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Parametric and nonparametric Granger causality testing: Linkages between international stock markets

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Abstract

This study investigates long-term linear and nonlinear causal linkages among eleven stock markets, six industrialized markets and five emerging markets of South-East Asia. We cover the period 1987–2006, taking into account the on-set of the Asian financial crisis of 1997. We first apply a test for the presence of general nonlinearity in vector time series. Substantial differences exist between the pre- and post-crisis period in terms of the total number of significant nonlinear relationships. We then examine both periods, using a new nonparametric test for Granger noncausality and the conventional parametric Granger noncausality test. One major finding is that the Asian stock markets have become more internationally integrated after the Asian financial crisis. An exception is the Sri Lankan market with almost no significant long-term linear and nonlinear causal linkages with other markets. To ensure that any causality is strictly nonlinear in nature, we also examine the nonlinear causal relationships of VAR filtered residuals and VAR filtered squared residuals for the post-crisis sample. We find quite a few remaining significant bi- and uni-directional causal nonlinear relationships in these series. Finally, after filtering the VAR-residuals with GARCH-BEKK models, we show that the nonparametric test statistics are substantially smaller in both magnitude and statistical significance than those before filtering. This indicates that nonlinear causality can, to a large extent, be explained by simple volatility effects.

Keywords: GARCH-BEKK; Granger causality; Hypothesis testing; Nonparametric; Stock market linkages

1. Introduction

Since the late 1980s many national stock exchange markets in industrial countries have become aware of the increased competitiveness among these markets. This, in conjunction with a less restrictive climate toward capital movements has brought about the view among economists that the major financial markets of the world are systematically interrelated. This interrelationship may indicate a growing similarity in reactions toward external developments in macroeconomic policies and in the world financial environment. In addition, it may also reflect a temporary, or perhaps more lasting, causal relationship between various individual stock exchanges.

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Causal linkages among stock markets have important implications for security pricing, hedging and trading strategies, and financial market regulations. Also the presence of long-term linear and nonlinear relationships may be used to achieve financial gains from international portfolio diversification and to reduce systematic local risks. Consequently, there exists a large body of literature examining the presence of causal linkages between developed (less risky) markets. They typically find that the US market leads other developed markets (e.g. Ref. [31]). However, there is substantially less literature on stock market linkages between developed markets and emerging markets; see Section 2 for a selective overview. Moreover, quite a few studies relied on the restrictive assumption of a causal linear relationship between stock markets through the use of Granger's [21], parametric, causality test. But, as noted by Hsieh [26,27] and many others, financial time series exhibit significant nonlinear features. Indeed, Hiemstra and Jones [25] argue that a nonlinear and nonparametric Granger causality test (hereafter HJ test), based on the work of Baek and Brock [4], is more effective in uncovering certain nonlinear causal relationships in daily stock prices.

The HJ causality test seems to be the one most used in economics and finance. Examples include stock-price–volume relationships [25,43], futures and cash markets [15], stock price dividend relationships [29], fundamentals and exchange rates [35], equity volatility returns [7]. However, Diks and Panchenko [12,13] demonstrate that the HJ test can severely over-reject if the null hypothesis of noncausality is not true. In addition, with instantaneous dependence, the HJ test has serious size distortion problems. As an alternative the authors of Ref. [13] (hereafter DP) develop a new test statistic which does not suffer from these limitations. Their empirical results suggest that some of the rejections of the Granger noncausality hypothesis, using the HJ causality test, may be spurious.

The objective of the current paper is two-fold. The first one is to explore the existence of linear and nonlinear causal relationships among eleven stock markets. Six of these (Germany, Hong Kong, Japan, Singapore, UK, and US) belong to the group of world's major stock markets, while five markets (India, Malaysia, South Korea, Sri Lanka, and Taiwan) are emerging stock markets in South-East Asia. Clearly South-East Asia as a region has undergone rapid market liberalization in the past decade, resulting in increased investment flows. A possible consequence of this financial openness is an increase in the causal linkages between these emerging markets and the world's major financial markets. In particular, the time period after the 1997 Asian financial crisis may have changed the direction and strength of the causal relationships among the markets under study. A second objective is to explore the ability of the DP test to detect nonlinear causal relationships.

The paper has five remaining sections. Section 2 presents a brief overview of the relevant literature. Also we point out some limitations of the reviewed studies. In Section 3 we present some selected stock market indicators jointly with a discussion of the eleven stock market indices. Section 4, entitled "Testing methodology", introduces (i) a multivariate test of nonlinearity; and (ii) the nonparametric DP causality test. The empirical findings are reported in Section 5. The final section closes the paper by discussing some of the main implications of the results and providing directions for future research.

2. Literature review

There is a wealth of literature on stock market interdependence and integration. However, depending on the data, methodology, and theoretical models used there is no clear resolution of the issue yet. Some previous work has have found that international stock markets are integrated; see, e.g., Refs. [2,23]. Others have found that stock markets are not interlinked; see, e.g., Refs. [41,44].

Most of the studies on stock market interdependence in emerging markets have been done on geographical groups of markets, such as markets in Central and Eastern Europe [20,22], Latin America [10,11,9], and in Asian countries. Since stock markets in South-East Asia form a substantial part of the set of markets considered here, we summarize some of the most recent findings.

Masih and Masih [33,34] found cointegration in the pre-financial crisis period of October 1987 among the stock markets of Thailand, Malaysia, the US, the UK, Japan, Hong Kong and Singapore. But there were no long-run relationships between these markets for the period after the global stock market crash of 1987. By contrast, Phylaktis and Ravazzolo [39] found no linkages and dynamic interactions amongst a group of Pacific-Basin stock markets (Hong Kong, South Korea, Malaysia, Singapore, Taiwan and Thailand) and the industrialized countries of Japan and US for the period 1980–1998. Further, Arshanapalli et al. [3] noted an increase in stock market interdependence after the 1987 crisis for the emerging markets of Malaysia, the Philippines, Thailand, and the developed markets of Hong Kong, Singapore, the US and Japan for the period 1986–1992. Likewise, when testing for causality-in-variance,