

**Online Appendix to**  
**“Stock Comovement and Financial Flexibility”**

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This online appendix (not for publication) to the paper “Stock Comovement and Financial Flexibility” reports the numerical details of the model solution in Appendix A, the construction of the market value of corporate real estate assets in Appendix B, and additional summary statistics and regression results to the ones in the paper in Appendix C.

## A Appendix: Numerical Details

We solve the model by value function iteration and discretization. The processes for the aggregate productivity shock  $x$ , the firm specific productivity shock  $z$ , and the log price of collateralizable assets  $p$  are discretized on  $N_x = 7$ ,  $N_z = 7$ , and  $N_p = 11$  points, respectively, using the method proposed by Rouwenhorst (1995). The grid points for capital  $k \in \mathcal{K}$  are evenly distributed in the log space between  $k_{min}$  and  $k_{max}$  with  $N_k = 101$  points, where the boundaries for capital  $k_{min}$  and  $k_{max}$  are set so that the optimal choice for capital never binds. The upper boundary of debt is given by  $b_{max} = s(1 - \delta)k_{max} + \mathbf{E}[e^{p'} | p_{max}]H$ , and we construct the grid points for debt  $b \in \mathcal{B}$  according to the convex function

$$b(n_b) = \left( \frac{n_b - 1}{N_b - 1} \right)^2 b_{max}, \text{ with } N_b = 101. \quad (1)$$

The grid points for  $b$  are convexly distributed so as to have a finer grid where the value function has the most curvature, and thus increase the accuracy of the solution.

After initializing the value function over the grid points in the first iteration, at each subsequent iteration  $n$  we obtain the value function and policy functions solving the Bellman equation

$$V_n(x, z, p, b, k) = \max_{\{b', k'\} \in \mathcal{B}' \times \mathcal{K}'} d(x, z, p, b, k, b', k') + \mathbf{E}[M' V_{n-1}(x', z', p', b', k') | x, z, p]. \quad (2)$$

We set the convergence criterion to  $\max |V_n(x, z, p, b, k) - V_{n-1}(x, z, p, b, k)| < 10^{-4}$ . After convergence from this first-stage iteration, we use an interpolation method similar to Lin and Zhang (2013) and Livdan, Sapriza, and Zhang (2009) in a second stage to increase the accuracy of the final solution. In particular, at each iteration  $n$ , we perform a local linear interpolation of the value function  $V_{n-1}$  over a grid of  $N_b = N_k = 51$  points centered around the optimal values of  $k'_{n-1}$  and  $b'_{n-1}$  found in iteration  $n - 1$ . The converge criterion for this second-stage iteration is  $10^{-5}$ .

## B Appendix: Computing Market Value of Corporate Real Estate

In this appendix, we provide details of the computation of the market value of a firm’s real estate assets in year  $t$  and location  $l$ ,  $REValue_{it}^l$ . We define the firm’s real estate assets as the sum of the three major categories of property, plant, and equipment (PPE): PPE land and improvement at cost (Compustat item FATP), PPE buildings at cost (FATB), and PPE construction-in-progress at cost (FATC). Because these assets are valued at historical cost rather than marked-to-market, we follow Chaney, Sraer, and Thesmar (2012) by calculating the average age of the assets and estimating their current market value using market prices.

The detailed steps to recover the market value of a firm’s real estate assets are as follows. First, we calculate the ratio of the accumulated depreciation of buildings (DPACB) to the historic cost of buildings and multiply it by the assumed mean depreciable life of 40 years (see Nelson, Potter, and Wilde 2000). This calculation approximates the age or the acquisition year of the firm’s real estate assets. Second, to adjust real estate prices, we retrieve the state-level residential real estate price index from the Office of Federal Housing Finance Agency (FHFA) for the period starting in 1975, when the FHFA residential real estate price index becomes available. We use the consumer price index (CPI) for the period prior to 1975.

Compustat stops reporting the accumulated depreciation of buildings after 1993. Because of the unavailability of data on accumulated depreciation, we cannot infer the market value of real estate assets acquired after 1993. Therefore, we start our sample from 1993 and keep only those firms which were active in Compustat in 1993. From 1993 onwards, we adjust the market value of firms’ real estate assets using real estate price indexes at the Metropolitan Statistical Area (MSA) level. The FHFA website provides MSA-level residential real estate price indexes for most of the MSAs starting from 1987. We use publicly available residential prices for our empirical analysis, even though the assets under consideration are commercial in nature, because the previous literature establishes the robustness of results while using either residential or commercial property price indexes (e.g., see Chaney, Sraer, and Thesmar 2012; Cvijanović 2014; Kumar and Vergara-Alert 2020).

To match the accounting data with the MSA-level real estate price indexes, we obtain the mapping table between the firms’ zip codes provided by Compustat and the MSA codes from the

U.S. Department of Labor’s Office of Workers’ Compensation Programs (OWCP). Once we obtain the yearly-adjusted real estate price index, we estimate the market value of each firm’s real estate assets for each year in the sample period (1993 to 2018) by multiplying the book value of the assets at acquisition ( $FATP + FATB + FATC$ ) times the real estate price index for the given year. Finally, to obtain  $REValue_{it}^l$ , we scale this value by the firm’s lagged PPE.

## C Additional results

This section presents summary statistics and additional results, both for the real and the simulated data, that complement the ones included in the paper. The order of the tables follows the organization of the topics in the paper.

### C.1 Summary Statistics of the Simulated Data

Table C.1 provides summary statistics for the simulated data. To generate the sample, we solve the model presented in section II of the paper according to the parameters in panel A of table 1. Table C.1 summarizes the main variables of interest in our analysis, including asset pricing variables, such as monthly returns and pairwise return correlations, and firm characteristics, such as investment rate, profitability, and leverage.

[Insert table C.1 around here]

### C.2 Sample Splits

Table C.2 shows the estimation results of the comovement regression in equation 20 for subsamples of firms in the simulated data. In column [1]-[2], we present the results by splitting the simulated samples into negative and positive aggregate productivity shocks, and in column [3]-[4] we present the results by splitting simulated samples into negative and positive collateral value shocks. In all regressions, the coefficients of interest on *SAMEFINFLEX* are significantly positive and similar in magnitude. These results complement the sample split results in Table 5 of the paper.

[Insert table C.2 around here]

### C.3 Alternative Factor Models

Table C.3 reports the results of the comovement regression using, as dependent variable, the correlation in stock return residuals from six-factor models that add, respectively, the *Quality-Minus-Junk* (QMJ) factor of Asness, Frazzini, and Pedersen (2019) and the *Betting-Against-Beta* (BAB) factor of Frazzini and Pedersen (2014) to the five-factor model of Fama and French (2015). See section III.A.3 in the paper for further details.

[Insert table C.3 around here]

### C.4 Summary Statistics for the COVID-19 and Financial Crisis Event Studies

Table C.4 reports the summary statistics of the sample used for estimation in the COVID-19 event study. Section III.B in the paper describes the data construction.

Table C.5 shows the summary statistics of the data sample that we use for the 2008 financial crisis event study described in section III.C.2 of the paper. The data includes all active firms for the three months preceding Lehman Brothers' bankruptcy and for the three months post-bankruptcy with available financial and stock price information. The data sources and filters are the same as those described in section III.B for the COVID-19 event study.

[Insert tables C.4 and C.5 around here]

### C.5 Time-Window for the COVID-19 Event Study

Table C.6 presents robustness tests for the COVID-19 event study by using expanded time windows around the event compared to the main results reported in table 7 of the paper. Columns [1]-[5] use a 3-month window (March 11, 2020 to June 10, 2020) while columns [6]-[10] use a 6-month window (March 11, 2020 to September 10, 2020). Notice that, for the reader's convenience, the main specifications in Table C.6 (columns [3], [5], [8], and [10]) are already part of Table 7 (see columns [6]-[9], respectively). The additional columns in Table C.6 show that our results remain robust for different specifications of the comovement regressions.

[Insert table C.6 around here]

## References

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**Table C.1: Summary Statistics of the Simulated Sample.** This table provides the summary statistics (mean, standard deviation, 25th and 75th percentiles) for the simulated samples. The statistics are averaged over 50 simulated samples, each consisting of monthly observations for 1,200 firms over 25 years. Section II.B.4 provides the details of the simulation, which is based on the parameter values reported in table 1. We report the returns and risk-free rate at a monthly frequency, while all other statistics are at the annual frequency, to maintain comparability with the real-data sample.  $\rho_{i,j}$  denotes the pairwise correlation computed at an annual frequency among monthly stock-return CAPM residuals.

	Mean	Median	Std. Dev.	p25	p75
Monthly return, $R - 1$	0.0109	0.0058	0.0869	0.0032	0.0097
Monthly risk-free rate, $r_f$	0.0010	-0.0007	0.0064	-0.0043	0.0047
Investment rate, $i$	0.1208	0.0977	0.1095	0.0291	0.1949
Profitability, $e^{x+z}k^\alpha/(k + H)$	0.2660	0.2499	0.0944	0.1964	0.3190
Market-to-book ratio, $(V + b)/(k + H)$	1.9244	1.8685	0.5288	1.5273	2.3055
Book leverage, $b/(k + H)$	0.2215	0.2082	0.1454	0.0983	0.3209
Frequency of equity issuance, $\mathbf{1}\{e < 0\}$	0.0686	0.0000	0.2306	0.0000	0.0000
Collateralizable assets, $e^p H/(k + H)$	0.1487	0.1270	0.0877	0.0867	0.1880
Pairwise correlation in CAPM residuals, $\rho_{i,j}$	0.0319	0.0045	0.3470	-0.1150	0.1439

Table C.2: **Sample Splits for the Simulated Data Sample.** This table provides sample-split regression results for the simulated data. Column [1]-[2] present the results splitting the sample according to the aggregate productivity shock, and Column [3]-[4] according to collateral value shocks. The dependent variable is stock comovement,  $\rho_{ij,t+1}$ , defined as the pairwise correlation in one-factor (CAPM) return residuals between firm  $i$  and  $j$  in year  $t + 1$ . The independent variable of main interest is *SAMEFINFLEX*, which is defined as the negative of the absolute value of the difference in percentile rankings of shadow price of new debt for the firms in a pair in year  $t$ . All statistics are averaged over 50 simulated samples. Section II.B.4 provides the details of the simulation, which is based on the parameter values reported in panel A of table 1. All the columns control for similarity in firm characteristics, captured by the variables *SAMESIZE*, *SAMEMB*, *SAMELEVERAGE*, *SIZE1*, *SIZE2*, *SIZE1*  $\times$  *SIZE2*, and year fixed effects. Standard errors are clustered at the stock-pair level. T-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Split by Aggregate Shock		Split by Collateral Value Shock	
	Negative Aggregate [1]	Positive Aggregate [2]	Negative Collateral [3]	Positive Collateral [4]
<i>SAMEFINFLEX</i>	0.0001*** (10.64)	0.0001*** (13.05)	0.0001*** (6.76)	0.0001*** (7.41)
<i>SAMESIZE</i>	-0.0001 (-0.27)	0.0001** (2.22)	0.0001 (0.67)	0.0001 (0.35)
<i>SAMEMB</i>	0.0006*** (112.38)	0.0002*** (26.41)	0.0004*** (41.71)	0.0003*** (37.33)
<i>SAMELEVERAGE</i>	0.0001*** (7.92)	0.0001*** (6.51)	0.0001*** (3.13)	0.0001*** (3.4)
Size1	-0.0036*** (-6.86)	-0.0035*** (-6.38)	-0.0029*** (-3.23)	-0.004*** (-4.6)
Size2	0.0005 (1.2)	-0.0001 (0.03)	0.0004 (0.43)	0.0002 (0.26)
Size1#Size2	0.0018*** (9.46)	0.0024*** (10.59)	0.0017*** (4.99)	0.0019*** (5.62)
Year FEs	Yes	Yes	Yes	Yes
Observations	7,755,132	7,251,552	2,558,801	2,605,878
$R^2$	0.0023	0.0010	0.0012	0.0012



**Table C.3: Robustness Tests: Alternative Factor Models.** This table reports the OLS estimates of the stock comovement regression specified in equation 20 using alternative factor models to compute stock return residuals. The dependent variable is the pairwise correlation,  $\rho_{ij,t+1}$ , computed for each year  $t + 1$ , between the monthly return residuals for stocks  $i$  and  $j$  in a pair. Return residuals are computed using the five factors in Fama and French (2015) (FF5) with the addition of the *Quality-Minus-Junk* (QMJ) factor of Asness, Frazzini, and Pedersen (2019) in columns [1]-[2], and the *Betting-Against-Beta* (BAB) factor of Frazzini and Pedersen (2014) in columns [3]-[4]. The independent variable of main interest is *SAMEFINFLEX*, which is defined as the negative of the absolute value of the difference in real estate market value (*REValue*) percentile ranking for the firms in a pair in year  $t$ . Columns [2] and [4] control for similarity in firm characteristics, captured by the variables *SAMESIZE*, *SAMEMB*, *SAMELEVERAGE*, *SIZE1*, *SIZE2*, *SIZE1*  $\times$  *SIZE2*, *SAMEMOM*, *NUMSIC*, *DSTATE*, *DINDEX*, and *DLISTING*. Details of the construction of the real data sample and variable definitions can be found in section III.A.1. All columns include year fixed effects. Standard errors are clustered at the stock-pair level. T-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Correlation of Six-Factor Residuals (FF5 + QMJ)		Correlation of Six-Factor Residuals (FF5 + BAB)	
	OLS [1]	OLS [2]	OLS [3]	OLS [4]
<i>SAMEFINFLEX</i>	0.0004*** (88.10)	0.0003*** (52.24)	0.0004*** (84.82)	0.0003*** (51.74)
<i>SAMESIZE</i>		0.0001** (2.05)		0.0001 (1.56)
<i>SAMEMB</i>		0.0002*** (37.81)		0.0002*** (37.22)
<i>SAMELEVERAGE</i>		0.0001*** (15.49)		0.0001*** (13.83)
<i>SIZE1</i>		-0.0087*** (-29.26)		-0.0095*** (-32.12)
<i>SIZE2</i>		0.0093*** (31.24)		0.0080*** (26.59)
<i>SIZE1</i> $\times$ <i>SIZE2</i>		0.0050*** (26.71)		0.0048*** (25.96)
<i>SAMEMOM</i>		0.0002*** (29.53)		0.0002*** (24.76)
<i>NUMSIC</i>		0.0066*** (32.17)		0.0066*** (31.85)
<i>DSTATE</i>		0.0011 (1.25)		0.0018** (2.19)
<i>DINDEX</i>		0.0774*** (57.55)		0.0719*** (53.61)
<i>DLISTING</i>		0.0078*** (26.20)		0.0068*** (22.80)
Year FE	Yes	Yes	Yes	Yes
Observations	5,591,712	5,145,143	5,591,712	5,145,143
$R^2$	0.0038	0.0075	0.0038	0.0070

Table C.4: **Summary Statistics of the COVID-19 Event Study Sample.** This table provides the summary statistics for the data sample used in the COVID-19 event study. Data sources and sample construction are described in section III.B. *Book leverage* is the sum of short-term and long-term debt normalized by book value of assets. *Firm size* is defined as the book value of total assets. *Market-to-book ratio* is the market value of equity plus the book value of assets minus the book value of equity, all divided by the book value of assets. *Cash holdings* account for cash and short term securities. *DSTATE*, *DINDEX*, and *DLISTING* are dummy variables that take value one if the two firms in a pair are headquartered in the same state, are included in the S&P500 index, and are listed on the same stock exchange, respectively.

	Mean	Median	Std. Dev.	p25	p75	Obs.
<i>Book leverage</i>	0.280	0.252	0.228	0.077	0.435	2,807
<i>Firm size</i> (\$ million)	6,120	609	24,859	85	2,820	2,807
<i>Market-to-book ratio</i>	2.667	1.776	2.423	1.157	3.103	2,635
<i>Cash holdings</i> (\$ million)	647	71	4,536	12	280	2,807
<i>DSTATE</i>	0.053	0.000	0.224	0.000	0.000	1,155,388
<i>DINDEX</i>	0.051	0.000	0.220	0.000	0.000	1,155,388
<i>DLISTING</i>	0.446	0.000	0.497	0.000	1.000	1,155,388

Table C.5: **Summary Statistics of the 2008 Financial Crisis Event Study Sample.** This table provides the summary statistics for the data sample used in the Lehman Brothers collapse event study. *Book leverage* is the sum of short-term and long-term debt normalized by book value of assets. *Firm size* is defined as the book value of total assets. *Market-to-book ratio* is the market value of equity plus the book value of assets minus the book value of equity, all divided by the book value of assets. *Cash holdings* account for cash and short term securities. *DSTATE*, *DINDEX*, and *DLISTING* are dummy variables that take value one if the two firms in a pair are headquartered in the same state, are included in the S&P500 index, and are listed on the same stock exchange, respectively.

	Mean	Median	SD	25th percentile	75th percentile	Obs.
<i>Book leverage</i>	0.212	0.153	0.226	0.003	0.347	4,159
<i>Firm size</i> (\$ million)	2,541	220	11,795	39	1,128	4,159
<i>Cash holding</i> (\$ million)	253	25	1,467	5	108	4,159
<i>Market-to-book ratio</i>	2.382	1.670	1.941	1.193	2.708	3,659
<i>DSTATE</i>	0.059	0.000	0.236	0.000	0.000	4,139,406
<i>DINDEX</i>	0.015	0.000	0.120	0.000	0.000	4,139,406
<i>DLISTING</i>	0.368	0.000	0.482	0.000	1.000	4,139,406

Table C.6: **COVID-19 Event Study: Alternative Time Windows.** This table reports the results of the stock comovement regression in equation 23. The dependent variable,  $\rho_{ij,t}$ , is the pairwise correlation in daily FF5 return residuals. *COVID19* is an indicator variable with value zero for the period between January 1, 2020 and March 10, 2020, and one for the period between March 11, 2020 and June 10, 2020 in columns [1]-[5] and between March 11, 2020 and September 10, 2020 in columns [6]-[10]. *SAMEFINFLEX* is defined as the negative of the absolute value of the difference in net leverage (net debt/total assets) percentile ranking across the stocks in a pair. Net debt is long and short term debt minus cash. *DSAMEFINFLEX* is an indicator variable with value one if the firms in a pair have a difference of less than 30 percentiles in the distribution of net leverage, and zero otherwise. All the columns control for similarity in firm characteristics, captured by the variables *SAMESIZE*, *SAMEMB*, *SIZE1*, *SIZE2*, *SIZE1*  $\times$  *SIZE2*, *SAMEMOM*, *NUMSIC*, *DSTATE*, *DINDEX*, and *DLISTING*. All firm characteristics are measured as of December 2019. Section III.B describes data sources and sample construction, and section III.A.1 provides the definitions of the control variables. Standard errors are clustered at the stock-pair level. T-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Correlation of FF5 Residuals									
	Post Covid Window: March 11, 2020 - June 10, 2020					Post Covid Window: March 11, 2020 - Sept. 10, 2020				
	OLS [1]	OLS [2]	OLS [3]	OLS [4]	OLS [5]	OLS [6]	OLS [7]	OLS [8]	OLS [9]	OLS [10]
<i>COVID19</i>	0.0055*** (12.05)	0.0055*** (12.13)	0.0154*** (20.17)	0.0055*** (12.07)	-0.0016** (2.49)	0.0048*** (11.78)	0.0049*** (12.00)	0.0110*** (15.73)	0.0049*** (11.87)	-0.0001 (-0.17)
<i>SAMEFINFLEX</i>		0.0005*** (47.95)	0.0003*** (23.13)				0.0004*** (46.27)	0.0003*** (23.23)		
<i>COVID19</i> $\times$ <i>SAMEFINFLEX</i>			0.0003*** (16.11)					0.0002*** (10.77)		
<i>DSAMEFINFLEX</i>				0.0179*** (40.45)	0.0105*** (17.59)				0.0158*** (39.50)	0.0105*** (17.70)
<i>COVID19</i> $\times$ <i>DSAMEFINFLEX</i>					0.0136*** (15.75)					0.0096*** (12.02)
<i>SAMESIZE</i>	0.0003*** (28.58)	0.0002*** (22.09)	0.0002*** (22.08)	0.0003*** (24.21)	0.0003*** (24.18)	0.0003*** (33.36)	0.0003*** (27.01)	0.0003*** (26.99)	0.0003*** (28.99)	0.0003*** (28.95)
<i>SAMEMB</i>	0.0002*** (17.11)	0.0002*** (18.18)	0.0002*** (18.25)	0.0002*** (17.75)	0.0002*** (17.82)	0.0002*** (18.96)	0.0002*** (19.99)	0.0002*** (20.04)	0.0002*** (19.60)	0.0002*** (19.66)
<i>SIZE1</i>	-0.0004 (-1.61)	-0.0003 (-1.56)	-0.0004 (-1.59)	-0.0004 (-1.61)	-0.0004 (-1.62)	0.0001 (0.42)	0.0001 (0.42)	0.0001 (0.43)	0.0001 (0.42)	0.0001 (0.42)
<i>SIZE2</i>	0.0001 (0.50)	0.0001 (0.47)	0.0001 (0.47)	0.0001 (0.50)	0.0001 (0.50)	-0.0001 (-0.33)	-0.0001 (-0.35)	-0.0001 (-0.36)	-0.0001 (-0.33)	-0.0001 (-0.34)
<i>SIZE1</i> $\times$ <i>SIZE2</i>	-0.0001 (-0.18)	-0.0001 (-0.19)	-0.0001 (-0.17)	-0.0001 (-0.17)	-0.0001 (-0.16)	-0.0001 (-0.63)	-0.0001 (-0.66)	-0.0001 (-0.67)	-0.0001 (-0.68)	-0.0001 (-0.68)
<i>SAMEMOM</i>	0.0004*** (38.96)	0.0004*** (37.93)	0.0004*** (38.06)	0.0004*** (38.42)	0.0004*** (38.52)	0.0004*** (44.04)	0.0004*** (42.88)	0.0004*** (42.95)	0.0004*** (43.41)	0.0004*** (43.47)
<i>NUMSIC</i>	0.0234*** (66.06)	0.0228*** (64.32)	0.0228*** (64.33)	0.0230*** (64.91)	0.0230*** (64.90)	0.0229*** (70.23)	0.0223*** (68.59)	0.0223*** (68.59)	0.0225*** (69.12)	0.0225*** (69.12)
<i>DSTATE</i>	0.0296*** (28.89)	0.0294*** (28.78)	0.0294*** (28.76)	0.0295*** (28.81)	0.0294*** (28.79)	0.0290*** (31.01)	0.0289*** (30.91)	0.0289*** (30.89)	0.0289*** (30.94)	0.0289*** (30.93)
<i>DINDEX</i>	0.0808*** (66.94)	0.0790*** (65.39)	0.0790*** (65.46)	0.0796*** (65.95)	0.0797*** (66.00)	0.0743*** (65.30)	0.0727*** (63.88)	0.0728*** (63.93)	0.0733*** (64.38)	0.0733*** (64.43)
<i>DLISTING</i>	0.0113*** (25.20)	0.0094*** (21.09)	0.0094*** (21.11)	0.0100*** (22.39)	0.0100*** (22.39)	0.0110*** (27.18)	0.0095*** (23.31)	0.0095*** (23.33)	0.0099*** (24.48)	0.0099*** (24.48)
Observations	1,237,108	1,237,108	1,237,108	1,237,108	1,237,108	1,255,305	1,255,305	1,255,305	1,255,305	1,255,305
Adjusted $R^2$	0.0152	0.0171	0.0173	0.0165	0.0153	0.0171	0.0187	0.0188	0.0183	0.0184