Finance Research Letters 44 (2022) 102037

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Firm efficiency and stock returns during the COVID-19 crisis

Daniel Neukirchen *, Nils Engelhardt, Miguel Krause, Peter N. Posch

TU Dortmund University, Faculty of Business and Economics, Chair of Finance, Otto-Hahn-Str. 6, Dortmund 44227, Germany

A R T I C L E   I N F O

JEL classification:
G01
G11

Keywords:
COVID-19
Firm efficiency
Resiliency

A B S T R A C T

We investigate the relationship between firm efficiency and stock returns during the COVID-19 pandemic. We find that highly efficient firms experienced at least 9.44 percentage points higher cumulative returns during the market collapse. A long-short portfolio consisting of efficient and inefficient firms would have also yielded a significantly positive weekly return of 3.53% on average. Overall, our results show that firm efficiency has significant explanatory power for stock returns during the crisis period.

1. Introduction

In theory, there is consensus that the efficiency with which firms operate and make use of their resources determines their future cash flows, and thus their respective stock prices (Fama, 1990; Subrahmanyam and Titman, 2001; Vuolteenaho, 2002). However, there are two contrasting views on how firm efficiency affects stock returns. On the one hand, firms using their resources inefficiently may have more risky future cash flows. To be attractive for (risk averse) investors, these firms may therefore have higher required rates of return. Further, more efficient firms may also earn higher profits and have a stronger position in the market due to their lower costs of production (Demsetz, 1973; Peltzman, 1977). This makes them less susceptible to demand side shocks and industry competition; and investors require a lower rate of return (Nguyen and Swanson, 2009). On the other hand, a firm which uses its resources more efficiently has more certain future cash flows and a significantly lower risk of corporate default. Thus, the firm should be valued higher by investors (Frijns et al., 2012).

So far, the empirical evidence regarding the relationship between a firm's efficiency and its stock returns is not only ambiguous but also rather limited. Nguyen and Swanson (2009) use Stochastic Frontier Analysis (SFA) to determine firm efficiency scores and find that portfolios consisting of highly efficient firms experience significantly lower returns than those consisting of inefficient firms. They also document a significant negative association in the cross-section between firm efficiency and stock returns for US firms in the period from 1980 to 2003. In contrast, Frijns et al. (2012) use Data Envelopment Analysis (DEA) to determine firm efficiency scores and show that portfolios composed of efficient US firms outperformed those composed of inefficient firms in the period from 1988 to 2007.

In this paper, we use the COVID-19 crisis and a sample of 884 US firms to shed further light on this relationship. The COVID-19 crisis and the respective lockdown led to an enormous temporary decline in revenues and to uncertainty about a firm's future cash flows (Fahlenbrach et al., 2020). Thus, we argue that firms using their resources more efficiently should be more resilient during the crisis period as their risk of corporate default is significantly lower. Therefore, these firms should be valued higher by investors.

Our empirical results support this hypothesis. Using efficiency scores calculated from both SFA and DEA, we find that more efficient firms experienced higher returns during the period where US stock markets declined dramatically. For instance, we document that

* Corresponding author.
E-mail address: daniel.neukirchen@udo.edu (D. Neukirchen).

https://doi.org/10.1016/j.frl.2021.102037
Received 25 January 2021; Received in revised form 18 March 2021; Accepted 30 March 2021
Available online 31 March 2021
1544-6123/

Table 1
This table presents the estimated parameters from the stochastic frontier analysis (SFA) and, for the purpose of comparison, from an OLS regression using accounting data for the year 2019. The dependent variable is the natural logarithm of a firm's market equity. All independent variables are defined in Table A.1 in the appendix. Both specifications also include industry-fixed effects based on the Fama & French 48-industry classification. Further, we report the expected sign on each coefficient following the argumentation in Nguyen and Swanson (2009). Standard errors are reported in parentheses, with ***, **, * denoting statistical significance at the 1%, 5%, and 10% level.

Dependent Variable: *ln(Market equity)*	*SFA*	*OLS*	*Expected Sign*
Size	0.9075***	0.9085***	+
	(0.0165)	(0.0170)	
CAPEX / sales	0.2203	0.1512	+
	(0.3470)	(0.3476)	
Long-term debt / assets	–0.1095	–0.1340	Indeterminant
	(0.1401)	(0.1431)	
EBITDA / sales	1.1682***	1.1593***	+
	(0.2207)	(0.2304)	
R&D / sales	0.0128*	0.0137**	+
	(0.0067)	(0.0068)	
Net property / sales	–0.5228***	–0.5212***	Indeterminant
	(0.1070)	(0.1098)	

firms having an efficiency score in the top decile had at least 9.44 percentage points higher cumulative returns. We also test whether there is a similar pattern during the Global Financial Crisis (GFC), but we do not find a statistically significant relation between the stock returns during the crisis period and firm efficiency. However, this might due to the substantial differences between the two crises. The GFC originated in the financial sector and did not have an immediate real effect on most firms' ability to produce and to generate cash flows (Fahlenbrach et al., 2020). Thus, investors might not have put as much emphasis on a firm's fundamentals and its efficiency compared to the COVID-19 pandemic.

We contribute to the existing literature in at least two ways. First, we contribute to the literature mentioned above examining the relationship between firm efficiency and stock returns (Frijns et al., 2012; Nguyen and Swanson, 2009). Second, we contribute to the emerging literature investigating the impact of the COVID-19 pandemic on global financial markets (see e.g Contessi and De Pace, 2021; Engelhardt et al., 2020b; Espinosa-Méndez and Arias, 2020; Zaremba et al., 2020; Zhang et al., 2020). Our paper more closely relates to the studies documenting that firms with higher financial flexibility (Fahlenbrach et al., 2020; Ramelli and Wagner, 2020) and firms with higher environmental and social ratings and higher CSR activity (Albuquerque et al., 2020; Ding et al., 2020) performed better during the COVID-19 crisis, while firms with lower credit-ratings performed worse (Acharya and Steffen, 2020). Also, Landier and Thesmar (2020) report that the stock prices' decline is associated with analysts' forecast revisions, while Cheema-Fox et al. (2020), Engelhardt et al. (2020a) and Cepoi (2020) employ cross-country data to show that stock price reactions are strongly associated with news sentiment and news attention.

The remainder of this paper is structured as follows: Section 2 describes the data, Section 3 presents our empirical results, and Section 4 concludes.

2. Data

We obtain financial and accounting data for 884 US firms from Compustat/Capital IQ. We exclude financial companies and companies whose stock trades for less than $5 per share. We also require the firms' stocks to be traded on the main US stock exchanges for at least two years.

Our main independent variable of interest is a firm's efficiency score based on accounting data for the year 2019, which we obtain by conducting both SFA and DEA (for an overview, see Koetter et al. (2006); for more detail, see e.g. Aigner et al. (1977); Chambers et al. (1996); Charnes et al. (1978); Meeusen and van Den Broeck (1977)). Following the existing literature (Frijns et al., 2012; Habib and Ljungqvist, 2005; Nguyen and Swanson, 2009), we use the natural logarithm of the market value of equity as the output and the following set of variables as the inputs: the natural logarithm of total assets, the ratio of capital expenditures (CAPEX) to sales, the ratio of long-term debt to assets, the ratio of earnings before interest, taxes, depreciation and amortization (EBITDA) to assets, the ratio of research and development expenditures (R&D) to sales and the ratio of net property to sales. Additionally, we include industry dummies. A description of the construction of these variables and of our other control variables is provided in appendix Table A.1. We obtain the efficiency scores as part of the composite error term from the SFA and by solving the DEA optimization problem of the output over input ratio. The correlation between the scores is approximately 60%.

For an overview of how the inputs relate to the output variable, we show the results from the SFA and a similar ordinary least squares (OLS) regression and report the expected signs following the argumentation in Nguyen and Swanson (2009) in Table 1. Overall, the results are broadly in line with those in Nguyen and Swanson (2009).

To study the association between firm efficiency and stock returns during the COVID-19 crisis, we use the cumulative raw stock

Table 2
This table reports descriptive statistics for our sample consisting of 884 US firms. Stock and accounting data come from Compustat/Capital IQ. We define all variables in detail in Appendix A.1 in the appendix.

	Obs.	Min.	Max.	Mean	Median	Std.
Raw returns	884	–1.3177	0.1203	–0.4531	–0.4149	0.2698
Abnormal returns	884	–0.9806	0.6910	–0.0168	–0.0006	0.3051
SFA	884	0.5043	0.8856	0.7801	0.7900	0.0600
DEA	884	0.4362	1.0000	0.8060	0.8083	0.1053
Size	884	3.6034	12.1755	7.6272	7.5423	1.7400
Long-term debt / assets	884	0.0000	1.0454	0.2572	0.2477	0.1989
Short-term debt / assets	884	0.0000	0.3064	0.0306	0.0137	0.0471
Cash / assets	884	0.0018	0.9111	0.2189	0.1375	0.2205
ROA	884	–0.5884	0.2835	0.0208	0.0468	0.1391
Market-to-book	884	–39.2491	72.8084	5.6060	3.5150	11.6653
Negative Market-to-book	884	0.0000	1.0000	0.0464	0.0000	0.2104
Momentum	884	–0.0154	0.0099	–0.0004	–0.0001	0.0048
Historical Volatility	884	0.1417	0.8127	0.3644	0.3403	0.1332

returns and the cumulative abnormal stock returns[1] for the period from February 3, 2020 through March 23, 2020, the so-called ”collapse period” as defined in Fahlenbrach et al. (2020), as the main dependent variables in our baseline regression. Additionally, we employ weekly returns in Fama-MacBeth (FMB) (Fama and MacBeth, 1973) and Fixed Effects (FE) regressions to ensure the validity of our results.

Table 2 provides summary statistics.

We find mean and median raw returns over the collapse period to be almost identical to Fahlenbrach et al. (2020), amounting to roughly − 45.31% and − 41.49%, respectively. The standard deviation of 26.98% (30.51%) shows that there is, however, large variation. The mean of the SFA efficiency scores is 78.01%, while the mean of the DEA efficiency scores is slightly higher at 80.60%. Concerning control variables, we find the average firm to own $9.802 billion in terms of total assets. Further, the average firm's return on assets (ROA) is 2.08%, its cash-to-assets ratio is 21.89% and its market-to-book ratio is 5.60.

3. Empirical analysis and results

To test for a relationship between stock returns and firm efficiency during the COVID-19 crisis, we perform a baseline OLS regression where we regress the cumulative (abnormal) stock returns during the collapse period on the firm efficiency scores, various control variables and industry dummies (based on the Fama & French 48-industry classification). The controls are similar to those in related studies (Albuquerque et al., 2020; Fahlenbrach et al., 2020; Lins et al., 2017; Ramelli and Wagner, 2020). Table 3 presents the results.

In Panel A, we show the regression results where the dependent variable is the cumulative raw stock return. Regardless of whether we control for industry effects only (columns (1) and (2)) or for industry effects and further firm characteristics (columns (3) and (4)), we find positive and highly statistically significant coefficients on the two efficiency scores *SFA* and *DEA*. For instance, we find that a one standard deviation increase in *SFA* (*DEA*) results in 11.86 (11.76) percentage points higher cumulative returns (in terms of its standard deviation) during the collapse period (columns (3) and (4)). In terms of the control variables, the picture is similar to the one found in related studies (Albuquerque et al., 2020; Ding et al., 2020; Fahlenbrach et al., 2020). While firms with less financial flexibility and higher prior stock volatility performed worse, those with better prior operating performance performed better.

In Panel B, we present the results where we regress the cumulative abnormal stock return on our firm efficiency scores and various controls. Across all columns, we also find positive and statistically significant coefficients on our two efficiency scores. In line with our previous results, this indicates that firms which use their resources more efficiently performed significantly better. Although not reported for reasons of brevity, we find the signs of the coefficients on the control variables to be almost identical to the regressions shown above. The only noteworthy differences are negative and statistically significant coefficients on *Momentum* and positive and statistically significant coefficients on *Historical Volatility*.

We also perform FMB and FE regressions of the weekly stock returns on our efficiency scores and the same control variables to validate our findings. Table 4 presents the results.

In columns (1) and (2), we present the results from the FMB regressions and find positive and statistically significant coefficients on our efficiency scores. In columns (3) and (4), we show the results from the FE regressions. While we find a positive and statistically significant coefficient on *SFA*, statistical significance slightly vanishes regarding the coefficient on *DEA*. In terms of control variables, we find a similar picture as in the baseline regressions. Overall, the results support the view that firm efficiency had a positive impact on stock returns during the crisis period.

Although not reported for reasons of brevity, we also test whether we find a similar pattern during the GFC. However, using the same methodology as above and the crisis periods as defined in Lins et al. (2017) and Goldman (2020), and the recession period

[1] The expected returns are based on market model estimations. We estimate firms' betas employing stock returns for the year 2019 and the returns of the S&P 500 index.

Table 3
This table shows the results from OLS regressions. In Panel A, we employ a firm's cumulative raw stock return for the period from February 3, 2020 to March 23, 2020, the so-called collapse period as defined in Fahlenbrach et al. (2020), as the dependent variable. The main independent variables of interest are both firm efficiency scores *SFA* and *DEA*. The efficiency scores are calculated from the Stochastic Frontier Analysis and the Data Envelopment Analysis, respectively. We define all variables in detail in Table A.1 in the appendix. Across all columns, we control for industry-fixed effects based on the Fama & French 48-industry classification. In columns (3) and (4), we further include control variables for a variety of firm characteristics. In Panel B, we employ a firm's cumulative abnormal return (based on market model estimations) for the period from February 3, 2020 to March 23, 2020 as the dependent variable. The regression specifications are similar to Panel A. Across both panels, we report robust standard errors in parentheses, with ***, **, * denoting statistical significance at the 1%, 5%, and 10% level.

Panel A:

Dependent Variable: *Raw returns*

	(1)	(2)	(3)	(4)
SFA	0.8702***		0.5337***	
	(0.1503)		(0.1793)	
DEA		0.6630***		0.3091**
		(0.0950)		(0.1417)
Size			0.0130**	0.0067
			(0.0063)	(0.0074)
Long-term debt / assets			–0.2561***	–0.2381***
			(0.0583)	(0.0590)
Short-term debt / assets			–0.2705	–0.3627**
			(0.1920)	(0.1843)
Cash / assets			0.1829***	0.2065***
			(0.0562)	(0.0542)
ROA			0.3020***	0.2737***
			(0.0849)	(0.0918)
Market-to-book			0.0008	0.0011
			(0.0009)	(0.0009)
Negative Market-to-book			0.0706	0.0818
			(0.0663)	(0.0646)
Momentum			1.7878	0.9015
			(2.1303)	(2.1656)
Historical Volatility			–0.2091**	–0.2372**
			(0.1003)	(0.1042)
Observations	884	884	884	884
Industry Fixed Effects	yes	yes	yes	yes
Adjusted R-Squared	0.22	0.23	0.28	0.28

Panel B:
Dependent Variable: *Abnormal returns*

	(1)	(2)	(3)	(4)
SFA	1.0092***		0.9760***	
	(0.1698)		(0.2045)	
DEA		0.6185***		0.4112**
		(0.1111)		(0.1649)
Observations	884	884	884	884
Firm controls	no	no	yes	yes
Industry Fixed Effects	yes	yes	yes	yes
Adjusted R-Squared	0.26	0.25	0.33	0.31

defined by the National Bureau of Economic Research (NBER), we cannot document a robust positive association[2] between firm efficiency and stock returns during the GFC. We relate this result to the fact that the GFC originated in the financial sector and did not have an immediate real effect on most firms' ability to produce and to generate cash flows. Hence, investors might not have put as much emphasis on a firm's fundamentals and its efficiency compared to the COVID-19 pandemic.

Robustness

To ensure the validity of our results regarding the COVID-19 crisis, we conduct a battery of further robustness checks. First, we run the same regressions using the efficiency scores estimated on the basis of accounting data for the year 2018. The rationale behind is

[2] We find positive and statistically significant coefficients in some baseline specifications, but statistical significance vanishes particularly in the FMB and FE regressions. Thus, we cannot document a robust positive association between firm efficiency and stock returns during the GFC.

Table 4
This table presents the results from Fama-MacBeth regressions (columns (1) and (2)) and Fixed Effects regressions (columns (3) and (4)). The dependent variable is the firm's weekly stock return for the period from February 3, 2020 to March 23, 2020, the so-called collapse period as defined in Fahlenbrach et al. (2020). The main independent variables of interest are both firm efficiency scores *SFA* and *DEA*. The efficiency scores are calculated from the Stochastic Frontier Analysis and the Data Envelopment Analysis, respectively. We define all variables in detail in Table A.1 in the appendix. Across all columns, we control for industry-fixed effects based on the Fama & French 48-industry classification and week-fixed effects. We report robust standard errors in parentheses, with ***, **, * denoting statistical significance at the 1%, 5%, and 10% level.

Dependent Variable: *Weekly returns*				
	(1)	(2)	(3)	(4)
SFA	0.0674***		0.0674***	
	(0.0205)		(0.0248)	
DEA		0.0291**		0.0291
		(0.0129)		(0.0193)
Size	0.0018*	0.0013	0.0018***	0.0013
	(0.0010)	(0.0009)	(0.0006)	(0.0008)
Long-term debt / assets	–0.0344*	–0.0322*	–0.0344***	–0.0322***
	(0.0200)	(0.0189)	(0.0067)	(0.0056)
Short-term debt / assets	–0.0477	–0.0538	–0.0477	–0.0538
	(0.0402)	(0.0397)	(0.0428)	(0.0431)
Cash / assets	0.0153**	0.0188**	0.0153*	0.0188**
	(0.0072)	(0.0079)	(0.0089)	(0.0079)
ROA	0.0371**	0.0319**	0.0371***	0.0319**
	(0.0162)	(0.0148)	(0.0120)	(0.0156)
Market-to-book	0.0001	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Negative Market-to-book	0.0089	0.0100	0.0089*	0.0100*
	(0.0086)	(0.0082)	(0.0053)	(0.0057)
Momentum	0.7867**	0.7228***	0.7867***	0.7228***
	(0.3092)	(0.2440)	(0.1633)	(0.1743)
Historical Volatility	–0.0408	–0.0424	–0.0408**	–0.0424**
	(0.0265)	(0.0269)	(0.0171)	(0.0181)
Observations	7016	7072	7016	7072
Estimator	FMB	FMB	FE	FE
R-Squared	0.01	0.01	0.01	0.01

that firm fundamentals for the year 2019 might not have not been available to investors during the collapse period. This is also the reason why Nguyen and Swanson (2009) run their cross-sectional regressions of monthly stock returns from July of year t to June of year $t+1$ on efficiency scores estimated on the basis of accounting data from December of year $t-1$. Nonetheless, we find even slightly more pronounced results using these scores in unreported regressions.

Second, we re-estimate the baseline regressions using dummy variables indicating whether a firm is highly efficient. Specifically, we define highly efficient firms as those with an efficiency score in the top decile of our sample as done in Frijns et al. (2012) and Nguyen and Swanson (2009). We find positive and highly statistically significant coefficients (1% level) on our dummy variables except for the regression using the efficiency scores obtained from DEA and controlling for further firms characteristics.[3] Although the coefficient remains positive in this regression, statistical significance slightly vanishes. The other results, however, indicate that highly efficient firms experienced at least 9.44 percentage points higher cumulative returns during the collapse period using the efficiency scores obtained from SFA. In additional regressions, we also find that the results are robust to changing the cut-off level to define efficient firms. For instance, we use the 75th percentile as well as the median as cut-off levels and find positive and statistically significant coefficients in all regressions.

Third, we re-estimate the FMB and FE regressions using the dummy variables and find qualitatively similar results.

Fourth, we also run the baseline regressions as well as the FMB regressions using alternative time windows to define the period where the market collapsed. For instance, we use the first quarter of 2020 as in Albuquerque et al. (2020), the period from February 19, 2020 to March 23, 2020 as well as the "fever period" of Ramelli and Wagner (2020) from February 24, 2020 to March 20, 2020 and find similar results. Appendix Table A.2 displays the results from the baseline regressions using these time windows.[4]

Fifth, we also construct ten equally-weighted and value-weighted portfolios based on our efficiency scores and investigate their mean weekly returns during the collapse period. Moreover, we construct a zero-cost portfolio called "Spread" which goes long in the portfolio of the highly efficient firms and short in the portfolio of the highly inefficient firms. For each portfolio, we present the mean efficiency scores, the mean weekly returns as well as its standard deviation in Table 5.

In line with our previous results, we find that the portfolios of the highly efficient firms significantly outperform the portfolios of the highly inefficient firms across all columns. The portfolios of the highly efficient firms do not only have a higher return but also offer

[3] This is the model presented in column (4) of Panel A of Table 3.

[4] The coefficients on our variables of interests in the FMB regressions using the alternative time windows are also positive and statistically significant in all specifications. The results are available upon request.

Table 5
This table shows the distribution of the weekly returns for all 10 efficiency score (ES) portfolios and the Spread portfolio over the collapse period from February 3, 2020 through March 23, 2020. The statistics include the mean and standard deviation. Additionally, we provide the mean efficiency score of each portfolio. We construct portfolios based on the SFA and the DEA method. For both methods we build equally-weighted portfolios and portfolios weighted by market value. We define all variables in detail in Table A.1 in the appendix. ***, **, * denote statistical significance at the 1%, 5%, and 10% level.

	SFA					DEA				
		Equally-weighted		*Value-weighted*			*Equally-weighted*		*Value-weighted*	
Portfolio	Eff.	Mean	Std.	Mean	Std.	Eff.	Mean	Std.	Mean	Std.
Inefficient	0.6525	–0.0617***	0.1497	–0.0674***	0.1206	0.6084	–0.0672***	0.1679	–0.0838***	0.1200
PF2	0.7207	–0.0570***	0.1414	–0.0592***	0.1624	0.7014	–0.0625***	0.1475	–0.0757***	0.0855
PF3	0.7488	–0.0581***	0.1408	–0.0344***	0.0782	0.7385	–0.0647***	0.1465	–0.0935***	0.1383
PF4	0.7678	–0.0512***	0.1288	–0.0446***	0.1238	0.7723	–0.0550***	0.1344	–0.0679***	0.0692
PF5	0.7825	–0.0553***	0.1307	–0.0634***	0.2295	0.7977	–0.0548***	0.1288	–0.0761***	0.1054
PF6	0.7965	–0.0494***	0.1337	–0.0384***	0.0667	0.8223	–0.0466***	0.1223	–0.0528***	0.0699
PF7	0.8097	–0.0497***	0.1229	–0.0473***	0.0810	0.8512	–0.0493***	0.1279	–0.0550***	0.0617
PF8	0.8233	–0.0458***	0.1255	–0.0417***	0.1170	0.8791	–0.0395***	0.1071	–0.0498***	0.0700
PF9	0.8395	–0.0450***	0.1207	–0.0374***	0.0873	0.9172	–0.0322***	0.0996	–0.0385***	0.0531
Efficient	0.8603	–0.0342***	0.1171	–0.0337***	0.0556	0.9778	–0.0357***	0.1156	–0.0342***	0.0549
Spread		0.0281***	0.1450	0.0321***	0.1379		0.0318***	0.1617	0.0492***	0.1353

lower risk in terms of standard deviation. Further, except for some minor outliers, we also find a clear pattern of portfolios composed of more efficient firms to perform significantly better across all columns. Finally, regarding the ”Spread” portfolio, we document that a long-short strategy would have experienced on average a significant 3.53% weekly return during the collapse period.

4. Conclusion

In conclusion, we find that firm efficiency significantly explains stock returns during the COVID-19 pandemic. In fact, highly efficient firms outperformed inefficient firms by at least 9.44 percentage points in terms of cumulative returns. This indicates that investors valued firms which used resources more efficiently and had thus more promising future cash flows and a potentially lower risk of corporate default. However, we do not see similar pattern when investigating this relationship during the GFC. We relate this result to the fact that the GFC originated in the financial sector and did not have an immediate real effect on most firms’ ability to produce and to generate cash flows. Hence, investors might not have put as much emphasis on a firm’s fundamentals and its efficiency compared to the COVID-19 pandemic.

CRediT authorship contribution statement

Daniel Neukirchen: Conceptualization, Methodology, Software, Data curation, Writing - original draft. **Nils Engelhardt:** Conceptualization, Methodology, Software, Data curation, Writing - original draft. **Miguel Krause:** Conceptualization, Methodology, Software, Data curation, Writing - original draft. **Peter N. Posch:** Conceptualization, Writing - original draft.

Appendix A

Table A1
This table provides definitions of the variables. Stock data and accounting data come from Compustat/Capital IQ.

Variable	Definition
Dependent variables:	
Raw returns	The cumulative daily logarithmic return of the stocks’ daily closing prices.
Abnormal returns	The cumulative daily abnormal return calculated as the raw return minus the expected return, which is estimated on the basis of a market model over a one year period ranging from January 2019 to January 2020.
Weekly returns	Weekly logarithmic return based on the stocks’ weekly closing prices.
ln(Market equity)	The logarithm of a firm’s closing price at the end of 2019 times the shares outstanding.
Independent variables:	
SFA	Efficiency scores from the SFA using the logarithm of market equity as the output variable and the natural logarithm of total assets, the ratio of CAPEX to sales, the ratio of long-term debt to assets, the ratio of EBITDA to assets, the ratio of R&D to sales and the ratio of net property to sales as input variables.
DEA	Efficiency scores from the DEA using the logarithm of market equity as the output variable and the same input variables as used in the SFA.

(*continued on next page*)

Table A1 (*continued*)

Variable	Definition
Control variables:	
Size	The logarithm of total assets, winsorized at the 1st and 99th percentiles.
Long-term debt / assets	Long-term debt over total assets, winsorized at the 1st and 99th percentiles.
Short-term debt / assets	Short-term debt over total assets, winsorized at the 1st and 99th percentiles.
Cash / assets	Cash over total assets, winsorized at the 1st and 99th percentiles.
ROA	Return on assets calculated as net income over total assets, winsorized at the 1st and 99th percentiles.
Market-to-book	Market capitalization over book value of equity, winsorized at the 1st and 99th percentiles.
Negative Market-to-book	Dummy variable equalling 1 if the market-to-book ratio is negative, and zero otherwise.
Momentum	Momentum factor based on the four-factor model from Carhart (1997) over a one year period from January 2019 until January 2020, winsorized at the 1st and 99th percentiles.
Historical volatility	Stock volatility of daily raw returns during 2019, winsorized at the 1st and 99th percentiles.
EBITDA / assets	Earnings before interest, taxes, depreciation and amortization over total assets, winsorized at the 1st and 99th percentiles.
CAPEX / sales	Capital expenditures over total sales, winsorized at the 1st and 99th percentiles.
R&D / sales	Research and development expense over total sales, winsorized at the 1st and 99th percentiles.
Net property / sales	Net property expense over total sales, winsorized at the 1st and 99th percentiles.

Table A2
This table shows the results from OLS regressions. In Panel A, we employ either a firm's cumulative raw stock return or the cumulative abnormal stock return as the main dependent variables of interest for the following periods: from January 1, 2020 to March 31, 2020 (columns (1) and (2)), from February 19, 2020 to March 23, 2020 (columns (3) and (4)), and from February 24, 2020 to March 20, 2020 (columns (5) and (6)). The main independent variable of interest is the firm efficiency score *SFA*. In Panel B, the main independent variable of interest is the firm efficiency score *DEA* with the same regression specifications as used in Panel A. The efficiency scores are calculated from the Stochastic Frontier Analysis and the Data Envelopment Analysis, respectively. We define all variables in detail in Table A.1 in the appendix. Across all columns, we control for industry-fixed effects based on the Fama & French 48-industry classification and for a variety of firm characteristics. Across both panels, we report robust standard errors in parentheses, with ***, **, * denoting statistical significance at the 1%, 5%, and 10% level.

Panel A:

	Jan 1 to Mar 31, 2020		*Feb 19 to Mar 23, 2020*		*Feb 24 to Mar 20, 2020*	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
	Raw	Abnormal	Raw	Abnormal	Raw	Abnormal
SFA	0.8081***	1.0627***	0.4406***	0.9313***	0.3763**	0.8178***
	(0.1820)	(0.1852)	(0.1572)	(0.1823)	(0.1565)	(0.1691)
Observations	884	884	884	884	884	884
Firm controls	yes	yes	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes	yes	yes
Adjusted R-Squared	0.32	0.34	0.30	0.33	0.33	0.34

Panel B:

	Jan 1 to Mar 31, 2020		*Feb 19 to Mar 23, 2020*		*Feb 24 to Mar 20, 2020*	
Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
	Raw	Abnormal	Raw	Abnormal	Raw	Abnormal
DEA	0.5462***	0.5977***	0.2592**	0.3725**	0.2464**	0.3515**
	(0.1412)	(0.1482)	(0.1308)	(0.1563)	(0.1214)	(0.1421)
Observations	884	884	884	884	884	884
Firm controls	yes	yes	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes	yes	yes
Adjusted R-Squared	0.32	0.32	0.30	0.31	0.33	0.33

References

Acharya, V.V., Steffen, S., 2020. The risk of being a fallen angel and the corporate dash for cash in the midst of COVID. The Review of Corporate Finance Studies 9 (3), 430–471. https://doi.org/10.1093/rcfs/cfaa013.

Aigner, D., Lovell, C.K., Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. J Econom 6 (1), 21–37. https://doi.org/10.1016/0304-4076(77)90052-5.

Albuquerque, R., Koskinen, Y., Yang, S., Zhang, C., 2020. Resiliency of environmental and social stocks: an analysis of the exogenous COVID-19 market crash. The Review of Corporate Finance Studies 9 (3), 593–621. https://doi.org/10.1093/rcfs/cfaa011.

Carhart, M.M., 1997. On persistence in mutual fund performance. J Finance 52 (1), 57–82. https://doi.org/10.1111/j.1540-6261.1997.tb03808.x.

Cepoi, C.-O., 2020. Asymmetric dependence between stock market returns and news during COVID19 financial turmoil. Finance Research Letters 101658. https://doi.org/10.1016/j.frl.2020.101658.

Chambers, R.G., Chung, Y., Färe, R., 1996. Benefit and distance functions. J Econ Theory 70 (2), 407–419. https://doi.org/10.1006/jeth.1996.0096.

Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring the efficiency of decision making units. Eur J Oper Res 2 (6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8.

Cheema-Fox, A., LaPerla, B.R., Serafeim, G., Wang, H.S., 2020. Corporate resilience and response during COVID-19. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3578167.

Contessi, S., De Pace, P., 2021. The international spread of COVID-19 stock market collapses. Finance Research Letters 101894. https://doi.org/10.1016/j.frl.2020.101894.

Demsetz, H., 1973. Industry structure, market rivalry, and public policy. The Journal of Law and Economics 16 (1), 1–9. https://doi.org/10.1086/466752.

Ding, W., Levine, R., Lin, C., Xie, W., 2020. Corporate immunity to the COVID-19 pandemic. NBER Working Paper Series. https://doi.org/10.3386/w27055.

Engelhardt, N., Krause, M., Neukirchen, D., Posch, P., 2020. What drives stocks during the corona-crash? news attention vs. rational expectation. Sustainability (12), 5014. https://doi.org/10.3390/su12125014.

Engelhardt, N., Krause, M., Neukirchen, D., Posch, P.N., 2020. Trust and stock market volatility during the COVID-19 crisis. Finance Research Letters 101873. https://doi.org/10.1016/j.frl.2020.101873.

Espinosa-Méndez, C., Arias, J., 2020. COVID-19 effect on herding behaviour in European capital markets. Finance Research Letters 101787. https://doi.org/10.1016/j.frl.2020.101787.

Fahlenbrach, R., Rageth, K., Stulz, R.M., 2020. How valuable is financial flexibility when revenue stops? Evidence from the covid-19 crisis. NBER Working Paper Series. https://doi.org/10.3386/w27106.

Fama, E.F., 1990. Stock returns, expected returns, and real activity. J Finance 45 (4), 1089–1108. https://doi.org/10.1111/j.1540-6261.1990.tb02428.x.

Fama, E.F., MacBeth, J.D., 1973. Risk, return, and equilibrium: empirical tests. Journal of Political Economy 81 (3), 607–636. https://doi.org/10.1086/260061.

Frijns, B., Margaritis, D., Psillaki, M., 2012. Firm efficiency and stock returns. Journal of Productivity Analysis 37 (3), 295–306. https://doi.org/10.1007/s11123-011-0246-y.

Goldman, J., 2020. Government as customer of last resort: the stabilizing effects of government purchases on firms. Rev Financ Stud 33 (2), 610–643. https://doi.org/10.1093/rfs/hhz059.

Habib, M.A., Ljungqvist, A., 2005. Firm value and managerial incentives: a stochastic frontier approach. The Journal of Business 78 (6), 2053–2094. https://doi.org/10.1086/497040.

Koetter, M., Karmann, A., Fiorentino, E., 2006. The cost efficiency of German banks: a comparison of SFA and DEA. Technical Report. Discussion Paper Series 2. https://doi.org/10.2139/ssrn.947340.

Landier, A., Thesmar, D., 2020. Earnings expectations during the COVID-19 crisis. The Review of Asset Pricing Studies 10 (4), 598–617. https://doi.org/10.1093/rapstu/raaa016.

Lins, K.V., Servaes, H., Tamayo, A., 2017. Social capital, trust, and firm performance: the value of corporate social responsibility during the financial crisis. J Finance 72 (4), 1785–1824. https://doi.org/10.1111/jofi.12505.

Meeusen, W., van Den Broeck, J., 1977. Efficiency estimation from cobb-Douglas production functions with composed error. Int Econ Rev (Philadelphia) 435–444. https://doi.org/10.2307/2525757.

Nguyen, G.X., Swanson, P.E., 2009. Firm characteristics, relative efficiency, and equity returns. Journal of Financial and Quantitative Analysis 44 (1), 213–236. https://doi.org/10.1017/S0022109009090012.

Peltzman, S., 1977. The gains and losses from industrial concentration. The Journal of Law and Economics 20 (2), 229–263. https://doi.org/10.1086/466902.

Ramelli, S., Wagner, A.F., 2020. Feverish stock price reactions to COVID-19. The Review of Corporate Finance Studies 9 (3), 622–655. https://doi.org/10.1093/rcfs/cfaa012.

Subrahmanyam, A., Titman, S., 2001. Feedback from stock prices to cash flows. J Finance 56 (6), 2389–2413. https://doi.org/10.1111/0022-1082.00409.

Vuolteenaho, T., 2002. What drives firm-level stock returns? J Finance 57 (1), 233–264. https://doi.org/10.1111/1540-6261.00421.

Zaremba, A., Kizys, R., Aharon, D.Y., Demir, E., 2020. Infected markets: novel coronavirus, government interventions, and stock return volatility around the globe. Finance Research Letters 101597. https://doi.org/10.1016/j.frl.2020.101597.

Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of COVID-19. Finance Research Letters 101528. https://doi.org/10.1016/j.frl.2020.101528.