

Liquidity in the Foreign Exchange Market:
Measurement, Commonality, and Risk Premiums

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Supplemental Appendix

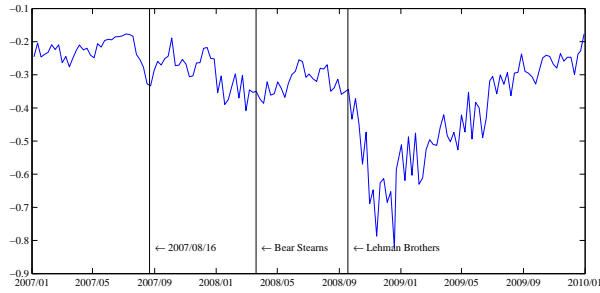
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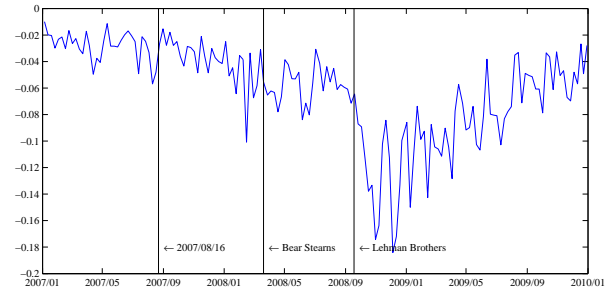
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February 12, 2011

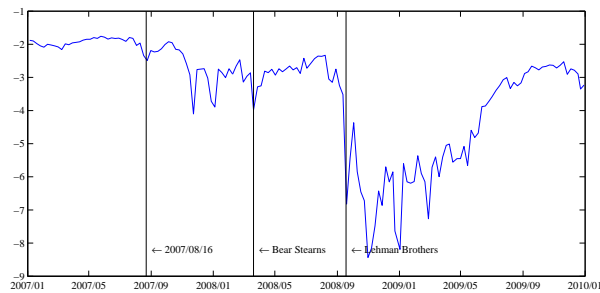
Additional Figures and Tables



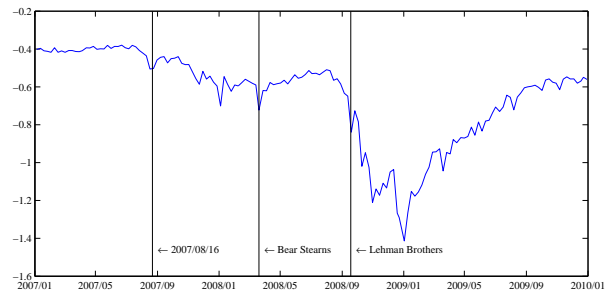
(a) Price impact



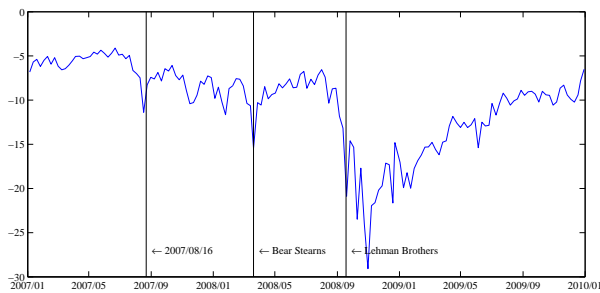
(b) Return reversal



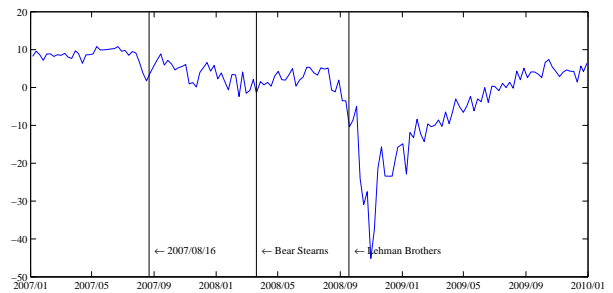
(c) Bid-ask spread



(d) Effective cost

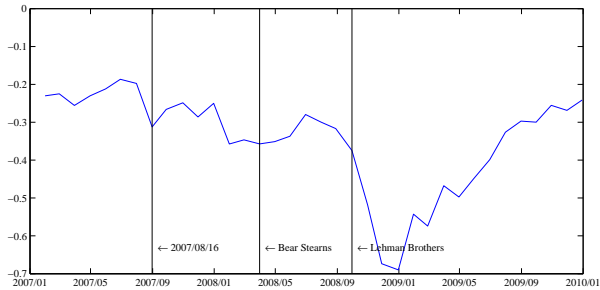


(e) Price dispersion

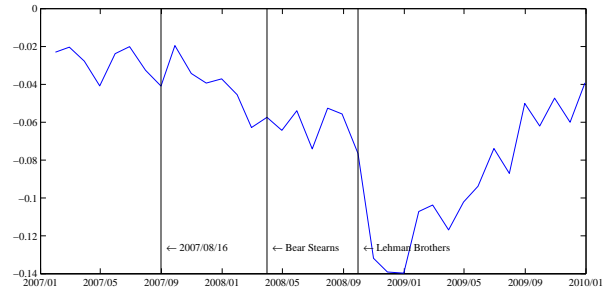


(f) Latent liquidity

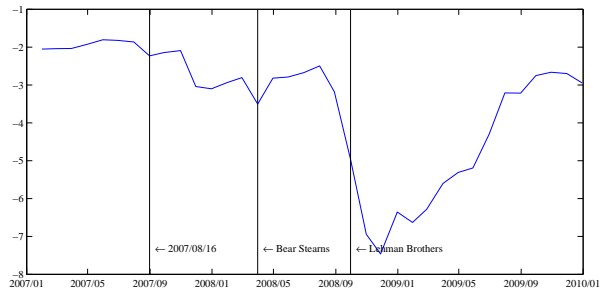
Figure I.1: Weekly systematic liquidity. Panels (a)–(e) depict market-wide FX liquidity based on (within measures) averaging of individual exchange rate liquidity (Equation (4)). Latent systematic liquidity obtained from Principle Component Analysis across exchange rates as well as across liquidity measures (Equation (5)) is depicted in Panel (f). The sign of each liquidity measure is adjusted such that the measure represents liquidity rather than illiquidity. The sample is January 2, 2007 – December 30, 2009.



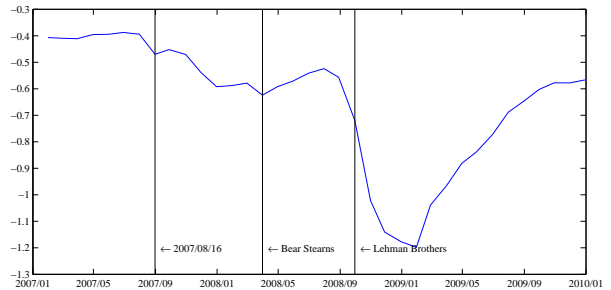
(a) Price impact



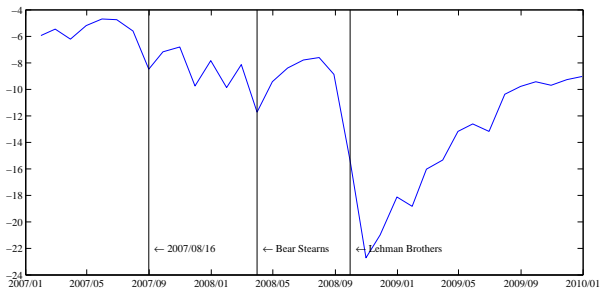
(b) Return reversal



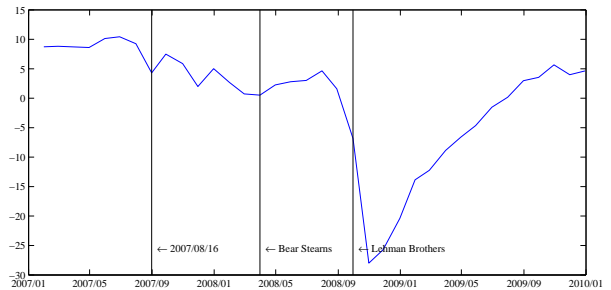
(c) Bid-ask spread



(d) Effective cost



(e) Price dispersion



(f) Latent liquidity

Figure I.2: Monthly systematic liquidity. Panels (a)–(e) depict market-wide FX liquidity based on (within measures) averaging of individual exchange rate liquidity (Equation (4)). Latent systematic liquidity obtained from principle component analysis across exchange rates as well as across liquidity measures (Equation (5)) is depicted in Panel (f). The sign of each liquidity measure is adjusted such that the measure represents liquidity rather than illiquidity. The sample is January 2007 – December 2009.

Table I.1: Principle component loadings across exchange rates

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
First principle component loadings									
Price impact	0.3026	0.3639	0.2868	0.3756	0.3930	0.3079	0.1718	0.3672	0.3729
Return reversal ($K = 1$)	0.3082	0.3299	0.2893	0.4456	0.3899	0.3672	0.1756	0.1937	0.3984
Return reversal ($K = 3$)	0.3285	0.3487	0.2715	0.3997	0.3816	0.3795	0.1165	0.3011	0.3784
Return reversal ($K = 5$)	0.3129	0.3835	0.2425	0.4049	0.3509	0.3648	0.1333	0.2866	0.4197
Bid-ask spread	0.3109	0.3798	0.2725	0.3801	0.3879	0.2407	0.2200	0.3739	0.3792
Effective cost	0.3270	0.3361	0.3221	0.3426	0.3269	0.3439	0.3247	0.3382	0.3377
Effective cost, volume-weighted	0.3188	0.3378	0.3265	0.3409	0.3335	0.3408	0.3236	0.3411	0.3361
Price dispersion (TSRV, one minute)	0.3310	0.3454	0.3383	0.3550	0.3601	0.2860	0.2932	0.3441	0.3389
Price dispersion (TSRV, five minute)	0.3334	0.3325	0.3398	0.3491	0.3561	0.3185	0.3079	0.3308	0.3294
Average	0.3193	0.3508	0.2988	0.3771	0.3644	0.3277	0.2296	0.3196	0.3656
Second principle component loadings									
Price impact	0.1801	0.1357	0.1733	0.0991	0.0071	-0.0269	-0.9519	-0.0481	-0.0108
Return reversal ($K = 1$)	0.4433	0.2132	0.3078	0.0915	-0.3494	-0.3097	0.2355	-0.6173	-0.0217
Return reversal ($K = 3$)	0.4739	0.2382	0.5237	-0.0072	-0.2554	-0.2057	0.0815	-0.5636	-0.1118
Return reversal ($K = 5$)	0.1526	0.0987	0.5847	-0.1148	-0.3472	0.2776	-0.5598	-0.3174	0.0126
Bid-ask spread	0.1776	0.1114	-0.4483	0.0067	0.0145	-0.6244	0.6005	0.0503	0.0417
Effective cost	-0.5420	-0.2097	0.5770	-0.0866	-0.3448	0.1727	0.3524	0.1946	-0.1048
Effective cost, volume-weighted	0.6606	0.1404	-0.4980	0.1693	0.1181	-0.2247	-0.2972	-0.2651	0.2102
Price dispersion (TSRV, one minute)	-0.0291	-0.0204	-0.1053	0.0646	0.0527	-0.8338	0.4814	0.1146	0.2014
Price dispersion (TSRV, five minute)	-0.4566	-0.0216	0.2978	-0.4013	0.2386	0.2607	0.1529	0.4162	-0.4689
Average	0.1178	0.0762	0.1570	-0.0199	-0.0962	-0.1683	0.0106	-0.1151	-0.0280

Notes: Given a standardized daily measure of liquidity, each row of the table shows principle component loadings for each exchange rate obtained by conducting Principle Component Analysis across the FX rate liquidities. The Principal Component Analysis is repeated for each liquidity measure. The sample is January 2, 2007 – December 30, 2009.

Table I.2: Commonality in liquidity using within measure PCA factors based on FX rates against USD

<i>Measure</i>	<i>Factor 1</i>	<i>Factors 1,2</i>	<i>Factors 1,2,3</i>
Daily data			
Price impact	0.6280	0.7671	0.8749
Return reversal ($K = 1$)	0.2991	0.4814	0.6335
Return reversal ($K = 3$)	0.3330	0.5049	0.6618
Return reversal ($K = 5$)	0.3205	0.4897	0.6427
Bid-ask spread	0.6682	0.7911	0.9016
Effective cost	0.8831	0.9282	0.9557
Effective cost, volume-weighted	0.8871	0.9321	0.9593
Price dispersion (TSRV, one minute)	0.7729	0.8547	0.9195
Price dispersion (TSRV, five minute)	0.7951	0.8574	0.9152
Weekly data			
Price impact	0.7231	0.8445	0.9246
Return reversal ($K = 1$)	0.4737	0.6794	0.7908
Return reversal ($K = 3$)	0.5196	0.7165	0.8233
Return reversal ($K = 5$)	0.5302	0.7113	0.8206
Bid-ask spread	0.7751	0.8609	0.9293
Effective cost	0.9085	0.9487	0.9737
Effective cost, volume-weighted	0.9194	0.9577	0.9800
Price dispersion (TSRV, one minute)	0.8644	0.9153	0.9545
Price dispersion (TSRV, five minute)	0.8711	0.9257	0.9602
Monthly data			
Price impact	0.7951	0.9053	0.9647
Return reversal ($K = 1$)	0.6580	0.8379	0.9123
Return reversal ($K = 3$)	0.6828	0.8357	0.9018
Return reversal ($K = 5$)	0.7184	0.8424	0.9099
Bid-ask spread	0.8604	0.9340	0.9680
Effective cost	0.9227	0.9607	0.9827
Effective cost, volume-weighted	0.9350	0.9676	0.9883
Price dispersion (TSRV, one minute)	0.9118	0.9488	0.9740
Price dispersion (TSRV, five minute)	0.9155	0.9543	0.9806

Notes: For each standardized daily measure of liquidity the first three common factors are extracted using Principle Component Analysis. Then, for each exchange rate and each standardized liquidity measure, liquidity is regressed on its common factors. The table shows the average adjusted- R^2 of these regressions using one, two and three factors. The sample is January 2, 2007 – December 30, 2009. This analysis is conducted using only currency pairs that include the USD.

Table I.3: Principle component loadings across liquidity measures and exchange rates: Average loading for FX rates

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Daily data									
PC1	0.3085	0.0444	0.1021	0.0790	0.0297	0.1707	0.1699	0.0453	0.0374
PC2	-0.1442	0.0087	0.0619	0.0192	0.0116	0.1679	0.1162	0.0219	0.0087
PC3	0.1335	0.0070	-0.0141	0.0112	0.0008	-0.0535	-0.1854	-0.0018	0.0044
Weekly data									
PC1	0.3123	0.0477	0.1076	0.0865	0.0320	0.1735	0.1574	0.0481	0.0395
PC2	-0.1791	0.0147	0.1189	0.0304	0.0208	0.2414	0.0884	0.0371	0.0096
PC3	0.1131	0.0050	-0.0282	0.0150	0.0005	0.0009	-0.1816	-0.0062	0.0034
Monthly data									
PC1	0.3079	0.0505	0.1139	0.0914	0.0342	0.1859	0.1543	0.0510	0.0411
PC2	-0.2223	0.0024	0.1298	0.0103	0.0164	0.2270	0.1160	0.0327	0.0026
PC3	0.0295	0.0013	0.0244	-0.0009	0.0019	0.1033	-0.2001	-0.0090	-0.0100

Notes: Principle component loadings across FX liquidity measures and exchange rates are extracted by Principle Component Analysis. The table reports the average loading for each exchange rate at different time frequencies. The sample is January 2, 2007 – December 30, 2009.

Table I.4: Principle component loadings across liquidity measures and exchange rates: Average loading for liquidity measures

	Return reversal	Price impact	Bid-ask spread	Effective cost	Price dispersion
Daily data					
PC1	0.1182	0.1161	0.1170	0.1025	0.0944
PC2	-0.0666	0.0430	0.1027	0.0439	0.0281
PC3	-0.0988	0.0418	-0.0093	0.0003	0.0115
Weekly data					
PC1	0.1219	0.1217	0.1087	0.1063	0.0995
PC2	-0.0236	0.0302	0.1034	0.0705	0.0318
PC3	-0.1045	0.0558	-0.0097	-0.0014	0.0166
Monthly data					
PC1	0.1185	0.1260	0.1100	0.1129	0.1049
PC2	0.0275	-0.0037	0.0869	0.0540	0.0102
PC3	-0.1037	0.0256	0.0474	-0.0049	0.0024

Notes: Principle component loadings across FX liquidity measures and exchange rates are extracted by Principle Component Analysis. The table reports the average loading for each measure of liquidity at different time frequencies. The sample is January 2, 2007 – December 30, 2009.

Table I.5: Further evidence for commonality

<i>Liquidity measure</i>	Mean β	Std. β	% pos.	% pos. & signif.	Adj.- R^2
Daily data					
Price impact	0.3405	0.1054	100.00%	77.78%	0.0143
Return reversal ($K = 1$)	0.0169	0.1462	55.56%	22.22%	0.0048
Return reversal ($K = 3$)	0.1401	0.1409	77.78%	55.56%	0.0059
Return reversal ($K = 5$)	0.1613	0.1417	77.78%	44.44%	0.0073
Bid-ask spread	0.4855	0.1899	88.89%	88.89%	0.1062
Effective cost	0.9460	0.0614	100.00%	100.00%	0.3461
Effective cost, volume-weighted	0.8842	0.0660	100.00%	100.00%	0.2955
Price dispersion (TSRV, one minute)	0.8780	0.0665	100.00%	100.00%	0.3739
Price dispersion (TSRV, five minute)	0.8873	0.0534	100.00%	100.00%	0.3793
Weekly data					
Price impact	0.6932	0.2227	100.00%	77.78%	0.0723
Return reversal ($K = 1$)	0.6971	0.2964	88.89%	44.44%	0.0437
Return reversal ($K = 3$)	0.4502	0.2793	100.00%	44.44%	0.0588
Return reversal ($K = 5$)	0.1971	0.2705	88.89%	55.56%	0.0572
Bid-ask spread	0.5615	0.2689	88.89%	77.78%	0.3465
Effective cost	1.0746	0.1027	100.00%	100.00%	0.4871
Effective cost, volume-weighted	1.0635	0.1048	100.00%	100.00%	0.4622
Price dispersion (TSRV, one minute)	1.0833	0.0929	100.00%	100.00%	0.5648
Price dispersion (TSRV, five minute)	1.0268	0.0810	100.00%	100.00%	0.5639
Monthly data					
Price impact	1.2571	0.3650	100.00%	88.89%	0.3887
Return reversal ($K = 1$)	0.8301	0.5774	88.89%	44.44%	0.1623
Return reversal ($K = 3$)	0.8909	0.5750	88.89%	44.44%	0.1209
Return reversal ($K = 5$)	0.8105	0.5487	88.89%	55.56%	0.1574
Bid-ask spread	1.1452	0.2941	100.00%	88.89%	0.5480
Effective cost	1.3638	0.1759	100.00%	100.00%	0.7129
Effective cost, volume-weighted	1.3332	0.1798	100.00%	100.00%	0.7129
Price dispersion (TSRV, one minute)	1.1339	0.1462	100.00%	100.00%	0.7007
Price dispersion (TSRV, five minute)	1.1136	0.1367	100.00%	100.00%	0.7047

Notes: This table shows time series regression results when daily relative changes in individual exchange rate j liquidity are regressed on relative changes in systematic FX liquidity. The latter is given by the average liquidity across exchange rates, without exchange rate j , similarly to Chordia, Roll, and Subrahmanyam (2000). Mean β and Std. β denote cross-sectional average and standard deviation of slope coefficients. % pos. and % pos. & signif. denote the percentages of estimates which are positive as well as positive and significantly different from zero. The last column shows the adjusted- R^2 . The sample is January 2, 2007 – December 30, 2009.

Table I.6: Further evidence for liquidity spirals in the FX market

	<i>const</i>	$L_{M,t-1}^{pca}$	VIX_{t-1}	$LIBOIS_{t-1}$	Adj. R^2
Coefficient	16.7529		-0.5270	-4.9014	0.7877
Std. error	(0.8049)		(0.0416)	(0.9838)	
Coefficient	8.4177			-13.3316	0.6353
Std. error	(0.7039)			(1.4024)	
Coefficient	10.6614	0.3553	-0.3294	-3.3678	0.8135
Std. error	(1.2812)	(0.0762)	(0.0491)	(0.6365)	
Coefficient	3.2151	0.6234		-5.0928	0.7503
Std. error	(0.4617)	(0.0465)		(0.8589)	

Notes: Regression of daily latent systematic FX liquidity ($L_{M,t}^{pca}$) on lagged VIX and LIBOR-OIS spread. Four different specifications of the regression model are estimated. Heteroscedasticity and autocorrelation (HAC) robust standard errors are shown in parenthesis. The sample is January 2, 2007 – December 30, 2009.