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An examination of higher-moment contagion during the South Sea Bubble

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ABSTRACT
The objective of this paper is to investigate the nature and the direction of the contagion during the episode of the South Sea Bubble. Previous research in this area has adopted a correlation and cointegration approach. In preference, though, we place reliance upon four different tests of linear and higher-moment contagion. From using daily data on the share prices of six companies from December 1719 to January 1721, strong evidence is obtained of contagion when applying co-skewness, co-volatility, and co-kurtosis tests.

KEYWORDS
South Sea Bubble; contagion; adjusted correlation coefficient; higher-moment tests

JEL CLASSIFICATION
G10; G15

I. Introduction

There has recently occurred the 300th anniversary of the episode, which has become known as the South Sea Bubble. The South Sea Bubble is a term that has been used to summarize the substantial upward and downward movements in the share price of the South Sea Company which took place during 1720.[1] The latter was formed in 1711 with British Royal Assent to supply African slaves to the Spanish colonies in South America. Although no significant profit emerged from having been granted a monopoly position, the share price of the Company rose considerably following an agreement to take over the British national debt. More specifically, having traded at 128 in January 1720, shares were being sold at a price as high as 820 later in August, only for the market to have collapsed by October, when a share was worth merely 170.

At approximately the same time as the share price of the South Sea Company (SS) was exhibiting boom and bust behaviour, similar rises and falls were occurring in the share prices of other interrelated enterprises, such as the Royal African Company (RA), the Mississippi Company (MS), the East India Company (EI), the Bank of England (BE) and the Million Bank (MB). In brief, to illustrate the connections between these companies, each of BE, EI and MB undertook investment in SS. Also, the same as SS, BE and EI both issued equity in exchange for government debt. RA fulfilled a pivotal role in performing triangle trade, by exporting manufactured goods to Africa, transporting African slaves to the New World, and bringing plantation-produced commodities to Europe.[2] Finally, MS was a company that was created by John Law, a Scottish economist, who operated as Controller General and Superintendent General of France. In 1717, Law established Compagnie d'Occident (otherwise known as MS), with the objective of developing the vast French territories in the valley of the Mississippi River in North America. In 1719, Law's company was renamed the Compagnie des Indes, by which time it had achieved a complete monopoly over French trade outside of Europe. Law acquired an interest in EI (as well as the China Company) in May 1719.

These co-movements in stock prices which have been observed motivate an investigation of whether they happened purely by coincidence or represent financial contagion. There would seem to be no universally accepted definition of contagion. However, Rigobon (2016), initially, very loosely describes both contagion and spillover as the phenomenon in which a shock from one country/company is transmitted to another. Subsequently, he seeks to distinguish between these two concepts, maintaining that spillover applies to both boom

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[1]Economic historians reflect on Tulipmania (1634–1637), the Mississippi Bubble (1719–1720) and the South Sea Bubble (1720) in an attempt to understand the stock market crashes of 1929 and 1987, the Japanese asset price bubble (1986–1991), and the dot-com bubble from 1995 to 2001.
[2]BE and MB provided financial support to these trading companies.

and bust periods, while[3] contagion tends to be of greater relevance during crises. Consequently, evidence that is obtained of either spillover or contagion necessarily refutes the Efficient Markets Hypothesis and restricts the scope for risk reduction through diversification.

It would seem to be particularly appropriate to undertake a formal examination of whether the changes in the aforementioned companies' share prices can be inferred as contagion, granted that they occurred during a period when communication was constrained by the absence of modern technology, unlike, for example, the 2008 Global Financial Crisis, which began in the US. Also, a reconsideration of the data would seem to be timely, given that there are available advanced statistical techniques, which have not been used in this context before. Previous research that has been concerned with the issue of stock market interdependence has employed correlation and cointegration methodology (e.g. Carlos, Moyen, and Hill 2002; Choudhry 2018; Dale, Johnson, and Tang 2005). However, Forbes and Rigobon (2002) showed that the conventional measure of cross-market correlation to identify contagion is biased upwards and inaccurate because of heteroskedasticity. Hence, they recommended an adjustment for this bias in the correlation measure. Also, Hakkio and Rush (1989) have argued that cointegration represents a long-run concept, in which case a long span of data is required, rather than a large number of observations at a high frequency, to provide the test with suitable power.

Hence, there are employed within this study four different methods of linear and higher-moment contagion for the purpose of analysing empirically daily data on the six interrelated companies during the period of the South Sea Bubble (8 December 1719–6 January 1721).[4] These are the Forbes-Rigobon correlation (FR) test, a co-skewness (CS) test (Fry, Martin, and Tang 2010), and co-volatility (CV) and co-kurtosis (CK) tests (Fry-McKibbin, Hsiao, and Martin 2017). In favouring these tests, we are effectively embracing the more specific definition of contagion that was offered by Dornbusch, Park, and Claessens (2000), i.e., 'changes of the moments of the distribution during a financial crisis over and above changes due to market fundamentals' (within Fry, Martin, and Tang 2010, 423). In section 2, which follows below, a discussion is provided of the various testing procedures, which are favoured in this study.[5]

II. Methodological approaches

For the purpose of outlining both linear and higher-moment-based contagion tests, we shall adopt the following notation. The boom period is signified as x and the bust period as y; the sample sizes are represented by T_x and T_y, respectively. The standard deviations of the asset returns of stocks i and j in boom and bust periods are signified by $\sigma_{x,i}$, $\sigma_{x,j}$, $\sigma_{y,i}$, and $\sigma_{y,j}$. Finally, the correlation coefficients corresponding to the two asset returns are signified by ρ_x (non-crisis) and ρ_y (crisis), accordingly.

Forbes and Rigobon (2002) identify contagion with an increase, from boom to bust, in the heteroskedasticity-adjusted correlation coefficient,

$$\upsilon_y = \frac{\rho_y}{\sqrt{1+\delta(1-\rho_y^2)}}, \text{ where } \delta = \frac{\sigma_{y,i}^2-\sigma_{x,i}^2}{\sigma_{x,i}^2}$$

For the purpose of testing the null hypothesis of no contagion (Ho: $\upsilon_y = \rho_x$) against the alternative hypothesis of contagion (H_1: $\upsilon_y > \rho_x$), Forbes and Rigobon recommend calculation of the t statistic (see Apergis, Christou, and Kynigakis 2019):

$$\mathrm{FR}(\mathrm{i} \rightarrow \mathrm{j}) = \frac{0.5\ln\left(\frac{1+\hat{\upsilon}_y}{1-\hat{\upsilon}_y}\right) - 0.5\ln\left(\frac{1+\hat{\rho}_x}{1-\hat{\rho}_x}\right)}{\sqrt{\frac{1}{T_y-3}+\frac{1}{T_x-3}}}$$

where i denotes the source market and j the recipient market.

Each one of the CS test (Fry, Martin, and Tang 2010) and the CV and CK tests (Fry-McKibbin, Hsiao, and Martin 2017) involves a statistic, which has a chi-square distribution. From boom to bust period

[3]Rigobon (2002) offered as theoretical explanations for the propagation of shocks across markets: bilateral trade links; indirect trade links; financial links; investor behaviour; and liquidity links.

[4]The data series can be accessed using the link: http://icf.som.yale.edu/south-sea-bubble-1720.

[5]For the sake of brevity, only the FR test will be described in detail. An overview will simply be supplied of the CS, CV and CK tests.

- the CS test compares the relationship between the mean return of asset i and the volatility of asset j, and *vice versa*;
- the CV test compares the relationship between the variances of the two asset returns;
- the CK test compares the relationship between the expected return of asset i and the skewness of asset j, and *vice versa*.[6]

III. Empirical results

Tables 1 and 2 show the results of the FR and CS tests of contagion across the stocks of the six companies. The findings are derived from estimation of a third-order vector autoregressive model. The subsequent residuals are used as proxies for the adjusted returns' innovations, net of market fundamentals. A study of Table 1 reveals that application of the FR test detects only five cases of contagion. In contrast, it is apparent from Table 2 that, after having performed the CS test, 14 significant values of the chi-square statistic are obtained. Tables 3 and 4 report the results of the CV and CK tests. In these two tables, there are 17 and 23 significant values of the chi-square statistic, respectively. Overall, each of the companies is seen to be both a source and a recipient of contagion.[7]

Upon reviewing these results, we find the following interesting features. First, during the South Sea Bubble (SSB), the six companies exhibited strong mutual interaction through several avenues, i.e. mean, volatility, skewness, and kurtosis. The strongest association would seem to be between EI and BE. As was mentioned earlier,

Table 1. The Forbes and Rigobon (2002) test results.

	BE	RA	EI	SS	MS	MB
BE		0.586	**4.003**	**2.607**	0.148	−0.227
		(0.279)	(0.001)	(0.005)	(0.442)	(0.590)
RA	0.361		0.333	0.520	0.766	0.226
	(0.360)		(0.370)	(0.302)	(0.222)	(0.411)
EI	**2.717**	0.006		−1.606	−0.828	−0.139
	(0.004)	(0.498)		(0.946)	(0.797)	(0.556)
SS	**3.314**	1.255	−0.161		−0.792	1.100
	(0.001)	(0.105)	(0.564)		(0.786)	(0.136)
MS	−0.179	0.801	−1.708	−0.941		0.106
	(0.572)	(0.212)	(0.957)	(0.827)		(0.458)
MB	0.082	−0.039	1.252	**1.763**	−6.898	
	(0.468)	(0.516)	(0.106)	(0.039)	(1.000)	

In all tables, the first column (row) indicates the source (recipient) stock.The table shows values of t statistics relating to the null hypothesis of no contagion, Ho: $v_y = \rho_x$. Probability values are contained in parentheses, in accordance with a one-tailed test, H1: v_y ρ_x.In all tables, the figures displayed in bold font correspond to instances in which it is possible to reject the null hypothesis at the 5 per cent level of s

Table 2. The Fry et al. (2010) CS test results.

	BE	RA	EI	SS	MS	MB
BE		**5.258**	**4.630**	2.528	**13.083**	0.050
		(0.021)	(0.031)	(0.111)	(0.000)	(0.823)
RA	1.587		1.443	2.531	**11.144**	**10.911**
	(0.207)		(0.229)	(0.111)	(0.000)	(0.000)
EI	**18.639**	0.837		**10.876**	2.514	**9.243**
	(0.000)	(0.360)		(0.000)	(0.112)	(0.002)
SS	**18.676**	**7.956**	2.114		**8.417**	**30.06**
	(0.000)	(0.004)	(0.145)		(0.003)	(0.000)
MS	0.037	**5.530**	**4.407**	0.164		1.947
	(0.847)	(0.018)	(0.035)	(0.685)		(0.162)
MB	0.283	0.0503	0.433	2.147	0.679	
	(0.594)	(0.822)	(0.510)	(0.142)	(0.409)	

The table shows values of a chi-square statistic, with one degree of freedom, relating to a null hypothesis of no contagion. Probability values are contained in parentheses.

Table 3. The Fry-McKibbin, Hsiao, and Martin (2017) CV test results.

	BE	RA	EI	SS	MS	MB
BE		0.636	**51.473**	0.670	**11.583**	0.057
		(0.425)	(0.000)	(0.413)	(0.000)	(0.811)
RA	0.665		0.451	**7.632**	**14.526**	**11.323**
	(0.414)		(0.501)	(0.005)	(0.000)	(0.000)
EI	**63.460**	0.476		**441.86**	1.528	**4.053**
	(0.000)	(0.490)		(0.000)	(0.216)	(0.044)
SS	0.581	**7.780**	**339.136**		0.136	0.243
	(0.445)	(0.005)	(0.000)		(0.712)	(0.622)
MS	**11.284**	**15.522**	1.361	**96.058**		**6.807**
	(0.000)	(0.000)	(0.243)	(0.000)		(0.009)
MB	0.056	**11.168**	**5.819**	2.358	**4.512**	
	(0.812)	(0.000)	(0.016)	(0.124)	(0.033)	

The table shows values of a chi-square statistic, with one degree of freedom, relating to a null hypothesis of no contagion. Probability values are contained in parentheses.

Table 4. The Fry-McKibbin, Hsiao, and Martin (2017) CK test results.

	BE	RA	EI	SS	MS	MB
BE		**28.418**	0.055	**59.675**	**37.206**	**31.466**
		(0.000)	(0.814)	(0.000)	(0.000)	(0.000)
RA	**238.015**		3.073	**90.198**	**15.083**	**529.076**
	(0.000)		(0.079)	(0.000)	(0.000)	(0.000)
EI	**295.878**	2.783		**1607.766**	**19.163**	**199.695**
	(0.000)	(0.095)		(0.000)	(0.000)	(0.000)
SS	**122.208**	0.059	**49.388**		**11.702**	**7.374**
	(0.000)	(0.808)	(0.000)		(0.000)	(0.006)
MS	**10.314**	**69.755**	**4.576**	1.680		**105.681**
	(0.001)	(0.000)	(0.032)	(0.194)		(0.000)
MB	2.909	2.847	**11.151**	**10.149**	**19.303**	
	(0.088)	(0.091)	(0.000)	(0.001)	(0.000)	

The table shows values of a chi-square statistic, with one degree of freedom, relating to a null hypothesis of no contagion. Probability values are contained in parentheses.

[6]Full details of the tests are contained within the respective source journal articles.
[7]Alternative measures of co-skewness and co-kurtosis produce similar results.

both of these companies had invested in SS and engaged in debt-for-equity swaps. Also, these were the only two companies for which the share price at the end of the sample period was below what this had been in December 1719. In contrast, for each of the remaining four companies, the share price increased, overall, between these two dates. In contrast, the least amount of contagion appears to stem from MB, with indeed there being no significant values in the bottom row of Table 2 in relation to the CS test. Such a finding is possibly the consequence of the boom-bust behaviour being less pronounced for this company. Finally, Tables 2, 3 and 4 show strong evidence of contagion in both directions between RA and each of MS and SS. This can be regarded as operating through the trade and financing channel, which accords well with the views of Carlos, Moyen, and Hill (2002) and Frehen, Goetzmann, and Rouwenhorst (2009).

IV. Conclusion

Through the application of linear and higher-order -moment contagion tests, we have sought to investigate the existence and direction of contagion among selected companies' stock prices using historical data at a daily frequency relating to the SSB period. In comparison to the correlation-based FR test, it has been apparent that the higher-order-moment contagion tests have the potential to identify additional forms of linkages across companies. In spite of the limited technology, which was available during the eighteenth century, the trade and financial links between the six companies have been found to be sufficiently strong for substantial evidence to have been obtained of contagion, especially when applying the CK test.

To conclude with a general statement, as financial bubbles and crashes generate irrational and inefficient economic activity (Garber 1990), the financial system needs a sound regulatory framework and effective enforcement mechanism. Given the evident susceptibility of the financial markets to contagion, even in an earlier era, financial regulators and policymakers should design strategies to protect investors' confidence and enhance resilience and efficiency of the financial system.

The table shows values of t statistics relating to the null hypothesis of no contagion, Ho: $v_y = \rho_x$. Probability values are contained in parentheses, in accordance with a one-tailed test, H_1: $v_y > \rho_x$.

In all tables, the figures displayed in bold font correspond to instances in which it is possible to reject the null hypothesis at the 5% level of significance.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Apergis, N., C. Christou, and J. Kynigakis. 2019. "Contagion across US and EU Financial Markets: Evidence from the CDS Markets." *Journal of International Money and Finance* 96: 1–12. doi:10.1016/j.jimonfin.2019.04.006.

Carlos, A. M., N. Moyen, and J. Hill. 2002. "Royal African Company Share Prices during the South Sea Bubble." *Exploration of Economic History* 39 (1): 61–87. doi:10.1006/exeh.2001.0776.

Choudhry, T. 2018. "Stock Prices' Interdependence during the South Sea Boom and Bust." *International Journal of Finance and Economics* 23 (4): 628–641. doi:10.1002/ijfe.1640.

Dale, R. S., J. E. V. Johnson, and L. Tang. 2005. "Financial Markets Can Go Mad: Evidence of Irrational Behavior during the South Sea Bubble." *Economic History Review* 58 (2): 233–271. doi:10.1111/j.1468-0289.2005.00304.x.

Dornbusch, R., Y. C. Park, and S. Claessens. 2000. "Contagion: Understanding How It Spreads." *World Bank Research Observer* 15 (2): 177–197. doi:10.1093/wbro/15.2.177.

Forbes, K. J., and R. Rigobon. 2002. "No Contagion, Only Interdependence: Measuring Stock Market Comovements." *Journal of Finance* 57 (5): 2223–2261. doi:10.1111/0022-1082.00494.

Frehen, R. G. P., W. N. Goetzmann, and K. Rouwenhorst. 2009. "*New Evidence on the First Financial Bubble.*" NBER Working Paper 15332, Cambridge.

Fry, R., V. L. Martin, and C. Tang. 2010. "A New Class of Tests of Contagion with Applications." *Journal Business & Economics Statistics* 28 (3): 423–437. doi:10.1198/jbes.2010.06060.

Fry-McKibbin, R., C. Y. Hsiao, and V. L. Martin. 2017. "*Joint Tests of Contagion with Applications to Financial Crises*." CAMA Working Paper 65/2017, Australian National University.

Garber, P. M. 1990. "Famous First Bubbles." *Journal of Economic Perspectives* 4 (2): 35–54. doi:10.1257/jep.4.2.35.

Hakkio, C. S., and M. Rush. 1989. "Market Efficiency and Cointegration: An Application to the Sterling and Deutschemark Exchange Markets." *Journal of International Money and Finance* 8: 75–88.

Rigobon, R. 2002. *International Financial Contagion: Theory and Evidence in Evolution*. Charlottesville, Virginia: Research Foundation of AIMR.

Rigobon, R. 2016. "*Contagion, Spillover and Interdependence*."European Central Bank Working Paper Series No, 1975/November