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Does the U.S. exercise contagion on Italy? A theoretical model and empirical evidence

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HIGHLIGHTS

- We explore the contagion between countries.
- We follow an econophysics-based approach on the basis of stochastic point processes and empirical experiments.
- We discuss the remarkable case of US as leader country and Italy as infected one.

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ABSTRACT

This paper deals with the theme of contagion in financial markets. At this aim, we develop a model based on Mixed Poisson Processes to describe the abnormal returns of financial markets of two considered countries. In so doing, the article defines the theoretical conditions to be satisfied in order to state that one of them – the so-called *leader* – exercises contagion on the others — the *followers*. Specifically, we employ an invariant probabilistic result stating that a suitable transformation of a Mixed Poisson Process is still a Mixed Poisson Process. The theoretical claim is validated by implementing an extensive simulation analysis grounded on empirical data. The countries considered are the U.S. (as the leader) and Italy (as the follower) and the period under scrutiny is very large, ranging from 1970 to 2014.

1. Introduction

Connections among international financial markets represent one of the most relevant themes in the macroeconomic and macrofinance context [1–4, and the literature herein cited]. Some countries seem to play a leading role – they are *leaders* – and their abnormal performances are likely to affect those of peripheral markets — the *followers*. When the shocks of a market affect some others, we are in presence of the so called *contagion effect*.

This paper deals with contagion among financial markets, exploring how the shocks of a leader market transpose themselves in shocks of a follower market. The topic is relevant because the availability of *ad hoc* statistical methods for extracting and describing the mechanisms of contagious can be very important. In fact, studies aimed at knowing with reasonable precision if and when contagion might occur, or at building possible scenarios through simulations, are vital steps not only for a better comprehension of the investigated system, but also in that they can be functional for the stability of financial markets.

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We proceed in two different and complementary directions. First, we conceptualize a model of econophysics nature based on stochastic processes, and argue that this model can accommodate for contagion cases. In our experiments, we consider the U.S. as the leader and Italy as the follower. In so doing, we agree with the stylized financial facts stating that the behavior of U.S. market is able to drive – after a delay – the paths of the European ones (see e.g. [5]).

In more details, our theoretical model captures connotations and features of the shocks. In particular, a shock in a financial market can be defined according to the presence of an abnormal return. Furthermore, the time at which the shocks occur do not follow regular and periodic paths, but rather they are random. A shock – or, equivalently a *jump* – is then viewed as a couple of stochastic terms, one for the (abnormal) size of the return and the other one for the random time of occurrence. The collection of random times is modeled through a Mixed Poisson Process (MPP). Such a typology of processes represents an extension of the usual Poisson Processes with parameter λ, with the remarkable difference that λ is assumed to be random. MPP's seem to be particularly appropriate for our purpose, because they describe random arrivals whose time distance is captured by a random variable.

Several theoretical applications have been proposed in the literature on MPPs (see e.g. [6,7]) but, to the best of our knowledge, this is the first attempt to investigate such a topic from an empirical point of view by examining financial contagion.

In the framework of MPP's, we adapt to our specific context an invariance result granting that a suitable transformation of a MPP is still a MPP (see e.g. [8]). In particular, contagion can be described by introducing a random "small enough" delay – the meaning of the terms "small enough" will be clear soon – between the jumps of the leader market and those of the follower one. In so doing, it is theoretically shown that the assumption of MPP for modeling the shocks of the leader and of the follower fits with the presence of a contagion of the former country over the latter one.

The empirical experiments are based on the standardized, comparable time series of equity markets provided by the Morgan Stanley country Index (MSCI). The investigated period ranges from 1st January 1970 to 27th May 2014, on a daily basis. First of all, we validate the theoretical assumption that the data obey to a MPP law, by applying a Kolmogorov–Smirnov test to compare the empirical distributions of the data with the theoretical MPP one. Second, we empirically work out the random delay between the shocks occurring in the U.S. and in Italy and study these series.

Afterwards, the analysis of the series of the delays provides also interesting information on the time in which contagion propagates. The series of the delays is also shown to exhibit some regularity properties in terms of the rank–size rule (for rank–size rules and applications, see e.g. [9–23]). In particular, delays have been ranked in decreasing order, from the largest to the smallest one, and the resulting rank–size plot is shown to be well-fitted by an exponential law. This evidence adds more on the conceptualization of the time propagation of the shocks, by giving information on how the delays distribute in terms of their size.

The novelties of the paper can be broken down as follows. First, we propose a conceptualization of the dynamics of the equity markets data through MPP's. In so doing, we offer a new vision of the financial markets in terms of the distribution of the dates of the abnormal returns. Second, we theoretically support the presence of contagion among countries by applying an invariance result on the MPP's. Third, we provide a validation of the theoretical results for the U.S. and Italy data over a very wide period – 44 years: from 1970 to 2014 – , hence obtaining evidence on the presence of contagion among such countries. Fourth, in the context of the empirical analysis, we discuss how contagion propagates by exploring the distribution of the delays between the leader market and the corresponding one of the follower country. Fifth, we provide a rank–size analysis of the series of the delays and obtain an excellent exponential fit. It is worth noting that the assessment of such a rank–size regularity has been rather neglected in the literature for the case of contagion and shock propagation.

The rest of the paper is organized as follows. After revising the literature on contagion in Section 2, Section 3 presents the theoretical model and the key invariance result. Section 4 is devoted to the empirical experiments: it contains the description of the data, the adopted methodologies, the obtained findings and related comments. The last section concludes and traces lines for future research.

2. Review of the literature

There are many definitions of the term contagion available in literature, according to the different perspectives it is considered from, Forbes [3]. Consequently, from a technical point of view, contagion can be studied under a variety of assumptions and quantitatively assessed through a wide range of mathematical tools. One of the oldest and perhaps most intuitive approach relies on probability theory. Shortly, probability models are employed to assess the likelihood for a given country to suffer from a crisis conditional on the occurrence of the same event elsewhere in the economy. On the one hand, probabilistic methods enjoy the properties of the tools of statistical decision theory. On the other hand, statistical tests suffer from limited power when endogenous relationships between variables involved in the analysis arise and limited robustness in case of omitted variables. As a result, the related outcomes can be severely biased and of little practical use.

During the nineties many procedures focused on the analysis of comovements, have been implemented. They focus on measuring comovements connections by means of the coefficient of correlation (e.g. [24–27]). The rationale behind such methods is of empirical nature and rests on the evidence that market comovements become more apparent during periods of crisis. For instance, many studies show how various contagious effects, triggered by the 1994 Mexican crisis, can be