

Value investing in emerging markets: The effectiveness of the Piotroski F-score strategy in Poland as a Central and Eastern European case study

Krzysztof Podgórski

ABSTRACT

Objective: The aim of this article is to verify the investment effectiveness of a long-only strategy based on the Piotroski F-score indicator on the Polish equity market, relative to the passive ‘buy and hold’ strategy tracking the broad WIG index.

Research Design & Methods: The study used data from the Warsaw Stock Exchange for the full investment cycle covering the years 2006-2025. The study deployed a long-only strategy variant (selection of companies with a score of 7-9 points), incorporating real trading frictions: brokerage commissions (0.39%), capital gains tax (19%) with a loss deduction mechanism, and annual rebalancing deferred to 31 May to preclude look-ahead bias. The non-parametric Wilcoxon signed-rank test verified the repeatability of the market advantage.

Findings: The F-score-based strategy generated a CAGR of 15.22% compared to 4.36% for the WIG index, yielding a cumulative return of 1 376.19% (compared to 124.78% for the WIG). Although the Wilcoxon test did not confirm the statistical regularity of excess returns year-on-year, the portfolio exhibited a highly right-skewed payout profile and a risk-adjusted return (Sharpe ratio of 0.37) almost four times higher than the broad market’s.

Implications & Recommendations: The lack of unconditional statistical regularity does not negate the high economic utility of the model. The results prove that investors on the Polish market should accept increased portfolio volatility and a lack of return linearity in exchange for an asymmetric risk premium. The Polish capital market still exhibits the characteristics of an emerging market, favouring classic value investing strategies. Treating Poland as a representative case study for the Central and Eastern European (CEE) region, these results provide useful guidance for international investors allocating capital in markets with lower informational efficiency.

Contribution & Value Added: Including rigorous transaction and tax costs significantly improves the realism of the results compared to the existing literature. The article first demonstrates the option-like payoff profile of Piotroski’s payout strategy over a long, twenty-year horizon on the Polish market, confirming that simple fundamental filters have not yet eroded here, as is typical of highly developed markets.

Article type: research article

Keywords: Piotroski F-score; fundamental analysis; value investing; market efficiency; Warsaw Stock Exchange

JEL codes: G11, G14, G15

Received: 3 March 2026

Revised: 29 April 2026

Accepted: 16 June 2026

Suggested citation:

Podgórski, K. (2026). Value investing in emerging markets: The effectiveness of the Piotroski F-score strategy in Poland as a Central and Eastern European case study. *International Entrepreneurship Review*, 12(3), 71-85. <https://doi.org/10.15678/IER.2026.1203.05>

INTRODUCTION

The classic efficient market hypothesis (Fama, 1970) remains a primary point of contention in contemporary finance theory. The hypothesis posits that financial asset prices immediately reflect all available information, which by definition renders any systematic attempt to achieve above-average returns futile. However, the literature describes numerous anomalies that undermine the assumption of a fully rational and immediate response by investors to incoming market data. A key phenomenon in this

domain is the post-earnings-announcement drift (PEAD), described by Bernard and Thomas (1989), whereby share prices continue to move for many months in line with the market surprise contained in corporate financial results, suggesting that the market discounts this information belatedly. Another example is the accruals anomaly, whereby Sloan (1996) shows that investors focus on net profit and ignore its components, leading to mispricing of companies with a high proportion of accruals. The overreaction and underreaction effect completes this picture: De Bondt and Thaler (1985) highlighted the psychological aspects of investing, pointing out that the market often overreacts to dramatic events, thereby creating opportunities for contrarian strategies.

Documented inefficiencies underpin value investing strategies rooted in fundamental analysis. These methods aim to achieve above-average returns by purchasing undervalued stocks and exploiting the divergence between their market price and intrinsic value (Frankel & Lee, 1998). However, a major challenge arises from the risk of a 'value trap', which occurs when an attractive valuation ratio reflects a permanent erosion of a company's financial fundamentals (Penman & Reggiani, 2018).

In response to this problem, Joseph Piotroski (2000) developed the innovative F-score indicator. The simple yet effective tool draws on nine publicly available accounting signals used to assess the fundamental condition of companies. By testing this method on the US market (1976-1996) within a group of 20% of companies with the lowest price-to-book ratio, Piotroski proved its strong predictive power. Piotroski further demonstrated that selecting and buying companies with high scores (8-9 points) yields an average annual return 7.5 percentage points higher than that of the entire portfolio of analysed value companies. Furthermore, applying a full long-short strategy, consisting of buying entities with strong fundamentals and short selling the weakest ones (0-1 points), generated a substantial 23% per annum above the return on the broad market.

Researchers have verified the F-score model over many time intervals and across global markets. Most international studies confirm the model's ability to deliver higher rates of return, although the final results depend on the period and geography studied. Studies report positive results in Europe, including Germany (Pătări *et al.*, 2022) and the Nordic countries (Brindelid & Nilsson, 2021), as well as in emerging markets (Hyde, 2014; Walkshäusl, 2020), including Vietnam (Ho *et al.*, 2023), Taiwan (Lin *et al.*, 2021), and India (Shah *et al.*, 2025; Tripathy & Pani, 2017). However, researchers also note limitations. For example, in the British market, the strategy was effective in the broad market but insignificant for the value segment itself (Rathjens & Schellhove, 2011), while post-1997 data from the USA suggest that this anomaly has gradually disappeared (Woodley *et al.*, 2011).

Regarding the Warsaw Stock Exchange (WSE), previous publications – notably those of Kusowska (2021) and Pilch (2023) – indicate the considerable potential of this method in selecting reliable companies; however, their narrow scope and comparisons mainly with proprietary models call for much broader empirical verification. To address these shortcomings, this article examines the effectiveness of Piotroski's strategy as a tool for active allocation across a broad spectrum of WSE-listed entities.

The aim of this study was to analyse the effectiveness of Piotroski's long-only strategy on the Polish equity market. The study used data from the Warsaw Stock Exchange. In this research, effectiveness means the strategy's ability to generate higher rates of return over the adopted period than investment in the broad WIG index on a 'buy-and-hold' basis. To achieve this objective, the study posed the following research questions:

- RQ1:** Does the Piotroski F-score strategy generate above-average rates of return compared to the broad market index on the Warsaw Stock Exchange?
- RQ2:** What is the risk-adjusted performance and payoff profile of the F-score portfolio over a long-term investment horizon in a developing market setting?

Deliberate reasoning guided the choice of the WSE. The study treated the Polish equity market as an international case study, representative of developing capital markets in the Central and Eastern Europe (CEE) region. Through this approach, the results transcend the local context and serve foreign investors seeking risk premiums in markets with delayed discounting of fundamental information. From a broader perspective of entrepreneurial finance, the effectiveness of fundamental analysis in emerging markets underscores the critical role of rational capital allocation. Rewarding

companies with sound financial health and operational stability – as captured by the F-score – lowers the cost of capital for well-managed enterprises, thereby stimulating sustainable business development and entrepreneurial resilience in the CEE region.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Before turning to empirical evidence, we must understand how the F-score is constructed to properly interpret the study results. The strength of Piotroski's (2000) strategy lies in its simplicity and reliance on readily available public financial data. The feature makes the F-score a universal preliminary selection tool that suits a wide range of investors in different markets without advanced models or paid analytical services.

The F-score is computed as the sum of points awarded for meeting nine binary criteria grouped into three analytical categories: profitability, financial stability and operational efficiency. A company receives one point for meeting each criterion; otherwise, it receives zero. Table 1 details the individual F-score components.

Table 1. Components of the Piotroski F-score indicator (theoretical framework)

Category	Signal	Criterion for awarding points (1 point)
Profitability	ROA (Return on Assets)	Positive return on assets ($ROA > 0$) in the current year.
	CFO (Cash Flow from Operating Activities)	Positive cash flow from operating activities ($CFO > 0$) in the current year.
	ΔROA (Change in return on assets)	Increase in ROA compared to the previous year ($\Delta ROA > 0$).
	ACCRUAL (Earnings quality)	Cash flow from operating activities (CFO) is higher than net profit ($CFO > \text{Net Profit}$).
Financial stability	$\Delta LEVER$ (Change in financial leverage)	Decrease in the long-term debt ratio compared to the previous year ($\Delta LEVER < 0$).
	$\Delta LIQUID$ (Change in current liquidity)	Increase in current liquidity ratio compared to the previous year ($\Delta LIQUID > 0$).
	EQ_OFFER (Share issue)	No new shares issued during the last year.
Operational efficiency	$\Delta MARGIN$ (Change in gross margin)	Increase in gross margin compared to the previous year ($\Delta MARGIN > 0$).
	$\Delta TURN$ (Change in asset turnover)	Increase in asset turnover ratio compared to the previous year ($\Delta TURN > 0$).

Source: own study based on Piotroski (2000).

The sum of these points determines the final F-score, which ranges from 0 (indicating the weakest fundamentals) to 9 (representing the strongest fundamentals). Piotroski (2000) originally defines firms with robust financial health, and consequently a high F-score, as those achieving a score of 8 or 9. However, contemporary research frequently broadens this threshold to include scores of 7 to 9, permitting more diversified and realistic portfolios, particularly within smaller capital markets. Conversely, entities with deteriorating fundamentals typically score 0 to 1, or occasionally 0 to 2.

Piotroski's initial investment methodology involved constructing a long-short portfolio. The preliminary step required selecting companies from the highest quintile of the book-to-market (B/M) ratio. Within this cohort, the strategy took long positions in high F-score companies, and short positions against low F-score firms, followed by complete annual portfolio reallocation (Piotroski, 2000). While this foundational application proved highly specific, later studies have shown that the predictive power of the indicator extends far beyond this original framework; nevertheless, as the review below shows, its efficacy remains subject to certain market conditions. Numerous empirical studies have assessed the Piotroski F-score strategy across diverse international markets. The literature offers mixed evidence; however, most studies confirm the utility of fundamental analysis in value stock selection, notwithstanding certain exceptions. While studies in emerging and European markets, such as those by Hyde (2014) and Walkshäusl (2020), indicate a premium for fundamental quality, findings from the post-1997 US market by Woodley

et al. (2011) suggest a temporal decay of this anomaly. Other scholars corroborate the strategy's diminishing effectiveness in highly efficient markets; Koutoupis *et al.* (2022) documented a negative premium across a sample of 21 European markets, where firms with weak indicators outperformed those with robust fundamentals, and Baschieri and Hunziker (2025) identified a marginally negative risk premium in the Italian market. Furthermore, as Krauss *et al.* (2015) argue, even when the strategy yields theoretical profits in the USA, it becomes practically unviable once investors incorporate liquidity constraints and transaction costs. Researchers frequently attribute these limitations to analytical neglect – the F-score performs optimally where accounting information is assimilated slowly by the market, thereby favouring smaller entities. In the Australian market, for instance, Hyde (2015) demonstrated that Piotroski's strategy generates peak rates of return predominantly within the small-cap segment. Bülow (2017) echoes this finding in the US market, highlighting arbitrage barriers for smaller-capitalisation companies.

In this context, studies of the WSE hold particular significance. Despite employing varied time horizons and methodological approaches, these studies yield consistent conclusions regarding the potential of the F-score indicator under Polish market conditions. Kusowska's (2021) pivotal study on the Polish market, which spanned the years 2014–2020 and concentrated on the largest entities comprising the WIG30 index, demonstrated the defensive characteristics of Piotroski's strategy. During the review period – marked by pandemic-induced market contractions – the portfolio of high F-score firms fell less (–37.32%) than the broader market (–40.82%) and posted a substantially lower loss than the portfolio of companies with weak fundamentals (–83.37%). The outcome implies that on the Polish market, the F-score functions as an effective capital preservation filter during economic downturns, even if it fails to generate absolute positive returns amid a severe bear market. Pilch's (2023) more expansive study complements these findings, examining a broader cross-section of companies between 2012 and 2022. There, the F-score strategy yielded an average annual market-adjusted return of +1.35%. Notably, Pilch (2023) demonstrated that Piotroski's foundational model outperformed proprietary adaptations (such as the X-Score and Y-Score) tailored specifically to the Polish market, which ultimately incurred losses.

Comparing these domestic outcomes with international research, such as the work of Pătări *et al.* (2022) on Germany or Ho *et al.* (2023) on Vietnam, situates Poland as a market where fundamental metrics continue to exert a substantial influence on corporate valuation, in contrast to markets with peak informational efficiency. Analyses of the Vietnamese and Indian stock exchanges illustrate this paradigm; there, researchers documented exceptional rates of return, occasionally reaching several dozen per cent annually (Ho *et al.*, 2023; Shah *et al.*, 2025). Furthermore, these investigations underscore that the profitability of the F-score in emerging economies systematically improves when the horizon extends to two years.

Recent literature further enriches this narrative by examining its robustness amidst shifting macroeconomic environments and its capacity for methodological modification. Anderson *et al.* (2025) emphasise the cyclicity of returns, indicating that the F-score's effectiveness fluctuates over time; during recessionary phases, monetary policy variables can overshadow fundamental signals, so deploying the method during slumps requires caution. Despite these macroeconomic constraints, empirical support for the indicator's usefulness remains robust across emerging markets. Within the Indian equity market, Tripathy and Pani (2017) and Shah *et al.* (2025) validated the effectiveness of Piotroski's model for stock screening. The latter study, via sensitivity analysis, revealed that profitability drivers – most notably ROA – are key determinants of portfolio performance, whereas other components (such as new share issuance) exert a negligible impact.

Lin *et al.* (2021) also identified scope for improving the original model in the Taiwanese market. Their research demonstrated that augmenting the F-score with supplementary screening criteria, such as price momentum or the P/E ratio, yields superior returns to the basic version. Modifications extend beyond the inclusion of alternative financial metrics to encompass advanced statistical frameworks; for example, Gimeno *et al.* (2020) show that deploying artificial neural networks (Neural F-score) markedly improves investment outcomes relative to the classical method in both the eurozone and the USA. Nevertheless, Rathjens and Schellhove (2011) report equivocal results for the British market. While their study corroborated the strategy's general effectiveness for the broad market, it failed to show its significant advantage among undervalued value stocks, thereby contradicting Piotroski's foundational hypothesis.

Synthesising empirical research findings from disparate markets poses challenges, primarily because of the profound heterogeneity of the evaluation methodologies used. As illustrated in Table 2, authors investigating the effectiveness of the F-score apply diverse performance metrics – from discrete monthly rates (Koutoupis *et al.*, 2022), through annualised risk premiums (Walkshäusl, 2020), to heavily aggregated cumulative rates (Shah *et al.*, 2025; Kusowska, 2021). Such discrepancies stem from different investment time horizons and the different benchmarks used (e.g. value portfolios, portfolios with the lowest F-score or general market indices). Although these results resist direct arithmetic comparison, their synthesis points unambiguously to a premium for fundamental quality, the magnitude and persistence of which depend on the informational efficiency of a given trading venue.

Table 2. Summary of international empirical research on the effectiveness of the F-score indicator (selected studies, 2000-2025)

Author and year	Market and period studied	Rate of return achieved using the strategy	Rate of return from the benchmark	Difference in p.p.
Ho <i>et al.</i> (2023)	Vietnam (2009-2019)	31.1% (annual raw)	18.4% (high B/M companies)	12.7
Shah <i>et al.</i> (2025)	India (2007-2024)	1 695.86% (cumulative)	approx. 250% (Nifty 100)	1445.86
Pätäri <i>et al.</i> (2022)	Germany (2000-2015)	12.17% (annual raw)	4.81% (sample average)	7.36
Rathjens & Schellhove (2011)	United Kingdom (1991-2008)	15.77% (annual average)	10.70% (market average)	5.07
Lin <i>et al.</i> (2021)	Taiwan (2001-2020)	26.78% (annual – modification)	22.18% (original F-score)	4.6
Kusowska (2021)	Poland (2014-2020)	-37.32% (cumulative)	-40.82% (WIG30 index)	3.5
Pilch (2023)	Poland (2012-2022)	+1.35% (mkt-adj)	0% (market benchmark)	1.35
Bülow (2017)	USA (2003-2015)	18.3% (mkt-adj)	4.0% (low F-score)	14.3
Koutoupis <i>et al.</i> (2022)	Europe – 21 countries (1989-2016)	0.30% (monthly)	1.30% (low F-score)	-1.00
Walkshäusl (2020)	35 markets (2000-2018)	~10% (annual premium)	(High-Low spread)	approx. 10.0
Gimeno <i>et al.</i> (2020)	Eurozone (2006-2017)	+3.53% (excess NF-score)	(relative to F-score)	3.53

Source: own study.

A comparative synthesis of international research indicates that the effectiveness of the F-score strategy is not uniform but depends largely on the degree of market efficiency and the prevailing phase of the business cycle (Anderson *et al.*, 2025). While highly developed markets, such as the US and the UK, exhibit a gradual erosion of extraordinary returns (Rathjens & Schellhove, 2011; Woodley *et al.*, 2011) or require methodological modifications incorporating additional filters (Gimeno *et al.*, 2020; Lin *et al.*, 2021), emerging and European markets continue to offer a premium for deploying fundamental analysis in corporate selection (Ho *et al.*, 2023; Hyde, 2014; Walkshäusl, 2020).

Drawing on this literature, which suggests that emerging and European markets persistently offer a premium for fundamental-based screening, our study hypothesised that the Polish capital market will exhibit a similar pattern. Therefore, we formulated the following hypothesis:

- H1:** While Piotroski's F-score strategy may lack unconditional statistical predictability year-on-year on the Polish stock market, it delivers substantial economic usefulness by generating asymmetric, risk-adjusted excess returns.

RESEARCH METHODOLOGY

The research period spans the years 2004 to 2025. The underlying financial statement data, sourced from the Biznesradar database (n.d.), derive from annual reports published between 2004 and 2024. The study subsequently calculated the F-score components for the years 2005 to 2024; this timeframe accounts for the inclusion of dynamic indicators (Δ ROA, Δ LEVER, Δ LIQUID, Δ MARGIN and Δ TURN), which require two

consecutive years of data. Consequently, the strategy executed purchases between 2006 and 2024, while corresponding sale transactions occurred from 2007 to 2025. Thus, the full investment cycle covers allocation decisions made from 2006 onwards, culminating in the sale of the final assets in 2025. All calculations used daily closing prices obtained from the Stooq financial portal (n.d.), strictly adjusted for corporate actions including stock splits, dividends, pre-emptive rights and subscription rights.

The study designated 31 May as the date for annual portfolio rebalancing, entailing full liquidation of existing holdings and simultaneous purchase of new ones. Aligning with the Polish corporate reporting cycle, this date fulfils Piotroski's requirement of ensuring the public availability of annual financial disclosures. The date provides investors with a safe time buffer to preclude inadvertent use of non-public data when making investment decisions, thereby minimising the risk of look-ahead bias (Daniel *et al.*, 2008).

The research sample comprised WSE-listed entities, with the broad WIG stock market index serving as a benchmark. The study implemented an extended F-score methodology, which involves buying shares with an F-score of 7-9 points. The approach mirrors the framework adopted in the two most recent studies for the Polish market by Kusowska (2021) and Pilch (2023). The study deliberately excluded the classic 'short leg' of Piotroski's original model, which involves taking short positions in shares of companies with the weakest fundamentals. The adjustment stems from the idiosyncratic constraints of the Polish capital market – notably, the stringent liquidity and capitalisation requirements on the WSE preclude the short selling of shares of smaller companies, a limitation compounded by regulatory restrictions on trading. Furthermore, given the limited number of companies listed on the Polish bourse, Piotroski's foundational constraint of restricting analysis to the lowest quintile based on the P/BV ratio – a standard practice in broader emerging market research – was omitted to maintain a viable sample size. The study weighted each year's final portfolio equally.

The primary analytical framework relied on statistical analysis of return time series. To ascertain the statistical significance of the observed excess returns, the study deployed the Wilcoxon signed-rank test (Barber & Lyon, 1997). Extreme outliers in the dataset necessitated this non-parametric test, because such outliers inherently violate the assumption of normal distribution required for classical parametric assessments, such as the paired-samples Student's t-test (Hsu & Lachenbruch, 2014).

To ensure real-world applicability, the study rigorously adjusted returns for transaction costs on equity purchases and sales; specifically, it incorporated a standard 0.39% brokerage commission (Alior Bank, n.d.). Furthermore, returns bore a 19% capital gains tax. Crucially, the empirical model integrated the statutory mechanism allowing incurred losses to offset income from the same capital source, subject to a limit of 50% of the loss reported in a given tax year. The adjustment follows the Polish Personal Income Tax Act (Ustawa z dnia 26 lipca 1991 r., Art. 9(3) and (3a)).

The empirical investigation proceeded as follows:

1. Collection of the raw financial data necessary to calculate the individual components of the Piotroski F-score from the Biznesradar database for all listed companies.
2. Processing of the aggregated data and computation of the constituent indicators and the final F-score (for the years 2006 to 2024).
3. Identification and selection of companies achieving an index value of 7 to 9 points across the respective annual periods (for the years 2006 to 2024).
4. Extraction of historical share prices for selected entities from the Stooq portal.
5. Assigning of precise entry and exit share prices for each selected company corresponding to the designated transaction dates.
6. Calculation of annual rates of return for individual companies, aggregated annual portfolios, and the benchmark WIG index, followed by derivation of mean rates of return.
7. Adjustment of gross rates of return to reflect brokerage transaction fees – applied annually for the actively rebalanced Piotroski F-score strategy and restricted to the initial and terminal year for the passive 'buy and hold' WIG benchmark.
8. Subsequent adjustment of the net returns to account for the 19% capital gains tax and the loss-deduction mechanism – levied annually on the F-score portfolio and at the culmination of the investment horizon for the WIG index.

9. Verification of the statistical significance of the resulting risk premiums utilising the Wilcoxon signed-rank test.
10. Final compilation, synthesis, and economic interpretation of the empirical findings.

RESULTS AND DISCUSSION

Table 3 compares the rates of return from the Piotroski F-score strategy and investments in the broad WIG index on a buy-and-hold basis in 2006-2025, after accounting for brokerage commissions and capital gains tax.

Table 3. Comparison of rates of return from the Piotroski F-score strategy and investments in the broad WIG index on the Warsaw Stock Exchange in 2007-2025

Year	Piotroski F-score	WIG Index	Difference
2007	190.99%	59.76%	131.23 p.p.
2008	-28.23%	-26.65%	-1.58 p.p.
2009	-36.89%	-37.11%	0.22 p.p.
2010	0.19%	41.63%	-41.44 p.p.
2011	11.15%	20.46%	-9.31 p.p.
2012	-20.59%	-24.45%	3.86 p.p.
2013	6.94%	26.49%	-19.55 p.p.
2014	20.76%	8.91%	11.85 p.p.
2015	102.13%	6.65%	95.48 p.p.
2016	3.30%	-17.45%	20.75 p.p.
2017	35.54%	31.08%	4.46 p.p.
2018	-11.69%	-4.68%	-7.01 p.p.
2019	0.76%	1.09%	-0.33 p.p.
2020	89.93%	-16.89%	106.82 p.p.
2021	85.99%	37.73%	48.26 p.p.
2022	-14.01%	-13.36%	-0.65 p.p.
2023	19.14%	8.45%	10.69 p.p.
2024	16.15%	38.58%	-22.43 p.p.
2025	-7.35%	3.61%	-10.96 p.p.
Arithmetic mean	24.43%	7.57%	16.86 p.p.
CAGR	15.22%	4.36%	10.87 p.p.

Source: own study.

The average annual rate of return including reinvestment of profits (CAGR) for the Piotroski F-score strategy reached 15.22%, while the broad WIG index returned only 4.36%. Therefore, the Piotroski strategy's result exceeded the broad-market average by 10.87 p.p. The rates of return from the Piotroski F-score-based strategy exceeded those from the 'buy and hold' strategy in 10 out of 19 periods (52.63%), while in nine periods (47.37%) the WIG index returned more.

Despite this notable outperformance in cumulative and average returns, the Wilcoxon signed-rank test did not reveal a statistically significant advantage of the F-score strategy over the broad market index at the conventional $\alpha = 0.05$ level. The result indicates a lack of systematic, year-on-year predictability. However, one must distinguish between statistical regularity and economic utility. As subsequent risk and distribution analyses will demonstrate, the strategy's impressive aggregate performance stems from a highly right-skewed, option-like payoff profile rather than consistent annual out-performance (Bessembinder, 2018).

Table 4 presents measures of the volatility of returns for the compared strategies.

The Piotroski F-score strategy yielded an arithmetic mean return (24.43%) more than three times that of the WIG index (7.57%). The strategy exhibited a comparable maximum drawdown risk (-36.89% against -37.11%) yet demonstrated substantial upside potential (+190.99% against +59.76%). Consequently, the strategy incurred more than twice the annual volatility (standard deviation of 54.54%

against 26.05%). Nonetheless, the markedly lower coefficient of variation (223.24% compared to 344.07% for the broad market) signifies a superior risk-reward profile. In essence, while the fundamental strategy entails higher absolute volatility, it generates disproportionately higher returns per unit of risk, making it suitable for investors resilient to market fluctuations.

Table 4. Measures of return volatility for the Piotroski F-score strategy and investment in the broad WIG index on the Warsaw Stock Exchange in 2006-2025

Volatility measure	Piotroski F-score	WIG index
Arithmetic mean	24.43%	7.57%
Min	-36.89%	-37.11%
Max	190.99%	59.76%
Range	227.88%	96.87%
Standard deviation	54.54%	26.05%
Average deviation	40.25%	21.57%
Coefficient of variation	223.24%	344.07%
Sharpe ratio	0.37	0.12
■ – more favourable value ■ – less favourable value		

Source: own study.

To fully verify the effectiveness of the strategy under review, the study extended the volatility analysis with a Sharpe-ratio assessment of risk-adjusted returns. The study defined the risk-free rate as the historical average yield on ten-year government bonds for the analysed period 2007-2025, amounting to 4.36% (Stooq, n.d.). According to the calculations, the Sharpe ratio reached 0.37 for the F-score portfolio, against only 0.12 for the broad WIG benchmark. The result proves that despite more than twice the total volatility (standard deviation of 54.54% compared to 26.05% for the broad market), Piotroski's fundamental strategy generates almost four times the excess return per unit of risk. The finding strongly supports the economic usefulness of the model on the Polish market, confirming that the generated risk premium more than compensates for the portfolio's high variance.

Figure 1 presents a comparison of cumulative rates of return from the Piotroski F-score strategy and investments in the broad WIG index.

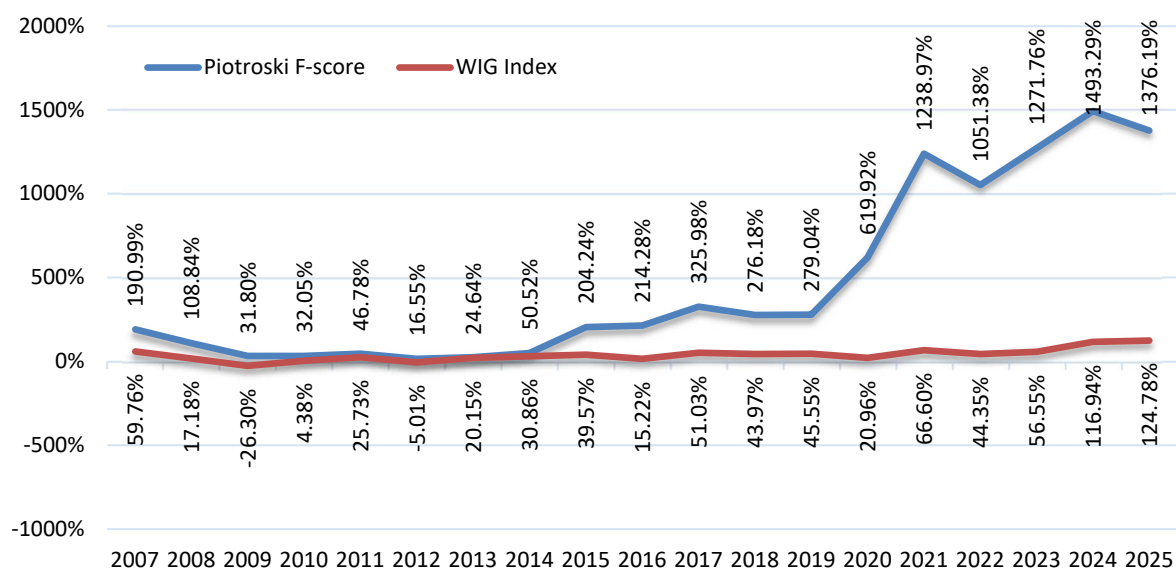


Figure 1. Comparison of cumulative rates of return from the Piotroski F-score strategy and investments in the broad WIG index on the Warsaw Stock Exchange in 2006-2025

Source: own elaboration.

The results indicate a clear advantage of the Piotroski strategy in cumulative return. The Piotroski strategy generated a cumulative rate of return of 1 376.19% compared to 124.78% for the strategy

of investing in the WIG index. Thus, the Piotroski strategy multiplied capital almost 15 times more effectively than passive market replication. The trajectories diverged decisively in 2020, when the rate of return generated by the Piotroski F-score strategy turned strongly positive. In this period, the market rebounded from declines driven by investors' reaction to the COVID-19 pandemic, but the broader market's rebound came later and proved weaker.

Figure 2 presents the distribution of rates of return for companies selected using the F-score indicator.

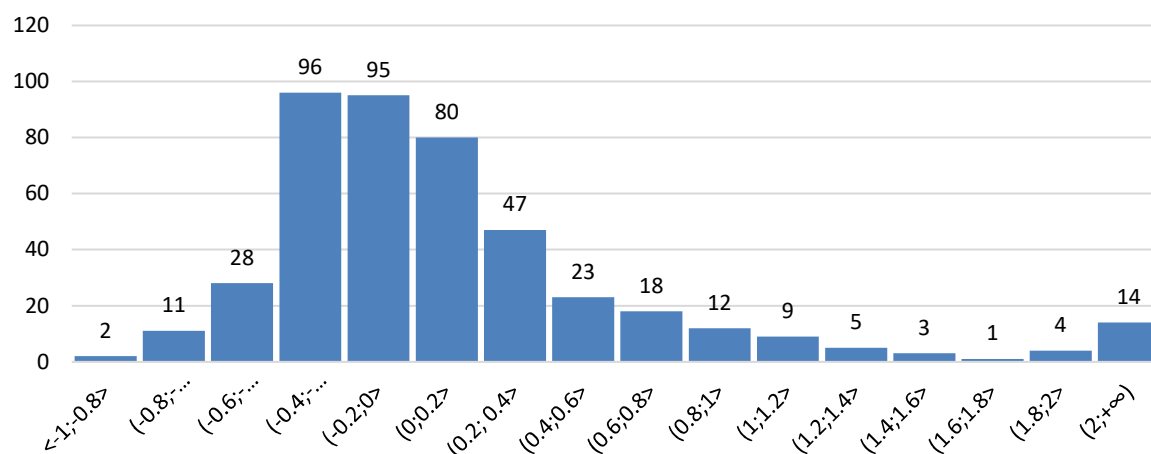


Figure 2. Histogram of the frequency of annual rates of return for companies selected using the F-score indicator on the Warsaw Stock Exchange in 2007-2025

Source: own elaboration.

The histogram of annual rates of return for individual companies reveals a clearly right-skewed, leptokurtic distribution with a strong concentration in the range of -40% to +40% (a maximum of 96 observations in the class from -40% to -20%). Most rates of return (approximately 71%) fall between -40% and +40%, reflecting the typical volatility of WSE shares. The significant asymmetry results from the long right tail: 89 rates of return exceeded 40%, and in 14 cases surpassed +200% (including an extreme of +3 003.45%). The distribution indicates high risk and the potential for extraordinary gains, typical of selective stock picking – most results hover around zero, but the few 'winners' significantly outweigh the losses.

Figure 3 presents the distribution of industries represented by companies selected using the F-score indicator.

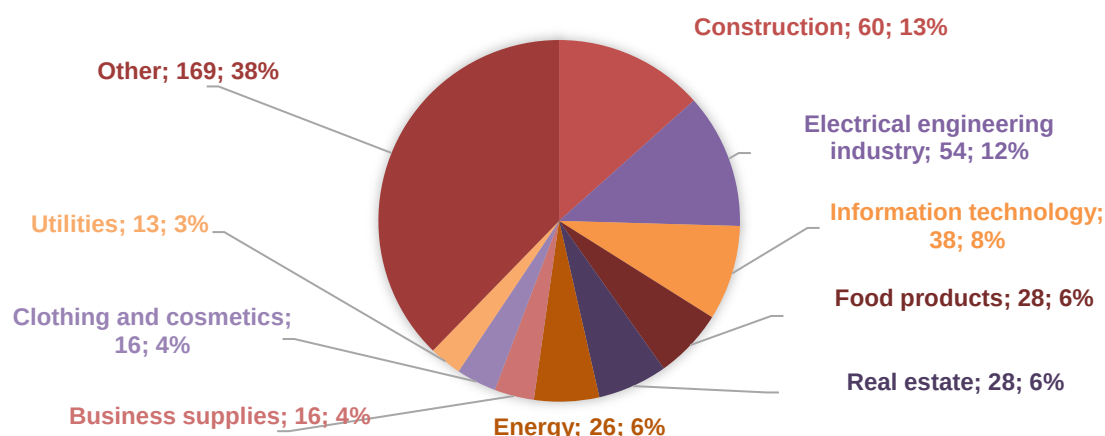


Figure 3. Distribution of industries represented by companies selected using the F-score indicator on the Warsaw Stock Exchange in 2007-2025

Source: own elaboration.

Among the companies selected using the F-score indicator, the most numerous came from construction (60 cases, 13%), electrical engineering industry (54 cases, 12%) and information technology (38 cases, 8%).

Table 5 presents the highest and lowest average rates of return generated by individual companies by industry. The left side shows extreme values for all industries, while the right side shows extreme values for industries with above-average company counts (minimum 13 occurrences).

Table 5. Highest and lowest average rates of return generated by companies selected using the F-score indicator by industry on the Warsaw Stock Exchange in 2007-2025

Industry name	Number of occurrences	Average rate of return	Industry name	Number of occurrences	Average rate of return
New technologies	4	778.57	Energy	26	65.57
Business services	6	228.38	Business supplies	16	34.04
Games	12	70.77	IT	38	26.50
Energy	26	65.57	Electrical machinery industry	54	17.85
Receivables	4	-13.52	Clothing and cosmetics	16	11.07
Financial intermediation	5	-16.79	Food products	28	9.64
Mining	7	-21.81	Real estate	28	7.04
Medical equipment and supplies	5	-28.48	Utilities	13	3.71

Source: own study.

Of all the industries analysed, the new technologies industry recorded the highest average return (778.57%) and the medical equipment and materials industry the lowest (-28.48%). Among the industries occurring more frequently than average (minimum 13 occurrences), the highest rate of return was recorded for the energy industry (65.57%) and the lowest for the media industry (3.71%). Interestingly, among these more frequent industries, even the lowest average returns proved positive.

Figure 4 shows the number of companies selected using the F-score indicator in individual years.

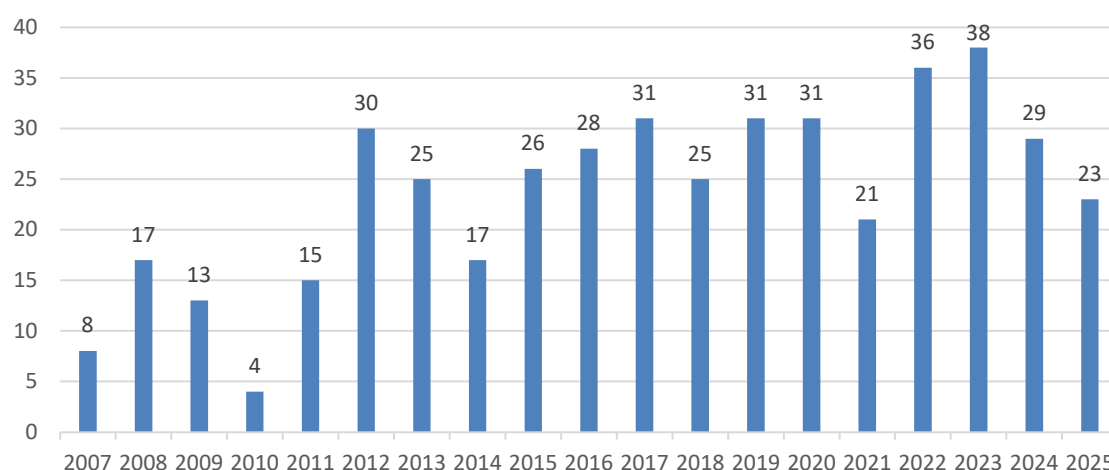


Figure 4. Number of companies selected using the F-score indicator in the portfolio on the Warsaw Stock Exchange in 2007-2025

Source: own elaboration.

The number of companies in the portfolio over the review period ranged from four (May 2009-May 2010) to a maximum of 38 entities in May 2022-May 2023. On average, the portfolio held 23.58 companies per year.

Figure 5 presents the number of individual companies selected using the F-score indicator.

Among all companies selected using the F-score indicator, the most frequently represented were: KPPD (seven times) and Ulma, Mobruk, Sunex and Stalexp (five times each).

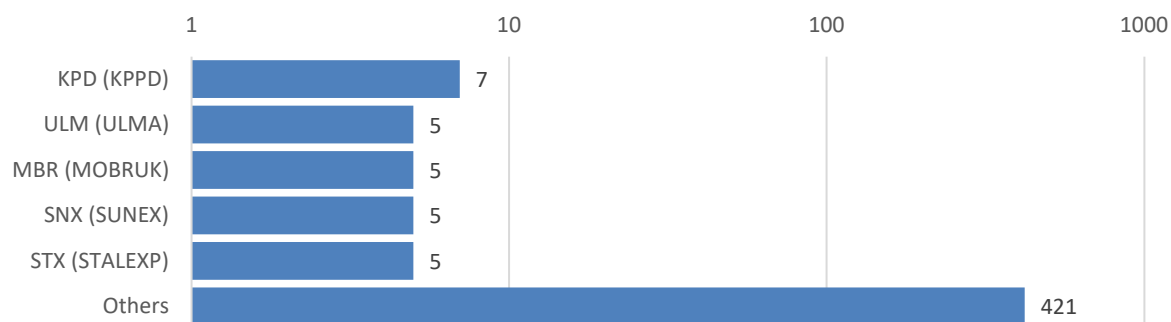


Figure 5. Number of individual companies selected using the F-score indicator on the Warsaw Stock Exchange in 2007-2025

Source: own elaboration.

Table 6 presents the highest and lowest average rates of return generated by individual companies. The left part shows extreme values for all companies, while the right part shows extreme values for companies appearing more often than average (minimum two occurrences).

Table 6. Highest and lowest average rates of return generated by companies selected using the F-score indicator on the Warsaw Stock Exchange in 2007-2025

Company name	Number of occurrences	Average rate of return	Company name	Number of occurrences	Average rate of return
CLD (CLOUD)	1	3 003.45%	CLC (COLUMBUS)	2	777.16%
NXG (NEXITY)	1	1 311.11%	AAT (ALTA)	2	208.72%
CLC (COLUMBUS)	2	777.16%	PAS (PASSUS)	2	196.52%
AGT (AGROTON)	1	429.84%	ULM (ULMA)	5	122.47%
LES (LESS)	1	-67.32%	AST (ASTARTA)	2	-38.81%
IMP (IMPERIO)	1	-68.86%	KDM (KDMSHIPNG)	2	-43.62%
SGR (SADOVAYA)	1	-71.67%	EQU (EQUNICO)	2	-51.94%
SFG (SILVANO)	1	-81.90%	08N (08OCTAVA)	2	-65.47%

Source: own study.

Among all the companies analysed, Cloud recorded the highest average return (3 003.45%) and Silvano the lowest (-81.90%). Among the companies appearing more often than average (minimum two occurrences), Columbus recorded the highest return (777.16%) and 08Octava the lowest (-65.47%).

These findings situate the WSE within the paradigm of emerging markets, where fundamental quality continues to command a substantial premium. The 15.22% CAGR aligns with evidence from other markets with lower informational efficiency, such as Vietnam (Ho *et al.*, 2023) and India (Shah *et al.*, 2025). The pattern contrasts sharply with highly developed equity markets (*e.g.*, the USA or the UK), where the original anomaly has largely eroded (Rathjens & Schellhove, 2011; Woodley *et al.*, 2011). Furthermore, the elevated volatility of the Polish portfolio and its sharp post-crisis rebound in 2020 corroborate Anderson *et al.*'s (2025) observations on the macroeconomic sensitivity and cyclicity of the F-score model.

Relative to prior domestic studies, this article considerably expands the analytical perspective. While Kusowska (2021) highlights the defensive properties of the F-score among WIG30 constituents during the pandemic-induced downturn, the present long-horizon analysis across a broader corporate spectrum reveals a distinctly offensive profile, enabling nearly 15-fold capital appreciation against a passive benchmark. The magnitude of this advantage – substantially exceeding the modest +1.35% market-adjusted return reported by Pilch (2023) – stems primarily from capturing the strategy's specific payout profile: a strongly right-skewed distribution where the extraordinary gains of a few accurately selected companies dictate the portfolio's ultimate success.

Ultimately, the disparity between the lack of unconditional statistical significance and the strategy's spectacular economic success underscores a pivotal attribute of fundamental investing on the WSE. The superior Sharpe ratio confirms that Piotroski's strategy adequately compensates investors for assuming

increased portfolio variance. Thus, in contrast to highly efficient global exchanges where augmenting algorithms are increasingly required (Gimeno *et al.*, 2020; Lin *et al.*, 2021), Piotroski's foundational selection criteria remain a self-sufficient and highly effective capital allocation framework in Poland.

CONCLUSIONS

The empirical investigation yields the following principal conclusions:

- **C₁**: The F-score strategy generated a CAGR of 15.22%, significantly outperforming the broad WIG index, which yielded merely 4.36% over the analysed period.
- **C₂**: The rates of return from the Piotroski F-score strategy outperformed the passive 'buy and hold' approach on the broad WIG index in 10 out of 19 evaluated periods (52.63%).
- **C₃**: Although the F-score strategy carries higher absolute volatility than the broad market benchmark, it delivers superior rates of return per unit of assumed risk.
- **C₄**: Over the analysed period, the rolling average rates of return showed strong positive skewness, yielding positive outcomes in 72.22% of two-year investment horizons (13 out of 18), 87.50% of five-year horizons (14 out of 16), and 100% of ten-year horizons (11 out of 11).
- **C₅**: The fundamental portfolio consisted of an average of 23.58 companies annually, with the number of selected constituents ranging from four to 38 entities.
- **C₆**: Among the companies selected using the F-score indicator, construction firms were the most prevalent, accounting for 13% of all cases (60 occurrences).
- **C₇**: Across all analysed industries, the new technologies sector recorded the highest average return (778.57%), and medical equipment and materials the lowest (-28.48%). However, when considering only industries that appeared more frequently than average, the energy sector generated the highest return (65.57%) and media the lowest (3.71%).
- **C₈**: Among all analysed companies, Cloud generated the highest average return (3 003.45%), and Silvano the lowest (-81.90%). Conversely, within the group of companies appearing in the portfolio more often than average, Columbus achieved the highest return (777.16%), and 08Octava the lowest (-65.47%).

Although formal statistical verification requires caution in generalising the results, the analysis confirms the investment utility of the strategy. The efficacy of Piotroski's model in generating excess returns lies not in linear profit generation but in effectively selecting undervalued companies with substantial growth potential. Because the Wilcoxon test showed no statistical significance, the hypothesis of the strategy's unconditional capacity to effectively predict prices year-on-year has not been fully confirmed. However, one must distinguish between statistical regularity and economic viability. As evidenced by the risk-return ratio (Sharpe ratio of 0.37) and the impressive cumulative return, this strategy serves as a highly effective practical capital-allocation tool, capturing asymmetric fundamental risk premiums. From an international perspective, these findings substantiate the rationale for global investors allocating capital in Central and Eastern Europe. While classic fundamental filters are gradually eroding in highly developed Western markets, the CEE region – as exemplified by Poland – still offers highly asymmetric fundamental risk premiums. Notably, this study provides the first long-horizon analysis in the CEE region confirming the strategy's viability under real-world trading constraints, fully incorporating rigorous transaction costs and capital gains taxes.

The main limitations of the study include the lack of unconditional statistical significance at the $\alpha = 0.05$ level and the risk of survivorship bias within the sample (Baquero *et al.*, 2009). The bias arises because historical data obtained from external aggregating services (Biznesradar, n.d.) may not encompass the full history of all entities withdrawn from stock exchange trading (e.g. as a result of bankruptcy) over such a prolonged, twenty-year horizon. In classic market tests, survivorship bias typically inflates historical portfolio returns artificially. However, the stringent design of the Piotroski ratio significantly mitigates this impact. The requirement to obtain 7-9 points acts as a restrictive filter, which by definition rejects entities with deteriorating fundamentals, typical of companies approaching delisting. Nevertheless, one cannot claim that this phenomenon has been completely eliminated. Sudden bankruptcies, often masked

by creative accounting, also occur in entities with previously high F-score results. For this reason, although the distortion of results is much smaller here than in strategies based solely on market valuation multiples (e.g. P/E or P/BV ratios), survivorship bias remains a limitation of this study.

Given the findings, the study proposes the following directions for future research:

- Testing the effectiveness of the Piotroski F-score strategy in a variant assuming both long and short positions, including extended company selection criteria (e.g. 7-9 points and 0-2 points instead of the classic 8-9 points and 0-1 points).
- Analysing the application of Piotroski's strategy in combination with other factors, such as price momentum, to determine whether such hybrid strategies can provide more stable and higher risk-adjusted returns.

REFERENCES

- Alior Bank. (n.d.). Taryfa opłat i prowizji Biura Maklerskiego Alior Bank [Tariff of fees and commissions of Alior Bank Brokerage House]. Retrieved from <https://www.aliorbank.pl/dam/jcr:726116b4-5e1a-4ef3-ae55-b00d1843c5cb/taryfa-oplat-i-prowizji-biura-maklerskiego-alior-bank.pdf> on January 31, 2026.
- Anderson, K., Chowdhury, A., & Uddin, M. (2025). Piotroski's Fscore under varying economic conditions. *Review of Quantitative Finance and Accounting*, 64, 1261-1307. <https://doi.org/10.1007/s11156-024-01331-y>
- Baquero, G., ter Horst, J., & Verbeek, M. (2009). *Survival, look-ahead bias and the persistence in hedge fund performance*. SSRN. <https://doi.org/10.1017/S0022109000001848>
- Barber, B. M., & Lyon, J. D. (1997). Detecting long-run abnormal stock returns: The empirical power and specification of test statistics. *Journal of Financial Economics*, 43(3), 341-372. [https://doi.org/10.1016/S0304-405X\(96\)00890-2](https://doi.org/10.1016/S0304-405X(96)00890-2)
- Baschieri, G., & Hunziker, M.D. (2025). *Evaluating the efficacy of the value factor in stock market analysis: A comparative analysis of market-to-book ratio and Piotroski F-Score*. SSRN. <https://doi.org/10.2139/ssrn.4840863>
- Bernard, V. L., & Thomas, J. K. (1989). Post-earnings-announcement drift: Delayed price response or risk premium?. *Journal of Accounting Research*, 27, 1-36. <https://doi.org/10.2307/2491062>
- Bessembinder, H. (2018). Do stocks outperform treasury bills?. *Journal of Financial Economics*, 129(3), 440-457. <https://doi.org/10.1016/j.jfineco.2018.06.004>
- Biznesradar. (n.d.). Retrieved from <http://www.biznesradar.pl> [in Polish] on December 6, 2025.
- Brindelid, L., & Nilsson, T. (2021). *Portfolio performance in Nordic countries: A quantitative comparison study of investment strategies in Denmark, Finland, Norway and Sweden* (Master's thesis, Umeå University).
- Bülow, S. (2017). *The effectiveness of fundamental analysis on value stocks – an analysis of Piotroski's F-score* (Bachelor thesis, Lund University). <https://lup.lub.lu.se/student-papers/search/publication/8912857>
- Daniel, G., Sornette, D., & Wöhrmann, P. (2008). Look-ahead benchmark bias in portfolio performance evaluation. *arXiv preprint arXiv:0810.1922*. <https://doi.org/10.48550/arXiv.0810.1922>
- De Bondt, W. F. M., & Thaler, R. (1985). Does the stock market overreact? *The Journal of Finance*, 40(3), 793-805. <https://doi.org/10.1111/j.1540-6261.1985.tb05004.x>
- Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417. <https://doi.org/10.1111/j.1540-6261.1970.tb00518.x>
- Frankel, R., & Lee, C. M. C. (1998). Accounting valuation, market expectation, and cross-sectional stock returns. *Journal of Accounting and Economics*, 25(3), 283-319. [https://doi.org/10.1016/S0165-4101\(98\)00026-3](https://doi.org/10.1016/S0165-4101(98)00026-3)
- Gimeno, R., Lobán, L., & Vicente, L. (2020). A neural approach to the value investing tool F-Score. *Finance Research Letters*, 37, 101367. <https://doi.org/10.1016/j.frl.2019.101367>
- Ho, T., Nguyen, Y. T., Tran, H. T. M., & Vo, D.-T. (2023). Fundamental analysis and the use of financial statement information to separate winners and losers in frontier markets: Evidence from Vietnam. *International Journal of Emerging Markets*, 18(10), 4130-4153. <https://doi.org/10.1108/IJOEM-03-2020-0279>
- Hsu, H., & Lachenbruch, P. A. (2014). Paired t test. In Wiley StatsRef: *Statistics Reference Online*. <https://doi.org/10.1002/9781118445112.stat05929>
- Hyde, C.E. (2014). An emerging markets analysis of the Piotroski F-score. *JASSA*, (2), 23-28. <https://doi.org/10.2139/ssrn.2274516>

- Hyde, C.E. (2015). *The Piotroski F Score in the Australian market: Performance & fundamental drivers*. SSRN. <https://doi.org/10.2139/ssrn.2577181>
- Koutoupis, A. G., Kampouris, C. G., & Sakellariadou, A. V. (2022). Can financial strength indicators form a profitable investment strategy? The case of F-Score in Europe. *Accounting and Management Information Systems*, 21(3), 355-372. <https://doi.org/10.24818/jamis.2022.03003>
- Krauss, C., Krüger, T., & Beerstecher, D. (2015). *The Piotroski F-Score: A fundamental value strategy revisited from an investor's perspective* (IWQW Discussion Papers, No. 13/2015).
- Kusowska, M. (2021). Assessment of efficiency of Piotroski F-score strategy in the Warsaw Stock Exchange. *Przedsiębiorstwo we Współczesnej Gospodarcie – Teoria i Praktyka*, 1(32), 47-59. <https://doi.org/10.19253/rem.2021.01.004>
- Lin, C.-H., Changchien, C.-C., Kao, T.-C., & Hsiao, M.-C. (2021). Revise the value investing strategy of F-score. *YMC Management Review*, 14(1), 45-61. <https://doi.org/10.53106/207308882021101401003>
- Pätäri, E. J., Leivo, T. H., & Ahmed, S. (2022). Can the FSCORE add value to anomaly-based portfolios? A reality check in the German stock market. *Financial Markets and Portfolio Management*, 36(3), 321-367. <https://doi.org/10.1007/s11408-021-00400-9>
- Penman, S., & Reggiani, F. (2018). Fundamentals of value versus growth investing and an explanation for the value trap. *Financial Analysts Journal*, 74(4), 103-119. <https://doi.org/10.2469/faj.v74.n4.6>
- Pilch, B. (2023). Building of F-Score-like models on the example of the Polish stock market. *Annales Universitatis Mariae Curie-Skłodowska, sectio H – Oeconomia*, 57(1), 155-180. <https://doi.org/10.17951/h.2023.57.1.155-180>
- Piotroski, J. D. (2000). Value investing: The use of historical financial statement information to separate winners from losers. *Journal of Accounting Research*, 38, 1-41. <https://doi.org/10.2307/2672906>
- Rathjens, H., & Schellhove, H. (2011). *Simple financial analysis and abnormal stock returns – analysis of Piotroski's investment strategy* (Master thesis, Stockholm School of Economics).
- Shah, A., Jain, K., Anand, P., & Bhadane, C. (2025). Evaluating the effectiveness of the Piotroski F-score in the Indian equity market: Evidence from Nifty 100 (2007-2024). *Communications on Applied Nonlinear Analysis*, 32(9S), 3228-3241. <https://doi.org/10.52783/cana.v32.6028>
- Sloan, R. G. (1996). Do stock prices fully reflect information in accruals and cash flows about future earnings? *The Accounting Review*, 71(3), 289-315. <https://www.jstor.org/stable/248290>
- Stooq. (n.d.). Retrieved from <http://www.stooq.pl> on December 6, 2025.
- Tripathy, T., & Pani, B. (2017). Effect of F-score on stock performance: Evidence from Indian equity market. *International Journal of Economics and Finance*, 9(2), 89-99. <https://doi.org/10.5539/ijef.v9n2p89>
- Ustawa z dnia 26 lipca 1991 r. o podatku dochodowym od osób fizycznych [Act of 26 July 1991 on personal income tax] (Journal of Laws 2025, item 163, as amended).
- Walkshäusl, C. (2020). Piotroski's FSCORE: International evidence. *Journal of Asset Management*, 21, 106-118. <https://doi.org/10.1057/s41260-020-00157-2>
- Woodley, M. K., Jones, S. T., & Reburn, J. P. (2011). Value stocks and accounting screens: Has a good rule gone bad? *Journal of Accounting and Finance*, 11(4), 87-104. <http://www.na-business-press.com/JAF/JonesWeb11-4.pdf>

Author**Krzysztof Podgórski**

Assistant Professor at the Department of Banking and Financial Markets, University of Economics in Katowice, Poland. Podgórski holds a PhD in Economics and Finance and an engineering degree in Logistics. His research interests include technical and fundamental analysis, investment from the individual investor's perspective, and the cyclical nature of financial markets.

Correspondence to: Krzysztof Podgórski, Department of Banking and Financial Markets, University of Economics in Katowice, 1 Maja 50, 40-287 Katowice, Poland, E-mail: krzysztof.podgorski@uekat.pl

ORCID  <https://orcid.org/0000-0002-7549-1997>

Acknowledgements and Financial Disclosure

The project was co-financed by the Ministry of Science under the Regional Excellence Initiative programme.

Use of Artificial Intelligence

The author declares the use of Artificial Intelligence (AI) and Generative AI (GAI) tools during the preparation of this manuscript. Specifically, the author used DeepL and Gemini Pro. The author limited their use strictly to proofreading and checking the English text for grammatical correctness. No AI tools generated original data, conducted statistical analysis, or formulated the scientific conclusions presented in this article.

Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright and License

This article is published under the terms of the Creative Commons Attribution (CC BY 4.0) License <http://creativecommons.org/licenses/by/4.0/>

Published by Krakow University of Economics – Krakow, Poland

