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Option-Implied Skewness and the Value of Financial Intermediaries

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Abstract
In this paper, we analyze the relationship among skewness, value, and stock returns for US financial intermediaries. Further, we compare skewness based on past returns to risk-neutral skewness based on options. We find that the option-implied skewness has a significantly higher explanatory power. In line with the strand of literature on investors exploiting mispriced stocks through option trading, we find that a higher ex ante skewness indicates a low valuation that predicts higher returns. We investigate the relationship between skewness and value for each segment of intermediaries, and we show that the link is strongest for financial technology firms.

Keywords Financial intermediaries · Corporate value · Stock returns · Option-implied skewness

JEL Classification G21 · G32

1 Introduction

In the empirical research on corporate valuation, studies normally analyze the financial sector differently than other sectors. Banks and financial firms are "special" because they have high leverage and stricter industry regulations. Therefore, they are hardly comparable to nonfinancial firms (Diamond 1984, 1991). The strand of literature on nonfinancial firms has shown that risk-neutral skewness ("ex ante skewness") from options has higher predictive power for future returns than skewness measures based on historical ("ex post skewness") returns. In this study, we analyze whether this finding holds true for the valuation of financial firms.

We examine US financial intermediaries traded on the NYSE and the NASDAQ from 2008Q2 to 2020Q4. In this sample, we distinguish among asset managers, banks, broker-dealers, financial technology firms, insurance brokers, insurance underwriters, investment

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firms, and specialty lenders. We use Tobin's q to measure corporate value, while we follow the method by Bakshi and Madan (2000) and extended by Bakshi et al. (2003) to compute the risk-neutral, option-implied skewness. Our main finding is that ex ante skewness has a negative and significant effect on the value of financial intermediaries. This effect is statistically important across all segments, but it is much stronger for financial technology firms. We also show that stocks that have a high option-implied skewness subsequently yield high returns. In contrast, the measure for historical (ex post) skewness does not have any explanatory power for either the value or the returns of financial intermediaries.

Overall, we argue that our findings are in line with other studies that relate risk-neutral skewness to misvaluation. We test this hypothesis on financial intermediaries, and we report evidence that intermediaries with ex ante highly skewed returns have low valuations while they earn high future returns. We confirm these findings by implementing an alternative measure of option-implied skewness as in Malz (2014). In statistical terms, the explanatory power of the ex ante skewness is always stronger than the ex post skewness. This finding corroborates the argument that options embed important information on the valuation of financial intermediaries. Therefore, our results are consistent with Borochin and Zhao (2019) who illustrate that stock market performance can be explained by disentangling the short-term hedging demands, which are captured by the option-implied ex ante skewness, from the preference for long-term skewness.

Furthermore, we separately analyze global systemically important financial institutions (GSIFIs) because explicit government guarantees and bailout provisions may have an effect on the performance of these institutions. As a consequence, the valuation may be different for GSIFIs compared to non-GSIFIs (Stern and Feldman 2004; Abreu and Gulamhussen 2013; Brewer and Jagtiani 2013). As our results show that the option-implied skewness is important in determining the values of GSIFIs and non-GSIFIs, we argue that potential too-big-to-fail provisions play only a minor role in our dataset.

This study is organized as follows: In Section 2, we review the related literature. In Section 3, we develop our working hypothesis and present the data we use in the analysis. We conduct a regression analysis to test the effect of option-implied skewness on the value of financial intermediaries in Section 4. In Section 5, we focus on GSIFIs. Section 6 contains the conclusion.

2 Literature review

Various studies have analyzed the relationship between stock return skewness and corporate valuation. Brunnermeier et al. (2007); Mitton and Vorkink (2007), and Barberis and Huang (2008) propose models in which investors show a preference for skewness. The authors predict that positively skewed assets have higher values (i.e. low expected returns). In other works, Arditti (1967); Kraus and Litzenberger (1976), and Harvey and Siddique (2000) argue that investors demand compensation for bearing systematic skewness, that is, the asset's co-skewness with the market portfolio. To test the validity of these models, other studies have measured skewness "ex post".

Empirical studies have focused primarily on nonfinancial firms and have shown that stock returns are negatively correlated with total skewness (Amaya et al. 2015), idiosyncratic firm-specific skewness (Boyer et al. 2010), and systematic skewness (Harvey and Siddique 2000) that corroborates the prediction that skewness is a priced factor.

However, there is no consensus in the literature on whether ex post (backward-looking) measures of skewness are suitable in disclosing meaningful information about the future performance of a firm. For example, Boyer et al. (2010) and Bali and Murray (2013) show that historical estimates of skewness provide poor forecasts of future returns as they fail to predict both equity valuations and skewness.

An alternative to the ex post skewness used in the above studies is the ex ante skewness of the option-implied (risk-neutral) densities. Among others, Bakshi and Madan (2000) and Bakshi et al. (2003) propose a model-free approach to calculate the skewness of the risk-neutral density. According to Bali and Murray (2013), these measures of ex ante skewness are helpful in mitigating measurement errors as they are able to predict returns more appropriately than those for ex post skewness.

The follow-up research is mixed on the pricing relation between ex ante skewness and subsequent stock returns. For example, Conrad et al. (2013) find that securities with ex ante negatively skewed returns yield subsequently higher returns. The authors motivate this pattern with behavioral preferences for lottery stocks, that is, their results are in line with the hypotheses based on the previous findings for ex post skewness.

Other studies have illustrated that the relationship between risk-neutral skewness and stock returns is positive. For example, Stilger et al. (2016) argue that as investors perceive certain stocks as relatively overpriced, they resort to the option market by buying out-of-the-money puts, selling out-of-the-money calls, and/or constructing synthetic short positions on these stocks to hedge their underlying positions or to speculate on their pessimistic expectations. Limits to arbitrage in the form of short-selling constraints do not allow market makers to fully hedge investors' options positions in the stock market. As a consequence, this hedging demand drives up (down) prices for the out-of-the-money puts (calls) that leads to a highly negative risk-neutral skewness in the option-implied distribution (Bollen and Whaley 2004; Garleanu et al. 2008). As investors transmit the mispricing information to the stock market over time, these relatively overpriced stocks with low risk-neutral skewness subsequently underperform that produces a positive relation between risk-neutral skewness and future realized equity returns.[1] While Stilger et al. (2016) focus on global equity markets, Fuertes et al. (2022) show that risk-neutral skewness is also a priced factor in the global market for commodity futures. The authors illustrate that commodities categorized as overpriced earn subsequent negative returns, that is, their findings are consistent with the mispricing hypothesis of Stilger et al. (2016).

Gkionis et al. (2021) posit that the mispricing argument of Stilger et al. (2016) also holds for optimistic beliefs due to underpricing. Investors exploit positive information about a firm by buying (selling) out-of-the-money (OTM) call (put) options due to their embedded leverage rather than directly buying the underlying stock with its potential downside risk. To hedge their positions, market makers need to buy the underlying stock and will quote higher (lower) prices for out-of-the-money calls (puts). This mechanism induces a higher risk-neutral skewness that leads to a stock's outperformance if market participants perceive this option trading as an informative signal.

[1] According to this theory, stock prices have not already embedded the information in option prices, which is in line with the models of Easley et al. (1998) and An et al. (2014). The argument of Stilger et al. (2016) is consistent with the evidence that investors' different beliefs may affect option prices through the slope of the implied-volatility smile and the skewness of the risk-neutral density function (Buraschi and Jiltsov 2006; Friesen et al. 2012; Ziegler 2012).

Chordia et al. (2021) test the relation of risk-neutral skewness to corporate news releases. They show that the risk-neutral skewness that is computed before the announcements of corporate earnings predicts future stock returns. This pattern also holds for scheduled and non-scheduled corporate news releases. The authors explain these outcomes as informed trading in option markets. They argue that option prices reflect new information before stock prices because investors prefer options markets due to the highly leveraged contracts and the avoidance of short-sale constraints. According to Chordia et al. (2021), the informed trading channel is an alternative and more plausible explanation for the observed positive correlation between risk-neutral skewness and stock returns than the mispricing channel of Stilger et al. (2016).

Finally, Borochin and Zhao (2019) compare skewness ex post and ex ante. They show that high risk-neutral skewness predicts positive stock performance, particularly after a period of underperformance when it also has a relation with the momentum crash phenomenon found by Daniel and Moskowitz (2016). For stocks without options, the authors estimate loadings on a constructed factor for risk-neutral skewness that shows this result is strongly robust and does not depend on the availability of stock options. Their outcomes corroborate the informed trading/hedging demand hypothesis of Stilger et al. (2016), that is, the risk-neutral skewness captures short-term arbitrage. Moreover, Borochin and Zhao (2019) find that historical skewness has a negative and significant effect for the same cross section of returns that thus, captures the skewness preferences outlined in the literature. Overall, the authors reconcile their different evidence for risk-neutral and historical skewness by arguing that the option-implied skewness captures the short-term hedging demand, while the return-based skewness reflects the investors' long-term preferences for lottery payoffs.

While the literature on firm valuation has mainly concentrated on nonfinancial firms, the evidence for financial firms is much more limited. Motivated by the trend inside the banking industry of extending the range of "traditional" services, some studies have investigated whether bank valuation is affected by business diversification.[2]

Bressan and Weissensteiner (2021) study this topic by relating measures of (co)skewness to the value of diversified banks. Their approach follows Mitton and Vorkink (2010) who examine diversification effects in the valuation of nonfinancial conglomerates. They show that ex post (co)skewness correlates negatively with bank value. Instead, inside a small subsample of banks with traded options, this correlation is positive when using the ex ante option-implied skewness (Bakshi and Madan 2000; Bakshi et al. 2003). In the following analysis we also implement measures of ex post and ex ante skewness, although for a much larger sample of a variety of financial intermediaries.[3]

[2] For example, Laeven and Levine (2007) show that the value of diversified banks (i.e. banks that engage in commercial and investment banking activities) is substantially lower than the value computed for equally diversified combinations of commercial banks and investment banks. Schmid and Walter (2009) extend this evidence to the broader financial services sector by examining commercial banks and bank holding firms, insurance firms, asset managers, and broker-dealers. The results confirm that the value of multi-firm corporations is much lower than the portfolios of stand-alone intermediaries, that is, there is a persistent "financial conglomerate discount". Overall, this evidence indicates that business diversification increases the expected returns of huge financial corporations.

[3] Our sample size is five times bigger than the subsamples of firms with stock options analyzed by Bressan and Weissensteiner (2021). Bressan and Weissensteiner (2018) analyze US banks and test whether firm-specific characteristics explain the measures of the skewness in stock returns. The main finding is that bank size is an important determinant of that skewness. Nonetheless, the authors do not test whether skewness has an effect on bank value, as we do in this study.

3 Risk-neutral skewness, stock returns, and corporate value

3.1 Working hypothesis

Stilger et al. (2016) and Gkionis et al. (2021) show that the mispricing of a firm leads to a positive relationship between risk-neutral skewness and future stock returns. In the following analysis, we empirically assess whether this relationship also holds for financial intermediaries. Our goal is to evaluate whether risk-neutral skewness plays a key role in determining the value of financial intermediaries. If an increasing (decreasing) risk-neutral skewness signals that the firm's equity is underpriced (overpriced), we expect to find that risk-neutral skewness correlates negatively (positively) with firm value, while at the same time predicting high (low) future stock returns.

3.2 Sample and firm value

We consider financial firms in the United States. Thomson Reuters Datastream provides option data for the period from 2008Q1–2020Q4. Investors can trade these firms on the NYSE or the NASDAQ, and we exclude those that were the target of mergers or acquisitions during this period. We follow the identification in the Standard and Poor's Capital IQ and classify the firms as asset managers, banks, broker-dealers, financial techs, insurance brokers, insurance underwriters, investment firms, or specialty lenders.[4]

We use the series of monthly stock prices and implied volatilities of options with a 3-month maturity and moneyness ranging from 80% to 120% to compute the option-implied (risk-neutral) skewness following the method in Bakshi and Madan (2000) and Bakshi et al. (2003).

Finally, we use Worldscope accounting data (available at quarterly frequency) in order to measure the value of our firms. The literature has proposed separate ways to measure value. We opt for Tobin's q that studies have defined theoretically as the market value of the firm divided by the replacement cost of assets. In practice, though, we cannot observe either the market value of the firm or the replacement cost of assets. Therefore, we approximate the firm's market value of assets with the market value of its common equity and the book value of preferred stock plus debt net of deferred taxes, where the book value of debt is assumed to equal the market value of debt. Furthermore, we also set the

[4] Our sample comprises US listed firms in Standard and Poor's Capital IQ database, which was formerly SNL Financial LC. The Standard Industrial Classification (SIC) code is 60-67 for asset managers, banks, broker-dealers, insurance brokers, insurance underwriters, and investment firms. Specialty lenders comprise the firms with SIC codes 70-80, while financial technology firms have SIC codes 70-80, although a few have SIC code 35. The Appendix has a list of the firms (by subindustry) covered by the sample. In Thomson Reuters Datastream, option data are available from 2008Q1 onward. As the sample period includes the financial crisis of 2008-2009, we verified that our findings did not vary in quality by excluding the observations during 2008Q1-2009Q4. These results are available on request. Thomson Reuters Datastream provides the constant maturity (3-month) volatility surfaces for moneyness from 80 to 120 in steps of 5, that is, 9 different strikes in total.

replacement cost of assets equal to the book value of assets.[5] Therefore, the Tobin's q (q) for each firm j at quarter t is computed as:

$$q_{j,t} = \frac{Market\ common\ equity_{j,t} + Preferred\ stock_{j,t} + Book\ debt_{j,t} - Deferred\ taxes_{j,t}}{Book\ assets_{j,t}}. \tag{1}$$

3.3 Option-implied skewness

The literature provides evidence that historical estimates of skewness predict future returns (Mitton and Vorkink 2007; Boyer et al. 2010; Mitton and Vorkink 2010). However, the use of historical skewness presents two main limitations. The first is the assumption that the return distribution remains stable over time while the second limitation is that skewness is very sensitive to rare events. In financial markets with time-varying return distributions, a short sample period would be necessary to mitigate the first limitation, while a long sample period would be needed to capture rare events appropriately.

Options embed the markets' view of the future (risk-neutral) return distribution. Without the need to rely on historical data, this forward-looking density can be used to predict the cross section of stock returns. We refer to Christoffersen et al. (2013) for a summary of the methods and empirical results in the literature that uses option-implied skewness to forecast expected returns. In order to calculate risk-neutral skewness, we use the method proposed by Bakshi and Madan (2000) and extended by Bakshi et al. (2003) that has the advantage of being model-free and simple to implement.

The method works as follows: For stock j at time t; $V_{j,t}(\tau)$, $W_{j,t}(\tau)$, and $X_{j,t}(\tau)$ define the prices of τ-maturity quadratic, cubic, and quartic contracts, respectively. These contracts are contingent claims with payoffs equal to the future second, third, and fourth powers of log returns computed from the stock price $S_{j,t}$. The contracts are based on $C_{j,t}(\tau; K_j)$ and $P_{j,t}(\tau; K_j)$ that denote the time t prices of European calls and puts written on j with strike price K and expiration τ periods from time t.

Bakshi et al. (2003) show that $V_{j,t}(\tau)$, $W_{j,t}(\tau)$, and $X_{j,t}(\tau)$ can be expressed as follows:

$$\begin{aligned} V_{j,t}(\tau) = & \int_{S_{j,t}}^{\infty} \frac{2(1 - \ln(K_j/S_{j,t}))}{K_j^2} C_{j,t}(\tau;K_j) dK_j \\ & + \int_0^{S_{j,t}} \frac{2(1 + \ln(K_j/S_{j,t})}{K_j^2} P_{j,t}(\tau;K_j) dK_j \end{aligned} \tag{2}$$

[5] We acknowledge that these assumptions may not hold for highly levered financial firms like banks that have a high probability of defaulting on their debt and that issue insured deposits. Also the hypothesis in which we assume that the replacement cost of assets is equal to the book value of assets might not be true because replacement costs change over time. Despite that Tobin's q requires making these quite strong assumptions, it remains a widely used measure of bank valuation in the empirical literature. For example, Laeven and Levine (2007) compute Eq. 1 for large banks (i.e., financial conglomerates) engaged in commercial and investment banking in order to analyze the effect of business diversification on the financial industry. Jones et al. (2011) use Tobin's q in Eq. 1 to examine the behavior of banks' charter value during the subprime financial crisis.

$$W_{j,t}(\tau) = \int_{S_{j,t}}^{\infty} \frac{6(\ln(K_j/S_{j,t})) - 3(\ln(K_j/S_{j,t}))^2}{K_j^2} C_{i,t}(\tau; K_i)dK_i + \int_0^{S_{j,t}} \frac{6(\ln(K_j/S_{j,t})) + 3(\ln(K_j/S_{j,t}))^2}{K_j^2} P_{i,t}(\tau; K_i)dK_i \tag{3}$$

$$X_{j,t}(\tau) = \int_{S_{j,t}}^{\infty} \frac{12(\ln(K_j/S_{j,t}))^2 - 4(\ln(K_j/S_{j,t}))^3}{K_j^2} C_{i,t}(\tau; K_i)dK_i + \int_0^{S_{j,t}} \frac{12(\ln(K_j/S_{j,t}))^2 + 4(\ln(K_j/S_{j,t}))^3}{K_j^2} P_{i,t}(\tau; K_i)dK_i. \tag{4}$$

The third risk-neutral moment is calculated as:

$$\hat{\gamma}_{j,t}^{Q}(\tau) = \frac{e^{r_f\tau} W_{j,t}(\tau) - 3\mu_{j,t}(\tau)e^{r_f\tau} V_{j,t}(\tau) + 2\mu_{j,t}(\tau)^3}{[e^{r_f\tau} V_{j,t}(\tau) - \mu_{j,t}(\tau)^2]^{3/2}}, \tag{5}$$

with $\hat{\gamma}_{j,t}^{Q}(\tau)$ denoting the risk-neutral skewness of the stock return of bank j at time t for maturity τ. Q and r_f denote the risk-neutral measure and the risk-free rate (three-month LIBOR rate) respectively, while μ is given by:

$$\mu_{j,t}(\tau) = e^{r_f\tau} - 1 - e^{r_f\tau} V_{j,t}(\tau)/2 - e^{r_f\tau} W_{j,t}(\tau)/6 - e^{r_f\tau} X_{j,t}(\tau)/24. \tag{6}$$

For notational reasons, whenever possible we omit the j and t to denote the option-implied skewness as $\hat{\gamma}^{Q}$. In Section 4.3 to corroborate our results, we also compute the skewness with risk-neutral densities that we estimated according to Malz (2014).

3.4 Control variables

Whether the option-implied risk-neutral skewness performs better at explaining and predicting the value of a firm and the returns on financial assets than historical skewness is still under debate. For this reason, in the regression analysis of Section 4 we control for the historical skewness of bank j at t. Following Mitton and Vorkink (2010), we calculate it by using a rolling window of 12 monthly returns:

$$\hat{\gamma}_{j,t} = \frac{\frac{1}{12}\sum_{\tau=t-11}^{t} (r_{j,\tau} - \hat{\mu}_j)^3}{\hat{\sigma}_j^3}. \tag{7}$$

A comparison of Eqs. 7 with 5 clearly shows that the option-implied skewness has the advantage by being forward-looking; that is, it does not rely on historical data. Another distinction between the two is the probability measure used to calculate the skewness. While Eq. 5 has a risk-neutral probability measure, Eq. 7 has a measure of skewness based on the physical (real) world. The densities of the risk-neutral returns play a central role in derivative pricing, and the densities of the physical returns are important to portfolio and risk management. Both of these densities would only coincide if the marginal investor were risk-neutral. As the scientific consensus indicates, the marginal investor is risk-averse in real-word markets. Therefore, the moments calculated from risk-neutral densities potentially indicate something different, and measuring option-implied forward-looking physical moments requires a change in the measure.[6] We follow the majority of papers in this strand of literature and use the risk-neutral skewness without a change in the measure. In doing so, we implicitly assume a positive relationship between the option-implied forward-looking risk-neutral density and the unknown forward-looking physical density, see for example Bali and Murray (2013); Conrad et al. (2013); Borochin et al. (2020), and Schneider et al. (2020).

In addition, we also consider the size and the leverage of firm j at time t as additional predictors. The variable *SIZE* is the natural logarithm of total assets, while *CAPITAL* is the ratio of book-value equity to total assets that is inversely related to the firm's leverage. This choice follows Laeven and Levine (2007) who model the bank's Tobin's q as a function of business diversification and bank-specific characteristics in order to study whether diversification destroys the value of financial conglomerates. These bank-specific characteristics include *SIZE* and *CAPITAL*, and the rationale is that a large and well-capitalized bank might have fewer incentives to engage in excessive risk-taking. If so, *SIZE* and *CAPITAL* should have a positive effect on bank value. In addition, we argue that with *SIZE* and *CAPITAL* we can approximate the size and the leverage across all our firms. Differently, we could not determine measures for the funding structure based on other variables, like demand deposits that are unique to banks.[7]

Tables 1 and 2 respectively present the descriptive statistics and correlation coefficients for all the variables that we have used in the analysis. In the segment of financial technology firms, the mean q value is equal to 3.3020, and it is the highest among all intermediaries. Instead investment firms are the segment with the lowest mean q value equal to 0.9736.[8] The option-implied skewness $\hat{\gamma}^Q$ is highest (lowest) for insurance underwriters (insurance brokers), while historical skewness $\hat{\gamma}$ is highest (lowest) for broker-dealers (investment companies). The correlation between $\hat{\gamma}^Q$ and q is negative and significant at the 1 In contrast, the correlation between $\hat{\gamma}$ and q is positive but not significant. The low and insignificant correlation between $\hat{\gamma}^Q$ and $\hat{\gamma}$ indicates that these two quantities are not considerably interlinked. The significant correlation among r, q, and $\hat{\gamma}^Q$ is in line with the theoretical rationale that a high option-implied skewness goes along with high expected returns and is associated with a low value. Regarding the control variables, we note that banks are the most highly leveraged intermediaries, as *CAPITAL* is close to 0.08, while asset managers are the best capitalized, as *CAPITAL* is close to 0.44. The larger firms (i.e. those with bigger *SIZE*) also feature high leverage and low option-implied skewness. Finally, we verify that the correlation between *SIZE* and *CAPITAL* with q is quite low and equals -0.45 and 0.26, respectively. Therefore, we argue that including these

[6] A whole strand of literature has had a discussion on the ways to transform forward-looking risk-neutral densities to forward-looking physical densities. This exercise is simplified with additional assumptions about the economy, see for example Bliss and Panigirtzoglou (2004) and Kostakis et al. (2011) for a representative agent having power or exponential utility. However, their approach has been criticized by Cuesdeanu and Jackwerth (2018) as being potentially too restrictive.

[7] Also the regressions for the excess returns of bank stocks that we estimate in Table 5 (columns (1)-(2)) control for *CAPITAL*, following, for example, the model in Cooper et al. (2003), where bank stock returns are explained significantly by leverage – as measured by *CAPITAL* – along with other bank-specific information, like earnings and non-interest income.

[8] For banks, we are in line with the evidence that banks typically have a Tobin's q greater than one. For example, using annual data for an international sample of banks during 1998-2002, Laeven and Levine (2007) find an average Tobin's q of 1.06. Schmid and Walter (2009) report that during 1985-2004 the mean and median Tobin's q of US financial intermediaries were both larger than one.

Table 1 Descriptive statistics for financial intermediaries during 2008Q2-2020Q4. See Appendix Table 9 for the definitions of all variables

	Mean	Median	St Deviation	N
Asset Manager				
q	1.8049	1.2276	1.0991	226
$\hat{\gamma}^Q$	−0.9575	−1.0120	0.1979	232
$\hat{\gamma}$	− 0.0367	−0.0958	0.5635	232
Total assets	43,068($m)	14,095($m)	70,451(m)	214
CAPITAL	0.4393	0.4847	32.5556	232
r	0.0283	0.0276	0.1166	232
Bank				
q	1.0135	1.0067	0.0468	1,035
$\hat{\gamma}^Q$	−0.9281	−1.0071	0.2415	1,054
$\hat{\gamma}$	−0.1268	−0.1311	0.5697	1,054
Total assets	422,001($m)	120,116($m)	699,050(m)	983
CAPITAL	0.0812	0.1035	5.2960	1,035
r	0.0311	0.0270	0.1255	1,054
Broker-Dealer				
q	1.8139	1.1340	0.2597	301
$\hat{\gamma}^Q$	−0.9912	−1.0281	0.1625	301
$\hat{\gamma}$	0.0457	0.0326	0.5825	301
Total assets	241,422($m)	68,482($m)	348,184(m)	301
CAPITAL	0.1567	0.0858	19.656	301
r	0.0408	0.0270	0.1058	301
Financial Technology				
q	3.3020	2.7573	2.0761	689
$\hat{\gamma}^Q$	−0.9413	−0.9977	0.2164	762
$\hat{\gamma}$	−0.0196	−0.0211	0.6414	762
Total assets	11,983($m)	6,035($m)	16,893(m)	666
CAPITAL	0.2665	0.3266	30.0170	689
r	0.0405	0.0420	0.1168	762
Insurance Broker				
q	1.9016	1.7812	0.3914	92
$\hat{\gamma}^Q$	−1.0082	−1.0759	0.2123	92
$\hat{\gamma}$	−0.0017	−0.0511	0.6114	92
Total assets	12,182($m)	11,935($m)	8,699(m)	92
CAPITAL	0.3448	0.4179	21.8231	92
r	0.0373	0.0268	0.0822	92
Insurance Underwriter				
q	1.1026	0.9935	0.2883	888
$\hat{\gamma}^Q$	−0.9026	−0.9964	0.2879	888
$\hat{\gamma}$	−0.0146	−0.0577	0.6400	888
Total assets	142,991($m)	57,383($m)	223,464($m)	657
CAPITAL	0.1582	0.1463	13.2712	888
r	0.0456	0.0346	0.1398	888

Table 1 (continued)

	Mean	Median	St Deviation	N
Investment Company				
q	0.9736	0.9845	0.0395	60
$\hat{\gamma}^Q$	−1.0051	−1.1283	0.3251	60
$\hat{\gamma}$	−0.7153	−0.6117	0.6282	60
Total assets	53,608($m)	59,224($m)	35,730(m)	60
CAPITAL	0.0515	0.0044	6.1461	60
r	0.0127	0.0151	0.0855	60
Specialty Lender				
q	1.1532	1.1018	0.2595	205
$\hat{\gamma}^Q$	−0.8611	−0.9335	0.2577	205
$\hat{\gamma}$	0.0146	−0.0309	0.7233	205
Total assets	29,813($m)	9,640($m)	35,577(m)	170
CAPITAL	0.1484	0.1312	12.8756	205
r	0.0464	0.0308	0.1482	205

Table 2 Correlation. See Appendix Table 9 for the definitions of all variables. P-values are reported in parenthesis

Variables	q	$\hat{\gamma}^Q$	$\hat{\gamma}$	*SIZE*	*CAPITAL*
$\hat{\gamma}^Q$	−0.1195				
	(0.0000)				
$\hat{\gamma}$	0.0108	0.0145			
	(0.1345)	(0.3886)			
SIZE	−0.4542	−0.1449	0.0755		
	(0.0000)	(0.0000)	(0.0000)		
CAPITAL	0.2640	−0.0665	0.0753	0.2287	
	(0.0000)	(0.0001)	(0.0000)	(0.0000)	
r	−0.0314	0.1144	0.0106	0.1198	0.0591
	(0.0311)	(0.0000)	(0.5296)	(0.0000)	(0.0005)

two variables in our regressions does not weaken the statistical power of our model due to multicollinearity.

4 Results

In order to analyze the relationship between corporate value and skewness, we run the following regression:

$$q_{j,t} = \alpha_0 + \alpha_1 \hat{\gamma}^Q_{j,t-1} + \alpha_2 \hat{\gamma}_{j,t-1} + \alpha_3 SIZE_{j,t} + \alpha_4 CAPITAL_{j,t} + \tau_t + \psi_j + \omega_{j,t}, \quad (8)$$

Table 3 The effect of option-implied skewness on the value of financial intermediaries. Columns (1)-(3) show regression results of Tobin's q. See Appendix Table 9 for the definitions of all variables included in the models. The subscript t denotes the year-quarter. N is the total number of observations. Standard errors are clustered at the company level and are reported in parenthesis

	(1)	(2)	(3)
Regressors	q_t	q_t	q_t
$\hat{\gamma}^{Q}_{t-1}$	−1.3501***	−1.3490**	
	(0.4982)	(0.5157)	
$\hat{\gamma}_{t-1}$	0.0186		−0.0190
	(0.0600)		(0.4982)
Controls	Yes	Yes	Yes
N	2,458	2,458	2,458
R-squared	0.3918	0.3916	0.3683

* p<0.05, ** p<0.01, *** p< 0.001

where τ_t and ψ_j denote time and firm fixed effects, respectively, while $\omega_{j,t}$ is the error term.[9] Potential unobserved random shocks at a group level can lead to correlations among all observations within each group. In order to avoid the standard independence assumption that erroneously indicates a too narrow confidence bound (with over-optimistic p-values), we rely on clustered standard errors.[10]

In column (1) of Table 3, we report the estimated coefficients. In columns (2)-(3) we also show the estimates from models that separately tested for the effects of $\hat{\gamma}^{Q}_{j,t-1}$ and $\hat{\gamma}_{t-1}$. The slope parameter α_1 is negative and is highly significant. Instead α_2 is never statistically significant. We draw the following insights from the results. The result for which the risk-neutral skewness has a strong statistical power in explaining Tobin's q is in line with previous arguments that risk-neutral skewness is informative on the misvaluation of firms, see Stilger et al. (2016) and Gkionis et al. (2021). As we find that risk-neutral skewness has a negative effect on firm value, it indicates that the main driver is undervaluation, which is in line with Gkionis et al. (2021).

We now verify whether the effect of $\hat{\gamma}^{Q}$ varies across segments of financial intermediaries and regress q on interactions between $\hat{\gamma}^{Q}$ and an indicator for the type of intermediary, and we report these outcomes in Table 4.

[9] For all the regressions that include fixed effects we perform the test in Hausman (1978). In all cases we reject the null hypothesis that fixed effects are not relevant in a statistical sense, that is, the fixed effects regression is preferred to both a pooled ordinary least squares and to a random effects regression.

[10] As the correlation may occur across more than one dimension, we want to verify if option-implied skewness effects are robust to different clusters. Therefore, we verify that the coefficient estimated for $\hat{\gamma}^{Q}$ also remains significant if we cluster the standard errors by quarter, by year, and by industry. These results support our earlier results, therefore we do not report them, but they are available on request. As we estimate the regression in Eq. 8, α_2 remains nonsignificant even if we eliminate γ^{Q} from the specification. This nonsignificance confirms that $\hat{\gamma}$ is not spanned by $\hat{\gamma}^{Q}$. We can see such a pattern in Table 2, where the correlation between $\hat{\gamma}$ and q is close to zero. Though, the negative α_2 becomes statistically significant for some segments. The q of banks and asset managers decrease with $\hat{\gamma}$, and the parameter is significant at a 10% level.

Table 4 The effect on the Tobin's q of financial intermediaries from the interaction terms between the option-implied skewness (column (1)) and size (column (2)) with the indicator for the intermediary's segment. See Appendix Table 9 for the definitions of all variables included in the models. The subscript t denotes the year-quarter. N is the total number of observations. Standard errors are clustered by year-quarter and are reported in parenthesis

Segment	(1)	(2)
	q_t	
	$\hat{\gamma}^{Q}_{t-1}$	$SIZE_t$
Asset Manager	−0.8722***	0.0000
	(0.1404)	(0.000)
Bank	−0.8609***	0.0054
	(0.1931)	(0.0150)
Broker-Dealer	−1.6070***	0.0297**
	(0.3153)	(0.0140)
Financial Technology	−1.8761***	0.0618***
	(0.1302)	(0.007)
Insurance Broker	−0.6643***	−0.0142**
	(0.1248)	(0.006)
Insurance Underwriter	−0.6158***	−0.0073
	(0.1606)	(0.0085)
Investment Company	−0.4957***	−0.0213***
	(0.1529)	(0.0080)
Specialty Lender	−0.5300***	−0.0161**
	(0.1494)	(0.0026)
Controls	Yes	Yes
N	2,458	2,458
R-squared	0.4717	0.4570

* p<0.05, ** p<0.01, *** p<0.001

The slope parameter of all the interactions is negative and significant at the 1% level.[11] This result is in line with the evidence in Bressan and Weissensteiner (2021) who use the measure of skewness in Bakshi et al. (2003) to explain the discount in the value of diversified banks. Table 4 shows that option-implied risk-neutral skewness also plays an important role in explaining the value of a broader variety of financial intermediaries; for instance in column (1), the negative correlation between risk-neutral skewness and value is highly and statistically significant across all the subgroups of intermediaries. The estimated coefficients are not hugely different in their magnitude across segments. However, this exercise indicates that potential mispricing differences may exist across intermediaries. Further, financial technology firms have the highest coefficient for $\hat{\gamma}^{Q}$ at approximately 3.8 times the coefficient estimated for investment firms – the lowest coefficient among the segments. This coefficient indicates that financial technology firms are more sensitive to changes in the risk-neutral skewness, that is, mispricing is stronger for them. Instead, the lowest coefficient for investment firms indicates that they are more price efficient than other segments.

These findings may be explained by the business model of these firms and their valuation. Moro-Visconti et al. (2020) study the growth of the financial technology industry compared to traditional banking activities and highlight how valuation issues for financial

[11] We can confirm that the coefficients estimated for $\hat{\gamma}^{Q}$ and *SIZE* also remain significant if we cluster the standard errors by year, by industry, and by firm. These results are in line with the results shown in Table 4. We do not report them, but they are available on request.

technology firms must be adapted to young and fragile firms, which have all the prerogatives of startups (e.g., in terms of expected growth, survival rate, and volatility).[12] Typically, young, or complex, businesses are difficult to estimate the value of and pose challenges to valuators given the so-called "information uncertainty" (IU). In fact, IU refers to the precision with which a firm value can be estimated by knowledgeable investors at a reasonable cost (Easley and O'hara 2004). For example, Jiang et al. (2005) find that banking sector had the lowest IU for listed US firms from 1965 to 2001, while the IU was higher in the business services, electronics, and engineering/research/consulting services industries, which financial technology firms share some common features. However, we do not measure for IU in our analysis because the coefficients estimated for them are affected considerably by the costs of acquiring information. That is, the high costs for acquiring information about financial technology firms could lead to a less efficient valuation.

According to Merton (1987) big firms are less susceptible to market frictions (such as information costs) than small firms. In our sample, financial technology firms are the segment with the lowest total assets (see Table 1); therefore, it is plausible that the issue of IU is stronger for them. To obtain further insights, we conduct a regression of q on *SIZE* and interact it with an indicator for the segment. The coefficients in column (2) of Table 4 for the interaction terms display differences across segments. In particular, financial technology firms display a marginal effect that is positive and significant at the 1% level, while for the other segments the sign is only marginally significant or even negative. Larger financial technology firms are valued more. As the segment of financial technology is composed of start-ups and/or relatively young firms, growth might reduce IU and, as a consequence, increase value. Despite the potential limitations of the results in Table 4, these outcomes show the need for a deeper understanding of the valuation pattern in the financial technology sector. We leave this research item for future research.

4.1 Regressions of realized stock returns on skewness

The previous outcomes show that risk-neutral skewness plays an important role in determining the value of financial intermediaries. As a consequence, we also expect to observe that risk-neutral skewness can predict returns. Under rational expectations the realized stock returns r_t on average reflect the returns demanded ex ante $\mathbb{E}_{t-1}[r_t]$. We now test whether $\hat{\gamma}^Q_{t-1}$ in Table 5 explains the excess return:

$$r_{j,t} - r_{f,t-1} = c + \alpha \hat{\gamma}^Q_{j,t-1} + \beta F_{j,t} + \epsilon_{j,t}, \tag{9}$$

where $r_{f,t}$ denotes the rate. The vector $F_{j,t}$ indicates additional factors that control for size, leverage, time, and firm fixed effects as well as the four (Carhart 1997) factors, which include the factors in Fama and French (1993), with the momentum factor as in Jegadeesh

[12] Moro-Visconti et al. (2020) point out a few important differences that distinguish financial technology firms from traditional banks and that possibly also affect the method of valuation. Financial technology firms are not deposit-taking institutions and (most frequently) do not engage in lending. As a consequence, they are mostly unsupervised by central banks. The absence of supervision allows these firms to pursue innovation strategies in order to get a competitive advantage over hyper-regulated banks. These elements are reflected also by differences in the accounting of financial technology firms compared to traditional banks. The balance sheet of a bank is characterized by a binding structure that is the result of the presence of supervisory capital, bank deposits, and loans to customers. Instead, financial technology firms have a much more lenient accounting structure (Moro-Visconti et al. 2020).

Table 5 The effect of option-implied skewness on the returns of financial intermediaries. See Appendix Table 9 for the definitions of all variables included in the models. The subscript t denotes the year-quarter. *ln* denotes the natural logarithm. N is the total number of observations. Standard errors are clustered at the company level and are reported in parenthesis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Regressors	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	r_t-$r_{f,t-1}$	$\hat{\epsilon}_t$	$ln(q_t/q_{t-1})$
		Fama and Mac Beth (1973)							
$\hat{\gamma}^Q_{t-1}$	0.1160***	0.0620*	0.1175***	0.1083***				0.0880***	0.0728***
	(0.0040)	(0.0317)	(0.0238)	(0.0237)				(0.0211)	(0.0241)
$\hat{\gamma}_{t-1}$	−0.0003	0.0226			−0.0006	−0.0024	−0.0015	0.0005	0.0001
	(0.0104)	(0.0231)			(0.0030)	(0.0040)	(0.0040)	(0.0038)	(0.0040)
$\hat{\gamma}5y_{t-1}$			−0.0057*						
			(0.0032)						
$\hat{\gamma}d_{t-1}$				−0.0052					
				(0.0042)					
$\hat{\gamma}^Q_{t-2}$					0.0465***				
					(0.0104)				
$\hat{\gamma}^Q_{t-3}$						0.0372**			
						(0.0090)			
$\hat{\gamma}^Q_{t-4}$							0.0294*		
							(0.0102)		
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,463	2,463	2,463	2,463	2,371	2,300	2,202	2,463	2,463
R-squared	0.1135	0.4434	0.1131	0.1162	0.0957	0.0901	0.0800	0.0298	0.2859

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

and Titman (1993). We downloaded the monthly risk-free rate (Treasury bill rate) and the factor returns from Kenneth R. French's data library and aggregated them to a quarterly frequency for which Compustat data were also available.

In column (1) of Table 5, the coefficient for $\hat{\gamma}^Q_{t-1}$ is positive and significant for the excess return at the 1% level.[13] In column (2), we report the results from the second-step regression in Fama and MacBeth (1973) to quantify the return premium for a skewness exposure. The coefficients are estimated from a cross-sectional regression of bank average returns against the average exposure to skewness, *SIZE*, and *CAPITAL*, while the four factors in Carhart (1997) are calculated in the first step (not-reported). We find that the premium for a marginal change in $\hat{\gamma}^Q_{t-1}$ is positive and significant at the 10% level, while the loading on historical skewness is never significant. These results corroborate our earlier explanation for the findings in Table 3. If the high risk-neutral skewness indicates a low valuation premium, we expect that it also indicates a high future stock return. The findings in Table 5 confirm this expectation. The outcomes are again in line with the rationale provided by Gkionis et al. (2021).

As we consider (5) and (7), we can link our outcomes to the insights from Borochin et al. (2020). Our findings show that long-term skewness does not play an important role in determining the value (and consequently the returns) of financial intermediaries, while short-term skewness has a much stronger explanatory power.

In columns (3)-(4) of Table 5, we check whether our results are robust to modifications to our estimate of physical skewness computed by Eq. 7. Precisely, in column (3) the quantity in Eq. 7 is calculated using five years of monthly stock returns (Mitton and Vorkink 2010), while in column (4) we use daily returns of the past month (Xu 2007). In both columns, the sign on the return-based historical skewness is negative and is consistent with our baseline outcomes in column (1). Only the five-year skewness is significant at the 10% level, while the daily skewness is not significant. The positive sign on $\hat{\gamma}^Q_{t-1}$ instead remains significant and supports the robustness of our baseline specification.

Furthermore, we examine the correction time of the mispricing. In general, this time depends on how fast fundamental uncertainty about the asset is resolved, how fast investors' misperceptions are corrected, and how rapidly arbitrage drives the price to the fundamental value (Shleifer and Vishny 1990). Columns (5)-(7) in Table 5 show the test effects for $\hat{\gamma}^Q_{t-2}$, $\hat{\gamma}^Q_{t-3}$, and $\hat{\gamma}^Q_{t-4}$ in which the slope parameters on the lagged $\hat{\gamma}^Q$ and their statistical significance decrease over time. These results point out that the option-implied skewness effects on equity returns are absorbed within one year, that is, the skewness due to mispricing is a temporary (Stilger et al. 2016).

In order to verify more carefully the effect of skewness on stock pricing, we report the estimates from the following test in column (8). In a first stage we regress the excess stock return on the four factors in Carhart (1997) according to the equation below:

$$r_{j,t} - r_{f,t-1} = \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \hat{\epsilon}_{j,t}, \tag{10}$$

[13] *SIZE* controls for the bank-specific size as it is based on the bank's balance-sheet assets. *SIZE* differs from the size factor of Fama and French (1993) that is computed from the stock market capitalization. For example Boyer et al. (2010) regress portfolio returns on variables for firm-specific size besides the factors in Fama and French (1993). The regression results in column (1) of Table 5 are in line with the regression in Table 19 of Bressan and Weissensteiner (2021) but we use a larger data sample and a huge variety of financial intermediaries.

where *MKTRF*, *SMB*, and *HML* are respectively the market, size, and value factors of Fama and French (1993); and *MOM* is the momentum factor of Carhart (1997). By estimating the equation in (10) and computing the residuals $\hat{\epsilon}_{j,t}$, we obtain an approximation for the abnormal stock return: A positive $\hat{\epsilon}_{j,t}$ indicates that the stock return is above the return predicted by the factor model. In a second stage, we regress the estimated residual terms on the lagged $\hat{\gamma}^Q$ and $\hat{\gamma}$. In column (8) of Table 5, the coefficient for $\hat{\gamma}^Q$ is positive and highly significant, while $\hat{\gamma}$ is not significant. This pattern confirms our earlier findings that the risk-neutral skewness is important to predicting the stock's outperformance in the subsequent period.

Finally, in order to propose a more formal explanation for the relationship between q and $\hat{\gamma}^Q$, we assume for simplicity that bank j issues stock at time 0 and has no debt in place. This issuance means that at time 0 the market value and the book value of equity are the same and equal to $S_{j,0}$, while q is equal to one (as in this simplified setting q is the ratio of market equity to the book value of equity). Also, we assume that in the subsequent periods t and $t+1$, the book value of equity stays constant at $S_{j,0}$, while the market equity varies and is denoted with $S_{j,t}$ and $S_{j,t+1}$. If all these assumptions are met, the log-change in q from $t-1$ to t for bank j satisfies the following identify[14]:

$$\begin{aligned} ln(q_{j,t}/q_{j,t-1}) = ln[(S_{j,t}/S_{j,0})/(S_{j,t-1}/S_{j,0})] = \\ ln(S_{j,t}/S_{j,t-1}) = \\ r_{j,t} = \\ r_{f,t-1} + c + \alpha\hat{\gamma}^Q_{j,t-1} + \beta F_{j,t} + \epsilon_{j,t}. \end{aligned} \tag{11}$$

Column (9) of Table 5 shows the estimates for Eq. 11, where the vector of factors F_t contains our usual controls: *SIZE*, *CAPITAL*, firm dummies, year-quarter dummies, and the four factors in Carhart (1997). The coefficient for $\hat{\gamma}^Q$ is positive and highly significant. This pattern corroborates the main reasoning that a high risk-neutral skewness indicates undervaluation over time.

4.2 Skewness and bank size

For US commercial banks, Bressan and Weissensteiner (2018) show that different measures of stock return skewness are negatively correlated to their size.

We analyze if this result also applies to a broader group of financial intermediaries. Therefore, columns (1)-(2) in Table 6 show the estimations of models for $\hat{\gamma}^Q$ and $\hat{\gamma}$ on *SIZE*. The sign on *SIZE* is negative and significant that means larger intermediaries are more negatively skewed, which is in line with the findings of Bressan and Weissensteiner (2018).[15]

This pattern is also consistent with the evidence in Dennis and Mayhew (2002) for global equity markets. They analyze stock options traded on the Chicago Board Options

[14] We thank an anonymous referee for pointing out this connection between $\hat{\gamma}^Q_t$ and the log-change of q_t.

[15] This pattern can be observed across all segments, and the coefficient of *SIZE* for skewness is similar across groups of intermediaries. These regressions by segments are available on request. Bressan and Weissensteiner (2018) find a negative relation between banks' sizes and a measure of option-implied skewness following Malz (2014), even though the authors work on a relatively small subsample of firms with stock options (721 observations). In this study, we rely on Bakshi et al. (2003) that the most recent empirical literature has often used. Furthermore, our sample is large so that we can draw a relatively robust inference.

Table 6 The effect of size for the skewness of financial intermediaries (columns (1)-(2)), and the effect of skewness on the value (column (3)) and the returns (columns (4)-(7)) of financial intermediaries. See Appendix Table 9 for the definitions of all variables included in the models. The subscript t denotes the year-quarter. N is the total number of observations. Standard errors are clustered at the company level and are reported in parenthesis

Regressors	(1) $\hat{\gamma}_t^Q$	(2) $\hat{\gamma}_t$	(3) q_t	(4) r_t-$r_{f,t-1}$	(5) r_t-$r_{f,t-1}$ FMB	(6) $\hat{\epsilon}_t$	(7) $ln(q_t/q_{t-1})$
$SIZE_t$	−0.0253***	−0.0294**					
	(0.0089)	(0.0115)					
$\hat{\gamma}(Malz)_{t-1}$			−1.3001***	0.1162***	0.0675*	0.0967***	0.1031***
			(0.0387)	(0.05725)	(0.0350)	(0.0326)	(0.0372)
$\hat{\gamma}_{t-1}$			−0.3704	−0.0058	0.0004	−0.0000	−0.0048
			(0.0844)	(0.0047)	(0.0036)	(0.0043)	(0.0049)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,502	3,502	1,847	1,847	1,847	1,847	1,847
R-squared	0.5229	0.1358	0.4105	0.3812	0.5199	0.0132	0.3432

* p<0.05, ** p<0.01, *** p<0.001

Exchange to examine whether firm-specific factors as well as systematic factors explain the option-implied risk-neutral skewness proposed by Bakshi et al. (2003). In line with our results in Table 6, they observe that size, as approximated with the firm's market value of equity, has a negative coefficient in the regression model explaining risk-neutral skewness.

Moreover, larger intermediaries in our sample might be huge multi-firm corporations, which are often organized as a parent with one or more subsidiaries. In this case, the stock can be seen as an index with different firm components. Dennis and Mayhew (2002) compare the (risk-neutral) skewness of S &P 500 index options with the skewness of individual stock options and observe that the skewness for index options is much more negative than the skewness for individual stock options.

4.3 Robustness check

In order to corroborate our earlier findings and to mitigate a potential concern that they are driven by relying on Bakshi and Madan (2000) and Bakshi et al. (2003), we now calculate the option-implied skewness from calibrated risk-neutral densities using Malz (2014). This calculation is denoted as $\hat{\gamma}(Malz)$. Malz (2014) uses a non-parametric approach for computing risk-neutral density functions based on option-implied volatilities. This method interpolates and extrapolates the volatility smile using a cubic spline function that is clumped at the endpoints.

The results in Table 6 are consistent with our earlier findings. In fact the slope parameter of $\hat{\gamma}(Malz)_{t-1}$ has a negative and significant sign on q_t, while it is positive on the excess stock return. The quality of the outcomes also does not change in the regressions (10) and (11). Again, we observe that the historical skewness $\hat{\gamma}$ is not significant, which confirms the fact that option-based skewness is superior to historical skewness in explaining the value of our firms.

5 Global systemically important financial institutions

The literature is inconclusive on whether bailout expectations determine the returns of banks (Stern and Feldman 2004; Abreu and Gulamhussen 2013; Brewer and Jagtiani 2013). In this section we test whether too-big-to-fail subsidies affect our results. For this reason we focus on global systemically important financial institutions (GSIFIs). The GSIFIs in our sample comprise banks, broker-dealers, and insurance underwriters. In this analysis, we want to determine whether the explicit too-big-to-fail subsidy lowers the price for out-of-the-money put options (i.e. the price for insurance against a market crash) that ultimately confounds the effect of risk-neutral skewness on the values and stock returns of banks.[16]

The banks in our sample are: Bank of America Corporation, Bank of New York Mellon Corporation, Citigroup, JPMorgan Chase & Co., State Street Corporation, Wells Fargo & Firm. Goldman Sachs Group Inc. and Morgan Stanley are classified by the database as systemically important broker-dealers. The insurance underwriters in our sample are American International Group and MetLife.

Table 7 presents the summary statistics for the GSIFIs. For broker-dealers and insurance underwriters, the mean Tobin's q is lower (0.99 and 0.98) than those of the corresponding segments in Table 1 (1.81 and 1.10). This evidence shows that systemically relevant broker-dealers and insurance underwriters have lower values than smaller relevant ones, which is in line with Table 2 that shows that firm size and Tobin's q are negatively correlated.

Table 8 shows the results for the relationship between skewness and q (r) for the GSIFIs that are analogous to those in Table 3. The coefficient for $\hat{\gamma}^{Q}$ is negative and statistically significant for the GSIFIs, although the magnitude of the effect is lower than for non-GSIFIs. To conclude, risk-neutral skewness is important for the value of intermediaries that are subject to an explicit government guarantee. However, the predictive power of risk-neutral skewness is no longer significant for the returns earned by the GSIFIs.[17] This lack of predictive power might be caused by the relatively small GSIFI subsample. The outcomes for non-GSIFIs are in line with our earlier results, that is, that option-implied skewness predicts stock returns.

6 Conclusion

This study establishes that the risk-neutral option implied-skewness plays a key role in the valuation of financial intermediaries. We analyze a sample that comprises asset managers, banks, broker-dealers, financial technology firms, insurance brokers, insurance underwriters, investment firms, and specialty lenders. We find that the firm value as measured by Tobin's q decreases with the risk-neutral skewness that is computed

[16] Kelly et al. (2016) have shown that during the Global Financial Crisis of 2007-2009, out-of-the-money put options for the financial sector stock index were extraordinarily cheap relative to out-of-the-money put options on the individual banks that constituted the index. They argue that this evidence indicates that a sector-wide bailout guarantee in the financial sector lowers the price of insurance against a market crash.

[17] Gandhi and Lustig (2015) show that size anomalies in bank stock returns come from the too-big-to-fail provisions that diminish the returns expected by large banks. Table 8 may show that the positive effect from risk-neutral skewness on stock returns is not statistically significant for the GSIFIs because when they have changes in their risk-neutral skewness, their stock returns do not vary substantially: Investors are still willing to hold GSIFIs as they will benefit from the government protection.

Table 7 Descriptive statistics for "Global Systemically Important Financial Institutions" (GSIFIs). "Global Systemically Important Financial Institutions" (GSIFIs) are "Global Systemically Important Banks" (G-SIBs), "Global Systemically Important Insurers" (G-SIIs), and systemically important broker-dealers. The "Global Systemically Important Banks" (G-SIBs) in our sample are: Bank of America Corporation, Bank of New York Mellon Corporation, Citigroup, JPMorgan Chase & Co., State Street Corporation, and Wells Fargo & Company. The "Global Systemically Important Insurers" (G-SIIs) in our sample are: American International Group and MetLife. See Appendix Table 9 for the definitions of all variables

	Mean	Median	St Deviation	N
Bank				
q	1.0026	1.0026	0.0317	276
$\hat{\gamma}^Q$	−0.9440	−1.0310	0.2598	276
$\hat{\gamma}$	−0.1458	−0.1899	0.5969	276
Total assets	1,569,250$m	1,879,700$m	853,572m	276
CAPITAL	0.0795	0.0955	4.3292	276
r	0.0312	0.0296	0.1399	276
Broker-Dealer				
q	0.9947	0.9941	0.0157	84
$\hat{\gamma}^Q$	−0.9819	−1.0321	0.1675	94
$\hat{\gamma}$	−0.0758	−0.0784	0.5185	94
Total assets	931,378$m	923,223$m	72,295m	94
CAPITAL	0.0657	0.0835	3.9234	94
r	0.0398	0.0335	0.1255	94
Insurance Underwriter				
q	0.9795	0.9836	0.0145	80
$\hat{\gamma}^Q$	−0.8954	−0.9989	0.3351	80
$\hat{\gamma}$	0.1116	−0.1318	0.7591	80
Total assets	786,041$m	797,386$m	117,387$m	80
CAPITAL	0.1019	0.0788	6.4432	80
r	0.0388	0.0242	0.1649	80

following Bakshi and Madan (2000) and Bakshi et al. (2003). We also examine the role of risk-neutral skewness in explaining (i) the changes in Tobin's q for subsequent quarters, and (ii) the observed cross section of stock returns. In both cases we find evidence of a negative relationship. We corroborate our results by calculating risk-neutral skewness following Malz (2014). All the outcomes are also confirmed by separately analyzing global systemically important financial institutions (GSIFIs).

Overall, our findings provide new insights about the effects of risk-neutral skewness on financial intermediaries' performance. We show that an increasing ex ante risk-neutral skewness signals low valuations, while it predicts future outperformance. This effect is statistically significant, in contrast to that of ex post historical skewness as computed from past stock returns. Our findings extend the evidence that risk-neutral skewness indicates a temporary mispricing of the financial sector in nonfinancial equity markets. We also show that the effect of option-implied skewness on value is stronger for financial technology firms than for other more "traditional" intermediaries; a finding that could trigger future research.

Table 8 The effect of option-implied skewness on the value (columns (1)-(2)) and the returns (columns (3)-(4)) of financial intermediaries separating "Global Systemically Important Financial Institutions" (GSIFIs) from "non-Global Systemically Important Financial Institutions" (nGSIFIs). "Global Systemically Important Financial Institutions" (GSIFIs) are "Global Systemically Important Banks" (G-SIBs), "Global Systemically Important Insurers" (G-SIIs), and systemically important broker-dealers. The "Global Systemically Important Banks" (G-SIBs) in our sample are: Bank of America Corporation, Bank of New York Mellon Corporation, Citigroup, JPMorgan Chase & Co., State Street Corporation, and Wells Fargo & Company. The "Global Systemically Important Insurers" (G-SIIs) in our sample are: American International Group and MetLife. See Appendix Table 9 for the definitions of all variables included in the models. The subscript t denotes the year-quarter. N is the total number of observations. Standard errors are clustered at the company level and are reported in parenthesis

Regressors	(1) q_t	(2)	(3) r_t-$r_{f,t-1}$	(4)
	GSIFIs	*nGSIFIs*	*GSIFIs*	*nGSIFIs*
$\hat{\gamma}^Q_{t-1}$	−0.1152***	−1.8014***	0.1939	0.1174***
	(0.0263)	(0.5791)	(0.1234)	(0.0254)
$\hat{\gamma}_{t-1}$	−0.0055	−0.0188	−0.0040	0.0004
	(0.0032)	(0.0635)	(0.0150)	(0.0047)
Controls	Yes	Yes	Yes	Yes
N	450	2,055	450	2,060
R-squared	0.6237	0.4224	0.1933	0.1136

* p<0.05, ** p<0.01, *** p<0.001

Appendix

These are the financial intermediaries that we analyze:

Asset Managers: Affiliated Managers Group Inc.; BlackRock Inc.; Blackstone Group L.P.; Franklin Resources Inc.; Invesco Ltd.; Legg Mason Inc.; T. Rowe Price Group Inc.

Banks: BB &T Corporation, Bank of America Corporation, Bank of New York Mellon Corporation, BankUnited Inc., CIT Group Inc., Capital One Financial Corporation, Citigroup Inc., Comerica Incorporated, Credicorp Ltd., Cullen/Frost Bankers Inc., East West Bancorp Inc., Fifth Third Bancorp, First Horizon National Corporation, Huntington Bancshares Incorporated, JPMorgan Chase & Co., KeyCorp, M &T Bank Corporation, Northern Trust Corporation, PNC Financial Services Group Inc., People's United Financial Inc., Regions Financial Corporation, State Street Corporation, SunTrust Banks Inc., U.S. Bancorp, Wells Fargo & Company, and Zions Bancorporation

Broker-Dealers: CME Group Inc., Cboe Global Markets Inc., Charles Schwab Corporation, E*TRADE Financial Corporation, Goldman Sachs Group Inc., Interactive Brokers Group Inc., Intercontinental Exchange Inc., Morgan Stanley, Nasdaq Inc., TD Ameritrade Holding Corporation

Financial Technology: Automatic Data Processing Inc., CA Inc., Cognizant Technology Solutions Corporation, Convergys Corporation, Dun & Bradstreet Corporation, Ebix Inc., Equifax Inc., F5 Networks Inc., Fidelity National Information Services Inc., Fiserv Inc., Fortinet Inc., Intuit Inc., Mastercard Incorporated, Moody's Corporation, PayPal Holdings Inc., Paychex Inc., Symantec Corporation, Total System Services Inc., Unisys Corporation, Verifone Systems Inc., Verisk Analytics Inc., Visa Inc., Western Union Firm, Athenahealth Inc.

Insurance Brokers: Brown & Brown Inc., Marsh & McLennan Firms Inc.

Insurance Underwriters: Aetna Inc., Aflac Incorporated, Allstate Corporation, American International Group Inc., Ameriprise Financial Inc., Assurant Inc., Assured Guaranty Ltd., CNO Financial Group Inc., Cigna Corporation, Cincinnati Financial Corporation, Everest Re Group. Ltd., Genworth Financial Inc., Hartford Financial Services Group Inc., Humana Inc., Lincoln National Corporation, Loews Corporation, MBIA Inc., MGIC Investment Corporation, MetLife Inc., Progressive Corporation, Prudential Financial Inc., Radian Group Inc., Torchmark Corporation, Travelers Companies Inc., UnitedHealth Group Incorporated, Unum Group, Validus Holdings. Ltd., WellCare Health Plans Inc., XL Group Ltd

Investment Firms: AGNC Investment Corp., Apollo Commercial Real Estate Finance Inc., Chimera Investment Corporation

Specialty Lenders: Aircastle Limited, American Express Company, Discover Financial Services, PRA Group Inc., Ryder System Inc., SLM Corporation.

The following Table 9 defines the variables for the analysis.

Table 9 Definition of variables

Variable	Definition
Dependent variables of the regressions	
q	Tobin's q of the company
$r\text{-}r_f$	Company's realized return exceeding the risk-free rate (three-month LIBOR rate)
$\hat{\epsilon}$	Abnormal stock return of the company.
Independent variables of the regressions	
$\hat{\gamma}^Q$	Option-implied skewness of the company estimated following Bakshi et al. (2003).
$\hat{\gamma}$	Historical skewness of the company determined using twelve monthly stock returns.
$\hat{\gamma}(Malz)$	Option-implied skewness of the company estimated following Malz (2014).
$\hat{\gamma}5y$	Historical skewness of the company determined using five years of monthly stock returns.
$\hat{\gamma}d$	Historical skewness of the company determined using daily stock returns of the past month.
Controls	
SIZE	Natural logarithm of the company's total assets.
CAPITAL	Company's book-value of equity divided by book value of total assets.
MKTRF	Market factor of Fama and French (1993).
SMB	Size factor of Fama and French (1993).
HML	Value factor of Fama and French (1993).
MOM	Momentum factor of Carhart (1997).
Time fixed effects	A set of dummy variables taking value of one in year-quarter t, while zero otherwise.
Company fixed effects	A set of dummy variables taking value of one for company j, while zero otherwise.

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Declarations

Conflicts of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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