Finance Research Letters 21 (2017) 47–52

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Analysis of the global financial crisis using statistical moments

Doobae Jun[a,c], Changmo Ahn[b], Gwangil Kim[a,c,*]

[a] Department of Mathematics, Gyeongsang National University, Jinju, 660-701, Republic of Korea
[b] Department of International Trade, College of Business Administration, GyeongSang National University, Jinju, 660-701, Republic of Korea
[c] Research Institute of Natural Science, Gyeongsang National University, Jinju, 660-701, Republic of Korea

ARTICLE INFO

Article history:
Received 28 November 2015
Revised 20 October 2016
Accepted 3 November 2016
Available online 4 November 2016

JEL Classification:
C02
C18
G01
G15

Keywords:
Global financial crisis
Stock-market index
Standardization
Standardized normalization
Statistical moments

ABSTRACT

In this paper, we investigate the impacts of the global financial crisis on the statistical properties of the stock market indices. And we also suggest a possible warning signal of the global financial crisis from the changes in the statistical properties. In order to do that, we treat the world stock markets as a web of relations, which is described by a distribution in the standardized normalization coordinate system: Quarterly world stock-market indices are standardized by re-scaling each index and then normalizing the whole time-series so that every sample of standardized indices has the same mean and variance. By plotting the higher moments of this normalized series, it is possible to identify singularities which might have warned of the dotcom bubble crash in 2002, the 2008 financial crisis, and the European sovereign debt crisis of 2009–10.

1. Introduction

Many efforts have been to relate economic variables to the 2008 crisis. Frequently cited indicators include declines in real GDP, international economic linkages, country credit ratings, the exchange rate overvaluation, current account deficit and reserve losses. To name a few of them, Lane and Milesi-Ferretti (2011) argue that pre-crisis variables such as the ratio of private credit to GDP, current account deficits, and openness to trade are helpful in explaining the different intensity of the crisis. Berkmen et al. (2012) and Blanchard et al. (2010) suggest the levels of trade and financial exposure as the new causes of the different degrees of output declines after the 2008 crisis. Trancoso (2014) finds that high levels of real and financial interdependence between economies are the determinants of the global recession after the crisis. Claessens et al. (2010) find that asset price bubbles and current account deficits help to explain differences in the intensity of the crisis, and also that increased financial integration helps to explain the global propagation of the crisis.

Rose and Spiegel (2010); 2012), among others, have made exhaustive efforts to explain differences in the intensity of the crisis between countries. Although they explored the significance of almost one hundred variables, they suggest that it is

* Corresponding author.
E-mail address: gikim@gnu.ac.kr (G. Kim).

http://dx.doi.org/10.1016/j.frl.2016.11.004
1544-6123/

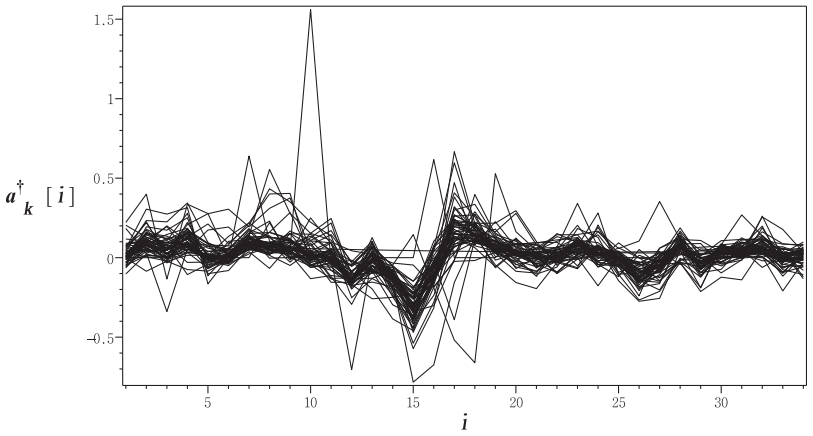

Fig. 1. Time-series of standardized stock-market indices for each quarter, from 1Q 2005 to 3Q 2013.

impossible to predict future crisis with the help of early warning indicators. Frankel and Saravelos (2012) argue that international reserves and real exchange-rate overvaluation, among the extensive candidates, are useful indicators in predicting the 2008 financial crisis. Studies related to the timing of the crisis have found that it is even more difficult to predict, although it has been suggested (Frankel and Saravelos, 2012) that international reserves and real exchange-rate overvaluation might have been used to predict the 2008 financial crisis. Overall, there seems to be no consensus on robust determinants of the crisis, or on the key indicators of its progress. The results vary depending on the definition of crisis incidence, method of measurement and time span of the analysis.

In this paper, we examine the impact of the financial crisis on the statistical properties of global stock market indices. Like previous authors, we search for early warning signals in collapse in stock indices and their determinants. This is difficult because the relationship between stock market indices and underlying factors is opaque. Therefore we look only at the movements of stock indices, on the basis that all other relevant factors are already reflected in the movements. Thus we expect the movements of stock prices to be strongly related to the origins and propagation of the crisis and, in hindsight, early warning signals should be observable in these stock indices. The stock market indices that we use are the IMF quarterly figures (IMF, 2015) from *Q*1 2000 to *Q*3 2013 for 54 countries. To describe and analyze the movements, we introduce a two-step processing of IMF stock market data: *standardization* of the data, and then a *normalization* of the distribution of the standardized data. Using this method, we obtain a measure of the state of a stock market, in terms of the normalized data and its distribution. We observe the movement of the distribution and analyze the evolution of the statistical moments of this distribution over time. We then attempt to relate trends in this data to the global financial crisis, and see whether they provide warning signals that might have been recognized.

The rest of this paper is organized as follows: In Section 2 we introduce our method of standardizing stock-market data, and relate it to the behavior of the markets near 2008, observable as changes in stock-market indices. In Section 3 we introduce our normalization of the distribution of the standardized data, and analyze the evolution of the normalized distribution as the 2008 crisis unfolds. In Section 4 we apply our method to the whole period covered by the IMF data, and find signs of three global financial crises: the collapse of the IT bubble in 2002; the global financial crisis in 2008; and the financial crisis of Europe in 2009 and 2010. In Section 5, we conclude this work and propose three directions for further study.

2. Standardization of data

We standardize the IMF stock-market data by re-scaling the market indices of each country so that the average index over 2005 is 100. If $\mathcal{A}_k = \{a_k[i]\}_{i\in\mathbb{N}}$ is the time-series of re-scaled indices $a_k[i]$ of a stock market k, out of n markets in total (i.e. $k = 1, 2, 3, \cdots, n$), then we define a new set of data $\mathcal{A}^{\dagger}_k = \{a^{\dagger}_k[i]\}_{i\in\mathbb{N}}$, where

$$a^{\dagger}_k[i] = \frac{a_k[i+1] - a_k[i]}{a_k[i]},$$

which is the proportional change in value over one step of the time-series. We can then compare two markets in terms of $\mathcal{A}^{\dagger}_k$, which provides a standardized measure of the movement of each market.

This standardized data is plotted in Fig. 1 for the period 2005 to 2013. The black band, where many curves overlap, gives an idea of the average stock-market trends over this period. As we expect, unusual behavior occurs near 2008 ($10 \leq i \leq 20$). But we also observe unusual behavior in the period ($10 \leq i \leq 20$), which covers 2008; in the period $11 \leq i \leq 13$, some change seems to have begun; and in the period $17 \leq i \leq 18$, another singular behavior occurs, but this has different characteristics. However, none of these events appears to constitute advance warning of the 2008 crisis.