)	USA, 1973–2015	Interaction between momentum and FSCORE	SZ-Adj.	8.59% p.a.	No	3F	Yes
Hyde (2018)	Australia, 1993–2013	FSCORE as a quality measure	EW, VW	1.31% p.m. (EW), 0.52% p.a. (VW)	Yes	4F	Yes (EW), No (VW)
Tikkanen and Äijö (2018)	Europe (value firms), 1992–2014	FSCORE among value firms	EW	8.00% p.a. to 17.33% p.a.	Yes	5F	Yes
Ng and Shen (2019)	5 Asian markets, 2000–2016	FSCORE as a quality measure	EW, VW	0.71% p.m. (EW)*, 0.26% p.m. (VW)*	No	4F	Yes
Walkshäusl (2019)	Europe, 1990–2017	Interaction between momentum and FSCORE	SZ-Adj.	1.03% p.m.*	Yes	6F	Yes

This table summarizes methodological aspects and performance-related findings of research on FSCORE in investment strategies. The table reports the sample of the given study and the emphasis of the analysis. Return measurement: equal-weighted (EW), market-adjusted, stock return minus the market return (MKT-Adj.), risk-adjusted, abnormal return after controls (Risk-Adj.), size-adjusted, stock return minus the return on its matching size group (SZ-Adj.), and value-weighted (VW). The FSCORE premium is the return difference between high- and low-FSCORE firms based on the given return measurement per month (p.m.) or per year (p.a.)

The asterisk (*) specifies that the reported value is a calculated average across individual countries or from bivariate sorts. ‘Size segmentation’ indicates that results for different size segments are reported in the given study. Risk adjustment: 3F (controls for firm size and book-to-market), 4F (controls for firm size, book-to-market, and momentum), 5F (controls for firm size, book-to-market, operating profitability, and investment), and 6F (controls for firm size, book-to-market, momentum, operating profitability, and investment). ‘Significant’ indicates whether the return effect associated with FSCORE is significant after risk adjustment

In an analogous manner, Ahmed and Safdar (2018) and Walkshäusl (2019) present evidence for the US and European equity markets that the FSCORE also helps to explain the momentum premium by finding strong interactions between FSCORE and the firms’ past price performance. In line with the notion that investors tend to underreact to changes in firm fundamentals, they find that the positive winner–loser returns are concentrated among those firms where past price performance is congruent with the firms’ fundamental strength but absent among those firms where past price performance is incongruent with the firms’ fundamental strength.

The pure FSCORE-return relation and size segmentation
As shown in Table 1, the analysis of different size segments is not uncommon in this strand of the literature. However, only three studies have explicitly investigated the pure FSCORE-return relation in detail without any complementing variables.¹ These studies consider the USA (Turtle and

¹ Though the emphasis of Piotroski and So (2012) and Walkshäusl (2017) is on the impact of FSCORE in value-growth strategies, they also present (introductory) results on the pure FSCORE-return relation across all US firms in their Table 1 (p. 2850) and across all European firms in Table II (p. 852).



Wang 2017), where the FSCORE has been initially discovered, Australia (Hyde 2018), and five individual Asian markets (Ng and Shen 2019).² Except for Ng and Shen (2019), who also focus on the post-2000 era, the two other studies investigate more extended sample periods that also include the years before 2000.

Risk adjustments and control variables The inference of abnormal returns is generally model-specific. The majority of previous works use, like the original study of Piotroski (2000), four-factor model adjustments (4F) with controls for firm size, book-to-market, and momentum in the spirit of Carhart (1997). Given the more recent asset pricing extensions of Fama and French (2015, 2018), there exist so far only three studies that additionally control for operating profitability and investment. These studies focus on the USA (Turtle and Wang 2017) and Europe (Tikkanen and Äijö 2018; Walkshäusl 2019).

Synthesis of contribution In light of the reviewed research on FSCORE in investment strategies, our focus on the pure FSCORE-return relation in the broad cross section of international firms, including the regions of developed EAFE markets, Asia-Pacific, Europe, and emerging markets in a unified framework of analysis, fills a gap in the existing literature. By taking into account the most recent developments in asset pricing and a thorough size segmentation analysis, our study offers a clear perspective on FSCORE's unique pervasiveness and persistence as a return-predictive device in international non-US equity markets in the post-2000 era after its publication.

Data and variables

The dataset in this study consists of firms from 20 developed non-US equity markets and 15 emerging markets. The selection of developed countries resembles the countries included in the well-known EAFE (Europe, Australasia, and the Far East) stock market benchmark from MSCI that measures the foreign stock market performance outside of North America. Among the countries classified as emerging by MSCI, we select those for which data coverage enables us to calculate valid FSCORES from the start of the sample period, which basically corresponds to the 15 largest markets in this region. We collect monthly total return data on common stocks from Datastream and firm-level accounting information from Worldscope. To ensure that accounting information is known before the returns are calculated, we match the latest accounting information for the fiscal year ending in the previous calendar year with stock returns from July of the current year to June of the following year throughout the

paper. All data are denominated in US dollars. To ensure that tiny or illiquid stocks do not drive our results, we follow Ang et al. (2009) and exclude very small firms by eliminating the 5% of firms with the lowest market equity in each country. In addition, we exclude firm-year observations with negative book equity and financial firms with Standard Industrial Classification (SIC) codes between 6000 and 6999 (Piotroski 2000; Piotroski and So 2012). Since we focus on examining FSCORE's post-publication performance, the sample period is from July 2000 to June 2018 (henceforth 2000–2018), and the dataset comprises on average 6787 firms per month from developed countries and 5016 firms per month from emerging countries. Table 2 shows distributional statistics of sample firms across individual countries (Panel A) and reports time-series averages of cross-sectional statistics of the employed variables for perspective (Panel B).

The construction of our key variable of interest, the FSCORE, follows Piotroski (2000). The composite measure of the firm's fundamental strength is based on the sum of nine binary indicator variables measuring different aspects of the firm's financial condition. An indicator variable is equal to one if the underlying condition holds for a firm and zero otherwise. The nine conditions are defined as follows. (1) Net income before extraordinary items is positive, (2) cash flow from operations is positive, (3) the annual change in return-on-assets (net income before extraordinary items divided by lagged total assets) is positive, (4) cash flow from operations is greater than net income before extraordinary items, (5) the annual change in leverage (long-term debt divided by total assets) is negative, (6) the annual change in liquidity (current assets divided by current liabilities) is positive, (7) the firm did not issue stocks, (8) the annual change in gross margin (sales minus cost of goods sold divided by sales) is positive, and (9) the annual change in turnover (sales divided by lagged total assets) is positive. High values on FSCORE indicate strong fundamentals, whereas low values on FSCORE indicate weak fundamentals.

The further variables used in this study are defined as follows. A firm's size (SZ) is its market equity (stock price multiplied by the number of shares outstanding) measured as of June of each year in million US dollars. Book-to-market (BM) is the ratio of book equity to market equity for the fiscal year ending in the previous calendar year. Momentum (MOM) is the cumulative prior 12-month stock return, skipping the most recent month (Jegadeesh and Titman 1993). Following Fama and French (2015), operating profitability (OP) is revenues minus cost of goods sold and interest expense, all divided by book equity.³ Investment (INV) is the annual change in total

² The five Asian markets in Ng and Shen (2019) are Hong Kong, Japan, Korea, Singapore, and Taiwan.

³ We do not include selling, general, and administrative expenses, as this item is not broadly available among international firms. The return predictability of operating profitability is, however, not affected by this adjustment.



Table 2 Summary statistics, 2000–2018

Developed EAFE markets				Emerging markets		
Country	Firms			Country	Firms	
Panel A: Sample countries						
Australia	763			Brazil	140	
Austria	38			Chile	100	
Belgium	59			China	762	
Denmark	83			India	812	
Finland	86			Indonesia	202	
France	413			Malaysia	567	
Germany	362			Mexico	72	
Hong Kong	545			Philippines	84	
Ireland	30			Poland	143	
Italy	154			Russia	64	
Japan	2328			South Africa	157	
Netherlands	87			South Korea	956	
New Zealand	61			Taiwan	539	
Norway	104			Thailand	298	
Portugal	34			Turkey	120	
Singapore	364					
Spain	66					
Sweden	212					
Switzerland	136					
United Kingdom	862					
Variable	Developed EAFE markets			Emerging markets		
	Mean	SD	Median	Mean	SD	Median
Panel B: Variables						
FSCORE	5.54	1.70	5.83	5.77	1.60	5.94
SZ	1311	3918	141	793	2409	131
BM	0.99	0.82	0.78	1.15	1.06	0.83
MOM	0.15	0.53	0.06	0.20	0.59	0.07
OP	0.75	0.91	0.52	0.44	0.57	0.32
INV	0.14	0.50	0.04	0.13	0.39	0.06
ROA	0.00	0.18	0.03	0.05	0.10	0.04
ROE	0.03	0.36	0.07	0.09	0.26	0.09

Panel A reports the average number of firms per month in each country over the sample period from July 2000 to June 2018. Panel B reports time-series averages of cross-sectional statistics of the variables, including the mean, standard deviation, and median. FSCORE is the composite measure of the firm's fundamental strength. Firm size (SZ) is market equity (stock price multiplied by the number of shares outstanding) measured as of June of each year in million US dollars. Book-to-market (BM) is the ratio of book equity to market equity for the fiscal year ending in the previous calendar year. Momentum (MOM) is the cumulative prior 12-month stock return, skipping the most recent month. Operating profitability (OP) is revenues minus cost of goods sold and interest expense, all divided by book equity. Investment (INV) is the annual change in total assets divided by lagged total assets. Return-on-assets (ROA) is net income before extraordinary items divided by lagged total assets. Return-on-equity (ROE) is net income before extraordinary items divided by lagged book equity

assets divided by lagged total assets. For the later analysis of the association of FSCORE with future firm profitability, we follow Piotroski (2000) and define profitability

based on return-on-assets (ROA), which is net income before extraordinary items divided by lagged total assets. The control for profitability in the q -factor model of Hou et al. (2015) that is applied as a further robustness test is based on return-on-equity (ROE) and defined as net



income before extraordinary items divided by lagged book equity.

Empirical results

Return behavior of high- and low-FSCORE firms

We begin our analysis of the FSCORE-return relation at the portfolio level. Each June, all firms in the considered regional sample are assigned to three portfolios based on their FSCORE characteristic from the fiscal year ending in the previous calendar year. A firm is assigned to the low, medium, or high portfolio if its FSCORE is between zero and three, between four and six, or between seven and nine. Monthly size-adjusted returns on the equal-weighted portfolios are calculated for the subsequent 12 months, and the portfolios are rebalanced each year. For the size adjustment, the monthly return on a stock is measured net of the return on its matching country-specific size quintile portfolio.⁴ We present market-wide results for four regions: (1) developed EAFE markets, (2) Asia–Pacific, (3) Europe, and (4) emerging markets. Asia–Pacific includes Australia, Hong Kong, Japan, New Zealand, and Singapore, while Europe encompasses the remaining developed equity markets. To shed further light on the economic importance and pervasiveness of FSCORE for predicting subsequent stock returns across the full firm size spectrum, we also report outcomes for three different size segments in each region. A firm is classified as a small-cap, mid-cap, or large-cap stock if its firm size is in the bottom, middle, or top tercile of the country-specific firm size distribution, measured as of June of each year.

Table 3 shows average monthly size-adjusted returns for the outlined FSCORE portfolios along with the average number of sample firms per month and the average firm size characteristic for perspective. The column ‘High–Low’ reports the spread return between high- and low-FSCORE firms for testing whether the return difference is significantly different from zero.

We find that high-FSCORE firms are rewarded with positive subsequent stock returns, while low-FSCORE are penalized with negative returns. The resulting (high–low) FSCORE premiums are economically large and statistically highly significant across all considered regions and size segments. Thus, international evidence for FSCORE is strong. Furthermore, the size-segmented results document that the positive FSCORE-return relation is not limited to smaller firms but likewise present among the largest and

economically most important firms in non-US countries. With monthly values of 0.79% (developed EAFE markets) and 0.95% (emerging markets), the average market-wide FSCORE premiums correspond to about 9.9% and 12.0% on an annual basis, which are just in the same range of magnitude as their US counterpart of 10.03% per year, reported in Piotroski and So (2012, Table 1).⁵ In addition, the market-wide results for Europe are also in line with Walkshäusl (2017, 2019) and suggest that the return effect associated with FSCORE is even somewhat stronger in the post-2000 era.

Incremental return predictability of FSCORE

Portfolio sorts represent a very useful approach to investigate how average returns vary with different levels of the variable of interest. However, the portfolio-level analysis also has the potential shortcoming that much of the individual stock information is lost through aggregation. In addition, showing that there exists a positive FSCORE-return relation does not rule out the possibility that the identified return effect is just a manifestation of already known determinants of the cross section.

To examine the incremental power of FSCORE for predicting subsequent stock returns, we conduct cross-sectional return regressions at the individual firm level using the Fama and MacBeth (1973) methodology, which provides a test setting that easily allows for multiple control variables. Specifically, we estimate a firm-level cross-sectional regression of monthly stock returns on FSCORE and common return controls. Taking into account the most recent developments in asset pricing (Fama and French 2015, 2018), the set of common controls includes firm size, book-to-market, momentum, operating profitability, and investment for measuring the abnormal return effect associated with FSCORE. Except for momentum, which is measured monthly, we update the explanatory variables each June to predict monthly stock returns from July to the following June. In the regression, firm size and book-to-market are measured in natural logs, and the regression includes country dummies to control for possible country effects.

Table 4 shows average slopes from the outlined firm-level cross-sectional regression. To gauge the strength of the abnormal return effect associated with FSCORE, the last column ‘Premium’ translates the corresponding slope into an abnormal return estimate by multiplying the average slope with the difference in average FSCORE characteristics between high and low firms.⁶

⁴ The size benchmark portfolios are formed each June by allocating all firms in a given country to quintiles based on firm size. Monthly raw returns on the equal-weighted size portfolios are calculated for the subsequent 12 months, and the portfolios are rebalanced each year.

⁵ Formally, e.g., $(1 + 0.0079)^{12} - 1$.

⁶ For perspective, across regions and size segments, the difference in average FSCORE characteristics between high and low firms is, with values close to five, very similar.



Table 3 Average monthly size-adjusted returns on FSCORE-sorted portfolios, 2000–2018

	Low	Medium	High	High–Low	Firms	SZ
Developed EAFE markets						
Market	−0.58 (−6.3)	0.01 (0.6)	0.20 (6.1)	0.79 (6.5)	6787	1311
Small	−0.50 (−5.3)	0.02 (0.8)	0.28 (5.8)	0.78 (6.0)	2229	41
Mid	−0.73 (−6.5)	−0.02 (−1.1)	0.23 (5.4)	0.96 (6.6)	2308	195
Large	−0.50 (−3.7)	0.03 (1.6)	0.12 (3.7)	0.62 (4.0)	2250	3713
Asia–Pacific						
Market	−0.43 (−4.6)	0.01 (0.8)	0.14 (4.0)	0.57 (4.8)	4061	1000
Small	−0.29 (−2.5)	0.01 (0.2)	0.19 (3.3)	0.47 (3.2)	1337	47
Mid	−0.58 (−4.9)	0.00 (0.1)	0.14 (3.1)	0.73 (5.0)	1381	183
Large	−0.49 (−3.2)	0.03 (1.0)	0.10 (2.2)	0.59 (3.3)	1343	2788
Europe						
Market	−0.78 (−7.2)	−0.01 (−0.5)	0.30 (6.2)	1.08 (7.1)	2726	1860
Small	−0.82 (−7.0)	0.02 (0.5)	0.46 (6.2)	1.28 (7.4)	892	42
Mid	−0.93 (−6.5)	−0.04 (−1.4)	0.34 (5.6)	1.27 (6.9)	927	250
Large	−0.39 (−2.4)	0.00 (0.2)	0.15 (3.2)	0.54 (2.8)	907	5293
Emerging markets						
Market	−0.71 (−8.8)	−0.04 (−2.8)	0.24 (9.1)	0.95 (9.6)	5016	793
Small	−0.70 (−7.0)	−0.02 (−0.6)	0.36 (8.5)	1.07 (8.5)	1647	73
Mid	−0.78 (−5.9)	−0.06 (−2.3)	0.25 (6.5)	1.03 (6.8)	1706	226
Large	−0.63 (−4.8)	−0.03 (−1.3)	0.13 (3.9)	0.76 (5.2)	1663	2089

Each June, all firms in the considered regional sample are assigned to three portfolios based on their FSCORE characteristic from the fiscal year ending in the previous calendar year. A firm is assigned to the low, medium, or high portfolio if its FSCORE is between zero and three, between four and six, or between seven and nine. Monthly size-adjusted returns on the equal-weighted portfolios are calculated for the subsequent 12 months, and the portfolios are rebalanced each year. For the size adjustment, the monthly return on a stock is measured net of the return on its matching country-specific size quintile portfolio. ‘High–Low’ provides the spread return between high- and low-FSCORE firms. The *t* statistic for the average monthly return is given in parentheses. The results are reported for all firms in the considered region (market) and for three different size segments. Asia–Pacific includes Australia, Hong Kong, Japan, New Zealand, and Singapore, while Europe encompasses the remaining developed equity markets (see Table 2). A firm is classified as a small-cap, mid-cap, or large-cap stock if its firm size is in the bottom, middle, or top tercile of the country-specific firm size distribution, measured as of June of each year. The table also reports the average number of sample firms per month and the average firm size characteristic for perspective



Table 4 Average slopes from monthly cross-sectional return regressions with controls, 2000–2018

	FSCORE	SZ	BM	MOM	OP	INV	R^2	Premium
Developed EAFE markets								
Market	0.106 (6.0)	-0.016 (-0.6)	0.365 (6.8)	0.375 (1.7)	0.164 (5.9)	-0.441 (-8.0)	0.079	0.53
Small	0.129 (6.1)	-0.320 (-5.6)	0.307 (5.8)	0.437 (2.3)	0.110 (3.3)	-0.373 (-4.1)	0.068	0.65
Mid	0.115 (5.4)	-0.002 (0.0)	0.398 (6.3)	0.509 (2.4)	0.198 (5.3)	-0.441 (-6.2)	0.091	0.57
Large	0.066 (3.3)	-0.019 (-0.5)	0.345 (5.0)	0.316 (1.1)	0.157 (4.2)	-0.359 (-5.1)	0.113	0.32
Asia-Pacific								
Market	0.079 (3.9)	-0.099 (-2.7)	0.386 (6.0)	0.116 (0.6)	0.211 (4.7)	-0.427 (-6.2)	0.080	0.39
Small	0.087 (3.2)	-0.711 (-7.6)	0.323 (4.2)	0.082 (0.4)	0.158 (2.9)	-0.409 (-3.1)	0.071	0.44
Mid	0.092 (3.6)	-0.119 (-1.4)	0.425 (5.7)	0.222 (1.1)	0.221 (4.0)	-0.439 (-4.2)	0.093	0.46
Large	0.059 (2.4)	-0.003 (-0.1)	0.399 (5.2)	0.280 (1.2)	0.263 (3.6)	-0.265 (-3.1)	0.106	0.29
Europe								
Market	0.141 (7.0)	0.056 (1.7)	0.294 (5.2)	0.905 (3.3)	0.111 (3.5)	-0.372 (-5.2)	0.050	0.69
Small	0.173 (6.4)	-0.027 (-0.4)	0.301 (5.3)	1.110 (4.9)	0.091 (2.0)	-0.364 (-3.1)	0.036	0.86
Mid	0.144 (5.7)	0.106 (1.7)	0.325 (4.4)	1.049 (3.9)	0.156 (3.2)	-0.339 (-3.6)	0.056	0.70
Large	0.061 (2.6)	-0.045 (-1.0)	0.194 (2.2)	0.503 (1.2)	0.071 (1.6)	-0.478 (-4.2)	0.083	0.28
Emerging markets								
Market	0.135 (8.3)	-0.064 (-2.0)	0.416 (7.7)	0.185 (0.9)	0.336 (7.0)	-0.243 (-4.7)	0.163	0.66
Small	0.189 (8.5)	-0.296 (-3.9)	0.369 (6.1)	0.119 (0.7)	0.252 (3.7)	-0.190 (-1.8)	0.157	0.93
Mid	0.129 (5.8)	-0.148 (-1.6)	0.466 (7.8)	0.352 (1.8)	0.363 (4.8)	-0.215 (-2.5)	0.181	0.63
Large	0.083 (4.4)	-0.010 (-0.2)	0.377 (5.7)	0.100 (0.4)	0.374 (7.2)	-0.237 (-3.4)	0.194	0.40

This table shows average slopes from firm-level cross-sectional regressions of monthly stock returns on FSCORE in combination with common return controls. The set of common controls includes firm size (SZ), book-to-market (BM), momentum (MOM), operating profitability (OP), and investment (INV). Except for momentum, which is measured monthly, the explanatory variables are updated each June to predict monthly stock returns from July to the following June. In the regressions, firm size and book-to-market are measured in natural logs, and all regressions include country dummies to control for possible country effects. The t statistic for the average slope is given in parentheses. The R^2 values are adjusted for degrees of freedom. 'Premium' gives the monthly abnormal return associated with the average FSCORE slope

The results make clear that the return-predictive power of FSCORE is not explained away in the presence of established cross-sectional benchmark variables. The return difference between high- and low-FSCORE firms remains

economically and statistically significant after controlling for firm size, book-to-market, momentum, operating profitability, and investment in all considered regions and size segments. Though we note the tendency of decreasing abnormal returns from small-cap to large-cap stocks, the monthly FSCORE premiums among large caps preserve a meaningful



Table 5 Average slopes from annual cross-sectional regressions to predict future profitability, 2000–2018

	Intercept	ROA	SZ	FSCORE	R ²	Difference
Developed EAFE markets						
Short term	−0.078 (−15.5)	0.591 (32.5)	0.009 (17.0)	0.006 (11.3)	0.446	0.031
Long term	−0.050 (−5.4)	0.338 (26.2)	0.008 (9.5)	0.004 (7.6)	0.319	0.018
Asia–Pacific						
Short term	−0.085 (−11.5)	0.577 (31.7)	0.011 (15.2)	0.006 (8.3)	0.441	0.030
Long term	−0.062 (−6.1)	0.345 (20.5)	0.011 (9.9)	0.003 (5.3)	0.337	0.017
Europe						
Short term	−0.065 (−9.9)	0.634 (26.4)	0.006 (16.4)	0.006 (6.7)	0.462	0.028
Long term	−0.030 (−4.2)	0.382 (11.9)	0.005 (9.4)	0.003 (5.1)	0.288	0.014
Emerging markets						
Short term	−0.059 (−16.5)	0.582 (32.4)	0.007 (22.6)	0.005 (12.3)	0.401	0.023
Long term	−0.028 (−10.6)	0.304 (18.8)	0.006 (17.9)	0.003 (5.7)	0.246	0.013

This table shows average slopes from firm-level cross-sectional regressions of future profitability using return-on-assets (short-term or long-term) on current profitability (ROA), firm size (SZ), and FSCORE. The explanatory variables are updated each year to predict the firm's 1-year-ahead profitability (short-term) or the average profitability over the 4-year period after the short-term horizon (long-term). In the regressions, firm size is measured in natural logs, and all regressions include country dummies to control for possible country effects. The *t* statistic for the average slope is given in parentheses. The R² values are adjusted for degrees of freedom. 'Difference' provides the annual difference in future profitability between high- and low-FSCORE firms based on the average FSCORE slope

magnitude of about 0.30% in the regions of developed markets and 0.40% in emerging markets.

The outcome that the information contained in FSCORE remains significant after risk-adjusting returns is consistent with the broad majority of prior studies that have examined the FSCORE mainly in combination with other variables (Piotroski 2000; Piotroski and So 2012; Ng and Shen 2016; Turtle and Wang 2017; Walkshäusl 2017; Ahmed and Safdar 2018; Tikkanen and Äijö 2018; Ng and Shen 2019; Walkshäusl 2019). Our results extend this finding to the major regions in international markets based on the most recent return controls (Fama and French 2018) and underscore that the FSCORE represents a return-predictive device on its own.

The market-wide slopes on the control variables echo in general prior results in the literature. International stock returns are significantly positively associated with book-to-market and operating profitability, while they are significantly negatively related to investment. In contrast, we mostly do not find reliable firm size effects or momentum effects (except for Europe) during the sample period.

These observations are, however, also in line with recent international evidence (Fama and French 2017) and the generally weak performance of momentum strategies since the late 1990s (Bhattacharya et al. 2017).

FSCORE and future firm profitability

To investigate the association of FSCORE with future firm profitability, we follow the methodology described in Bradshaw et al. (2006) and conduct Fama–MacBeth-type regressions based on annual realizations of fundamentals. Specifically, we estimate a firm-level cross-sectional regression of the firm's future profitability using return-on-assets (short-term or long-term) on current profitability, firm size, and FSCORE, which all can be observed before the future firm performance is realized. Our investigation is inspired by Piotroski (2000), Piotroski and So (2012), and Walkshäusl (2017), who have stressed a positive univariate relation between FSCORE and future firm profitability. Controlling for current profitability and firm size helps to uncover the genuine incremental effect of FSCORE. The existing



literature shows that the current level of profitability is economically the most important determinant of future profitability because profitability is only slowly mean-reverting (e.g., Fama and French 2006). The addition of firm size to the explanatory variables is motivated by our previous size segmentation and takes into account the evidence that smaller firms tend to be less profitable (Fama and French 1995).

Table 5 shows average slopes from the outlined firm-level cross-sectional regression to forecast profitability. We evaluate the firm's future profitability both over short-term and long-term horizons, where the former is the 1-year-ahead profitability, and the latter is the average profitability over the 4-year period after the short-term horizon. As before, firm size is measured in natural logs, and the regression includes country dummies. The last column 'Difference' provides the annual difference in future profitability between high- and low-FSCORE firms based on the corresponding slope.

First and expectedly, current profitability exerts the most substantial impact on the firm's subsequent fundamental performance. Over the short-term horizon, the current level of profitability accounts on average for about 60% of the future level and still more than 30% over the long-term horizon. Second, as indicated by the significantly positive firm size slope, larger firms are also in international markets, on average, more profitable than smaller firms. Third and finally, we observe that FSCORE captures additional information about subsequent fundamental performance in all considered regions and therefore helps to forecast profitability. Over the short-term horizon, the difference in 1-year-ahead profitability between high- and low-FSCORE firms amounts to 3.1 percentage points among developed countries and 2.3 percentage points among emerging countries, which appears economically sizable given the mean and median return-on-assets profitability of the typical sample firm (see Panel B in Table 2). The long-term horizon results document that the positive relation between FSCORE and subsequent fundamental performance remains intact over extended periods, causing an average annual difference in future profitability of at least 1.3 percentage points between high and low firms over the 4 years following the short-term horizon.

These findings are altogether consistent with the view that investors tend to underreact to changes in firm fundamentals (e.g., Lakonishok et al. 1994). Since FSCORE measures the improvement or deterioration in the firm's fundamental strength, the positive FSCORE-return relation arises because investors do not fully anticipate the positive association of FSCORE with future firm profitability. Such investor behavior should result in predictable return patterns for high- and low-FSCORE firms, and this is indeed what we find here.

Further robustness tests

In this section, we further test the robustness of our key findings using value-weighted returns that overweight larger firms and alternative methods for risk-adjusting returns based on the CAPM and q -factor model.

First, we repeat our market-wide portfolio-level analysis of Table 3 employing value-weighted returns. Hou et al. (2018) recently show that many of the previously documented anomalies on the US equity market fail to hold when value-weights are used. Second, we measure abnormal returns on the FSCORE-sorted portfolios relative to the market in a CAPM setting because investors still base their capital allocation decisions primarily on this model, as found by Barber et al. (2016) and Berk and van Binsbergen (2016). The market excess return is the value-weighted return of all firms in the considered region in excess of the risk-free rate, the 1-month US Treasury bill rate. To obtain the abnormal return relative to the market (CAPM alpha), the portfolio excess returns are regressed on the market excess return. Third, we consider the controls of the q -factor model of Hou et al. (2015) as an alternative to the applied risk adjustment based on the Fama and French (2015, 2018) approach. The q -factor model is motivated by the q -theory of investment and controls for firm size, investment, and return-on-equity in the cross section of average returns. Hou et al. (2015) found that when returns are adjusted by these controls, the difference between high- and low-FSCORE firms in the USA is rendered insignificant using value-weights. To examine whether this is also the case in non-US equity markets, we proceed as follows. In each region, we estimate a weighted least squares cross-sectional regression of monthly stock returns on firm size, investment, and return-on-equity that uses firm size as the weights (value-weights).⁷ The residuals from this regression are then sorted on the firm's FSCORE characteristic into the low, medium, and high groups. Within each group, the residuals are value-weighted and then averaged across months. In this way, we obtain abnormal returns that are adjusted for effects associated with firm size, investment, and return-on-equity. If the controls of the q -factor model can describe the spread return between high- and low-FSCORE firms, the corresponding abnormal return should be statistically indistinguishable from zero.

Table 6 shows average monthly value-weighted returns for market-wide FSCORE portfolios (Panel A), their abnormal returns relative to the market (Panel B), and their abnormal returns relative to the q -factor model (Panel C). Except for the region of Asia-Pacific, we find significantly positive FSCORE-return relations using value-weighted

⁷ As before, the explanatory variable firm size is measured in natural logs, and the regression includes country dummies.



Table 6 Robustness of FSCORE using value-weights, 2000–2018

	Low	Medium	High	High–Low
Panel A: Average returns				
Developed EAFE markets	0.28 (0.7)	0.61 (1.9)	0.72 (2.5)	0.44 (2.4)
Asia–Pacific	0.15 (0.4)	0.48 (1.6)	0.53 (1.9)	0.38 (1.6)
Europe	0.30 (0.7)	0.71 (2.0)	0.92 (2.7)	0.62 (3.4)
Emerging markets	0.37 (0.7)	0.86 (2.1)	0.97 (2.4)	0.60 (2.6)
Panel B: Abnormal returns relative to the market				
Developed EAFE markets	−0.47 (−3.7)	−0.03 (−1.3)	0.14 (2.7)	0.61 (3.9)
Asia–Pacific	−0.44 (−2.4)	−0.01 (−0.3)	0.08 (1.5)	0.52 (2.4)
Europe	−0.56 (−4.1)	−0.04 (−2.3)	0.20 (3.3)	0.76 (4.6)
Emerging markets	−0.59 (−2.8)	−0.02 (−0.5)	0.12 (2.1)	0.71 (3.1)
Panel C: Abnormal returns relative to the q -factor model				
Developed EAFE markets	−0.27 (−2.5)	−0.01 (−0.8)	0.06 (1.7)	0.33 (2.7)
Asia–Pacific	−0.36 (−2.4)	0.00 (0.0)	0.03 (0.6)	0.39 (2.2)
Europe	−0.32 (−2.8)	−0.02 (−1.2)	0.09 (1.7)	0.41 (2.9)
Emerging markets	−0.40 (−2.5)	0.03 (0.9)	0.00 (0.1)	0.40 (2.4)

Panel A reports average monthly value-weighted returns on FSCORE-sorted portfolios using all firms in the considered region (market-wide sorts). The portfolio formation is analogous to Table 3. ‘High–Low’ provides the spread return between high- and low-FSCORE firms. Panel B reports abnormal returns relative to the market (CAPM alphas). The abnormal returns are obtained by regressing the monthly portfolio returns in excess of the risk-free rate (1-month US Treasury bill rate) on the market excess return, the value-weighted excess return of all firms in the considered regional sample. Panel C reports abnormal returns relative to the controls of the q -factor model. The abnormal returns are based on the residuals from weighted least squares cross-sectional regressions of monthly stock returns on firm size, investment, and return-on-equity in each region that are sorted into the three FSCORE groups. Within each group, the residuals are then value-weighted and averaged across months. The weighted least squares regressions use firm size as the weights. In the regressions, the explanatory variable firm size is measured in natural logs, and all regressions include country dummies to control for possible country effects. The t statistic for the average monthly return or abnormal return is given in parentheses

returns. Among firms from developed EAFE markets, the average (high–low) spread return amounts to 0.44% per month and 0.60% per month in emerging markets. Second, the abnormal returns relative to the market are very similar to our size-adjusted return results among large-cap stocks,

as reported in Table 3. All considered regions display now significantly positive return differences between high- and low-FSCORE firms. When the controls of the q -factor model are applied, the FSCORE premiums are reduced but remain economically meaningful and statistically significant. Thus, in contrast to the US findings of Hou et al. (2015, 2018), the return predictability of FSCORE appears to be more robust outside the USA even when value-weights are used. However, from an investment perspective, we note that the resulting FSCORE premiums are more driven by the significant underperformance of low-FSCORE firms than by the outperformance of high-FSCORE firms after controlling for firm size, investment, and return-on-equity.⁸

In light of the fact that investors tend to underreact to changes in firm fundamentals, and the finding that the return predictability of FSCORE largely can be traced back to its ability to forecast the firm’s future profitability, adjusting returns for profitability effects will likely reduce abnormal returns.⁹ This particularly has to be expected when larger firms are overweighted in the analysis since the largest firms are regularly followed by more analysts, leading to more timely incorporation of fundamental information into prices (Hameed et al. 2015). The observation that this has a more significant impact on the long leg of the FSCORE premium than on its short leg is consistent with the concept of arbitrage asymmetry (Stambaugh et al. 2015). Buying the (undervalued) high-FSCORE firms is for most investors easier than shorting the (overvalued) low-FSCORE firms. Circumventing firms with low-FSCORE characteristics may be advisable to investors regardless of the considered weighting scheme and irrespective of the applied control variables given their persistent underperformance. Nevertheless, the value-weighted results also document that long-only investors that are only benchmarked against the market would have been able to display significantly positive alphas by investing in the largest high-FSCORE firms in the majority of regions over the sample period 2000–2018.

Conclusions

In this paper, we have studied the pure FSCORE-return relation in the broad cross section of international firms with the aim to shed light on the genuine return-predictive power of Piotroski’s (2000) FSCORE when used on its own. We find that the FSCORE is an economically meaningful

⁸ In unreported tests, we have also applied the risk adjustment based on Fama and French (2015, 2018) using value-weights. The obtained results are very similar to those presented here.

⁹ Profitability exhibits a strong autocorrelation over several years, i.e., lagged profitability is a strong predictor of future profitability (Fama and French 2006).



and statistically significant predictor of the cross section of international stock returns. Its return-predictive ability is similarly present among developed non-US markets and emerging markets, pervasive across small and large firms, and remains robust after controlling for established determinants of the cross section, such as firm size, book-to-market, momentum, operating profitability, and investment. The FSCORE premium also preserves its significance when benchmarked against the market or the controls of the q -factor model using value-weights that overweight larger firms in the market. All in all, our results imply that the FSCORE remains a rather global phenomenon around the world. Furthermore, in light of the fact that it seems implausible that fundamentally strong firms may be considered riskier than fundamentally weak firms, our findings are still consistent with the view that fundamental information is only gradually incorporated into prices by investors, which has been emphasized by Piotroski (2000) almost 20 years ago.

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