Internet appendix to "Understanding FX Liquidity"

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1 Details on the High-frequency Measures

The effective cost (*EC*) captures the cost of executing a trade. The *EC* is computed by comparing transaction prices with the quotes prevailing at the time of execution as

$$EC = \begin{cases} (P^T - P)/P, & \text{for buyer-initiated trades,} \\ (P - P^T)/P, & \text{for seller-initiated trades,} \end{cases} \tag{1}$$

with P denoting the transaction price, superscripts A and B ask and bid quotes, and $P = (P^A + P^B)/2$ the midquote price. Following the previous literature, we refer to the *EC* as the main benchmark measure for market liquidity.

Another measure of transaction cost is the proportional quoted bid-ask spread, *BA*,

$$BA = (P^A - P^B)/P. \tag{2}$$

The price impact (*PI*) measures the FX return associated with the order flow (Kyle (1985)). Similarly, the return reversal (*RR*) shows the reversal of the price to the fundamental value after the initial price impact (Campbell, Grossman, and Wang (1993)). We estimate *PI* and *RR* from the linear regression

$$\Delta p_t = \vartheta + PI \times (\upsilon_{b,t} - \upsilon_{s,t}) + \sum_{k=1}^{5} \gamma_k (\upsilon_{b,t-k} - \upsilon_{s,t-k}) + \varepsilon_t, \tag{3}$$

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where Δp_t is the change of the log midquote price between t and $t-1$, $\upsilon_{b,t}$ is the number of buyer-initiated trades and $\upsilon_{s,t}$ the number of seller-initiated trades at time t (i.e. the order flow). For each day, we estimate the parameter vector $[\vartheta, PI, \gamma_1 ... \gamma_5]$. The price impact *PI* is expected to be positive due to net buying pressure, while the return reversal $RR = \sum_{k=1}^{5} \gamma_k$ is expected to be negative.

The price dispersion (*PD*) or volatility is often used as an additional proxy for illiquidity (Chordia, Roll, and Subrahmanyam (2001)). To get a consistent and unbiased estimate, we use the two-scale nonparametric estimator (Aït-Sahalia, Mykland, and Zhang (2005)) of realized volatility.[1]

A liquid exchange rate is associated with a lower value of *EC*, *BA*, *PI*, *PD* as well as lower absolute value of (*RR*).

Using the EBS data set over January 2007 – May 2012, we estimate effective cost and four alternative HF liquidity measures (bid-ask spread, price impact, return reversal, and price dispersion) for each month and each exchange rate.

The full descriptive statistics are found in the tables below, but the following are worth mentioning. First, average effective costs are smaller than average bid-ask spreads, reflecting within-quote trading. Second, the average return reversal (temporary price change accompanying order flow) is negative and the order flow price impact is positive for all exchange rates. Third, comparing liquidity estimates across currencies, we observe a substantial cross-sectional variation in which EUR/USD is the most liquid exchange rate, while AUD/USD is the least liquid.

2 Details on the Low-frequency Measures

For each currency pair, we compute the eight low-frequency liquidity measures most widely used in the research on equity and corporate bonds: the Roll spread, BPW measure, bid-ask spread, Gibbs estimate, CS estimate, volatility, Effective Tick, and the LOT measure. In the main horse races we do not consider price impact liquidity proxies from Amihud (2002), Pàstor and Stambaugh (2003) and Amivest proxy from Cooper, Groth, and Avera (1985), Amihud, Mendelson, and Lauterbach (1997), since we do not have the daily FX trading volumes data over the our sample period. We do not consider the Zeros

[1] We compute the effective cost, bid-ask spread, price impact, return reversal and price dispersion for each FX rate.

measure from Lesmond, Ogden, and Trzcinka (1999) and the FHT measure from Fong, Holden, and Trzcinka (2011) due to the almost complete absence of unchanged FX mid prices over two consequent trading days.

Our first low-frequency liquidity measure is the *Roll* estimator of transaction costs from Roll (1984). Roll suggests a simple model of security prices in the market with transaction costs

$$\begin{cases} m_t = m_{t-1} + u_t \\ p_t = m_t + cq_t \end{cases} \tag{4}$$

where m_t is the log quote midpoint prevailing prior to the t^{th} trade ("efficient price"), p_t is the log trade price, and q_t are direction indicators, which take the values +1 (for a buy) or -1 (for a sell) with equal probability. The disturbance, u_t, reflects public information and is assumed to be uncorrelated with q_t. The Roll model (4) implies

$$\Delta p_t = c\Delta q_t + u_t, \tag{5}$$

where Δ is a change operator. Given this setup, Roll shows that the effective (transaction) cost c is the square root of minus auto-covariance of consecutive price changes. When the auto-covariance is negative, we substitute the transaction cost estimator with zero.[2] Instead of log trade prices, we use the daily log mid prices to compute the Roll estimate

$$Roll = \begin{cases} 2\sqrt{-\operatorname{Cov}(\Delta p_t, \Delta p_{t-1})}, & \text{when } \operatorname{Cov}(\Delta p_t, \Delta p_{t-1}) < 0, \\ 0, & \text{when } \operatorname{Cov}(\Delta p_t, \Delta p_{t-1}) \geqslant 0, \end{cases} \tag{6}$$

where Δp_t is the change of the log midquote price (the return) between t and $t-1$.

The Roll model is designed for the trade (tick) data and implies MA(1) process for log price changes. Using time-aggregated (lower frequency) data in the Roll model does not change the MA(1) property for log price changes. Suppose we only observe every second transaction price (p_t, p_{t+2}, p_{t+4}, ...). First, notice that $\mathrm{E}(p_t - p_{t-2}) = 0$, so the covariance equals $\mathrm{E}(p_t - p_{t-2})(p_{t+2} - p_t)$. We have

$$\mathrm{E}(p_t - p_{t-2})(p_{t+2} - p_t) = \mathrm{E}[u_t + u_{t-1} + c(q_t - q_{t-2})][u_{t+2} + u_{t+1} + c(q_{t+2} - q_t)] = -c^2\,\mathrm{E}\,q_t$$

since u_t and q_t are uncorrelated with everything. Notice that $\mathrm{E}\,q_t^2 = 0.5 \times (1)^2 + 0.5 \times$

[2]Goyenko, Holden, and Trzcinka (2009) also use this modified version of the Roll transaction cost estimator.

$(-1)^2 = 1$. The autocovariance is then

$$\mathrm{Cov}(p_t - p_{t-2}, p_{t+2} - p_t) = -c^2. \tag{7}$$

Alternatively, just notice that the covariance in (7) can be written

$$\mathrm{Cov}(\Delta p_t + \Delta p_{t-1}, \Delta p_{t+2} + \Delta p_{t+1}) = \mathrm{Cov}(\Delta p_t, \Delta p_{t+1}).$$

The result follows from $\mathrm{Cov}(\Delta p_t, \Delta p_{t+s}) = 0$ for $s \geq 2$.

The *Roll* estimate is feasible only if the first-order sample autocovariance is negative. In samples of daily frequency this is often not the case. For instance, Roll (1984) finds positive autocovariances in roughly half the cases in annual samples of daily returns. Harris (1990) shows that positive autocovariances are more likely for low values of the spread. Another problem arises when using the mid prices instead of the trade prices to compute the *Roll* estimate. The estimated cost will generally be biased downward, because midpoint realizations do not include the cost.

Being an estimate of the effective cost, the *Roll* spread is a measure directly linked to liquidity. The higher is the *Roll* spread, the lower is the liquidity. We compute the *Roll* estimate for each month in our sample from the daily mid prices data.

Our second low-frequency liquidity proxy is the gamma (*BPW*) measure for corporate bond market from Bao, Pan, and Wang (2011). They show that *BPW* captures the broader impact of liquidity on prices, above and beyond the effect of bid-ask spread. The *BPW* measure is defined as

$$BPW = -\mathrm{Cov}(\Delta p_t, \Delta p_{t-1}). \tag{8}$$

The *BPW* estimate is a simple and robust measure of illiquidity for corporate bonds, as argued by Bao et al. The higher is the *BPW*, the lower is liquidity. We compute the *BPW* measure for each month in our sample from the daily mid FX prices data.

Our third low-frequency liquidity measure is the relative *bid-ask spread* (*BA*) defined as in 2. The *BA* spread is the measure, directly linked to liquidity. The higher is the *BA*, the less liquid is the FX rate. We get the monthly *BA* estimates by averaging the daily bid-ask estimates over the month.

Below we contrast the quality of the HF and LF proportional bid-asks. First, we compare the HF EBS transactable bid-asks with the LF Thomson Reuters (TR) indicative bid-asks. Daily snaps of the EBS bid-ask at 22:00 GMT have weak correlations (0.02–0.27

for 9 FX rates) with the TR daily bid-asks over Jan 2007–May 2012. Daily averages of the five-minute EBS bid-asks have somewhat higher correlations (0.05–0.35) with the TR bid-asks. Second, we consider daily bid-asks from an alternative data provider WM/Reuters (WMR). WMR rates are fixings at 16:00 GMT, which is the time of the highest liquidity at the FX market. The correlations of the EBS bid-asks at 16:00 GMT with the WMR fixings range from -0.19 to 0.44 depending on the currency pair. Daily averages of the five-minute EBS bid-asks have -0.18–0.46 correlations with the WMR bid-asks. A negative correlation for one of the exchange rates (USD/CAD) points to the worse ability of the WMR versus TR bid-asks to capture the actual liquidity for some FX pairs. The correlations of daily WMR and TR bid-asks are 0.03–0.26 depending on the FX rate. Finally, we compare the monthly averages of the three data sources and get the same patterns as for daily data, but the correlations are generally higher. See Table 6 and 7 for the full correlation table between daily and monthly bid-asks from EBS, TR and WMR. It is worth noting that daily and monthly EBS bid-asks are highly correlated with the EBS effective cost (0.82 and 0.93 mean correlations across the 9 FX rates), confirming that both HF benchmarks represent high-quality liquidity cost estimates.

Overall, we conclude that (1) daily indicative quotes from TR and WMR have weak correlations with the daily EBS transactable quotes, (2) daily averages of the HF transactable EBS quotes are more correlated with the TR and WMR quotes than the EBS snaps at the same time when daily TR and WMR quotes are taken, (3) TR bid-ask quotes provide more accurate liquidity estimates than the WMR ones for our 9 currency pairs (in terms of correlations of with the daily EBS bid-asks and EC).[3]

Our fourth low-frequency liquidity measure is the *Gibbs* effective cost estimate based on the Bayesian approach to the Roll model (4), see Hasbrouck (2009). In particular, Hasbrouck assumes that the disturbance u_t is normally distributed with zero mean and standard deviation σ_t. The transaction cost, c, standard deviation of the disturbance, σ_u^2, and trade direction indicators q are unknown parameters in the Roll model. The unknown parameters are re-estimated using the Bayesian approach and Gibbs procedure.[4] Hasbrouck corrects for possible negative transaction cost estimates in the Roll model by restricting them to be positive in the Bayesian approach.

Being an estimator of effective cost, the *Gibbs* estimate is a direct proxy of liquidity.

[3] See internet appendix to Mancini, Ranaldo, and Wrampelmeyer (2012) for the comparison of different FX data sources.

[4] See Hasbrouck (2009) for detailed description of the estimation procedure.

The higher is the *Gibbs*, the lower is liquidity. We compute the *Gibbs* estimates for each month from the daily log midquote prices. We run each Gibbs sampler for 1000 sweeps and discard first 200 draws.

Joel Hasbrouck generously provides the programming code of the Gibbs estimation procedure on his web-site. We use this code for our estimations. This code uses a half-normal distribution - and we set (for each currency and month) the standard deviation of the transaction cost prior equal to $\sqrt{\overline{p}^A - \overline{p}^B}$, where $\overline{p}^A$ and $\overline{p}^B$ are the monthly averages of log ask and log bid prices, respectively. The estimates are robust to this choice, unless we choose a very small value. Using a higher number of sweeps (up to 10000) or changing the prior of the transaction cost does not affect the mean parameter estimates materially. However, there are two exceptions to this finding: (a) setting the standard deviation of the prior to a very small value (eg. 0.001) gives estimates that are much less correlated with the HF benchmark; (b) when we study liquidity on a weekly instead of the monthly frequency, then the prior becomes more important. (The latter confirms the evidence in Hasbrouck (2009).)

Our fifth low-frequency liquidity measure is the *CS*, the simple closed-form bid-ask estimator from daily high and low prices from Corwin and Schultz (2012). The daily high prices are almost always buyer-initiated trades and daily low prices are almost always seller-initiated trades. The ratio of high-to-low prices for a day therefore reflects both the fundamental volatility of the asset and its bid-ask spread. Although the variance component of the high-low ratio is proportional to the return interval, the spread component is not. The component of the high-to-low price ratio that is due to volatility increases proportionately with the length of the trading interval, while the component due to bid-ask spreads does not. This implies that the sum of the price ranges over 2 consecutive single days reflects 2 days' volatility and twice the spread, while the price range over one 2-day period reflects 2 days' volatility and one spread. Corwin and Schultz derive a spread estimator as a function of high-low ratios over 1-day and 2-day intervals. Since the high-low estimator relies on the volatility of the asset to derive the spread estimate, the *CS* estimate seems to mix liquidity and volatility. In fact, the high-low estimator may capture other forms of transitory volatility, and therefore liquidity costs, that are not reflected in the effective spread (see Corwin and Schultz (2012)).

The method produces an estimate of the spread and an estimate of the daily standard deviation using only the high and low prices from 2 consecutive days. The CS (high–low

spread estimate) is calculated as

$$CS = \frac{2(e^{\alpha}-1)}{1+e^{\alpha}} \approx \alpha, \text{ for small values of } \alpha \in [-0.25, 0.25], \tag{9}$$

$$\begin{aligned} \text{where } \alpha &= \left(1+\sqrt{2}\right)\sqrt{\beta} - \frac{1}{\sqrt{3-2\sqrt{2}}}\sqrt{\gamma} \\ &= \left(1+\sqrt{2}\right)(\sqrt{\beta}-\sqrt{\gamma}), \end{aligned} \tag{10}$$

$$\beta = \left[\ln\left(\frac{H_t}{L_t}\right)\right]^2 + \left[\ln\left(\frac{H_{t+1}}{L_{t+1}}\right)\right]^2, \text{ and } \gamma = \left[\ln\left(\frac{H_{t,t+1}}{L_{t,t+1}}\right)\right]^2,$$

where H_t and L_t denote the observed high and low prices on day t (similarly for day $t+1$), while $H_{t,t+1}$ and $L_{t,t+1}$ are the high and low over two days (t to $t+1$). We apply the simplified expression (10) to compute the monthly *CS* estimates. Using the original expression from Corwin and Schultz (2012) gives same results. We compute the *CS* spread estimates separately for each 2-day period and calculate the average across all overlapping 2-day periods in the month.

Before applying the estimator, we correct for the overnight returns, as described by Corwin and Schultz. We use the Reuters daily high and low prices to compute the monthly CS spread estimates. The drawback of the method is an increasing number of negative transaction costs estimates when the spread is squeezing. Therefore, when the *CS* transaction cost estimate is negative, we set it to zero. The higher is the *CS*, the lower is the liquidity.

Our sixth low-frequency liquidity measure is the *Volatility* of daily mid-prices data, computed for each month. Tinic and West (1972) argue that there is a positive relationship between spreads and price volatility for the reason that the greater the variability in price, the greater risk associated with the performance of the dealership function. If possessed monopolistically by traders who have no competitors, more rampant asymmetric information should increase both volatility and spreads, inducing correlation but not causation; and if, as seems plausible, informed traders earn greater profits when volatility is generally high, spreads should increase in response (see Chordia, Roll, and Subrahmanyam (2001)). Following Menkhoff, Sarno, Schmeling, and Schrimpf (2012), we use a straightforward measure to proxy for FX volatility. First, we calculate the absolute daily log return for each day. Then, we average daily values up to the monthly frequency. This proxy has obvious similarities to measure of realized volatility (see, for example, Ander-

sen, Bollerslev, Diebold, and Labys (2001)), although we use absolute returns and not squared returns to minimize the impact of outlier returns.

Our seventh low-frequency liquidity measure is the *Effective Tick* (*Efftick*) from Holden (2009) and Goyenko, Holden, and Trzcinka (2009). The *Efftick* is the effective spread proxy based on the observable price clustering. Following the negotiation cost theory of Harris (1991), Holden assumes that transaction prices are clustered in order to minimize negotiation costs between potential traders. The frequency of price clusters (or the frequency of a specific last digit in the observed prices) is used to infer the effective spread. For example, transaction prices of a type an integer plus 0.23 can only be observed when the spread is one cent. Alternatively, prices of a type an integer plus 0.25 can be triggered either by a one cent of by a five cent spread.

We adjust the *Efftick* method for the fact, that FX mid prices are available for each day.[5] Assuming that the realization of the spread on the daily mid price is randomly drawn from a set of possible spreads 0.01, 0.05, 0.1, 0.25, 1, we compute the *Efftick* measure as a probability-weighted average of each effective spread size divided by the average mid price over the month

$$Efftick = \frac{\sum_{k=1}^{J} \hat{\gamma}_j s_j}{\bar{P}}, \tag{11}$$

$$\hat{\gamma}_j = \begin{cases} \text{Min}[\text{Max}\{U_j, 0\}, 1], & j = 1 \\ \text{Min}[\text{Max}\{U_j, 0\}, 1 - \sum_{k=1}^{j-1} \hat{\gamma}_j], & j = 2 \dots J, \end{cases} \tag{12}$$

$$U_j = \begin{cases} \left(\frac{A_1}{B_1}\right) F_1, & j = 1 \\ \left(\frac{A_j}{B_j}\right) F_j - \sum_{k=1}^{j-1} \left(\frac{O_{jk}}{B_k}\right) F_k, & j = 2 \dots J, \end{cases} \tag{13}$$

$$F_j = \frac{N_j}{\sum_{k=1}^{J} N_j}, \tag{14}$$

where $\hat{\gamma}_j$ and U_j are the constrained and unconstrained probabilities of the jth spread

[5]Goyenko, Holden, and Trzcinka (2009) and Holden (2009) use CRSP data, where closing price for trade and mid price for no-trade days are available. Therefore they need to accommodate for the absence of information whether the closing trade is at ask, bid or mid. Since we have mid prices data for every trading day, we do not have to do this adjustment.

($j = 1, 2, \ldots J$, $J = 5$); A_j are the total number of midpoints corresponding to the jth spread ($A = [100, 20, 10, 4, 1]$ for our price grid); B_j is the number of special midpoints corresponding to the jth spread ($B = [80, 16, 10, 4, 1]$); O_{jk} is the number of overlapping midpoints for the jth spread which overlap the midpoints of the kth spread and do not overlap the midpoints of any spread between jth spread and kth spread ($O_{21} = 20, O_{42} = 4, O_{31} = O_{41} = O_{43} = O_{51} = O_{52} = O_{53} = O_{54} = 0$ for our decimal price grid). For more detailed examples of the modification of Holden model to accommodate decimal grid see www.kelley.iu.edu/cholden/examples.pdf; F_j are the probabilities of mid prices corresponding to the jth spread; N_j is the observed number of mid prices corresponding to the jth spread.

For each month, we scale the mid FX prices to fit the relevant possible effective spreads grid. For example, if in one month the maximum number of digits in the daily mid prices is five after the point (say, 1.28265 for EUR/USD mid-price), we multiply all prices in this month by 1000. As the result, the maximum number of digits after the point is two, that makes the set of possible spreads 0.01, 0.05, 0.1, 0.25, 1 relevant.

The larger is the *Efftick*, the less liquid is the FX rate. Being an estimator of effective spread, the *Efftick* is directly linked to liquidity. We compute the monthly *Efftick* estimates from daily mid prices.

Our eighth low-frequency liquidity measure is the *LOT* effective spread estimator from Lesmond, Ogden, and Trzcinka (1999). The approach is based on the assumption that the security with higher transaction costs has less frequent price movements and more zero returns than a security with lower transaction costs. Following the setting of the LOT model, we assume that the observable "true return" r_{jt}^* of FX rate j on day t is given by

$$r_{jt}^* = \beta_j r_{mt} + e_{jt}, \tag{15}$$

where β_j is the sensitivity of FX rate j to the market return r_{mt} on day t and e_{jt} is a public information shock on day t. The shock e_{jt} is normally distributed with mean zero and standard deviation σ_j. We use the Fed effective exchange rate as the proxy for a market return in the LOT model. Alternatively, we use the average exchange rate return across the nine exchange rates as the market return in the LOT model. The resulting LOT estimates have lower correlations with the effective cost benchmark.

Let $\alpha_{1j} \leqslant 0$ be the percent transaction cost of selling FX rate j and $\alpha_{2j} \geqslant 0$ be the percent transaction cost of buying FX rate j. Then the observed return r_{jt} on FX rate j

is given by

$$\begin{cases} r_{jt} = r^*_{jt} - \alpha_{1j}, & r^*_{jt} < \alpha_{1j} \\ r_{jt} = r^*_{jt}, & \alpha_{1j} < r^*_{jt} < \alpha_{2j} \\ r_{jt} = r^*_{jt} - \alpha_{2j}, & \alpha_{2j} < r^*_{jt}. \end{cases} \tag{16}$$

The *LOT* liquidity measure is the difference between the percent buying cost and the percent selling cost

$$LOT = \alpha_{2j} - \alpha_{1j}. \tag{17}$$

Lesmond, Ogden, and Trzcinka (1999) develop the following maximum likelihood estimator of the model's parameters

$$\begin{aligned} L(\alpha_{1j}, \alpha_{2j}, \beta_j, \sigma_j | r_{jt}, r_{mt}) = & \prod_1 \frac{1}{\sigma_j} \phi \left[\frac{r_{jt} + \alpha_{1j} - \beta_j r_{mt}}{\sigma_j} \right] \\ & \times \prod_0 \left[\Phi \left(\frac{\alpha_{2j} - \beta_j r_{mt}}{\sigma_j} \right) - \Phi \left(\frac{\alpha_{1j} - \beta_j r_{mt}}{\sigma_j} \right) \right] \\ & \times \prod_2 \frac{1}{\sigma_j} \phi \left[\frac{r_{jt} + \alpha_{2j} - \beta_j r_{mt}}{\sigma_j} \right] \\ & s.t.\ \alpha_{1j} \leqslant 0, \alpha_{2j} \geqslant 0, \beta_j \geq 0, \sigma_j \geq 0, \end{aligned} \tag{18}$$

where $\phi()$ is the standard normal and $\Phi()$ is the cumulative normal distribution. Following Lesmond, Ogden, and Trzcinka (1999), we define the three regions over which the estimation is done. Region 0 is $r_{jt} = 0$, region 1 is $r_{jt} > 0$ and region 2 is $r_{jt} < 0$.

We compute the LOT effective cost estimate for each month using the daily mid prices and the daily effective exchange rate prices. The higher is the *LOT*, the lower is the FX rate liquidity. We are very grateful to David Lesmond for providing us with the code for computing the LOT measure.

As a robustness check, we extended the set of LF liquidity measures to three price impact proxies, namely the liquidity measures proposed by Amihud (2002), Pàstor and Stambaugh (2003) and the so-called Amivest proxy from Cooper, Groth, and Avera (1985) and Amihud, Mendelson, and Lauterbach (1997). These proxies require trading volume data, which are available only from January 2007. We decided to exclude these proxies from the main analysis (above) since they are not helpful in building LF proxies for a long sample period.

The *Amihud* proxy proposed by Amihud (2002) measures the absolute price changes

per unit of dollar volume

$$Amihud = \frac{|\, r_t|}{v_t}, \tag{19}$$

where r_t is the currency return on day t and v_t is the dollar volume on day t. We use the daily volume data from Thomson Reuters that is available for all nine currencies from 17 January 2007. Thus, we use 11 daily observations to compute the monthly Amihud estimates for January 2007.

The higher is the *Amihud*, the less liquid is the FX rate (larger price impact). We get the monthly *Amihud* estimates by averaging the daily *Amihud* estimates over the month.

Pàstor and Stambaugh (2003) introduce price impact measure called gamma (γ), which is estimated from the regression

$$r^e_{t+1} = \theta + \phi r_t + \gamma \,\text{sign}(r^e_t) v_t + \varepsilon_t, \tag{20}$$

where r_t is the daily log currency return; r^e_t is the daily excess currency return on day t, computed as $r^e_{t+1} \approx f_t - s_{t+1}$, where f_t is the log forward rate at day t and s_{t+1} is the spot rate at day $t+1$; $\text{sign}(r^e_t)$ is one if r^e_t is positive, and zero otherwise. Since daily excess currency returns are almost perfectly (above 0.99) correlated with the daily log currency returns, we use the latter in the regression. We estimate the regression for each month to get monthly γ (*Pastor-Stambaugh*) estimates. The gamma measure should have a negative sign. The larger is the γ in absolute terms, the lower is liquidity (larger price impact).

The *Amivest* proxy is a measure of price impact, used by Cooper, Groth, and Avera (1985) and Amihud, Mendelson, and Lauterbach (1997), and others. The *Amivest* proxy is defined as

$$Amivest = \frac{v_t}{|\, r_t|} \tag{21}$$

and calculated over all non-zero-return days. The larger is the *Amivest*, the higher is liquidity (lower price impact).

3 Additional Figures and Tables

In this section we show some further tables and figures from the paper "Understanding FX Liquidity" by Karnaukh, Ranaldo, and Söderlind.

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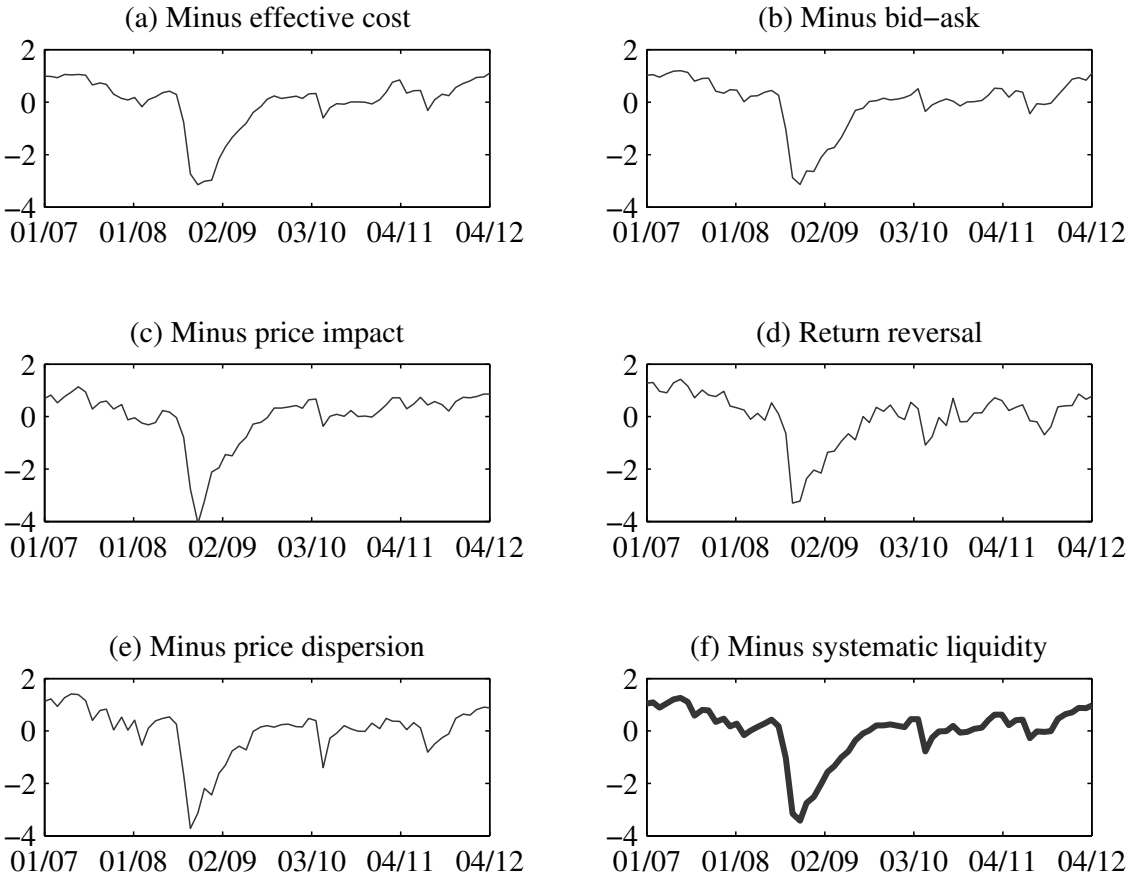

Figure 1 **Across-currencies and systematic high-frequency (HF) liquidity.**
Panels (a)–(e) depict the monthly standardized across-currencies HF liquidity based on the PCA (within measures) across individual FX rate liquidities. Systematic HF liquidity depicted in Panel (f) is obtained from the PCA across exchange rates as well as across liquidity measures. The sign of each liquidity measure is adjusted such that the measure represents liquidity rather than illiquidity: Minus price impact (Panel (a)), Return reversal (Panel (b)), Minus bid-ask (Panel (c)), Minus effective cost (Panel (d)), Minus price dispersion (Panel(e)), Minus systematic liquidity (Panel (f)). The sample is January 2007 – May 2012.

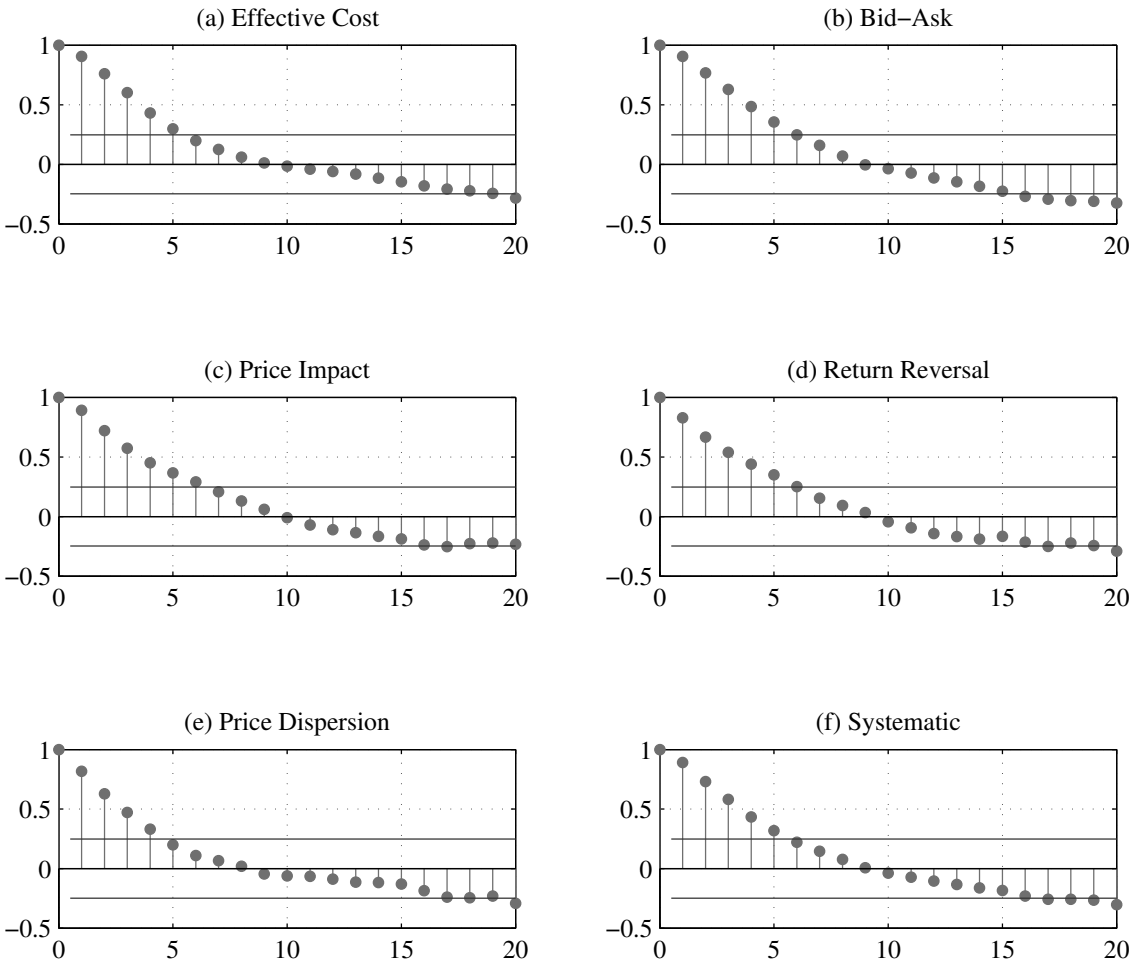

Figure 2 **Autocorrelations of monthly systematic FX high-frequency liquidity.**
Panels (a)–(e) depict autocorrelations (up to 20 lags) for the monthly across-currencies HF liquidity based on the PCA (within measures) across individual FX rate liquidities. Panel (f) depicts the autocorrelation of the systematic HF liquidity, which is obtained from the PCA across exchange rates as well as across five HF liquidity measures. The solid horizontal lines indicate upper and lower 95% confidence bounds. The sample is January 2007 – May 2012.

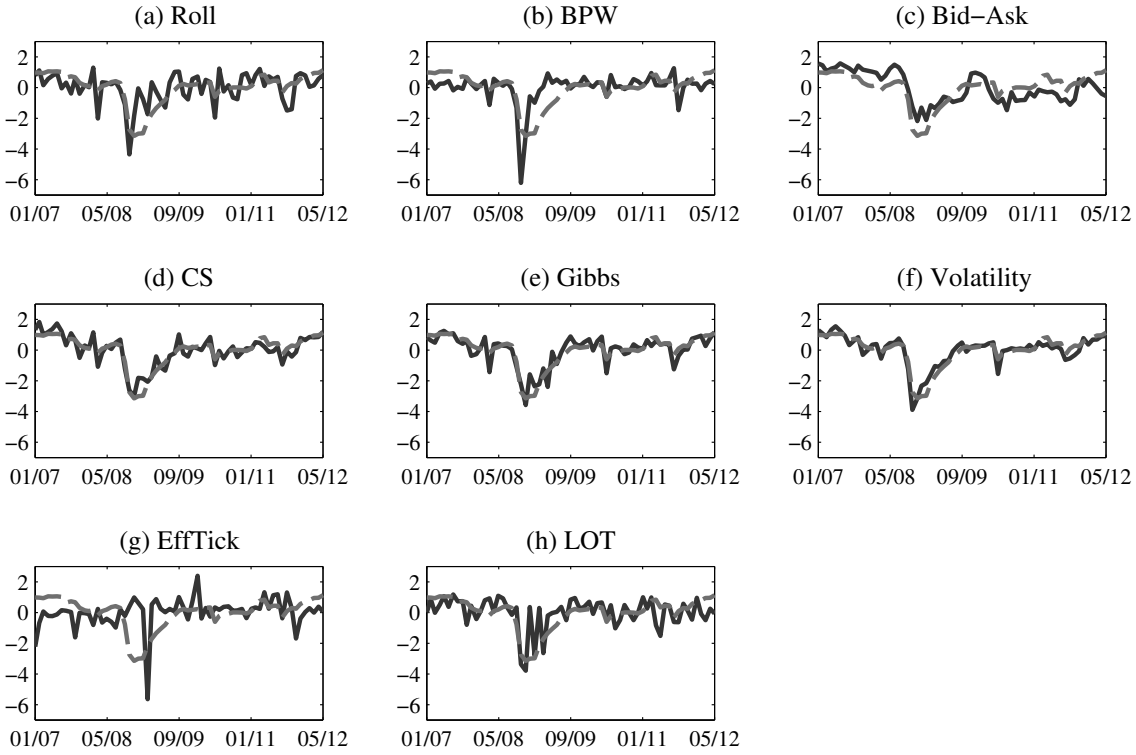

Figure 3 **Across-currencies low-frequency (LF) liquidity vs across-currencies effective cost.** Panels (a)–(h) depict monthly standardized across-currencies LF liquidity based on the PCA (within measures) across individual FX rate liquidities. The standardized across-currencies effective cost liquidity is dotted. The sign of each liquidity measure is adjusted such that the measure represents liquidity rather than illiquidity. The sample is January 2007 – May 2012.

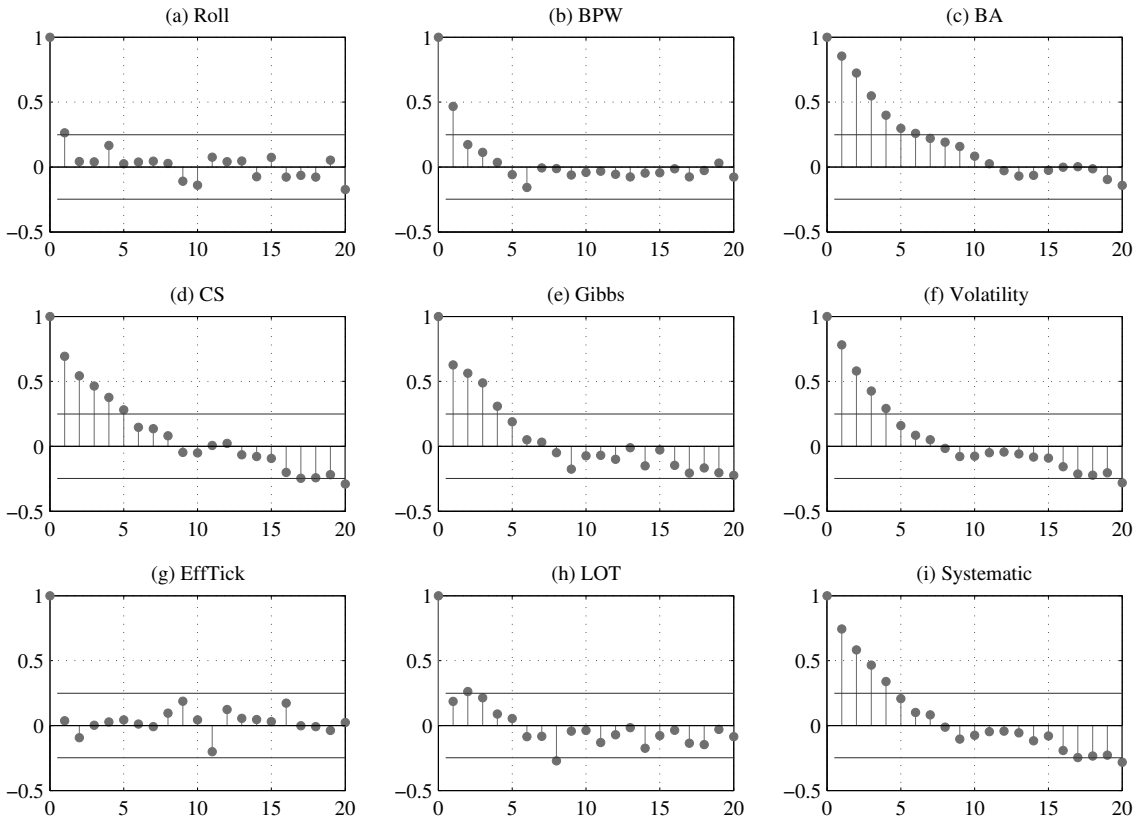

Figure 4 **Autocorrelations of the monthly low-frequency (LF) liquidities.**
Panels (a)–(h) depict autocorrelations (up to 20 lags) of the monthly across-currencies LF liquidities based on the PCA (within measures) across individual FX rate liquidities. Panel (i) depicts the autocorrelation of the systematic LF liquidity, which is obtained from the PCA across exchange rates as well as across three "best" LF liquidity measures (*CS*, *Gibbs* and *Volatility*). The solid horizontal lines indicate upper and lower 95% confidence bounds. The sample is January 2007 – May 2012.

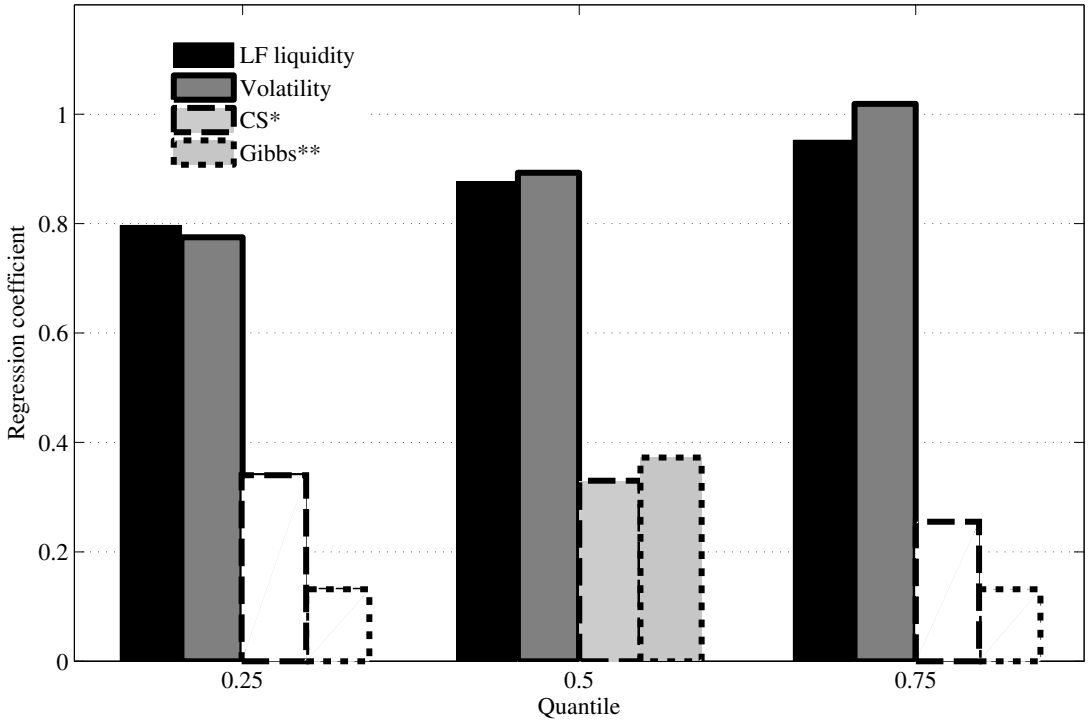

Figure 5 **Beta coefficients in the quantile regressions of the EC on the LF measures.**
For each quantile (0.25, 0.5, 0.75), we run three quantile regressions of the across-currencies effective cost on (1) systematic LF liquidity (first PC across the FX rates and the three best LF measures), (2) across-currencies *Volatility*, (3) across-currencies *Volatility*, *CS** and *Gibbs***. Four bars represent the beta coefficients in these quantile regressions, from left to right: coefficient of the systematic LF liquidity in the regression (1), coefficient of the *Volatility* in the regression (2), coefficient of the *CS** in the regression (3), coefficient of the *Gibbs*** in the regression (3). The bars representing insignificant beta coefficients are filled with white. * denotes the second factor in the rotation [Volatility, CS, Gibbs]. ** denotes the third factor in the rotation [Volatility, CS, Gibbs]. The sample is January 2007 – May 2012, 65 months.

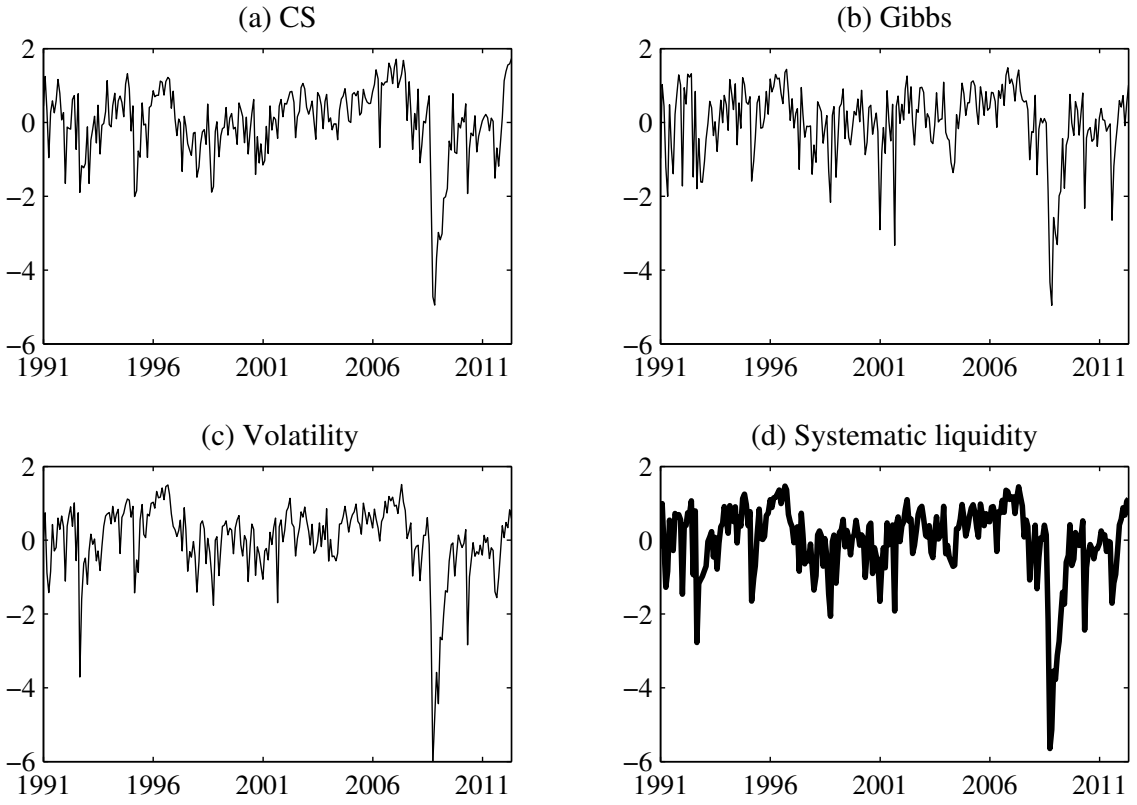

Figure 6 **Across-currencies and systematic low-frequency (LF) FX liquidity over 1991-2012.** Panels (a)–(c) depict the monthly standardized across-currencies LF liquidity obtained from the PCA (within measures) across the forty exchange rates. Panel (d) depicts the systematic LF liquidity obtained from the PCA across the 40 exchange rates as well as the three "best" LF liquidity measures (*CS*, *Gibbs* and *Volatility*). The sign of each liquidity measure is adjusted such that the measure represents liquidity rather than illiquidity. The sample is January 1991 – May 2012, 257 months.

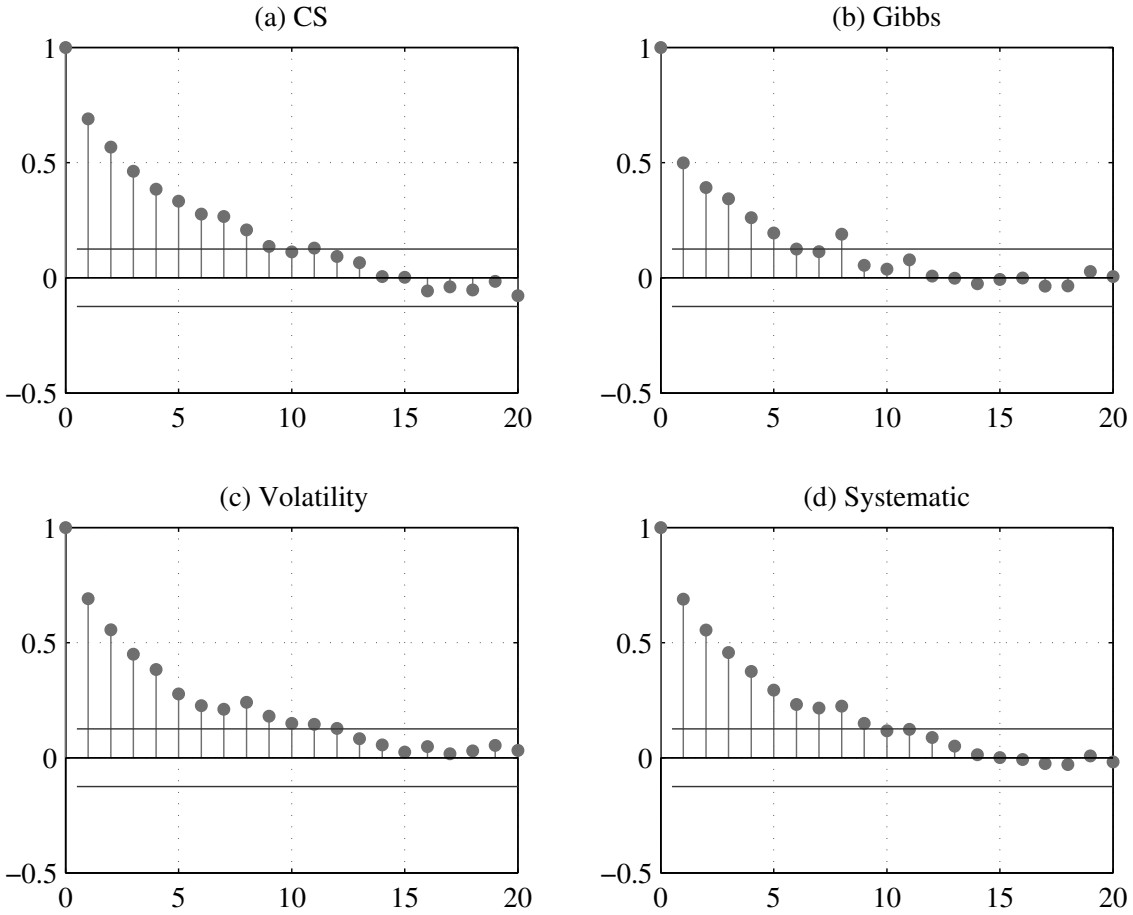

Figure 7 **Autocorrelations of the monthly low-frequency (LF) liquidities over 1991-2012.** Panels (a)–(c) depict autocorrelations (up to 20 lags) of the monthly "best" across-currencies LF liquidities (*CS*, *Gibbs* and *Volatility*) based on the PCA (within measures) across individual FX rate liquidities. Panel (i) depicts the autocorrelation of the systematic LF liquidity, which is obtained from the PCA across forty exchange rates as well as across the three "best" LF liquidity measures (*CS*, *Gibbs* and *Volatility*). The solid horizontal lines indicate upper and lower 95% confidence bounds. The sample is January 1991 – May 2012.

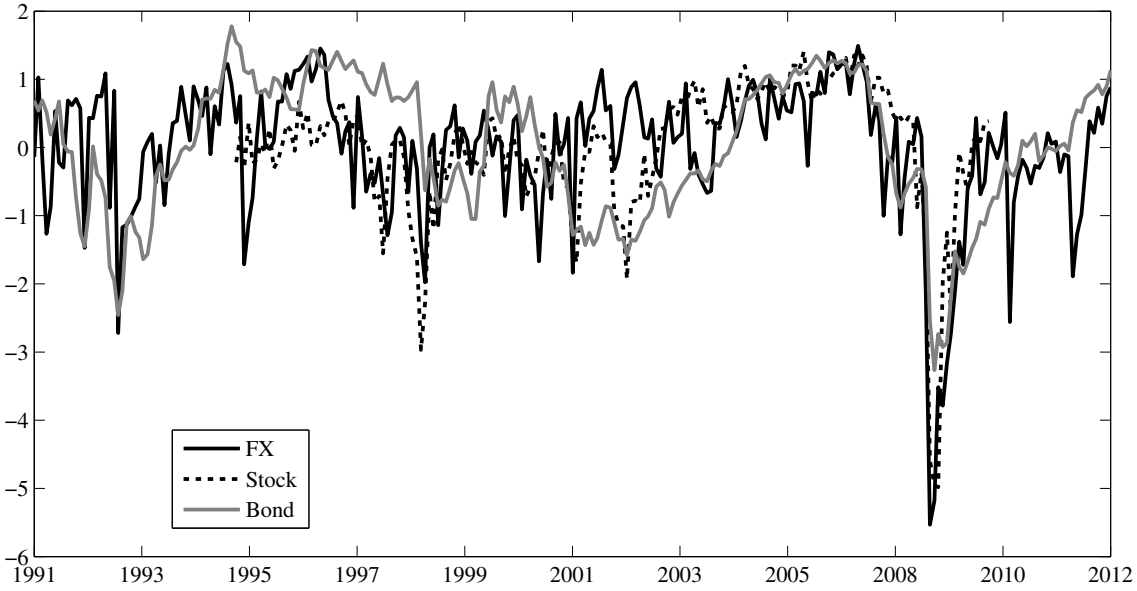

Figure 8 **Liquidity in FX, stock, and bond markets.**
The figure depicts systematic liquidity on the FX market (obtained from the PCA across 40 exchange rates and three best LF liquidity measures), stock market (Amihud measure), and bond market (on-off-the run 10-year spread). All measures are standardized. The full sample is January 1991 – May 2012, the stock market liquidity is from January 1995 to December 2009.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
					Effective cost (in bps)				
Mean	1.119	0.388	0.760	0.460	0.292	0.693	1.074	0.473	0.401
Std. dev.	0.652	0.125	0.260	0.132	0.053	0.381	0.406	0.094	0.091
					Bid-ask spread (in bps)				
Mean	4.693	2.331	4.019	2.418	1.057	4.480	6.050	2.539	1.501
Std. dev.	2.982	1.015	1.645	0.717	0.227	3.603	3.328	0.812	0.364
					Price impact				
Mean	0.804	0.128	0.432	0.242	0.070	0.383	0.689	0.172	0.099
Std. dev.	0.533	0.068	0.175	0.113	0.029	0.199	0.248	0.061	0.041
					Return reversal (K=5)				
Mean	-0.153	-0.024	-0.092	-0.053	-0.013	-0.093	-0.131	-0.024	-0.020
Std. dev.	0.117	0.015	0.044	0.025	0.005	0.059	0.066	0.013	0.009
					Price dispersion (TSRV, five minutes, in %, annualized)				
Mean	15.00	6.87	8.70	13.26	9.89	11.18	11.91	10.87	10.23
Std. dev.	7.84	4.01	3.36	6.06	3.64	6.09	4.28	3.49	3.83

Table 1 **Monthly liquidity measures from high-frequency (HF) data.**
The table shows summary statistics for FX liquidity measures computed from one-min data. Effective cost spread denotes the monthly average of daily effective cost estimates. The effective cost is measured as in Equation (1), in bps. Bid-ask spread denotes the monthly average of daily proportional bid-ask spreads. The proportional bid-ask spread is measured as in Equation (2), in bps. Price impact is monthly average of daily estimated coefficients of contemporaneous order flow in a regression of one-minute returns on the contemporaneous and lagged order flow (Equation (3)). Return reversal is monthly average of daily sum of estimated coefficients of lagged order flow (1-5 lags) in the same regression. Price dispersion is estimated using two-scale realized volatility (TSRV). It is expressed in a percentage on an annual basis. The sample covers 65 months, January 2007 – May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
					Roll spread (in %)				
Mean	0.70	0.25	0.24	0.53	0.32	0.30	0.36	0.43	0.41
Std. dev.	0.88	0.32	0.28	0.57	0.38	0.30	0.40	0.45	0.47
					BPW measure (in bps)				
Mean	0.28	0.03	-0.01	0.12	0.03	0.01	0.05	0.05	0.07
Std. dev.	1.21	0.12	0.16	0.31	0.15	0.13	0.15	0.22	0.22
					Bid-ask spread (in bps)				
Mean	4.60	7.37	4.80	6.14	2.38	2.42	4.16	4.91	3.68
Std. dev.	0.87	1.76	0.83	0.96	0.45	0.44	0.39	1.45	0.67
					CS measure (in %)				
Mean	0.19	0.11	0.13	0.19	0.14	0.14	0.15	0.17	0.15
Std. dev.	0.26	0.14	0.09	0.22	0.15	0.12	0.13	0.15	0.15
					Gibbs measure (in %)				
Mean	0.37	0.17	0.19	0.33	0.26	0.24	0.26	0.27	0.25
Std. dev.	0.26	0.14	0.09	0.22	0.15	0.12	0.13	0.15	0.15
					Volatility (in %, annualized)				
Mean	2.76	1.25	1.59	2.45	1.91	1.80	1.98	1.99	1.89
Std. dev.	1.74	0.91	0.71	1.26	0.75	0.83	0.86	0.74	0.81
					EffTick measure (in bps)				
Mean	1.88	1.14	1.64	1.31	1.12	1.04	1.82	1.49	0.45
Std. dev.	1.08	0.95	1.13	1.36	0.68	0.91	1.45	1.20	0.76
					LOT measure (in %)				
Mean	0.48	0.18	0.27	0.40	0.36	0.31	0.34	0.35	0.30
Std. dev.	0.53	0.23	0.26	0.40	0.32	0.35	0.29	0.30	0.29

Table 2 **Monthly liquidity measures from low-frequency data.**
The table shows summary statistics for various low-frequency measures of liquidity. The *Roll* measure (from Roll (1984)) is computed as the square root of negative consecutive price changes autocovariance, if the autocovariance is positive, and zero, otherwise. The *BPW* measure (from Bao, Pan, and Wang (2011) is computed as minus autocovariance of consecutive price changes. Bid-ask (*BA*) is the average over daily relative bid-ask estimates. The *CS* measure is computed as in Corwin and Schultz (2012). The *Gibbs* measure is computed as in Hasbrouck (2009). The *Volatility* is computed as in Menkhoff, Sarno, Schmeling, and Schrimpf (2012). The *EffTick* measure is computed as in Holden (2009). The *LOT* measure is computed as in Lesmond, Ogden, and Trzcinka (1999). The sample covers 65 months, January 2007 – May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
					Amihud				
Mean	16.18	9.57	11.52	12.67	7.90	9.53	16.95	10.87	8.26
Std. dev.	10.28	6.07	5.82	6.64	4.10	6.26	12.80	4.17	3.54
					Amivest				
Mean	27.60	62.35	35.28	37.08	57.84	48.79	27.55	38.10	54.89
Std. dev.	25.40	60.20	23.01	30.18	46.97	44.50	19.36	25.88	40.95
					Pastor-Stambaugh				
Mean	-0.42	-7.87	-7.58	-5.21	-2.80	-4.49	-5.35	-4.52	-3.14
Std. dev.	16.89	18.55	17.14	13.81	9.75	13.94	22.46	11.50	11.01

Table 3 **Monthly quote-based liquidity measures from low-frequency data.**
This table shows summary statistics for monthly quote-based low-frequency (LF) measures of liquidity. The volume-based LF measures are: *Amihud* from Amihud (2002), *Amivest* from Cooper, Groth, and Avera (1985) and Amihud, Mendelson, and Lauterbach (1997), and *Pastor-Stambaugh* from Pàstor and Stambaugh (2003). *Amihud* and *Pastor-Stambaugh* measures are multiplied by 100,000,000. *Amivest* measures are divided by 1,000,000. The sample covers 65 months, January 2007 - May 2012.

	EC	BA	PI	RR	PD
Effective cost	**1**				
Bid-ask	**0.985**	**1**			
Price impact	**0.963**	**0.946**	**1**		
Return reversal	**-0.939**	**-0.951**	**-0.917**	**1**	
Price dispersion	**0.940**	**0.947**	**0.898**	**-0.937**	**1**

Table 4 **Correlations between the across-currencies high-frequency (HF) liquidity measures.** The table shows correlations between the across-currencies effective cost (*EC*), bid-ask spread (*BA*), price impact (*PI*), return reversal (*RR*), and price dispersion (*PD*). The across-currencies *EC*, *BA*, *PI*, *RR*, and *PD* are computed from the PCA (within measures) across individual FX rate liquidities. Bold numbers are statistically significant at the 5% level. The significance test is the GMM based test using a Newey and West (1987) covariance estimator with 4 lags. Correlations are computed using 65 non-overlapping monthly observations. The sample is January 2007 – May 2012.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Roll	**1**							
BPW	**0.748**	**1**						
BA	**0.381**	**0.311**	**1**					
CS	**0.708**	**0.537**	**0.659**	**1**				
Gibbs	**0.715**	**0.541**	**0.594**	**0.876**	**1**			
Volatility	**0.747**	**0.694**	**0.669**	**0.924**	**0.912**	**1**		
EffTick	0.025	**-0.127**	**-0.237**	-0.006	**0.056**	**-0.072**	**1**	
LOT	**0.425**	**0.578**	**0.521**	**0.595**	**0.591**	**0.624**	**-0.120**	**1**

Table 5 **Correlations between the across-currencies low-frequency (LF) liquidity measures.** The table shows correlations between across-currencies LF liquidity measures for the FX market. The LF liquidity measures are: *Roll* from Roll (1984), *BPW* from Bao, Pan, and Wang (2011), *BA* is the relative bid-ask spread, *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are obtained from the PCA (within measures) across individual FX rate liquidites. Bold numbers are statistically significant at the 5% level. The significance test is the GMM based test using a Newey and West (1987) covariance estimator with 4 lags. Correlations are computed using 65 non-overlapping monthly observations. The sample is January 2007 – May 2012, 65 months.

	EBS BA	EBS EC	EBS BA 22:00 GMT	EBS BA 16:00 GMT	TR 22:00 GMT	WMR 16:00 GMT
Panel A. Mean correlations						
EBS BA	1.00					
EBS EC	0.82	1.00				
EBS BA 22:00 GMT	0.41	0.43	1.00			
EBS BA 16:00 GMT	0.59	0.63	0.28	1.00		
TR 22:00 GMT	0.25	0.26	0.13	0.19	1.00	
WMR 16:00 GMT	0.19	0.16	0.03	0.19	0.17	1.00
Panel B. Min correlations						
EBS BA	1.00					
EBS EC	0.59	1.00				
EBS BA 22:00 GMT	0.25	0.27	1.00			
EBS BA 16:00 GMT	0.33	0.37	0.11	1.00		
TR 22:00 GMT	0.05	0.06	0.02	0.03	1.00	
WMR 16:00 GMT	-0.18	-0.24	-0.19	-0.19	0.03	1.00
Panel C. Max correlations						
EBS BA	1.00					
EBS EC	0.95	1.00				
EBS BA 22:00 GMT	0.77	0.69	1.00			
EBS BA 16:00 GMT	0.77	0.78	0.56	1.00		
TR 22:00 GMT	0.35	0.41	0.27	0.33	1.00	
WMR 16:00 GMT	0.46	0.52	0.33	0.44	0.26	1.00

Table 6 **Correlation matrix between daily quotes from EBS, TR and WMR.**
This table shows the correlations between the daily mean EBS bid-asks (BA), EBS effective cost (EC), EBS bid-ask snap at 22:00 GMT (17:00 EST), EBS bid-ask snap at 16:00 GMT, Thomson Reuters (TR) bid-ask collected at 22:00 GMT (17:00 EST), and WM/Reuters (WMR) bid-ask collected at 16:00 GMT. Panel A shows the mean correlation across 9 FX rates, Panel B shows the minimum correlation across 9 FX rates, Panel C shows the maximum correlation across 9 FX rates. The sample is January 1991 – May 2012, 1325 days.

	EBS BA	EBS EC	EBS BA 22:00 GMT	EBS BA 16:00 GMT	TR 22:00 GMT	WMR 16:00 GMT
Panel A. Mean correlations						
EBS BA	1.00					
EBS EC	0.93	1.00				
EBS BA 22:00 GMT	0.68	0.71	1.00			
EBS BA 16:00 GMT	0.90	0.90	0.60	1.00		
TR 22:00 GMT	0.55	0.55	0.39	0.57	1.00	
WMR 16:00 GMT	0.24	0.20	0.02	0.31	0.48	1.00
Panel B. Min correlations						
EBS BA	1.00					
EBS EC	0.89	1.00				
EBS BA 22:00 GMT	0.43	0.48	1.00			
EBS BA 16:00 GMT	0.81	0.83	0.25	1.00		
TR 22:00 GMT	0.21	0.25	0.04	0.17	1.00	
WMR 16:00 GMT	-0.42	-0.47	-0.55	-0.44	0.05	1.00
Panel C. Max correlations						
EBS BA	1.00					
EBS EC	0.97	1.00				
EBS BA 22:00 GMT	0.96	0.94	1.00			
EBS BA 16:00 GMT	0.98	0.97	0.85	1.00		
TR 22:00 GMT	0.77	0.75	0.73	0.76	1.00	
WMR 16:00 GMT	0.63	0.68	0.59	0.68	0.64	1.00

Table 7 **Correlation matrix between monthly average quotes from EBS, TR and WMR.**
This table shows the correlations between the monthly averages of mean EBS bid-asks (BA), EBS effective cost (EC), EBS bid-ask snap at 22:00 GMT (17:00 EST), EBS bid-ask snap at 16:00 GMT, Thomson Reuters (TR) bid-ask collected at 22:00 GMT (17:00 EST), and WM/Reuters (WMR) bid-ask collected at 16:00 GMT. Panel A shows the mean correlation across 9 FX rates, Panel B shows the minimum correlation across 9 FX rates, Panel C shows the maximum correlation across 9 FX rates. The sample is January 1991 – May 2012, 65 months.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Panel A. Whole sample (Jan 2007 - May 2012), 65 months								
	0.584	**0.555**	**0.663**	**0.896**	**0.890**	**0.930**	0.023	**0.612**
Idf	BPW	Roll	Roll	Gibbs	CS	CS	*	Roll
	BA	BA	BPW	Volatility	Volatility	Gibbs		BPW
	LOT	LOT	LOT					BA
Panel B. Pre-crisis (Jan 2007 - Jun 2008), 18 months								
	0.493	**0.282**	**0.704**	**0.838**	**0.761**	**0.887**	**-0.156**	**0.066**
Idf	BPW	Roll	Roll	BA	BA	BA	BPW	Roll
	BA	Efftick	CS	Gibbs	CS	CS	LOT	BPW
	LOT	LOT	Gibbs	Volatility	Gibbs	Gibbs		EffTick
			Volatility			Volatility		
Panel C. Financial crisis (Jul 2008 - Dec 2009), 18 months								
	0.568	**0.591**	**0.818**	**0.902**	**0.900**	**0.935**	**0.072**	**0.702**
Idf	BPW	Roll	BPW	BA	BA	BA	*	BA
	BA	BA	BA	Gibbs	CS	CS		
			CS	Volatility	Volatility	Gibbs		
			Gibbs					
			Volatility					
			LOT					
Panel D. European sovereign debt crisis (Jan 2010 - May 2012), 29 months								
	0.445	**0.110**	**0.390**	**0.826**	**0.763**	**0.783**	**0.086**	**0.139**
Idf	BA	BA	Roll	Gibbs	CS	CS	BPW	BPW
		EffTick	BPW	Volatility	Volatility	Gibbs	BA	BA
		LOT	EffTick				LOT	EffTick
			LOT					

Table 8 **Correlations between the across-currencies LF liquidities and the EC (extended).** The table shows times-series correlations of the across-currencies LF liquidities with the across-currencies effective cost over the whole period (Panel A) and over three subperiods: pre-crisis, January 2007 – June 2008 (Panel B), financial crisis, July 2008 – December 2009 (Panel C) and European sovereign debt crisis, January 2010 – May 2012 (Panel D). The monthly low-frequency spread proxies are: *Roll* from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are based on PCA (within measures) across the individual FX rate liquidites. Bold numbers are statistically significant at the 5% level. * means that the correlation is statistically significantly different at the 5% level from all other correlations in the same row. Both significance tests are the GMM based tests using a Newey and West (1987) covariance estimator with 4 lags. **Idf stands for insignificantly different from. The sample covers 65 months, January 2007 – May 2012.

	Amihud	Amivest	Pastor-Stambaugh
AUD/USD	**0.892**	**-0.321**	0.028
EUR/CHF	**0.537**	**-0.481**	**0.046**
EUR/GBP	**0.540**	**-0.193**	**-0.070**
EUR/JPY	**0.458**	0.012	**-0.114**
EUR/USD	**0.866**	**-0.457**	**-0.075**
GBP/USD	**0.906**	**-0.351**	**-0.186**
USD/CAD	**0.748**	**-0.503**	**-0.164**
USD/CHF	**0.340**	**-0.186**	**0.087**
USD/JPY	**0.765**	**-0.399**	**-0.227**
Average	0.673	-0.320	-0.075

Table 9 **Correlations between the volume-based FX rate low-frequency and effective cost liquidity.**
The table shows the time-series correlations of the three volume-based low-frequency measures for each exchange rate with the effective cost measure for the same exchange rate. Effective cost denotes the monthly average of daily effective cost estimates. The monthly volume-based low-frequency proxies are: *Amihud* from Amihud (2002), *Amivest* from Cooper, Groth, and Avera (1985) and Amihud, Mendelson, and Lauterbach (1997), and *Pastor-Stambaugh* from Pàstor and Stambaugh (2003). Bold numbers are statistically significant at the 5% level. The sample covers 65 months, January 2007 - May 2012.

AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012), 65 months								
0.877	**0.855**	**0.825**	**0.765**	**0.672**	**0.908**	**0.731**	**0.869**	**0.768**
Pre-crisis (Jan 2007 - Jun 2008), 18 months								
0.720	**0.813**	**0.693**	**0.590**	**-0.407**	**0.846**	**0.535**	**0.891**	**0.753**
Financial crisis (Jul 2008 - Dec 2009), 18 months								
0.900	**0.903**	**0.892**	**0.856**	**0.909**	**0.938**	**0.733**	**0.888**	**0.807**
European sovereign debt crisis (Jan 2010 - May 2012), 29 months								
0.393	**0.867**	**0.613**	**0.531**	**0.341**	**0.742**	**0.334**	**0.818**	**0.450**

Table 10 **Correlation between the across-measures LF liquidity and the EC.**
The table shows times-series correlations of the across-measures low-frequency (LF) liquidity with the effective cost for each FX rate over the whole period and over three subperiods: pre-crisis, January 2007 – June 2008, financial crisis, July 2008 – December 2009 and European sovereign debt crisis, January 2010 – May 2012. The across-measures liquidity is based on the PCA (within FX rates) across the best LF liquidity measures. Bold numbers are statistically significant at the 5% level (GMM based tests using a Newey and West (1987) covariance estimator with 4 lags). The sample covers 65 months, January 2007 - May 2012.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
				Bid-ask spread				
AUD/USD	**0.685**	**0.613**	**0.489**	**0.862**	**0.808**	**0.865**	**0.093**	**0.635**
EUR/CHF	**0.440**	**0.200**	**0.617**	**0.773**	**0.747**	**0.810**	**0.157**	**0.402**
EUR/GBP	**0.180**	**-0.236**	**0.604**	**0.696**	**0.546**	**0.736**	**0.189**	**0.173**
EUR/JPY	**0.462**	**0.443**	**0.774**	**0.650**	**0.630**	**0.678**	**0.041**	**0.334**
EUR/USD	**0.303**	**0.120**	**0.640**	**0.682**	**0.678**	**0.860**	**-0.163**	**0.303**
GBP/USD	**0.143**	**-0.207**	**0.653**	**0.656**	**0.747**	**0.786**	**-0.085**	**0.289**
USD/CAD	0.019	-0.065	**0.211**	**0.628**	**0.615**	**0.753**	**0.018**	**0.146**
USD/CHF	**0.298**	**0.065**	**0.470**	**0.601**	**0.716**	**0.866**	-0.013	**0.292**
USD/JPY	**0.323**	**0.307**	**0.450**	**0.684**	**0.574**	**0.695**	**-0.411**	**0.170**
Average	0.317	0.138	0.545	0.692	0.673	0.783	-0.019	0.305
				Price impact				
AUD/USD	**0.650**	**0.616**	**0.459**	**0.776**	**0.744**	**0.791**	**0.047**	**0.579**
EUR/CHF	**0.404**	**0.174**	**0.439**	**0.693**	**0.687**	**0.797**	**0.111**	**0.310**
EUR/GBP	**0.187**	**-0.190**	**0.453**	**0.615**	**0.558**	**0.717**	**0.042**	**0.220**
EUR/JPY	**0.688**	**0.715**	**0.499**	**0.705**	**0.755**	**0.842**	**-0.020**	**0.403**
EUR/USD	**0.256**	**0.073**	**0.599**	**0.697**	**0.730**	**0.892**	**-0.088**	**0.238**
GBP/USD	0.065	**-0.338**	**0.624**	**0.710**	**0.759**	**0.822**	**-0.142**	**0.358**
USD/CAD	-0.023	**0.053**	**0.236**	**0.430**	**0.475**	**0.491**	**0.074**	**-0.045**
USD/CHF	**0.163**	**0.043**	**0.175**	**0.447**	**0.530**	**0.542**	0.015	**-0.037**
USD/JPY	**0.457**	**0.460**	**0.486**	**0.788**	**0.714**	**0.805**	**-0.268**	**0.198**
Average	0.316	0.178	0.441	0.651	0.661	0.744	-0.025	0.247
				Return reversal				
AUD/USD	**-0.718**	**-0.708**	**-0.372**	**-0.825**	**-0.801**	**-0.888**	**-0.153**	**-0.749**
EUR/CHF	**-0.351**	**-0.163**	**-0.382**	**-0.616**	**-0.529**	**-0.613**	**-0.084**	**-0.351**
EUR/GBP	**-0.100**	**0.186**	**-0.473**	**-0.563**	**-0.365**	**-0.558**	**0.066**	**-0.092**
EUR/JPY	**-0.457**	**-0.485**	**-0.630**	**-0.633**	**-0.633**	**-0.678**	**-0.050**	**-0.388**
EUR/USD	**-0.347**	**-0.228**	**-0.602**	**-0.699**	**-0.642**	**-0.783**	**0.104**	**-0.198**
GBP/USD	**-0.182**	**0.225**	**-0.655**	**-0.712**	**-0.723**	**-0.734**	**0.053**	**-0.271**
USD/CAD	**0.120**	**0.128**	**-0.087**	**-0.252**	**-0.364**	**-0.467**	-0.025	**-0.028**
USD/CHF	**-0.241**	**-0.197**	**-0.104**	**-0.332**	**-0.417**	**-0.255**	**0.063**	**-0.062**
USD/JPY	**-0.499**	**-0.489**	**-0.380**	**-0.731**	**-0.679**	**-0.770**	**0.184**	**-0.243**
Average	-0.308	-0.192	-0.409	-0.596	-0.572	-0.638	0.018	-0.265
				Price dispersion				
AUD/USD	**0.757**	**0.683**	**0.471**	**0.893**	**0.890**	**0.969**	**0.176**	**0.709**
EUR/CHF	**0.453**	**0.158**	**0.576**	**0.850**	**0.890**	**0.966**	**0.269**	**0.468**
EUR/GBP	**0.060**	**-0.470**	**0.742**	**0.808**	**0.663**	**0.921**	0.019	**0.151**
EUR/JPY	**0.756**	**0.779**	**0.593**	**0.790**	**0.838**	**0.939**	**-0.069**	**0.410**
EUR/USD	**0.341**	**0.160**	**0.606**	**0.761**	**0.722**	**0.965**	**-0.077**	**0.261**
GBP/USD	-0.074	**-0.576**	**0.709**	**0.795**	**0.722**	**0.941**	**-0.062**	**0.302**
USD/CAD	**0.123**	0.009	**0.135**	**0.719**	**0.737**	**0.891**	**0.084**	**0.231**
USD/CHF	**0.397**	**0.143**	**0.465**	**0.642**	**0.778**	**0.905**	0.005	**0.389**
USD/JPY	**0.628**	**0.606**	**0.509**	**0.863**	**0.801**	**0.944**	**-0.138**	**0.258**
Average	0.382	0.166	0.534	0.791	0.782	0.938	0.023	0.353

Table 11 **Correlations of the FX rate LF and (alternative to effective cost) HF liquidity measures.**

The table shows the time-series correlations of the eight low-frequency liquidity measures for each exchange rate with the (alternative to effective cost) high-frequency liquidity for the same exchange rate. High-frequency liquidity measures include bid-ask spread, price impact, return reversal, and price dispersion. Bid-ask spread denotes the monthly average of daily proportional bid-ask spreads. The proportional spread is measured as in Equation (2). Price impact is monthly average of daily estimated coefficients of contemporaneous order flow in a regression of one-minute returns on the contemporaneous and lagged order flow (Equation (3)). Return reversal is monthly average of daily sum of estimated coefficients of lagged and order flow (1-5 lags) in the same regression. Price dispersion is estimated using two-scale realized volatility (TSRV). The monthly low-frequency spread proxies are: *Roll* from Roll from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). Bold numbers are statistically significant at the 5% level (GMM based test using a Newey-West covariance estimator with 4 lags). The sample covers 65 months, January 2007 – May 2012.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Panel A. Whole sample (Jan 2007 - May 2012), 65 months								
Bid-ask spread	**0.595**	**0.552**	**0.702**	**0.909**	**0.888**	**0.936**	-0.010	**0.620**
Price impact	**0.553**	**0.588**	**0.570**	**0.849**	**0.857**	**0.891**	0.037	**0.597**
Return reversal	**-0.610**	**-0.590**	**-0.706**	**-0.887**	**-0.835**	**-0.922**	0.004	**-0.603**
Price dispersion	**0.719**	**0.682**	**0.689**	**0.932**	**0.901**	**0.986**	**-0.055**	**0.647**
Panel B. Pre-crisis (Jan 2007 - Jun 2008), 18 months								
Bid-ask spread	**0.511**	**0.302**	**0.676**	**0.863**	**0.774**	**0.885**	**-0.150**	0.004
Price impact	**0.408**	**0.181**	**0.717**	**0.780**	**0.603**	**0.766**	**-0.069**	-0.021
Return reversal	**-0.309**	**-0.079**	**-0.526**	**-0.728**	**-0.446**	**-0.635**	0.045	**0.102**
Price dispersion	**0.661**	**0.414**	**0.746**	**0.924**	**0.835**	**0.943**	**-0.236**	0.016
Panel C. Financial crisis (Jul 2008 - Dec 2009), 18 months								
Bid-ask spread	**0.609**	**0.613**	**0.822**	**0.911**	**0.918**	**0.950**	**0.052**	**0.715**
Price impact	**0.566**	**0.627**	**0.779**	**0.871**	**0.903**	**0.928**	0.010	**0.692**
Return reversal	**-0.671**	**-0.711**	**-0.809**	**-0.886**	**-0.894**	**-0.955**	**-0.079**	**-0.714**
Price dispersion	**0.750**	**0.806**	**0.724**	**0.913**	**0.876**	**0.988**	0.022	**0.754**
Panel D. European sovereign debt crisis (Jan 2010 - May 2012), 29 months								
Bid-ask spread	**0.457**	**0.071**	**0.324**	**0.879**	**0.769**	**0.795**	**0.090**	**0.143**
Price impact	**0.301**	**0.128**	**0.288**	**0.733**	**0.607**	**0.631**	**0.174**	**0.218**
Return reversal	**-0.471**	**-0.200**	**-0.229**	**-0.773**	**-0.625**	**-0.774**	**-0.105**	**-0.137**
Price dispersion	**0.644**	**0.224**	**0.445**	**0.886**	**0.885**	**0.972**	0.001	**0.233**

Table 12 **Correlations between the across-currencies LF liquidities and (alternative to the EC) HF liquidity measures.**
The table shows the time-series correlations of the eight across-currencies LF liquidities with the across-currencies (alternative to effective cost) HF liquidity measures over the whole period (Panel A) and over three subperiods: pre-crisis, January 2007 – June 2008 (Panel B), financial crisis, July 2008 – December 2009 (Panel C) and European sovereign debt crisis, January 2010 – May 2012 (Panel D). HF liquidity measures include bid-ask spread, price impact, return reversal, and price dispersion. Bid-ask spread denotes the monthly average of daily proportional bid-ask spreads. The proportional spread is measured as in Equation (2). Price impact is monthly average of daily estimated coefficients of contemporaneous order flow in a regression of one-minute returns on the contemporaneous and lagged order flow (Equation (3)). Return reversal is monthly average of daily sum of estimated coefficients of lagged and order flow (1-5 lags) in the same regression. Price dispersion is estimated using two-scale realized volatility (TSRV). The monthly low-frequency spread proxies are: *Roll* from Roll from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are based on PCA (within measures) across the individual FX rate liquidites. Bold numbers are statistically significant at the 5% level (GMM based test using a Newey-West covariance estimator with 4 lags). The sample covers 65 months, January 2007 – May 2012.

Prior for σ_c	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Panel A. Correlations of the Gibbs estimates with the EC									
0.00013	**-0.0624**	**0.0414**	**-0.1507**	**-0.1494**	-0.0060	**-0.1328**	**-0.0961**	**-0.0676**	-0.0183
0.00063	**-0.1439**	**0.3627**	-0.0086	**0.0805**	**-0.0522**	**-0.1374**	**-0.2114**	**-0.1156**	**0.0796**
0.00125	**-0.0824**	**0.5624**	**0.2144**	**0.2452**	**-0.0204**	-0.0022	**-0.1344**	**0.1213**	**0.2544**
0.00313	**0.3279**	**0.7303**	**0.4558**	**0.4418**	**0.3414**	**0.4649**	**0.3919**	**0.5875**	**0.5186**
0.00626	**0.6484**	**0.7851**	**0.5588**	**0.6041**	**0.5432**	**0.6685**	**0.5617**	**0.7211**	**0.6208**
0.00940	**0.7604**	**0.7892**	**0.5908**	**0.6495**	**0.5768**	**0.7101**	**0.5983**	**0.7454**	**0.6347**
0.01253	**0.7947**	**0.7925**	**0.6025**	**0.6640**	**0.5868**	**0.7280**	**0.6081**	**0.7526**	**0.6378**
0.03132	**0.8152**	**0.7903**	**0.6233**	**0.6706**	**0.6003**	**0.7492**	**0.6167**	**0.7556**	**0.6397**
0.06265	**0.8140**	**0.7901**	**0.6279**	**0.6725**	**0.6016**	**0.7515**	**0.6182**	**0.7457**	**0.6428**
0.12530	**0.8145**	**0.7900**	**0.6283**	**0.6725**	**0.6017**	**0.7522**	**0.6193**	**0.7456**	**0.6428**
1.25300	**0.8148**	**0.7899**	**0.6285**	**0.6728**	**0.6018**	**0.7523**	**0.6193**	**0.7452**	**0.6429**
Panel B. Mean values of the alternative priors for σ_c									
1.25*Roll*/2, if *Roll*>0, 0.005 otherwise	0.00436	0.00159	0.00150	0.00332	0.00202	0.00189	0.00228	0.00268	0.00256
$1.25(\overline{p^A} - \overline{p^B})$	0.00058	0.00092	0.00060	0.00077	0.00030	0.00030	0.00052	0.00061	0.00046
$1.25(\overline{p^A} - \overline{p^B})/2$	0.00029	0.00046	0.00030	0.00038	0.00015	0.00015	0.00026	0.00031	0.00023
$\sqrt{(\overline{p^A} - \overline{p^B})}$	0.02136	0.02695	0.02184	0.02470	0.01537	0.01551	0.02038	0.02189	0.01911

Table 13 **Calibrating the prior for the standard deviation of transaction cost in the *Gibbs* procedure.**
Panel A of the table shows time-series correlations of the monthly *Gibbs* estimates (from Hasbrouck (2009)) based on different priors for the standard deviation of transaction cost (σ_c) with the effective cost for each exchange rate. The half-normal distribution implies $\sigma_c = \sqrt{\pi/2}Ec \approx 1.25Ec$, where Ec is the mean of the transaction cost. Effective cost denotes the monthly average of daily effective cost estimates. Bold numbers are statistically significant at the 5% level (GMM based test using a Newey-West covariance estimator with 4 lags). Panel B of the table shows the mean value of the alternative EC prior specifications, used in the Gibbs estimation, for each exchange rate. $\overline{p^A}$ and $\overline{p^B}$ denote the monthly averages of log ask and log bid prices, respectively. The sample covers 65 months, January 2007 - May 2012.

	HF method	LF methods							
	EC	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Simple average	**0.999**	**0.940**	**0.488**	**0.986**	**0.999**	**0.999**	**0.998**	**0.445**	**0.894**
Trimmed mean	**0.999**	**0.924**	**0.382**	**0.992**	**0.997**	**0.997**	**0.998**	**0.586**	**0.919**

Table 14 **Correlations of the across-currencies LF and EC measures based on the PCA with the simple average and trimmed mean.**

The table shows the time-series correlations of the across-currencies liquidities based on the PCA with the across-currencies liquidities based on the simple and trimmed averaging. Effective cost denotes the monthly average of daily effective cost estimates. The monthly low-frequency spread proxies are: *Roll* from *Roll* from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are based on PCA (within measures) across the individual FX rate liquidites. Bold numbers are statistically significant at the 5% level (GMM based test using a Newey-West covariance estimator with 4 lags). The sample covers 65 months, January 2007 – May 2012.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Panel A. Whole sample (Jan 2007 - May 2012), 65 months								
Simple mean	**0.529**	**0.210**	**0.700**	**0.896**	**0.868**	**0.932**	-0.103	**0.740**
Trimmed mean	**0.464**	0.008	**0.686**	**0.897**	**0.864**	**0.922**	**-0.080**	**0.713**
Panel B. Pre-crisis (Jan 2007 - Jun 2008), 18 months								
Simple mean	**0.620**	**0.449**	**0.683**	**0.842**	**0.798**	**0.896**	0.086	**0.392**
Trimmed mean	**0.642**	**0.409**	**0.672**	**0.864**	**0.834**	**0.894**	**-0.095**	**0.329**
Panel C. Financial crisis (Jul 2008 - Dec 2009), 18 months								
Simple mean	**0.397**	0.012	**0.823**	**0.903**	**0.890**	**0.939**	**-0.055**	**0.819**
Trimmed mean	**0.325**	**-0.175**	**0.820**	**0.899**	**0.876**	**0.932**	0.017	**0.789**
Panel D. European sovereign debt crisis (Jan 2010 - May 2012), 29 months								
Simple mean	**0.522**	**0.349**	**0.328**	**0.832**	**0.741**	**0.813**	**-0.173**	**0.448**
Trimmed mean	**0.440**	**0.224**	**0.328**	**0.784**	**0.682**	**0.760**	**-0.066**	**0.347**

Table 15 **Correlations between the across-currencies LF liquidities based on the simple and trimmed mean with the EC.**

The table shows times-series correlations of the across-currencies LF liquidities based on the simple and trimmed mean with the across-currencies effective cost over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The monthly low-frequency spread proxies are: *Roll* from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are based on the simple and trimmed mean (within measures) across individual FX rate liquidites. Bold numbers are statistically significant at the 5% level. * means that the correlation is statistically significantly different at the 5% level from all other correlations in the same row. Both significance tests are the GMM based tests using a Newey and West (1987) covariance estimator with 4 lags. **Idf stands for insignificantly different from. The sample covers 65 months, January 2007 – May 2012.

	Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
AUD/USD	**0.617**	**0.660**	**0.353**	**0.619**	**0.610**	**0.809**	0.007	**0.541**
EUR/CHF	-0.041	**-0.281**	**0.180**	**0.635**	**0.546**	**0.726**	**0.315**	**-0.038**
EUR/GBP	**0.120**	**-0.137**	**0.226**	**0.313**	**0.252**	**0.494**	**-0.112**	**0.072**
EUR/JPY	**0.435**	**0.500**	**0.143**	**0.533**	**0.447**	**0.540**	**-0.023**	**0.351**
EUR/USD	**0.233**	**0.225**	**0.197**	**0.323**	**0.338**	**0.564**	**0.103**	**0.210**
GBP/USD	**-0.072**	**-0.307**	**0.253**	**0.453**	**0.208**	**0.656**	**0.074**	**0.337**
USD/CAD	**-0.106**	**-0.126**	**0.034**	**0.094**	**0.352**	**0.429**	**-0.076**	**-0.119**
USD/CHF	-0.047	**-0.265**	**0.231**	**0.335**	**0.402**	**0.528**	0.001	**0.342**
USD/JPY	**0.326**	**0.389**	**0.349**	**0.421**	**0.399**	**0.560**	**-0.229**	**0.379**
Average	0.163	0.073	0.219	0.414	0.395	0.590	0.007	0.231

Table 16 **Correlations between changes in the FX rate LF liquidities and changes in the EC.** The table shows the time-series correlations of changes in the eight low-frequency liquidity measures for each exchange rate with changes in the effective cost measure for the same exchange rate. Effective cost denotes the monthly average of daily effective cost estimates. The monthly low-frequency spread proxies are: *Roll* from Roll from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). Bold numbers are statistically significant at the 5% level (GMM based test using a Newey-West covariance estimator with 4 lags). The sample covers 65 months, January 2007 – May 2012.

Roll	BPW	BA	CS	Gibbs	Volatility	EffTick	LOT
Whole sample (Jan 2007 - May 2012), 65 months							
0.426	**0.462**	**0.369**	**0.621**	**0.585**	**0.790**	**-0.039**	**0.394**
Pre-crisis (Jan 2007 - Jun 2008), 18 months							
0.562	**0.546**	**0.585**	**0.730**	**0.764**	**0.798**	**-0.488**	-0.055
Financial crisis (Jul 2008 - Dec 2009), 18 months							
0.461	**0.630**	**0.624**	**0.609**	**0.481**	**0.848**	**-0.126**	**0.464**
European sovereign debt crisis (Jan 2010 - May 2012), 29 months							
0.402	0.006	**-0.084**	**0.767**	**0.802**	**0.737**	**0.335**	**0.357**

Table 17 **Correlations between changes in the across-currencies LF liquidities and changes the EC.**

The table shows times-series correlations between changes in the across-currencies LF liquidities and changes in the across-currencies effective cost over the whole period and over three subperiods: pre-crisis (Jan 2007 – June 2008), financial crisis (Jul 2008 – Dec 2009) and European sovereign debt crisis (Jan 2010 – May 2012). The monthly low-frequency spread proxies are: *Roll* from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The across-currencies measures are based on the PCA (within measures) across individual FX rate liquidites. Bold numbers are statistically significant at the 5% level (GMM based test using a Newey and West (1987) covariance estimator with 4 lags). The sample covers 65 months, January 2007 – May 2012.

	(1)	(2)	(3)	(4)
Intercept	-0.001	0.058	-0.007	-0.007
	[-0.014]	[0.676]	[-0.140]	[-0.140]
LF liquidity	**0.877**			
	[13.626]			
Vol		**0.893**	**0.893**	**0.893**
		[6.432]	[17.769]	[17.769]
CS*			**0.330**	
			[2.334]	
Gibbs**			**0.372**	
			[3.221]	
Gibbs^{+}				**0.421**
				[3.472]
CS^{++}				0.245
				[1.796]
Adj. R-squared	0.566	0.550	0.578	0.578

Table 18 **Quantile regressions of the across-currencies EC on the LF liquidities.**
The table shows the output of median quantile regressions of the across-currencies effective cost on (1) the systematic LF liquidity, obtained from the PCA across FX rates as well as best LF liquidities, (2) the across-currencies volatility, (3)-(4) the rotated best across-currencies low-frequency measures. The best across-currencies low-frequency measures include: *Volatility*, *CS* (from Corwin and Schultz (2012)), *Gibbs* (Hasbrouck (2009)). All the across-currencies liquidity measures are obtained from the PCA (within measures) across individual FX rates liquidites and standardized. * denotes the second factor in the rotation [Volatility, CS, Gibbs]. ** denotes the third factor in the rotation [Volatility, CS, Gibbs]. $^{+}$ denotes the second factor in the rotation [Volatility, Gibbs, CS]. $^{++}$ denotes the third factor in the rotation [Volatility, Gibbs, CS]. The t-statistics is shown in the brackets. Bold numbers are statistically significant at the 5% level. The sample is January 2007 – May 2012, 65 months.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY	Cum. % explained
First principal loadings										
EC	0.349	0.256	0.356	0.321	0.346	0.369	0.343	0.309	0.339	76.71%
Roll	0.454	0.370	0.071	0.467	0.337	0.009	0.161	0.369	0.397	34.34%
BPW	0.455	0.382	-0.209	0.444	0.040	-0.369	-0.265	0.161	0.415	35.55%
BA	0.169	0.373	0.413	0.389	0.391	0.366	0.032	0.350	0.317	54.75%
CS	0.344	0.225	0.365	0.351	0.357	0.354	0.328	0.298	0.356	59.81%
Gibbs	0.356	0.281	0.311	0.354	0.370	0.341	0.350	0.325	0.302	59.54%
Volatility	0.362	0.215	0.330	0.360	0.373	0.375	0.346	0.282	0.325	69.05%
EffTick	0.535	0.143	0.620	-0.045	-0.006	-0.259	-0.386	0.143	0.265	20.16%
LOT	0.442	0.349	0.020	0.485	0.381	0.445	-0.113	0.047	0.297	40.89%
Second principal loadings										
EC	-0.224	0.602	-0.066	0.352	-0.206	-0.131	-0.309	0.484	-0.264	90.12%
Roll	-0.083	-0.295	0.265	-0.102	0.453	0.442	0.519	0.194	-0.343	53.89%
BPW	0.020	0.199	-0.050	0.146	0.621	0.284	0.437	0.516	-0.115	54.81%
BA	0.663	-0.411	0.074	0.015	-0.004	0.227	0.279	-0.452	0.228	69.42%
CS	-0.285	0.646	0.006	-0.171	0.262	-0.245	-0.231	0.502	-0.198	72.03%
Gibbs	0.249	-0.055	-0.426	0.378	-0.163	-0.356	0.164	-0.357	0.550	71.28%
Volatility	-0.235	0.625	0.137	-0.241	0.143	-0.080	-0.264	0.546	-0.288	82.67%
EffTick	0.472	-0.103	0.224	0.465	-0.227	0.367	0.416	-0.012	-0.376	35.12%
LOT	0.078	0.223	0.042	-0.072	-0.160	-0.138	0.595	0.683	0.268	74.05%

Table 19 **Principal component loadings across currencies.**
Given a standardized monthly measure of liquidity, each row of the table shows principal component loadings for each exchange rate obtained by conducting the PCA across the FX rate liquidities. The Principal Component Analysis is repeated for each liquidity measure. Effective cost (*EC*) high-frequency measure denotes the monthly average of daily effective cost estimates. The low-frequency measures are: *Roll* from Roll (1984), *BA* is the relative bid-ask spread, *BPW* from Bao, Pan, and Wang (2011), *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009), *Volatility*, *EffTick* from Holden (2009), and *LOT* from Lesmond, Ogden, and Trzcinka (1999). The sample covers 65 months, January 2007 – May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY	Cum. % explained
PC1	0.181	0.196	0.178	0.173	0.201	0.180	0.186	0.224	0.197	59.06%
PC2	0.087	-0.014	0.012	0.129	0.004	0.001	0.080	-0.076	-0.039	69.47%
PC3	-0.060	0.095	0.115	-0.063	0.055	-0.032	-0.085	-0.010	-0.058	74.89%

Table 20 **Principal component loadings across the best LF liquidity measures and currencies: Average loading for FX rates.** Principal component loadings across the best FX liquidity measures and FX rates are extracted by the PCA. The table reports the average (across the best LF measures) loading for each exchange rate. The sample covers 65 months, January 2007 – May 2012.

	CS	Gibbs	Volatility	Cum. % explained
PC1	0.202	0.170	0.200	59.06%
PC2	-0.138	0.249	-0.050	69.47%
PC3	-0.097	-0.028	0.111	74.89%

Table 21 **Principal component loadings across the best LF liquidity measures and currencies: Average loading for liquidity measures.**
Principal component loadings across the best FX liquidity measures and FX rates are extracted by the PCA. The table reports the average (across nine currency pairs) loading for each LF liquidity measure. The best FX liquidity measures are: *CS* from Corwin and Schultz (2012), *Gibbs* from Hasbrouck (2009) and *Volatility*. The sample covers 65 months, January 2007 – May 2012.

	CS	Gibbs	Volatility	Systematic
CS	**1**			
Gibbs	**0.808**	**1**		
Volatility	**0.838**	**0.889**	**1**	
Systematic	**0.923**	**0.948**	**0.969**	**1**
40 FX rates	**0.940**	**0.962**	**0.974**	**0.968**

Table 22 **Correlations between the across-currencies and systematic LF measures based on the nine and forty FX rates over 1991-2012.**
The table shows correlations between the across-currencies LF liquidities and systematic LF liquidity based on the nine FX rates (used in the core paper analysis). The across-currencies CS, Gibbs, and Volatility liquidities are obtained from the PCA (within measures) across the individual FX rate liquidites. The systematic liquidity measure is obtained from the PCA across FX rates as well as across *CS*, *Gibbs*, and *Volatility* liquidities. The last row reports the correlations of the across-currencies and systematic LF liquidities based on the nine FX rates with the ones based on the forty FX rates. the Bold numbers are statistically significant at the 5% level. The significance test is the GMM based test using a Newey and West (1987) covariance estimator with 4 lags. Correlations are computed using 257 non-overlapping monthly observations. The sample is January 1991 – May 2012, 257 months.

	CS	Gibbs	Volatility	Systematic
CS	**1**			
Gibbs	**0.812**	**1**		
Volatility	**0.861**	**0.877**	**1**	
Systematic	**0.931**	**0.935**	**0.973**	**1**

Table 23 **Correlation between the across-currencies low-frequency (LF) liquidities over 1991-2012.**
The table shows correlations between the across-currencies LF liquidities and systematic LF liquidity based on 40 FX rates. The across-currencies *CS*, *Gibbs*, and *Volatility* liquidities are obtained from the PCA (within measures) across individual FX rate liquidites. The systematic liquidity measure is obtained from the PCA across FX rates as well as across *CS*, *Gibbs*, and *Volatility* liquidities. Bold numbers are statistically significant at the 5% level. The significance test is the GMM based test using a Newey and West (1987) covariance estimator with 4 lags. Correlations are computed using 257 non-overlapping monthly observations. The sample is January 1991 – May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	1.119	0.388	0.760	0.460	0.292	0.693	1.074	0.473	0.401
Median	0.953	0.373	0.693	0.446	0.281	0.576	1.008	0.461	0.406
Std. dev.	0.652	0.125	0.260	0.132	0.053	0.381	0.406	0.094	0.091
Min	0.566	0.134	0.453	0.263	0.213	0.337	0.632	0.334	0.259
Max	3.722	0.836	1.596	0.853	0.458	1.879	2.326	0.719	0.669
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	1.003	0.320	0.586	0.325	0.280	0.495	1.017	0.392	0.363
Median	0.990	0.304	0.578	0.330	0.280	0.472	1.062	0.368	0.362
Std. dev.	0.240	0.051	0.093	0.049	0.006	0.129	0.245	0.058	0.049
Min	0.707	0.262	0.462	0.263	0.269	0.337	0.709	0.334	0.305
Max	1.337	0.433	0.718	0.403	0.292	0.691	1.387	0.505	0.459
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	1.795	0.429	1.058	0.554	0.340	1.159	1.534	0.527	0.495
Median	1.491	0.393	1.037	0.494	0.335	1.074	1.506	0.519	0.469
Std. dev.	0.890	0.132	0.297	0.166	0.071	0.448	0.435	0.110	0.086
Min	0.953	0.290	0.660	0.348	0.257	0.561	0.973	0.393	0.381
Max	3.722	0.707	1.596	0.853	0.458	1.879	2.326	0.719	0.669
European sovereign-debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.772	0.405	0.683	0.486	0.271	0.528	0.825	0.489	0.365
Median	0.751	0.409	0.692	0.476	0.268	0.531	0.767	0.477	0.337
Std. dev.	0.169	0.138	0.115	0.058	0.036	0.088	0.154	0.069	0.070
Min	0.566	0.134	0.453	0.416	0.213	0.360	0.632	0.389	0.259
Max	1.165	0.836	1.088	0.617	0.345	0.733	1.128	0.716	0.463

Table 24 **Effective cost: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for effective cost FX liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign-debt crisis (Jan 2010 - May 2012). Effective cost denotes the monthly average of daily effective cost estimates. Effective cost is measured in bps. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	0.696	0.253	0.239	0.530	0.323	0.302	0.364	0.427	0.409
Median	0.551	0.144	0.122	0.418	0.229	0.331	0.246	0.340	0.326
Std. dev.	0.884	0.321	0.280	0.570	0.384	0.296	0.397	0.451	0.466
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	6.189	1.595	1.326	2.581	1.383	1.270	1.576	2.005	1.920
% positive	24.6%	29.2%	40.0%	32.3%	40.0%	38.5%	33.8%	35.4%	35.4%
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	0.547	0.174	0.202	0.409	0.206	0.248	0.338	0.319	0.433
Median	0.519	0.121	0.159	0.264	0.194	0.233	0.300	0.260	0.388
Std. dev.	0.434	0.229	0.246	0.434	0.197	0.251	0.362	0.348	0.422
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	1.674	0.891	1.033	1.251	0.651	0.735	1.181	1.264	1.648
% positive	16.7%	38.9%	27.8%	33.3%	33.3%	38.9%	33.3%	33.3%	27.8%
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	1.173	0.301	0.290	0.795	0.455	0.347	0.410	0.623	0.580
Median	1.184	0.173	0.191	0.836	0.347	0.345	0.026	0.637	0.466
Std. dev.	1.448	0.355	0.358	0.728	0.485	0.380	0.539	0.479	0.674
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	6.189	1.272	1.326	2.581	1.383	1.270	1.576	1.449	1.920
% positive	27.8%	27.8%	44.4%	27.8%	38.9%	44.4%	50.0%	27.8%	38.9%
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.493	0.273	0.230	0.440	0.313	0.308	0.351	0.372	0.288
Median	0.508	0.149	0.098	0.418	0.157	0.363	0.267	0.295	0.291
Std. dev.	0.442	0.348	0.249	0.493	0.388	0.267	0.319	0.465	0.280
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	1.426	1.595	0.742	2.276	1.300	0.873	1.068	2.005	0.766
% positive	27.6%	24.1%	44.8%	34.5%	44.8%	34.5%	24.1%	41.4%	37.9%

Table 25 **Roll spread: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for Roll liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The *Roll* percentage spread estimates (from Roll (1984)) are computed as square root of negative consecutive price changes autocovariance, if the autocovariance is positive, and zero, otherwise. % negative denotes the percentage of positive monthly autocovariance estimates. The *Roll* is measured in %. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	0.275	0.027	-0.011	0.120	0.030	0.006	0.047	0.054	0.073
Median	0.076	0.005	0.004	0.044	0.013	0.027	0.015	0.029	0.027
Std. dev.	1.213	0.117	0.165	0.314	0.153	0.130	0.152	0.218	0.219
Min	-0.913	-0.330	-1.001	-0.334	-0.475	-0.424	-0.540	-0.739	-0.317
Max	9.575	0.636	0.439	1.666	0.478	0.403	0.621	1.005	0.921
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	0.111	0.015	0.013	0.071	0.006	0.021	0.044	0.028	0.078
Median	0.068	0.004	0.007	0.018	0.010	0.014	0.025	0.017	0.040
Std. dev.	0.179	0.050	0.071	0.137	0.050	0.049	0.108	0.123	0.165
Min	-0.119	-0.039	-0.086	-0.107	-0.133	-0.057	-0.097	-0.159	-0.085
Max	0.701	0.198	0.267	0.391	0.106	0.135	0.349	0.400	0.679
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	0.777	0.043	-0.065	0.257	0.057	-0.051	0.057	0.107	0.156
Median	0.351	0.007	0.011	0.175	0.030	0.030	-0.010	0.102	0.054
Std. dev.	2.250	0.114	0.294	0.445	0.223	0.227	0.248	0.225	0.359
Min	-0.913	-0.134	-1.001	-0.222	-0.475	-0.424	-0.540	-0.364	-0.317
Max	9.575	0.405	0.439	1.666	0.478	0.403	0.621	0.525	0.921
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.066	0.025	0.009	0.065	0.027	0.033	0.043	0.038	0.019
Median	0.064	0.006	0.002	0.044	0.006	0.033	0.018	0.022	0.021
Std. dev.	0.219	0.146	0.062	0.277	0.145	0.056	0.092	0.258	0.084
Min	-0.679	-0.330	-0.140	-0.334	-0.274	-0.060	-0.124	-0.739	-0.279
Max	0.509	0.636	0.138	1.295	0.423	0.190	0.285	1.005	0.147

Table 26 **BPW measure: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for **BPW** liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The *BPW* estimates (from Bao, Pan, and Wang (2011) are measured as minus autocovariance of consecutive price changes. The *BPW* is measured in bps. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	4.599	7.375	4.804	6.139	2.385	2.423	4.163	4.905	3.682
Median	4.447	7.806	4.723	6.123	2.392	2.305	4.163	5.043	3.571
Std. dev.	0.867	1.763	0.833	0.959	0.453	0.442	0.391	1.448	0.671
Min	3.345	4.528	3.310	4.191	1.530	1.677	3.068	2.450	2.565
Max	7.009	11.014	6.952	8.179	3.540	3.816	5.085	7.634	5.243
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	4.521	5.129	3.891	5.087	1.976	2.052	4.236	3.156	3.257
Median	4.583	4.874	3.925	5.068	2.015	2.039	4.196	2.881	3.228
Std. dev.	0.477	0.639	0.244	0.520	0.230	0.142	0.357	0.695	0.459
Min	3.614	4.528	3.310	4.191	1.530	1.821	3.443	2.450	2.585
Max	5.525	6.568	4.343	6.123	2.432	2.328	4.862	4.667	4.028
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	5.021	7.658	5.400	6.560	2.594	2.812	4.262	5.106	3.997
Median	4.600	7.977	5.723	6.658	2.762	2.886	4.255	5.044	3.816
Std. dev.	1.169	1.031	0.935	0.893	0.531	0.462	0.267	0.841	0.636
Min	3.531	5.722	3.670	5.152	1.642	1.964	3.740	3.815	3.180
Max	7.009	9.298	6.952	7.934	3.540	3.816	4.732	7.100	4.960
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	4.386	8.593	5.001	6.530	2.509	2.412	4.056	5.866	3.751
Median	4.198	8.440	5.006	6.537	2.587	2.331	4.026	5.852	3.638
Std. dev.	0.765	1.176	0.463	0.686	0.337	0.344	0.455	1.059	0.687
Min	3.345	5.874	4.317	5.237	1.720	1.677	3.068	3.547	2.565
Max	5.846	11.014	6.041	8.179	3.127	3.141	5.085	7.634	5.243

Table 27 **Bid-ask spread: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for *BA* liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). Bid-ask percentage spread is the average over daily relative bid-ask estimates. The *BA* is measured in bps. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	0.194	0.115	0.133	0.190	0.144	0.136	0.155	0.165	0.153
Median	0.167	0.097	0.132	0.169	0.133	0.134	0.139	0.161	0.145
Std. dev.	0.107	0.062	0.057	0.088	0.056	0.058	0.056	0.060	0.068
Min	0.078	0.052	0.040	0.042	0.038	0.033	0.065	0.042	0.049
Max	0.690	0.436	0.277	0.462	0.298	0.290	0.309	0.323	0.396
% zero	39.06%	28.62%	36.49%	38.52%	37.97%	39.93%	36.17%	33.64%	36.04%
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	0.158	0.083	0.095	0.147	0.100	0.097	0.135	0.129	0.142
Median	0.153	0.074	0.090	0.145	0.094	0.096	0.124	0.115	0.139
Std. dev.	0.059	0.030	0.044	0.084	0.039	0.037	0.055	0.064	0.066
Min	0.086	0.052	0.046	0.040	0.042	0.033	0.066	0.043	0.049
Max	0.266	0.179	0.210	0.374	0.188	0.173	0.308	0.258	0.311
% zero	37.11%	34.40%	34.47%	35.55%	33.01%	40.04%	31.18%	34.32%	37.26%
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	0.289	0.117	0.174	0.237	0.181	0.190	0.198	0.201	0.208
Median	0.288	0.101	0.172	0.244	0.175	0.187	0.197	0.191	0.191
Std. dev.	0.122	0.048	0.069	0.095	0.064	0.063	0.058	0.051	0.075
Min	0.102	0.060	0.040	0.100	0.086	0.068	0.099	0.144	0.122
Max	0.526	0.220	0.277	0.463	0.297	0.311	0.304	0.323	0.396
% zero	39.49%	27.20%	36.76%	42.78%	35.37%	44.21%	41.67%	31.74%	37.85%
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.155	0.133	0.132	0.186	0.148	0.128	0.140	0.166	0.124
Median	0.151	0.106	0.135	0.168	0.134	0.135	0.130	0.161	0.126
Std. dev.	0.045	0.076	0.037	0.073	0.040	0.040	0.039	0.048	0.038
Min	0.092	0.052	0.045	0.099	0.084	0.065	0.084	0.068	0.053
Max	0.267	0.433	0.214	0.444	0.234	0.204	0.244	0.264	0.210
% zero	40.22%	26.64%	37.77%	38.04%	42.17%	36.90%	35.90%	34.61%	33.96%

Table 28 **CS measure: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for Corwin-Schultz (*CS*) liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The *CS* spread estimates are computed as in Corwin and Schultz (2012). % zero denotes the mean monthly proportion of zero 2-day CS estimates. The *CS* is measured in %. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	0.369	0.167	0.193	0.330	0.257	0.238	0.265	0.270	0.252
Median	0.276	0.128	0.179	0.244	0.210	0.197	0.236	0.234	0.228
Std. dev.	0.264	0.136	0.087	0.218	0.148	0.118	0.127	0.153	0.151
Min	0.103	0.007	0.061	0.081	0.075	0.076	0.083	0.102	0.071
Max	1.720	0.761	0.507	1.109	0.888	0.636	0.744	0.901	0.840
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	0.291	0.111	0.149	0.238	0.171	0.183	0.245	0.198	0.223
Median	0.224	0.091	0.120	0.215	0.155	0.178	0.238	0.183	0.220
Std. dev.	0.157	0.066	0.100	0.147	0.084	0.074	0.103	0.099	0.111
Min	0.155	0.044	0.061	0.081	0.075	0.076	0.104	0.102	0.071
Max	0.757	0.327	0.507	0.580	0.350	0.331	0.556	0.486	0.550
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	0.549	0.162	0.243	0.476	0.343	0.332	0.347	0.359	0.365
Median	0.443	0.116	0.211	0.370	0.291	0.308	0.319	0.319	0.322
Std. dev.	0.405	0.109	0.088	0.305	0.202	0.149	0.156	0.193	0.181
Min	0.139	0.035	0.146	0.139	0.110	0.171	0.185	0.126	0.128
Max	1.720	0.363	0.423	1.109	0.888	0.636	0.744	0.901	0.840
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.306	0.204	0.188	0.297	0.256	0.214	0.226	0.258	0.200
Median	0.270	0.177	0.175	0.240	0.213	0.185	0.208	0.226	0.153
Std. dev.	0.127	0.171	0.060	0.136	0.107	0.083	0.096	0.128	0.115
Min	0.103	0.007	0.115	0.125	0.112	0.083	0.083	0.107	0.100
Max	0.698	0.761	0.354	0.697	0.559	0.410	0.493	0.655	0.667

Table 29 **Gibbs measure: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for Gibbs liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The Gibbs spread estimates are computed as in Hasbrouck (2009). The *Gibbs* is measured in %. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	2.762	1.247	1.593	2.445	1.904	1.791	1.984	1.994	1.886
Median	2.261	1.057	1.518	2.192	1.785	1.583	1.838	1.871	1.766
Std. dev.	1.742	0.906	0.712	1.267	0.748	0.829	0.864	0.742	0.810
Min	1.123	0.053	0.640	0.685	0.730	0.734	0.891	0.661	0.592
Max	12.945	5.453	4.280	7.952	4.233	4.593	5.462	4.450	5.142
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	2.080	0.889	1.132	1.795	1.258	1.275	1.679	1.535	1.761
Median	1.896	0.906	0.979	1.546	1.217	1.149	1.674	1.348	1.779
Std. dev.	0.778	0.339	0.432	0.789	0.396	0.397	0.521	0.618	0.720
Min	1.123	0.459	0.640	0.685	0.730	0.734	0.997	0.661	0.592
Max	4.044	1.804	2.028	3.397	1.829	2.005	3.182	2.737	3.583
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	4.141	1.185	2.176	3.343	2.454	2.653	2.766	2.344	2.603
Median	3.549	0.846	1.882	3.097	2.465	2.559	2.608	2.453	2.551
Std. dev.	2.649	0.824	0.952	1.772	0.907	1.032	1.074	0.756	0.944
Min	1.532	0.315	1.114	1.321	1.311	1.180	1.219	1.204	1.333
Max	12.945	2.885	4.280	7.952	4.233	4.593	5.462	4.450	5.142
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	2.328	1.507	1.518	2.291	1.965	1.576	1.688	2.061	1.520
Median	2.042	1.518	1.527	2.243	1.891	1.451	1.666	1.917	1.483
Std. dev.	0.767	1.113	0.368	0.756	0.466	0.363	0.547	0.679	0.403
Min	1.381	0.053	0.739	1.244	1.240	1.028	0.891	1.213	0.838
Max	4.510	5.453	2.483	5.617	3.519	2.552	3.115	4.238	2.830

Table 30 **Volatility: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for effective cost FX liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The *Volatility* is computed as in Menkhoff, Sarno, Schmeling, and Schrimpf (2012), i.e. monthly average of the daily absolute FX rate returns. The *Volatility* is measured in %, annualized. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	1.884	1.139	1.642	1.306	1.116	1.036	1.821	1.490	0.451
Median	1.539	0.782	1.264	0.888	0.829	0.693	1.221	1.065	0.037
Std. dev.	1.077	0.945	1.129	1.363	0.680	0.913	1.453	1.196	0.758
Min	0.928	0.603	1.087	0.045	0.634	0.483	0.804	0.808	0.001
Max	6.640	5.436	8.449	10.559	4.734	5.482	7.835	8.241	3.492
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	1.934	1.174	1.847	1.121	0.984	0.737	1.405	1.838	1.295
Median	1.549	0.623	1.459	0.803	0.816	0.510	1.059	0.942	1.138
Std. dev.	0.964	1.241	1.131	0.648	0.412	0.529	0.555	1.955	0.736
Min	1.051	0.603	1.257	0.601	0.642	0.483	0.854	0.808	0.067
Max	4.200	4.873	5.067	2.693	2.375	2.482	2.326	8.241	3.492
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	2.355	0.919	1.765	1.586	1.202	1.185	2.014	1.264	0.290
Median	1.690	0.661	1.183	0.765	0.857	0.927	1.794	0.950	0.028
Std. dev.	1.566	0.569	1.722	2.305	1.008	0.887	1.319	0.726	0.731
Min	1.086	0.617	1.087	0.594	0.634	0.530	0.804	0.860	0.001
Max	6.640	2.627	8.449	10.559	4.734	4.236	4.789	3.760	2.978
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	1.561	1.255	1.439	1.246	1.145	1.128	1.959	1.414	0.028
Median	1.401	0.911	1.182	0.905	0.834	0.805	1.221	1.144	0.025
Std. dev.	0.589	0.929	0.505	0.830	0.565	1.086	1.851	0.715	0.014
Min	0.928	0.678	1.110	0.045	0.691	0.611	0.977	0.884	0.003
Max	2.812	5.436	2.730	3.911	2.602	5.482	7.835	4.519	0.058

Table 31 **Effective Tick measure: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for Effective Tick (*EffTick*) liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The Effective Tick spread estimates are computed as in Holden (2009). The *Efftick* is measured in bps. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	EUR/CHF	EUR/GBP	EUR/JPY	EUR/USD	GBP/USD	USD/CAD	USD/CHF	USD/JPY
Whole sample (Jan 2007 - May 2012, 65 months)									
Mean	1.119	0.388	0.760	0.460	0.292	0.693	1.074	0.473	0.401
Median	0.953	0.373	0.693	0.446	0.281	0.576	1.008	0.461	0.406
Std. dev.	0.652	0.125	0.260	0.132	0.053	0.381	0.406	0.094	0.091
Min	0.566	0.134	0.453	0.263	0.213	0.337	0.632	0.334	0.259
Max	3.722	0.836	1.596	0.853	0.458	1.879	2.326	0.719	0.669
Pre-crisis (Jan 2007-Jun 2008, 18 months)									
Mean	1.003	0.320	0.586	0.325	0.280	0.495	1.017	0.392	0.363
Median	0.990	0.304	0.578	0.330	0.280	0.472	1.062	0.368	0.362
Std. dev.	0.240	0.051	0.093	0.049	0.006	0.129	0.245	0.058	0.049
Min	0.707	0.262	0.462	0.263	0.269	0.337	0.709	0.334	0.305
Max	1.337	0.433	0.718	0.403	0.292	0.691	1.387	0.505	0.459
Financial crisis (Jun 2008-Dec 2009, 18 months)									
Mean	1.795	0.429	1.058	0.554	0.340	1.159	1.534	0.527	0.495
Median	1.491	0.393	1.037	0.494	0.335	1.074	1.506	0.519	0.469
Std. dev.	0.890	0.132	0.297	0.166	0.071	0.448	0.435	0.110	0.086
Min	0.953	0.290	0.660	0.348	0.257	0.561	0.973	0.393	0.381
Max	3.722	0.707	1.596	0.853	0.458	1.879	2.326	0.719	0.669
European sovereign debt crisis (Jan 2010-May 2012, 29 months)									
Mean	0.772	0.405	0.683	0.486	0.271	0.528	0.825	0.489	0.365
Median	0.751	0.409	0.692	0.476	0.268	0.531	0.767	0.477	0.337
Std. dev.	0.169	0.138	0.115	0.058	0.036	0.088	0.154	0.069	0.070
Min	0.566	0.134	0.453	0.416	0.213	0.360	0.632	0.389	0.259
Max	1.165	0.836	1.088	0.617	0.345	0.733	1.128	0.716	0.463

Table 32 **LOT measure: descriptive statistics over Jan 2007 - May 2012.**
This table shows summary statistics for LOT liquidity measure over the whole period and over three subperiods: pre-crisis (Jan 2007 - Jun 2008), financial crisis (Jul 2008 - Dec 2009) and European sovereign debt crisis (Jan 2010 - May 2012). The *LOT* percentage spread estimates are computed as in Lesmond, Ogden, and Trzcinka (1999). The *LOT* is measured in %. The sample covers 65 months, January 2007 - May 2012.

	AUD/USD	CAD/USD	DKK/USD	HKD/USD	INR/USD	JPY/USD	MYR/USD	MXN/USD	NZD/USD	NOK/USD
Mean	0.148	0.097	0.128	0.009	0.111	0.139	0.049	0.109	0.148	0.174
Median	0.131	0.082	0.122	0.008	0.092	0.131	0.030	0.089	0.141	0.165
Std. dev.	0.069	0.056	0.049	0.006	0.078	0.052	0.099	0.103	0.074	0.071
Min	0.052	0.012	0.009	0.001	0.003	0.006	0.000	0.000	0.035	0.015
Max	0.567	0.344	0.298	0.055	0.416	0.411	0.893	1.099	0.524	0.473
% zero	35.54%	37.45%	37.18%	17.47%	17.15%	35.10%	28.99%	34.76%	36.46%	33.43%
	SGD/USD	ZAR/USD	KRW/USD	SEK/USD	CHF/USD	TWD/USD	GBP/USD	AUD/EUR	CAD/EUR	HKD/EUR
Mean	0.075	0.214	0.087	0.180	0.150	0.071	0.120	0.189	0.158	0.135
Median	0.064	0.166	0.057	0.161	0.141	0.065	0.113	0.169	0.149	0.129
Std. dev.	0.048	0.166	0.099	0.075	0.055	0.047	0.050	0.084	0.053	0.046
Min	0.005	0.014	0.001	0.011	0.010	0.000	0.005	0.063	0.058	0.044
Max	0.307	0.936	0.712	0.509	0.344	0.258	0.346	0.671	0.385	0.300
% zero	33.43%	34.15%	40.91%	33.69%	36.14%	25.61%	36.97%	31.65%	34.69%	35.66%
	JPY/EUR	NZD/EUR	NOK/EUR	SGD/EUR	CHF/EUR	GBP/EUR	AUD/GBP	CAD/GBP	DKK/GBP	HKD/GBP
Mean	0.175	0.208	0.171	0.154	0.128	0.147	0.186	0.149	0.141	0.123
Median	0.169	0.190	0.156	0.138	0.118	0.141	0.167	0.134	0.131	0.114
Std. dev.	0.069	0.090	0.075	0.063	0.057	0.053	0.079	0.057	0.056	0.048
Min	0.041	0.062	0.063	0.048	0.046	0.040	0.079	0.060	0.046	0.036
Max	0.473	0.660	0.451	0.475	0.449	0.327	0.699	0.443	0.410	0.340
% zero	34.75%	31.61%	18.14%	30.02%	20.26%	27.31%	31.78%	34.40%	28.76%	35.84%
	JPY/GBP	MYR/GBP	NZD/GBP	NOK/GBP	SGD/GBP	ZAR/GBP	SEK/GBP	CHF/GBP	TRY/GBP	EUR/USD
Mean	0.171	0.158	0.211	0.192	0.148	0.285	0.187	0.151	0.300	0.139
Median	0.164	0.127	0.192	0.186	0.130	0.272	0.181	0.142	0.241	0.133
Std. dev.	0.069	0.106	0.088	0.070	0.066	0.144	0.069	0.053	0.255	0.046
Min	0.037	0.042	0.054	0.067	0.063	0.057	0.058	0.052	0.054	0.042
Max	0.592	0.907	0.606	0.501	0.511	0.908	0.606	0.370	2.469	0.297
% zero	35.01%	33.02%	31.02%	24.25%	30.15%	25.72%	26.69%	30.53%	27.97%	35.80%

Table 33 **CS measure: descriptive statistics over Jan 1991 - May 2012.**
This table shows summary statistics for monthly Corwin-Schultz (CS) liquidity measure over Jan 1991 - May 2012. The *CS* percentage spread estimates are computed as in Corwin and Schultz (2012). % zero denotes the mean monthly proportion of zero 2-day CS estimates. The *CS* is measured in %. The sample covers 257 months, Jan 1991 - May 2012.

	AUD/USD	CAD/USD	DKK/USD	HKD/USD	INR/USD	JPY/USD	MYR/USD	MXN/USD	NZD/USD	NOK/USD
Mean	0.257	0.159	0.234	0.010	0.109	0.239	0.096	0.225	0.254	0.257
Median	0.221	0.127	0.213	0.006	0.082	0.212	0.051	0.153	0.216	0.234
Std. dev.	0.174	0.104	0.107	0.018	0.123	0.117	0.160	0.276	0.160	0.121
Min	0.048	0.030	0.083	0.000	0.002	0.071	0.000	0.000	0.045	0.063
Max	1.807	0.668	0.653	0.248	1.110	0.793	1.506	2.001	1.143	0.804
	SGD/USD	ZAR/USD	KRW/USD	SEK/USD	CHF/USD	TWD/USD	GBP/USD	AUD/EUR	CAD/EUR	HKD/EUR
Mean	0.116	0.296	0.187	0.266	0.262	0.091	0.208	0.266	0.236	0.231
Median	0.096	0.232	0.120	0.235	0.234	0.070	0.186	0.231	0.207	0.201
Std. dev.	0.082	0.254	0.319	0.127	0.123	0.079	0.099	0.168	0.103	0.106
Min	0.027	0.023	0.016	0.089	0.082	0.000	0.066	0.080	0.083	0.065
Max	0.591	2.291	4.322	0.934	1.050	0.703	0.620	1.892	0.726	0.696
	JPY/EUR	NZD/EUR	NOK/EUR	SGD/EUR	CHF/EUR	GBP/EUR	AUD/GBP	CAD/GBP	DKK/GBP	HKD/GBP
Mean	0.258	0.282	0.158	0.209	0.123	0.172	0.271	0.228	0.184	0.209
Median	0.231	0.235	0.125	0.188	0.098	0.158	0.244	0.206	0.160	0.185
Std. dev.	0.144	0.260	0.130	0.098	0.096	0.084	0.153	0.099	0.100	0.102
Min	0.077	0.075	0.034	0.056	0.007	0.027	0.088	0.076	0.044	0.065
Max	1.144	3.852	1.169	0.787	0.756	0.572	1.569	0.529	0.786	0.621
	JPY/GBP	MYR/GBP	NZD/GBP	NOK/GBP	SGD/GBP	ZAR/GBP	SEK/GBP	CHF/GBP	TRY/GBP	EUR/USD
Mean	0.264	0.251	0.276	0.213	0.205	0.318	0.223	0.205	0.371	0.237
Median	0.225	0.199	0.251	0.188	0.179	0.267	0.197	0.180	0.244	0.213
Std. dev.	0.150	0.201	0.169	0.106	0.106	0.199	0.114	0.107	0.463	0.104
Min	0.077	0.065	0.083	0.048	0.061	0.078	0.046	0.066	0.068	0.079
Max	0.935	2.230	2.109	0.750	0.830	1.634	0.766	0.730	4.379	0.694

Table 34 **Gibbs measure: descriptive statistics over Jan 1991 - May 2012.**
This table shows summary statistics for the monthly Gibbs liquidity measure over over Jan 1991 - May 2012. The *Gibbs* spread estimates are computed as in Hasbrouck (2009). The *Gibbs* is measured in %. The sample covers 257 months, Jan 1991 - May 2012.

	AUD/USD	CAD/USD	DKK/USD	HKD/USD	INR/USD	JPY/USD	MYR/USD	MXN/USD	NZD/USD	NOK/USD
Mean	1.880	1.220	1.752	0.062	0.727	1.775	0.683	1.507	1.876	1.949
Median	1.662	1.026	1.666	0.046	0.556	1.682	0.392	1.178	1.772	1.844
Std. dev.	1.074	0.697	0.589	0.054	0.671	0.655	1.093	1.580	0.981	0.726
Min	0.548	0.248	0.762	0.000	0.016	0.592	0.000	0.030	0.412	0.665
Max	12.382	5.628	4.343	0.259	4.448	4.918	8.926	14.042	8.164	6.324
	SGD/USD	ZAR/USD	KRW/USD	SEK/USD	CHF/USD	TWD/USD	GBP/USD	AUD/EUR	CAD/EUR	HKD/EUR
Mean	0.832	2.174	1.325	2.036	1.911	0.574	1.551	1.977	1.812	1.719
Median	0.720	2.001	0.946	1.849	1.810	0.481	1.429	1.817	1.679	1.601
Std. dev.	0.493	1.501	1.908	0.797	0.585	0.385	0.625	0.880	0.559	0.597
Min	0.187	0.254	0.114	0.832	0.661	0.000	0.650	0.798	0.788	0.708
Max	3.830	11.868	23.362	5.769	4.475	2.888	4.413	10.192	5.176	4.907
	JPY/EUR	NZD/EUR	NOK/EUR	SGD/EUR	CHF/EUR	GBP/EUR	AUD/GBP	CAD/GBP	DKK/GBP	HKD/GBP
Mean	1.973	1.994	1.046	1.547	0.893	1.292	1.991	1.720	1.372	1.546
Median	1.777	1.898	0.941	1.422	0.741	1.216	1.846	1.680	1.272	1.413
Std. dev.	0.897	0.682	0.561	0.576	0.575	0.541	0.843	0.551	0.582	0.625
Min	0.599	0.939	0.197	0.610	0.052	0.263	0.859	0.804	0.430	0.648
Max	7.606	5.813	3.345	4.462	5.453	4.066	9.344	4.347	4.144	4.404
	JPY/GBP	MYR/GBP	NZD/GBP	NOK/GBP	SGD/GBP	ZAR/GBP	SEK/GBP	CHF/GBP	TRY/GBP	EUR/USD
Mean	2.010	1.763	1.971	1.577	1.484	2.342	1.660	1.531	2.488	1.778
Median	1.802	1.494	1.880	1.484	1.355	2.083	1.548	1.407	1.954	1.668
Std. dev.	0.928	1.018	0.685	0.652	0.593	1.197	0.678	0.686	1.940	0.584
Min	0.667	0.563	0.611	0.623	0.550	0.480	0.447	0.506	0.712	0.730
Max	8.564	9.258	5.361	4.910	4.224	9.676	5.182	5.425	20.909	4.049

Table 35 **Volatility: descriptive statistics over Jan 1991 - May 2012.**
This table shows summary statistics for the monthly volatility over over Jan 1991 - May 2012. The monthly volatility estimates are computed as in Menkhoff, Sarno, Schmeling, and Schrimpf (2012) and reported in %, annualized. The sample covers 257 months, Jan 1991 - May 2012.

				(1)			(2)			(3)		
FX pair	Type	Country	Type	beta	tstat	R^2	beta	tstat	R^2	beta	tstat	R^2
AUD/USD	floating	Australia	developed	**0.553**	[4.323]	0.306	**0.515**	[4.108]	0.265	**0.417**	[3.829]	0.174
CAD/USD	floating	Canada	developed	**0.475**	[5.314]	0.226	**0.451**	[5.062]	0.203	**0.421**	[5.048]	0.177
DKK/USD	pegged2	Denmark	developed	**0.798**	[13.675]	0.636	**0.776**	[12.554]	0.602	**0.715**	[15.335]	0.511
HKD/USD	pegged1	Hong Kong	emerging	**0.148**	[2.476]	0.022	**0.140**	[2.427]	0.020	**0.135**	[2.364]	0.018
INR/USD	floating	India	emerging	0.132	[1.423]	0.017	0.118	[1.271]	0.014	0.107	[1.191]	0.012
JPY/USD	floating	Japan	developed	**0.630**	[7.437]	0.397	**0.600**	[7.008]	0.360	**0.597**	[7.301]	0.356
MYR/USD	pegged1	Malaysia	emerging	**0.139**	[2.570]	0.019	**0.128**	[2.506]	0.016	**0.127**	[2.425]	0.016
MXN/USD	floating	Mexico	emerging	**0.315**	[3.149]	0.099	**0.293**	[2.987]	0.086	**0.237**	[2.784]	0.056
NZD/USD	floating	New Zealand	developed	**0.607**	[7.708]	0.368	**0.579**	[7.271]	0.336	**0.548**	[7.594]	0.300
NOK/USD	floating	Norway	developed	**0.689**	[11.641]	0.475	**0.663**	[10.860]	0.440	**0.606**	[9.285]	0.367
SGD/USD	floating	Singapore	emerging	**0.443**	[6.726]	0.196	**0.417**	[6.586]	0.174	**0.359**	[6.225]	0.129
ZAR/USD	floating	South Africa	emerging	**0.382**	[3.286]	0.146	**0.360**	[3.148]	0.129	**0.303**	[3.069]	0.092
KRW/USD	pegged1	South Korea	emerging	**0.169**	[2.327]	0.028	**0.149**	[1.966]	0.022	**0.120**	[1.825]	0.014
SEK/USD	floating	Sweden	developed	**0.709**	[11.770]	0.503	**0.683**	[10.852]	0.466	**0.637**	[10.842]	0.406
CHF/USD	floating	Switzerland	developed	**0.736**	[7.776]	0.541	**0.711**	[7.194]	0.506	**0.672**	[9.228]	0.452
TWD/USD	floating	Taiwan	emerging	**0.280**	[4.036]	0.078	**0.260**	[3.866]	0.067	**0.242**	[3.799]	0.059
GBP/USD	floating	UK	developed	**0.721**	[11.291]	0.520	**0.695**	[10.454]	0.483	**0.659**	[11.125]	0.434
AUD/EUR	floating	Australia	developed	**0.690**	[6.925]	0.476	**0.661**	[6.812]	0.436	**0.637**	[7.437]	0.406
CAD/EUR	floating	Canada	developed	**0.721**	[9.871]	0.519	**0.694**	[9.092]	0.482	**0.760**	[14.973]	0.578
HKD/EUR	pegged2	Hong Kong	emerging	**0.806**	[13.067]	0.650	**0.785**	[12.032]	0.616	**0.730**	[14.896]	0.533
JPY/EUR	floating	Japan	developed	**0.668**	[9.400]	0.446	**0.636**	[8.835]	0.405	**0.682**	[9.641]	0.465
NZD/EUR	floating	New Zealand	developed	**0.704**	[7.238]	0.495	**0.682**	[7.050]	0.465	**0.723**	[8.427]	0.523
NOK/EUR	floating	Norway	developed	**0.464**	[8.493]	0.215	**0.436**	[7.479]	0.190	**0.501**	[8.657]	0.251
SGD/EUR	floating	Singapore	emerging	**0.710**	[10.908]	0.504	**0.686**	[10.392]	0.471	**0.704**	[15.210]	0.495
CHF/EUR	floating	Switzerland	developed	**0.610**	[6.933]	0.372	**0.585**	[6.749]	0.342	**0.629**	[8.805]	0.395
GBP/EUR	floating	UK	developed	**0.687**	[9.790]	0.472	**0.663**	[9.199]	0.440	**0.757**	[14.774]	0.573
AUD/GBP	floating	Australia	developed	**0.670**	[6.474]	0.449	**0.640**	[6.296]	0.409	**0.584**	[6.213]	0.341
CAD/GBP	floating	Canada	developed	**0.614**	[8.716]	0.377	**0.584**	[8.076]	0.341	**0.628**	[10.434]	0.394
DKK/GBP	pegged2	Denmark	developed	**0.686**	[9.461]	0.471	**0.658**	[9.062]	0.433	**0.738**	[12.245]	0.544
HKD/GBP	pegged2	Hong Kong	emerging	**0.728**	[11.871]	0.530	**0.702**	[11.032]	0.493	**0.667**	[11.740]	0.445
JPY/GBP	floating	Japan	developed	**0.676**	[9.851]	0.458	**0.646**	[9.176]	0.417	**0.713**	[10.601]	0.509
MYR/GBP	pegged2	Malaysia	emerging	**0.465**	[8.811]	0.216	**0.437**	[8.429]	0.191	**0.426**	[7.597]	0.181
NZD/GBP	floating	New Zealand	developed	**0.717**	[8.385]	0.515	**0.695**	[8.167]	0.483	**0.741**	[9.745]	0.549
NOK/GBP	floating	Norway	developed	**0.643**	[14.847]	0.413	**0.613**	[13.210]	0.376	**0.678**	[13.852]	0.459
SGD/GBP	floating	Singapore	emerging	**0.631**	[10.242]	0.398	**0.601**	[9.775]	0.362	**0.625**	[11.412]	0.391
ZAR/GBP	floating	South Africa	emerging	**0.439**	[4.935]	0.193	**0.412**	[4.682]	0.170	**0.394**	[5.023]	0.155
SEK/GBP	floating	Sweden	developed	**0.564**	[9.466]	0.318	**0.534**	[8.587]	0.285	**0.623**	[11.997]	0.388
CHF/GBP	floating	Switzerland	developed	**0.676**	[9.405]	0.456	**0.646**	[8.934]	0.417	**0.719**	[12.029]	0.517
TRY/GBP	pegged2	Turkey	emerging	**0.290**	[4.535]	0.084	**0.278**	[4.234]	0.077	**0.292**	[4.543]	0.085
EUR/USD	floating	Eurozone	developed	**0.819**	[14.643]	0.670	**0.798**	[13.533]	0.637	**0.725**	[15.707]	0.526

Table 36 **Commonality regressions for each currency pair.**
The table shows the regressions output from regressing (changes in) individual FX rate liquidities on the (changes in) systematic LF liquidity. Specification (1) refers to regressing each FX rate liquidity on the common systematic FX liquidity, obtained from the PCA across the 40 exchange rates as well as the three best LF liquidity proxies. Specification (2) refers to regressing each FX rate liquidity on the systematic FX liquidity, obtained from the PCA across 39 exchange rates (excluding the liquidity of the regressed currency pair) and the three best LF liquidity proxies. Specification (3) refers to regressing each FX rate liquidity on the systematic FX liquidity, obtained from the PCA across the liquidities for those floating exchange rates which exclude two currencies forming the regressed currency pair and the three best LF liquidity proxies. The individual FX rate liquidities are obtained from the PCA across the three best LF liquidity proxies for each currency pair. *Pegged1* denotes the pegged currency pair. *Pegged2* denotes the currency pair, where one currency in a pair is pegged to the currency outside the pair. HKD is pegged to the USD over the whole sample; KRW is pegged to the USD till Dec 1997; MYR is pegged to the USD over Sep 1998 - Jul 2005; DKK is pegged to the EUR from Jan 1999 till the end of the sample; TRY is pegged to the USD over the whole sample. The t-statistics are reported in brackets. Bold numbers are statistically at the 5% level. The R-squred are equal to the squared betas (all variables are standardized to have zero mean and unit variance). The sample is January 1991 – May 2012.

Currency pair	Type	Country	Type	lag		cont.		lead		R2
AUD/USD	floating	Australia	developed	**0.16**	[2.26]	**0.65**	[5.03]	0.17	[1.95]	0.352
CAD/USD	floating	Canada	developed	**0.09**	[1.95]	**0.55**	[6.63]	**0.16**	[2.06]	0.252
DKK/USD	pegged2	Denmark	developed	**-0.11**	[-2.89]	**0.75**	[13.11]	-0.06	[-1.15]	0.648
HKD/USD	pegged1	Hong Kong	emerging	0.02	[0.42]	**0.14**	[2.33]	-0.04	[-0.70]	0.024
INR/USD	floating	India	emerging	0.09	[1.57]	**0.17**	[2.02]	0.04	[0.44]	0.027
JPY/USD	floating	Japan	developed	0.02	[0.40]	**0.64**	[7.47]	0.02	[0.22]	0.393
MYR/USD	pegged1	Malaysia	emerging	0.03	[0.69]	**0.16**	[2.15]	0.04	[0.47]	0.022
MXN/USD	floating	Mexico	emerging	0.07	[0.77]	**0.33**	[2.73]	-0.02	[-0.23]	0.105
NZD/USD	floating	New Zealand	developed	**0.12**	[2.30]	**0.65**	[9.07]	0.03	[0.56]	0.385
NOK/USD	floating	Norway	developed	-0.04	[-0.85]	**0.67**	[11.35]	-0.02	[-0.46]	0.478
SGD/USD	floating	Singapore	emerging	0.06	[1.17]	**0.48**	[6.56]	0.07	[1.07]	0.202
ZAR/USD	floating	South Africa	emerging	**0.17**	[2.46]	**0.45**	[3.58]	0.06	[0.64]	0.172
KRW/USD	pegged1	South Korea	emerging	**0.21**	[2.65]	**0.24**	[3.06]	0.04	[0.56]	0.070
SEK/USD	floating	Sweden	developed	-0.06	[-1.42]	**0.69**	[12.41]	-0.01	[-0.27]	0.508
CHF/USD	floating	Switzerland	developed	**-0.09**	[-2.03]	**0.66**	[6.83]	**-0.17**	[-2.57]	0.570
TWD/USD	floating	Taiwan	emerging	-0.05	[-0.88]	**0.28**	[3.63]	0.07	[0.84]	0.086
GBP/USD	floating	UK	developed	-0.06	[-1.24]	**0.69**	[12.13]	-0.04	[-0.70]	0.522
AUD/EUR	floating	Australia	developed	0.07	[0.94]	**0.70**	[5.56]	-0.03	[-0.28]	0.479
CAD/EUR	floating	Canada	developed	-0.06	[-1.37]	**0.67**	[9.88]	-0.10	[-1.83]	0.529
HKD/EUR	pegged2	Hong Kong	emerging	**-0.09**	[-2.83]	**0.76**	[12.75]	-0.07	[-1.46]	0.663
JPY/EUR	floating	Japan	developed	0.07	[1.64]	**0.71**	[10.06]	0.08	[1.25]	0.450
NZD/EUR	floating	New Zealand	developed	-0.02	[-0.42]	**0.66**	[7.81]	**-0.13**	[-2.49]	0.508
NOK/EUR	floating	Norway	developed	0.00	[-0.01]	**0.46**	[7.82]	-0.02	[-0.41]	0.216
SGD/EUR	floating	Singapore	emerging	**-0.14**	[-3.03]	**0.66**	[10.46]	-0.03	[-0.56]	0.518
CHF/EUR	floating	Switzerland	developed	0.08	[1.90]	**0.62**	[7.24]	-0.05	[-0.84]	0.379
GBP/EUR	floating	UK	developed	**-0.08**	[-1.18]	**0.67**	[8.97]	0.01	[0.21]	0.474
AUD/GBP	floating	Australia	developed	0.09	[1.29]	**0.71**	[6.03]	0.05	[0.57]	0.456
CAD/GBP	floating	Canada	developed	0.01	[0.30]	**0.62**	[9.21]	0.03	[0.56]	0.375
DKK/GBP	pegged2	Denmark	developed	-0.07	[-1.09]	**0.68**	[8.27]	0.05	[0.78]	0.473
HKD/GBP	pegged2	Hong Kong	emerging	-0.06	[-1.45]	**0.70**	[12.31]	-0.04	[-0.71]	0.533
JPY/GBP	floating	Japan	developed	0.03	[0.50]	**0.69**	[10.00]	0.04	[0.74]	0.456
MYR/GBP	pegged2	Malaysia	emerging	0.06	[0.63]	**0.48**	[6.71]	0.01	[0.12]	0.217
NZD/GBP	floating	New Zealand	developed	0.02	[0.37]	**0.71**	[9.61]	-0.06	[-1.21]	0.518
NOK/GBP	floating	Norway	developed	**-0.12**	[-2.68]	**0.63**	[13.60]	0.07	[1.45]	0.432
SGD/GBP	floating	Singapore	emerging	-0.06	[-1.13]	**0.62**	[9.81]	0.04	[0.55]	0.399
ZAR/GBP	floating	South Africa	emerging	0.11	[1.84]	**0.48**	[5.11]	0.04	[0.44]	0.203
SEK/GBP	floating	Sweden	developed	-0.03	[-0.45]	**0.59**	[8.69]	0.12	[1.68]	0.330
CHF/GBP	floating	Switzerland	developed	0.00	[0.03]	**0.66**	[9.06]	-0.07	[-1.21]	0.461
TRY/GBP	pegged2	Turkey	emerging	**-0.03**	[-0.52]	**0.27**	[4.55]	-0.05	[-0.79]	0.087
EUR/USD	floating	Eurozone	developed	**-0.09**	[-2.20]	**0.78**	[13.13]	-0.04	[-0.90]	0.675

Table 37 **Commonality regressions for each currency pair: adding leading and lagged systematic FX liquidity.**

The table shows the regressions output from regressing (changes in) individual FX rate liquidities on the (changes in) lagged, contemporaneous and leading systematic LF liquidity. The systematic FX liquidity is obtained from the PCA across the 40 exchange rates as well as the three best LF liquidity proxies. The individual FX rate liquidities are obtained from the PCA across the three best LF liquidity proxies (*CS*, *Gibbs* and *Volatility*) for each currency pair. "Pegged1" denotes the pegged currency pair. "Pegged2" denotes the currency pair, where one currency in a pair is pegged to the currency outside the pair. HKD is pegged to the USD over the whole sample; KRW is pegged to the USD till Dec 1997; MYR is pegged to the USD over Sep 1998 - Jul 2005; DKK is pegged to the EUR from Jan 1999 till the end of the sample; TRY is pegged to the USD over the whole sample. The t-statistics based on the standerd errors, robust to conditional heteroscedasticity and serial correlation up to one lag as in Newey and West (1987) are reported in brackets. Bold numbers are statistically at the 5% level. The R-squred are equal to the squared betas (all variables are standardized to have zero mean and unit variance). The sample is January 1991 – May 2012.

	Implied FX volatility	TED spread	MSCI volatility	Losses on on 3 investment currencies	Losses on carry trade portfolio
Panel A					
Mean(β_{ij})	0.157	0.154	0.150	0.155	0.153
Mean($\gamma_{DOWN,ij}$)	**0.012**	**0.020**	**0.024**	0.010	0.012
t-stat of mean($\gamma_{DOWN,ij}$)	[1.961]	[2.180]	[3.378]	[1.456]	[1.754]
Panel B					
Mean(β_{ij})	0.157	0.154	0.150	0.154	0.153
Mean($\gamma_{DOWNSMALL,ij}$)	0.007	0.001	**0.017**	0.003	0.005
t-stat of mean($\gamma_{DOWNSMALL,ij}$)	[1.531]	[0.129]	[2.830]	[0.523]	[0.860]
Mean($\gamma_{DOWNLARGE,ij}$)	**0.038**	**0.052**	**0.032**	**0.034**	**0.032**
t-stat of mean($\gamma_{DOWNLARGE,ij}$)	[2.899]	[6.314]	[2.887]	[2.413]	[2.310]
t-stat of mean($\gamma_{DOWNSMALL,ij}$, $\gamma_{DOWNLARGE,ij}$)	[3.122]	[4.582]	[3.661]	[2.324]	[2.356]

Table 38 **Commonality in FX liquidity in the distressed markets: more evidence.**
In Panel A monthly changes in 31 (floating) FX rate liquidities $\triangle L_{ij,t}$ are regressed (one by one) on the changes in systematic FX liquidity $\triangle L_{M,t}$ and $\triangle L_{M,t}$, interacted with a dummy $D_{DOWN,t}$ for distressed market periods, equal to one if the risk factor above its mean in period t. $\Delta L_{M,t}$ is based on the first principal component across 39 out of 40 liquidities (excluding the FX rate liquidity $\triangle L_{ij,t}$). Specifically, Panel A shows the mean coefficients from the regressions $\triangle L_{ij,t} = \alpha_{ij} + \beta_{ij}\Delta L_{M,t} + \gamma_{DOWN,ij}\Delta L_{M,t} \cdot D_{DOWN,t} + \varepsilon_{ij,t}$. In Panel B monthly changes in 31 (floating) FX rate liquidities $\triangle L_{ij,t}$ are regressed (one by one) on the changes in systematic FX liquidity $\triangle L_{M,t}$, $\triangle L_{M,t}$, interacted with a dummy $D_{DOWNSMALL,t}$ (equal to one if the risk factor above its mean and less than 1.5 standard deviations above its mean in period t), and $\triangle L_{M,t}$, interacted with a dummy $D_{DOWNLARGE,t}$ (equal to one if the risk factor more than 1.5 standard deviations above its mean in period t). Specifically, Panel B shows the mean coefficients from the regressions $\triangle L_{ij,t} = \alpha_{ij} + \beta_{ij}\Delta L_{M,t} + \gamma_{DOWNSMALL,ij}\Delta L_{M,t} \cdot D_{DOWNSMALL,t} + \gamma_{DOWNLARGE,ij}\Delta L_{M,t} \cdot D_{DOWNLARGE,t} + \varepsilon_{ij,t}$. $\Delta L_{M,t}$ is based on the first principal component across 39 out of 40 liquidities (excluding the FX rate liquidity $\triangle L_{ij,t}$). The risk factors are the implied FX volatility, TED spread, MSCI volatility, losses on 3 investment currencies (minus mean return at time t on 3 currencies with the highest forward discounts at time $t-1$), and losses on carry trade portfolio (minus mean FX return at time t on 3 currencies with the highest forward discount at time $t-1$ plus mean FX return at time t on 3 currencies with the lowest forward discount at time $t-1$). The intercepts are omitted. The t-statistics for testing the hypothesis of the cross-sectional mean coefficients (mean($\gamma_{DOWN,ij}$), mean($\gamma_{DOWNSMALL,ij}$), and mean($\gamma_{DOWNLARGE,ij}$)) and the sum of the cross-sectional mean coefficients (mean($\gamma_{DOWNSMALL,ij}$, $\gamma_{DOWNLARGE,ij}$)) being equal to zero are calculated using a GMM based method that accounts for serial and cross-sectional correlations and reported in brackets. Bold numbers are statistically significant at the 5% level. The sample for specifications (1) and (3)–(5) is January 1991 – May 2012, the sample for specification (2) is April 1992 – May 2012.

Variable	Description	Source
I. Trade / gravity		
(Export i + Import i) / GDP i + (Export j + Import j) / GDP j	Overall foreign trade importance of countries i and j as a fraction of GDP, mean across annual data over 1991–2012	IMF
|(Export i + Import i) / GDP i - (Export j + Import j) / GDP j |	Economic "distance" between the countries i and j as a fraction of GDP, mean across annual data over 1991–2012	IMF
Export i to j / GDP i + Export j to i / GDP j	Bileral trade beween i and j as a fraction of GDP, mean across annual data over 1991–2012	IMF
Geographical distance from i to j	Gegraphical distance between the capitals of country i and j, in km	distancefromto.net/
Trade flow (gravity model)	Trade flow between country i and j is measured as ln GDP i plus ln GDP j minus ln (Geographical distance ij)	IMF, distancefromto.net/
II. Portfolio positions and capital flows		
International debt issues i / GDP i + International debt issues j / GDP j	Overall international debt issues (all issuers) in country i and j as a fraction of GDP, mean across annual data over 1991–2012	FDSD
|International debt issues i / GDP i - International debt issues j / GDP j |	Absolute difference in international debt issues (all issuers) between country i and j as a fraction of GDP, mean across annual data over 1991–2012	FDSD
Stock market capitalization i / GDP i + Stock market capitalization j / GDP j	Overall value of listed shares in country i and j as a fraction of GDP, mean across annual data over 1991–2012	FDSD
|Stock market capitalization i / GDP i - Stock market capitalization j / GDP j	Difference in value of listed shares between country i and j as a fraction of GDP, mean across annual data over 1991–2012	FDSD
Net foreign assets i / GDP i + Net foreign assets j / GDP j	Overall net foreign assets (foreign assets minus liabilities) in country i and j as a fraction of GDP, mean across annual data over 1991–2012	WDI
|Net foreign assets i / GDP i - Net foreign assets j / GDP j |	Absolute difference in net foreign assets (foreign assets minus liabilities) in country i and j as a fraction of GDP, mean across annual data over 1991–2012	WDI
III. Macro / fundamental FX value		
GDP per capita i + GDP per capita j	Overall GDP per capita in USD in country i and j, mean across annual data 1991–2012	IMF
|GDP per capita i - GDP per capita j |	Absolute difference in GDP per capita in USD between country i and j, mean across annual data 1991–2012	IMF
Inflation i + Inflation j	Overall inflation in country i and j, mean across annual data 1991–2012	IMF
|Inflation i - Inflation j	Absolute difference in inflation between country i and j, mean across annual data 1991–2012	IMF
Money supply i / GDP i + Money supply j / GDP j	Overall money supply (money plus quasi-money) in country i and j as a fraction of GDP, mean across annual data 1991–2011	FDSD
|Money supply i / GDP i - Money supply j / GDP j |	Absolute difference in money supply (money plus quasi-money) between country i and j as a fraction of GDP, mean across annual data 1991–2011	FDSD
Change in PPP i + change in PPP j	Overall change in purchasing-power-parity (PPP) implied conversion rate in country i and j, expressed in national currency per current international dollar, mean across annual data 1991-2012	IMF
|Change in PPP i - change in PPP j |	Absolute difference in purchasing-power-parity (PPP) implied conversion rate between country i and j, expressed in national currency per current international dollar, mean across annual data 1991-2012	IMF
IV. Institutional		
Good government index i + good government index j	Overall good government index in country i and j. Following Morck, Yeung, and Wu (2000), the good government index is defined as the sum of the following three indices from the International Country Risk Guide (each ranging from zero to ten): (i) government corruption, (ii) the risk of expropriation of private property by the government, and (iii) the risk of the government repudiating contracts. Lower scores for each index indicate less respect for private property	La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998)
|Good government index i - good government index j |	Absolute difference in good government index between country i and j	La Porta et al (1998)
Both i and j are in OECD	Sum of the dummy for the OECD membership for country i and j	oecd.org
V. Parity conditions / Asset markets		
Stock returns i + stock returns j	Overall mean stock daily return in country i and j, 1991–2012. Returns on MSCI index (or alternative USD-based stock market index) are used as the proxy for the country's stock return.	Datastream
|Stock returns i - stock returns j |	Absolute difference in mean stock return (from daily data) between country i and j, 1991–2012	Datastream
Interest rate i + interest rate j	Overall money market rate in country i and j, mean across annual data 1991–2012	IMF
|Interest rate i - interest rate j |	Absolute difference in money market rate between country i and j, mean across annual data 1991–2012	IMF
Volatility of stock returns i + volatility of stock returns j	Overall volatility of daily stock returns in country i and j, 1991–2012	Datastream
|Volatility of stock returns i - volatility of stock returns j |	Absolute difference in volatility of daily stock returns between country i and j, 1991–2012	Datastream
VI. Emerging market dummy		
Emerging dummy	The dummy takes 1 if country i is emerging.	

Table 39 **Description of the factors for explaining commonality in FX liquidity.**

The Financial Development and Structure Dataset (FDSD) is from Beck, Demirgüc-Kunt, and Levine (2000), Beck, Demirgüc-Kunt, and Levine (2009), Cihak, Demirgüc-Kunt, Feyen, and Levine (2012).

		I	II	III	IV	V	VI
I	Export i to j / GDP i + Export j to i / GDP j	1					
II	Intern debt issues i / GDP i + Intern debt issues j / GDP j	0.04	1				
III	Inflation i + Inflation j	0.11	-0.42	1			
IV	Good government index i + good government index j	-0.01	0.58	-0.88	1		
V	|Interest rate i - interest rate j |	0.05	-0.54	0.86	-0.82	1	
VI	Emerging dummy	0.16	-0.37	0.68	-0.77	0.59	1

Table 40 **Correlations between the best factors for explaining commonality**

Variable	Period	Description	Source
FX return			
Mean IMF return	Jan 1995–May 2012	Mean IMF exchange rate returns across 40 countries in our sample. IMF exchange rate returns are monthly returns in the value of each currency wrt to the SDR (Special Drawing Right), a basket of major currencies created by the IMF.	Own calculations based on data from IMF, Datastream
AER factor	Jan 1991–May 2012	AER (dollar) factor from Lustig, Roussanov, and Verdelhan (2011) - mean excess return on six portfolios, sorted each month by their forward discounts.	Hanno Lustig's personal website
Mean USD return	Feb 1991–May 2012	Mean USD exchange rate returns across all countries in our sample. Exchange rate returns are monthly returns in the value of each country's currency wrt to the US dollar.	Own calculations based on data from Datastream
FX risk			
HML	Jan 1991–May 2012	HML factor from Lustig, Roussanov, and Verdelhan (2011) - returns on the portfolio, long in the currencies with the highest forward discounts and short in the currencies with the lowest forward discounts.	Hanno Lustig's personal website
JP FX imlp vol	Apr 1992–May 2012	The JP Morgan Global FX volatility index tracks implied volatility of three-month at-the-money forward options on major and developing currencies.	Bloomberg
Interest rates return			
Fin comm paper	Jan 1997–May 2012	Overnight AA Financial Commercial Paper Interest Rate	Federal Reserve
Fedfunds rate	Jan 1991–May 2012	The effective federal funds rate is a weighted average of rates on brokered trades.	Federal Reserve
Interest rates risk			
TED spread	Jan 1991–May 2012	TED spread represents the difference in the interest rates between the three-month U.S. Treasury bill and the three-month USD LIBOR.	Bloomberg
MOVE index	Jan 1991–May 2012	The Merrill Lynch MOVE Index reports the average implied volatility across a range of outstanding options on the two-year, five-year, 10-year, and 30-year U.S. Treasury securities.	Bloomberg
Corporate bonds return			
i_{AAA}	Jan 1991–May 2012	Moody's long-term AAA corporate bond yields are derived from pricing data on a regularly replenished population of AAA-rated corporate bonds in the U.S. market, each with current outstandings over $100 million.	Bloomberg
i_{BAA}	Jan 1991–May 2012	Moody's long-term BAA corporate bond yields are derived from pricing data on a regularly replenished population of BAA-rated corporate bonds in the U.S. market, each with current outstandings over $100 million.	Bloomberg
Corporate bonds risk			
US def spread	Jan 1991–May 2012	Percentage difference between Moody's corporate bond index BAA and AAA yields.	Bloomberg
Stocks return			
MSCI return	Jan 1991–May 2012	MSCI World Index captures large and mid cap representation across 24 Developed Markets countries.	Bloomberg
Stocks risk			
VIX Index	Jan 1991–May 2012	Chicago Board Options Exchange Market Volatility Index (VIX) index measures implied volatility of S&P 500 index options. Often referred to as the fear index or the fear gauge, it represents one measure of the market's expectation of stock market volatility over the next 30 day period.	Bloomberg
MSCI volatility	Jan 1991–May 2012	Volatility (based on the daily data) on the MSCI World index	Own calculations based on the data from Bloomberg

Table 41 **Description of the monthly return and risk factors on the FX/money/bond/stock markets.**

		USD	EUR	GBP
Group		(1)	(2)	(3)
FX ret	Mean FX return	-0.019	-0.036	-0.031
		[-0.590]	[-0.958]	[-0.839]
FX risk	Δ JP FX impl vol	**-0.179**	**-0.140**	**-0.188**
		[-4.077]	[-2.290]	[-3.474]
Int rate ret	Δ Fefunds rate	-0.004	-0.005	-0.009
		[-0.142]	[-0.127]	[-0.248]
Int rate risk	ΔTED	-0.029	**-0.067**	**-0.077**
		[-1.293]	[-2.398]	[-2.793]
Corp bond ret	Δi_{BAA}	0.029	0.050	0.033
		[0.771]	[1.330]	[0.798]
Corp bond risk	Δ US def spread	-0.029	-0.076	**-0.111**
		[-0.799]	[-1.809]	[-2.972]
Stock ret	MSCI return	-0.029	0.001	-0.015
		[-0.676]	[0.028]	[-0.366]
Stock risk	Δ MSCI volatility	**-0.223**	**-0.173**	**-0.146**
		[-4.834]	[-2.865]	[-2.874]
	$\Delta L_{M,t-1}$	**-0.141**	**-0.261**	**-0.189**
		[-4.880]	[-4.302]	[-4.257]
	Δ Bond liquidity	**0.099**	**0.176**	**0.145**
		[2.831]	[3.189]	[2.966]
	R^2	0.173	0.223	0.204

Table 42 **Explaining FX liquidity: using FX rates against USD, EUR, and GBP.**
Panel of floating FX rate liquidities is regressed on all contemporaneous risk and return variables, lagged systematic FX liquidity, and bond liquidity. In (1) panel consists out of 14 (floating) USD-based currencies, in (2)–out of 8 (floating) EUR-based currencies, in (3) - out of 9 (floating) GBP-based currencies. All variables except for the mean USD return and MSCI return are in changes. The t-statistics are based on the standard errors robust to conditional heteroscedasticity, cross-sectional and serial (up to one lag) correlation as in Driscoll and Kraay (1998) and reported in brackets. The sample is April 1992 – May 2012, 241 months.

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