Internet Appendix for "Relationship Trading in OTC Markets"

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In this Internet Appendix, we provide Propositions 1 and 2, as well their proofs, in Section I and additional empirical results mentioned in the paper but unreported there for brevity in Section II.

I. Proofs

PROPOSITION 1: *Bid and ask prices are*

$$P^b = \left[\frac{C(1-L)}{\lambda N}\Psi_1 + \frac{C}{r+\kappa}\Psi_2 + K\Pi_1(\kappa,\eta)\right] w + \left[M^{ask}\Pi_2 + M^{bid}\Pi_3\frac{\kappa}{r+\kappa}\right](1-w), \tag{IA1}$$

$$P^s = \left[\frac{C(1-L)}{\lambda N}\Psi_3 - \frac{C}{r+\kappa}\Psi_4 - K\Pi_1(\eta,\kappa)\right] w + \left[M^{bid}\Pi_2 + M^{ask}\Pi_3\frac{\eta}{r+\eta}\right](1-w), \tag{IA2}$$

where the coefficients $\Psi_1, \Psi_2, \Psi_3,\ \Psi_4$ *are given as*

$$\Psi_1 \equiv \frac{\widetilde{\kappa}\widetilde{\Lambda}}{A_5(w)}\left[1-\widetilde{\Lambda}+(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda})\frac{A_4(w)}{A_1(w)}\right], \tag{IA3}$$

$$\Psi_2 \equiv \frac{(1-\widetilde{\Lambda})}{A_5(w)}\left[1-\widetilde{\kappa}\widetilde{\eta}\frac{A_4(w)}{A_1(w)}\widetilde{\Lambda}\right], \tag{IA4}$$

$$\Psi_3 \equiv \frac{\widetilde{\Lambda}}{A_5(w)}\left[1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}+\widetilde{\kappa}\widetilde{\eta}(1-\widetilde{\Lambda})\frac{A_4(w)}{A_1(w)}\right], \tag{IA5}$$

$$\Psi_4 \equiv \frac{\widetilde{\eta}(1-\widetilde{\Lambda})}{A_5(w)}\left[\widetilde{\Lambda}-\frac{A_4(w)}{A_1(w)}\right], \tag{IA6}$$

with $\widetilde{\kappa} = \frac{\kappa}{r+\kappa}$, $\widetilde{\Lambda} = \frac{\lambda N}{r+\lambda N}$, $\widetilde{\eta} = \frac{\eta}{r+\eta}$ *and coefficient functions* $A_1(w), A_4(w), A_5(w)$ *given in the proof. The function* $\Pi_1(x,y)$ *and the coefficients* Π_2 *and* Π_3 *are given as*

$$\Pi_1(x,y) \equiv \frac{1}{A_5(w)}\left[A_2(x) - xA_2(y)\frac{A_4(w)}{A_1(w)}\right], \tag{IA7}$$

$$\Pi_2 \equiv \frac{1}{A_5(w)}\left[A_3(w) - \widetilde{\kappa}\widetilde{\eta}\frac{A_4(w)}{A_1(w)}\widetilde{\lambda}\right], \tag{IA8}$$

$$\Pi_3 \equiv \frac{1}{A_5(w)}\left[A_3(w)\frac{A_4(w)}{A_1(w)} - \widetilde{\lambda}\right], \tag{IA9}$$

with $\widetilde{\lambda} = \frac{\lambda}{r+\Lambda}$ *and coefficient functions* $A_1(w), A_2(w), A_3(w), A_4(w), A_5(w)$ *given in the proof.*

Proof of Proposition 1: Define $\Lambda = \lambda N$, $\widetilde{\lambda} = \frac{\lambda}{r+\Lambda}$, $\widetilde{\Lambda} = \frac{\lambda N}{r+\lambda N}$, $\widetilde{\eta} = \frac{\eta}{r+\eta}$, and $\widetilde{\kappa} = \frac{\kappa}{r+\kappa}$. We can rewrite both the client's and the dealers' valuations as

$$\begin{aligned} V^b &= \frac{C}{r+\kappa}\widetilde{\Lambda} - (P^b + k)\widetilde{\Lambda} + V^s\widetilde{\kappa}\widetilde{\Lambda} \\ &= \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{r+\Lambda}\widetilde{\kappa} + \frac{C}{r+\kappa} - (P^b + K) + (P^s - k)\widetilde{\kappa}\widetilde{\Lambda}\right], \end{aligned} \tag{IA10}$$

$$\begin{aligned} V^s &= \frac{C(1-l)}{r+\Lambda} + (P^s - k)\widetilde{\Lambda} + V^b\widetilde{\eta}\widetilde{\Lambda} \\ &= \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{\Lambda} + \frac{C}{r+\kappa}\widetilde{\eta}\widetilde{\Lambda} + (P^s - K) - (P^b + K)\widetilde{\eta}\widetilde{\Lambda}\right], \end{aligned} \tag{IA11}$$

and

$$U^s = (M^{bid} - P^s)\widetilde{\lambda} + U^b\widetilde{\eta}\widetilde{\Lambda} = \frac{\widetilde{\lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[(M^{bid} - P^s) + (P^b - M^{ask})\widetilde{\eta}\widetilde{\Lambda}\right], \tag{IA12}$$

$$U^b = (P^b - M^{ask})\widetilde{\lambda} + U^s\widetilde{\kappa}\widetilde{\Lambda} = \frac{\widetilde{\lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[(P^b - M^{ask}) + (M^{bid} - P^s)\widetilde{\kappa}\widetilde{\Lambda}\right]. \tag{IA13}$$

After some algebra one obtains

$$
\begin{aligned}
V^o - V^b &= \frac{C}{r+\kappa} + V^s\widetilde{\kappa} - V^b \\
&= \frac{C}{r+\kappa} + \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{\Lambda}\widetilde{\kappa} - \frac{C(1-l)}{r+\Lambda}\widetilde{\kappa} - \frac{C}{r+\kappa}(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) + \right. \\
&\quad \left. +(P^b+K)(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) + (P^s-K)\widetilde{\kappa}(1-\widetilde{\Lambda})\right], \\
V^s - V^{no} &= V^s - V^b\widetilde{\eta} \\
&= \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{\Lambda}(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) - \frac{C}{r+\kappa}\widetilde{\eta}(1-\widetilde{\Lambda}) + \right. \\
&\quad \left. +(P^b+K)\widetilde{\eta}(1-\widetilde{\Lambda}) + (P^s-K)(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda})\right].
\end{aligned}
$$

Substituting these expressions into (20) and (21) yields

$$
\begin{aligned}
P^b &= \frac{C}{r+\kappa}w + \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{\Lambda}\widetilde{\kappa} - \frac{C(1-l)}{r+\Lambda}\widetilde{\kappa} - \right. \\
&\quad \left. -\frac{C}{r+\kappa}(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) + (P^b+K)(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) + (P^s-K)\widetilde{\kappa}(1-\widetilde{\Lambda})\right] w + \\
&\quad +M^{ask}(1-w) - \frac{\widetilde{\lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[(M^{bid}-P^s) + (P^b-M^{ask})\widetilde{\eta}\widetilde{\Lambda}\right]\widetilde{\kappa}(1-w), \quad \text{(IA14)} \\
P^s &= \frac{\widetilde{\Lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[\frac{C(1-l)}{\Lambda}(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) - \right. \\
&\quad \left. -\frac{C}{r+\kappa}\widetilde{\eta}(1-\widetilde{\Lambda}) + (P^b+K)\widetilde{\eta}(1-\widetilde{\Lambda}) + (P^s-K)(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda})\right] w + \\
&\quad +M^{bid}(1-w) + \frac{\widetilde{\lambda}}{1-\widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2}\left[(P^b-M^{ask}) + (M^{bid}-P^s)\widetilde{\kappa}\widetilde{\Lambda}\right]\widetilde{\eta}(1-w). \quad \text{(IA15)}
\end{aligned}
$$

These expressions can be rewritten as

$$
\begin{aligned}
P^b A_1(w) &= \left[\frac{C(1-l)}{\Lambda}\widetilde{\kappa}\widetilde{\Lambda} + \frac{C}{r+\kappa}\right](1-\widetilde{\Lambda})w + KA_2(\widetilde{\kappa}, w) \\
&\quad + M^{ask}A_3(w) - M^{bid}\widetilde{\kappa}\widetilde{\lambda}(1-w) + P^s\widetilde{\kappa}A_4(w), \qquad \text{(IA16)}\\
P^s A_1(w) &= \left[\frac{C(1-l)}{\Lambda}(1-\widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}) - \frac{C}{r+\kappa}\widetilde{\eta}(1-\widetilde{\Lambda})\right]\widetilde{\Lambda}w - KA_2(\widetilde{\eta}, w) \\
&\quad - M^{ask}\widetilde{\eta}\widetilde{\lambda}(1-w) + M^{bid}A_3(w) + P^b\widetilde{\eta}A_4(w), \qquad \text{(IA17)}
\end{aligned}
$$

where we define

$$A_1(w) \equiv 1 - \widetilde{\Lambda}w - \widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2(1-w) + \widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}\widetilde{\lambda}(1-w), \qquad \text{(IA18)}$$

$$A_2(x, w) \equiv [1 - \widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda} - x(1-\widetilde{\Lambda})]\widetilde{\Lambda}w, \qquad \text{(IA19)}$$

$$A_3(w) \equiv [1 - \widetilde{\kappa}\widetilde{\eta}(\widetilde{\Lambda})^2 + \widetilde{\kappa}\widetilde{\eta}\widetilde{\Lambda}\widetilde{\lambda}](1-w), \qquad \text{(IA20)}$$

$$A_4(w) \equiv (1-\widetilde{\Lambda})\widetilde{\Lambda}w + \widetilde{\lambda}(1-w), \qquad \text{(IA21)}$$

$$A_5(w) \equiv A_1(w) - \widetilde{\kappa}\widetilde{\eta}\frac{A_4(w)^2}{A_1(w)}. \qquad \text{(IA22)}$$

The system of equations (IA16)–(IA17) can be solved to yield expressions (IA1) and (IA2).

PROPOSITION 2: *The optimal size of the client's dealer network solves*

$$\underset{N\in\{\lfloor N^*\rfloor,\lceil N^*\rceil\}}{\text{argmax}}\ \widehat{V}^b(N), \tag{IA23}$$

where N^* is given by the condition

$$\begin{aligned}\frac{rV^b}{(\lambda N^*)^2}\left(1+\frac{\kappa}{r+\kappa}\frac{\eta}{r+\eta}\left(\frac{\lambda N^*}{r+\lambda N^*}\right)^2\right) = \\ -\left(\frac{r+\lambda N^*}{\lambda N^*}-\frac{\eta}{r+\eta}\frac{\kappa}{r+\kappa}\frac{\lambda N^*}{r+\lambda N^*}\right)\frac{dV^r}{d\lambda N^*} \\ +\frac{\kappa}{r+\kappa}\frac{r}{(r+\lambda N^*)^2}\left(\frac{C(1-L)}{r}-P^s+K\right) \\ +\frac{dP^s}{d\lambda N^*}\frac{\kappa}{r+\kappa}\frac{\lambda N^*}{r+\lambda N^*}-\frac{dP^b}{d\lambda N^*}.\end{aligned} \tag{IA24}$$

Proof of Proposition 2: We solve for the optimal network size on the grid of integers $N \in \mathbb{I}_{\geq 0}$. To do so, we assume that all value functions are wellbehaved as functions of the network size, N. We then solve for the optimal network size on the continuous grid $N^* \in \mathbb{R}_{\geq 0}$ and select the closest integer value to N^* maximizing $\widehat{V}^b(N)$. Equation (IA23) reflects this exercise.

Since $\frac{d\widehat{V}^b}{dN} = \frac{dV^b}{dN} + \frac{dV^r}{dN}$, we need to calculate the derivative of V^b with respect to N. We start by rewriting expression (24) as

$$\begin{aligned}V^b = \Bigg[\frac{C}{r+\kappa}+\frac{C(1-L)}{r+\lambda N}\frac{\kappa}{r+\kappa}+\left(E[P^s]+V^b\frac{\eta}{r+\eta}-K\right) \\ \times\frac{\kappa}{r+\kappa}\frac{\lambda N}{r+\lambda N}-P^b-K\Bigg]\frac{\lambda N}{r+\lambda N},\end{aligned} \tag{IA25}$$

which we solve for V^b to obtain

$$V^b = \frac{\frac{\lambda N}{r+\lambda N}}{1 - \frac{\kappa}{r+\kappa}\frac{\eta}{r+\eta}(\frac{\lambda N}{r+\lambda N})^2}\left[\frac{C}{r+\kappa} + \frac{C(1-L)}{r+\lambda N}\frac{\kappa}{r+\kappa} + \right.$$
$$\left. +(P^s - K)\frac{\kappa}{r+\kappa}\frac{\lambda N}{r+\lambda N} - (P^b + K)\right]. \quad \text{(IA26)}$$

Taking into account

$$\frac{d\left(\frac{\lambda N}{r+\lambda N}\right)}{d\lambda N} = \frac{r}{(r+\lambda N)^2}, \quad \text{(IA27)}$$

we obtain the following expression for the derivative in question:

$$\frac{dV^b}{d\lambda N} = \left(\frac{r+\lambda N}{\lambda N} - \frac{\eta}{r+\eta}\frac{\kappa}{r+\kappa}\frac{\lambda N}{r+\lambda N}\right)^{-1}\left[\frac{rV^b}{(\lambda N)^2}\left(1 + \frac{\kappa}{r+\kappa}\frac{\eta}{r+\eta}\left(\frac{\lambda N}{r+\lambda N}\right)^2\right)\right.$$
$$\left. -\frac{\kappa}{r+\kappa}\frac{r}{(r+\lambda N)^2}\left(\frac{C(1-L)}{r} - P^s + K\right) + \frac{dP^s}{d\lambda N}\frac{\kappa}{r+\kappa}\frac{\lambda N}{r+\lambda N} - \frac{dP^b}{d\lambda N}\right], \quad \text{(IA28)}$$

which after setting $\frac{d\widehat{V}^b}{dN} = 0$ leads to (IA24) after some algebra.

II. Empirical Results

Table IA.I
Correlation Matrix

This table reports correlations between insurer-dealer volume, network size, and insurer characteristics.

	Insurer-dealer volume, year t	N	$ln(N)$	Size	RBC	Cash	Life	P&C	A–B
Insurer no. of dealers N	0.27	1.00							
$ln(N)$	0.20	0.90	1.00						
Insurer size	0.54	0.61	0.56	1.00					
Insurer RBC ratio	-0.08	-0.09	-0.11	-0.20	1.00				
Insurer cash-to-assets	-0.04	-0.04	-0.03	-0.09	0.03	1.00			
Life insurer	0.36	0.27	0.26	0.47	0.02	-0.04	1.00		
P&C insurer	-0.24	-0.27	-0.24	-0.34	0.03	-0.03	-0.72	1.00	
Insurer rated A–B	-0.14	0.01	0.05	-0.15	0.01	0.03	-0.06	0.06	1.00
Insurer rated C–F	-0.03	-0.05	-0.05	-0.07	-0.05	-0.07	-0.02	0.03	-0.07

Table IA.II
Scope of Bond Coverage by Dealers

This table documents the scope of bond coverage by top dealers. We report the fraction of active bonds traded by each of the top 10 dealers in each category. We define a bond as active if it has at least a certain number of trades during the sample period, with the threshold indicated in the column header. We vary the activity threshold across columns.

	Fraction of active bonds traded by each dealer				
	No. of bond trades≥200 (No. of bonds=992)	≥100 (3,135)	≥50 (6,821)	≥10 (15,398)	≥1 (21,007)
Dealer rank	(1)	(2)	(3)	(4)	(5)
1	0.998	0.983	0.923	0.731	0.587
2	0.997	0.981	0.919	0.707	0.564
3	0.997	0.965	0.887	0.680	0.544
4	0.996	0.965	0.868	0.651	0.519
5	0.995	0.956	0.863	0.645	0.512
6	0.994	0.948	0.853	0.631	0.505
7	0.994	0.939	0.812	0.576	0.453
8	0.985	0.919	0.799	0.576	0.451
9	0.981	0.913	0.795	0.568	0.449
10	0.959	0.884	0.752	0.533	0.419

Table IA.III
Dealer Concentration by Insurers

This table documents the dealer concentration by top insurers. We report descriptive statistics for the number of dealers used to trade a given bond across all active bonds. We define a bond as active if it has 200 or more trades during the sample period.

	Number of dealers used to trade an active bond				
Insurer rank	Mean	S.D.	Median	95%	Max
1	2.83	1.73	2	6	11
2	2.67	1.64	2	6	9
3	2.42	1.38	2	5	8
4	2.01	1.22	2	4	7
5	2.18	1.28	2	5	8
6	2.66	1.73	2	6	10
7	2.13	1.44	2	5	8
8	2.42	1.48	2	5	9
9	2.57	1.69	2	6	9
10	2.65	1.70	2	6	13
Large insurers	1.71	0.99	1	4	13
Small insurers	1.29	0.52	1	2	6

Table IA.IV
Investor-Dealer Relations and Execution Costs

This table reports the determinants of execution costs. Execution costs are expressed in basis points relative to the Merrill Lynch quote at the time of the trade. See the caption of Table II for additional details. Standard errors are adjusted for heteroskedasticity and clustered at the insurer, dealer, bond, and day level. Significance levels are indicated by * (10%), ** (5%), and *** (1%).

Determinant	(1)	(2)	(3)	(4)	(5)	(6)
Insurer-dealer volume, year t	-15.62**			14.08*		
Insurer-dealer volume, year t-1		-35.31***			-8.29	
Insurer-dealer volume, years t & t-1			-19.10***			3.16
Insurer no. of dealers				0.31***	0.33***	0.32***
ln(Insurer no. of dealers)				-6.12***	-6.37***	-6.23***
Insurer size				-3.80***	-3.49***	-3.67***
Insurer RBC ratio	1.04	0.88	0.87	-4.26***	-4.16***	-4.21***
Insurer cash-to-assets	-0.02	-0.02	-0.02	-0.04**	-0.04**	-0.04**
Life insurer	3.27***	3.51***	3.52***	4.36***	4.54***	4.42***
P&C insurer	3.54***	3.53***	3.51***	1.70**	1.75**	1.71**
Insurer rated A–B	2.95***	2.71***	2.72***	-0.00	-0.00	0.01
Insurer rated C–F	18.12***	17.81***	17.82***	11.05*	11.15*	11.10*
Insurer unrated	6.29***	6.00***	6.02***	0.55	0.63	0.60
Insurer buy	40.17***	40.15***	40.15***	39.28***	39.27***	39.27***
Trade size × Buy	-0.69***	-0.67***	-0.64***	-0.28***	-0.24***	-0.26***
Trade size × Sell	0.16	0.19*	0.21*	0.46***	0.51***	0.48***
Bond fixed effects (16,823)	Yes	Yes	Yes	Yes	Yes	Yes
Dealer fixed effects (401)	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects (3,375)	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.152	0.153	0.152	0.155	0.155	0.155
N	918,279	918,279	918,279	918,279	918,279	918,279

Table IA.V
Estimated Model Parameters—Robustness to Minimum-Distance Weight ω

Panel A reports the estimated model parameters $\theta = (\theta_L, \theta_K, \theta_\kappa, \theta_\lambda, \theta^j_{w^i}, \theta_V)$. Estimates are based on the minimum-distance estimation with weight ω indicated in the column header. Standard errors are computed using the sandwich estimator and reported in parentheses. Panel B reports the implied values for the model parameters $L = \Phi(\theta_L)$, $K = e^{10*\theta_K}$, $\kappa = e^{10*\theta_\kappa}$, $\lambda = e^{10*\theta_\lambda}$, $w^i = \Phi(\theta^0_{w^i} + \theta^1_{w^i} ln\,\eta)$ for $i = s, b$, where $\Phi \in (0,1)$ is the normal cdf, and nontrade value $V^r = e^{\theta^0_V}\eta^{\theta^1_V}N^{\theta^2_V}$. Panel C reports statistics on the model fit.

	$\omega = .1$ (1)	$\omega = .5$ (2)	$\omega = .9$ (3)
Panel A: Parameter estimates			
θ_L	2.61 (0.07)	2.51 (0.01)	2.57 (0.00)
θ_K	-0.64 (0.00)	-0.64 (0.00)	-0.64 (0.00)
θ_κ	0.31 (0.00)	0.31 (0.00)	0.30 (0.00)
θ_λ	0.50 (0.00)	0.50 (0.00)	0.51 (0.00)
$\theta^0_{w^b}$	2.51 (0.00)	2.52 (0.00)	2.51 (0.00)
$\theta^1_{w^b}$	-1.03 (0.00)	-1.02 (0.00)	-1.03 (0.00)
$\theta^0_{w^s}$	1.23 (0.00)	1.24 (0.00)	1.25 (0.00)
$\theta^1_{w^s}$	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)
θ^0_V	-1.70 (0.00)	-1.70 (0.00)	-1.70 (0.00)
θ^1_V	0.32 (0.00)	0.33 (0.00)	0.32 (0.00)
θ^2_V	0.14 (0.00)	0.13 (0.00)	0.14 (0.00)
Panel B: Implied model parameters			
L	1.00	0.99	0.99
K $(*10^4)$	16.65	15.82	16.28
κ	22.46	21.19	20.14
λ	147.07	145.56	158.10
w^b (S.D.)	0.86 (0.05)	0.86 (0.05)	0.86 (0.05)
w^s (S.D.)	0.88 (0.01)	0.88 (0.01)	0.89 (0.01)
Nontrade value V^r (S.D.)	0.32 (0.03)	0.32 (0.03)	0.32 (0.03)
Panel C: Model fit			
Minimum distance $(\times 10^2)$	1.97	2.82	2.10
S.D. residuals	0.14	0.17	0.15
S.D. residuals network	0.24	0.19	0.14
S.D. residuals prices	0.13	0.14	0.20