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ORIGINAL RESEARCH

Piotroski's Fscore under varying economic conditions

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Abstract
Piotroski's Fscore has become increasingly important to investment managers and analysts as a simple measure of a company's financial strength. However, how it changes over time, and in particular how it reacts under different economic conditions, has not been considered until now. Macroeconomic conditions and the business cycle affect corporate valuations via stock prices. They also affect corporate liquidity, cash flow, profitability, efficiency, financing, capital structure, and thus Fscores. The Fscore is currently used as if it gives similar results in all economic states, but this is not the case. While macroeconomic conditions strongly affect the aggregate Fscore, the effect of particular variables changes greatly depending on the stage of the economic cycle. During contractionary episodes, monetary and macro-economic factors become much more critical and outweigh firm-level factors in determining Fscore values. Investors should, therefore, be particularly cautious in applying the Fscore equally during contractions as during expansionary periods.

Keywords Fscore · Macroeconomic conditions · Business cycle · Contractionary episodes

JEL Classification G11 · G12

1 Introduction

Maximizing risk-adjusted returns is at the centre of attention for most portfolio investors. A number of studies have shown that, on average, value stocks outperform growth stocks. For example, Rosenberg et al. (1985) and Fama and French (1992) provide evidence by using US stock market data that value stocks give better returns than growth stocks. Similarly, using international stock market data, Fama and French (2012) and Asness et al. (2013)

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show that value stocks outperform growth stocks. However, identifying value stocks that will be profitable is not straightforward. Piotroski (2000) found that a large proportion of value stocks continue to underperform. To overcome this, Piotroski proposed a simple model to identify appropriate value stocks to set up a profitable value stock portfolio. Piotroski argued that the valuation of value stocks should be based on recent changes in firm fundamentals using firms' historical financial statements. The suggestion of using historical financial statement data came from the fact that high book to market firms usually suffers from less analyst coverage and therefore could suffer from nonavailability of forecast data. Piotroski's (2000) Fscore has become well known as an easily understood way of summarising a firm's financial stability. Its sum of nine 0/1 flags describe a firm's operating efficiency, capital structure changes and profitability, and in particular whether those attributes are improving or declining. Among the top 20% of firms by book value to price (i.e. value firms, to which Piotroski said his new measure should be particularly applicable), annual returns of high minus low Fscore stocks differed by almost 30% in US stock markets 1976–1996. Piotroski's results have been replicated in European stock markets (Tikkanen and Äijö 2018; Walkshaüsl 2020; Koutoupis et al. 2022), Brazil (Souza Domingues et al. 2022), the Asia–Pacific region (Ng and Shen 2016, 2020) and Australia (Hyde 2018), although the effect is not usually found to be as strong as in the US. Piotroski's and later robustness checks have shown its power comes largely from investing in small, financially distressed firms that receive little or no analyst coverage.

The possibility of aggregate Fscore varying with the changes in the economy should not be a surprise: one could measure the health of the economy by considering the aggregate financial health (Fscore) of the firms that make up the economy. However, what has not been considered until now is how in detail the Fscore reacts as economic conditions vary. This is surprising as a sizable literature supports the notion that smaller and financially poor quality firms are affected most by changing macroeconomic conditions (Fama and French 1995; Armstrong et al. 2019). Flannery and Protopapadakis (2002) pointed out that macroeconomic variables simultaneously affect cash flows and risk adjusted discount rate. They also stated that economic conditions influence the number and types of investment opportunities available. These in turn have profound impacts on firms' profitability. As a consequence, the Fscore which is mostly based on accounting fundamentals such as cash flow, profitability, leverage, and operating efficiency should also be affected by changes in macroeconomic conditions. In this paper we have examined the effect of macroeconomic variables on Piotroski's Fscore.

Our research question is therefore: Is the Fscore affected similarly by monetary and economic factors throughout the economic cycle? Finding out how monetary and macroeconomic variables affect the Fscore as the economy expands and contracts will be of great value to individual investors and portfolio managers who use the Fscore in their stock screens. It will also inform the academic debate on whether markets are really inefficient, or whether the superior returns on high Fscore stocks are payoff for some definition of risk. Using financial and macroeconomic data from the US over a 44-year window starting from 1973 and ending in 2016 that represents 137,548 firm-level yearly observations of all 14,887 publicly listed companies in the US, we have found that monetary and macroeconomic variables affect the Fscore very differently depending on the stage of the economic cycle. In the aggregate time period a company/year with 25th and 75th percentile values chosen to maximise the difference results in an Fscore of 4.35 versus 6.16 depending on the macroeconomic and firm-level control values chosen. During the overall period and during expansions two-thirds of the difference is explained by firm-level control variables. One-third is due to macroeconomic factors and (mostly) monetary policy. However, the situation is very different during contractionary cycles, when the economic factors become much more important. Monetary and macro-economic variables actually influence the Fscore more than the firm-specific factors. In particular macro-economic variables are five times as important in determining the Fscore during contractions compared to expansions.

The paper contributes in several ways. First, our paper contributes to a growing literature that relates the macroeconomic conditions with various firm level issues such as macroeconomic conditions and corporate default (Xing et al. 2022), macroeconomic condition and R&D investments (Alexeeva-Alexeev et al. 2024), macroeconomic condition and firm level investment (Sahoo and Bishnoi 2023), macroeconomic condition and corporate risk taking (Gupta and Krishnamurti 2018), corporate tax policy and macroeconomy (Shevlin et al. 2019), macroeconomic fluctuations and corporate financial fragility (Bruneau et al. 2012) and macroeconomic condition and systemic risk (Kurter 2024). Although this literature is growing over the time, looking at the role of macroeconomic condition to assess the financial strength of companies is rare. In our paper we have filled this gap by looking at the effect of selected macroeconomic variables on the variations of outcome of Fscore which is a widely used accounting based corporate performance measure.

Second, Fscore was introduced by Piotroski (2000) to identify good companies among a set of high book to market firms that are treated at value stocks. By construction, this outcome is conditional on a selected set of accounting indicators. However, we argue that whether high book to market firms are good or bad investments is not solely dependent on accounting information. Rather the choice is conditional on the state of economy as accounting fundamentals are heavily influenced by macroeconomic conditions. Since the global financial crisis in 2007–2008, there has been a general consensus that models that assess the financial strength of firms using firm level fundamentals are not capable of capturing the true strength of firms (Tinoco et al. 2018). The authors highlighted the need for models that are adjusted to more dynamic macroeconomic conditions. The findings from our paper strongly support our conjecture and help to inform us that the appropriate choice of value stocks is not only an outcome of accounting performance but also of the overall macroeconomic conditions and their fluctuations over the time.

Third, our results provide important warnings to help investors use the Fscore in a more efficient way. The results suggest that investors should be more cautious about macroeconomic factors during the contractionary phase as the Fscore becomes more sensitive to economic conditions when the economy goes through a contractionary phase. More specifically, investors who use the Fscore in their stock screens should in particular take much more cognizance of monetary and macro-economic factors during contractions. Our results are robust for alternative test specifications such as the lag impact of the previous state of monetary policy and a range of macroeconomic control variables.

Our paper proceeds as follows. Section 2 looks at Piotroski's model, the prior research into it and into how economic conditions affect fundamental analysis. Section 3 gives details of our data and empirical models. Section 4 provides our results and analysis, Sect. 5 gives details of additional robustness checks, then Sect. 6 concludes.

2 Related literature

2.1 Fscore and its antecedents

Pope (2010) noted that there exists a gap between the academic disciplines of accounting and finance. One consequence of that gap is that many of the most popular finance valuation models make little use of the huge array of accounting numbers available (400 on Compustat). For example, the Fama and French three-factor model uses only book value. Piotroski's Fscore is an outstanding example of how we can use fundamental analysis of earnings and balance sheet quality to screen stocks. Piotroski's Fscore, while innovative, can be placed in a line of papers that show that it is possible to forecast a firm's fortunes based on accounting information. Altman (1968) and Ohlson (1980) both predicted the risk of bankruptcy using the available accounting measures, while Ou and Penman (1989) showed that accounting information can be used to predict returns.

More recent predecessors to Piotroski (2000) start with Lev and Thiagarajan (1993). Using 12 accounting fundamentals claimed by analysts to be useful in securities valuation, they were able to predict both earnings changes and returns, though some of their variables were only useful under specific economic conditions. Their "aggregate fundamental score" (p210) that used a sum of 12 0/1 flags bear a strong resemblance to Piotroski's later Fscore.

Close precursor papers to Piotroski's Fscore paper were those by Abarbanell and Bushee (1997, 1998). In their 1997 paper they used the nine successful fundamental signals from Lev and Thiagarajan (1993) to predict earnings changes, concluding that analysts' revisions of earnings forecasts did not impound all new information. Their 1998 paper used the same nine signals but to forecast stock returns rather than earnings changes, finding an average one-year abnormal return of 13.2%, with the abnormal returns concentrated around earnings announcements. Importantly, the abnormal returns were not closely related to Fama and French's HML and SMB factors.

Piotroski's (2000) paper has been influential, perhaps because his aggregate signal F_SCORE is easily understood even by those with no statistical background, and it also appears to show clear inefficiency in the market's pricing of high book-to-value stocks. This is especially marked for smaller firms with little or no analyst coverage. As Piotroski noted (p10), compared to Ou and Penman (1989) his paper represented a "step back" from complex models, because the Fscore does not require the estimation of probability models nor the fitting of data year-by-year, only the summation of nine binary signals for each company.

2.2 Changing economic conditions and fundamental analysis

Piotroski (2000) provided a simple accounting based fundamental analysis strategy that helps us to identify high yielding portfolios. The strategy suggests that taking long position in financially stronger firms with high book-to market (BM) ratio would generate above average return. Piotroski (2000) suggested that value stocks are better analysed by using historical financial information and therefore subsequently suggested using nine indicators that are taken from firms' financial statements. However, all these nine indicators are subject to strong influence from macroeconomic conditions. Fama and French (1995) mentioned that high BM firms are financially distressed. In a recent paper, Chang et al. (2019) have shown that financially distressed firms are more prone to changing macroeconomic conditions. Given the fact that Piotroski's (2000) Fscore is mainly about financially distressed firms with a high BM ratio, there is every possibility that those ratios would be affected heavily by the changing macroeconomic conditions. Armstrong et al. (2019) also pointed out that firms with lower accounting quality are more sensitive to changes in macroeconomic policies. Therefore, it is important that we examine the resilience of Fscore in response to changes in macroeconomic variables so that investors can adjust their predictions based on fundamental analysis for any possible changes in macroeconomic conditions.

Cenesizoglu (2011) has mentioned that the relationship between company fundamentals and macroeconomic conditions is of central importance to financial decision making. Understanding this relationship is of immense importance for portfolio allocation, risk management and asset pricing purposes. Merton (1973) also advocated the necessity of examining effects of macroeconomic variables core financial models such as ICAPM. In this regard, Cenesizoglu (2011) stated that variations of sensitivities of company fundamentals to changes in aggregate macroeconomic conditions can help explain variations in cross-section returns. Despite these strong opinions about the effect of macroeconomic variables on company fundamentals, there is a dearth of research in this area. Richardson et al. (2010) identified the papers that have used accounting information from financial statements to predict future profitability and stock return. However, the authors mentioned that among those papers very few had used macroeconomic information to strengthen the predictive power of those models. They suggested further research that would combine macroeconomic variables into accounting information-based predictive models.

Macroeconomic variables will affect accounting fundamentals through the balance sheet channel. Bernanke and Gertler (1995) have provided evidence on the mechanism of transmission of macroeconomic effects to accounting fundamentals. In a recent paper, Armstrong et al. (2019) pointed out that monetary policy adopted by central banks can affect interest rates. This will eventually affect net income or the net worth of borrowers, both of which will ultimately affect their ability to access external finance. Difficulties in accessing external finance will lead to an increase in the discount rate and subsequent investment opportunities. A number of papers have highlighted the effect of macroeconomic factors on various financial matters. For example, Oxelheim (2003) pointed out that the corporate environment is greatly affected by external macroeconomic conditions. These influences are not reflected fully by corporate reporting but have significant impacts on corporate profitability and competitiveness. Profitability, cash flow, capital structure and liquidity are subject to fluctuations due to macroeconomic conditions. For example, Flannery and Protopapadakis (2002) argued that macroeconomic conditions affect cash flow and discount rate. These in turn affect future investment opportunities. Chen and Mahajan (2010) pointed out that both current and future macroeconomic conditions influence corporate liquidity. Cook and Tang (2010) stated that corporate capital structure is greatly affected by macroeconomic conditions. They concluded that capital structure adjustment speed is dependent on good or bad macroeconomic conditions. The speed of adjustment becomes faster in good economic conditions. Issah and Antwi (2017) found evidence supporting the influence of macroeconomic factors on firm profitability using a sample from the UK. Moreover, there is a sizable literature that supports the notion that macroeconomic conditions affect stock returns (Flannery and Protopapadakis 2002). Ewing (2002) found that the Fed Funds rate, bond spread and consumer price index affect firms' financial performance. Similarly, Williams (2003) found that ROA is associated with GDP growth.

These findings confirm that macroeconomic conditions do affect profitability, liquidity, cash flow, financing and the capital structure of the firm. Therefore, it is to be expected that the Fscore which is calculated by using these variables should also be influenced by global and domestic macroeconomic conditions. While there has been no research into how the Fscore itself varies under different economic conditions, two of the papers referred to above do point the way. Lev and Thiagarajan (1993) found that some accounting variables were value-relevant (i.e. reliable indicators of high future returns) under certain economic conditions and not others. For example, accounts receivable and provision for doubtful receivables showed a high correlation with returns during times of high inflation. Turtle and Wang (2017) found that the best returns from using the Fscore came during exuberant periods when prices in the overall market had diverged significantly from fundamental values. There is, therefore, some basis in the relevant past literature for our more detailed investigation.

3 Empirical models and data

3.1 Data set and variables

In order to understand the resilience of the Fscore to macroeconomic policies, we use financial and macroeconomic data from the US over a 44-year window starting from 1973 and ending in 2016. Our dataset includes 137,548 firm-level yearly observations of all 14,887 publicly listed companies in the US. We have collected these financial and macroeconomic data from CRSP/Compustat and Refinitiv (Thomson Reuters) Datastream. Following earlier research, such as Chang et al. (2019), Chordia et al. (2005), Chowdhury et al. (2018), Gagnon and Gimet (2013), Gallo et al. (2016), Goyenko and Ukhov (2009), Gupta and Krishnamurti (2018), and Kurov and Stan (2018) we adopt corporate finance and macroeconomic theories to establish firm-level regressions for the influence of macroeconomic policies against a wide range of factors over each firm's entire time profile. Our range of variables is formally structured to incorporate the following perspectives.

3.2 Monetary policy variables

Table 1 presents a detailed description of the variables used in the monetary policies and the firm-and macro-level control variables. The first exogenous variable to represent monetary policy shock is the three-month interest rate (3MM). This is the standard tool in the literature to assess monetary policy (see e.g., Gagnon and Gimet 2013; Kim and Roubini 2000; Mackowiak 2007; Sims and Zha 1995). The second variable that we use to see the impact of monetary policy changes is the liquidity of the banking sector (LIQ), which is measured as the spread between the bank prime lending rate and the risk-free rate. As suggested in Gagnon and Gimet (2013), this is a different spread from the one used in the funding risk literature, which focuses on interbank market liquidity. However, as Gagnon and Gimet (2013) have suggested, the focus of our paper is not the interbank market, rather the ability of the banking sector to transfer liquidity from the interbank market to financial markets and the real economy, thus the performance of businesses (i.e., Fscores). Therefore, using this variable we seek to capture the liquidity character of the economy, particularly during the financial crises that the US economy has faced over our sample periods. Supporting the argument, Blanchard et al. (2010) also highlighted that the financial crisis of 2007–2008 was characterized by a diminished access to credit by firms and consumers.

Table 1 Summary of the firm-level and macroeconomic control variables and variables in the monetary policy model. *Sources*: CRSP/Compustat and Refinitiv (Thomson Reuters) Datastream

Name	Variable	Definition
Variables to represent monetary policy shocks		
3MM	Short-term rate	The three-month interest rate
BLIQ	Liquidity of the banking sector	Spread between the prime lending rate and the three-month risk-free rate
TS	Term spread	Spread between the annual yield of ten-year bonds and the annualised three-month risk-free rate
M2	Money supply	Liquid money supply in the economy expressed as a percentage of the total GDP. We use the growth rate of that percentage
EXRATE	Exchange rate	The US dollar index, which represents the value of the US dollar against a trade-weighted basket of currencies. We use the growth rate of that index
Firm-level control variables		
ROA	Return on assets	Income before extraordinary items (IB) scaled by lagged total assets (AT)
CFO	Cash flow from operations	Item OANCF after 1988; before that FOPT (funds from operations) minus WCAP (annual change in working capital). Scaled by lagged total assets (AT)
LEVER	Leverage	Debt-equity ratio
LIQUID	Liquidity	Current assets (ACT) divided by current liabilities (LCT)
MARGIN	Profit margin	Gross margin (SALE–COGS) divided by sales
AST	Asset turnover	Sales divided by total assets
SIZE	Size of the firm	Natural logarithm of CPI adjusted total sale
RISK	Business cycle risk	The rolling standard deviation of annual revenue
AGE	Age of the firm	The number of consecutive years the firm is listed in CRSP/Compustat
Macroeconomic control variables		
CRISIS	Financial crisis	The oil crisis of 1973–1974, the Capital market crash of 1987, the Dotcom crisis of 2000–2001, and the Financial Crisis of 2007–2009
UNEMP	Unemployment	The average yearly unemployment rate in the United States
IP	Industrial production	Industrial production index of US (2012 = 100). We use the growth in the index
MKTR	Market return	Yearly average of monthly average returns of the NYSE composite index
CPI	CPI	US inflation rate based on the growth of the consumer price index

Table 1 (continued)

Name	Variable	Definition
OIL	Oil price	The growth rate in the dollar price of a barrel of crude oil
Other variables (used in robustness tests)		
LPF	Low performing firms	A low-performing firm has an Fscore of zero to four. We use a dummy 1 if a firm achieves an F-score between zero and four in any particular year; otherwise, it is grouped as a high-performing firm in that year with a dummy 0
YOF	Young firms	A young firm is a firm aged less than our sample mean age. We apply the aggregate sample mean age to separate our firms between young versus mature and use a dummy 1 for young firms. To determine the firm's age, we use the years a firm remains listed on a US stock exchange according to the CRSP database
SML	Small firms	A small firm with a size less than the sample mean. We used a log of sales to estimate the mean size of our sample firms, and smaller firms take a dummy 1

Third, the term spread (TS) is the spread between a long-term government bond (i.e., ten years) and a short-term risk-free rate. An increase in the term spread predicts an increase in economic activity, whereas a decrease in the term spread typically precedes a recession (see e.g., Adrian and Estrella 2008). Fama and French (1989) report that the term spread is related to shorter-term business cycles. Since we investigate the short-term influence of monetary interventions on the Fscore, the term spread factor is included as a short-term financial indicator to predict economic and financial recovery that could affect firm-level financial operations and performance (see Gagnon and Gimet 2013, for further discussion on the motivation). Fourth, we use aggregate money supply (M2) as a percentage of GDP to proxy for liquidity in the financial market. An increase in money supply growth indicates sound market liquidity, greater access to capital and real economic activity. The impact of money supply on financial markets and firm-level performance has been highlighted in a lot of earlier literature, such as Bjornland and Leitemo (2009), Chowdhury et al. (2018), Chung and Ariff (2016), and Laopodis (2013). We expect a positive impact of money supply on businesses e.g. via their capital structure, short-term liquidity and business transactions. It is important to note that we have applied both spread and rate as components of monetary policy, as suggested in earlier studies such as Frank and Goyal (2009) and Karpavicius and Yu (2017).

Finally, given the importance of cross-border business engagement of the US economy and its flexible exchange rate regime, we capture the exchange rate channel of monetary policy by including the impact of exchange rate fluctuations using the nominal U.S. dollar index (EXRATE) (see Kurov and Stan 2018; Ireland 2008; Kearns and Manners 2006). The US is the world's largest cross-border trader, e.g. the US Chamber of Commerce reports that in 2018 the country exported \$1.4 trillion worth of goods and \$828 billion worth of services. Similarly, US firms are listed in many different markets and are heavily involved in borrowing from and investing in various markets and currencies. Thus, the exchange rate could significantly influence the aggregate firm-level cost, revenue, investment, leverage, and their transfer pricing strategy (see Bernard et al. 2006).

In this study, we use the year of Federal Open Market Committee (FOMC) announcement of the policy rate to separate the contractionary (CON) episodes from expansionary (EXP) periods, as suggested in earlier literature such as Albagli et al. (2019), Kudlyak and Sanchez (2017), Gallo et al. (2016), Bordo and Landon-Lane (2013), and Hausman and Wongswan (2006). In Fig. 1 we summarize the yearly effective Federal Reserve monetary policy rate for the period of 1973 through to the end of 2016. The figure therefore indicates the periods when the FOMC announced a tight funding policy as well as the periods when the Fed began slashing the rate to reduce unemployment. For example, as displayed in Fig. 1, during the late 1970s when the inflation rate was very high (exceeding 10% in 1979 and 1980) the Fed used tight monetary policy to raise the interest rate from 5.5% in 1977 to 16.4% in 1981 (see Greenlaw and Shapiro 2017). Similarly, the Federal Reserve introduced a loose monetary policy and reduced the policy rate from 6.2% in 2000 to just 1.7% in 2002, and then again to 1% in 2003 to increase liquidity and reduce unemployment.

3.3 Control variables

We follow prior literature (e.g. Chang et al. 2019; Bhargava 2014; Gupta and Krishnamurti 2018) and apply several firm-level indicators as control variables. Since our objective is to investigate the resilience of the Fscore solely to macroeconomic policies, we control for return on assets (ROA), total cash flow (CFO), liquidity (LIQUID) and profit margin

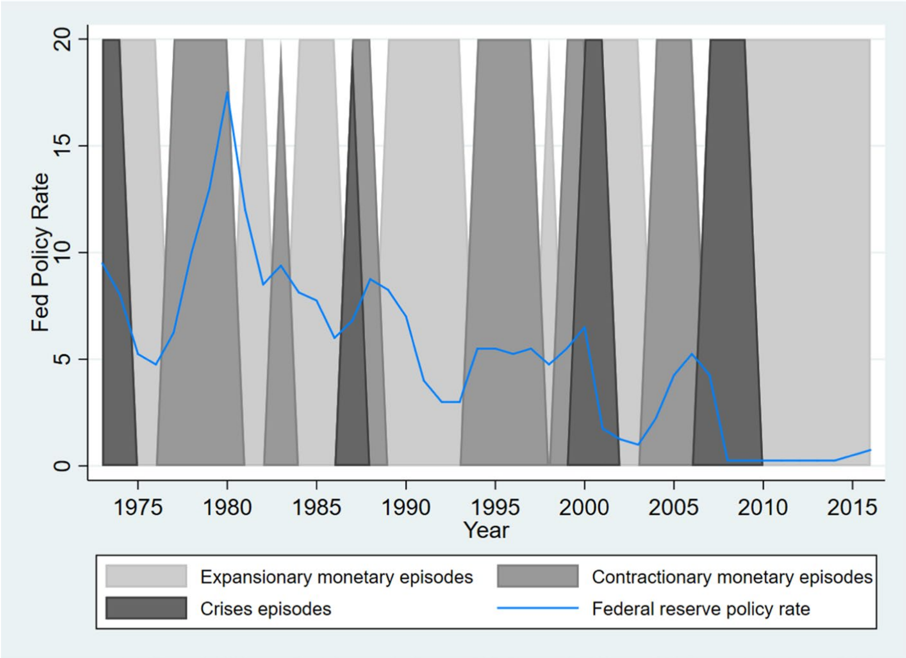

Fig. 1 Episodes of expansionary and contractionary measures of the Federal Open Market Committee (FOMC) from 1973 to 2016 based on the changing Federal Reserve Policy Rate

(MARGIN), which are directly linked to the Fscore measure. We would expect larger firms generally to be blue chip firms (i.e. Fscore 7 to 9) and blue chips firms typically have higher market capital. We therefore use the natural logarithm of sales to control for firm size in our main models (SIZE) and total market capitalisation to check the robustness. Financial performance and risk-taking capacity are also constrained by the amount of debt a firm holds. The capital structure decision of a firm directly influences its profitability, cash flow, liquidity and risk; hence, we control for the debt-equity ratio (LEVER). To capture the firm-level exposure to business cycle fluctuations, we control for earnings volatility (RISK), using the standard deviation of annual revenue in our robustness check.

In addition to the firm-level control variables we include some macroeconomic variables. Industrial production measures productive activity of an economy as explained in e.g. Almunia et al. (2010), Bénassy-Quéré and Cimadomo (2012), Kim and Roubini (2000), and Mackowiak (2007). We therefore apply the log of the industrial production index (IP) to control for aggregate economic (as well as business) cycle fluctuations. Unexpected inflationary pressure can increase market prices and volatility. Hence, to capture the development of inflation we control for the US consumer price index (CPI). The oil price (OIL) and unemployment index (UMEMP) are two other major indicators used by researchers and policymakers to measure the macroeconomic strength of any developed market (see e.g. Bhargava 2014), so we control for these two factors in our robustness models. Similarly, in the robustness checks we use average monthly returns on the NYSE composite index (MKTR) as a proxy to control for the capital market cycle (see Chang et al. 2019), which allows us to control for the variations in market capitalization due to cyclical behaviour other than the fundamentals. Finally, we use dummy variables across our econometric models to indicate the financial crises in 1973–1974, 1986, 2000–2001 and 2007–2009 (see Fig. 1). All the macroeconomic variables have been checked for the unit root problem using various Fisher-type panel specific tests, as we are using unbalanced panel data in this paper. Firm level data are winsorised by one per cent to avoid the outlier problem.

3.4 Econometric modelling

To examine the impact of monetary policies on the firm-level Piotroski Fscore and each of the Fscore's nine flags, we adopt multivariate analyses. The benchmark panel model is specified below.

$$\begin{aligned} Fscore_{i,t} = {} & \alpha_1 + \beta_1(\text{monetary policies})_t + \beta_2(\text{firm characteristics})_{i,t} \\ & + \beta_3(\text{control variables})_{i,t} + \text{TIME} + \text{FIRM} + \varepsilon_{i,t} \end{aligned} \tag{1}$$

where $Fscore_{i,t}$ is an unobservable dependent variable, estimated by Piotroski's (2000) approach for the firm-level Fscore (aggregate of nine 0/1 flags). The variable matrices of firm monetary policies, firm-level characteristics and control variables are broad groups for the variables described in earlier sections and in Table 1. $\varepsilon_{i,t}$ is the error term. In our fixed effect models, we have used TIME and FIRM level control variables for both time and firm (industry) level heterogeneity. For the industry level fixed effects, we use SIC codes from CRSP. However, we report the results with firm-level fixed effects across this paper, which are also statistically robust to industry-level fixed effects. We include results for the baseline model with industry fixed effects in the Appendix.

For contractionary and expansionary monetary episodes, we estimate Eq. (1) by separating the periods (i.e. t) within our 44 years window following the FOMC announcement displayed in Fig. 1. The models are as following:

$$\begin{aligned} Fscore_{i,t_{EXP}} = {} & \alpha_1 + \beta_1(\text{monetary policies})_t + \beta_2(\text{firm characteristics})_{i,t} \\ & + \beta_3(\text{control variables})_{i,t} + \text{TIME} + \text{FIRM} + \varepsilon_{i,t} \end{aligned} \tag{2}$$

$$\begin{aligned} Fscore_{i,t_{CON}} = {} & \alpha_1 + \beta_1(\text{monetary policies})_t + \beta_2(\text{firm characteristics})_{i,t} \\ & + \beta_3(\text{control variables})_{i,t} + \text{TIME} + \text{FIRM} + \varepsilon_{i,t} \end{aligned} \tag{3}$$

where $Fscore_{i,t_{EXP}}$ and $Fscore_{i,t_{CON}}$ are the firm-level (Piotroski 2000) Fscore during expansionary and contractionary monetary policy cycles respectively. The *EXP* and *CON* periods are determined based on the Federal Reserve rate over our 44 year sample. The definitions of other components of these Eqs. (2) and (3) are similar to Eq. (1). The primary interest of this paper is to investigate the resilience of Fscore to simultaneous changes of monetary policy (i.e. contractionary and expansionary), hence we test our models without any lag impact from the monetary policy variables (as in Eqs. 1, 2 and 3).

Finally, we developed a model to check the causal association between Fscore and monetary policies. Since the Fscore represents the change in firm level fundamentals at any point of time relative to the previous year, thus simultaneous causality with changing monetary policy would help us to understand their dynamic linkage. We are therefore looking at whether the Fscore increases or decreases due to the changing monetary policy variables. Moreover, we control the lag impact of monetary policy variables across these models. The models are as follows:

$$Fscore_{i,t} = \alpha_1 + \beta_1(\text{monetary policies})_{\text{t}} + \beta_2(\text{firm characteristics})_{\text{i,t}} \\ + \beta_3(\text{monetary policies})_{\text{t}-1} + \beta_4(\text{control variables})_{\text{i,t}} + \text{TIME} + \text{FIRM} + \varepsilon_{\text{i,t}} \tag{4}$$

$$Fscore_{i,t} = \alpha_1 + \beta_1(\text{monetary policies})_{\text{t}_{\Delta EXP}} + \beta_2(\text{firm characteristics})_{\text{i,t}} \\ + +\beta_3(\text{monetary policies})_{\text{t}-1} + \beta_4(\text{control variables})_{\text{i,t}} \\ + \text{TIME} + \text{FIRM} + \varepsilon_{\text{i,t}} \tag{5}$$

$$Fscore_{i,t} = \alpha_1 + \beta_1(\text{monetary policies})_{\text{t}_{\Delta CON}} + \beta_2(\text{firm characteristics})_{\text{i,t}} \\ + +\beta_3(\text{monetary policies})_{\text{t}-1} + \beta_4(\text{control variables})_{\text{i,t}} \\ + \text{TIME} + \text{FIRM} + \varepsilon_{\text{i,t}} \tag{6}$$

where we have estimated the simultaneous impact of monetary policy after controlling for the lag impact from the previous state of monetary policy. ΔEXP and ΔCON are the years when the FOMC announced a decrease or increase in the Federal Reserve rate respectively, i.e., the years when monetary policy entered 'expansion from contraction' or 'contraction from expansion'. Therefore Eqs. (5) and (6) will help us to understand the significance of short run 'time shock' on Fscore purely due to the changes of monetary cycles, even after controlling the lag impact of previous state of the policy. The definitions of the other components of Eqs. (4), (5) and (6) are similar to Eqs. (1), (2) and (3).

For robustness testing of baseline regressions, we incorporate cross-sectional variation in external dependence to identify the differential influences that monetary policies, firm characteristics, and other macro variables may have had on firms' Fscore across multiple industries employing various quasi-natural experiments, such as dividing firms by blue chip status, by age, by size and adding additional control variables.

4 Empirical findings

4.1 Descriptive statistics

We show descriptive statistics for the macroeconomic variables in Table 2 Panel A, for the firm-level control variables in Panel B and for the individual Fscore flags in Panel C. In Panel A, the mean 3-month interest rate over the sample period is 4.79% with a standard deviation of 3.53%. The short-term interest rate varied from 14.11% in 1980 down to 0.02% in 2011. Our variable M2 is actually the growth in the M2 money supply expressed as a percentage of GDP. The mean of M2 is 0.16% in our period, with a maximum 5.30% in 2010 and a minimum of − 2.43% in 1979. The mean of liquidity in the banking sector and term spread are 3.01 and 1.78, respectively. The liquidity in the banking sector in our paper represents the spread between the prime lending rate and the three months risk-free rate. This spread was only 0.31% in 1979 but increased to the highest point of 7.23% in 1981. The term spread was highest in 1991 at 3.91% and lowest in 1979 at − 2.92%. The US dollar index represents the value of the US dollar against a trade-weighted basket of

Table 2 Descriptive statistics

Variable	Mean	Std. dev	Distribution				Rank-sum test	Mean equality test
			25%	50%	75%	95%		
Panel A: Macroeconomic variables								
Monetary policy variables								
3MM	4.7868	3.5302	1.4600	5.1150	7.2050	11.6400	319.339***	372.089***
M2	0.1576	1.6384	– 1.2606	0.1964	1.1201	2.4630	– 182.385***	– 202.003***
BLIQ	3.0118	1.4634	2.3850	3.1000	3.4350	5.1900	– 472.182***	507.220***
TS	1.7841	1.6694	0.7200	1.9500	3.1000	3.9100	– 530.212***	– 604.020***
EXRATE	– 0.1804	7.5558	– 6.121	0.8166	5.4723	11.2504	– 166.386***	– 74.445***
General macro-economic variables								
UNEMP	6.4091	1.5291	5.3000	6.0500	7.4500	9.6000	– 314.955***	– 403.302***
IP	1.4234	3.0286	0.5706	2.2657	3.3204	4.8416	268.778***	357.297***
MKTR	0.0633	0.1685	– 0.0172	0.0952	0.1846	0.2647	– 4.584***	51.542***
CPI	4.5484	1.9223	3.5750	4.3500	5.6090	7.9100	164.793***	191.957***
OIL	4.3913	37.0526	– 4.4409	2.0169	18.3000	56.3580	236.780***	197.795***
Panel B: Firm-level control variables								
ROA	0.0093	0.1922	– 0.0063	0.0443	0.0904	0.1965	15.437***	8.200***
CFO	0.0583	0.1816	0.0195	0.0808	0.1403	0.2711	3.422***	3.133***
LEVER	0.1809	0.1754	0.0159	0.1472	0.2881	0.5126	5.194***	– 2.746***
LIQUID	2.6787	2.4689	1.3377	2.0112	3.0617	6.9075	3.885***	– 4.010***
MARGIN	0.2535	1.0415	0.2120	0.3228	0.4696	0.7426	– 10.856***	10.031***
AST	1.3975	1.0188	0.6932	1.2097	1.8097	3.3298	28.056***	25.088***
SIZE	5.0621	2.2984	3.5197	5.0107	6.6309	8.9301	– 17.336***	– 17.230***
RISK	0.4718	0.4065	0.1943	0.3557	0.6153	1.2966	– 18.469***	– 21.013***
AGE	10.2558	9.8484	3.000	7.000	14.000	31.000	4.121***	5.110***
Panel C: Individual Fscore flags								
F_SCORE	5.0779	1.7822	4	5	6	8	9.169***	8.460***
F_ROA	0.7367	0.4404	0	1	1	1	14.436***	14.641***
F_CFO	0.7944	0.4041	1	1	1	1	– 11.024***	– 11.023***
F_ΔROA	0.4275	0.4947	0	0	1	1	16.311***	16.268***
F_ACCRUAL	0.7462	0.4352	0	1	1	1	– 12.516***	– 12.381***
F_ΔLEVER	0.4939	0.5000	0	0	1	1	11.487***	11.492***
F_ΔLIQUID	0.4776	0.4995	0	0	1	1	– 4.713***	– 4.715***
F_EQ	0.4725	0.4992	0	0	1	1	– 16.704***	– 16.753***
F_ΔMARGIN	0.4976	0.5000	0	0	1	1	6.366***	6.367***
F_ΔTURN	0.4315	0.4953	0	0	1	1	16.849***	16.808***

This table shows the descriptive statistics of our monetary policy variables, general macroeconomic variables, firm-level control variables, and Fscores. The last two columns of each panel display the non-parametric Wilcoxon Rank-Sum (Mann-Whitey) test and pairwise T-test to confirm the statistical difference of median and mean in expansionary versus contractionary episodes

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

currencies. It started at 101 in our data and peaked at 135 in 1984, but since then it has generally declined down to 94 in 2016. Hence its median growth rate (EXRATE) is 0.8166 with a 95th percentile of 11.95. The last column of Panel A reports the non-parametric Rank Sum test. The results confirm that the median of each monetary policy variable is statistically different between expansionary and contractionary periods.

The second half of Panel A of Table 2 shows the descriptive statistics for our macroeconomic control variables. IP is a first difference, so this is the year-to-year change in the industrial production index (2012 = 100) rather than an annual percentage change. The median of MKTR in our sample is 0.10, representing the yearly average of monthly average returns from the NYSE composite index. Finally, the median values of CPI and OIL are 4.35% and 2.02% respectively. We measure US inflation as the growth in the composite price index and oil price inflation as the growth in the dollar price of a barrel of crude oil. A Wilcoxon Rank-Sum test and pairwise T-test for each variable confirm that the medians and means of these control variables were all statistically different at the 1% level in contractions versus expansions.

In the firm-level control variables in Panel B, ROA has a mean 0.16% but median 4.43% so this is left-skewed. This is plausible as with the "big bath" syndrome there may be huge losses in some company/years. In fact, the first percentile is − 94.08% but the 99th percentile is 34.94%. We should note that the US economy has grown many times over in nominal terms since 1973 but the mean company/year is only just positive. Note however that these figures are equally weighted, not weighted by the size of the company, so the economy-wide growth could be driven by large ROAs for large companies. CFO is also slightly left-skewed with mean 5.2% but median 8.08% due to a few companies making large cash profits. 5% of companies have a cash flow from operations greater than 27% of lagged total assets. The mean and median of the natural logarithm of market capitalization are almost the same, meaning little skewness in the logged data. The figures in Table 2 give a dollar mean market cap of $122m and median of $103m, but note this is across all company/years of our dataset. Sales are also hardly skewed at all once logarithms are taken, with mean

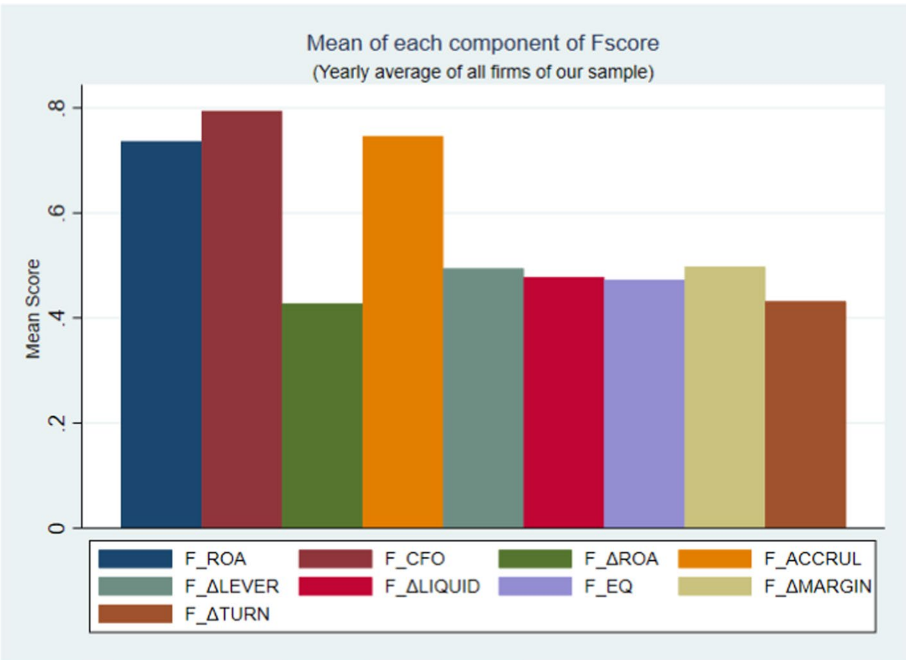

Fig. 2 Mean of Fscore component flags, all US firms 1973–2016

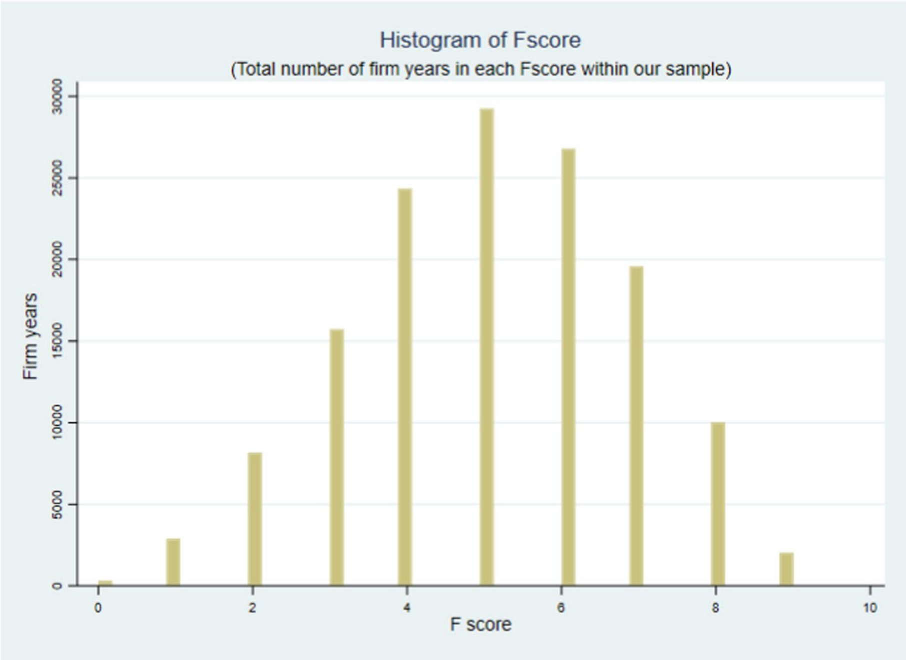

Fig. 3 Histogram of the Fscore, all US firms 1973–2016

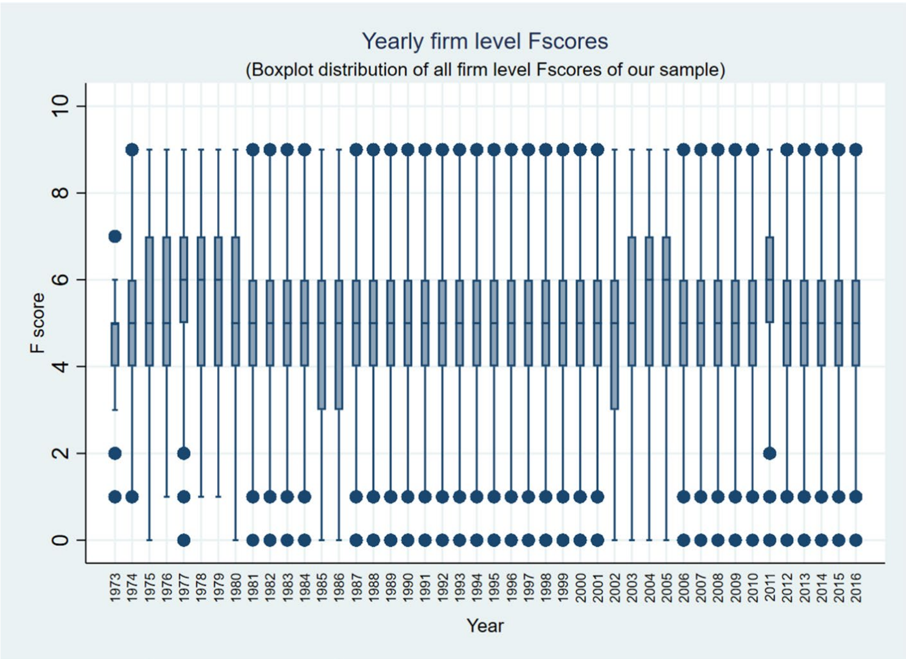

Fig. 4 Fscore distribution by year, all US firms 1973–2016

sales of \$156m and median of \$150m. RISK is the standard deviation of log(sales), calculated over the whole retrospective period for which we have the company's data.

Finally, we look at the data in Table 2 Panel C and refer to Fig. 2. To discriminate between financially stable and unstable companies it would make sense for the individual Fscore flags to average around 0.5, but this is the case for only six of the nine. F_ROA, F_CFO and F_ACCRUAL all stand out in Fig. 2. F_ROA (is the ROA positive?), F_CFO (is the cash flow from operating activities positive?) and F_ACCRUAL (is cash flow greater than profit, i.e., profit is driven by real sales rather than accounting accruals?) are all between 0.7 and 0.8. This is due to the natural growth in the economy—if they were about 0.5 that would mean the US economy was not growing in the long term. An obvious improvement to the Fscore here would be to ask, "Is this ROA [etc.] figure better than the median in the economy this year?", rather than just "Is it positive?".

The three flags with means significantly higher than 0.5 result in the slight left-skewness of the composite Fscore across all years that we see in Fig. 3. Other than the slight skewness, and the fact that Fscore values of 9 (while rare) are far more common than values of zero, the Fscore distribution conforms well to a standard bell-shaped curve. To our knowledge this is the first time that anyone has published a histogram of how Fscores are distributed.

We show the history of the market average Fscore since 1973 in Fig. 4. The Fscore with possible values from 0 to 9 has in most years averaged a value of five. Interestingly it does not show a drop before the economic crises of the mid-1970s, early 1980s, early 2000s and 2007–8 (see Fig. 4). Being based on company accounting data that refer to transactions that are up to two years old, the Fscore is necessarily a backward-looking statistic. However, Fig. 4 does show a slightly higher market average Fscore of six in 1977–1979, 2004–2005 and 2011 as companies come out of recessions. This results in the overall mean for the Fscore across all years of 5.08. However, the exception is the mid-1980s when the Fscore shows no evidence of economic exuberance.

We display the correlations between macroeconomic variables, between firm-level variables and between Fscore flags in Table 3. For information we include the correlations with the Fscore in each panel.

Table 3 Panel A displays the correlations between the macro-economic variables. Notably, all correlations between the Fscore and macroeconomic variables are between ± 0.05, so we should not expect any high explanatory power from any single variable, however it is the overall economic situation that we are interested in. There is only one correlation over 0.7: one of 0.76 between CPI and the oil price. This is unsurprising as oil prices are likely to be affected by general inflation (and vice-versa).

Table 3 Panel B shows the correlations between the firm-level control variables. Even for these the correlations with Fscore are all within ± 0.45. All other correlations are low too. The highest is 0.69 between ROA and CFO, as these are alternative ways of considering how profitable a company is.

The correlations between the individual flags that compose the Fscore are shown in Table 3 Panel C. Reassuringly all correlations with the overall Fscore are positive, since each flag is one of the nine that sum to the Fscore itself. However, some are twice as closely related to the Fscore as others, with the accruals and liquidity flags having correlations of only 0.26 with the Fscore compared to 0.58 for F_ΔROA. There are no large correlations between the Fscore flags themselves, but interestingly out of 45 correlations ten are negative. The largest negative figure is -0.14, but nevertheless it implies that some Fscore flags are working against others. In particular the accruals flag F_ACCRUAL has five out

Table 3 Correlation matrix between variables

	Fscore	3MM	M2	BLIQ	TS	EXRATE	UNEMP	IP	MKRT	CPI	OIL
Panel A: correlations between macroeconomic variables											
Fscore	1.0000										
3MM	− 0.0078	1.0000									
	(0.0449)										
M2	0.0064	− 0.5071	1.0000								
	(0.0515)	*(0.0000)*									
BLIQ	− 0.0447	− 0.2357	0.0034	1.0000							
	(0.0000)	*(0.0000)*	*(0.0016)*								
TS	− 0.0330	− 0.5217	0.3457	0.5681	1.0000						
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*							
EXRATE	0.0164	0.0509	− 0.0717	0.3538	0.0574	1.0000					
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*						
UNEMP	0.0320	− 0.0148	0.2852	0.0530	0.4696	0.0239	1.0000				
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*					
IP	0.0035	0.1753	− 0.5515	− 0.0680	− 0.3956	0.0803	− 0.5778	1.0000			
	(0.0193)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*				
MKTR	− 0.0170	0.1594	− 0.1194	− 0.2059	− 0.1449	− 0.1383	0.1401	− 0.0354	1.0000		
	(0.0002)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*			
CPI	0.0501	0.4587	− 0.4490	0.1430	− 0.3122	0.2368	− 0.0931	0.2007	− 0.2012	1.0000	
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*		
OIL	0.0496	0.1164	− 0.1697	0.0521	− 0.1285	0.1624	− 0.0960	0.1438	− 0.2789	0.7594	1.0000
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	

	Fscore	ROA	CFO	LEVER	LIQUID	MARGIN	AST	SIZE	RISK	AGE
Panel B: correlations between firm-level control variables										
Fscore	1.0000									
ROA	0.4104	1.0000								
	(0.0000)									

Table 3 (continued)

	Fscore	ROA	CFO	LEVER	LIQUID	MARGIN	AST	SIZE	RISK	AGE
CFO	0.4471	0.6897	1.0000							
	(0.0000)	*(0.0000)*								
LEVER	0.0242	− 0.0402	− 0.0020	1.0000						
	(0.0000)	*(0.0000)*	*(0.0000)*							
LIQUID	− 0.0991	− 0.0342	− 0.1383	− 0.2686	1.0000					
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*						
MARGIN	0.1408	0.3320	0.3008	0.0148	− 0.1433	1.0000				
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*					
AST	0.1059	0.2486	0.1230	− 0.1186	− 0.1488	0.0613	1.0000			
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*				
SIZE	0.2598	0.3396	0.3555	0.2157	− 0.3203	0.1765	0.1177	1.0000		
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*			
RISK	− 0.0639	− 0.1007	− 0.0680	− 0.0102	0.0525	− 0.1084	− 0.1046	0.1133	1.0000	
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0003)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*		
AGE	0.1571	0.1955	0.1594	0.0018	− 0.0473	0.0520	0.0170	0.3086	0.2746	1.0000
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0004)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	

	Fscore	F_ROA	F_CFO	F_ΔROA	F_ACCRUAL	F_ΔLEVER	F_ΔLIQUID	F_EQ	F_ΔMARGIN	F_ΔTURN
Panel C: correlations between individual Fscore flags										
Fscore	1.0000									
F_ROA	0.5196	1.0000								
	(0.0000)									
F_CFO	0.5513	0.4445	1.0000							
	(0.0000)	*(0.0000)*								
F_ΔROA	0.5846	0.2011	0.0875	1.0000						
	(0.0000)	*(0.0000)*	*(0.0000)*							

Table 3 (continued)

	Fscore	F_ROA	F_CFO	F_ΔROA	F_ACCRUAL	F_ΔLEVER	F_ΔLIQUID	F_EQ	F_ΔMARGIN	F_ΔTURN
F_ACCRUAL	0.2555	− 0.1506	0.3304	− 0.0545	1.0000					
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*						
F_ΔLEVER	0.3862	0.1431	0.1391	0.1082	0.0501	1.0000				
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*					
F_ΔLIQUID	0.2564	0.1203	0.0014	0.0483	− 0.1364	− 0.0747	1.0000			
	(0.0000)	*(0.0000)*	*(0.0604)*	*(0.0000)*	*(0.0000)*	*(0.0000)*				
F_EQ	0.3287	0.0921	0.1612	− 0.0016	0.0746	− 0.0317	− 0.0550	1.0000		
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0546)*	*(0.0000)*	*(0.0000)*	*(0.0000)*			
F_ΔMARGIN	0.4394	0.1147	0.0502	0.2795	− 0.0230	0.0553	0.0548	− 0.0208	1.0000	
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*		
F_ΔTURN	0.4547	0.0749	0.0397	0.4641	− 0.0054	0.0388	− 0.0467	0.0059	0.0795	1.0000
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0437)*	*(0.0000)*	*(0.0000)*	*(0.0279)*	*(0.0000)*	

This table presents the pairwise correlation coefficient between the variables of our study. The *p* values are reported in brackets and italic fonts denote statistical significance at the 1%, 5% and 10% levels

Table 4 Baseline model for Fscore

Variables	Dependent variable: firm-level Fscore		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	− 0.0580***	− 0.0668***	− 0.1106***
	(0.0033)	(0.0039)	(0.0087)
M2	0.0136***	− 0.0206***	0.0082
	(0.0043)	(0.0056)	(0.0085)
BLIQ	− 0.0468***	0.0142**	− 0.1288***
	(0.0051)	(0.0070)	(0.0145)
TS	− 0.0112**	− 0.0212***	0.0542**
	(0.0056)	(0.0065)	(0.0229)
EXRATE	0.0057***	0.0051***	0.0097***
	(0.0006)	(0.0008)	(0.0015)
ROA	1.7213***	1.8857***	1.7176***
	(0.0695)	(0.0892)	(0.1056)
CFO	3.1138***	2.9299***	3.6555***
	(0.0598)	(0.0734)	(0.0918)
LEVER	− 0.8205***	− 0.7885***	− 0.9236***
	(0.0463)	(0.0571)	(0.0861)
LIQUID	0.0268***	0.0290***	0.0245***
	(0.0033)	(0.0040)	(0.0057)
MARGIN	0.0447***	0.0311**	0.1151***
	(0.0113)	(0.0134)	(0.0193)
AST	0.1696***	0.1881***	0.1485***
	(0.0120)	(0.0150)	(0.0191)
SIZE	0.0669***	0.0747***	0.0017
	(0.0083)	(0.0098)	(0.0160)
CRISIS	− 0.0967***	− 0.1955***	0.0225
	(0.0130)	(0.0169)	(0.0288)
IP	0.0176***	0.0043*	0.0658***
	(0.0019)	(0.0023)	(0.0151)
CPI	0.0433***	0.0227***	0.1270***
	(0.0030)	(0.0034)	(0.0139)
Intercept	4.6069***	4.4764***	4.9130***
	(0.0539)	(0.0628)	(0.1594)
Firm years	137,548	90,107	47,441
Adj. R^2	0.3661	0.3286	0.2817
F-statistic	522.31***	380.64***	213.85***
Number of firms	14,877	14,090	11,316
Year & firm FE	Yes	Yes	Yes
Clustered by firm	Yes	Yes	Yes

This table displays the results of our baseline model using Eqs. (1), (2) and (3) where our dependent variable is firm-level Fscore. In column (1), we use the data of the 44 year window from 1973 to 2016. However, in column (2) and (3), we separate our sample periods based on the FOMC announcements of increasing (contractionary) and decreasing (expansionary) Federal Reserve policy rate (see Fig. 1). The simultaneous impact of an expansionary monetary policy environment on the firm level Fscore is reported in column (2), and the impact of contractionary policy is reported in column (3). We have 90,107 firm-year observations

Table 4 (continued)

during the expansionary cycle and 47,441 firm-year observations during the contractionary cycle. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

of eight correlations that are negative, and F_ΔLIQUID and F_EQ each have four negative correlations out of eight.

4.2 Results of our baseline model

In Table 4 we present the results from our baseline model. The first results column is our model from Eq. (1). In order to distinguish the relative importance of monetary policy during expansions and contractions we report regressions using data during expansionary periods only and during contractionary periods only in column (2) and (3), respectively, where we have applied Eqs. (2) and (3), respectively.

The first group of variables in Table 4 is the five monetary policy variables 3MM to EXRATE. All five variables are highly significant over the sample periods and during expansionary episodes. Four of these are also statistically significant in contractionary episodes. Therefore, our models depict a very strong result and show that an active monetary policy has a substantial effect on firm level Fscores. For example, the short-term interest rate (3MM) is negative and highly significant in all three regressions. Results show that an increase 100 basis points in 3MM would (other things being equal) mean a drop of 0.058 in the Fscore during overall period. The adverse impact of such an increase in the short-term interest rate on the Fscore is -0.0668 and -0.1106 during expansionary and contractionary episodes respectively. The negative association of 3MM therefore supports the earlier literature that a higher interest rate increases firms' borrowing costs (see e.g. Armstrong et al. 2019; Karpavicius and Yu 2017; Flannery and Protopapadakis 2002) and thus limits their available funds for taking advantage of investment opportunities. Moreover, firms might eat up their cash to replace the cost of borrowing and cast a shadow on their overall financial health. Supporting this argument, Ashcraft and Campello (2007) highlight that higher interest rates increase debt service costs, erode cash flows, and depress collateral values.

M2 is highly significant and positive in our aggregate model in column (1), which suggests that in general a looser money supply improves the Fscore. However during expansionary periods (column 2) our findings suggest a further supply of money is not needed and might reduce firm performance. This significant association therefore highlights the notion that an excessively loose monetary policy can be the source of the financial instability mentioned in Borio and White (2004) and Rajan (2005). The money supply is positively associated with Fscore in contractionary periods but the relationship is not statistically significant at the 10% level.

BLIQ is negative and significant in our aggregate model and during contractionary periods. We apply this variable as a proxy of monetary policy to assess the ability of the banking sector to transfer liquidity from the interbank market to the financial markets and the real economy (see Gagnon and Gimet 2013), and thus to firms' balance sheets. The negative sign of BLIQ indicates the adverse effect of a higher banks' lending rate over and above the base rate on firms' financial health in our 44 year sample period. As expected, the adverse impact of increasing the lending rate is stronger on the Fscore in contractionary periods when the base rate is already high. The − 0.1288 coefficient for BLIQ in column 3 means that, other things being equal, a 100 basis point increase in the spread between the prime lending rate and the three month risk-free rate is associated with a fall of 0.1288 in the Fscore. In this regard, Gagnon and Gimet (2013) mentioned that the liquidity spread (i.e., the difference between the prime lending rate and the 3 months risk free rate) never narrows when interest rates (i.e., the base rate) are lowered, in fact, in most cases it increases. This highlights the possibility that private banks do not follow the central bank's lead in lowering the prime lending rate despite the liquidity crisis (Almunia et al. 2010). Thus, based on our findings, the real economy as shown in firms' financial health hardly benefited from the banks' liquidity. Moreover, through the bank lending channel, a tight monetary policy reduces bank reserves and forces banks to shrink their loans, which reduces the commercial bank loans available to enterprises (Kashyap et al. 1993).

In Table 4 TS is found to be negative and statistically significant in columns (1) and (2). That means that the Fscore is adversely affected by the higher term spread in our overall sample and during an expansionary monetary policy cycle. Results therefore highlight the impact of monetary policy on firm performance via the credit channel. Long-term loans are usually considered riskier than short-term debt, owing to the maturity risk premium. So long-term debt typically would have a positive yield spread over short-term debt. In our analysis, a widening TS implies that the market is factoring in high risk in the bond (particularly for lower graded bonds) and thus firms' cost of borrowing increases. Hence leverage decreases and the overall financial health of a firm suffers. In this line of thought, Frank and Goyal (2009) find that firms' leverage decreases with the difference between the 10-year and the one-year Treasury bond yields. During an expansionary monetary cycle, a decrease in base rate reduces the short-term interest rate and induces the slope of the yield curve (measured by TS) to increase (Gagnon and Gimet 2013). A contrasting market behaviour and association is observed during contractionary period.

The coefficients of EXRATE are positive and statistically significant across Table 4. Therefore, our findings suggest that US firms are benefiting from higher exports during the expansionary cycle (due to depreciation of currency) and cheaper imports during the contractionary cycle (due to appreciation of currency). Moreover, a higher interest rate attracts huge foreign investment into the economy (bank lending channel).

All the firm-level accounting variables (ROA down to SIZE) that underlie the Fscore are significant at the 1% level, except for SIZE in column (3) which is not found to be statistically robust during contractionary cycles. Therefore, we find support for the view that the internal attributes of an organization determine its position in the competitive environment (see Wernerfelt 1982). From our findings, higher ROA, cash flow, liquidity, asset turnover and lower leverage are all associated with higher company financial stability whatever the state of the economy. This is easily understood since higher profits, more cash / cash equivalents in the business or sweating the assets more efficiently are clearly good for a firm's finances. In particular cash flow from operations (CFO) is the most significant component to enhance the Fscore of a firm. Our finding suggest that ROA, LIQUID and AST have stronger impacts on the Fscore during an expansionary cycle, however, MARGIN and CFO are important determinants of the Fscore during a contractionary cycle. For example, using Table 2 Panel B, if a firm could move from the 25th to the 75th percentile of CFO, this would (other things being equal) entail an improvement in the Fscore of $(0.1403 - 0.0195) \times 3.6555 = 0.4416$.

We find the coefficient of LEVER to be negative as expected, since high leverage would usually be equated with high risk. Moreover, a tight monetary policy should increase the cost of borrowing and reduce profitability. Thus, we observe a greater impact from the

Table 5 Demonstration of how the Fscore is affected by monetary, macro-economic and firm-level variables

Variable	Distribution		Coefficient	Low quartile * coefficient	High quartile * coefficient	Difference	Sum of differences	Percentage of total
	25%	75%						
Panel A: All data								
Monetary policy variables								
3MM	1.46	7.205	− 0.058	− 0.4179	− 0.0847	0.3332		
M2	− 1.2606	1.1201	0.0136	− 0.0171	0.0152	0.0324		
BLIQ	2.385	3.435	− 0.0468	− 0.1608	− 0.1116	0.0491		
TS	0.72	3.1	− 0.0112	− 0.0347	− 0.0081	0.0267		
EXRATE	− 6.121	5.4723	0.0057	− 0.0349	0.0312	0.0661	0.5075	27.21%
Firm-level control variables								
ROA	− 0.0063	0.0904	1.7213	− 0.0108	0.1556	0.1664		
CFO	0.0195	0.1403	3.1138	0.0607	0.4369	0.3761		
LEVER	0.0159	0.2881	− 0.8205	− 0.2364	− 0.0130	0.2233		
LIQUID	1.3377	3.0617	0.0268	0.0359	0.0821	0.0462		
MARGIN	0.212	0.4696	0.0447	0.0095	0.0210	0.0115		
AST	0.6932	1.8097	0.1696	0.1176	0.3069	0.1894		
SIZE	3.5197	6.6309	0.0669	0.2355	0.4436	0.2081	1.2212	65.47%
General macro-economic variables								
CRISIS			− 0.0967					
IP	0.5706	3.3204	0.0176	0.0100	0.0584	0.0484		
CPI	3.575	5.609	0.0433	0.1548	0.2429	0.0881	0.1365	7.32%
Intercept			4.6069	4.6069	4.6069			
Total				4.3182	6.1833	1.8651		100%
Panel B: Expansionary cycle								
Monetary policy variables								
3MM	1.46	7.205	− 0.0668	− 0.4813	− 0.0975	0.3838		
M2	− 1.2606	1.1201	− 0.0206	− 0.0231	0.0260	0.0490		

Table 5 (continued)

Variable	Distribution		Coefficient	Low quartile * coefficient	High quartile * coefficient	Difference	Sum of differences	Percentage of total
	25%	75%						
BLIQ	2.385	3.435	0.0142	0.0339	0.0488	0.0149		
TS	0.72	3.1	− 0.0212	− 0.0657	− 0.0153	0.0505		
EXRATE	− 6.121	5.4723	0.0051	− 0.0312	0.0279	0.0591	0.5573	29.86%
Firm-level control variables								
ROA	− 0.0063	0.0904	1.8857	− 0.0119	0.1705	0.1823		
CFO	0.0195	0.1403	2.9299	0.0571	0.4111	0.3539		
LEVER	0.0159	0.2881	− 0.7885	− 0.2272	− 0.0125	0.2146		
LIQUID	1.3377	3.0617	0.029	0.0388	0.0888	0.0500		
MARGIN	0.212	0.4696	0.0311	0.0066	0.0146	0.0080		
AST	0.6932	1.8097	0.1881	0.1304	0.3404	0.2100		
SIZE	3.5197	6.6309	0.0747	0.2629	0.4953	0.2324	1.2513	67.04%
General macro-economic variables								
CRISIS			− 0.1955					
IP	0.5706	3.3204	0.0043	0.0025	0.0143	0.0118		
CPI	3.575	5.609	0.0227	0.0812	0.1273	0.0462	0.0580	3.11%
Intercept			4.4764	4.4764	4.4764			
Total				4.2494	6.1160	1.8666		100%
Panel C: Contractionary cycle								
Monetary policy variables								
3MM	1.46	7.205	− 0.1106	− 0.7969	− 0.1615	0.6354		
M2	− 1.2606	1.1201	0.0082	− 0.0103	0.0092	0.0195		
BLIQ	2.385	3.435	− 0.1288	− 0.4424	− 0.3072	0.1352		
TS	0.72	3.1	0.0542	0.0390	0.1680	0.1290		

Table 5 (continued)

Variable	Distribution		Coefficient	Low quartile * coefficient	High quartile * coefficient	Difference	Sum of differences	Percentage of total
	25%	75%						
EXRATE	− 6.121	5.4723	0.0097	− 0.0594	0.0531	0.1125	1.0316	40.09%
Firm-level control variables								
ROA	− 0.0063	0.0904	1.7176	− 0.0108	0.1553	0.1661		
CFO	0.0195	0.1403	3.6555	0.0713	0.5129	0.4416		
LEVER	0.0159	0.2881	− 0.9236	− 0.2661	− 0.0147	0.2514		
LIQUID	1.3377	3.0617	0.0245	0.0328	0.0750	0.0422		
MARGIN	0.212	0.4696	0.1151	0.0244	0.0541	0.0296		
AST	0.6932	1.8097	0.1485	0.1029	0.2687	0.1658		
SIZE	3.5197	6.6309	0.0017	0.0060	0.0113	0.0053	1.1021	42.83%
General macro-economic variables								
CRISIS			0.0225					
IP	0.5706	3.3204	0.0658	0.0375	0.2185	0.1809		
CPI	3.575	5.609	0.127	0.4540	0.7123	0.2583	0.4393	17.07%
Intercept			4.913	4.9130	4.9130			
Total				4.0951	6.6680	2.5729		100%

This table shows the potential effect on the Fscore of high and low values of the monetary, economic and firm-level control variables. Positive coefficients from Table 4 are multiplied by the (25th, 75th) percentile values from Table 2 and negative coefficients are multiplied by the (75th, 25th) percentile values leverage ratio during contractionary cycles. Interestingly, SIZE is found to be positive and statistically significant for the overall data and during expansionary cycles. This suggests that larger firms achieve higher Fscores in our sample and particularly during expansionary periods. This is probably because of their higher risk bearing capacity, higher profitability, higher cashflows and minimum dependency on external financing. The associations between firm level variables and Fscore reported in Table 4 are similar to their correlation coefficients reported in Panel B of Table 3, except between LEVER and LIQUID. This is because Table 3 shows only a pair wise correlation between dependent and explanatory variables. On the other hand, Table 4 reports the dynamic and robust relationship between our variables within a multiple regression model, which explains the cause-and-effect association.

Among the general economic indicators, CRISIS is negative and significant in our overall sample and during expansions, i.e. Fscores decrease during crises. The proxy for the economic cycle (IP) is positive and significant across our three models, showing the identity between economic growth and better firm performance. The association is stronger when the central bank is following an expansionary monetary policy. Surprisingly, the CPI is always a positive and significant influence on the Fscore. This probably indicates that US firms manage to increase their prices to consumers more than their cost of production rises. The other possible reason is that most firms are always indebted so a certain level of inflation will help to inflate away the real value of their debts, just as it does for individuals with mortgages and for countries.

We demonstrate the economic significance of the results in Table 4 using the calculations shown in Table 5. For each variable in the main regression, we take its coefficient from Table 4 and multiply it by the 25th and 75th percentile values from Table 2, but choosing which in order to maximise the difference in the total Fscore. For example, in Table 2 3MM has a 25th percentile value of 1.46 and 75th percentile of 7.205. Because its regression coefficient is − 0.0580 in Table 4, i.e. it is negative, to get a low Fscore we multiply the 75th percentile value by the coefficient, and to get the high Fscore we multiply the 25th percentile value by the coefficient. This would be the other way round if the coefficient were positive. We are effectively creating two synthetic company/year records, to either minimise or maximise the Fscore, but using 25th/75th percentile variable values rather than extreme values.

The monetary and macro-economic variables used in the main regression in Table 4 have a significant effect on the expected Fscore over the period as a whole. While the Fscore could vary by 1.22 between 75 and 25th percentile values due to the firm-level control variables, a total of 0.644 difference in the Fscore (0.5075 + 0.1365) could occur simply due to the monetary and macro-economic conditions existing at the time. The relative importance of the three sets of variables is very similar during the overall period and during expansions: two-thirds of the variation in the Fscore is due to firm-level variables and most of the rest is due to monetary policy variables. However the picture is very different during contractions: slightly more than half the variation in the Fscore then is due to monetary and macro-economic variables. 3MM and CPI double their influence and IP quadruples. The macro-economic variables in fact have five times the effect during contractions compared to expansions. This is a new and important result: the Fscore is mostly influenced by monetary and macro-economic factors during contractions.

To summarise the main model, our monetary policy variables are highly significant drivers of the Fscore, and they influence the overall financial health of firms during both expansions and contractions. However which variables are important and what their relative impacts are depends on the economic cycle. For example, despite the importance of the monetary policy variables to the Fscore during both cycles, the weight of impact is significantly stronger in contractionary cycles.

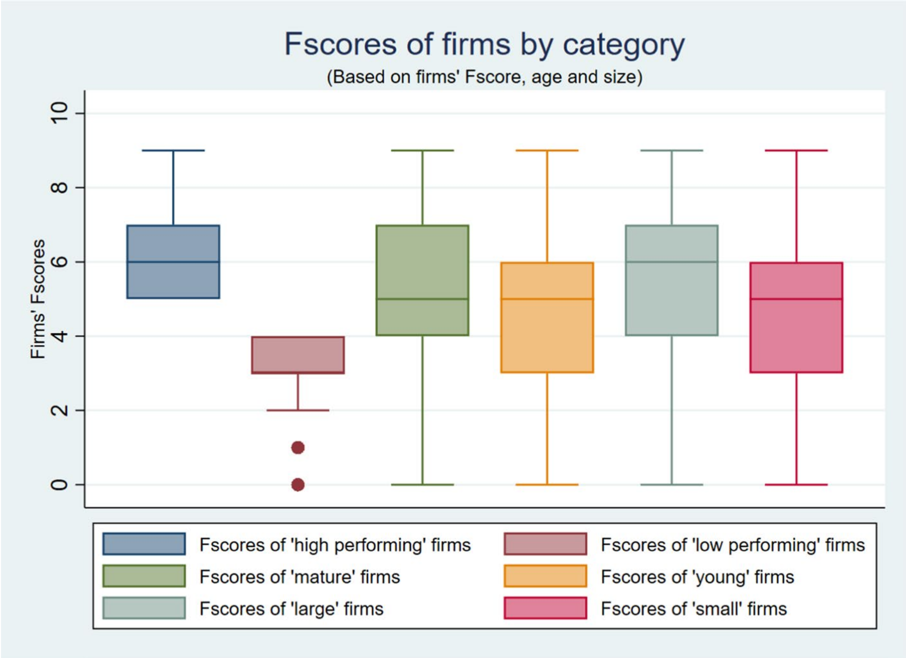

Fig. 5 Fscore distributions of high versus low performing, mature versus young and large versus small firms. All US firms 1973–2016

4.3 Robustness checks

To better understand the drivers of the results reported above, we now consider various ways of sub-dividing the dataset to check the robustness of our models. We consider high versus low performing firms (based on Fscore), young versus mature (dividing by mean age (AGE) of all firms), and large versus small (dividing by mean of sales (SIZE)). The empirical literature has highlighted the crucial role of firm characteristics, such as performance, age and size in understanding financial frictions and firm dynamics (e.g. Cooley and Quadrini 2006; Fort et al. 2013; Haltiwanger et al. 2013; Cloyne et al. 2018). For an overall view we start with Fig. 5, showing how the Fscores of the six categories are distributed. Since our definition of high performing firms uses the Fscore itself, it is not surprising that the Fscores of this group are considerably higher than the low performing category. Also large and mature firms have on average higher Fscores than their counterparts.

4.3.1 High versus low performing firms

Table 6 reports the results between variables of interest for high versus low performing firms (LPF). Here we define high performing stocks as the most financially stable firms, with an Fscore of five to nine, and the opposite group as having an Fscore of zero to four. A firm is included in the high performing group if it achieves an Fscore between five to nine in any particular year, otherwise it is grouped as a low performing firm in that year. Therefore, a firm may be in the low performing group in a year but could be

Table 6 High versus low performing firms

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	– 0.0306***	– 0.0373***	– 0.0396***
	(0.0023)	(0.0028)	(0.0068)
LPF*3MM	– 0.0102***	– 0.0162***	– 0.0141
	(0.0026)	(0.0033)	(0.0093)
M2	– 0.0015	– 0.0173***	– 0.0147*
	(0.0036)	(0.0047)	(0.0076)
LPF*M2	0.0138***	0.0230***	0.0103
	(0.0052)	(0.0068)	(0.0118)
BLIQ	– 0.0372***	– 0.0057	– 0.0825***
	(0.0042)	(0.0061)	(0.0125)
LPF*BLIQ	0.0395***	0.0231***	0.0601***
	(0.0061)	(0.0085)	(0.0196)
TS	0.0044	– 0.0110**	0.0869***
	(0.0044)	(0.0055)	(0.0201)
LPF*TS	– 0.0229***	0.0006	– 0.1605***
	(0.0059)	(0.0075)	(0.0335)
EXRATE	0.0008	0.0000	0.0052***
	(0.0006)	(0.0007)	(0.0013)
LPF*EXRATE	0.0034***	0.0047***	– 0.0030
	(0.0008)	(0.0010)	(0.0021)
ROA	0.7509***	0.8887***	0.6892***
	(0.0483)	(0.0592)	(0.0955)
LPF*ROA	– 0.3539***	– 0.4072***	– 0.3692***
	(0.0545)	(0.0694)	(0.1059)
CFO	1.5963***	1.4981***	1.8121***
	(0.0444)	(0.0559)	(0.0791)
LPF*CFO	– 0.4095***	– 0.3604***	– 0.4635***
	(0.0533)	(0.0677)	(0.0987)
LEVER	– 0.2952***	– 0.2464***	– 0.4429***
	(0.0351)	(0.0430)	(0.0659)
LPF*LEVER	– 0.0694*	– 0.1449***	0.0851
	(0.0373)	(0.0452)	(0.0717)
LIQUID	– 0.0057**	– 0.0037	– 0.0049
	(0.0024)	(0.0030)	(0.0045)
LPF*LIQUID	0.0322***	0.0292***	0.0375***
	(0.0027)	(0.0034)	(0.0053)
MARGIN	– 0.0038	– 0.0107	0.0499**
	(0.0083)	(0.0091)	(0.0238)
LPF*MARGIN	0.0448***	0.0463***	0.0166
	(0.0088)	(0.0099)	(0.0232)
AST	0.0470***	0.0721***	0.0161
	(0.0075)	(0.0093)	(0.0129)

Table 6 (continued)

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
LPF*AST	0.0486***	0.0347***	0.0747***
	(0.0066)	(0.0083)	(0.0115)
SIZE	0.0080	0.0082	− 0.0123
	(0.0050)	(0.0061)	(0.0102)
LPF*SIZE	0.0274***	0.0291***	0.0255***
	(0.0034)	(0.0041)	(0.0064)
CRISIS	− 0.0494***	− 0.0923***	0.0042
	(0.0113)	(0.0146)	(0.0260)
LPF*CRISIS	0.0236	0.0431**	0.0119
	(0.0165)	(0.0213)	(0.0417)
IP	0.0142***	0.0061***	0.0496***
	(0.0017)	(0.0021)	(0.0133)
LPF*IP	− 0.0197***	− 0.0124***	− 0.0626***
	(0.0025)	(0.0030)	(0.0220)
CPI	0.0249***	0.0206***	0.0694***
	(0.0026)	(0.0031)	(0.0123)
LPF*CPI	− 0.0134***	− 0.0238***	− 0.0419**
	(0.0039)	(0.0048)	(0.0205)
LPF	− 2.9281***	− 2.8793***	− 2.5354***
	(0.0368)	(0.0444)	(0.1879)
Intercept	6.0203***	5.9479***	5.9672***
	(0.0369)	(0.0439)	(0.1285)
Firm years	137,548	90,107	47,441
Adj. R^2	0.6261	0.6263	0.6195
F-statistics	6781.05***	4549.87***	2155.17***
Number of firms	14,877	14,090	11,316
Year & firm FE	Yes	Yes	Yes
Clustered by firms	Yes	Yes	Yes

In this table we report the impact of monetary policy on the Fscores of high versus low performing firms (LPFs). To separate the high versus low performing stocks we use firms' year-by-year Fscores. A firm includes in the high performing group if it achieves a Fscore between five to nine in any particular year, otherwise it is grouped as a low performing firm in that year. We have 90,107 firm-year observations during the expansionary cycle and 47,441 firm-year observations during the contractionary cycle. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

included in the higher performing firm in the following year by achieving Fscore five or more. By doing this we are avoiding the strict assumption of considering a firm either as a low or high performer over the 44 years. Furthermore, firm characteristics such as capital requirements, sales growth, profitability, cost structure, risk level, and size vary over time. Hence, we could expect the impact of monetary policy to be different at different stages in the life cycle of a firm. Due to the skewness in the Fscore there are

87,683 high performing company-years but only 51,434 low performing company-years in our sample, which are distributed both in expansionary and contractionary cycles. For example, out of 51,434 low-performing company-years, 33,877 observations were recorded in expansionary and 17,557 in contractionary cycles.

The interaction results in Table 6 suggest that monetary policy significantly influences the Fscores of LPFs in the US in relation to high performing firms. LPF's interaction with all our proxies of monetary policy variables are statistically robust in our aggregate model (column 1), four of them in expansionary times (column 2) and two in contractions (column 3). The short-term interest rate 3MM is negatively associated with the Fscores of LPF over our 44-year window and the linkage is slightly stronger during contractionary than expansionary cycles (3MM coefficient − 0.0396 versus -0.0373). A 100 basis point increase in 3MM is associated with a reduction in the Fscore of LPF by − 0.0537 and − 0.0535 respectively during contractions and expansions, and − 0.0408 (− 0.0306 plus − 0.0102) overall. That means that during low performing years (or years of poorer financial health), firms depend more on external funds (due to less profit and cash), thus an increasing interest rate creates further distress via their borrowing costs and interest liabilities. Ashcraft and Campello (2007) mention that a higher interest rate could worsen firms' creditworthiness via the balance sheet channel, thus increasing the external finance premium and squeezes firms' demand for loans. Moreover, due to higher interest rates firms lose the value of their assets and thus investment decreases (see Cloyne et al. 2018; Kiyotaki and Moore 1997), which creates further adverse impact on the financial health of an LPF firm by limiting its growth opportunities.

The money supply (M2), on the other hand, is positively associated with the Fscores of LPF, suggesting that increased liquidity minimizes the financial constraints for these firms and improves their access to capital. The relationship is robust in our aggregate model and during expansionary cycles. For example, an increase in the money supply of 1% of GDP makes no significant difference to the Fscore of all firms (coefficient − 0.0015 for M2 in column 1) but significantly increases the Fscore of LPFs by 0.0138 (LPF*M2). The net effect of M2 on LPFs is an increase of 0.0123 (− 0.0015, $p>0.10$ plus 0.0138, $p<0.01$). The US economy has observed various expansionary measures including unconventional monetary policy to relax firms' external finance constraint around financial crises (see e.g. Nathan et al. 2016; Gertler and Kardi 2011), thus providing access to capital for firms which are facing financial constraints due to their poorer financial health.

The liquidity of the banking sector (BLIQ) is positive and statistically significant for the Fscores of LPF across our three models. According to credit transmission theory monetary policy affects the availability of financing through increasing or decreasing the supply of bank loans, thereby affecting the supply of corporate investment (see Oliner and Rudebusch 1996; Bernanke and Gertler 1995). The positive association indicates that bank liquidity transfers from the interbank market to LPF despite a higher prime lending rate. However, the relationship is stronger during a loose monetary policy (i.e., − 0.0057 plus 0.0231), when the economy has a greater supply of bank loans. This is probably because during high performing years (i.e. better financial health and Fscores), firms could invest their internally generated funds and liquid savings (see e.g. Bacchetta et al. 2020) but during lower Fscore years (i.e., poorer financial health) they depend more on external funds.

The LPF-TS interaction term is negative and statistically significant in column (1) and (3). This indicates that a high term spread adversely affects the Fscore of LPF in our overall sample and the impact is substantial during a tight monetary policy cycle. The Fscore reduces by − 0.0736 (TS coefficient 0.0869 in column 3 plus LPF*TS coefficient − 0.1605) with a

100 basis point increase in TS during contractionary episodes. The market is factoring in the high risk of the bonds of firms with weaker financial health, and thus firms' interest liabilities increase. Finally, low performing US firms are benefiting from depreciation of the US dollar (LPF*EXRATE interaction of column 2), where they could earn more revenue by exporting.

The firm-level variables in Table 6 suggest that LPF could improve their financial health by reducing leverage and improving liquidity, profit margin and asset turnover. However, the return on assets and cash flow from operations are negatively influencing Fscores of LPF compared to high performing firms across the table. For example, results in column (1) suggest that the LPF's Fscore increases by 0.3970 (0.7509 for ROA plus − 0.3539 for LPF*ROA) with a 1% increase in ROA, whereas high performing firms achieve an increase of 0.7509. Similarly, a unit increase in the CFO (as scaled by lagged total assets) would increase the Fscore of LPF by 1.1868 (1.5963 for CFO plus − 0.4095 for LPF*CFO) in the aggregate sample in column (1). Interestingly, ROA's impact on the Fscores of LPF is greater during expansion, and CFO's impact is on contraction. The relative effect of CFO is far larger than any other variable, however this represents a unit increase in CFO scaled by lagged total assets whereas the other variables are e.g. a 1% increase in ROA. To summarize, to influence their Fscores, US firms should apply a corporate policy of maximizing the CFO and ROA during low performing years. Finally, the sign and significance of SIZE imply that despite their low performance, larger LPF achieve higher Fscores than others.

Financial crises positively affect the Fscores of LPF, and it is significant in column (2), yet the IP and CPI are negatively related compared to high performing firms. That suggests that during low performing years LPF fail to take advantage of business cycle movements and price adjustments. Alternatively, when a firm fails to use the benefits of a business cycle boom or price-level adjustment, they perform poorly.

4.3.2 Fscore and firm age

In Table 7 we report the results related to the impact of monetary policy on firm-level Fscores for mature versus young (YOF) firms. We apply the aggregate sample mean age to separate our firms between mature versus young. To determine the firm age, we use the number of years a firm remains listed with a US stock exchange according to CRSP database. Results of the 44 year period are displayed in column (1). Columns (2) and (3) show the impact during expansionary and contractionary cycles respectively.

The findings in Table 7 suggest the existence of an important credit channel of monetary policy on young firms. The Fscores of YOFs are significantly affected by monetary policy. We observe a stronger effect of YOF interactions during contractionary cycles compared to mature firms. Four of our monetary policy interactions are statistically robust in the aggregate model and during contractionary cycles, whereas three of them are significant in expansions. Cloyne et al. (2018) and Durante et al. (2020) among many others also show that young firms are more sensitive to monetary policy shocks. The signs of the associations between YOF and monetary policy are similar across the table. In particular, the Fscores of young firms are negatively affected by the short-term interest rate and term spread but positively by the money supply, bank liquidity and exchange rate (though not statistically significant) compared to mature firms. For example, a 100 basis point increase in 3MM substantially reduces the Fscore of YOFs, by 0.3963 during contraction (− 0.0987 for 3MM in column 3 plus − 0.2976 for 3MM*YOF). Similarly, the Fscore of YOFs increases by 0.0977 in column (3) and 0.0548 in column (1) with an increase in money supply of 1% of GDP, which is a much larger effect than for mature firms. That highlights

Table 7 Mature versus young firms

Variables	Dependent variables: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	− 0.0549***	− 0.0600***	− 0.0987***
	(0.0035)	(0.0041)	(0.0092)
YOF*3MM	− 0.0745***	− 0.0941***	− 0.2936***
	(0.0100)	(0.0127)	(0.0322)
M2	0.0047	− 0.0177***	− 0.0188**
	(0.0049)	(0.0063)	(0.0095)
YOF*M2	0.0548***	0.0191	0.0977***
	(0.0099)	(0.0137)	(0.0224)
BLIQ	− 0.0520***	0.0068	− 0.1413***
	(0.0058)	(0.0078)	(0.0163)
YOF*BLIQ	0.0542***	0.0764***	0.1238***
	(0.0119)	(0.0177)	(0.0364)
TS	− 0.0042	− 0.0127*	0.0569**
	(0.0062)	(0.0073)	(0.0263)
YOF*TS	− 0.1031***	− 0.1074***	− 0.3609***
	(0.0151)	(0.0181)	(0.0605)
EXRATE	0.0058***	0.0055***	0.0085***
	(0.0007)	(0.0009)	(0.0016)
YOF*EXRATE	0.0003	0.0026	0.0045
	(0.0015)	(0.0020)	(0.0038)
ROA	1.8740***	2.0361***	1.7443***
	(0.1002)	(0.1227)	(0.1407)
YOF*ROA	− 0.3958***	− 0.4484***	− 0.0743
	(0.1342)	(0.1714)	(0.2081)
CFO	3.4444***	3.2737***	3.8497***
	(0.0819)	(0.0994)	(0.1131)
YOF*CFO	− 0.9658***	− 1.0289***	− 0.6416***
	(0.1161)	(0.1428)	(0.1877)
LEVER	− 0.6926***	− 0.6454***	− 0.8438***
	(0.0540)	(0.0654)	(0.0966)
YOF*LEVER	− 0.6149***	− 0.6986***	− 0.6383***
	(0.1038)	(0.1320)	(0.2125)
LIQUID	0.0157***	0.0179***	0.0159**
	(0.0040)	(0.0048)	(0.0066)
YOF*LIQUID	0.0390***	0.0408***	0.0477***
	(0.0066)	(0.0084)	(0.0127)
MARGIN	0.0311**	0.0234	0.0882***
	(0.0154)	(0.0196)	(0.0242)
YOF*MARGIN	0.0156	0.0087	0.0776*
	(0.0217)	(0.0259)	(0.0401)
AST	0.1265***	0.1411***	0.1053***
	(0.0148)	(0.0177)	(0.0229)

Table 7 (continued)

Variables	Dependent variables: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
YOF*AST	0.0962***	0.1402***	0.1781***
	(0.0250)	(0.0329)	(0.0426)
SIZE	0.0511***	0.0605***	0.0055
	(0.0093)	(0.0108)	(0.0174)
YOF*SIZE	0.1303***	0.1081***	− 0.0535
	(0.0211)	(0.0265)	(0.0451)
CRISIS	− 0.0796***	− 0.1389***	0.0027
	(0.0147)	(0.0189)	(0.0329)
YOF*CRISIS	− 0.0898***	− 0.2704***	− 0.0371
	(0.0306)	(0.0414)	(0.0678)
IP	0.0183***	0.0082***	0.0584***
	(0.0022)	(0.0027)	(0.0174)
YOF*IP	− 0.0038	− 0.0098*	− 0.0198
	(0.0043)	(0.0057)	(0.0357)
CPI	0.0439***	0.0273***	0.1038***
	(0.0034)	(0.0039)	(0.0160)
YOF*CPI	− 0.0085	− 0.0145*	− 0.1781***
	(0.0072)	(0.0082)	(0.0365)
YOF	− 0.6142***	− 0.6476***	− 0.5331***
	(0.0561)	(0.0674)	(0.2836)
Intercept	4.6196***	4.4899***	5.3272***
	(0.0543)	(0.0640)	(0.1642)
Firm years	137,548	90,107	47,441
Adj. R^2	0.2818	0.2586	0.2271
F-statistics	277.61***	199.84***	117.60***
Number of firms	14,877	14,090	11,316
Year & firm FE	Yes	Yes	Yes
Clustered by firms	Yes	Yes	Yes

This table reports the impact of monetary policy on firm-level Fscores of mature versus young firms (YOF). To determine the firm age, we use the number of years a firm remains listed with a US stock exchange according to CRSP database. We apply the sample mean age to separate our firms between mature and young. The results of the aggregate model using Eq. (1) are reported in column (1). Columns (2) and (3) report the results of expansionary and contractionary cycles as defined in Eqs. (2) and (3) respectively. We have 90,107 firm-year observations during the expansionary cycle and 47,441 firm-year observations during the contractionary cycle. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively

the lower access of young firms to external capital (see Durante et al. 2020; Haskel 2020), yet the access could improve with an increased money supply. Moreover, due to lack of collateral (see Haskel 2020), young firms find it difficult to access a low lending rate. YOFs only get access to bank liquidity when the prime rate is high and mature firms avoid this lending, rather financing investment from internal sources. Finally, the negative YOF*TS interaction implies that the market is factoring high risk into the bonds issued by YOFs and hence widening the spread, affecting Fscores negatively compared to mature firms.

The firm-level variables in Table 7 all follow what we have observed in Table 6. YOFs could improve their Fscores by lowering debt and increasing liquidity, margin, and asset turnover. However, their Fscores are negatively sensitive to return on assets and cash flows from operations when compared to mature firms. Interestingly, the impacts of ROA and CFO are much larger in Table 7 than in Table 6. That means firms' age could capture the dynamic association of ROA and CFO with Fscore better than financial health. For example, YOFs could increase Fscore by 1.67 and 3.2081 respectively by unit improvements in ROA and CFO during a contraction (1.7443 plus − 0.0743 for ROA + YOF*ROA and 3.8497 plus − 0.6416 for CFO + YOF*CFO). The impact is 1.5877 and 2.2448 respectively during expansionary periods. SIZE is positive and statistically significant in columns (1) and (2), suggesting that a firm with higher sales should enjoy better financial health in our aggregate model and during expansions, despite being a young company in the industry.

The economic variables in Table 7 show that CRISIS reduces the financial health of YOF as expected. However, our findings indicate that YOFs fails to compete with mature firms during industrial booms in expansionary periods. Increasing IP is negatively associated with the Fscores of YOFs across the table compared to mature firms, and it is statistically significant at the 10% level in column (2). Inflation also adversely affects the financial health of YOFs. Yet it creates a differential net impact during expansions and contractions (0.0273 plus − 0.0145 = + 0.0128 during expansions, but 0.1038 plus − 0.1781 = − 0.0743 during contractions). Therefore, relative to mature firms, it is evident that YOFs find it difficult to adjust their price level with inflation in expansionary cycle. Moreover, YOFs might fails to hedge against inflation by holding liquid assets (due to weaker financial health) compared to mature firms. In relation to this view, Curtis et al. (2017) argue that the real value of liquid assets erodes in periods of high inflation, prompting US firms to decrease their liquid assets. The impact is expected to be higher on YOFs than mature firms in our paper.

4.3.3 Size of company

In this section we check the robustness of our empirical model estimated in Table 4 by dividing companies into two groups based on the mean log of sales. Note that we have adjusted nominal sales figures for CPI. The results of large (larger than mean) versus small (smaller than mean, SML) firms are exhibited in Table 8. Surprisingly, our findings on the interaction terms of SML suggest that the Fscores of small firms are mostly influenced positively (though not statistically significantly across the table) by monetary policy compared to larger firms. This is true across the table except TS's effect during contractions. Therefore, our results support earlier empirical studies such as Gertler and Gilchrist (1994), Ehrmann (2000), and Cooley and Quadrini (2006) that small firms (SML) are sensitive to monetary policy, and this is true even when a firm's financial health is measured by the Fscore.

Based on our findings, the Fscores of larger firms are negatively affected by the short-term interest rate, yet the adverse impact is lower on SMLs' Fscores. For example, in our aggregate model the influence of a 100 basis point increase in 3MM on SML is only − 0.0464 (− 0.0650 plus 0.0186), compare to − 0.0650 for larger firms. Similarly, the net effect of bank liquidity (BLIQ) is negative on SMLs' Fscores but the size of the impact is less than for larger firms. On the other hand, the net effects of money supply (M2) and term spread (TS) are positive and higher on SMLs' Fscores than for larger firms except the effect of SML*TS in column (3). For example, the net effect of M2 on SML is 0.0381 and

Table 8 Larger versus smaller firms

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	− 0.0650***	− 0.0658***	− 0.1127***
	(0.0044)	(0.0055)	(0.0111)
SML*3MM	0.0186***	0.0053	0.0333**
	(0.0059)	(0.0071)	(0.0166)
M2	− 0.0204***	− 0.0380***	− 0.0411***
	(0.0059)	(0.0075)	(0.0113)
SML*M2	0.0585***	0.0456***	0.0578***
	(0.0085)	(0.0111)	(0.0171)
BLIQ	− 0.0494***	0.0010	− 0.1484***
	(0.0069)	(0.0102)	(0.0198)
SML*BLIQ	0.0044	0.0151	0.0177
	(0.0097)	(0.0139)	(0.0285)
TS	− 0.0328***	− 0.0506***	0.1063***
	(0.0077)	(0.0093)	(0.0325)
SML*TS	0.0478***	0.0555***	− 0.0503
	(0.0104)	(0.0128)	(0.0455)
EXRATE	0.0039***	0.0032***	0.0075***
	(0.0008)	(0.0010)	(0.0019)
SML*EXRATE	0.0023*	0.0027*	0.0055*
	(0.0013)	(0.0015)	(0.0030)
ROA	3.2150***	3.1963***	3.6584***
	(0.1902)	(0.2338)	(0.2660)
SML*ROA	− 1.8878***	− 1.7719***	− 2.2750***
	(0.1987)	(0.2455)	(0.2834)
CFO	4.7551***	4.7306***	4.9237***
	(0.1117)	(0.1424)	(0.1732)
SML*CFO	− 1.8994***	− 2.0696***	− 1.5127***
	(0.1251)	(0.1587)	(0.1951)
LEVER	− 0.6444***	− 0.6308***	− 0.6853***
	(0.0656)	(0.0800)	(0.1185)
SML*LEVER	− 0.0492	− 0.0041	− 0.1690
	(0.0824)	(0.1033)	(0.1495)
LIQUID	0.0319***	0.0303***	0.0489***
	(0.0084)	(0.0098)	(0.0140)
SML*LIQUID	− 0.0072	− 0.0021	− 0.0299**
	(0.0087)	(0.0103)	(0.0144)
MARGIN	0.6521***	0.6829***	0.6026***
	(0.0770)	(0.0890)	(0.1562)
SML*MARGIN	− 0.5990***	− 0.6438***	− 0.4755***
	(0.0773)	(0.0894)	(0.1564)
AST	0.0716***	0.0921***	0.0514*
	(0.0191)	(0.0236)	(0.0287)

Table 8 (continued)

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
SML*AST	0.1588***	0.1571***	0.1581***
	(0.0198)	(0.0248)	(0.0315)
SIZE	0.1199***	0.1194***	0.0760***
	(0.0135)	(0.0154)	(0.0253)
SML*SIZE	− 0.1085***	− 0.0982***	− 0.1414***
	(0.0182)	(0.0213)	(0.0336)
CRISIS	− 0.0680***	− 0.1375***	− 0.0099
	(0.0166)	(0.0217)	(0.0372)
SML*CRISIS	− 0.0639**	− 0.1199***	0.0892
	(0.0261)	(0.0349)	(0.0586)
IP	0.0130***	0.0146***	0.0947***
	(0.0025)	(0.0030)	(0.0212)
SML*IP	− 0.0014	− 0.0103**	− 0.0358
	(0.0038)	(0.0048)	(0.0305)
CPI	0.0319***	0.0221***	0.1499***
	(0.0037)	(0.0042)	(0.0197)
SML*CPI	0.0208***	0.0018	0.0516*
	(0.0062)	(0.0073)	(0.0282)
SML	− 0.5310***	− 0.5471***	− 1.0983***
	(0.1245)	(0.1454)	(0.3340)
Intercept	4.0213***	3.9046***	3.8737***
	(0.1114)	(0.1282)	(0.2678)
Firm years	137,548	90,107	47,441
Adj. R^2	0.3814	0.3407	0.2972
F-statistics	328.16***	236.70***	140.25***
Number of firms	14,877	14,090	11,316
Year & firm FE	Yes	Yes	Yes
Clustered by firms	Yes	Yes	Yes

This table displays the result of monetary policy impact on firm-level Fscores of large versus small firms (SML). We separate our 44 year sample based on the mean of CPI adjusted sales. The aggregate model is reported in column (1) using Eq. (1). Columns (2) and (3) show the results for expansionary and contractionary cycles using Eqs. (2) and (3) respectively. We have 90,107 firm-year observations during the expansionary cycle and 47,441 firm-year observations during the contractionary cycle. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

0.0167 respectively in columns (1) and (3), however the impact is negative on larger firms. Similarly, TS increases the Fscores of SMLs by 0.015 and 0.0049 respectively in columns (1) and (2). In contractions the net effect of TS is negative but the interaction with SML is not statistically significant.

The positive response of SMLs' Fscores to the short-term interest rate, money supply and term spread in column (1) suggests the impact of financial constraints on small firms (e.g., Gertler and Gilchrist 1994; Gilchrist and Himmelberg 1996) relative to larger firms. Furthermore, SML*M2 is significant across Table 8, and SML*TS is significant during expansions. Therefore, we can assert that small firms get better access to funds when the economy has an excess money supply, and when large firms raise less capital from external sources due to higher interest rates or a wider term spread. Our findings further suggest that regardless of the state of the economic cycle, smaller firms are gaining better financial health through the exchange rate channel. During expansions, this may be due to higher earnings from international markets through exports. During contractions this may be due to lower production costs (through lower imported cost of materials) and access to foreign investments.

The firm-level control variables indicate that SMLs can improve their Fscores significantly by improving return on assets (ROA) and cash flow from operations (CFO), but the relative impact is less than for larger firms. However, SMLs achieve a higher Fscore than larger firms by increasing their asset turnover (AST). The impact of leverage on SMLs' Fscores is negative and higher than for larger firms. But the net effect of LIQUID and MARGIN are slightly positive and significantly lower than for larger firms. Interestingly, relative to larger firms, SIZE is negatively associated with Fscore. That means that, as opposed to young firms in Table 7, firm with lower sales within the SML category could achieve better financial health during expansion. This is probably due to their specialized products for niche markets, low sales variability, stable profit and a lesser need for external finance (e.g., Cooper et al. 1986; You 1995).

CRISIS is negative and statistically significant in our aggregate model and during expansionary monetary cycles. Finally, the net effect of industrial production is lower, and for CPI is higher than for larger firms. Therefore, we can conclude that similar to young firms, SMLs fail to compete with larger firms during economic booms but could adjust prices to inflation.

5 Additional robustness and causality checks

In this section we present additional robustness checks on the relationship between Fscores and monetary policy. Table 9 reports the results of simultaneous linkage between our variables of interest after controlling for the lag impact from the previous state of monetary policy. In Table 10 we include several additional control variables.

Column (2) and (3) of Table 9 show the impact of the years when the FOMC announce a decrease or increase of Federal Reserve rate, respectively. That is, the year when monetary policy enters "expansion from contraction" or "contraction from expansion" respectively. Therefore, we will understand the significance of the short run 'time shock' purely from the change of monetary cycles on Fscores after controlling for the lag impact of the previous state of the policy. In both Tables 9 and 10 we find a consistent influence of monetary policy on firm-level Fscores as reported in Table 4.

In Table 9, the short-term interest rate is negatively and significantly associated with the financial health of a firm. The money supply is positive in the aggregate model and negative when monetary policy enters expansions from contractions. BLIQ is negative in column (1) and when entering contractions (column 3), yet positive when entering expansions (column 2). The term spread, on the other hand, is significant in column (1) and (3), and the signs are negative and positive, respectively. EXRATE is positive and significant across the table. All these linkages between Fscores and monetary policy are in line with our earlier findings and true after controlling the lag impact of previous state of the policy cycle.

In Table 10, results with additional control variables further suggest that monetary policy strongly influences firm-level Fscores. The sign and statistical significance are similar

Table 9 Lag periods as control variables

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	ΔEXP	ΔCON
3MM	− 0.0127*		
	(0.0068)		
M2	0.0149***		
	(0.0046)		
BLIQ	− 0.0702***		
	(0.0089)		
TS	− 0.0216**		
	(0.0087)		
EXRATE	0.0053***		
	(0.0006)		
$3MM_{YEAR\Delta EXP}$		− 0.0168***	
		(0.0034)	
$M2_{YEAR\Delta EXP}$		− 0.0635*	
		(0.0348)	
$BLIQ_{YEAR\Delta EXP}$		0.0833***	
		(0.0177)	
$TS_{YEAR\Delta EXP}$		− 0.1360*	
		(0.0766)	
$EXRATE_{YEAR\Delta EXP}$		0.0227**	
		(0.0105)	
$3MM_{YEAR\Delta CON}$			− 0.0372***
			(0.0059)
$M2_{YEAR\Delta CON}$			0.0801***
			(0.0117)
$BLIQ_{YEAR\Delta CON}$			− 0.1815***
			(0.0170)
$TS_{YEAR\Delta CON}$			0.2359***
			(0.0238)
$EXRATE_{YEAR\Delta CON}$			0.0319***
			(0.0030)
$3MM_{(t-1)}$	− 0.0825***	− 0.0619***	− 0.0566***
	(0.0073)	(0.0033)	(0.0033)
$M2_{(t-1)}$	0.0393***	0.0447***	0.0467***
	(0.0039)	(0.0037)	(0.0037)
$BLIQ_{(t-1)}$	− 0.0459***	− 0.0238***	− 0.0068
	(0.0054)	(0.0050)	(0.0052)
$TS_{(t-1)}$	0.0216***	− 0.0010	− 0.0284***
	(0.0074)	(0.0061)	(0.0064)
$EXRATE_{(t-1)}$	0.0019***	0.0033***	0.0024***
	(0.0007)	(0.0007)	(0.0008)
ROA	1.7390***	1.7464***	1.7326***
	(0.0697)	(0.0692)	(0.0697)
CFO	3.1415***	3.1110***	3.1042***

Table 9 (continued)

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	ΔEXP	ΔCON
	(0.0594)	(0.0598)	(0.0597)
LEVER	− 0.7958***	− 0.8102***	− 0.8227***
	(0.0465)	(0.0464)	(0.0464)
LIQUID	0.0251***	0.0253***	0.0258***
	(0.0033)	(0.0033)	(0.0033)
MARGIN	0.0520***	0.0478***	0.0465***
	(0.0115)	(0.0113)	(0.0113)
AST	0.1998***	0.1920***	0.1845***
	(0.0121)	(0.0121)	(0.0120)
SIZE	0.0174*	0.0381***	0.0515***
	(0.0092)	(0.0084)	(0.0085)
CRISIS	− 0.0096	− 0.0646***	0.0199
	(0.0145)	(0.0150)	(0.0150)
IP	0.0101***	0.0091***	0.0097***
	(0.0020)	(0.0017)	(0.0017)
CPI	0.0348***	0.0452***	0.0365***
	(0.0037)	(0.0035)	(0.0035)
Intercept	4.6749***	4.6398***	4.6014***
	(0.0579)	(0.0555)	(0.0566)
Observations	134,969	134,969	134,969
Adj. R^2	0.3361	0.3519	0.3623
F-statistic	411.99***	404.92***	407.52***
Number of firms	14,836	14,836	14,836
Year & firm FE	Yes	Yes	Yes
Clustered by firms	Yes	Yes	Yes

In this table we report the simultaneous association of Fscores with monetary policy after controlling for the lag impact of monetary policy variables. Column (1) shows the results of our empirical model presented in Eq. (4). Columns (2) and (3) display the results of the short run 'time shock' purely from the change of monetary cycles on Fscores after controlling for the lag impact of the previous state; we use Eqs. (5) and (6) respectively. Here, $YEAR\Delta EXP$ = the year when FOMC announce a decrease of Federal Reserve rate $YEAR\Delta CON$ = the year when FOMC announce an increase of Federal Reserve rate. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

to our previous findings, except M2. Money supply becomes a statistically significant factor in determining financial health during contractions.

The sign and significance of firm-level control variables in both Tables 9 and 10 are consistent with earlier findings. Excess leverage could adversely affect the Fscore, yet return on assets, cash flows from operations, liquidity, profit margin and asset turnover are

Table 10 Additional control variables

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	− 0.0618***	− 0.0656***	− 0.2593***
	(0.0037)	(0.0043)	(0.0313)
M2	0.0089*	− 0.0111*	0.0441***
	(0.0047)	(0.0063)	(0.0115)
BLIQ	− 0.0349***	0.0164*	− 0.3626***
	(0.0058)	(0.0085)	(0.0451)
TS	− 0.0205***	− 0.0388***	0.2300***
	(0.0068)	(0.0080)	(0.0380)
EXRATE	0.0047***	0.0053***	0.0200***
	(0.0007)	(0.0008)	(0.0032)
ROA	2.3256***	2.4264***	2.3535***
	(0.0853)	(0.1076)	(0.1288)
CFO	3.5218***	3.4036***	3.9153***
	(0.0720)	(0.0892)	(0.1091)
LEVER	− 0.7545***	− 0.7141***	− 0.8567***
	(0.0504)	(0.0616)	(0.0929)
LIQUID	0.0171***	0.0185***	0.0200***
	(0.0037)	(0.0045)	(0.0064)
MARGIN	0.0452***	0.0366**	0.0914***
	(0.0144)	(0.0172)	(0.0239)
AST	0.2088***	0.2241***	0.1607***
	(0.0144)	(0.0175)	(0.0224)
SIZE	0.0333***	0.0369**	0.0306
	(0.0125)	(0.0145)	(0.0239)
CRISIS	− 0.0482***	− 0.0694***	0.0898
	(0.0144)	(0.0190)	(0.1145)
IP	0.0182***	0.0090***	0.1987***
	(0.0021)	(0.0025)	(0.0271)
CPI	0.0330***	0.0339***	0.3108***
	(0.0062)	(0.0087)	(0.0511)
RISK	− 0.0074	0.0357	− 0.0212
	(0.0411)	(0.0478)	(0.0766)
UNEMP	− 0.0068	0.0053	− 0.1266***
	(0.0051)	(0.0056)	(0.0343)
MKTR	0.1137**	0.1084***	0.9901***
	(0.0326)	(0.0378)	(0.1928)
OIL	0.0001	0.0006*	− 0.0146***
	(0.0002)	(0.0003)	(0.0034)
Intercept	5.2278***	5.1348***	4.5855***
	(0.0668)	(0.0782)	(0.2099)
Firm years	124,230	81,127	43,103
Adj. R^2	0.2926	0.2731	0.2669

Table 10 (continued)

Variables	Dependent variable: firm-level Fscores		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
F-statistic	346.94***	261.02***	142.09***
Number of firms	13,192	12,455	10,026
Year & firm FE	Yes	Yes	Yes
Clustered by firms	Yes	Yes	Yes

This table shows the influence of monetary policy on firm-level Fscores using additional control variables in Eqs. (1), (2) and (3). Due to missing observations of additional control variables, our firm-year observations during the expansionary cycle were reduced to 81,127 in this table, and during the contractionary cycle, they were reduced to 43,103 observations. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

positively associated with the financial health of a firm. Among the other variables, SIZE, IP and CPI are positive and CRISIS is negatively related to Fscores.

We have included additional control variables in Table 10: RISK, UNEMP, MKTR and OIL as defined in Table 1. Capital market returns are positively associated with Fscores across the table. This highlights the possibility that firms might be benefiting from growth in the capital market (including equity financing via seasoned issues and investment choices) and access to international trade. The oil price affects the Fscore adversely during contractions, as it may raise the production cost coupled with the cost of financing.

6 Conclusion

There has been longstanding empirical evidence of the profitability of value stocks overgrowth stocks. Given this evidence, investors try to set up profitable strategies using value stocks, but many value stocks do in fact lose money. Piotroski's Fscore (2000) is a leading innovation to identify financially strong value stocks that investors can use to change the returns distribution. However, the Fscore has not been examined so far to assess its resilience. More specifically, we do not know how the Fscore may be affected by macroeconomic policy changes over the time. This is important because even after identifying financially strong companies, the Fscore of those companies may change only due to macroeconomic policy changes. Therefore, examining the resilience of the Fscore is important in the interests of value investors.

In order to understand the resilience of the Fscore to macroeconomic policies, we use financial and macroeconomic data from the US over a 44-year window starting from 1973 and ending in 2016. Our dataset includes 655,028 firm-level yearly observations of all publicly listed companies in the US. The paper has tested the resilience by using four main macroeconomic variables—the short-term interest rate, the liquidity of the banking sector, the term spread and money supply. The study has controlled for various firm level (such as ROA, CFO, LEVER, LIQUID, SIZE, RISK and AGE) and macroeconomic variables (such as CRISIS, UNEMP, IP and CPI). Using appropriate economic methods and various robustness tests, we have found that all four main macroeconomic variables are highly significant over the sample periods and during expansionary episodes. In particular the effect of the short-term interest rate (3MM) on Fscore is negative and highly significant during both expansions and contractions. The negative association of 3MM therefore supports the earlier literature that a higher interest rate increases firms' borrowing costs and thus limits their available funds for investment opportunities. The liquidity of the banking sector (BLIQ) is negative and significant in our aggregate model and during contractionary periods. The negative sign of BLIQ indicates the adverse effect of a higher prime lending rate over and above the base rate on firms' financial health in our 44-year sample period. Similarly, term spread (TS) is found to be negative and statistically significant in our analysis. That means that the Fscore is adversely affected by a higher term spread in our overall sample and during an expansionary monetary policy cycle. Results therefore highlight the impact of monetary policy on firm performance via the credit channel.

All the firm-level accounting variables that underlie the Fscore are found to be significant. Among the general economic indicators, CRISIS is negative and significant in our overall sample and during expansions, i.e. Fscores decrease during crises. The proxy for the economic cycle (IP) is positive and significant across our three models, showing the identity between economic growth and better firm performance. However, we found CPI to be positively associated with Fscore.

Using 25th and 75th percentile values of the variables in our main regression, we showed that a 0.59 difference in the Fscore could result based on the monetary policy and economic conditions at the time. This compares to a 1.22 potential difference due to our company-level control variables, which is the only influence that investors would currently expect to see manifested in the Fscore. This is an economically significant amount, showing that investors should take the prevailing economic conditions into account if using the Fscore to screen stocks. During contractionary cycles the monetary and economic factors, in particular 3MM, CPI and IP, actually influence the Fscore more heavily than the firm-specific factors. It is therefore particularly important to be cognizant of the economic and monetary environment if using the Fscore during a downturn.

For robustness checks, we split the sample between high versus low performing firms (based on Fscore), young versus mature (dividing by mean age of firms), and large versus small (dividing by CPI-adjusted mean of sales). The interaction results suggest that monetary policy significantly influences the Fscores of low performing firms in the US in relation to high performing firms. The Fscores of young firms are significantly affected by monetary policy. However, our findings on the interaction terms of small firms suggest that although their Fscores are influenced by an active monetary policy, the effect is not statistically significant compared to larger firms.

This paper is the first attempt to examine the resilience of Fscore to macroeconomic policies. Due to space limitations we have not attempted to improve the Fscore to take account of monetary and economic variables when forecasting returns. The results provide important implications for investors. Piotroski's (2000) finding that the Fscore helps to identify financially stronger firms and thus improve the returns distribution of value investors remains valid, however this paper provides evidence that this expectation of higher returns may be disrupted by macroeconomic changes. Therefore, the Fscore as a tool to identify better investment opportunities should be applied with great care amid macroeconomic volatility.

Appendix

See Table 11.

Table 11 Baseline regression using industry fixed effects

Variables	Dependent variable: firm-level Fscore		
	(1)	(2)	(3)
	All data	Expansionary cycle	Contractionary cycle
3MM	− 0.0204**	− 0.0211***	− 0.0397***
	(0.0046)	(0.0048)	(0.0026)
M2	0.0469***	− 0.0431***	0.0171
	(0.0028)	(0.0026)	(0.0159)
BLIQ	− 0.0526***	0.0872***	− 0.0159***
	(0.0075)	(0.0074)	(0.0022)
TS	− 0.0311***	− 0.0252***	0.0821**
	(0.0054)	(0.0057)	(0.0408)
EXRATE	0.0272***	0.0259***	0.0127***
	(0.0094)	(0.0094)	(0.0019)
ROA	1.2422***	1.3968***	0.8635***
	(0.0462)	(0.0595)	(0.0693)
CFO	3.0074***	2.8341***	3.4412***
	(0.0434)	(0.0531)	(0.0648)
LEVER	− 0.2333***	− 0.1145***	− 0.1102**
	(0.0260)	(0.0317)	(0.0454)
LIQUID	0.0037*	0.0067***	0.0091***
	(0.0020)	(0.0024)	(0.0034)
MARGIN	0.0317***	0.0262***	0.0483***
	(0.0051)	(0.0059)	(0.0102)
AST	0.0098**	0.0278***	0.0668***
	(0.0046)	(0.0059)	(0.0073)
SIZE	0.1202***	0.1108***	0.0035
	(0.0024)	(0.0030)	(0.0040)
CRISIS	− 1.5166***	− 1.4725***	0.0602
	(0.2987)	(0.2987)	(0.0605)
IP	0.0718***	0.0706***	0.1782***
	(0.0118)	(0.0118)	(0.0283)
CPI	0.1080***	0.1032***	0.4878***
	(0.0312)	(0.0312)	(0.0256)
Intercept	7.4348***	6.9413***	3.2968***
	(2.0936)	(2.0929)	(0.2688)
Firm years	137,548	90,107	47,441
Adj. R^2	0.2516	0.2442	0.2659
F-statistics	600.96***	518.40***	592.73***
Number of firms	14,877	14,090	11,316
Year & industry FE	Yes	Yes	Yes
Clustered by firm	Yes	Yes	Yes

This table displays the results of our baseline model using industry fixed effects. We have 90,107 firm-year observations during the expansionary cycle and 47,441 firm-year observations during the contractionary cycle. The variable definitions are available in Table 1. The standard errors are clustered by firm and reported in parentheses

***, ** and * denote statistical significance at the 1%, 5% and 10% levels respectively

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