Online Appendix to "International Illiquidity"

This online appendix contains three sections. We first study how our country-level illiquidity proxies are related to country-level illiquidity measures using the methodology in Amihud (2002). We then study how the country-level illiquidity proxies are related to measures of country-level VIX. In the last section, we compare our global illiquidity proxies to other common proxies of illiquidity extracted from bond and stock markets.

Appendix OA-1 Comparison with Amihud (2002) Illiquidity Measures

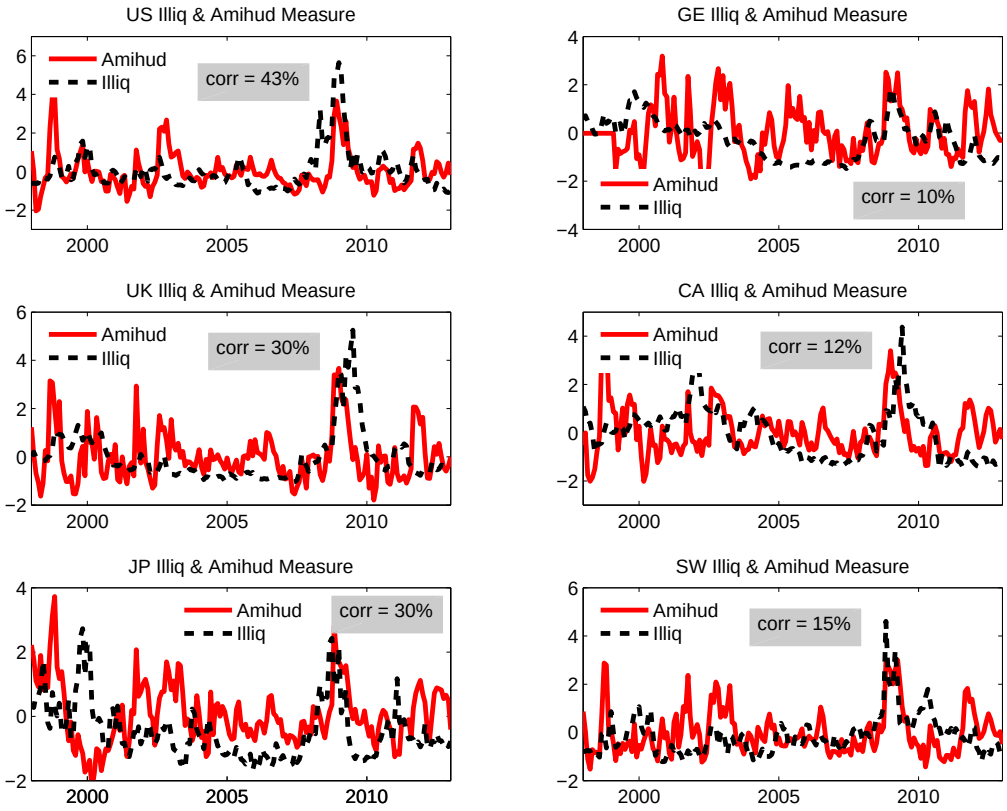

Figure OA-1. Illiquidity Proxies and Amihud Measure

This figure plots our illiquidity proxies together with country-level Amihud (2002) illiquidity measures. All variables are normalized, i.e., they are de-meaned and have a standard deviation of one.

Value-weighted averages of the Amihud illiquidity measures are plotted in Figure OA-1 together with our illiquidity proxies. We note that overall correlations between the two measures vary a lot. For example, correlations range from as little as 10% for Germany to 43% for the

US. We also note that the correlations seem to be come stronger after 2008, when the two measures co-move more.

Appendix OA-2 Comparison with Country-Level VIX

There is an intimate link between margins and market volatility. Per a Congressional mandate, margins on stocks have been controlled by the Federal Reserve since 1934. The objective of this regulation includes curbing excessive leverage and reducing the stock price volatility. However, empirical evidence on the relationship between margins and stock market volatility is often ambiguous. On the one hand, Schwert (1989) and Hsieh and Miller (1990) find no effect from margin requirements as set by the Federal Reserve on prices but find that market volatility tends to increase together with margins. More recently, Hedegaard (2014) finds a large effect from margins onto volatility in the commodity market. Hardouvelis (1990) and Hardouvelis and Peristiani (1992), on the other hand, argue that more stringent margins lead to lower stock market volatility in the US and in Japan, respectively.

While from a policy perspective it is interesting to study how margins affect volatility, the relationship can also go the opposite direction. For options and futures, margin requirements are set based on volatility itself. For example, the Chicago Mercantile Exchange (CME) uses the so called SPAN (Standard Portfolio Analysis of Risk) method that calculates the maximum likely loss that could be suffered by a portfolio. The method consists of 16 different scenarios which are comprised of different market prices and volatility.* Similarly, on the London Stock Exchange, the initial margin is calculated based on the maximum loss according to volatility and investors' leverage.

One natural question that arises is obviously whether and how the illiquidity measures relate to proxies of conditional market volatility. In the following, we study the relationship between country-level VIX proxies and our illiquidity measures. The reason why we look at the VIX rather than say conditional volatility measures using country-level returns, is because the VIX is often used as a proxy for funding illiquidity itself (see e.g., Brunnermeier and Pedersen (2009)).

Figure OA-2 plots the illiquidity proxies together with country-level VIX for the longest time-series available.† We note that overall the correlation between the time-series is quite high ranging from 49% (Japan) to 66% (Germany and Switzerland).

Appendix OA-2.1 Causality

In the following, we study in more detail the relationship between stock volatility, Amihud and our illiquidity measure. A priori, the causality between the three variables could go either way. For example, a crash in market prices could impose greater constraint on traders' resources (i.e. funding liquidity) and consequently traders are less able to provide liquidity to the market. As funding liquidity declines, so does market liquidity. This however generates a liquidity spiral: reduced market liquidity pushes prices down and worsens the funding problem which again reduces market liquidity and increases market volatility as market conditions deteriorate. We look at this relationship by performing Granger causality tests using a vector autoregression (VAR) framework. Table OA-1 reports the results.

*For more information see `http://www.cmegroup.com/clearing/files/span-methodology.pdf`.
†We did not find any data on a Canadian VIX.

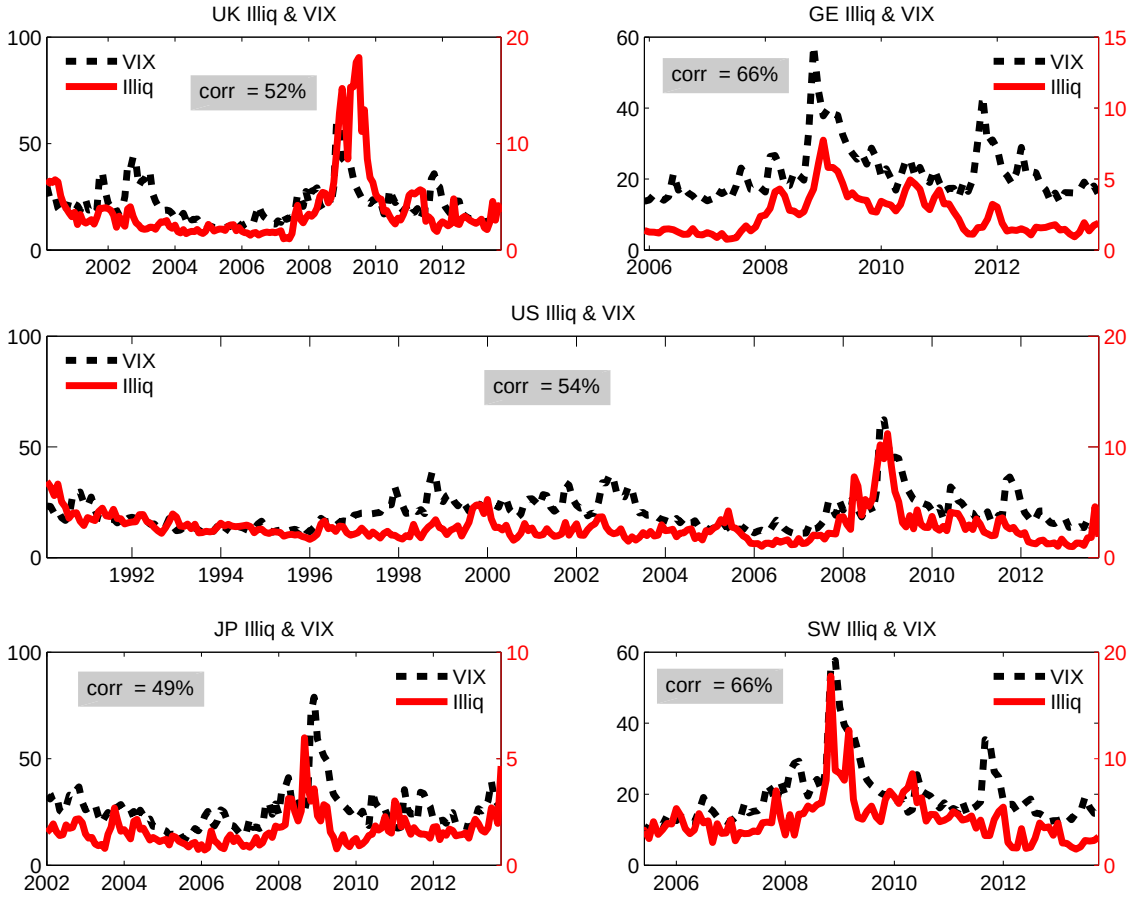

Figure OA-2. Illiquidity Proxies and Country-Level VIX

This figure plots monthly country-level VIX together with the illiquidity proxies. Data is monthly and starts in January 1990 (US), February 1992 (GE), February 2000 (UK), February 2001 (JP), May 2005 (SW) and ends in December 2012.

- **Illiquidity ⇒ Volatility and Amihud:** We find that for the US and Switzerland, we reject the null that illiquidity does not Granger cause volatility and for the US and Japan we reject the null that Illiquidity does not cause the Amihud illiquidity.
- **Volatility ⇒ Illiquidity and Amihud:** We reject the null of no Granger causality between volatility and illiquidity (Amihud) for US, Germany and United Kingdom (US and United Kingdom).
- **Amihud ⇒ Illiquidity and Volatility:** We reject the null of no Granger causality from the Amihud illiquidity proxy onto our illiquidity proxy (volatility) for the UK only (US, Germany and UK).

Table OA-1
Granger Causality Test

This table shows Granger causality tests between illiquidity, the Amihud measure and the country-level VIX. We test whether the row variable does not Granger cause the column variable. We report the χ^2 and p-value (in parentheses) for each pair. The optimal lag length is chosen according to the Schwartz criterion.

	US				GE		
	Illiq	VIX	Amihud		Illiq	VIX	Amihud
Illiq		4.27	3.84	Illiq		0.06	0.018
		(0.02)	(0.02)			(0.94)	(0.98)
VIX	3.84		7.69	VIX	2.79		0.52
	(0.02)		(0.00)		(0.06)		(0.59)
Amihud	1.73	3.50		Amihud	0.29	4.16	
	(0.18)	(0.03)			(0.74)	(0.01)	
	CA				UK		
	Illiq	VIX	Amihud		Illiq	VIX	Amihud
Illiq			0.52	Illiq		0.11	0.89
			(0.60)			(0.89)	(0.40)
VIX				VIX	7.22		2.61
					(0.00)		(0.08)
Amihud	1.95			Amihud	8.26	3.66	
	(0.14)				(0.00)	(0.02)	
	JP				SW		
	Illiq	VIX	Amihud		Illiq	VIX	Amihud
Illiq		0.61	2.76	Illiq		3.86	1.94
		(0.55)	(0.06)			(0.02)	(0.15)
VIX	0.05		0.19	VIX	1.66		1.15
	(0.95)		(0.83)		(0.20)		(0.32)
Amihud	0.07	0.35		Amihud	1.02	1.02	
	(0.93)	(0.71)			(0.36)	(0.36)	

Appendix OA-3 Comparison Funding Proxies Others

In the following, we compare different proxies of illiquidity used in the literature with our global illiquidity measure.

- Goyenko, Subrahmanyam, and Ukhov (2011), Goyenko (2013), and Goyenko and Sarkissian (2014) calculate the illiquidity of off-the-run T-Bills with maturities between 6 and 12 months. Illiquidity is the average spread between ask and bid prices scaled by the mid-point. The monthly average spread is then computed for each security and then equal weighted across different assets for each month.

- Based on theory in Vayanos (2004), Fontaine and Garcia (2012) extract a latent liquidity premium from estimating a term structure model from a panel of pairs of US Treasury securities where each pair has similar cash flows but different ages. The intuition is that older bonds are less liquid.
- The US VIX is often used as a proxy of funding illiquidity (see e.g., Brunnermeier and Pedersen (2009)). We also look at Treasury implied volatility (TIV) constructed in Choi, Mueller, and Vedolin (2015). The TIV is akin to the VIX and represents a model-free implied volatility measure from one-month options written on 30-year Treasury futures.
- The TED spread is the difference between the three-month Eurodollar deposit yield (LIBOR) and three-month US T-Bills.
- The global Amihud illiquidity proxy is constructed in a similar way as our global illiquidity proxy by weighting each country specific Amihud illiquidity proxy by its GDP and then aggregate it to the global measure.

The different time-series are plotted in Figure OA-3. We note that all proxies tend to increase during crisis periods such as the 2008 financial crisis. The unconditional correlation between the different proxies and our global can be as big as 65% (Goyenko, Subrahmanyam, and Ukhov (2011) proxy) and as low as 4% (Fontaine and Garcia (2012) measure).

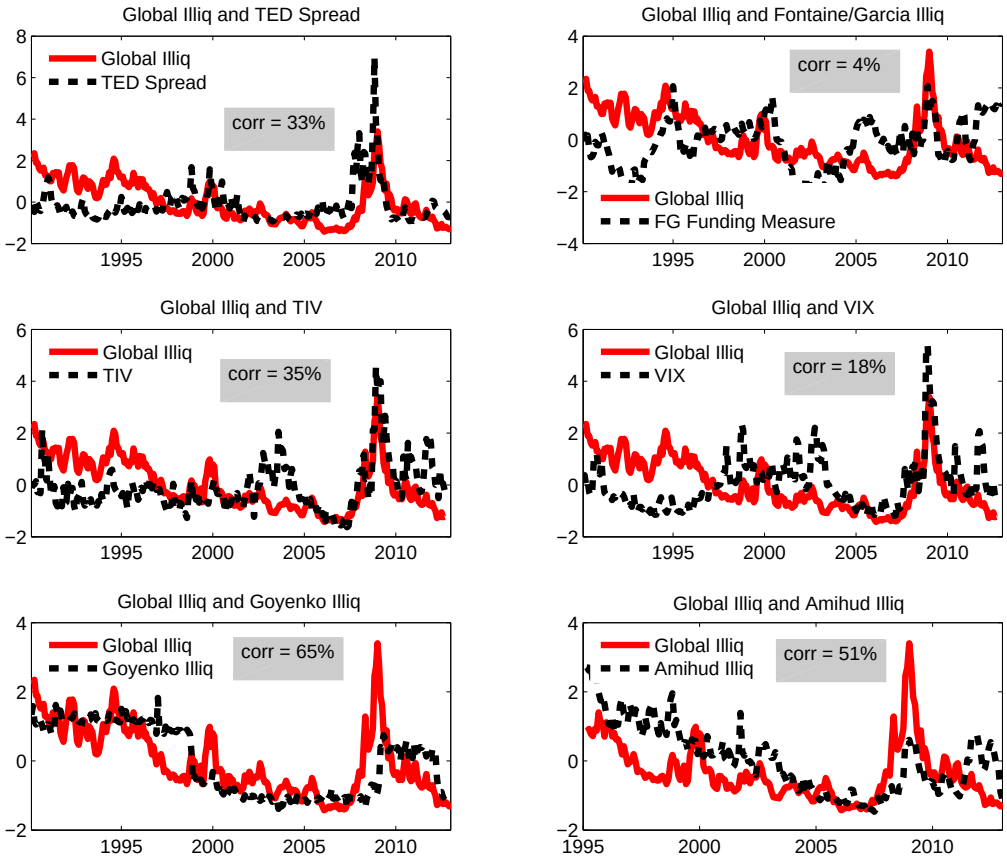

Figure OA-3. Global Illiquidity Proxy and Other Funding Measures

This figure plots monthly global illiquidity together with different proxies of illiquidity such as the TED spread (upper left panel), the Fontaine and Garcia funding measure (upper right panel), Treasury implied volatility (middle left panel), US VIX (middle right panel), the Goyenko, Subrahmanyam, and Ukhov (2011) illiquidity proxy (lower left panel) and a global Amihud illiquidity proxy (lower right panel). All variables are normalized, i.e., they are de-meaned and have a standard deviation of one.