Quantifying the contagion effect of the 2008 financial crisis between the G7 countries (by GDP nominal)

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HIGHLIGHTS

- We apply ρ_{DCCA} to analyze the stock market of the G7 countries in GDP (nominal).
- We analyzed the 2008 financial crisis in terms of ρ_{DCCA}, in function of time.
- $\Delta\rho_{DCCA}$ is defined in order to measure the contagion/interdependence effect.

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ABSTRACT

In this paper we quantify the cross-correlation between the adjusted closing index of the G7 countries, by their Gross Domestic Product (nominal). For this purpose we consider the 2008 financial crisis. Thus, we intend to observe the impact of the 2008 crisis by applying the DCCA cross-correlation coefficient ρ_{DCCA} between these countries. As an immediate result we observe that there is a positive cross-correlation between the index, and this coefficient changes with time between weak, medium, and strong values. If we compare the pre-crisis period (before 2008) with the post-crisis period (after 2008), it is noticed that ρ_{DCCA} changes its value. From these facts, we propose to study the contagion (interdependence) effect from this change by a new variable, $\Delta\rho_{DCCA}$. Thus, we present new findings for the 2008 crisis between the members of the G7.

1. Introduction

The study of economic complexity belongs to the field of complex systems. This field has become significant and naturally appeared as an area of interdisciplinary research, called econophysics [1–6]. One of the many ways of studying economics and physics problems is to try understanding the (auto or cross)-correlations in the time series of these non-linear systems [7–14]. The analysis of the cross-correlation between financial time series has been of great importance

in understanding the financial links between the different markets and assets (exchange rates, stocks, interest rates). In this context, Podobnik and Stanley developed a method to investigate the power law cross-correlation between two simultaneous and non-stationary time series, called *Detrended Cross Correlation Analysis* (DCCA) [15].

The DCCA method was applied to check the cross-correlation between price and volume [16], to study correlations and cross-correlations in Brazilian agrarian commodities and stocks [17], to find a cross-correlation between WTI crude oil and the US dollar [18], and a number of other things [19,20]. The DCCA method is a generalization of the Detrended Fluctuation Analysis (DFA), one of the most popular methods for non-stationary time series auto-correlation analysis [21]. With this knowledge, Zebende combined these two methods and has defined the detrended cross-correlation coefficient, ρ_{DCCA}, which measures the level of cross-correlation between two non-stationary time series [22]. The value of ρ_{DCCA} varies between -1 and 1. When $\rho_{DCCA} = 1$, the time series are perfectly correlated, whereas $\rho_{DCCA} = -1$ means that the time series are perfectly anti-correlated. The value, $\rho_{DCCA} = 0$, represents no correlation between these series. This cross-correlation coefficient is being applied to many areas of knowledge, such as the study of homicide [23], to quantify the level of cross-correlation between the Dow Jones and Nasdaq indexes [24], to verify the cross-correlation between the West Texas Intermediate (WTI) crude oil spot price and some exchange rates around the world [25], and to measure the cross-correlation of the 44 variations of the currencies of the largest economies in the world [26,27].

Kristoufek, in order to ensure the efficiency of ρ_{DCCA}, tested the cross-correlation coefficient using Monte Carlo simulations. It was compared to the Pearson correlation coefficient. The conclusion was that the ρ_{DCCA} remains a promising tool for measuring the dependence of non-stationary time series [28,29]. Other tests with ρ_{DCCA} have also been performed [26,30]. Multifractal extensions of DCCA can be seen in Refs. [31,32,12,33–36,9].

In economics, the search for auto- or cross-correlations between stock markets has been important, especially in a period marked by globalization and financial crises (like in 2008) [37,38]. In this context, in accordance with Ref. [39], there is some pre-existing integration between the economies of countries. During a period of financial instability, this relationship intensifies. This intensity may be sufficient to promote pre-existing structural breaks in transmission collisions between two countries. Thus, the contagion effect is characterized by, e.g., shocks occurring in a certain economy infecting the economy of another country, regardless of the macroeconomic fundamentals of the two or more countries concerned. In contrast, interdependence between countries is characterized by an increase in the level of cross-correlation due to pre-existing economic relations (see Refs. [40–43]).

As we know, the 2008 financial crisis was the second largest crisis for capitalism after the Great Depression of 1929. It began in the USA with the collapse of the speculative bubble in the housing market, caused mainly by the abundance of real estate loans and financial innovations. As a result of the 2008 crisis, industrial production and GDP declined rapidly in the last quarter of 2008 in several countries. The height of the crisis was the bankruptcy of the Lehman Brothers investment bank on September 15, 2008, after the refusal of the Federal Reserve (the "Fed", the US central bank) to rescue that institution. After this event, the financial markets went into a panic situation, since it had been expected that the Fed would help all institutions which were failing. This led to a significant increase in the preference for liquidity, especially in the case of commercial banks. The increased demand for liquidity triggered a process of selling financial assets on a large scale, leading to a Minskyan process of asset deflation, with a sudden and violent fall in the prices of financial assets, and a contraction of bank credit for commercial and industrial transactions. This credit evaporation resulted in a rapid and deep fall in industrial production and international trade worldwide. Therefore, in the last quarter of 2008, industrial production experienced a very significant reduction, see for example Fig. 1 2008 (black line). After the Lehman Brothers event, several countries adopted fiscal and monetary policies to reduce the effects of the crisis on their economies. These included Brazil, which carried out fiscal stimulus and monetary policies to reduce the effects of the economic crisis. But, because of these policies, Brazil has, over the last year, suffered economically. It is known that blue chip companies play a key role in the national economy [44]. In this sense, IBOVESPA (the blue chips sum) has suffered successive drops (see the last years in Fig. 1 IBO).

Taking into account the above, in this paper we apply the Detrended Cross-Correlation Coefficient, ρ_{DCCA}, to indicate whether or not there was a contagion/interdependence effect in the 2008 financial crisis. We propose to study financial indexes relevant to the group of seven largest economies, G7, measured by their Gross Domestic Product (GDP) (nominal) according to the International Monetary Fund list. These are:

- **CAC 40** (Currency in EUR), the most widely-used indicator of the Paris market, reflects the performance of the 40 largest equities listed in France, measured by free-float market-capitalization and liquidity.
- **DAX** (Currency in EUR), the German Stock Index is a total return index of 30 selected German blue chip stocks traded on the Frankfurt Stock Exchange. The equities use free float shares in the index calculation.
- **DJI** (Currency in USD), the Dow Jones Industrial Average is a price-weighted average of 30 blue-chip stocks that are generally the leaders in their industry.
- **FTSE 100** (Currency in GBP), the FTSE 100 index is a capitalization-weighted index of the 100 most highly capitalized companies traded on the London Stock Exchange. The equities use an investibility weighting in the index calculation.
- **IBOVESPA** (Currency in BRL), a gross total return index weighted by market value to the free float and comprises the most liquid stocks traded on the São Paulo Stock Exchange.
- **Nikkei 225** (Currency in JPY), the Nikkei-225 Stock Average is a price-weighted average of 225 top-rated Japanese companies listed in the First Section of the Tokyo Stock Exchange.
- **SSE Composite Index** (Currency in CNY), the Shanghai Stock Exchange Composite Index is a capitalization-weighted index. The index tracks the daily price performance of all A-shares and B-shares listed on the Shanghai Stock Exchange.