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Are stock market crises contagious? The role of crisis definitions

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ABSTRACT

Financial contagion studies generally examine whether co-movement between markets increases during a crisis. We use a flexible co-movement measure to examine how conclusions of such analyses depend on the sample chosen as the 'crisis'. To this end, we analyse stock market co-movement during the 1997 Asian crisis and the 2007 global financial crisis for all possible source countries and for all possible time periods or extreme return quantiles. This way we account for the main crisis dating approaches adopted in the literature. Our results suggest there is no clear relationship between excess co-movement and commonly used crisis samples.

1. Introduction

Financial crises are characterised by the sudden and simultaneous materialisation of risks that in tranquil times were believed to be independent. As a result, the opportunities for risk spreading are diminished when they are most needed, which can pose a substantial threat to the stability of the financial system. The behaviour of international stock markets illustrates this effect: while in tranquil times returns across markets correlate only mildly, the correlation between them tends to jump when sudden price drops occur. This break-down of risk spreading opportunities in times of stock market crashes has induced investors to fear that during financial crises *contagion* takes place, i.e. a significant increase in co-movement between markets after controlling for economic fundamentals.[2] While the economic literature has proposed a large variety of methods to analyse contagion risk, consensus on the nature and magnitude thereof is yet to be reached.

The present paper contributes to the debate by analysing how conclusions about contagion depend on the choice of the 'crisis' sample. To this end, we use a flexible measure of stock market synchronicity proposed by Morck et al. (2000), and examine contagion by comparing synchronicity between various crisis and non-crisis samples. The interpretation of synchronicity is straightforward. In a two-market setting, for instance, the measure indicates whether or not both markets move in the same direction, i.e. up or down. While several useful approaches to analyse contagion have been proposed in the literature, for the purpose of our analysis, the synchronicity measure has the advantage of being directly applicable to various types of crisis samples. That is, it can be used to analyse co-movement between an arbitrary number of markets, over periods as short as a single trading day. Importantly, the measure allows us to vary the definition of the crisis sample while keeping the definition of co-movement constant, and, instead of requiring the market returns to be standardised, allows us to focus on returns as they are actually observed in financial markets. Moreover, by focusing on the synchronicity measure our analysis has implications for alternative approaches as well, as it is hard to think of a measure that would consider returns to be co-moving without at least requiring them to have similar signs.[3]

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[2] See, for instance, Forbes and Rigobon (2002), Bekaert et al. (2005), Dungey et al. (2005) and Corsetti et al. (2011). Pericoli and Sbracia (2003) provide an overview of alternative contagion definitions.

[3] Increases in synchronicity can only be attributed to financial contagion after controlling for the impact of economic fundamentals on co-movement between markets. This point was most clearly made by Forbes and Rigobon (2002) and Corsetti et al. (2005), who adjust their co-movement measures based on a model of fundamental stock market returns. Bekaert et al. (2005) suggest not to adjust the co-movement measure itself, but to instead estimate a model of fundamental stock market returns and then examine the co-movement between its residuals. We use a Vector Autoregression (VAR) model with commonly used indicators of economic fundamentals to filter the market returns.

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We use the synchronicity measure to analyse how choosing a particular 'crisis' sample affects the outcomes of the analysis. Defining such a sample amounts to deciding upon the stock markets between which co-movement is to be analysed, and upon the trading days for which the analysis is to be performed. Both decisions require some subjective judgement. Baur (2012), for instance, explains that even studies that avoid discretion in the definition of the crisis, use discretion in the choice of the econometric model to estimate when (and where) the crisis took place. Most studies choose the stock markets to be analysed by first selecting a 'source' market from which any contagion effects could have originated, and thereafter examine co-movement of this market with several other stock markets in the region. When studying the 1997 Asian crisis, Hong-Kong is often seen to be the culprit, while for the 2007 global financial crisis the United States is regarded as the source. For both crises we examine how such discretionary choices affect the contagion test results.

As is the case with choosing the stock markets to be analysed, choosing the trading days to be examined requires some arbitrary judgement as well. Broadly speaking two approaches exist: Forbes and Rigobon (2002) define a crisis period using a fixed time-frame after a critical event, while Bae et al. (2003) define the crisis sample as a quantile of returns which are considered 'extreme' in the sense that they exceed a given threshold (this quantile may be an adjacent period but may also be a set of non-sequential trading days). Although both approaches can be seen as canonical for the literature, they are not always straightforward to implement. Indeed, over 80 years after the Great Crash it is still not clear what can be considered the critical event that caused markets to collapse. In a similar vein, it is not directly obvious what can be considered an extreme return. We therefore study how discretionary choices for the implementation of both dating methods affect the outcomes of the analysis. To this end we examine synchronicity during all possible crisis periods, by varying these periods' lengths and starting dates, as well as during all possible crisis quantiles, by varying these quantiles' cut-off value for extreme returns.

Our analysis shows that, despite the common practise to report results for contagion during a predefined 'crisis' sample, there exist numerous combinations of countries and time periods or return quantiles for which synchronicity is significantly elevated. These sub-samples, however, are not clearly associated with particular 'crisis' countries, periods or thresholds. In addition, synchronicity during periods which usually are associated with financial crises is not found to be higher than synchronicity during many other periods. As a result, we find no evidence for a clear relationship between excess co-movement and commonly used crisis samples.

Our findings suggest that future research could shed more light on contagion risk by focusing on the determinants of excess co-movement, for instance along the lines of Christiansen and Ranaldo (2009) or Mink and de Haan (2013). While the first study focuses on the determinants of stock market integration, the second examines contagion during the 2010 Greek sovereign debt crisis. Analysing the news that drives excess co-movement between European bank stocks and Greek government bonds, the authors find that co-movement seems mainly driven by common fundamental factors rather than by contagion effects. Examining the determinants of excess synchronicity should be relatively straightforward as well, as the daily observations for synchronicity can directly be used as the dependent variable in a regression analysis. In addition, the measure could be used to examine contagion in other types of markets, such as the market for bonds or for foreign exchange (see, amongst others Gravelle et al., 2006; Garcia and Tsafack, 2011).

The remainder of the paper is structured as follows. The next section introduces the synchronicity measure and discusses the definition of financial crises. Section 3 applies the synchronicity measure to the 1997 Asian crisis and the 2007 global financial crisis. The final section provides an interpretation of our results and offers some concluding comments.

2. Method

2.1. Measuring stock market co-movement

Measuring contagion amounts to studying the difference in co-movement in filtered market returns (to control for economic fundamentals, see below) between tranquil times and times of crisis. In its purest form this boils down to performing a standard two-sample t-test:

$$t = \frac{f^{crisis} - f^{tranquil}}{S^{crisis}/\sqrt{T^{crisis}}} \sim t(v) \qquad (1)$$

where f is the value of the co-movement measure, S indicates the measure's standard deviation and T equals the number of trading days. If the value of the (one-tailed) test statistic exceeds the critical value corresponding to the distribution's degrees of freedom $v = T^{crisis} - 1$ and the desired significance level, the t-test indicates that co-movement is higher during crisis periods than at tranquil times. Hence, a value of t above the critical value indicates the existence of contagion.[4]

In order to measure co-movement between stock market returns we use the synchronicity measure proposed by Morck et al. (2000), which reads

$$f_{Nt} = \frac{\max\left[n_t^{up}, n_t^{down}\right]}{n_t^{up} + n_t^{down}} \qquad (2)$$

where n_t^{up} is the number of markets in which returns increased at trading day t, n_t^{down} is the number of markets in which returns decreased, and N denotes the total number of markets being studied. We focus on synchronicity values transformed to a (0,1) scale, by calculating $2f_{Nt} - 1$, so that the measure indicates the *proportion* of markets that were synchronised on trading day t. For $N = 2$, synchronicity then equals 1 when both markets move in the same direction and 0 when both markets move in opposite directions. Synchronicity between a single country i and the rest of the N markets is denoted as f_{iNt}, which is defined to equal 1 when market i moves in the same direction as the majority of the other markets, and 0 otherwise. In keeping with Morck et al. (2000), the averages of these measures over time are denoted as f_N for synchronicity between N markets, and f_{iN} for synchronicity of market i with the rest of the N markets. We denote $f_N^{tranquil}$ and $f_{iN}^{tranquil}$ as the values of synchronicity during tranquil periods, and f_N^{crisis} and f_{iN}^{crisis} as the values during the crisis period.

For sufficiently large N, Morck et al. (2000) invoke the central limit theorem and relate the the difference between two observed synchronicity values to the normal distribution. We instead relate this difference to the t-distribution, but for $N = 2$ use the fact that synchronicity on a given trading day can only equal 0 or 1, and thus follows a binomial distribution. Therefore, for $N = 2$ we test for a change in synchronicity by examining whether the number of synchronous trading days during the crisis period, $T^{crisis}f^{crisis}$, exceeds the critical value from the $\mathcal{B}(T^{crisis}, f^{tranquil})$ distribution.[5] By contrast,

[4] For simplicity we ignore the uncertainty surrounding the estimate for $f^{tranquil}$ when setting up the t-test. If we allow for this uncertainty, the denominator of the test is $\sqrt{S^2_{crisis}/T^{crisis} + S^2_{tranquil}/T^{tranquil}}$ and the degrees of freedom equal $\frac{\left(S^2_{crisis}/T^{crisis} + S^2_{tranquil}/T^{tranquil}\right)^2}{\left(S^2_{crisis}/T^{crisis}\right)^2/(T^{crisis}-1) + \left(S^2_{tranquil}/T^{tranquil}\right)^2/(T^{tranquil}-1)}$. In our empirical analysis, the values for $T^{tranquil}$ are large enough to avoid this simplification from biasing our test results.

[5] Under the null-hypothesis that synchronicity during the crisis period f^{crisis} is equal to synchronicity during the tranquil period $f^{tranquil}$, the observed number of synchronous trading days during the crisis period $T^{crisis}f^{crisis}$ thus follows a binomial distribution with the number of observations being equal to the number of days in the crisis period T^{crisis}, and the probability of success being equal to synchronicity during the tranquil period $f^{tranquil}$.