Illiquidity, return and risk in G7 stock markets: interdependencies and spillovers

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2012

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July 2012

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Abstract: Trading activity in G7 stock markets reflects not only the macroeconomic and financial impact of these G7 economies in international economic growth, but also their financial interdependence. While this nexus of major stock market has been explored in terms of volatility and return spillovers, there has been no combined analysis of return, volatility and illiquidity spillovers. We study illiquidity spillovers because they are transmissions of trading activity and, thereof, transmissions of information and market sentiment. We discover Granger-causal associations between risk, return and illiquidity across G7 stock market and also within each stock market. Our findings bear significance for the regulation of international financial markets and also for international portfolio diversification.

JEL classification: C32; G12; G15.

Keywords: Illiquidity spillovers,

return spillovers, volatility spillovers, VAR, G7 stock markets.

1. Introduction

Major systemic changes in the financial marketplace may be of local origin but they are articulated in an international factual context. Recent stories of financial shock have been characteristic. For instance, the crisis in the US financial system in 2007 quickly spread to major international markets of money and capital, propagating shortages in liquidity which led to a subsequent international recession. More recently, the liquidity crisis of a single sovereign debtor (Greece) has challenged the viability of the Euro and the Eurozone; this national crisis has been politically confronted in the context of international financial institutions: resort to the International Monetary Fund and the European Central Bank with the strategic objective of getting sustainable access to lower interest rates in international capital markets. This process of international impact, originating from local financial origins, is a process of continuous change. Markets change as an internationally dispersed mass of market participants trade securities and signal their views on asset values, regulators restructure the institutions of capital flows and asset prices constellate a fragile market consensus on the prospects of capital investments.

In this international and volatile setting of capital allocation, we focus on stock markets because of their importance for economic growth, social welfare, and political reform (e.g. Shen and Lee, 2006; Gustman et al., 2010; Bieling, 2003). Out of the ensemble of international stock markets, we focus on the stock markets of G7 countries, because a) they have been the trading platforms for a major part of international market capitalization over the past three decades and b) the dynamics of stock prices in these markets are interwoven, in a manner that mirrors the interdependence of macroeconomic fundamentals of these industrialized economies (Morana, 2008).

Exploring financial integration among G7 stock markets, we focus on liquidity, risk and return spillovers for two reasons. Firstly, stock market liquidity, risk and return on a national level have been shown to be driven by respective changes in liquidity, risk and return on an international level (e.g. Brockman et al. 2009; Griffin, 2002; Faff et al., 2006) and, secondly, there is ample empirical evidence on the interaction across liquidity, volatility and risk. The argument for a causal link between liquidity and returns is originated in microeconomic arguments (Amihud and Mendelson, 1986; Holmström and Tirole, 2001) as well empirical evidence (e.g. Brennan and Subrahmanyam, 1996; Brennan et al., 1998; Amihud, 2002; Liu, 2006) that liquidity is a priced factor in the cross section of expected stock returns but also in evidence that liquidity itself is affected by stock returns (Brockman et al., 2009). Our argument for the dependence of liquidity on risk and returns is corroborated by evidence that liquidity is affected by trading activity (e.g., Branch and Freed, 1977; Menyah and Paudyal, 1996; Chai et al., 2010) and variations in trading activity are determined by variations in returns and risk (Chordia et al., 2007); volatility spillovers across major stock markets are associated with spillovers in trading activity (Gagnon and Karolyi, 2003).

Prior research on the integration of international stock markets can be classified in two major strands. There is, on one hand, the part of the literature that focuses on phenomena of regional origin and global impact, like the Asian crisis or the introduction of the Euro (e.g., Kim, 2005; Gebka and Serva, 2006; Caporale and Spagnolo, 2011); these studies explore financial integration between regional stock markets and some leading stock exchanges, typically from United States (US) and Japan. The other strand of literature studies financial integration between major international stock markets; these studies include data from Japan, US and some major European markets; they are motivated by the influence of these stock markets on the international financial marketplace and they largely focus on return and volatility spillovers.

Early research on financial integration and spillovers, in the context of major capital markets, includes Hamao et al. (1990) and Koutmos and Booth (1995). These two papers were the first to study the effect of the financial crisis of 1987 on the transmission of returns and volatility across major stock markets (New York, London and Tokyo); they were also the first to employ autoregressive conditional heteroskedasticity (ARCH) models in the analysis of volatility transmission across markets. These early studies on spillovers discovered that the transmission of asset price dynamics increased as a result of the 1987 crash. In Europe, the convergence of major stock markets in the 1990's was attributed with macroeconomic converge in the period before the introduction of the Euro (Baele, 2005) (Kim et al. (2005) and Savva et al. (2009) also produced results the monetary integration in the European Union was instrumental in fostering the integration of European stock markets).

After the crash of 1987, the analysis of spillovers of market fluctuations focused on subsequent events of international impact, as these events triggered transmission of information and trading activity across leading stock markets (the Mexican crisis of 1994, Asian crisis of 1997, the Russian crisis of 1998, the introduction of the euro in 1999). Even though most studies explored the spillovers between southeast Asian markets and US or Japan, Caporale et al. (2006) incorporated US, Japan and major European stock markets in the analysis of contagion effects of the Asian crisis; they conducted a GARCH-BEKK analysis with daily data and discovered that the transmission of returns and volatility was unidirectional in times of crisis, from the Asian markets to US and European markets. In this line of work, studying the impact of crises in contagion effects, Diebold and Yilmaz (2009) studied 19 international equity markets in a period covering all major financial events from 1992 to 2007; the authors produced a method to measure separately the volatility spillovers and the return spillovers and discovered that, over their sample period, return spillovers demonstrated an increasing trend and thus produced evidence of increased integration of international equity markets, while volatility spillovers exhibited bursts in times of crises.[1]

While all previous research examined spillovers of risk and return across stock markets, the analysis of the international transmission of asset price dynamics has yet to incorporate the critical asset-pricing factor of liquidity. Our contribution is to perform an analysis on (il)liquidity spillovers across G7 capital markets, extending previous work on the transmission of asset price dynamics across major capital markets. In the context of a spillover analysis, our results demonstrate the significant impact of illiquidity in the fluctuation of asset prices in major international stock markets: across G7 stock markets, illiquidity bears a Granger-causal effect on volatility and illiquidity shocks are internationally correlated; our results on the role of illiquidity are robust to presence of major financial crises. In this way we extend the literature on return and volatility spillovers by demonstrating the effect of trading activity and, ultimately, illiquidity on the transmission of information across major international financial markets. We also make a contribution to the literature on international comovements of illiquidity, extending it beyond the scope of commonality and demonstrating the Granger-causal impact of volatility and return spillovers to cross-country variations of illiquidity. The following section will describe our sample and methodology; the third section will present and discuss our econometric results; the final section concludes the paper.

3. Data and descriptive statistics

We collect daily data on stock returns and dollar volumes from Thomson Datastream. Our sample incorporates all the stocks that were traded (dead or alive) from June 28, 1991 to December 30, 2009, in the G7 markets: Canada, France, Germany, Italy, UK, and U.S. All stock prices are denominated in US dollars. Stock returns were calculated as log-differences of successive closing prices. Illiquidity was measured with the measure of Amihud (2002). The daily illiquidity measure for each stock is computed based on volume and return as follows:

$$Ill_{i,t} = \frac{|R_{i,t}|}{Vol_{i,t}}$$

where $R_{i,t}$ is the logarithmic return of stock i at day t and $Vol_{i,t}$ is the dollar volume of stock i at day t.

[1] In terms of methodology and data set, previous research on volatility spillovers can be compactly synopsized in the work of Singh et al. (2010). Studying a large sample of national stock markets –including all G7 markets- and employing special attention to the time differences among markets, they employed a Vector Autoregressive (VAR) approach to AR-GARCH volatility spillovers and discovered that return and volatility spillover effects on a market originate from international markets that close just before it, confirming similar empirical results in Milunovich and Thorp (2007) for British, US and Japanese equity markets

Our measures for aggregate stock market returns and illiquidity are equally-weighted, consistent with previous literature in the field (e.g. Brockman et al., 2009). We convert our data from the daily to the weekly frequency in order to avoid the problem of non-synchronous trading. Weekly market returns (Wednesday-to-Wednesday) are calculated by compounding daily market returns over a week period. Weekly market illiquidity measures are calculated as the mean of the daily illiquidity measure over the week.

Ince and Porter (2006) have argued that equity data from Thomson Datastream must be handled with care, as economic inference may be misleading without cleaning procedures of the data. Therefore, we impose the following filters,[2] in order to minimize the risk of data errors and to account for potential peculiarities of the dataset:

1. We include in our database only the stocks that were classified as "equities" (Datastream stock type: EQ).
2. We exclude all the foreign companies by using the geography group code (Datastream datatype: GEOG).
3. We excluded all the companies that are not listed on the primary stock exchange (Datastream datatype: EXMNEM).
4. We use Level 2, Level 3, and Level 4 sector names and the names of the companies to identify and exclude closed end funds, REITs, ADRs and preferred stocks.
5. We delete all the zero returns from the last observation to the first with non-zero return.
6. We set the return as missing if the return index[3] was below 3 (Datastream datatype: RI).
7. We only use daily returns that are higher (lower) than the 1% (99%) of all the stocks returns in a day.
8. We remove 2% of the stocks with the smallest capitalization, in each stock market, in order to address the outlier effect[4]. We also remove 2% of the stocks with the smallest unadjusted price, in order to minimize the bias that may arise from the low-priced stocks.

Table 1 presents some key statistical properties of our data set. We observe that the Canadian market has the highest illiquidity and is also the one with the highest return (0,16% in terms of weekly return and an Amihud measure of 4.9%), hinting to the familiar intuition that investments in illiquid stocks are undertaken on the expectation of higher returns. We also find the market with the highest volatility of returns (Italy, with 2.1% volatility of weekly returns) is also the most liquid market (the lowest Amihud measure equal to 0.08%), producing support for the argument of Bushee (2004) that more volatile stocks are also the most liquid, as they are associated with higher levels of share turnover. The well known features of asymmetry and

[2] Hou et al. (2011), Guo and Savickas (2008), and Busse et al. (2011) impose similar filters to account for potential data errors.
[3] The return index is a Datastream variable that is used to calculate the total return of a stock. A return index less than 3 indicates that the security lost 97% of its value over its life.
[4] Simiraly, Ang et al. (2009) remove 5% of the stocks with the smallest capitalization to address the outlier effect.

fat tails in returns series are also present in the illiquidity series for the G7 stock markets (with the exception of Japan and US). Moreover, Table 2 shows evidence of significantly positive correlation of the illiquidity measures of our stock markets with the exception of Canada and Italy supporting our initial assumption that trading activity – and hence illiquidity- across leading stock markets is interconnected. The Canadian and Italian stock market illiquidity measures are significantly positively correlated only with US. Figure 1 plots the time series for the illiquidity measures in the G7 stock markets. Corroborating the results of Chordia et al. (2005), we also discover that illiquidity is in all markets, except Canada, expectedly higher in times of financial crises, rising during the financial crisis of 2007and 2008, while being preceded by a period of relatively stable and low illiquidity in the two years before the crisis.

<Take in Tables 1 and 2 about here>
<Take in Figure 1 about here>

Modeling the volatility of stock returns, we employ the EGARCH model of Nelson (1991) as follows:

$$R_{i,t} = \mu_i + u_{i,t}$$

$$ln\left(\sigma_{i,t}^2\right) = a_{i0} + a_{i1}\left(\frac{\left|u_{i,t-1}\right|}{\sigma_{i,t-1}} - E\frac{\left|u_{i,t-1}\right|}{\sigma_{i,t-1}}\right) + \gamma_{i1}\frac{u_{i,t-1}}{\sigma_{i,t-1}} + \varphi_{i1} ln\left(\sigma_{i,t-1}^2\right)$$

Following Gallant et al. (1992), we adjust all return, volatility and illiquidity measures for deterministic time series variations as follows.

We regress the series, w, on a set of adjustment variables, x.

$$w = x'b + e$$

The residuals are used to construct the following variance equation

$$\log\left(e^2\right) = x'g + v$$

The variance equation is used to standardize the residuals from the mean equation and the adjusted w was calculated in the following equation:

$$w_{adj} = \delta + \varepsilon\left[\frac{\hat{e}}{exp(x'\gamma/2)}\right]$$

where δ and ε are chosen such that the sample means and the variance of the adjusted and unadjusted series remain the same and x is the vector of the adjustment variables including eleven month of the year dummies, a time trend squared time trend and three lags.

All adjusted series are tested for stationarity using the augmented Dickey-Fuller and Phillips-Perron tests. We include an intercept in the alternative hypothesis and use information criteria to select the lag length. We reject the unit-root hypothesis in all series at least at the 1% significance level.

4. Vector autoregression: estimation and empirical results

Having adjusted our stock market measures in order to account for time series effects, we approximate the association between illiquidity, risk and return with a Vector Autoregression approach (VAR). In the first part of our analysis we explore return, volatility and illiquidity spillovers within each market. For each country we estimate a three equation VAR that incorporates three variables (i.e. measures of returns, volatility and illiquidity).

$$Y_{i,t} = \sum_{k=1}^{m} a_{ik} \mathrm{U}_{i,t-k} + u_{i,t}$$

where $Y_{i,t}$ is a vector representing the adjusted measures of illiquidity, returns and volatility in stock market i at week t.

In the second part of our analysis we investigate cross-market price, volatility and illiquidity spillovers for each pair of countries. We estimate a six equation VAR for each pair of countries that incorporates six variables, (i.e. measures of returns, volatility and liquidity for each country.

$$Y_{i,t} = \sum_{k=1}^{m} a_{ik} Y_{i,t-k} + \sum_{k=1}^{m} b_{ik} Y_{j,t-k} u_{i,t}$$
$$Y_{j,t} = \sum_{k=1}^{m} a_{jk} Y_{j,t-k} + \sum_{k=1}^{m} b_{jk} Y_{i,t-k} + u_{j,t}$$

where Y_{it}, Y_{jt} are vectors representing liquidity, returns and volatility in country i and j, respectively. We choose the number of lags m based on the Akaike information criterion (AIC) and the Schwartz Bayesian information criterion (SIC). When these two criteria suggest different lag lengths we chose the lesser lag length for the sake of parsimony.

Furthermore, since spillovers of market dynamics are spillovers of market sentiment and trading activity and such effects are typical of financial crises, in the third section of our analysis we explore the performance of our model in times of crisis: the Asian crisis (July 2 to December 31 1997), the Russian crisis (August 17 1998 to December 31 1998) and the recent credit crisis (August 9 2007 to December 30 2009).

In Table 3 we report the results of individual VAR estimations for each country for the whole sample. Panel A of Table 3 presents the correlation matrix of contemporaneous innovations from VAR estimation while Panel B reports the p-values of the pair-wise Granger causality tests between the endogenous variables of VAR. Innovations in stock market returns and illiquidity are significantly negatively correlated in the case of Canada, France, Japan and UK, but with a low degree of correlation. Return and illiquidity shocks in these countries have an average correlation of -0,094. The tables also show that shocks to volatility and shocks to illiquidity are significantly and positively correlated only in the case of the US stock market, the correlation coefficient assuming a value of 0,1763. This is consistent with the results of Chordia et al. (2011) who report strong positive correlations between volatility and illiquidity innovations for the US stock market.

Furthermore, we test the null hypothesis that variable i does not Granger cause variable j i.e. that the lag coefficients of variable i are jointly zero when variable j is the dependent variable. Panel B of Table 3 reports the p-values of the above test hypotheses where i is the column variable and j is the row variable. The Granger-causal effect of return on volatility is evident within all markets of our sample and can thus corroborate an argument in favor of a leverage effect which has been established in developed capital markets (Bekaert and Wu, 2000). On the contrary, there is some evidence on a Granger-causal effect of illiquidity on return (it is only observed in the German and the UK market) and vice versa (for Canada, Italy, Japan and US). We hold that the contrast between this unexpected result and previous findings in the literature can be explained with the fact that previous studies on the cross section of stock returns have been mostly structured on monthly data (e.g. Lee, 2011. The significant (causal) bidirectional interaction between volatility and illiquidity -largely associated with the risks that the market makers undertake- is only present also in the US, confirming the intuition that has been documented in previous studies of the US stock market (e.g. Chordia et al., 2000; Chordia et al., 2001; Chordia et al., 2006).

<Take in Tables 3 and 4 about here>

The analysis of the functional association between illiquidity, volatility and returns extends to the estimation of causal effects and correlations across stock markets. Table 4 presents a synopsis of the VAR estimation results for all pairs of countries.[5] Our empirical results also indicate that the structural interdependence of illiquidity, return and volatility is extensively present across G7 stock markets, with, e.g., volatility in the UK Granger-causing illiquidity in the US. Such results are largely expected since major stock markets are substantially integrated, as our evidence and many previous papers (e.g. Milunovich and Thorp, 2007; Morana, 2008). Markedly, the interdependence of major stock markets is documented in the comovements of return, volatility and illiquidity across markets. While spillovers and correlations of volatility and returns have been discovered in previous studies (e.g. Caporale et al., 2006; Diebold and Yilmaz, 2009), our analysis incorporates the effect of illiquidity in the discussion of inter-market comovements. In this context, we

[5] The complete VAR results are available by the authors upon request.

see that the contemparenous correlation between innovations in index returns reaches 100%, covering all our sample, in both crisis and non-crisis periods. In terms of volatility and illiquidity, evidence of cross-country shock correlations is still manifest (more than two thirds of the cases exhibit significant positive correlations). In terms of structural dependence, we see that volatility Granger-causes illiquidity (and vice versa) across markets, in more than 30% of the cases, supporting the intuition and findings of previous research on the international character of the liquidity-volatility relation (Brockman et al., 2009). One of the most interesting results is that in 81% of the cases illiquidity in one market causes illiquidity in other markets while a causal relationship in terms of returns and volatility is reported in 19% and 69% of the cases, respectively, underlining the principal role of illiquidity in financial contagion. In the third section of our analysis we repeat the VAR analysis for the sub-sample of crisis periods and the sub-sample of non crisis periods. Table 5 reports the correlation matrix of cross-country VAR innovations for crisis and non crisis periods while Table 6 presents the p-values of the Granger causality tests for crisis and non crisis periods. Interestingly, evidence of comovements in illiquidity and volatility is less manifest in times of crisis. With respect to returns and volatility, there is no substantial shift in and correlation between crisis and non crisis periods.In terms of causality, Moreover, volatility spillovers and illiquidity spillovers across markets are less frequent in times of crisis (the percentage of significant illiquidity spillovers drops from 62% to 33%). This could be attributed to the fact that - as trading activity reflects the flow of sentiment and information across markets - transmissions of illiquidity and volatility in times of crisis take place almost immediately and are thus less evident in our data of weekly frequency. This also explains why evidence of interaction is richer in our correlation results rather than Granger-causality which allows for a lag in order for causal relations to be effective.

<Take in Tables 5 and 6 about here>

Summarizing, we find out that spillover effects in both returns and volatility are neutral to the effects of financial crises, the key results being essentially stable in both crisis and non-crisis periods. While such a finding might be striking for a study of spillovers (and therefore of contagion effects), we hold that this is due to the fact that crises often have regional origin and global impact (e.g. Peso crisis, Asian crisis) and the transmission of trading activity and sentiment trigger spillover effects in the direction from the crisis' regional origin to the major markets rather than spillover effects across major, mature markets which rapidly assimilate the impact of regional shocks (Caporale et al., 2006).

5. Final remarks

International financial crises have had a significant toll over European capital markets and national economies over the past 15 years. Market collapses of initially local origin -the Mexican crisis in 1994, the Asian financial crisis in 1997, the Russian financial crisis in 1998- had an immediate, fundamental impact in economic activities and financial systems worldwide. The contagious nature of these economic events has motivated an ongoing debate on the effects of financial contagion on risk management and market efficiency. The speed and impact of contagion effects as well as the extent of their association with economic fundamentals are significant for the assessment of the informational and valuation efficiency of stock markets. Furthermore, the degree of comovement among stock markets is important in portfolio selection, as risk and return of national stock indices may be increasingly correlated as a result of an event with local origin but global impact.

The empirical results of this study suggest that there is a strong negative contemporaneous relationship between illiquidity and return within each market with returns causing illiquidity and not vice versa in most of the cases. We discover that the contemparenous association as well as the causal relationship between illiquidity and volatility is significant only within the US stock market. Our results indicate significant cross-market effects in terms of return, volatility and illiquidity. The causal association between international stock markets is strongly documented first in terms of illiquidity, secondly in terms of volatility and thirdly in terms of returns. In major stock markets, the interdependence of illiquidity, returns and risk are structurally invariant to the presence of international financial crises.

Future research in this field could respond to a plethora of challenges. First, the robustness of our findings on spillovers has to be checked in non Gaussian modeling frameworks, given previous evidence that spillover results in major equity markets are sensitive on the modeling of fat tails in the distribution of asset returns (Ané and Labidi, 2006). Second, the effect of time differences between stock markets should be further explored with respect with transmissions of trading activity and illiquidity across markets. Finally, we should note that time series of stock prices are financial events. As such, they are generated by causal mechanisms that drive the behavior of market participants and transformations of institutional structures and macroeconomic environment; Granger causality is one way of identifying causes and results in finance, but, in an analysis of volatility and liquidity spillovers, it does not account for the causal significance of institutional and political environment; it also does not account for the non-deterministic choices of market participants who reproduce or transform these environments. Econometric results on spillovers are very useful for international portfolio diversification (e.g. Milunovich and Thorp, 2006), but the identification of causality –and the success of portfolio diversification itself- needs to account for the fact that financial markets are open systems, with social coordinates and indeterminate institutional evolution.

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TABLES

Table 1

Descriptive statistics of returns and illiquidity

Country	Mean	Median	Minimum	Maximum	SD	Skewness	Kurtosis
(a) Return							
Canada	0,0016	0,0036	-0,1480	0,0762	0,0199	-1,1709	8,8735
France	0,0011	0,0015	-0,0692	0,0740	0,0148	-0,4239	5,2173
Germany	-0,0009	0,0001	-0,0853	0,0683	0,0160	-0,6139	5,2571
Italy	-0,0009	0,0002	-0,0923	0,0809	0,0210	-0,2211	4,3850
Japan	-0,0005	-0,0003	-0,0825	0,0737	0,0208	0,0175	3,7339
UK	-0,0010	0,0001	-0,0751	0,0514	0,0144	-0,6571	5,3861
US	0,0013	0,0037	-0,1210	0,0804	0,0172	-0,8791	7,1880
(b) Illiquidity							
Canada	0,0490	0,0439	0,0028	0,1859	0,0380	0,7728	3,1051
France	0,0024	0,0017	0,0004	0,0121	0,0020	1,7097	5,8808
Germany	0,0044	0,0019	0,0000	0,0315	0,0056	1,6128	5,4635
Italy	0,0008	0,0004	0,0000	0,0093	0,0012	3,1195	14,7025
Japan	0,0011	0,0009	0,0002	0,0044	0,0007	0,6612	2,5174
UK	0,0081	0,0053	0,0002	0,0537	0,0088	1,9940	7,6625
US	0,0013	0,0013	0,0001	0,0037	0,0008	0,4061	2,5277

The table presents the mean, median, minimum, maximum, standard deviation (SD), skewness and kurtosis for the stock market return and illiquidity of each country. The sample runs from June 28, 1991 to December 30, 2009.

Table 2

Correlation analysis of the illiquidity measures

	Canada	France	Germany	Italy	Japan	UK	US
Canada	1						
France	-0,2571*	1					
Germany	-0,4069*	0,9114*	1				
Italy	0,0395	-0,0620	-0,0632*	1			
Japan	-0,0096	0,5664*	0,4981*	-0,0772*	1		
UK	-0,2812*	0,8076*	0,7856*	-0,0829*	0,5167*	1	
US	0,6805*	0,2424*	0,1155*	0,1403*	0,1989*	0,1345*	1

The table presents the correlation matrix of the time-series of illiquidity measures. The sample runs from June 28, 1991 to December 30, 2009. * denotes significance at the 5% level.

Table 3

VAR estimation results for individual countries

		Return	Volatility	Illiquidity
(a) Contemporaneous correlations between VAR innovations				
Canada	Return	1		
	Volatility	-0,0047	1	
	Illiquidity	-0,1177*	0,0532	1
France	Return	1		
	Volatility	0,0266	1	
	Illiquidity	-0,0907*	-0,0014	1
Germany	Return	1		
	Volatility	-0,0019	1	
	Illiquidity	-0,0587	0,0331	1
Italy	Return	1		
	Volatility	0,0187	1	
	Illiquidity	-0,0508	0,0342	1
Japan	Return	1		
	Volatility	0,0695*	1	
	Illiquidity	-0,0846*	0,006	1
UK	Return	1		
	Volatility	0,0278	1	
	Illiquidity	-0,0846*	0,0174	1
US	Return	1		
	Volatility	-0,0308	1	
	Illiquidity	-0,0278	0,1761*	1
(b) P-values of the null hypothesis that the column variable does not Granger cause the row variable				
		Return	Volatility	Illiquidity
Canada	Return		0,5160	0,1502
	Volatility	0,0000		0,7511
	Liquidity	0,0009	0,4195	
France	Return		0,2083	0,1739
	Volatility	0,0000		0,1779
	Liquidity	0,4694	0,6331	
Germany	Return		0,0695	0,0332
	Volatility	0,0000		0,0662
	Liquidity	0,3748	0,5884	
Italy	Return		0,3841	0,3706
	Volatility	0,0025		0,1660
	Liquidity	0,0002	0,6019	
Japan	Return		0,0666	0,5981
	Volatility	0,0000		0,5253
	Liquidity	0,0000	0,4332	
UK	Return		0,2315	0,0453
	Volatility	0,0000		0,2393
	Liquidity	0,5179	0,1972	
US	Return		0,9250	0,3935
	Volatility	0,0000		0,0005
	Liquidity	0,0000	0,0192	

The table presents results from a three-variate VAR (vector autoregressive) for each country, $Y_{i,t} = \sum_{k=1}^{m} a_{ik} U_{i,t-k} + u_{i,t}$, where $Y_{i,t}$ is a vector of endogenous variables (return, volatility, illiquidity) for country *i* at week *t*. All variables are adjusted for deterministic time series variations. We choose the number of lags, m, based on the AIC and SBIC criteria. The sample runs from June 28, 1991 to December 30, 2009. * denotes significance at the 5% level.

Table 4

Summary of VAR estimation results for pairs of countries for the whole sample

			Country *i*		
			Return	Volatility	Illiquidity
(a) Contemporaneous correlations between VAR innovations					
Country *j*	Return	Mean	0,5441		
		Min	0,2665		
		Max	0,9231		
		Significant positive correlations (%)[a]	100,00		
		Significant negative correlations (%)[a]	0,00		
	Volatility	Mean	-0,0104	0,1790	
		Min	-0,2160	-0,0172	
		Max	0,0948	0,7922	
		Significant positive correlations (%)[a]	4,76	66,67	
		Significant negative correlations (%)[a]	16,67	0,00	
	Illiquidity	Mean	-0,0561	0,0449	0,0992
		Min	-0,1534	-0,1970	0,0065
		Max	0,0177	0,3895	0,2253
		Significant positive correlations (%)[a]	0,00	40,48	71,43
		Significant negative correlations (%)[a]	35,71	4,76	0,00
(*b) P-values of the null hypothesis that the column variable does not Granger cause the row variable*					
Country *j*	Return	Mean	0,4023	0,4830	0,3707
		Min	0,0120	0,0216	0,0050
		Max	0,9929	0,9379	0,9896
		Significant Granger causality tests (%)[a]	19,05	2,38	4,76
	Volatility	Mean	0,3970	0,1497	0,1991
		Min	0,0001	0,0000	0,0000
		Max	0,9923	0,8682	0,9972
		Significant Granger causality tests (%)[a]	16,67	69,05	33,33
	Illiquidity	Mean	0,4581	0,3753	0,0601
		Min	0,0251	0,0000	0,0000
		Max	0,9944	0,9500	0,6347
		Significant Granger causality tests (%)[a]	4,76	33,33	80,95

The table presents summary statistics for the results from a six-variate VAR for the cross-section of all pair of countries *i* and *j*,

$$Y_{i,t} = \sum_{k=1}^{m} a_{ik} Y_{i,t-k} + \sum_{k=1}^{m} b_{ik} Y_{j,t-k} + u_{i,t}$$

$$Y_{j,t} = \sum_{k=1}^{m} a_{jk} Y_{i,t-k} + \sum_{k=1}^{m} b_{jk} Y_{j,t-k} + u_{j,t}$$

where $Y_{i,t}$, $Y_{j,t}$ are vectors of endogenous variables (return, volatility and liquidity) for countries *i* and *j*, respectively, at week *t*. All variables are adjusted for deterministic time series variations. We choose the number of lags based on the AIC and SBIC criteria. The sample runs from June 28, 1991 to December 30, 2009.

[a]Tests are conducted at the 5% level of significance.

Table 5

Summary of VAR estimation results for pairs of countries for crisis periods and non crisis-periods – Contemporaneous correlations between VAR innovations

			Country *i*		
			Return	Volatility	Illiquidity
(a) Non crisis periods					
Country *j*	Return	Mean	0,4158		
		Min	0,2012		
		Max	0,8460		
		Significant positive correlations (%)[a]	100,00		
		Significant negative correlations (%)[a]	0,00		
	Volatility	Mean	0,0124	0,1139	
		Min	-0,0289	-0,0206	
		Max	0,0989	0,3454	
		Significant positive correlations (%)[a]	0,00	57,14	
		Significant negative correlations (%)[a]	0,00	0,00	
	Illiquidity	Mean	-0,0212	0,0218	0,0742
		Min	-0,0937	-0,2528	-0,0346
		Max	0,0735	0,1005	0,2941
		Significant positive correlations (%)[a]	2,38	9,52	57,14
		Significant negative correlations (%)[a]	16,67	2,38	0,00
(b) Crisis periods					
Country *j*	Return	Mean	0,5780		
		Min	0,1872		
		Max	0,9443		
		Significant positive correlations (%)[a]	100,00		
		Significant negative correlations (%)[a]	0,00		
	Volatility	Mean	-0,0060	0,1784	
		Min	-0,3752	-0,1087	
		Max	0,9443	0,9279	
		Significant positive correlations (%)[a]	2,38	57,14	
		Significant negative correlations (%)[a]	7,14	0,00	
	Illiquidity	Mean	-0,0576	0,0428	0,1113
		Min	-0,1752	-0,2010	-0,0527
		Max	0,1292	0,5493	0,2390
		Significant positive correlations (%)[a]	0,00	11,90	38,10
		Significant negative correlations (%)[a]	14,29	4,76	0,00

The table presents summary statistics for the contemporaneous correlations between VAR innovations from a six-variate VAR for the cross-section of all pair of countries i and j,

$$Y_{i,t} = \sum_{k=1}^{m} a_{ik} Y_{i,t-k} + \sum_{k=1}^{m} b_{ik} Y_{j,t-k} + u_{i,t}$$

$$Y_{j,t} = \sum_{k=1}^{m} a_{jk} Y_{i,t-k} + \sum_{k=1}^{m} b_{jk} Y_{j,t-k} + u_{j,t}$$

where Y_{it}, $Y_{j,t}$ are vectors of endogenous variables (return, volatility and liquidity) for countries *i* and *j*, respectively, at week t. All variables are adjusted for deterministic time series variations. We choose the number of lags based on the AIC and SBIC criteria. The crisis period sample spans the Asian crisis (July2, 1997 to December 31, 1997), the Russian crisis (August 17, 1998 to December 31, 1998) and the 2008 financial crisis (August 9, 2007 to December 30, 2009).

[a]Tests are conducted at the 5% level of significance.

Table 6

Summary of VAR estimation results for pairs of countries for crisis periods and non crisis-periods – P-values of Granger causality tests

			Country *i*		
			Return	Volatility	Illiquidity
(a) Non crisis periods					
Country *j*	Return	Mean	0,4704	0,4531	0,4103
		Min	0,0083	0,0078	0,0034
		Max	0,9557	0,9775	0,9898
		Significant Granger causality tests (%)[a]	4,76	11,90	11,90
	Volatility	Mean	0,3435	0,2288	0,2652
		Min	0,0032	0,0000	0,0000
		Max	0,9945	0,9821	0,8971
		Significant Granger causality tests (%)[a]	19,05	54,76	38,10
	Illiquidity	Mean	0,4698	0,3033	0,1969
		Min	0,0006	0,0000	0,0000
		Max	0,9763	0,9490	0,9989
		Significant Granger causality tests (%)[a]	19,0476	35,7143	61,90
(b) Crisis periods					
Country *j*	Return	Mean	0,4751	0,4147	0,5837
		Min	0,0071	0,0063	0,0267
		Max	0,9549	0,9954	0,9978
		Significant Granger causality tests (%)[a]	4,76	14,29	7,14
	Volatility	Mean	0,4831	0,2643	0,3836
		Min	0,0002	0,0000	0,0014
		Max	0,9398	0,9410	0,9682
		Significant Granger causality tests (%)[a]	7,14	38,10	21,43
	Illiquidity	Mean	0,6687	0,3731	0,2617
		Min	0,1423	0,0000	0,0000
		Max	0,9642	0,9517	0,9891
		Significant Granger causality tests (%)[a]	0,00	21,43	33,33

The table presents summary statistics for Granger causality tests from a six-variate VAR for the cross-section of all pair of countries i and j,

$$Y_{i,t} = \sum_{k=1}^{m} a_{ik} Y_{i,t-k} + \sum_{k=1}^{m} b_{ik} Y_{j,t-k} + u_{i,t}$$

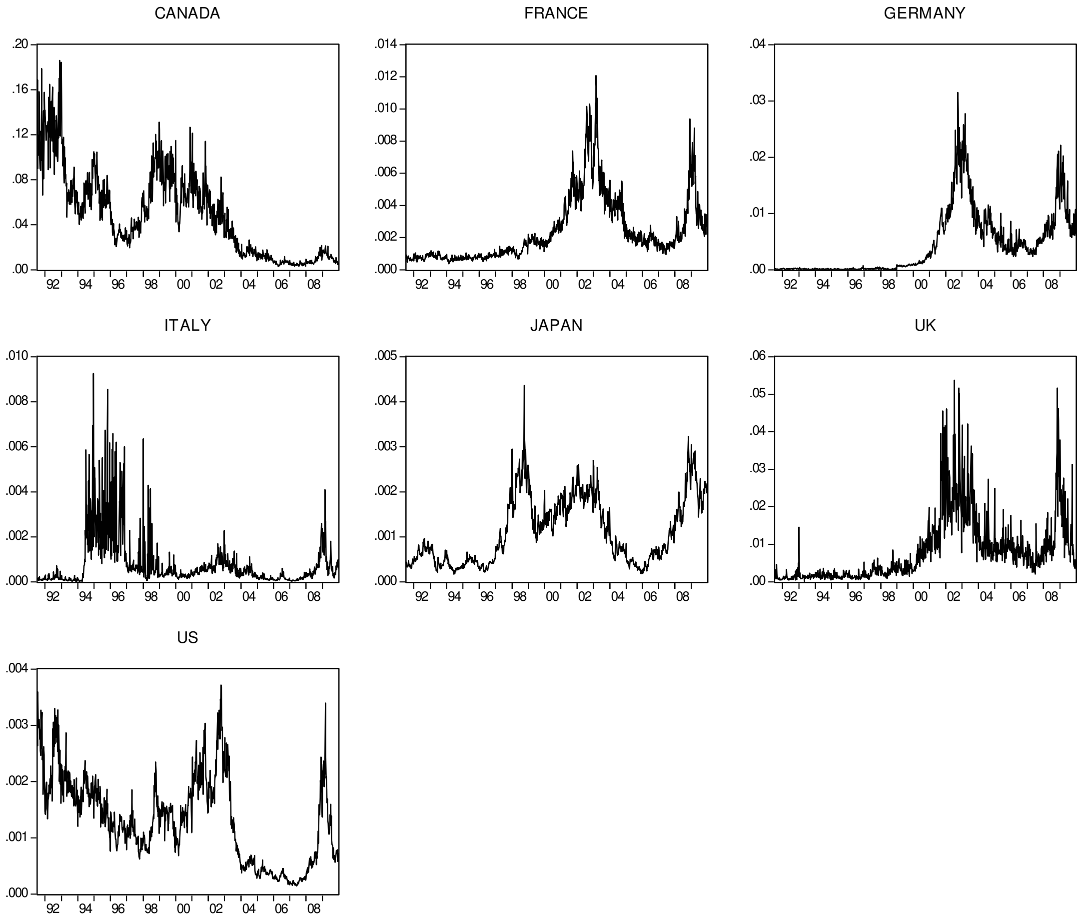
$$Y_{j,t} = \sum_{k=1}^{m} a_{jk} Y_{i,t-k} + \sum_{k=1}^{m} b_{jk} Y_{j,t-k} + u_{j,t}$$

where $Y_{i,t}$, $Y_{j,t}$ are vectors of endogenous variables (return, volatility and liquidity) for countries *i* and *j*, respectively, at week *t*. All variables are adjusted for deterministic time series variations. We choose the number of lags based on the AIC and SBIC criteria. *)* P-values of the null hypothesis that the column variable does not Granger cause the row variable. The crisis period sample spans the Asian crisis (July2, 1997 to December 31, 1997), the Russian crisis (August 17, 1998 to December 31, 1998) and the 2008 financial crisis (August 9, 2007 to December 30, 2009).

[a]Tests are conducted at the 5% level of significance.

Figure 1

Time-series plots of illiquidity measures



The figure depicts the time-series of the illiquidity measures for each country for the sample period, June 28, 1991 to December 30, 2009.