Missing Markets

Market Microstructure and Market Failure on the 19th c. London Stock Exchange

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People Are Worried About Bond Market Liquidity

As you might have heard.

4 June 2015 at 02:12 EEST

By Matt Levine

Matt Levine is a Bloomberg Opinion columnist. A former investment banker at Goldman Sachs, he was a mergers and acquisitions lawyer at Wachtell, Lipton, Rosen & Katz; a clerk for the U.S. Court of Appeals for the 3rd Circuit; and an editor of Dealbreaker.

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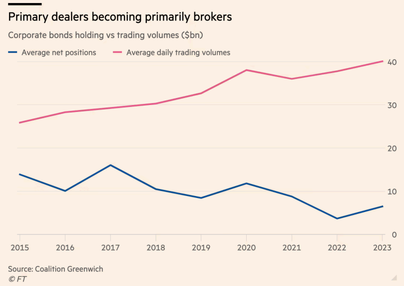

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- We find substantial evidence of **liquidity bifurcation**:
  - dealers provide liquidity to securities that are already easy to trade
- The reason dealers fail to make markets in such a large proportion of securities is likely a combination of **adverse selection** and **balance sheet constraints**
- We estimate that if dealers had made markets in everything average spreads would have risen substantially.

Roadmap

1. Market microstructure and liquidity
2. How trading worked on the LSE
3. The LSE data
4. The econometric approach
5. Our estimates and discussion
6. Conclusion

Market microstructure and liquidity in theory

Market structures: Dealers, Auctions, Limit order books

The bid-ask spread

- **Transaction costs** (Roll's Bid-Ask Bounce [1984])
- **Inventory costs** (Garman [1976], Stoll [1978], Ho and Stoll [1981])
- **Adverse selection costs** (Bagehot [1971], Copeland and Galai [1983], Glosten and Milgrom [1985])

Market collapse

- **Adverse selection** (Glosten and Milgrom [1985])
- **Inventory risk** (Grossman and Miller [1988])

Market Collapse: some intuition

Adverse selection

- Dealers are exposed to better informed customers. They charge a spread such that **gains against noise traders will offset their losses to informed traders.**
- But noise trader volume falls as the spread grows.
- The market can unravel as high spreads filter transactions toward the informed.

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Information problems: the risk that new public information (**inventory risk**) or new private information (**adverse selection**) changes asset values between transactions.

Trading on the LSE

The ‘theory of the Stock Exchange Business’

“The theory of business on our Stock Exchange is this, that a broker has an order given him by a client, … goes to a dealer in the stock specified, and that ***without disclosing his business to the dealer*** *he gets what in Stock Exchange parlance is called a price, that is to say, the dealer names a figure at which he will either buy or sell.” —Charles Branch, testimony to Roy. Com. LSE, p. 129.*

From theory to practice

*"...and in a great many stocks it is also the practice, and where it prevails I think that it is a very good system; ...**But this theory only holds good with a certain portion of stocks in the Stock Exchange; it is true only, I may say, of a minority of securities.**"—Charles Branch, testimony to Roy. Com. LSE, p. 130.*

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- This understanding repeated in later sources (Clare [1898], Chavaz and Flandreau [2017])
- Branch testifies that *most* securities (**80%!**) did not have dealers supporting them
- The unsupported securities were traded but
  - Only if a counter-party was found
  - Or only if the client revealed the size and direction of trade
- Attempts to fix with limit order book blocked by dealers ▸ More

Branch's Evidence

"I have taken the trouble to go through the Stock Exchange List, and I have marked the securities in it in black and red; I have marked in red those securities which are ***not marketable*** *in the sense which I have described"—Charles Branch, testimony to Roy. Com. LSE, p. 130.*

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But Branch's annotated share list was not published...

APPENDIX No. VI.

SUMMARY of the OFFICIAL LIST of the LONDON STOCK EXCHANGE of 19th October 1877, handed in by MR. BRANCH, showing the Comparative Number of MARKETABLE and NON-MARKETABLE STOCKS.

Description of Securities.	No. of Stocks.	Marketable. Amount in Millions.	No. of Stocks.	Not Marketable. Amount in Millions.	Description of Securities.	No. of Stocks.	Marketable. Amount in Millions.	No. of Stocks.	Not Marketable. Amount in Millions.
Funds and Government stocks	10	—	21	—	Foreign mines	1	5·	44	6·4
Colonial Government	12	46·4	47	38·	Telegraphs	16	20·3	18	4·6
Foreign Government stocks	69	—	99	—	Insurance	3	4·5	50	50·
Railways, ordinary stocks	22	158·	38	43·5	Gas	2	3·2	54	15·6
„ preference cumulative	1	12·	54	53·	Docks	1	5·7	10	8·
„ preference contingent	5	37·7	75	65·3	Waterworks	—	—	17	7·
„ leased lines	—	—	39	21·3	Canals	—	—	4	2·9
„ debenture stocks	9	67·	40	39·	Loans and trusts	16	29·8	46	14·6
„ British Colonies	18	113·3	39	13·	Coal, copper, and iron	—	—	25	12·
Indian Railway debentures	—	—	7	3·	Commercial, financial, &c.	17	15·	46	20·
„ debenture stocks	—	—	5	5·4	Land	7	3·7	12	3·1
Foreign railways	15	34·8	35	14·2	Shipping	3	4·4	13	5·1
American dollar bonds	20	—	24	—	Tea	—	—	7	1·1
„ sterling bonds	9	29·	40	32·5	Tramways	12	2·5	5	0·6
Foreign railway obligations	8	—	44	—	Miscellaneous	8	3·6	32	6·9
Banks	10	20·1	64	76·7	Total	285	610·	1,082	562·8
British mines	—	—	28	—					

The amount in these figures is in millions; in some cases I have not been able to follow out the amounts, and have given only the numbers of the stocks. *See* Evidence, 3447–59.

The LSE data

Reading the Daily Share Price List

TRAMWAYS.

7,140	10	....	Belfast Street Tramways	all	$10 — 10\frac{1}{4}$	
50,000	2	12 Oct.	Brazilian Street, Limited	all	$\frac{3}{8} — \frac{5}{8}$	
14,000	10	....	Buenos Ayres National, Limited	all	$1\frac{1}{2} — 2\frac{1}{2}$	
5,700	5	16 May	City of Buenos Ayres, Limited	all	$4\frac{3}{4}$ - 5	
108,000l.	Stock	29 June	Do. Permanent 6 per ct. Debenture Stock	100	97 - 100	
24,000	10	30 Aug.	Dublin	all	$17\frac{3}{8} — 17\frac{5}{8}$	
14,690	10	15 Aug	Edinburgh	all	$15\frac{1}{8} — 15\frac{3}{8}$	
85,000	10	30 Aug.	Glasgow Tramway and Omnibus, Limited	9	$2\frac{1}{8} — 2\frac{3}{8}$ pm	
20,000	10	27June74	Lisbon Steam, Limited	all	.. — ..	
34,000	10	15 Aug.	Liverpool United Tram. and Omnibus, Limited	all	$14\frac{1}{4} — 14\frac{1}{2}$	$14\frac{1}{4} a \frac{3}{8}$
25,000	10	15 Aug.	London, Limited	all	$12\frac{3}{8} — 12\frac{5}{8}$	
8,000	10	"	Do. 6 per cent. Preference	all	$11\frac{7}{8} — 12\frac{1}{8}$	
12,500	10	31 July	London Street Tramways	all	$13\frac{7}{8} — 14\frac{1}{8}$	$14 a \frac{1}{8} a 14$
10,000	10	30Dec.73	Madras, Limited	all	.. — ..	
60,000	10	15 Aug.	North Metropolitan	all	$16\frac{1}{8} — 16\frac{3}{8}$	$16\frac{3}{8}$
15,000	10	"	Provincial, Limited	all	$8\frac{7}{8} — 9\frac{1}{8}$	9
31,500	5	"	Tramways' Union, Limited	all	$5\frac{1}{8} — 5\frac{3}{8}$	$5\frac{1}{2} a \frac{1}{4} a \frac{3}{8} a \frac{7}{16}$

Two key pieces of info

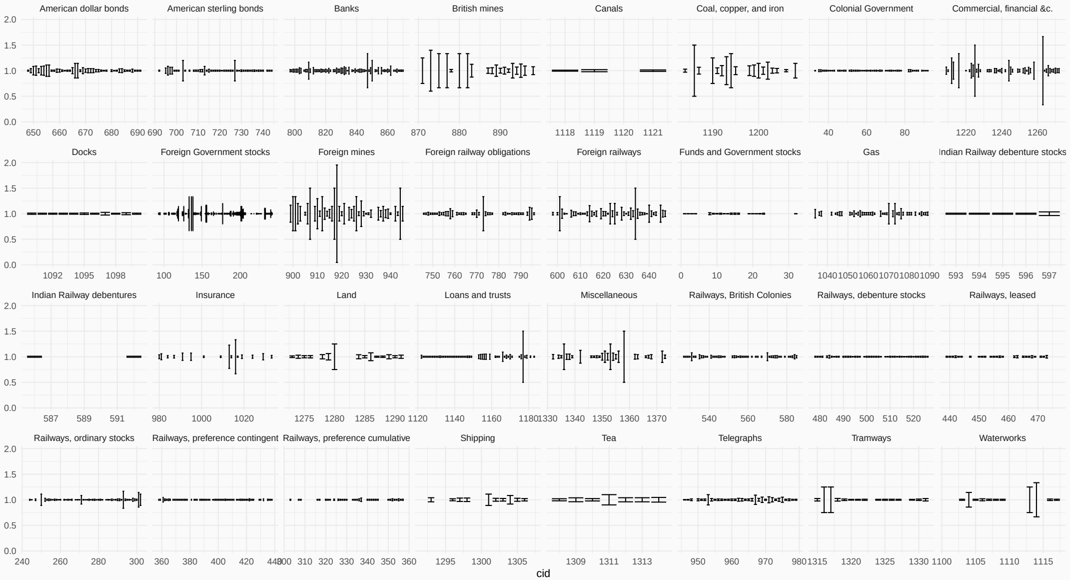
Closing quotations: Sometimes a bid-ask and sometimes not!

Business done: a partial list of some unique transaction prices

More

- Collected at 3pm by surveying dealers
- The broker Spurling testifies that in thickly traded markets they are **spreads**
- In thinly traded markets they are dealers' **valuation** of where they think the security is trading

Closing quotations over midpoint: all securities



What information can we get from Branch's table?

Security	Market	Bid	Ask	Turn over mid	Branch Probability
Security 1	Gas	10	10.5	4.88%	1.0
Security 2	American Railroad Bonds	100	101.0	1.00%	0.5
Security 3	American Railroad Bonds	101	103.0	1.96%	0.5
Security 4	Banks	NA	NA	NA	0.0

1. When no closing quotations are published, we know the security is not dealer supported
2. When Branch reports no dealer support in a *group* we know all those securities are not dealer supported
3. When securities are specifically noted as dealer/not-dealer supported in testimony
4. When Branch's reported 'Amount in Millions' figures identify which securities are or are not dealer supported

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At each step we update the probability of dealer-support for each security

The distribution of dealer support

- 34 known positives
- 500 known negatives (540 close to zero)
- 839 know only the probability

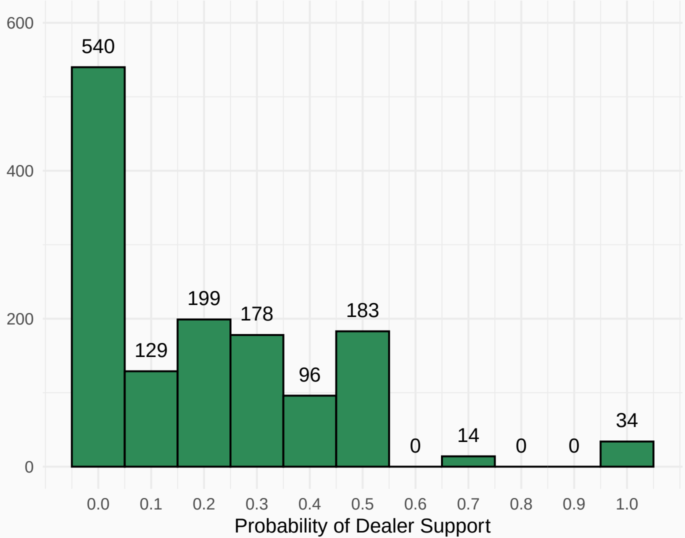

Figure 2: Histogram of computed probabilities of dealer support.

The econometric approach

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2. We would like to know $P(\texttt{spread}|X)$

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This is a **sample selection** problem:

- The securities dealers are supporting are not chosen randomly

Modeling strategy: the selection problem

We begin by assuming

1. The spreads are competitive
2. Dealers are profit motivated

True classification is $z_i \in \{0, 1\}$, the spread is s_{1i}, and dealers' valuations are s_{2i}.

Dealers make a market when the spread overcomes their reservation wage.

This is a Roy model aka 'switching regression' aka Tobit-5

$$s_{1i} = X_{1i}\beta_1 + v_i, \iff z_i = 1 \quad (1)$$

$$s_{2i} = X_{2i}\beta_2 + e_i, \iff z_i = 0 \quad (2)$$

$$z_i = \mathbf{1}[Z\gamma + \xi_i \geq 0] \quad (3)$$

$$[v_i, e_i, \xi_i] \sim N_3(\mathbf{0}, \Sigma) \quad (4)$$

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\xi} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2\xi} \\ \sigma_{1\xi} & \sigma_{2\xi} & 1 \end{bmatrix} \quad (5)$$

Modeling strategy: definitions and simplifications

We work with the log spread normalized by the mid-price

$$s_i = \ln\left(\frac{A_i - B_i}{p_{i,mid}}\right)$$

$$p_{i,mid} = \frac{A_i + B_i}{2}$$

A normalized spread is the % return on a round-trip transaction.

In switching models σ_{12} is never observed so we can set it to zero.

We assume $\sigma_{2\xi} = 0$ for convenience.

This might bias β_2.

The variance-covariance matrix thus simplifies to:

$$\Sigma = \begin{bmatrix} \sigma_1^2 & 0 & \sigma_{1\xi} \\ 0 & \sigma_2^2 & 0 \\ \sigma_{1\xi} & 0 & 1 \end{bmatrix}$$

Reasoning about the model

The expectation of the spread **conditional on dealer support** is given by:

$$E(s_{1i}|z_i = 1) = X_i\beta_1 + \rho\sigma_1\Big[\frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)}\Big] \tag{6}$$

The coefficients β_1 are for the **population**.

The parameter ρ tells us about whether observed means tend to be higher or lower than population means. If ρ is negative then on average observed spreads are smaller than unobserved spreads.

The classification problem

But we don't observe z_i

- This is not fatal – switching regressions can be estimated with no classification information at all (Maddala [1986])
- We adapt ideas from
  - Lee and Porter [1984]; Hausman, Abrevaya and Scott-Morton [1998].
- We combine these ideas to derive a likelihood function for the data generating process.

Estimation strategy

Where the true classification is known we do not want to estimate error rates. Divide the sample into $i \in \{n_0, n_1, n_p\}$ for true negatives, true positives, and probabilistic information. **The estimated likelihood is:**

$$\log \mathcal{L} = \underbrace{\sum_{i \in n_o} \ln\Big(1 - \Phi(Z_i\gamma)\Big) + \sum_{i \in n_1} \ln\Big(\Phi\Big\{\frac{Z_i\gamma + \rho/\sigma_1(s_i - X_i\beta_1)}{\sqrt{1-\rho^2}}\Big\}\phi(\frac{s_i - X_i\beta}{\sigma_1})\Big) +}_{\texttt{Heckman selection likelihood}}$$

$$\underbrace{\sum_{i \in n_p} \Big\{(1 - p_i)\ln\Big(1 - \Phi(Z_i\gamma)p_{11} - [1 - \Phi(Z_i\gamma)]p_{01}\Big) + p_i \ln\Big(\Phi\Big\{\frac{Z_i\gamma + \rho/\sigma_1(s_i - X_i\beta_1)}{\sqrt{1-\rho^2}}\Big\}\phi(\frac{s_i - X_i\beta}{\sigma_1})p_{11} + \phi(\frac{s_i - X_i\beta_2}{\sigma_2})[1 - \Phi(Z_i\gamma)]p_{01}\Big)\Big\}}_{\texttt{Mixture model}}$$

We estimate full Bayesian models with priors on all parameters. Posterior distributions obtained via Hamiltonian Monte Carlo MCMC sampling in `Stan` and ▸ tested it.

Estimates and discussion

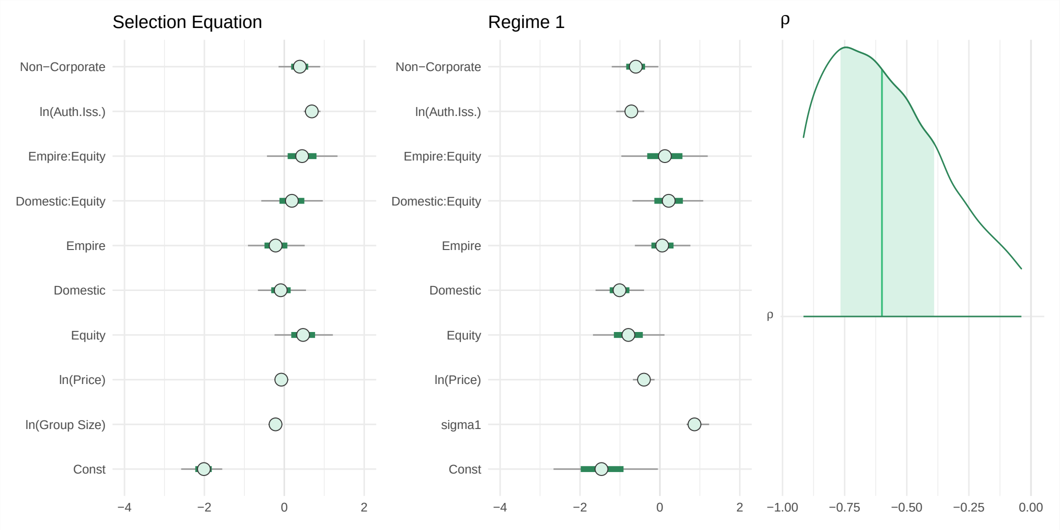
We focus on simple categories

variable	Mean	Median	Std.Dev.	Min	Max
domestic	0.43	0.00	0.49	0.00	1.00
empire	0.17	0.00	0.38	0.00	1.00
equity	0.49	0.00	0.50	0.00	1.00
non-corporate	0.23	0.00	0.42	0.00	1.00
ln(Auth. Iss.)	0.00	-0.02	1.00	-2.49	4.05
ln(Price)	0.00	0.53	1.00	-3.54	2.32
ln(Group Size)	0.00	0.06	1.00	-4.34	1.84

- All continuous variables are **standardized** to be mean-zero and unit standard-deviation

Figure 3: Posterior parameter distributions.

▸ Sub-sample Heckman ▸ Regime 2



Average Marginal Effects: Selection Equation				
Coef.	Linear	80% Posterior	Quadratic	80% Posterior
ln(Group Size)	-0.02	$[-0.04, -0.01]$	-0.07	$[-0.10, -0.04]$
ln(Price)	-0.01	$[-0.03, 0.01]$	-0.04	$[-0.07, -0.01]$
ln(Auth. Iss.)	0.10	$[0.08, 0.13]$	0.08	$[0.05, 0.11]$
Equity	0.07	$[0.00, 0.14]$	0.06	$[0.00, 0.13]$
Domestic	-0.06	$[-0.13, 0.01]$	-0.06	$[-0.14, 0.01]$
Empire	0.05	$[-0.03, 0.14]$	0.06	$[-0.03, 0.15]$
Non-Corporate	-0.02	$[-0.10, 0.05]$	0.14	$[0.03, 0.25]$

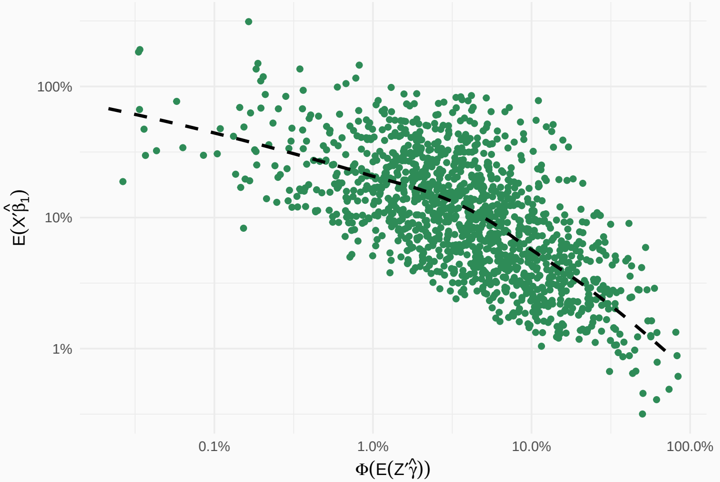
Marginal effect on the probability of dealer support computed for each listed security at its given covariates and then averaged.

▸ AME spreads

Interpretation: Average selection vs average spread

- The types of securities that have higher predicted spreads are **less likely** to be supported by dealers
- Preference based on **both observables and unobservables**

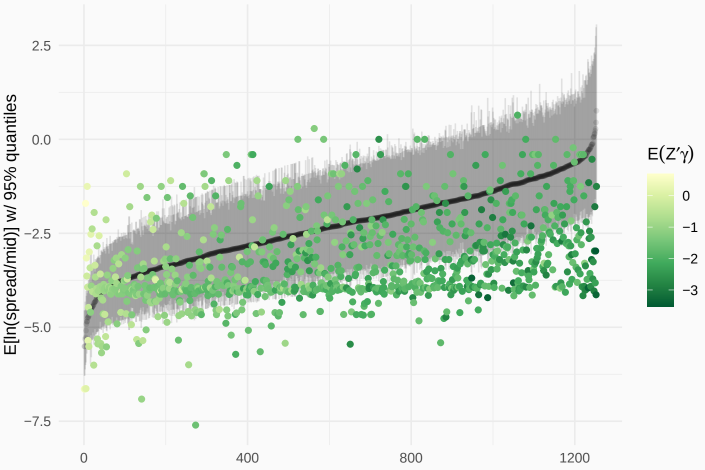
Figure 4: Scatter of predicted means from selection and spread equations with fitted LOESS smoother



Interpretation: pitfalls of observed spreads

- Observed spreads contain many entries that are merely valuations.
- The valuations are in general **smaller** than what a real spread would be (75% below the line)

Figure 5: Predicted Bid-Ask Spreads vs. Closing Quotations



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The LSE had many missing markets.

- This may have been because of **adverse selection** in a context of weak investor protections
- This may have been because **inventory costs** were too high and profits too low relative to set-up costs to motivate enough balance sheet capacity to enter

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The differences in spreads across securities can matter for understanding returns.

Appendix Slides

A generative probabilistic model

$$
\begin{aligned}
P(w_i^{(t)}, s_i) &= P(w_i^{(t)} = 0)P(w_i^{(t)} = 1, s_i) && (7)\\
&= [1 - \Phi(Z\gamma)p_{11} - (1 - \Phi(Z\gamma))p_{01}] && (8)\\
[P(w_i^{(t)} &= 1, s_i|z_i = 1)P(z_i = 1)+ && (9)\\
P(w_i^{(t)} &= 1, s_i|z_i = 0)P(z_i = 0)] && (10)\\
&= [1 - \Phi(Z\gamma)p_{11} - (1 - \Phi(Z\gamma))p_{01}] && (11)\\
[h(w_i^{(t)} &= 1, s_i)p_{11} + f_2(s_i)(1 - \Phi(Z\gamma))p_{01}] && (12)
\end{aligned}
$$

Where

$$
h(w_i^{(t)} = 1, s_i) = \Phi\Big(\frac{Z_i\gamma + \rho/\sigma_1(s_i - X_i\beta_1)}{\sqrt{1-\rho^2}}\Big)\phi\Big(\frac{s_i - X_i\beta_1}{\sigma_1}\Big) = P(s_i, z_i = 1)
$$

and $f_2(.)$ is just a normal density.

Estimation strategy

Imagine we draw a proxy $w_i^{(t)} \sim Bern(p_i)$, where p_i is the probabilities we have computed from Branch and the published spreads.

z_i relates to $w_i^{(t)}$ such that $p_{ij} = P(w_i^{(t)} = j | z_i = i)$ and thus p_{11} is the true-positive rate and p_{01} is the false-positive rate.

In theory we could generate many $w_i^{(t)}$. The likelihood across these draws would be:

$$\log \mathcal{L} = \sum_t \sum_i (1 - w_i^{(t)}) \ln \Big(1 - \Phi(Z_i \gamma) p_{11} - [1 - \Phi(Z_i\gamma)] p_{01} \Big) + \\ w_i^{(t)} \ln \Big(\Phi \Big\{ \frac{Z_i \gamma + \rho/\sigma_1 (s_i - X_i \beta_1)}{\sqrt{1-\rho^2}} \Big\} \phi(\frac{s_i - X_i\beta_1}{\sigma_1}) p_{11} + \\ \phi(\frac{s_i - X_i \beta_2}{\sigma_2}) [1 - \Phi(Z_i \gamma)] p_{01} \Big)$$

Estimation strategy

In practice, we want to integrate out these draws

$$\log \mathcal{L} = \sum_i \Big\{(1-p_i)\ln\Big(1-\Phi(Z_i\gamma)p_{11}-[1-\Phi(Z_i\gamma)]p_{01}\Big)+$$

$$p_i \ln\Big(\Phi\Big\{\frac{Z_i\gamma+\rho/\sigma_1(s_i-X_i\beta_1)}{\sqrt{1-\rho^2}}\Big\}\phi(\frac{s_i-X_i\beta}{\sigma_1})p_{11}+\phi(\frac{s_i-X_i\beta_2}{\sigma_2})[1-\Phi(Z_i\gamma)]p_{01}\Big)\Big\}$$

Thus we can express the likelihood in terms of our observed vector p. back

Figure 6: Example of SBC draw and estimated posteriors

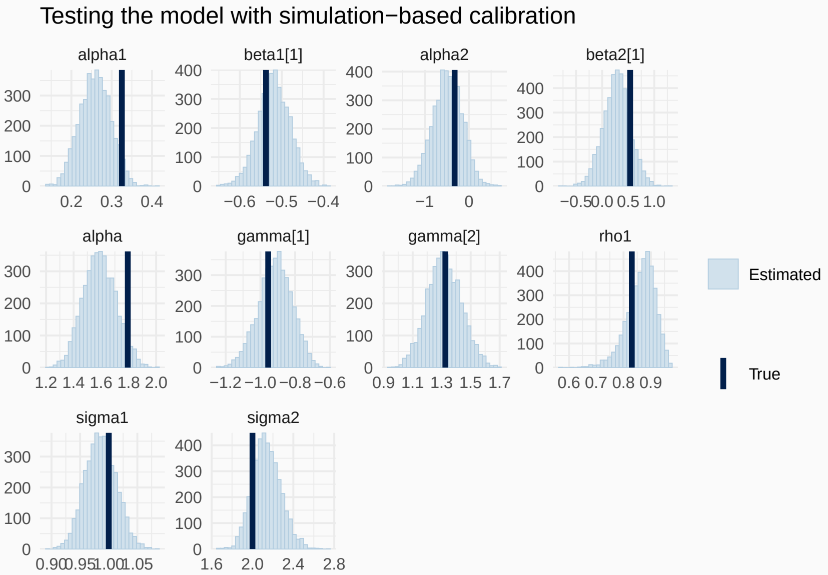
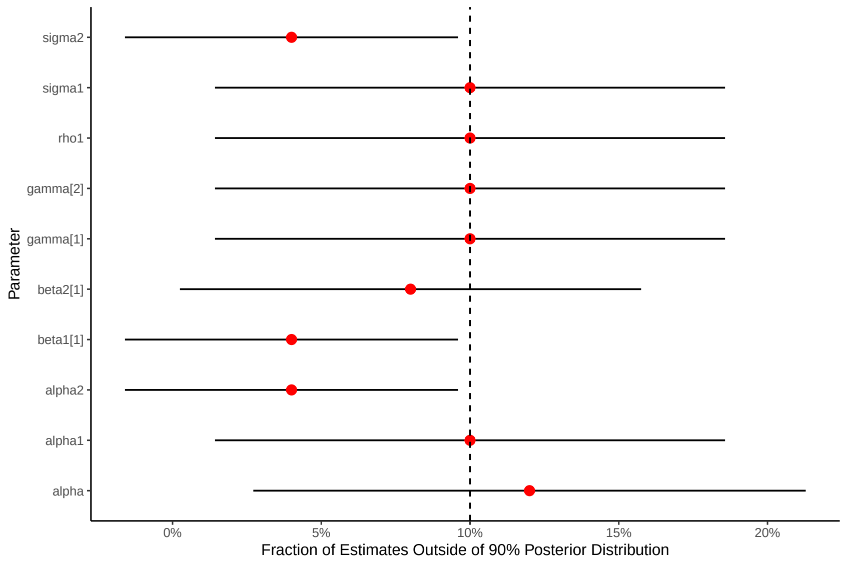
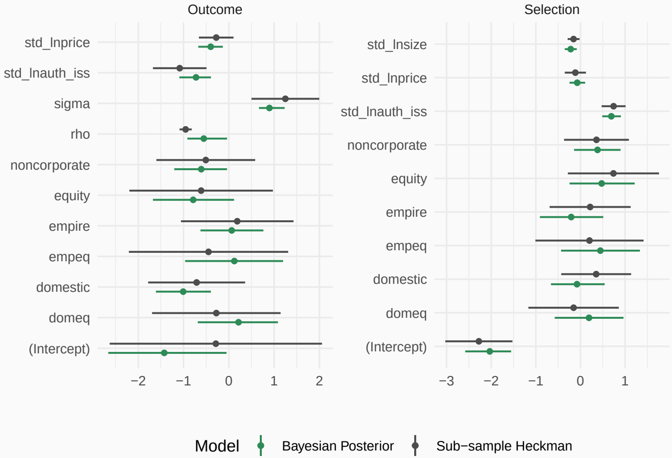


Figure 7: Estimated coverage rates of posterior estimates (◂ back)



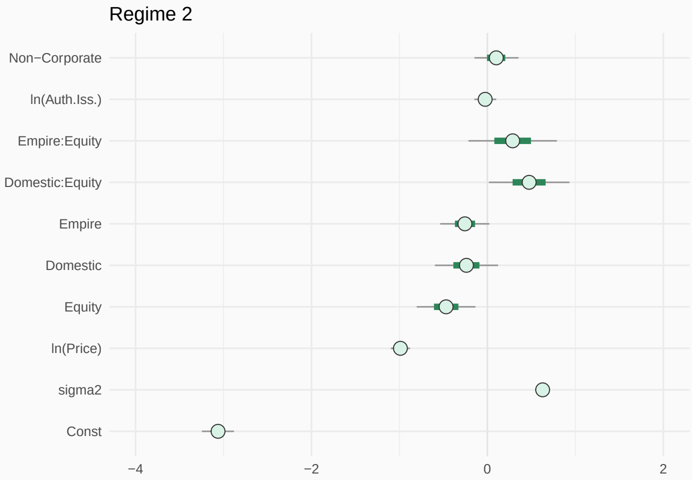
Comparison to sub-sample Heckman estimation

Figure 8: Posterior distributions vs estimate +/- 2 s.e. from Heckman on sub-sample. back



Regime 2 posterior parameter distributions

Figure 9: Posterior parameter distributions. ◂ Return



Why don't we use daily price data?

Why look at business done?

- Modern literature uses intra-day prices (Glosten 1987)
- We may be interested in *volume*

What does the business done column reveal?

- Marking prices is **optional**
- Dealers never mark
- Brokers mark to signal to clients
- **Don't mark repeat prices**

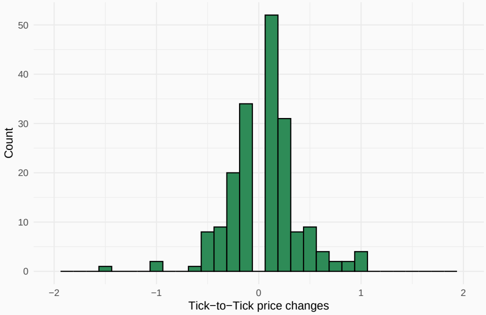


Figure 10: Missing zeros

"...[brokers] go and see whether there was marked on the board the price at which he had dealt or the price within which he had dealt. ***If he found it not marked*** *he would mark it" — Testimony of Daniels, Roy. Com. LSE, p. 20.*

Back

Why not fix this with limit-order books?

This is proposed by many brokers and endorsed in official report:

> *"a book or register should be kept… in which brokers should be invited to enter from time to time the names and quantities of any securities … with or without a price at which they are willing to deal"—Roy. Com. LSE, p. 10.*

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But in 1877 brokers report that LSE has:

> *"a theoretical facility ... in the shape of a pillar with notices upon it [but they are] often torn down ... the committee therefore locked up those notices in glass-cases, and now you have to go, I think, to the Secretary of the Stock Exchange to get one of those notices put up"—Testimony of Banbury, Roy. Com. LSE, p. 179.*

Branch says pillar "is jealously supervised by jobbers dealers, who exclude notices upon what have appeared to me to be the most idle pretences" —Testimony of Branch, Roy. Com. LSE, p. 132. back

Average Marginal Effects: Spread Equation				
Coef.	Linear	80% Posterior	Quadratic	80% Posterior
ln(Price)	-0.42	$[-0.63, -0.23]$	-0.25	$[-0.71, 0.11]$
ln(Auth. Iss.)	-0.74	$[-1.03, -0.48]$	-0.28	$[-0.62, 0.08]$
Equity	-0.86	$[-1.57, -0.10]$	-0.35	$[-1.38, 0.41]$
Domestic	-0.23	$[-1.13, 0.68]$	-0.53	$[-1.30, 0.22]$
Empire	-0.04	$[-0.97, 0.89]$	-0.01	$[-0.84, 0.85]$
Non-Corporate	-0.25	$[-0.84, 0.39]$	-0.26	$[-0.79, 0.23]$

Marginal effect on the log of the normalized spread computed for the population of listed securities at the given value of their covariates and averaged.

Back