Separate Appendix for Online Publication

Delta-Matched Spreads

An alternative to strike-matching is to construct the option basket such that the BS delta of the basket and the index are equal. In this appendix we discuss this approach, and refer to it as "delta-matching." Delta represents the derivative of an option price with respect to the underlying asset price. This derivative provides an approximate percentage probability that the option expires with a positive payoff. Low values such as 20 indicate an option has a low payoff probability (or is "out-of-the-money"), and high values such as 80 indicate "in-the-money" (ITM) options. While put options have negative delta, we use the convention of taking the absolute value, so that all reported deltas are positive. Short-dated at-the-money (ATM) forward options have a delta of approximately 50.

We find qualitatively identical behavior of delta-matched and strike-matched basket-index spreads. The time series correlation between spreads for the two approaches is over 95%. Table A1 compare average option prices under delta-matching (Panel A) and strike-matching (Panel B, and shown in the main text as Panel B of Table 3).

The rise in crisis put spreads is 3.1 cents under delta-matching, versus 3.2 cents under strike matching. The rises in put spreads relative to call spreads is 3.5 cents and 2.7 cents, respectively. The difference-in-differences (put minus call spreads, financials minus non-financials) is 2.4 cents for delta-matching and 2.3 for strike-matching.

Table A1—Cost of Insurance with Delta Matching

	Financials						Non-financials					
	Puts			Calls			Puts			Calls		
	Basket	Index	Spread	Basket	Index	Spread	Basket	Index	Spread	Basket	Index	Spread
	Panel A: Delta-matching											
Pre-crisis	4.8	3.8	1.0	2.2	1.8	0.4	5.4	3.8	1.6	2.5	1.9	0.6
Crisis	15.3	11.3	4.0	3.4	3.4	0.0	9.3	6.8	2.5	3.0	2.5	0.5
Crisis diff.	10.5	7.5	3.1	1.2	1.6	-0.4	3.9	3.0	0.9	0.5	0.7	-0.2
	Panel B: Strike-matching											
Pre-crisis	5.2	3.8	1.4	3.4	1.8	1.6	6.2	3.7	2.4	4.2	1.8	2.4
Crisis	15.9	11.3	4.6	5.5	3.4	2.1	10.0	6.7	3.3	5.4	2.5	2.9
Crisis diff.	10.6	7.5	3.2	2.2	1.6	0.5	3.9	2.9	0.9	1.2	0.7	0.5

Note: Basket and index insurance cost comparison in delta-matching approach (Panel A) and strike-matching approach (Panel B).

Sample Detail

Our sample uses exchange traded funds (ETFs) belonging to the Select Sector SPDR. SPDRs are a large ETF family traded in the U.S., Europe, and Asia-Pacific and managed by State Street Global Advisors. These sector funds represent nine separate portfolios based on the industry sectors comprising all stocks in the S&P 500 index. The S&P 500 is classified into ten sectors but, due to the small number of telecommunications firms in the index, technology and telecommunications are combined in a single ETF. The investment objective of each fund is to provide investment results that, before expenses, correspond generally to the return performance of the stocks represented in each specified sector index. The financial sector index ticker is XLF, and Table B1 reports the XLF holdings before and after the crisis. Options on SPDR sector ETFs are physically settled and have an American-style exercise feature. Further detail regarding SPDR S&P 500 sector ETFs is available at `https://www.spdrs.com/`.

Bid-Ask Spread Adjustment

To ensure that the increase in the basket-index put spread is not solely due to wider bid-ask spreads during the financial crisis, we reconstruct an alternative basket-index spread series using raw option price quotes rather than the interpolated volatility surface provided by OptionMetrics. This also serves as a check that OptionMetrics interpolated prices do not suffer from inaccurate extrapolation or reliance on illiquid contracts. To summarize, results from raw options data combined with accounting for bid-ask spreads and contract liquidity generates put spreads that are qualitatively identical, and quantitatively very similar, to the results we report in the main text.

For this analysis, we construct synthetic options with constant maturity (365 days) and constant delta of 30 by interpolating raw option prices in a similar vein as OptionMetrics. We impose two constraints on our interpolation to ensure its robustness to liquidity concerns. First, we restrict the universe of raw options to those with positive open interest to ensure a minimum degree of liquidity. Results are similar if we instead require that contracts have positive volume. Second, when constructing synthetic options with constant maturity and constant delta, we *strictly interpolate* and never extrapolate. In particular, we require at least one option with delta above 30 and one with delta below 30, and similarly require one option with maturity greater than 365 and one with maturity less than 365. Often a stock has only one option near delta 25, which is why we construct synthetic options with delta 30. Finally, to account for bid-ask spreads, all individual option prices are set equal to the bid price, and all index option prices are set equal to their ask price. This results in the most conservative spread in prices of index puts versus the basket of individual puts, so that the bid-ask-adjusted put spread is always narrower than the spread calculated from midquotes.

The resulting "net of transaction costs" basket-index put spread has very similar behavior to the analogous spread series calculated from the volatility surface. Their correlation is 96% over the entire sample and 93% over the crisis subsample. The "net of transaction costs" rise in financial sector put spreads (after differencing with the rise in non-financials) is 90% of that calculated from the volatility surface, indicating that the spread dynamics we document are not driven by bid-ask spreads.

Stock Heterogeneity and BS Model Fits

Our main model-based analysis is conducted under the simplifying assumption that the sector basket consists of ex ante identical stocks. We do so by examining BS model-based prices for the basket and index, $P^{BS}(\sigma)$ and $P^{BS}(\sqrt{\rho}\sigma)$, described in Section II. By assuming ex ante identical stocks, our approach asks the model to fit the average option price in the basket, rather than fitting the prices of each option in the basket. Because the true basket is composed of non-identical firms, our model fits will be biased due to Jensen's inequality. This section shows that our results and conclusions are unchanged when we individually fit the price of each individual option in the basket and that the Jensen's effect is quantitatively tiny.

In particular, we explicitly account for heterogeneity in the basket by using the exact daily index weights, stock-specific call implied volatility, and stock-specific strike prices to construct the BS model predicted basket cost of insurance. We focus on a sector index comprised of different stocks j.

To insure the sector using puts on individual stocks, we consider a basket of options that matches the sector index composition on each day. Let $w_{j,t}$ be the number of shares outstanding, respectively, for stock j in the index on day t. Denoting the price of a put option as P_t, the dollar cost of the basket is the sum of individual stock puts necessary to insure each share in the index, and is given by $P_t^{basket} = \sum_{j=1}^{N} w_{jt} P_{jt}$ on day t. The model-predicted option prices are calculated each day by feeding in estimates for σ_{jt} and ρ_t. We estimate σ_{jt} as the BS implied volatility for the individual OTM (delta 25) call option on stock j. The necessary inputs for calculating BS implied volatility include the time-to-maturity which is fixed at one year, the risk-free rate, the stock's dividend yield calculated from OptionMetrics data, and the strike price of each option. Re-estimating σ each day allows the model to account for the often drastic differences in risk levels across regimes. We estimate ρ each day from realized returns following equation (14).

The fits are shown in Table D1, and are directly comparable to the main BS model fits in Table 3 that abstract from heterogeneity. The BS model's quantitative failure to match financial sector put spreads is nearly identical in the two tables.

Merton Jump Model Derivations

E1. Environment without Bailout

For the reader's convenience, we restate the model here. The annual returns on the financial sector index, r_x, and an individual bank, r_s, are:

$$\begin{aligned} r_x &= \mu_x + \sqrt{\rho}\epsilon_x + J_x \\ r_I &= \mu_s + \sqrt{1-\rho}\epsilon_s + J_s \\ r_s &= r_x + r_I, \end{aligned}$$

where we introduced the idiosyncratic component of a bank's return r_I. In the model with a bailout, a government guarantee caps the log index return from below at $\underline{x}$. The no-bailout case is the special case with $\underline{x} = -\infty$.

In Section II.B, we assume a representative agent with reduced-form preferences over aggregate stock returns. The derivation is based on Backus et al. (2011) who consider a setting with CRRA preferences over consumption, in which case risk premia are increasing not only in α but also in the covariance between consumption growth and returns. We opt for less model complexity and directly define utility over market wealth. The log of the stochastic discount factor (SDF) is given by:

$$m = \mu_m - \alpha r_x,$$

where α is the agent's risk aversion.

We use the following notation for parameters of the index and idiosyncratic shocks in the pricing derivations below. The total volatility of the Gaussian index return is denoted σ_x, and corresponds to the quantity $\sqrt{\rho}\sigma$ in the main paper. Likewise σ_I is the total volatility of the Gaussian idiosyncratic returns and maps to $\sqrt{1-\rho}\sigma$ in the main paper. The index and idiosyncratic jump intensities are ω_x and ω_I, and map to $\rho\sigma^2\omega$ and $(1-\rho)\sigma^2\omega$ in the main paper. This derivation allows for separate jump size means and standard deviations for the index jump (θ_x, δ_x) and the idiosyncratic jump (θ_I, δ_I), though in the main paper these are equal to the same values (θ, δ).

In this notation, the mean log SDF follows from solving for the Euler equation of the one period bond:

$$\exp\{-r^f\} = E\left[\exp\{m\}\right].$$

Appendix F.2 shows (for the more general case with a bailout) that the resulting expression for μ_m is:

$$\mu_m = -r^f + \alpha\mu_x - 0.5\alpha^2\sigma_x^2 - \omega_x[\exp\{-\alpha\theta_x + 0.5\alpha^2\delta_x^2\} - 1].$$

E2. Transformation to Risk Neutral Measure

We verify the transformation between physical and risk-neutral measures, stated in the main text:

$$E\left[\exp\{r_x\}\right] = \exp\left\{\mu_x + \frac{1}{2}\sigma_x^2 + \omega_x\left[\exp\left(\theta_x + 0.5\delta_x^2\right) - 1\right]\right\}$$

$$\begin{aligned}
E^*\left[\exp\{r_x\}\right] &= E\left[\exp\{m+r_x\}\right]/E\left[\exp\{m\}\right] \\
&= \frac{E\left[\exp\{\mu_m+(1-\alpha)r_x\}\right]}{E\left[\exp\{\mu_m-\alpha r_x\}\right]} \\
&= \frac{E\left[\exp\{(1-\alpha)(\mu_x+\sigma_x\epsilon^X+J^X)\}\right]}{E\left[\exp\{-\alpha(\mu_x+\sigma_x\epsilon^X+J^X)\}\right]} \\
&= \exp\{\mu_x\}\frac{E\left[\exp\{(1-\alpha)\sigma_x\epsilon^X\}\right]E\left[\exp\{(1-\alpha)J^X\}\right]}{E\left[\exp\{-\alpha\sigma_x\epsilon^X\}\right]E\left[\exp\{-\alpha J^X\}\right]} \\
&= \exp\{\mu_x\}\frac{\exp\{0.5(1-\alpha)^2\sigma_x^2\}E\left[\exp\{(1-\alpha)J^X\}\right]}{\exp\{0.5(\alpha)^2\sigma_x^2\}E\left[\exp\{-\alpha J^X\}\right]} \\
&= \exp\{\mu_x\}\frac{\exp\{0.5(1-2\alpha)\sigma_x^2\}\exp\{\omega_x[\exp\{(1-\alpha)\theta_x+0.5(1-\alpha)^2\delta_x^2\}-1]\}}{\exp\{\omega_x[\exp\{-\alpha\theta_x+0.5\alpha^2\delta_x^2\}-1]\}} \\
&= \exp\left\{\mu_x+\frac{1}{2}\sigma_x^2-\alpha\sigma_x^2+\omega_x\exp\{-\alpha\theta_x+0.5\alpha^2\delta_x^2\}[\exp\{\theta_x-\alpha\delta_x^2+0.5\delta_x^2\}-1]\right\} \\
&= \exp\left\{\mu_x^*+\frac{1}{2}\sigma_x^2+\omega_x^*\left[\exp\left(\theta_x^*+0.5\delta_x^2\right)-1\right]\right\}
\end{aligned}$$

The mapping between the physical and risk-neutral parameters is:

$$\mu_x^*=\mu_x-\alpha\sigma_x^2,\quad \theta_x^*=\theta_x-\alpha\delta_x^2,\quad \omega_x^*=\omega_x\exp\{-\alpha\theta_x+0.5\alpha^2\delta_x^2\},\quad \delta_x^*=\delta_x$$

Note that this is the same expression as in the main text once we impose that $\sigma_x=\sqrt{\rho}\sigma$, $\theta_x=\theta$, and $\delta_x=\delta$. Because

$$1=E\left[\exp\{m+r_x\}\right]=E^*\left[\exp\{r_x\}\right]E\left[\exp\{m\}\right]=E^*\left[\exp\{r_x\}\right]\exp\{-r^f\}$$

we have that

$$r^f=\mu_x^*+\frac{1}{2}\sigma_x^2+\omega_x^*\left[\exp\left(\theta_x^*+0.5\delta_x^2\right)-1\right]$$

or

$$\mu_x=r^f+\alpha\sigma_x^2-\frac{1}{2}\sigma_x^2-\omega_x^*\left[\exp\left(\theta_x^*+0.5\delta_x^2\right)-1\right].$$

Note that this is the same expression as in the main text once we impose that $\sigma_x=\sqrt{\rho}\sigma$.

E3. Auxiliary Lemmas

Before turning to option pricing, we introduce two auxiliary lemmas which are necessary for the models with and without bailouts. Proofs for the lemmas are available from the authors upon request.

LEMMA 1: *Let $y\sim N(\mu_y,\sigma_y^2)$. Then*

$$E\left[\exp\{by\}1_{c>y}\right] = \exp\{b\mu_y+0.5b^2\sigma_y^2\}\Phi\left(\frac{c-\mu_y-b\sigma_y^2}{\sigma_y}\right).$$

LEMMA 2: *Let $x\sim N(\mu_x,\sigma_x^2)$, then*

$$E\left[\Phi\left(b_0+b_1x\right)\exp\left(ax\right)1_{x<c}\right] = \Phi\left(\frac{b_0-t_1}{\sqrt{1+b_1^2\sigma_x^2}}\,,\,\frac{c-t_2}{\sigma_x}\,;\rho\right)\exp(z_1)$$

where $t_1=-b_1t_2$, $t_2=a\sigma_x^2+\mu_x$, $z_1=\frac{a^2\sigma_x^2}{2}+a\mu_x$, $\rho=\frac{-b_1\sigma_x}{\sqrt{1+b_1^2\sigma_x^2}}$, and $\Phi(\cdot\,,\cdot\,;\rho)$ is the cumulative density function (CDF) of a bivariate standard normal with correlation parameter ρ.

E4. Option Pricing in MJ Model Without Bailout

We derive the expressions for put prices in the no-bailout case below. Option prices in the MJ model without a government bailout are a special case of the option pricing formulae developed in Appendix F. Specifically, the no-bailout case arises by setting $\underline{x} = -\infty$. We study the price of a put option on an individual bank stock. The price of the index option follows the same formulation after setting all idiosyncratic risk to zero. The option matures in one-period and has European exercise. We normalize the initial stock price to unity, which is equivalent to solving for the put price in terms of cost per dollar insured. Likewise, the strike price $K = \exp(k)$ is expressed as a fraction of a dollar (that is, $K = 1$ is the ATM option).

The price of the put is derived from:

$$Put = E\left[\exp(m)\left[K - \exp(r)\right]^{+}\right] = \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} \frac{e^{-\omega_x}\omega_x^i}{i!}\frac{e^{-\omega_I}\omega_I^j}{j!} Put_{i,j}$$

where the $Put_{i,j}$ is the option price conditional on i aggregate jumps and j idiosyncratic jumps. We next evaluate the price of the put specifically conditioning on the number of realized aggregate and idiosyncratic jumps. The price of a put conditional on (i, j) jumps is:

$$Put_{i,j} = -V_1^{NB} + V2^{NB}$$

The first term is:

$$\begin{aligned}
V_1^{NB} &= E\left[\exp\left(m + r\right) 1_{k>r}\right] \\
&= E\left[E\left\{\exp\left(\mu_m - \alpha r_x + r^I + r_x\right) 1_{k-r_x>r_I} | r_x\right\}\right] \\
&= E\left[E\left\{\exp\left(r^I\right) 1_{k-r_x>r_I} | r_x\right\} \exp\left\{\mu_m + (1-\alpha) r_x\right\}\right] \\
&= \exp\left\{\mu_m\right\} \Psi(1; r_I) E\left[\Phi\left(\phi_0 + \phi_1(-r_x)\right) \exp\left\{(\alpha-1)(-r_x)\right\} 1_{-r_x<+\infty}\right] \quad \text{by Lemma 1} \\
&= \exp\left(\mu_m\right) \Psi(1; r^I) \exp(z_1) \Phi\left(\frac{\phi_0 - t_1}{\sqrt{1+\phi_1^2(\sigma_x^2 + i\delta_x^2)}}, \frac{+\infty - t_2}{\sqrt{\sigma_x^2 + i\delta_x^2}}; \hat{\rho}\right) \quad \text{by Lemma 2}
\end{aligned}$$

where

$$\begin{aligned}
\Psi(1; r_I) &= \exp\{\mu_I + j\theta_I + 0.5(\sigma_I^2 + j\delta_I^2)\}, \\
\phi_1 &= \frac{1}{\sqrt{\sigma_I^2 + j\delta_I^2}}, \\
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I - (\sigma_I^2 + j\delta_I^2)\right), \\
t_2 &= (\alpha-1)(\sigma_x^2 + i\delta_x^2) - \mu_x - i\theta_x, \\
t_1 &= -\phi_1 t_2, \\
z_1 &= \frac{(\alpha-1)^2(\sigma_x^2 + i\delta_x^2)}{2} + (1-\alpha)(\mu_x + i\theta_x), \\
\hat{\rho} &= \frac{-\phi_1\sqrt{\sigma_x^2 + i\delta_x^2}}{\sqrt{1+\phi_1^2(\sigma_x^2 + i\delta_x^2)}}.
\end{aligned}$$

The second term can be solved as follows:

$$\begin{aligned}
V_2^{NB} &= KE\left[\exp(m)\, 1_{k>r}\right] \\
&= KE\left[E\left\{\exp\left\{\mu_m - \alpha r_x\right\} 1_{k-r_x>r_I} | r_x\right\}\right] \\
&= K\exp\left\{\mu_m\right\} E\left[E\left\{1_{k-r_x>r_I} | r_x\right\} | \ \exp\left\{-\alpha r_x\right\}\right] \\
&= K\exp\left\{\mu_m\right\} E\left[\Phi\left(\phi_0 + \phi_1(-r_x)\right)\exp\left\{\alpha(-r_x)\right\} 1_{-r_x<+\infty}\right] \quad \text{by Lemma 1} \\
&= K\exp\left\{\mu_m\right\}\exp\{z_1\}\Phi\left(\frac{\phi_0 - t_1}{\sqrt{1+\phi_1^2(\sigma_x^2 + i\delta_x^2)}}, \frac{+\infty - t_2}{\sqrt{\sigma_x^2 + i\delta_x^2}}; \hat{\rho}\right) \quad \text{by Lemma 2}
\end{aligned}$$

where

$$\begin{aligned}
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I\right), \\
t_2 &= \alpha(\sigma_x^2 + i\delta_x^2) - (\mu_x + i\theta_x), \\
z_1 &= \frac{\alpha^2(\sigma_x^2 + i\delta_x^2)}{2} - \alpha(\mu_x + i\theta_x).
\end{aligned}$$

The other terms are as in the V_1^{NB} term. Each $Put_{i,j}$ term delivers the standard Black-Scholes expression so that the MJ put price is a Poisson mixture of Black-Scholes put price components.

Merton Jump Model with Government Bailout

F1. Environment with Bailout

For the reader's convenience, we restate the model here for convenience. The annual returns on the financial sector index, $\tilde{r}_x$, and an individual bank, r_s, are:

$$\begin{aligned}
\tilde{r}_x &= \max[r_x, \underline{x}] \\
r_x &= \mu_x + \sqrt{\rho}\epsilon_x + J_x \\
r_I &= \mu_s + \sqrt{1-\rho}\epsilon_s + J_s \\
r_s &= \tilde{r}_x + r_I.
\end{aligned}$$

A government guarantee caps the log index return from below at $\underline{x}$. As discussed in Appendix E, the log of the stochastic discount factor (SDF) is given by:

$$m = \mu_m - \alpha r_x,$$

where α is the agent's risk aversion. The notation follows that of Appendix E.

F2. Deriving μ_m

We start by deriving the mean of the log SDF in the bailout model. We take r_f as an exogenous parameter, since this will be an empirical input determined by data.

$$\begin{aligned}
\exp\{-r^f\} &= E\left[\exp\{m\}\right], \\
&= \exp\{\mu_m\}E\left[\exp\{-\alpha r_x\}\right], \\
&= \exp\{\mu_m - \alpha(\mu_x + i\theta_x) + \frac{\alpha^2}{2}(\sigma_x^2 + i\delta_x^2)\}.
\end{aligned}$$

This expression is summed over the various possibilities for the number of jumps i.

$$\exp\{-r^f\} = \exp\{\mu_m - \alpha\mu_x + 0.5\alpha^2\sigma_x^2\}\sum_{i=0}^{\infty}\frac{e^{-\omega_x}\omega_x^i}{i!}e^{-\alpha(i\theta_x)+0.5\alpha^2(i\delta_x^2)}.$$

This allows us to solve for μ_m as a function of all other parameters:

$$\mu_m = -r^f + \alpha\mu_x - 0.5\alpha^2\sigma_x^2 - \omega_x[\exp\{-\alpha\theta_x + 0.5\alpha^2\delta_x^2\} - 1].$$

This is the same risk-free rate expression as in the case without a bailout, except that μ_x is different in the presence of a bailout.

F3. Deriving μ_x

Now, we price the stock return for a bank in order to obtain the expected return μ_x. Starting from the standard Euler equation:

$$\begin{aligned}
1 &= E\left[\exp\{m+r\}\right], \\
&= E\left[\exp\{\mu_m - \alpha r_x + \max\{r_x, \underline{x}\} + r^I\}\right], \\
&= \exp\{\mu_m\}E\left[\exp\{r^I\}\right]\left\{E\left[\exp\{(1-\alpha)r_x\}1_{r_x>\underline{x}}\right] + \exp\{\underline{x}\}E\left[\exp\{-\alpha r_x\}1_{r_x<\underline{x}}\right]\right\}.
\end{aligned}$$

For a given number of idiosyncratic jumps j, the first expectation is:

$$E\left[\exp\{r_I\}\right] = \exp\{\mu_I + j\theta_I + 0.5(\sigma_I^2 + j\delta_I^2)\}$$

and given a number of aggregate jumps i, the second expectation equals:

$$\begin{aligned}
E\left[\exp\{(1-\alpha)r_x\}1_{r_x>\underline{x}}\right] &= e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)} \\
&\quad \Phi\left(\frac{\mu_x + i\theta_x - \underline{x} + (1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right),
\end{aligned}$$

and the third expectation is:

$$E\left[\exp\{-\alpha r_x\}1_{r_x<\underline{x}}\right] = e^{-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x} - \mu_x - i\theta_x + \alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right).$$

All three expectations are summed over the various possibilities for the number of jumps i and j. After taking logs on both sides, we get:

$$\begin{aligned}
0 = \;& \mu_m + \mu_I + 0.5\sigma_I^2 + \omega_I[\exp\{\theta_I + 0.5\delta_I^2\} - 1] \\
&+ \log\left(\sum_{i=0}^{\infty}\frac{e^{-\omega_x}\omega_x^i}{i!}\left\{e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\mu_x + i\theta_x - \underline{x} + (1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\right.\right. \\
&\left.\left. + e^{\underline{x}-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x} - \mu_x - i\theta_x + \alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\right\}\right).
\end{aligned}$$

Because idiosyncratic risk is not priced, $\mu_I = -0.5\sigma_I^2 - \omega_I[\exp\{\theta_I + 0.5\delta_I^2\} - 1]$, so that the final expression is:

$$0 = \mu_m + \log\left(\sum_{i=0}^{\infty} \frac{e^{-\omega_x}\omega_x^i}{i!}\left\{e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\mu_x + i\theta_x - \underline{x} + (1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\right.\right.$$
$$\left.\left.+e^{\underline{x}-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x} - \mu_x - i\theta_x + \alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\right\}\right).$$

We can plug in for the expression for μ_m from above, and solve the resulting non-linear equation for μ_x.

F4. Valuing Put Options with Bailout

The price of the put is derived from:

$$Put = E\left[\exp(m)\left[K - \exp(r)\right]^+\right] = \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} \frac{e^{-\omega_x}\omega_x^i}{i!}\frac{e^{-\omega_I}\omega_I^j}{j!} Put_{i,j}$$

where the $Put_{i,j}$ is the option price conditional on i aggregate jumps and j idiosyncratic jumps. We next evaluate the price of the put specifically conditioning on the number of realized aggregate and idiosyncratic jumps. To avoid repetitive notation, we suppress notation for this conditioning, though it is assumed whenever the put price takes (i, j) subscripts.

$$Put_{i,j} = -E\left[\exp\left(m + r\right)1_{k>r}\right] + KE\left[\exp\left(m\right)1_{k>r}\right] = -V_1 + V_2.$$

We solve for V_1 and V_2 in turn.

Deriving V_1

We can rewrite V_1 as

$$V_1 = E\left[\exp\left(m + r^I + r_x\right)1_{k>r}1_{r_x>\underline{x}}\right] + E\left[\exp\left(m + r^I + \underline{x}\right)1_{k>r}1_{r_x<\underline{x}}\right] = V_{11} + V_{12}$$

The first term V_{11} reflects the situation where the option expires in the money but the bailout is not activated. It can be solved as follows:

$$\begin{aligned}
V_{11} &= E\left[\exp\left(m + r^I + r_x\right)1_{k>r}1_{r_x>\underline{x}}\right] \\
&= E\left[E\left\{\exp\left(\mu_m + (1-\alpha)r_x + r^I\right)1_{k-r_x>r_I}|r_x\right\} \mid 1_{r_x>\underline{x}}\right] \\
&= E\left[E\left\{\exp\left(r^I\right)1_{k-r_x>r_I}|r_x\right\}\exp\left\{\mu_m + (1-\alpha)r_x\right\}1_{r_x>\underline{x}}\right] \\
&= \exp\left(\mu_m\right)\Psi(1; r_I)E\left[\Phi\left(\phi_0 + \phi_1(-r_x)\right)\exp\left\{(\alpha-1)(-r_x)\right\}1_{-r_x<-\underline{x}}\right] \quad \text{by Lemma 1} \\
&= \exp\left(\mu_m\right)\Psi(1; r^I)\exp(z_1)\Phi\left(\frac{\phi_0 - t_1}{\sqrt{1+\phi_1^2(\sigma_x^2+i\delta_x^2)}}, \frac{-\underline{x} - t_2}{\sqrt{\sigma_x^2+i\delta_x^2}}; \hat{\rho}\right) \quad \text{by Lemma 2}
\end{aligned}$$

where

$$\begin{aligned}
\Psi(1;r_I) &= \exp\{\mu_I + j\theta_I + 0.5(\sigma_I^2 + j\delta_I^2)\}, \\
\phi_1 &= \frac{1}{\sqrt{\sigma_I^2 + j\delta_I^2}}, \\
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I - (\sigma_I^2 + j\delta_I^2)\right), \\
t_2 &= (\alpha - 1)(\sigma_x^2 + i\delta_x^2) - \mu_x - i\theta_x, \\
t_1 &= -\phi_1 t_2, \\
z_1 &= \frac{(\alpha-1)^2(\sigma_x^2 + i\delta_x^2)}{2} + (1-\alpha)(\mu_x + i\theta_x), \\
\hat{\rho} &= \frac{-\phi_1\sqrt{\sigma_x^2 + i\delta_x^2}}{\sqrt{1 + \phi_1^2(\sigma_x^2 + i\delta_x^2)}}.
\end{aligned}$$

The second term V_{12} reflects the situation where the option expires in the money and the bailout is activated. It can be solved as follows:

$$\begin{aligned}
V_{12} &= E\left[\exp(m + r)\, 1_{k>r} 1_{r_x<\underline{x}}\right] \\
&= E\left[E\left\{\exp\left(\mu_m - \alpha r_x + \underline{x} + r^I\right) 1_{k-\underline{x}>r_I}\right\} 1_{r_x<\underline{x}}\right] \\
&= \exp(\mu_m + \underline{x})\, E\left[\exp\left(r^I\right) 1_{k-\underline{x}>r_I}\right] E\left[\exp(-\alpha r_x)\, 1_{r_x<\underline{x}}\right] \\
&= \exp\{\mu_m + \underline{x}\}\, \Psi(1;r_I)\Phi\left(\phi_0 + \phi_1(-\underline{x})\right) e^{-\alpha(\mu_x + i\theta_x) + 0.5\alpha^2(\sigma_x^2 + i\delta_x^2)}\Phi\left(\frac{\underline{x} - \mu_x - i\theta_x + \alpha(\sigma_x^2 + i\delta_x^2)}{\sqrt{\sigma_x^2 + i\delta_x^2}}\right)
\end{aligned}$$

where $\Psi(1;r_I)$, ϕ_0, and ϕ_1 are identical to those defined above in the V_{11} term.

Deriving V_2

We can rewrite V_2 as

$$V_2 = KE\left[\exp\{m\}\, 1_{k>r} 1_{r_x>\underline{x}}\right] + KE\left[\exp(m)\, 1_{k>r} 1_{r_x<\underline{x}}\right] = V_{21} + V_{22}.$$

The first term V_{21} reflects states where the option expires in the money and the bailout is inactive. It can be solved as follows:

$$\begin{aligned}
V_{21} &= KE\left[\exp(m)\, 1_{k>r} 1_{r_x>\underline{x}}\right] \\
&= KE\left[E\left\{\exp\{\mu_m - \alpha r_x\}\, 1_{k-r_x>r_I} | r_x\right\} \mid 1_{r_x>\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, E\left[E\left\{1_{k-r_x>r_I} | r_x\right\} \mid \exp\{-\alpha r_x\}\, 1_{r_x>\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, E\left[\Phi\left(\phi_0 + \phi_1(-r_x)\right)\exp\{\alpha(-r_x)\}\, 1_{-r_x<-\underline{x}}\right] \quad \text{by Lemma 1} \\
&= K\exp\{\mu_m\}\exp\{z_1\}\Phi\left(\frac{\phi_0 - t_1}{\sqrt{1 + \phi_1^2(\sigma_x^2 + i\delta_x^2)}}, \frac{-\underline{x} - t_2}{\sqrt{\sigma_x^2 + i\delta_x^2}}; \hat{\rho}\right) \quad \text{by Lemma 2}
\end{aligned}$$

where

$$\begin{aligned}
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I\right), \\
t_2 &= \alpha(\sigma_x^2 + i\delta_x^2) - (\mu_x + i\theta_x), \\
t_1 &= -\phi_1 t_2, \\
z_1 &= \frac{\alpha^2(\sigma_x^2 + i\delta_x^2)}{2} - \alpha(\mu_x + i\theta_x).
\end{aligned}$$

The other elements are the same as in the V_1 term.

Finally, V_{22} captures states when the bailout is activated:

$$\begin{aligned}
V_{22} &= KE\left[\exp(m)\, 1_{k>r} 1_{r_x<\underline{x}}\right] \\
&= KE\left[\exp\{\mu_m - \alpha r_x\}\, 1_{k-\underline{x}>r_I} 1_{r_x<\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, E\left[1_{r_I<k-\underline{x}}\right] E\left[\exp(-\alpha r_x)\, 1_{r_x<\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, \Phi\left(\frac{k-\underline{x}-\mu_I - j\theta_I}{\sqrt{\sigma_I^2 + j\delta_I^2}}\right) e^{-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x}-\mu_x - i\theta_x + \alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right).
\end{aligned}$$

Call options can then be priced via put-call parity, which holds in this model.

MJ Model with Uncertain Bailout

We now extend the model to a case in which the investor is uncertain about the nature of the bailout. The investor believes that with probability p there will be a bailout and with probability $1-p$ there will not be a bailout.

G1. Deriving μ_m and μ_x

The mean SDF μ_m follows the same expression as in the bailout and no-bailout cases.

Next, we price the stock return for a bank.

$$\begin{aligned}
1 &= E\left[\exp\{m+r\}\right], \\
&= \exp\{\mu_m\} E\left[\exp\{r_I\}\right] \left\{ E\left[e^{(1-\alpha)r_x} 1_{r_x>\underline{x}}\right] + pe^{\underline{x}} E\left[e^{-\alpha r_x} 1_{r_x<\underline{x}}\right] + (1-p) E\left[e^{(1-\alpha)r_x} 1_{r_x<\underline{x}}\right]\right\}
\end{aligned}$$

We recall that:

$$E\left[\exp\{-\alpha r_x\} 1_{r_x<\underline{x}}\right] = e^{-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x}-\mu_x - i\theta_x + \alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)$$

and that:

$$\begin{aligned}
E\left[\exp\{(1-\alpha)r_x\} 1_{r_x>\underline{x}}\right] &= e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)} \\
&\quad \Phi\left(\frac{\mu_x + i\theta_x - \underline{x} + (1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)
\end{aligned}$$

The last term is:

$$\begin{aligned}
E\left[e^{(1-\alpha)r_x} 1_{r_x<\underline{x}}\right] &= e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)} \\
&\quad \Phi\left(\frac{\underline{x}-\mu_x - i\theta_x - (1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)
\end{aligned}$$

Define the term B_i as:

$$
\begin{aligned}
B_i &= e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\mu_x+i\theta_x-\underline{x}+(1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\\
&+pe^{\underline{x}-\alpha(\mu_x+i\theta_x)+0.5\alpha^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x}-\mu_x-i\theta_x+\alpha(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)\\
&+(1-p)e^{(1-\alpha)(\mu_x+i\theta_x)+0.5(1-\alpha)^2(\sigma_x^2+i\delta_x^2)}\Phi\left(\frac{\underline{x}-\mu_x-i\theta_x-(1-\alpha)(\sigma_x^2+i\delta_x^2)}{\sqrt{\sigma_x^2+i\delta_x^2}}\right)
\end{aligned}
$$

Putting all the terms together, we get:

$$
1 = e^{\mu_m}e^{\mu_I+0.5\sigma_I^2+\omega_I[\exp\{\theta_I+0.5\delta_I^2\}-1]}\sum_{i=0}^{\infty}\frac{e^{-\omega_x}\omega_x^i}{i!}B_i
$$

After taking logs on both sides, and noting that $\mu_I+0.5\sigma_I^2+\omega_I[\exp\{\theta_I+0.5\delta_I^2\}-1]=0$, the final expression is:

$$
0 = \mu_m+\log\left(\sum_{i=0}^{\infty}\frac{e^{-\omega_x}\omega_x^i}{i!}B_i\right)
$$

This is a non-linear expression in μ_x.

G2. Option Prices With Uncertain Bailout

We still start from:

$$
\begin{aligned}
Put_t &= E_t\left[M_{t+1}\left(K-R_{t+1}\right)^+\right]=\sum_{i=0}^{\infty}\sum_{j=0}^{\infty}\frac{e^{-\omega_x}\omega_x^i}{i!}\frac{e^{-\omega_I}\omega_I^j}{j!}Put_{i,j}\\
Put_{i,j} &= -E\left[\exp\left(m+r\right)1_{k>r}\right]+KE\left[\exp\left(m\right)1_{k>r}\right]=-V_1^U+V_2^U.
\end{aligned}
$$

The superscript U stands for *U*ncertain bailout. We now develop the two terms.

$$
V_1^U = E\left[\exp\left(m+r\right)1_{k>r}1_{r_x>\underline{x}}\right]+E\left[\exp\left(m+r\right)1_{k>r}1_{r_x<\underline{x}}\right]=V_{11}^U+V_{12}^U
$$

The first term V_{11}^U reflects the situation where the option expires in the money and the return is above the cutoff. Whether or not there is a bailout, it would not be activated anyway. So, this term is identical to the one derived above: $V_{11}^U=V_{11}$.

Next, we turn to V_{12}^U. It reflects the situation where the option expires in the money and the return is below the cutoff. With probability p, the bailout is activated and we obtain the V_{12} term from before. With probability $1-p$, there is no bailout and the option is worth $\hat{V}_{12}$.

$$
\begin{aligned}
V_{12}^U &= E\left[\exp\left(m+r\right)1_{k>r}1_{r_x<\underline{x}}\right]=pV_{12}+(1-p)\hat{V}_{12}^U\\
\hat{V}_{12}^U &= E\left[E\left\{\exp\left(\mu_m+(1-\alpha)r_x+r^I\right)1_{k-r_x>r_I}\right\}1_{r_x<\underline{x}}\right]\\
&= \exp\left(\mu_m\right)E\left[E\left[\exp\left(r^I\right)1_{k-r_x>r_I}|r_x\right]e^{(1-\alpha)r_x}1_{r_x<\underline{x}}\right]\\
&= \exp\left(\mu_m\right)\Psi(1;r_I)E\left[\Phi\left(\phi_0+(-\phi_1)r_x\right)e^{(1-\alpha)r_x}1_{r_x<\underline{x}}\right] \quad \text{by Lemma 1}\\
&= \exp\left(\mu_m\right)\Psi(1;r^I)\exp(z_1)\Phi\left(\frac{\phi_0-t_1}{\sqrt{1+\phi_1^2(\sigma_x^2+i\delta_x^2)}}\,,\,\frac{\underline{x}-t_2}{\sqrt{\sigma_x^2+i\delta_x^2}}\,;\hat{\rho}\right) \quad \text{by Lemma 2}
\end{aligned}
$$

where

$$\begin{aligned}
\Psi(1;r_I) &= \exp\{\mu_I + j\theta_I + 0.5(\sigma_I^2 + j\delta_I^2)\}, \\
\phi_1 &= \frac{1}{\sqrt{\sigma_I^2 + j\delta_I^2}}, \\
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I - (\sigma_I^2 + j\delta_I^2)\right), \\
t_2 &= (1-\alpha)(\sigma_x^2 + i\delta_x^2) + \mu_x + i\theta_x, \\
t_1 &= \phi_1 t_2, \\
z_1 &= \frac{(1-\alpha)^2(\sigma_x^2 + i\delta_x^2)}{2} + (1-\alpha)(\mu_x + i\theta_x), \\
\hat{\rho} &= \frac{\phi_1\sqrt{\sigma_x^2 + i\delta_x^2}}{\sqrt{1 + \phi_1^2(\sigma_x^2 + i\delta_x^2)}}.
\end{aligned}$$

Next, we work on the second term.

$$\begin{aligned}
V_2^U &= KE\left[\exp\{m\}\, 1_{k>r}\right] \\
&= KE\left[\exp\{m\}\, 1_{k>r} 1_{r_x>\underline{x}}\right] + KE\left[\exp(m)\, 1_{k>r} 1_{r_x<\underline{x}}\right] = V_{21}^U + V_{22}^U.
\end{aligned}$$

The first component V_{21}^U reflects states where the option expires in the money and the return is above the cutoff. Whether or not there exists a bailout, it does not matter. So, $V_{21}^U = V_{21}$. For the second component, V_{22}^U, we have:

$$\begin{aligned}
V_{22}^U &= KE\left[\exp(m)\, 1_{k>r} 1_{r_x<\underline{x}}\right] = pV_{22} + (1-p)\hat{V}_{22}^U \\
\hat{V}_{22}^U &= KE\left[\exp\{\mu_m - \alpha r_x\}\, 1_{k-r_x>r_I} 1_{r_x<\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, E\left[E\left[1_{k-r_x>r_I}|r_x\right] e^{-\alpha r_x} 1_{r_x<\underline{x}}\right] \\
&= K\exp\{\mu_m\}\, E\left[\Phi\left(\phi_0 + (-\phi_1)r_x\right) e^{-\alpha r_x} 1_{r_x<\underline{x}}\right] \qquad \text{by Lemma 1} \\
&= K\exp\{\mu_m\}\exp\{z_1\}\Phi\left(\frac{\phi_0 - t_1}{\sqrt{1 + \phi_1^2(\sigma_x^2 + i\delta_x^2)}}\ , \frac{\underline{x} - t_2}{\sqrt{\sigma_x^2 + i\delta_x^2}}\ ;\hat{\rho}\right) \qquad \text{by Lemma 2}
\end{aligned}$$

where

$$\begin{aligned}
\phi_1 &= \frac{1}{\sqrt{\sigma_I^2 + j\delta_I^2}}, \\
\phi_0 &= \phi_1\left(k - \mu_I - j\theta_I\right), \\
t_2 &= -\alpha(\sigma_x^2 + i\delta_x^2) + \mu_x + i\theta_x, \\
t_1 &= \phi_1 t_2, \\
z_1 &= \frac{(-\alpha)^2(\sigma_x^2 + i\delta_x^2)}{2} - \alpha(\mu_x + i\theta_x), \\
\hat{\rho} &= \frac{\phi_1\sqrt{\sigma_x^2 + i\delta_x^2}}{\sqrt{1 + \phi_1^2(\sigma_x^2 + i\delta_x^2)}}.
\end{aligned}$$

In sum, we find:

$$\begin{aligned}
Put_{i,j} &= -(V_{11}^U + V_{12}^U) + V_{21}^U + V_{22}^U \\
&= -(V_{11} + pV_{12}^U + (1-p)\hat{V}_{12}^U) + V_{21} + pV_{22} + (1-p)\hat{V}_{22}^U
\end{aligned}$$

G3. Numerical Illustration

In order to illustrate the effects of uncertainty over the bailout, we consider the MJ model with parameters estimated form the physical stock return distribution, as presented in Table 4. We focus on the financial sector and the crisis period. Specifically, $(\omega, \theta, \delta) = (7, -0.05, 0.25)$, $\sigma = 0.79$, and $\rho = 0.67$ during the crisis. We consider a bailout of $\underline{x} = -0.45$, the point estimate from Section IV.B. Risk aversion is $\alpha = 1$. The option has one year maturity, the initial price is $S_0 = 1$ and the strike price is $K = 0.78$. For these parameters, the price of the basket (individual put option) is 0.225 without bailout, 0.159 with a certain bailout (which corresponds to the value in the data), and 0.195 when a bailout occurs with probability 0.5. We note that the put price under an uncertain bailout is higher than the probability-weighted average of the put prices under the bailout and no-bailout cases. In our example, $0.195 > 0.192 = 0.5 \times 0.225 + 0.5 \times 0.159$. This is a Jensen effect which arises from the drift adjustment μ_x. The equity risk premium is higher under uncertain bailout than the weighted average risk premium under no and certain bailouts.

Interpreting Jump Parameter Estimates

In this appendix, we further discuss the estimated jump parameter values from Sections III and IV. As shown in Section 3.3.2, jump parameters implied by the physical return calibration, $(\omega, \theta, \delta) = (7, -0.05, 0.25)$, do not generate enough risk to account for the high put option prices.

The estimation in Section 3.3.3 gives the no-bailout model a better chance of fitting the data by choosing parameters without regard to the physical return moments. Yet, as we show in the main text, it still cannot produce the required run-up in the basket-index put spread in the financial sector. The estimated parameters are $(\omega, \theta, \delta) = (3.2, -0.34, 0.54)$ for the financial sector and $(\omega, \theta, \delta) = (739.2, -0.07, 0.40)$ for the non-financial sector. The intensity of aggregate jumps is given by $\omega_x = \omega\rho\sigma^2$ in the model of Section II.B. Therefore, an estimate of $\omega = 3.2$ translates into a low frequency of jumps for the index, 0.11, on average during the full sample (i.e. based on the daily time series of estimates of ρ and σ). This, together with an average jump size of -34%, indicate that the data prefer what amounts to a rare disaster model for the financial sector.

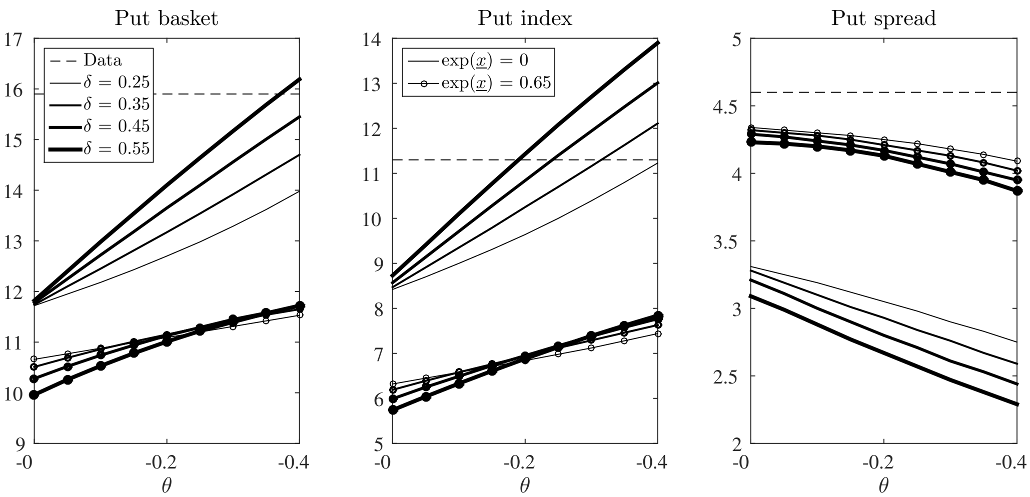
Figure H1 illustrates how the model prices the put basket, the put index, and the put spread in the financial sector for various combinations of the parameters θ (on the horizontal axis) and δ (various lines without markers). It does so for a value of $\omega = 5$, an intermediate value between the point estimate from the physical calibration and that from the no-bailout MJ model. The fits from the physical calibration of Section III.C correspond to the left side of the figures (as $\theta = -.05$ and in that calibration). The figure shows how the option prices are far off the mark in the physical calibration. It shows clearly that one needs to increase the risk in the model until θ is about -0.35 and δ is about 0.55 if one wants to be near the range of put prices we see in the data. Unfortunately, at these values, the third panel shows that this calibration is far off on the basket-index spread.

Next we explore what happens when we introduce a bailout in the MJ model. We assume a bailout size of $\exp(\underline{x}) = 0.65$, motivated by our estimate from the data. The corresponding bailout model prices are indicated by the lines marked with circles, again for various values of δ. With a bailout, even at the high risk levels included in the figure, puts are not expensive enough. However, one important change is that the basket-index spread is now substantially higher and closer to the data. It becomes clear that matching the data requires a big enough bailout so that the spread is large while at the same time making sure risks are high enough to match the level of put basket and index prices. This is exactly what the best-fitting bailout model accomplishes by further increasing the magnitudes of θ and δ.

Figure H2 shows the same option price panels for a larger range of θ values (top row) and δ values (bottom row), each time holding fixed the other parameters at their point estimate in the bailout model estimation of Table 8. For any level of bailout (different lines in each panel), we can see that stronger bailouts shift put prices down. The graph also illustrates that we must gradually increase the risk parameters in order to reach the observed put levels. The best fit is from $\theta = -0.75$ and $\delta = 2.5$. The slopes are steepest for θ, suggesting that this is the parameter to which moments are most sensitive. The put prices are less steep for δ, so the loss in fit from having a lower value of δ is not as severe.

To further emphasize that the parameters are well identified by our estimation approach, Figure H3 shows the GMM objective function. Recall that the GMM objective function is the average squared distance between 18 option pricing moments in the model and data (basket put prices, index put prices,

Figure H1. Crisis Puts – Model and Data



Note: Fitted crisis put prices for the financial sector at various θ and δ values, with ω held fixed at 5 (which is about halfway between the ω of 7 in the physical calibration, and the value of 3.2 in the option estimation with no bailout). These fits follow our usual approach. That is, given a set of jump parameters, we fix ρ at the estimated return correlation, and invert σ from the call basket. This is done day by day, just like in our estimation, then averaged over the crisis sample. Heavier lines correspond to higher δ values. Lines with (without) circles correspond to fits based on a 65% (0%) bailout. Data values are shown as dashed lines.

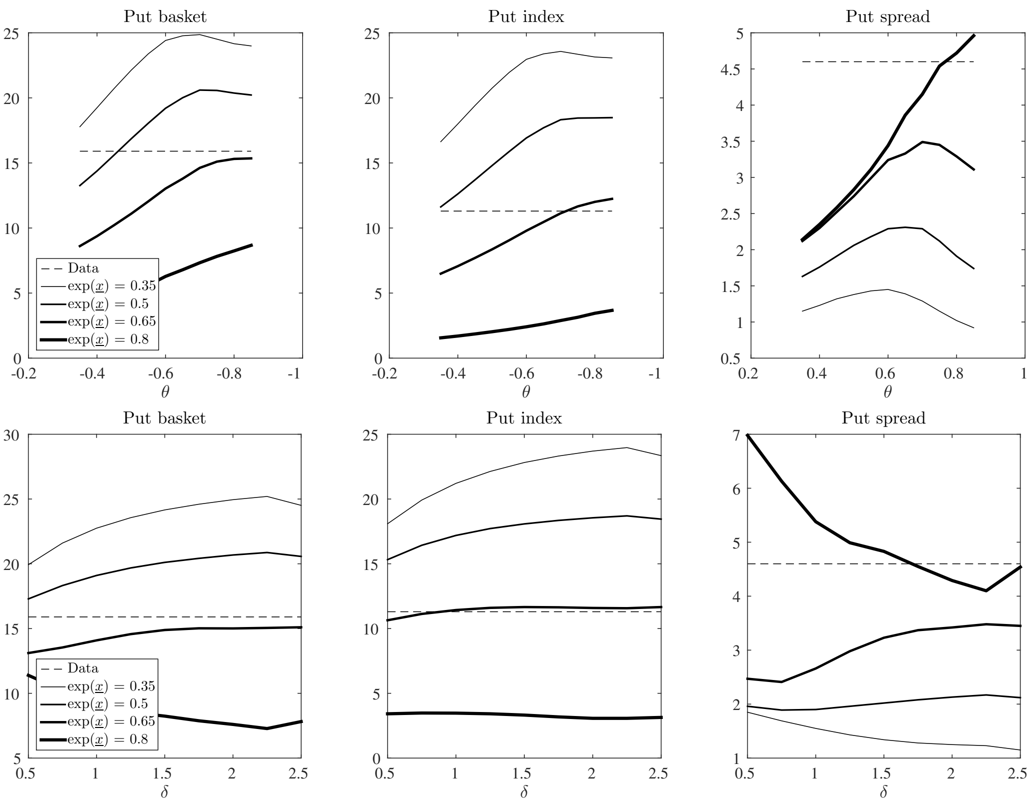
their spread, in pre-crisis, crisis, and their difference). For convenience, we plot the inverse of the objective function, so that higher values indicate a better fit. The bottom panel shows that the objective function is sharply identified in the dimension of the bailout, $\exp(\underline{x})$, and in the dimension of the average jump size, θ. The other panels show that the objective function is flatter in the δ dimension, but there is still clearly good identification. The objective function is also flatter in the ω dimension (not shown), though again there is a clear optimum in this dimension.

In order to understand the parameter estimates in the bailout model, we have also analyzed the moment generating function of returns under the risk neutral measure. It reveals that the risk neutral probability density function is bimodal with one peak in positive return territory (corresponding to the case with zero jumps) and one peak at the bailout threshold deep into negative return territory (corresponding to the cases of one or more jumps, the "disaster state"). At high enough levels of θ and δ, the bailout level $\underline{x}$ pins down the size of the financial disaster because the bailout will be activated whenever there is at least one jump. In other words, in the presence of a bailout, the parameters θ and δ lose their usual interpretation of controlling the size the jump, and instead primarily influence the likelihood of triggering the bailout.

Given our estimates, the bailout model essentially behaves as a rare disaster model, where the size of the aggregate disaster is determined by the bailout threshold. That is, if a jump occurs, it is very large and is essentially guaranteed to trigger the bailout. This concentrates probability mass at the bailout threshold (at -36%, according to our estimates). But the occurrence of a jump is also very infrequent, occurring with a probability of only 0.8% each year. This feature is unique to financials. For non-financial sectors, our estimates imply more frequent and smaller downward jumps.

Our estimates throughout the paper also indicate that financial sector option prices require especially high levels of risk relative to standard estimates for S&P 500 index options in the options literature. However, it is important to note that our estimates for the financial sector and estimates for S&P 500 index options in the literature are not directly comparable. First, the underlying assets have different

FIGURE H2. CRISIS PUTS – MODEL AND DATA



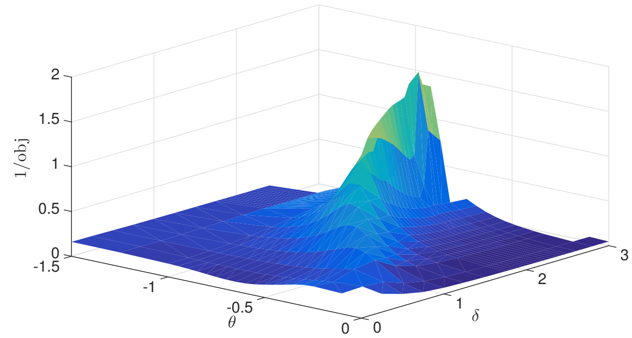
Note: Fitted crisis put prices for the financial sector at various θ, δ, and $\exp(\underline{x})$ values, with ω held fixed at 37.9 (its value in the bailout estimation). In the top panel we vary θ, holding δ fixed at its value in bailout estimation (2.47), and vice versa in the bottom panel (there θ is fixed at -0.75). These fits follow our usual approach. That is, given a set of jump parameters, we fix ρ at the estimated return correlation, and invert σ from the call basket. This is done day by day, just like in our estimation, then averaged over the crisis sample. Heavier lines correspond to larger bailouts. Data values are shown as dashed lines.

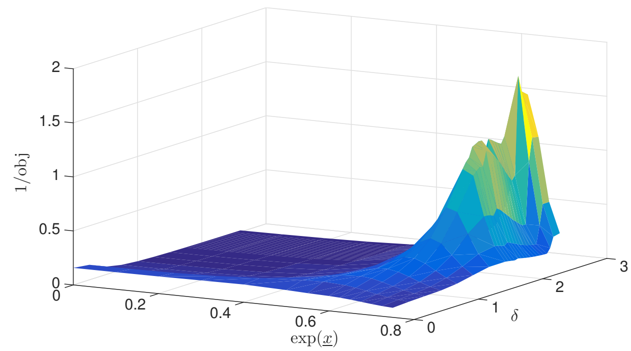
riskiness, and second, the estimates are based on different samples. Most studies of the S&P 500 index use data from the 1990s and early 2000s, prior to the financial crisis, while our data are from 2003 to 2009. Finally, all of our risk estimates take risk prices as given, since we fix the CRRA risk aversion at $\alpha = 1$ throughout our model estimation. We can lower the jump risk parameters and still match high put price levels in the financial sector if we allow for $\alpha > 1$. However, as Section II.B illustrates, this will produce to an even poorer match of the financial sector put spread in the baseline MJ model.

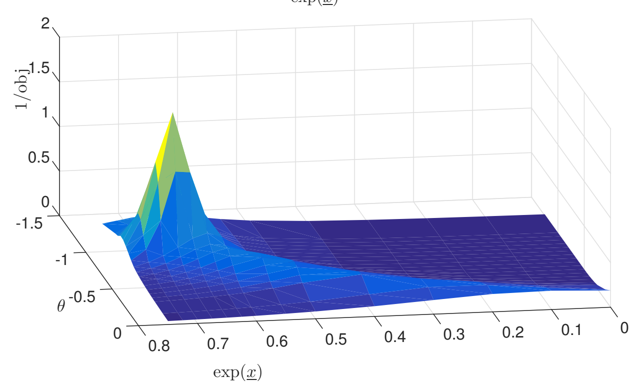
ALTERNATIVE FORM OF BAILOUT

Figure I1 studies an alternative bailout model, where rather than capping the maximum financial index return loss the bailout provides a dollar floor on the price level of the financial sector index level. We plot the basket-index spreads for financials for an alternative bailout specification (dashed line marked by asterisks) in which the index value is never allowed to fall below a per share value of $6 and assuming the same risk parameters estimated for the bailout model of Section IV. The graph also plots the put spread

Figure H3. Objective Function Surface







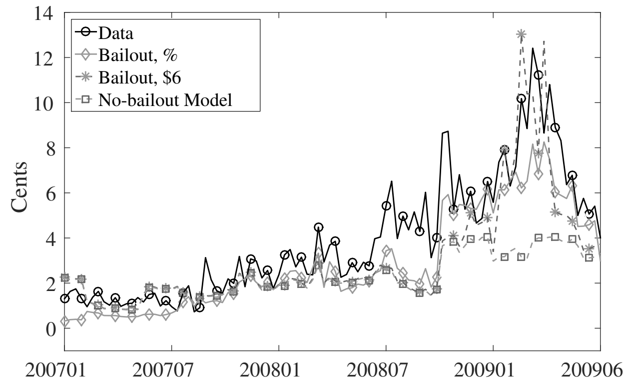
Note: The inverse of the GMM objective function at various gridpoints (50,000 points). These are 3-dimensional representations of a 5-dimensional space (the five dimensions are $\omega, \theta, \delta, \exp(\underline{x}), 1/\text{gmmobj}$).

in the estimated MJ bailout model which assumes a fixed percentage bailout (marked by diamonds). The alternative specification generates an even larger increase in the basket-index put spread than the baseline bailout specification.

The Effects of Moneyness and Maturity

Table J1 report basket-index put and call spreads for both sectors at different moneyness and maturity than the one year, delta 25 data reported in Table 1. Panel A and B report spreads for options that are closer-to-the-money (that is, have a higher probability of positive payoff). The proportional increase in

Figure I1. Basket-Index Spreads in Bailout Model



Note: Basket-index put spreads for the financial sector in the data (marked by circles). Also shown are spreads in the estimated MJ bailout model reported in Section IV which assumes a fixed percentage bailout (marked by diamonds). Next we plot spreads for an alternative bailout specification in which the index value is never allowed to fall below a per share value of $6 and assuming the same risk parameters estimated for the bailout model of Section IV (marked by asterisks). Finally, we plot the spread from the estimated MJ model without bailouts (marked by squares). Units are cents per dollar insured.

the basket-index spread from pre-crisis to crisis is larger for OTM put options than for ATM put options, as OTM options isolate payouts to the crash state in which a bailout is more likely to be active.

Panel C shows one month delta 25 spreads. Because the maturity is 1/12 that of our main analysis, the levels of option prices and spreads are much smaller. However, the percentage effects are magnified. One month put spreads increased by a factor of 3.5 during the crisis (versus 3.3 times for one year options) and the put spread rise is 2.5 times that of calls (versus 2.2 times for one year options). The change in financial sector one month put spreads is ten times larger than non-financials, versus 3.6 times larger in the case of one year options.

Lastly, we assess the robustness of our parameter estimates using options with different moneyness. Our main analysis uses delta 25 options. Table J2 below reports results when we instead estimate the MJ bailout model using options with delta 35. We repeat our entire GMM estimation using these distinct options data, yet the results are very similar to those in our main analysis (see Table 8). Because delta 35 options are closer-to-the-money, all option price levels are higher. Overall, the MJ bailout model achieves a very close fit for all options – puts and calls, basket and index, pre-crisis and crisis. For example, the price of the basket put during the crisis is 18.4 cents in the model and 18.7 cents in the data. More importantly, it closely matches the rise in the put spread during the crisis (2.1 cents in the model versus 2.3 cents in the data). The jump parameter estimates are also very similar to those in the main text. We estimate (ω, θ, δ) to be (7.6,-0.80,2.16) based on delta 35 options, while Table 8 reports estimates of (37.9,-0.75,2.47) based on delta 25 options. Similarly, the estimated size of the bailout, $\exp(\underline{x})$, is 0.69 for delta 35 and 0.64 for delta 25.

Option Liquidity

Table K1 reports summary statistics for the liquidity of put options on the S&P 500 index, sector indices (a value-weighted average across all 9 sectors), the financial sector index, all individual stock options (a value-weighted average), and individual financial stock options. The table reports daily averages of the bid-ask spread in dollars, the bid-ask spread in percentage of the midpoint price, trading volume, and open interest. The columns cover the full range of moneyness, from deep OTM ($\Delta < 20$) to deep ITM ($\Delta > 80$), while the rows report a range of option maturities. We separately report averages for the pre-crisis and crisis periods. A substantial fraction of trade in index options takes place in over-thecounter markets, which are outside our database. Hence, the bid-ask and volume numbers understate the degree of liquidity. However, absent arbitrage opportunities across trading locations, the option prices in our database do reflect this additional liquidity.

OTM put options with $\Delta < 20$ have large spreads, and volume is limited. OTM puts with delta between 20 and 50 still have substantial option spreads. For long-dated OTM puts (maturity in excess of 180 days), the average pre-crisis spread is 5.5% for the S&P 500, 12.8% for the sector options, 10.8% for the financial sector options, 6.8% for all individual stock options, and 7.0% for individual stock options in the financial sector. Financial sector index options appear, if anything, more liquid than other sector index options. The liquidity difference between index and individual put options is smaller for the financial sector than for the average sector.

Furthermore, during the financial crisis, the liquidity of the options appears to increase. For long-dated OTM puts, the spreads decrease from 5.5% to 4.7% for S&P 500 options, from 12.8% to 7.8% for sector options, from 10.8% to 4.5% for financial sector options, from 6.8 to 5.5% for all individual options, and from 7.0% to 5.8% for financial firms' options. (We note that the absolute bid-ask spreads increase during the crisis but this is explained by the rise in put prices during the crisis. The absolute bid-ask spreads increase by less than the price.) At the same time, volume and open interest for long-dated OTM puts increased. Volume increased from 400 to 507 contracts for the S&P 500 index options, from 45 to 169 for the sector options, from 287 to 1049 for financial index options, and from 130 to 162 for individual stock options in the financial sector. During the crisis, trade in OTM financial sector put options exceeds not only trade in the other sector OTM put options but also trade in the OTM S&P 500 options. The absolute increase in liquidity of financial sector index puts during the financial crisis and the relative increase versus individual put options suggest that index options should have become more expensive, not cheaper during the crisis.

Table K2 reports the same liquidity statistics for calls. Calls and puts are similarly liquid yet display very different basket-index spread behavior. The increase in the put spreads during the crisis is also present in shorter-dated options, which are more liquid. These facts suggest that illiquidity is an unlikely explanation for our findings.

Table B1—Top 40 Holdings of the Financial Sector Index XLF

	12/30/2010		07/30/2007	
	Name	Weighting	Name	Weighting
1	JPMorgan Chase	9.01	Citigroup	11.10
2	Wells Fargo	8.86	Bank of America	10.14
3	Citigroup	7.54	AIG	8.02
4	Berkshire Hathaway	7.52	JPMorgan Chase	7.25
5	Bank of America	7.30	Wells Fargo	5.44
6	Goldman Sachs	4.66	Wachovia	4.35
7	U.S. Bancorp	2.82	Goldman Sachs	3.71
8	American Express	2.44	American Express	3.35
9	Morgan Stanley	2.25	Morgan Stanley & C	3.25
10	MetLife	2.21	Merrill Lynch	3.11
11	Bank of New York Mellon	2.04	Federal National Mortgage	2.81
12	PNC Financial Services	1.75	US Bancopr	2.51
13	Simon Property	1.60	Bank of New York Mellon	2.32
14	Prudential	1.56	Metlife	2.15
15	AFLAC	1.45	Prudential	2.00
16	Travelers	1.39	Federal Home Loan Mortgage	1.83
17	State Street	1.27	Travelers	1.63
18	CME Group	1.18	Washington Mutual	1.61
19	ACE Ltd.	1.15	Lehman Brothers	1.59
20	Capital One Financial	1.06	Allstate	1.56
21	BB&T	1.00	CME Group	1.46
22	Chubb	0.99	Capital One Financial	1.41
23	Allstate	0.93	Hartford Financial	1.40
24	Charles Schwab	0.93	Suntrust Banks	1.35
25	T. Rowe Price	0.89	State Street	1.28
26	Franklin Resources	0.87	AFLAC	1.23
27	AON	0.82	PNC	1.11
28	Equity Residential	0.81	Regions Financial	1.02
29	Marsh & McLennan	0.81	Loews	1.02
30	SunTrust Banks	0.80	Franklin Resources	1.01
31	Ameriprise Financial	0.78	Charles Schwab	0.98
32	Public Storage	0.77	BB&T	0.98
33	Vornado Realty Trust	0.74	Fifth Third Bancorp	0.98
34	Northern Trust	0.73	Chubb	0.97
35	HCP	0.73	SLM	0.97
36	Progressive	0.71	Simon Property	0.93
37	Loews	0.67	ACE Ltd.	0.91
38	Boston Properties	0.66	National City	0.82
39	Host Hotels & Resorts	0.64	Countrywide Financial	0.81
40	Fifth Third Bancorp	0.64	Lincoln National	0.79

Note: This table reports the 40 firms with the largest weights in the financial sector index ETF, XLF, on 12/30/2010 and 07/30/2007. On 12/30/2010, there were 81 companies in XLF; on 07/30/2007, there were 96 companies. The weights are the relative market capitalizations of the top 40 holdings of the index.

Table D1—Cost of Insurance in BS Model with Stock Heterogeneity

	Financials						Non-financials					
	Puts			Calls			Puts			Calls		
	Basket	Index	Spread	Basket	Index	Spread	Basket	Index	Spread	Basket	Index	Spread
Panel A: Model												
Pre-crisis	3.8	1.8	1.9	3.4	1.6	1.8	4.9	1.8	3.1	4.2	1.5	2.7
Crisis	11.4	8.2	3.1	5.5	3.5	2.1	7.7	4.6	3.1	5.4	2.9	2.5
Crisis diff.	7.6	6.4	1.2	2.2	1.9	0.3	2.8	2.7	0.0	1.2	1.4	-0.2
Panel B: Data												
Pre-crisis	5.2	3.8	1.4	3.4	1.8	1.6	6.2	3.7	2.4	4.2	1.8	2.4
Crisis	15.9	11.3	4.6	5.5	3.4	2.1	10.0	6.7	3.3	5.4	2.5	2.9
Crisis diff.	10.6	7.5	3.2	2.2	1.6	0.5	3.9	2.9	0.9	1.2	0.7	0.5

Panel C: Data Spread–Model Spread

	Financials			Non-financials			F–NF
	Put	Call	P–C	Put	Call	P–C	P–C
Crisis diff.	2.0	0.3	1.7	0.9	0.7	0.2	1.5

Note: Summary statistics for the cost of basket and index insurance in the BS model and in the data. Delta is 25 and time to maturity is 365 days. Units are cents per dollar insured. Unlike the analysis in Table 3, these results explicitly allow for heterogeneity in sector index weights, stock-specific call implied volatility, and stock-specific strike prices.

Table J1—Basket-Index Spreads by Moneyness and Maturity

	Financials		Non-financials		Financials–Non-financials		
	Puts	Calls	Puts	Calls	Puts	Calls	Puts–Calls
Panel A: Maturity 1 year, $\Delta = 35$							
Pre-crisis	1.6	1.8	2.5	2.5	-0.9	-0.8	-0.1
Crisis	3.9	2.2	3.3	3.0	0.6	-0.8	1.4
Crisis diff.	2.2	0.5	0.7	0.5	1.5	0.0	1.5
Panel B: Maturity 1 year, $\Delta = 45$							
Pre-crisis	1.7	1.8	2.6	2.6	-0.9	-0.8	-0.1
Crisis	3.5	2.5	3.3	3.1	0.2	-0.7	0.8
Crisis diff.	1.8	0.7	0.7	0.5	1.1	0.2	0.9
Panel C: Maturity 1 month, $\Delta = 25$							
Pre-crisis	0.4	0.5	0.7	0.7	-0.3	-0.2	-0.1
Crisis	1.4	1.0	0.8	1.0	0.6	-0.1	0.6
Crisis diff.	1.0	0.4	0.1	0.3	0.9	0.2	0.7

Note: Summary statistics of basket-index put and call spreads for the financial sector, non-financial sectors, and their difference. Panel A and B report option price spreads using delta 35 and delta 45 options, respectively, with time to maturity of 365 days. Panel C reports spreads for one month options with 30 days to maturity.

TABLE J2—COST OF INSURANCE: MJ BAILOUT MODEL FOR DELTA 35 OPTIONS

	Financials					
	Puts			Calls		
	Basket	Index	Spread	Basket	Index	Spread
			Panel A: Model			
Pre-crisis	7.0	5.9	1.1	4.8	1.9	2.9
Crisis	18.4	15.2	3.1	8.4	5.5	2.9
Crisis diff.	11.4	9.3	2.1	3.6	3.6	0.1
			Panel B: Data			
Pre-crisis	6.8	5.2	1.6	4.8	3.0	1.8
Crisis	18.7	14.8	3.9	8.4	6.1	2.3
Crisis diff.	11.9	9.6	2.3	3.6	3.1	0.5

Panel C: Data Spread–Model Spread

	Financials			F–NF
	Put	Call	P–C	P–C
Crisis diff.	0.3	0.4	-0.2	-0.6

Panel D: Financial Sector Parameter Estimates

ω	θ	δ	$\exp(\underline{x})$
7.6	-0.80	2.16	0.69

Note: Summary statistics for the financial sector cost of basket and index put and call prices in the MJ bailout model (Panel A), in the data (Panel B), and their difference (Panel C). The last column in Panel C compares the unexplained difference in put and call spreads for the financial sector (including a bailout) with that of the non-financial sector (excluding a bailout). Fits are based on MJ bailout model parameters estimated from options data, and Panel D reports jump parameter estimates (ω, θ, δ) and estimated bailout threshold $\exp(\underline{x})$. Risk aversion is $\alpha = 1$. Delta is 35 and time to maturity is 365 days. Units are cents per dollar insured.

TABLE K1—LIQUIDITY IN PUTS

	$0 \leq \Delta < 20$				$20 \leq \Delta < 50$				$50 \leq \Delta < 80$				$80 \leq \Delta < 100$			
	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.
Pre-Crisis Sample								**10 Days < TTM ≤ 90 Days**								
S&P 500	0.450	80.5	1072	15783	1.295	9.4	2219	16594	1.821	5.8	693	6807	1.959	3.7	93	3138
All Sector SPDRs	0.133	150.5	80	3205	0.141	35.0	867	7606	0.167	13.7	269	3221	0.239	7.9	26	339
Financial SPDR	0.096	142.3	187	10494	0.109	30.9	1791	19708	0.125	12.4	502	7907	0.182	7.0	44	689
Indiv. Stocks	0.088	106.3	169	5447	0.106	13.2	836	9225	0.152	6.2	473	5990	0.230	3.1	76	1550
Fin. Indiv. Stocks	0.095	103.5	142	4534	0.116	13.4	691	7667	0.169	6.4	380	4888	0.254	3.3	65	1288
								90 Days < TTM ≤ 180 Days								
S&P 500	0.701	56.3	373	18107	1.719	6.9	1242	22052	1.982	3.4	198	5962	2.076	1.5	14	1949
All Sector SPDRs	0.141	96.0	21	1132	0.156	19.0	163	3057	0.198	8.7	40	1258	0.273	6.3	3	118
Financial SPDR	0.103	71.0	103	4307	0.119	16.8	452	13713	0.142	7.6	96	3891	0.182	4.9	16	347
Indiv. Stocks	0.094	72.4	66	4326	0.133	8.1	278	7760	0.196	4.3	123	4622	0.242	2.3	21	1138
Fin. Indiv. Stocks	0.103	68.4	56	3445	0.147	8.3	229	6509	0.216	4.4	103	3565	0.271	2.5	18	807
								180 Days < TTM ≤ 365 Days								
S&P 500	1.067	33.7	237	12015	2.093	5.5	400	10895	2.185	2.6	52	2837	2.174	1.1	4	1359
All Sector SPDRs	0.130	60.6	9	857	0.156	12.8	45	1290	0.203	6.8	10	593	0.273	4.7	2	129
Financial SPDR	0.095	47.5	24	2448	0.105	10.8	287	7823	0.139	5.6	53	3313	0.188	4.0	4	128
Indiv. Stocks	0.103	55.3	52	4432	0.156	6.8	170	6880	0.224	3.8	65	4040	0.255	2.1	15	1208
Fin. Indiv. Stocks	0.112	49.8	48	3782	0.174	7.0	130	5582	0.247	3.9	50	2972	0.278	2.2	11	756
Crisis Sample								**10 Days < TTM ≤ 90 Days**								
S&P 500	1.120	61.7	1369	14797	2.663	9.4	2652	18992	2.974	4.5	871	14305	3.033	2.4	120	9284
All Sector SPDRs	0.087	59.4	667	8801	0.130	11.8	2849	20540	0.226	6.9	963	12846	0.388	4.8	72	3724
Financial SPDR	0.042	24.7	4422	52042	0.054	6.5	12983	88367	0.107	4.4	4336	56684	0.206	3.7	376	19916
Indiv. Stocks	0.108	55.5	344	5590	0.153	7.9	1170	9400	0.244	4.5	529	6857	0.481	2.9	87	2404
Fin. Indiv. Stocks	0.126	56.2	296	4390	0.181	8.1	1041	8047	0.288	4.6	452	5741	0.516	3.0	83	2435
								90 Days < TTM ≤ 180 Days								
S&P 500	1.723	35.2	568	16641	3.003	6.2	1147	18511	3.179	2.8	212	12697	3.255	1.3	25	7625
All Sector SPDRs	0.112	31.1	209	4218	0.184	8.1	527	8681	0.286	4.9	162	5310	0.407	3.6	17	1598
Financial SPDR	0.055	18.7	1421	24285	0.079	5.3	3012	49466	0.159	4.0	1008	28769	0.227	3.0	129	8338
Indiv. Stocks	0.133	38.2	119	4640	0.214	5.5	339	7705	0.318	3.2	115	4908	0.492	2.2	15	1593
Fin. Indiv. Stocks	0.154	37.9	106	3405	0.253	5.6	301	6235	0.376	3.3	94	4085	0.536	2.2	16	1637
								180 Days < TTM≤ 365 Days								
S&P 500	2.402	22.3	272	12355	3.409	4.7	507	13293	3.538	2.1	60	7814	3.593	1.1	8	5226
All Sector SPDRs	0.177	22.1	57	1693	0.300	7.8	169	3428	0.410	4.8	50	3257	0.474	3.3	44	1818
Financial SPDR	0.057	12.9	238	7318	0.089	4.5	1049	19391	0.170	3.5	300	13661	0.219	2.4	121	6042
Indiv. Stocks	0.186	30.4	69	2713	0.294	5.5	173	5372	0.423	3.1	55	3653	0.623	2.2	9	1269
Fin. Indiv. Stocks	0.208	30.6	54	1984	0.338	5.8	162	4654	0.474	3.3	47	3529	0.630	2.3	9	1459

Note: Value-weighted liquidity statistics for individual equity and sector ETF options.

Table K2—Liquidity in Calls

	$0 \leq \Delta < 20$				$20 \leq \Delta < 50$				$50 \leq \Delta < 80$				$80 \leq \Delta < 100$			
	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.	Spr. ($)	Spr. (%)	Vol.	O.I.
Pre-Crisis Sample								**10 Days < TTM ≤ 90 Days**								
S&P 500	0.405	96.9	1002	11990	1.204	10.3	1598	12885	1.836	5.3	930	11351	2.006	1.9	71	3476
All Sector SPDRs	0.123	169.3	23	745	0.135	42.3	262	2970	0.160	14.3	187	2790	0.236	7.4	16	931
Financial SPDR	0.081	177.4	22	1497	0.107	38.2	512	6477	0.129	13.4	311	6428	0.183	6.7	28	1995
Indiv. Stocks	0.077	140.7	203	5916	0.100	14.6	1430	14839	0.144	6.1	928	11702	0.229	3.1	186	3840
Fin. Indiv. Stocks	0.083	138.1	179	4926	0.110	15.1	1145	11640	0.160	6.2	738	9123	0.252	3.3	142	3189
								90 Days < TTM ≤ 180 Days								
S&P 500	0.592	85.7	301	10160	1.662	8.2	703	17315	1.983	3.0	364	13038	2.049	1.1	22	3148
All Sector SPDRs	0.134	122.8	8	434	0.154	24.1	59	1481	0.195	9.1	50	1365	0.282	5.9	4	306
Financial SPDR	0.085	94.5	12	1012	0.120	22.2	134	4566	0.148	8.1	109	3734	0.214	5.0	7	748
Indiv. Stocks	0.082	112.2	77	4798	0.122	9.5	512	11756	0.187	4.5	262	8052	0.251	2.4	34	2248
Fin. Indiv. Stocks	0.089	111.2	60	3468	0.136	9.9	395	8320	0.207	4.6	187	5686	0.279	2.5	26	1567
								180 Days < TTM ≤ 365 Days								
S&P 500	0.872	50.0	113	6705	2.001	6.9	249	10021	2.198	2.3	106	7283	2.224	0.9	11	1200
Sector SPDRs	0.121	89.4	3	455	0.151	17.2	23	1070	0.204	7.0	19	825	0.270	4.8	2	258
Financial SPDR	0.088	64.8	7	493	0.108	15.1	48	2362	0.139	5.8	45	2548	0.198	3.7	3	497
Indiv. Stocks	0.090	93.6	51	5189	0.143	8.5	259	9021	0.215	4.1	147	6730	0.271	2.2	23	2363
Fin. Indiv. Stocks	0.096	96.1	40	3962	0.158	8.9	207	6783	0.238	4.3	109	5349	0.292	2.3	16	1877
Crisis Sample								**10 Days < TTM ≤ 90 Days**								
S&P 500	0.705	118.6	580	10797	2.497	11.4	1857	16012	2.968	4.3	1047	9846	3.047	1.8	50	2157
All Sector SPDRs	0.080	103.7	390	7908	0.121	14.1	3386	19642	0.211	7.2	1552	11705	0.350	4.6	98	2581
Financial SPDR	0.037	47.7	3007	52259	0.050	8.5	17312	93957	0.097	4.8	8020	56259	0.178	4.0	628	19025
Indiv. Stocks	0.094	96.6	341	6754	0.141	9.5	1623	11596	0.230	4.8	838	7407	0.446	3.1	103	2423
Fin. Indiv. Stocks	0.110	93.6	293	5739	0.169	10.0	1362	9587	0.263	4.9	754	6157	0.490	3.3	104	1742
								90 Days < TTM ≤ 180 Days								
S&P 500	1.067	97.4	183	10138	2.913	8.8	637	12846	3.167	3.0	326	4394	3.219	1.3	13	912
All Sector SPDRs	0.099	81.2	109	4741	0.168	10.8	480	7791	0.278	5.6	219	3878	0.394	3.6	19	702
Financial SPDR	0.051	50.3	749	25321	0.077	8.2	2916	42929	0.139	4.4	1193	18780	0.219	3.5	107	3391
Indiv. Stocks	0.118	75.5	100	5023	0.197	7.5	460	9358	0.299	3.9	216	5972	0.496	2.5	25	1818
Fin. Indiv. Stocks	0.136	73.9	93	4523	0.236	7.9	375	7207	0.350	4.1	181	4543	0.537	2.7	19	1269
								180 Days < TTM ≤ 365 Days								
S&P 500	1.625	66.6	62	8211	3.420	7.7	237	8752	3.500	2.5	126	4713	3.485	1.1	5	510
All Sector SPDRs	0.151	63.6	45	2964	0.280	11.6	162	4348	0.411	5.8	77	2034	0.507	3.8	6	431
Financial SPDR	0.054	35.2	154	8949	0.088	7.5	836	18346	0.151	4.1	480	11201	0.207	3.0	18	1960
Indiv. Stocks	0.159	62.1	57	4033	0.274	8.0	210	5991	0.395	4.2	118	3886	0.609	2.8	14	891
Fin. Indiv. Stocks	0.170	63.9	54	4381	0.311	8.6	190	5345	0.451	4.5	103	3124	0.630	3.1	13	702

Note: Value-weighted liquidity statistics for individual equity and sector ETF options.