A Comparative Study of Canadian and U.S. Price Discovery In the Ten-Year Government Bond Market

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Overview of Papers Discussed

Bruce Mizrach and Chris Neely (2005), "The Microstructure of Bond Market Tatonnement," St. Louis Federal Reserve Working Paper #2005-70.

Bruce Mizrach and Chris Neely (2006), "The Transition to Electronic Communication Networks In the Secondary Treasury Market." Federal Reserve Bank of St. Louis *Review*, Nov/Dec 2006, forthcoming.

Oleg Korenok, Bruce Mizrach, and Stan Radchenko (2006), "Structural Estimation of Information Shares."

Michael Fleming, Bruce Mizrach, and Chris Neely (2006): preliminary results comparing BrokerTec to Cantor.

Outline

I. Concepts
II. Markets
III. Unobserved Components Model
IV. Estimation
V. Structural Approach
VI. Conclusion

I. Microstructure Concepts

Fundamental Concepts – Price Discovery

Madhavan (2002, *FAJ*): *Price discovery* is the process by which prices incorporate new information.

The papers discussed today focus on the dimension of which market leads other markets in the price discovery process. This concept is called *information share*.

Hasbrouck (1995): "The information share associated with a particular market is defined as the proportional contribution of that market's innovations to the innovation in the common efficient price." Lehmann (2002): "a decomposition of the variance of innovations to the long run price."

Mizrach and Neely (2005) and the authors compare information shares for spot and derivatives markets in U.S. Treasuries. Campbell and Hendry also look at the Canadian bond market.

Market Fragmentation

Similar or identical securities often trade in multiple venues.

Hasbrouck: “In all security markets there is a trade-off between consolidation and *fragmentation*. Consolidation or centralization brings all trading interest together in one place, thereby lessening the need for intermediaries, but as a regulatory principle it favors the establishment and perpetuation of a single market venue with consequent concern for monopoly power. Allowing new market entrants (like the ATSs) maximizes competition among trading venues, but at any given time the trading interest in a security is likely to be dispersed (*fragmented*) among the venues, leading to increased intermediation and price discrepancies among markets.” (Italics added).

Campbell and Hendry (2006) and Mizrach and Neely (2005): Spot versus futures markets in Treasuries.

Mizrach and Neely (2006): Open outcry versus electronic markets Treasuries.

Korenok, Mizrach and Radchenko (2006): 6 stocks that have dual listings on NYSE and Nasdaq.

II. Markets

Canadian Bond Market

10-year Spot

Spot market data for the Government of Canada 10-year bond is Moneyline Telerate's CanPx system. Analog of US GovPX.

Canada's fixed-income interdealer brokers (IDBs): (1) Freedom International Brokerage Company; (2) Prebon Yamane (Canada) Ltd., (3) Shorcan Brokers Limited; and (4) Tullett Liberty (Canada) Ltd.

Prebon and Tullett are also major players in the U.S. market.

<u>Remark</u>: These are voice transactions.

Futures

Montreal Exchange Ten-Year Government of Canada Bond futures: CGB.

Became electronic in September 2000.

U.S. Treasury Market

Stage	Factoid	How Traded	Database
When Issued	Before auction	ECN, Voice	eSpeed, GovPX, BrokerTec
New Issues	Discrete issues	Auction	Treasury Department
On The Run	Commoditized	ECNs	BrokerTec, eSpeed eSpeed, BrokerTec
Off the Run	Illiquid	Voice	GovPX, BrokerTec
Futures	Liquid	Trading pits CBOT, CME	TickData Cisco futures, TickData

This paper focuses on voice transactions in GovPX, and after 2001, BrokerTec for on-the-run Treasuries.

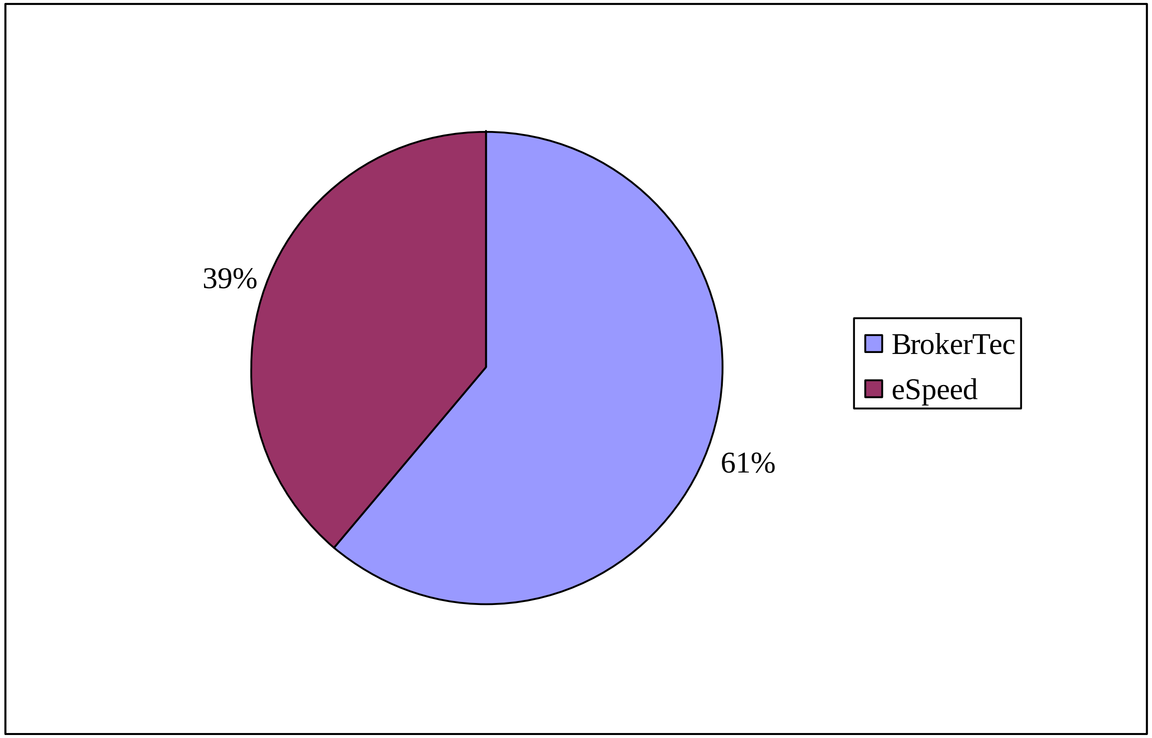
The notable omission from the spot market is Cantor's eSpeed.

Campbell/Hendry (2005) - Sample

		Contracts Studied	Days in Sample	Full Days in San
Contract 1	March 2000	GovPx Data; 60 sec	36	36
Contract 2	June 2000	GovPx Data; 60 sec	64	63
Contract 3	Sept 2000	GovPx Data; 60 sec	64	62
Contract 4	Dec 2000	GovPx Data; 60 sec	62	59
Contract 5	March 2001	GovPx Data; 60 sec	61	39
Contract 6	June 2001	GovPx Data; 60 sec	63	36
Contract 7	Sept 2001			
Contract 8	Dec 2001			
Contract 9	March 2002			
Contract 10	*June 2002*	BrokTec Data; 60 sec	37	36
		CanPx Data; 30 sec*	58	58
Contract 11	*Sept 2002*	BrokTec Data; 60 sec	63	62
		CanPx Data; 30 sec*	58	56
Contract 12	*Dec 2002*	BrokTec Data; 60 sec	61	58
		CanPx Data; 30 sec*	55	53
Contract 13	*March 2003*	BrokTec Data; 60 sec	61	56
		CanPx Data; 30 sec*	59	56
Contract 14	June 2003	BrokTec Data; 60 sec	64	62
Contract 15	Sept 2003	BrokTec Data; 60 sec	64	63
		BrokTec Data; 30 sec	63	62
Contract 16	Dec 2003	BrokTec Data; 30/60 sec	60	57
Contract 17	*March 2004*	BrokTec Data; 30/60 sec	62	57
		CanPx Data; 30 sec*	57	55
Contract 18	*June 2004*	BrokTec Data; 30/60 sec	63	62
		CanPx Data; 30 sec*	62	60
Contract 19	*Sept 2004*	BrokTec Data; 30/60 sec	64	62
		CanPx Data; 30 sec*	60	57
Contract 20	Dec 2004	BrokTec Data; 30/60 sec	62	58
Contract 21	March 2005	BrokTec Data; 30/60 sec	23	21

On-The Run Treasury Market in 2005

Mizrach/Neely (2006): On-the-run volume nearly 100% electronic, split between eSpeed and BrokerTec, two ECNs.



Momentum is with BrokerTec. Cantor had 70% share in 2001.

On The Run Market Quality

	Trades		Spreads (bp)		Market Impact	
	GovPX	**eSpeed**	**GovPX**	**eSpeed**	**GovPX**	**eSpeed**
2Y	97,105	225,505	0.8344	0.2053	0.4235	0.2321
5Y	90,150	663,152	1.1572	0.2738	0.9368	0.1709
10Y	33,514	777,301	2.0986	0.3819	0.9066	0.1850
30Y	15,533	213,275	5.4484	1.1862	2.2936	0.2749

Data: 1999 for GovPx, 2004 for eSpeed Source: Mizrach/Neely (2006).

Observation: This looks like a different universe. Black box trading 40% of volume = New players, hedge funds, etc.

Liquidity in the ECN Duopoly

	2Y		5Y		10Y		30Y	
Liq. Measure	**Cantor**	**ICAP**	**Cantor**	**ICAP**	**Cantor**	**ICAP**	**Cantor**	**ICAP**
Ticks	26,934	60,152	70,105	113,887	57,036	127,138	68,621	54,308
Inside Bid Depth	71.77	105.48	26.69	28.65	35.31	33.27	8.57	6.72
Inside Ask Depth	71.55	99.38	26.16	28.51	34.96	33.28	8.76	6.61
Inside #Bids	8.39	7.60	6.07	5.28	8.20	7.44	3.55	2.42
Inside #Asks	8.24	7.25	6.07	5.64	8.15	7.47	3.64	2.41
25m Bid	0.0110	0.0097	0.0160	0.0149	0.0271	0.0258	0.0494	0.0546
25m Ask	0.0111	0.0097	0.0160	0.0149	0.0272	0.0258	0.0503	0.0550
0.025% Q	321.95	477.50	126.89	131.08	48.68	52.78	3.93	2.32

Daily averages: October to December 2004.

Source: Fleming, Mizrach, Neely (WIP, 2006).

III. UC Model

HUC Model - Hasbrouck (1995)

The price in security market *i* differs from the fundamental price *p** only transiently. The coefficient β is there because futures and cash markets may have a slightly different basis.

$$p_{i,t} = \beta_i p^*_t + u_t$$

The fundamental price itself follows a random walk.

$$p^*_t = p^*_{t-1} + \eta_t, \quad E(\eta_t^2) = \sigma_\eta^2$$

Error terms ξ and η can be contemporaneously and serially correlated.

$$u_t = \xi_t + e_t, \quad E(e_t e_t') = \Sigma,$$

This is called an *unobserved components model* because we don't observe the efficient price directly.

Permanent Component

If we assume the individual prices are *I(1)*, have a VAR(*r*) representation, and that markets are cointegrated, the price vector has the Engle-Granger error correction form:

$$\Delta p_t = \alpha z_{t-1} + A_1 \Delta p_{t-1} + \cdots + A_r \Delta p_{t-r-1} + \varepsilon_t,$$

$$\underset{(N-1\times 1)}{z_{t-1}} = \begin{bmatrix} p_{1,t-1} - \beta_2 p_{2,t-1} \\ \vdots \\ p_{1,t-1} - \beta_N p_{N,t-1} \end{bmatrix}$$

Matrix of long run multipliers

$$\Psi(1) = \beta_{\perp} \gamma \alpha_{\perp}' = \gamma \begin{bmatrix} \psi_1 & \cdots & \psi_N \\ \vdots & & \vdots \\ \psi_1 & \cdots & \psi_N \end{bmatrix},$$

Non-Uniqueness

In computing the long-run effects of a shock, we need to take into account contemporaneous correlation

$$\Omega = E(\varepsilon_t \varepsilon_t')$$

by taking a Choleski decomposition, finding

$$M = \sum_{i=1}^{N} \sum_{j=1}^{i} m_{ij} \text{ such that } MM' = \Omega$$

Now, of course, we have all the same problems that the macroeconomists do. The Choleski decomposition is not unique.

An argument in favor of working directly with the structural model.

Information Shares

Hasbrouck

$$H_j = \frac{\left[\sum_{i=1}^{n} \Lambda_i m_{ij}\right]^2}{\left[\sum_{i=1}^{n} \Lambda_i m_{i1}\right]^2 + \left[\sum_{i=1}^{n} \Lambda_i m_{i2}\right]^2 + \ldots + \left(\Lambda_n m_{nn}\right)^2}.$$

Gonzalo-Granger

$$GG_j = \frac{\Lambda_j}{\sum_{i=1}^{N} \Lambda_i}.$$

Lehmann (2002) attempts to reconcile these. Two different forms of variance decomposition. One includes the noise from the individual markets and the other does not.

IV. Estimation

Bivariate Estimates

Campbell and Hendry work with the reduced form, a bivariate VAR.

The *n*-market case is examined in Mizrach/Neely (2005).

CH impose that the error correction coefficients are positive and between (0,1). An additional source of uncertainty.

CH assume that *f(t)-s(t)* is a stationary process. While it may be hard to reject this, as the contract month proceeds, there will be a basis change between the spot and cheapest to deliver futures contract which needs to be adjusted for.

Campbell/Hendry Canadian Estimates

	GG	HH-LB	HH-UB
Jun-02	0.59	0.63	0.72
	(0.26,0.92)	(0.21,1.05)	(0.32,1.12)
Sep-04	0.68	0.69	0.81
	(0.28,1.08)	(0.26,1.12)	(0.46,1.16)

Means centered above 50% so futures markets definitely matter. but there is a great deal of "sampling uncertainty."

The standard errors of the GG and HH estimates are based on sample average of the daily estimates. This would make sense only under the null that the information shares are constant.

Each day needs to be bootstrapped, and better yet, structural estimation performed.

Campbell/Hendry U.S. Estimates

GG estimates of futures share:

GovPx:

March 2000 – 0.67, March 2001 – 0.95

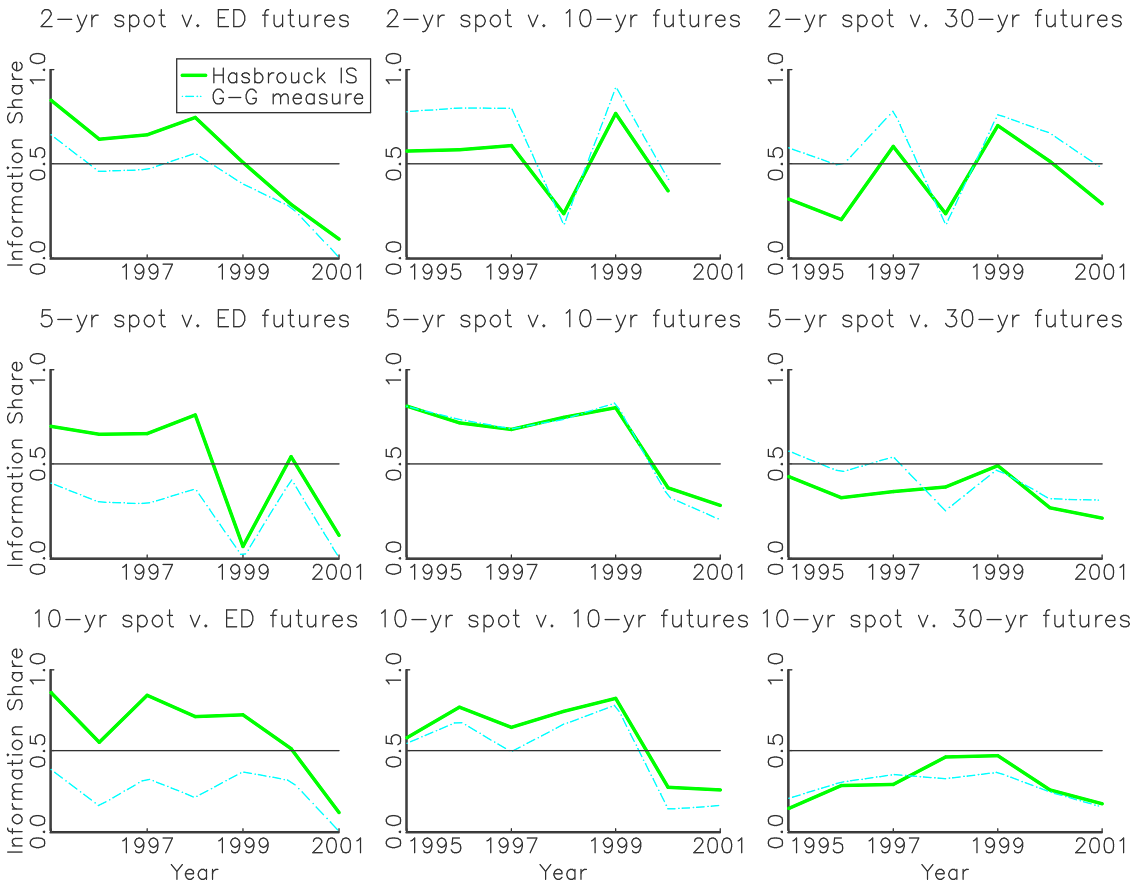
BrokerTec:

June 2002 – 0.75; March 2005 – 0.66;

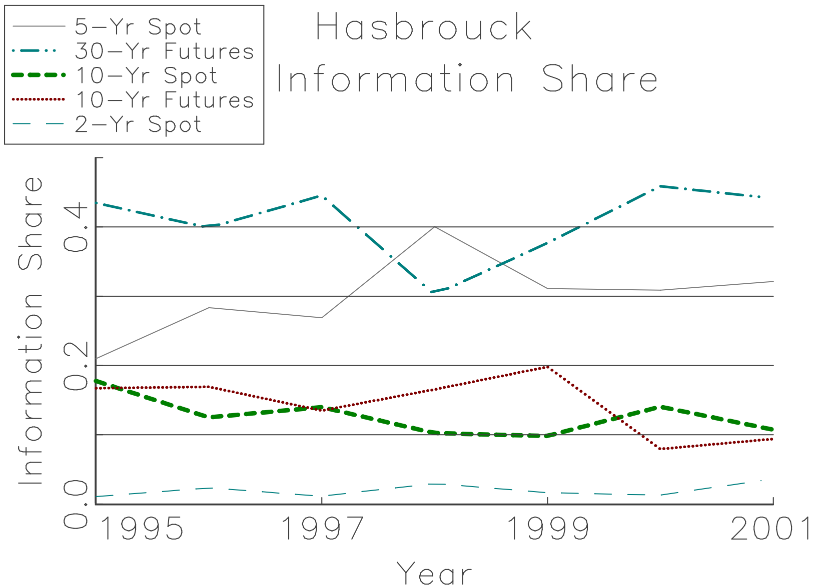
Hasbrouck's below 0.5 in lower bound, but huge range.

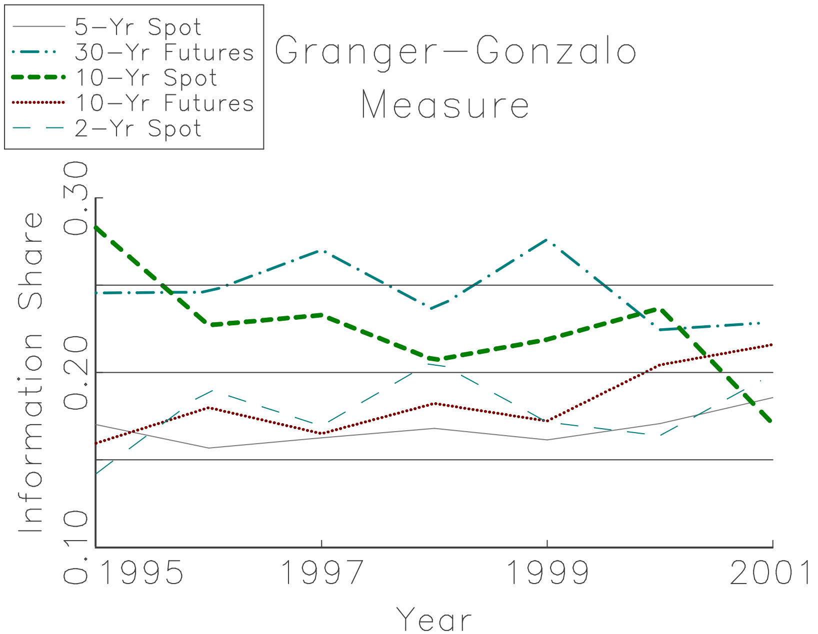
The growing liquidity and importance of BrokerTec is regaining information share.

Mizrach/Neely (2005) Estimates



Full System Estimation





HH: 30-year futures and 5-year spot have the largest information shares.

The GG story is a little cleaner: by 2001, the 10-year and 30-year futures have the dominant information shares.

Yan Zivot Information Share

IRF:

$$\frac{\partial p_{i,t+j}}{\partial \varepsilon_t}$$

Cointegration restriction:

$$\frac{\partial p_{i,t+j}}{\partial \varepsilon_t} = 1$$

Normalize with loss function to form information share:

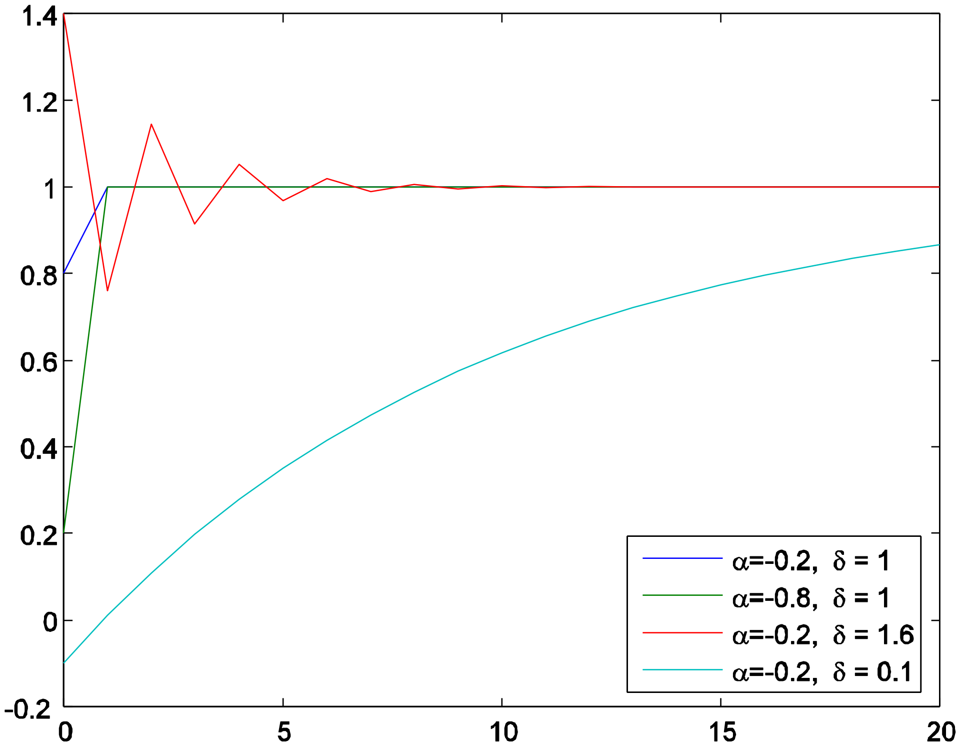
$$IS_i^{YZ} = \sum_{k=0}^{K} L\left(\frac{\partial p_{i,t+j}}{\partial \varepsilon_t} - 1\right)$$

CH report not the IS but the “number of periods until long-run equilibrium is reached.” They find it is longer in the spot market than the futures market.

Time ranges from 3 to 17 minutes.
<u>Puzzling result</u>: <u>BrokerTec</u> rising from 2002 to 2004.

Does not address how the model converges. Serial correlation may imply some kind of market efficiency.

IRF of Ahimud/Mendelsohn Partial Adjustment Model



Source: Korenok, Mizrach and Radchenko (2006).

Mizrach/Neely (2005) What Explains Information Share?

Relative trades (+) and spreads (+) explain 10-15% of the differences in information shares. (Not bad for microstructure studies).

What does not: Macroeconomic announcements are rarely significant. Only the PPI report (on 2 occasions) is significant more than once.

Campbell Hendry Regressors for IS

Significant +: Constant; Contracts 11,19; Number of trades – F,C: Half Spread-C; Pseudo Spread – C;

Significant -: First 3 Days; First 10 Days; Half Spread-F; Pseudo Spread-F; Trade Ratio;

R^2 between 7.4% and 22%.

V. Structural Estimation

State Space Representation

$$p_t = H x_t$$
$$x_t = F x_{t-1} + v_t,$$

For the HUC model:

$$H = \begin{pmatrix} \Theta & I_{N\times N} \end{pmatrix}, \; x_t = \begin{pmatrix} p_t^{\Delta} \\ u_t \end{pmatrix}$$

$$F = \begin{pmatrix} 1 & 0_{1\times N} \\ 0_{N\times 1} & 0_{N\times N} \end{pmatrix}, \; v_t = \begin{pmatrix} 1 & 0_{1\times N} \\ \vartheta & I_{N\times N} \end{pmatrix} \begin{pmatrix} \Pi_t \\ e_t \end{pmatrix}, \; E(v_t v_t') = \begin{pmatrix} \sigma^2 & \vartheta'\sigma^2 \\ \vartheta\sigma^2 & \sigma^2\vartheta\vartheta' + \Omega \end{pmatrix}$$

We are interested in estimation of the structural parameters α, σ^2, Ω. Parameters are estimated by MCMC, drawing the variance-covariance matrix of v_t and computing α, σ² and Ω using this matrix.

We also obtain confidence measures on these estimates from the Markov chain Monte Carlo iterations. These are much less ad hoc than sample averages of daily estimates and/or the upper lower bound estimates from the Hasbrouck orthogonalization.

Information Shares – Mapping From Structural Model

Structural autocovariances:

$\gamma_0 = E[\Delta p_t \Delta p_t'] =$ [illegible],

$\gamma_1 = E[\Delta p_t \Delta p_{t-1}'] =$ [illegible].

Reduced form:

$\Delta p_t = e_t - C e_{t-1}$,

$C =$ [illegible]

$\gamma_0 = \Omega + C \Omega C'$,

$\gamma_1 = -C\Omega$.

Moments matched:

$Var(e_t) =$ [illegible]

$Cov(\Delta p_t, e_t) =$ [illegible]

$Cov(\Delta p_t, \Delta p_{t-1}) =$ [illegible].

Solution:

IS derived from these:

$\Omega =$ [illegible]

[illegible]

Structural Model Implications

GG Information shares can be negative.

Hasbrouck shares are positive by construction, but can give the largest IS to a market which moves prices *away* from the efficient price.

The uncertainty of the information shares is not measured by sample average estimates of IS.

Open Questions in the Literature

Q1: Does the notion of information shares make sense?

A1: Without the structural model, they can be hard to interpret.

Q2: Is the Hasbrouck unobserved components model (HUC) a good structural model?

A2: In many ways no. Better models should exploit links to other aspects of microstructure, e.g. the bid ask spread, etc. Korenok, Mizrach and Radchenko (2006) explore this.

VII. Conclusion

Conclusions

Information shares are a useful summary statistic of the relative importance of market structures that are fragmented or where spot and derivative instruments are available.

Despite strong identification assumptions, these measures correlate well with observable liquidity.

U.S. secondary Treasury market traders:

You need 3 trading screens, BrokerTec, Cantor and the futures

Direct estimation of the structural model seems to be the best way to go forward in this literature.

VII. Supplemental