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Dynamic and Structure of the Italian stock market based on returns and volume trading

Juan Gabriel Brida
School of Economics and Management - Free University of Bolzano

W. Adrian Risso
University of Siena

Abstract

In this paper we introduce a new method to describe dynamical patterns of multidimensional time. The method combines the tools of Symbolic Time Series Analysis with the nearest neighbor single linkage clustering algorithm. Data symbolization allows to obtain a metric distance between two different time series that is used to construct an ultrametric distance. The methodology is applied to examine the dynamics and structure of the Italian stock market considering both asset returns and volume trading to model the market. We derive a hierarchical organization, constructing minimal-spanning and hierarchical trees, both in normal and extreme situations of the market. From these trees we detect four clusters of firms according to their proximity. We show that the financial cluster is in a central position of the minimal spanning tree, both in normal and extreme situations, reflecting that financial companies represent more than 30% of the Italian market capitalization. We also show that the derived clusters corresponds with companies sharing common economic activities.

1. INTRODUCTION

Lo and Wang (2000) assert that, if price and quantity are fundamental in any theory of market interactions, the importance of trading volume in modeling asset markets is clear. However, most of the models of asset markets have focused on the behavior of returns, giving far less attention to trading volume. In addition, Souminen (2001) point out that, despite the academic literature in finance contains few theoretical papers on the role of trading volume, many practitioners use that information. Karpoff (1987) surveys previous research on two stylized facts. At first, as in an old Wall Street adage that says "*It takes Volume to make prices move*". Numerous empirical findings support what is called positive volume-absolute price change correlation (see Crouch (1970)**,** Clark (1973)**,** Morgan (1976)**,** Westerfield (1977)**,** Cornell (1981) and Harris (1983), among others). Another familiar adage says that, "*Volume is relatively heavy in bull markets and light in bear markets*". Karpoff remarks that, in equity markets there is evidence of positive relation between volume and price change (see Morgan (1976), Jain and Joh (1986)**,** Rogalski (1978) and Harris, (1986), among others). Karpoff concludes that even if these two empirical findings seem to set up a contradiction, it could be explained by an asymmetric volume-price change relationship, indicating that the relation is fundamentally different for positive and negative price changes. Since volume trading seems to carry important information to the market, we aim to describe the Italian stock market, introducing a methodology which embodies information supplied not only by returns but also by volume trading.

As a manner of describing the structure of a market, Mantegna (1999) proposed the construction of Minimal Spanning Trees (MST) and Hierarchical Trees (HT). These graphs show the interconnection among the firms, detecting clusters and taxonomic relations in a financial market. Mantegna (1999) and Brida *et al*. (2009) introduce a symbolic method which gives more flexibility to the above method by using Symbolic Analysis. However, both methods only apply for one dimensional time series, loosing the possibility of embodying information from the volume trading. We propose a multidimensional generalization of the previous methods and we apply it to detect the structure of the Italian stock market. The paper is organized as follows. Section II explains the methodology. In section III we describe data and analyze the hierarchical structure of the Italian market. Section IV concludes the paper.

2. Multidimensional Symbolic based Minimal Spanning Tree

MST and HT are useful tools represented by visual nets, showing the most relevant connections and interactions in the stock market. To obtain these graph representations we applied a metric, computing all the distances between companies. Assume we have a multidimensional time series with real values, as follows:

$$\{\mathbf{X}_i\}_{t=1}^{t-T} = \left\{ \begin{pmatrix} x_{i1} \\ y_{i1} \\ . \\ z_{i1} \end{pmatrix}, \begin{pmatrix} x_{i2} \\ y_{i2} \\ . \\ z_{i2} \end{pmatrix}, ..., \begin{pmatrix} x_{iT} \\ y_{iT} \\ . \\ z_{iT} \end{pmatrix} \right\} \tag{1}$$

We can convert into a one-dimensional symbolic space S, by defining a determined threshold in the multidimensional space R^n, defined by the series x, obtaining the following symbolic time series for each company i, obtaining the following coded time series:

$$\{s_{i1}, s_{i2}, ..., s_{iT}\} \tag{2}$$

Once this symbolic time series is obtained for each firm, we can compute the distance between the companies, according to the following distance function:

$$d_0(s_i, s_j) = \sqrt{\sum_{t=1}^{t=T} (s_{it} - s_{jt})^2} \tag{3}$$

Note that *{s_{i1}, s_{i2}, ..., s_{iT}}* and *{s_{j1}, s_{j2}, ..., s_{jT}}* are two symbolic sequences for companies *i* and *j* respectively. When all the distances are computed, we can derive the structure of the financial market by constructing the MST and HT. The MST is progressively constructed by linking all the time series together in a graph characterized by a minimal distance between the firms. In words, we rank the obtained distances form the smallest to largest and start linking the two firms with the shortest distance. In the second step, we take the second smallest distance in the rank, linking the corresponding pair of companies. We proceed linking all the companies according to the rank of distance until obtaining a graph connecting all the firms in the market. Note that the Kruskal algorithm is applied and then, loops among firms are forbidden in the tree. The MST

permits to obtain the subdominant ultrametric distances $d^<$ permitting to construct the HT. This distance, $d^<(i,j)$ between i and j is the maximum value of any Euclidean distance $d(l,m)$ detected by moving in single steps from i to j through the shortest path connecting i and j in the MST(see Ramal *et al*. (1986), for a definition of ultrametricity).

3. Structure of the Main Italian Companies

The Milan Stock Exchange (MSE) concentrates more than 90 percent of the transaction volume of the Italian stock market. It was founded in 1808, privatized in 1997 and acquired by the London Stock Exchange Group in 2007. The most important index is the S&P/Mib, embodying the highest capitalized companies (more than 1000 million euros). An important characteristic is that the 30% of these companies work in the financial sector (insurance and bank firms) representing the 48% of the market capitalization. Few papers have studied the Italian Stock market. We can refer to Barone (1990) analyzing the efficiency and the anomalies in this market, Michaely and Murgia (1995), studying the effects of tax heterogeneity on price and volume in the MSE and Brida and Risso (2007) studying the structure of the market considering the asset returns. In this paper we apply daily data from the S&P/Mib index for the period December 6, 2001 to April 17, 2007, collecting data of trading volume and asset returns for 32 companies.

In order to obtain a partition in the bidimensional space (asset returns, volume trading), at first, we consider a kind of global return for each company i, given by the product between returns and volume trading at moment t: $R_i(t)=r_i(t).V_i(t)$. Being $r_i(t)$ defined as the difference between logarithm of prices for the company i at time t and $t-1$. For a series of size T, thus we can construct the empirical distribution $f^*(R_i)$ of these returns for company i. According to Molgedey and Ebeling (2000) we should use small partitions with three pieces. We would like to study the market structure in both normal and critical situations. Therefore, for the normal situation we define three equally probable regions where empirical density cumulates 1/3 and 2/3 of the distribution (see Figure 1). For the extreme situation, we defined thresholds where empirical distribution cumulates 15% and 85% of the distribution (see Figure 1).
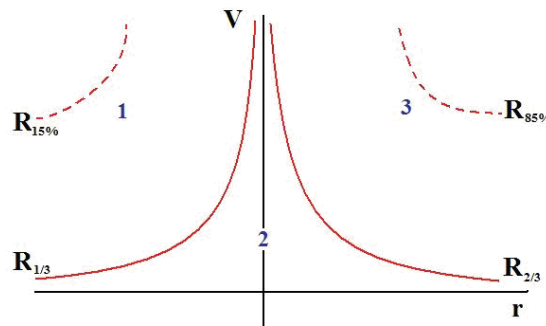

Figure 1: Thresholds in the Bidimensional Space (r, V)

Note that, each pair (return, volume trading) takes a unique symbol according to the region they are in. Figure 1 shows the different regions in the bidimensional space. Note also that since R_{in} is constant for $n=17/20,1/3,2/3,3/20$, the curve $V_i(t)=R_{in}/r_i(t)$ is hyperbolic. Once, the symbolization is complete we can compute all the distances and construct the MST and the HT as explained above. Note that the distance between two companies as in equation (3) represents how close the qualitative dynamics of asset returns and volume trading was during the period of study. (see Brida et al. (2003) for a pedagogical exposition of this qualitative dynamics) The MST obtained for the Italian case in a normal situation is shown in Figure 2.
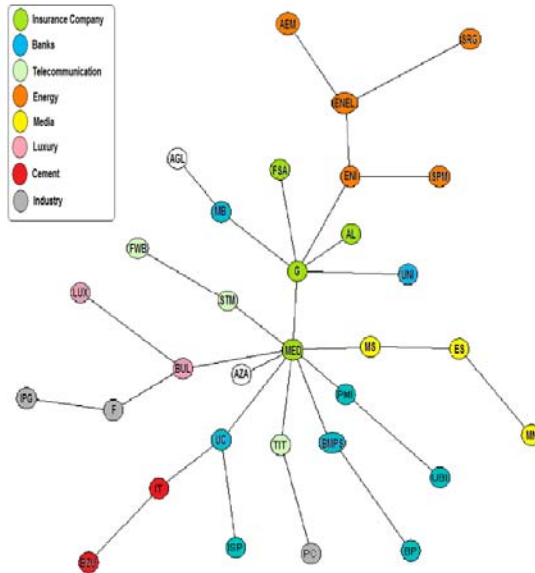
Figure 2: MST for Italy in a normal situation

The MST allows to reveal geometrical aspects of the asset returns and volume trading. The length of the link between connected firms is proportional to the distance between them and the geometrical aspect of the MST reveals the possible intermediate connections between any two firms of the group. Note that companies working in the same branch tend to belong to the same cluster. In the north of the tree we note a cluster of energy companies, AEM working on liquid gas, SRG, ENEL, ENI and SPM working in Gas and Electricity. The central cluster is composed by Banks and Insurance companies; actually Mediolanum (MED) and Generali (G) have a central position with more connections than the other companies. At the left we have a cluster composed by luxury firms (Luxottica and Bulgari) and a group of Telecommunication formed by Fastweb (FWB) and STMicroelectronics (STM). The right side cluster is identified with the media sector: Mediaset (MS), L'Espresso (ES) and Mondadori (MN). At the south, three groups appear, one formed by two companies working in cement, Buzzi Unicem (BZU) and Italcementi (IT). Note that the main banks of Italy (Unicredit (UC) and Intesa-San Paolo (ISP)) are very close. A third group is composed by Telecom (TIT) and Pirelli (PC). Pirelli is the major shareholder of the Olimpia group and this group is the principal shareholder of Telecom.
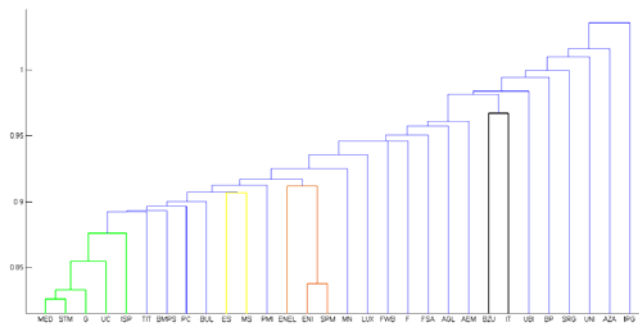

Figure 3: HT for Italy in the normal case

The hierarchical tree obtained starting from the MST described in Figure 2 is shown in Figure 3. In the figure, each vertical line indicates a firm. The height of the horizontal line indicates the ultrametric distance at which the two firms are connected.Each of the investigated stocks is indicated with its tick symbol in the figure caption. The HT allows to reveal taxonomic aspects of the asset returns and volume trading. Several clusters are clearly identified. The central cluster is composed by financial firms: two insurance companies (Generali (G) and Mediolanum (MED)) and the main banks in the Italian market (Unicredit (UC) and Intesa San Paolo (ISP)). This group represents more than 30% of the capitalization (in particular, the capitalization of Generali was of 31 billion euros at September 2008). STMicroelectronic (STM) is a technological firm with a close connection to this group. A second cluster connected to the media sector is composed by L'Espresso (ES) and Mediaset (MS). The third group is composed by firms belonging to the energy sector: ENEL , ENI and Saipem (SPM). Note that the distance between ENI and SPM is one of the smallest of the sample, indicating a strong relationship between these companies. From the other hand, SPM (plant design and installation) was part of ENI (Petroil

3

subsector) until 1969, government has the 42.9% of the shares of the first and 20,32% of the second. A cluster composed by two cement companies (Buzzi Unicem (BZU) and Italcemento (IT)) is colored in red.

Figure (4) shows the MST in the extreme situation. Studying the extreme situation is important in order to detect changes in the market structure. In particular, this could be interesting in currency crisis, detecting different clusters (see Pérez (2005) trying to detect clusters in currency crisis using a dendrogram similar to the HT).

Note that the fundamental structure of the tree remains showing stability of the tree from a normal to an extreme situation. Basic groups remain, financial sector (Banks and insurance companies) are the center of the tree with especial focus on Generali (G) and Mediolanum (MED).
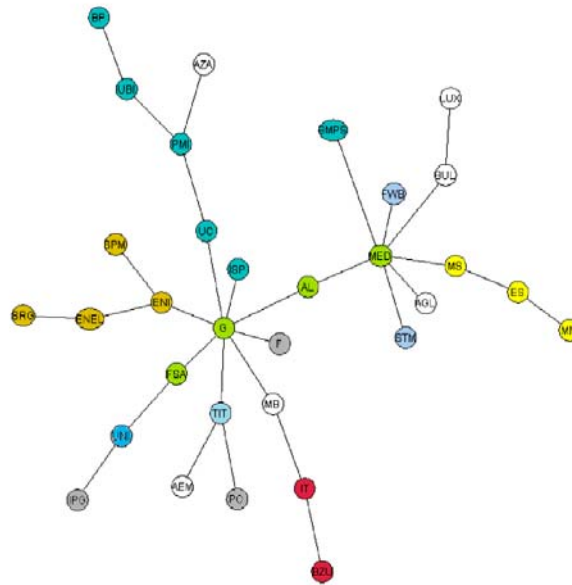

Figure 4: MST for Italy in extreme situation

Figure (5) shows the HT in the extreme situation, note here that a cluster composed by Pirelli (PC) and (TIT) Telecom is highlighted this could reflect the affair about the decision of selling part of the shares of Telecom which happened in the considered period.

This method could be useful in portfolio construction and management. Since Markowitz (1952) establishes that putting uncorrelated assets in a portfolio reduces the risk many strategies to select assets have been applied using this idea. Some authors such as Bouchaud and Potters (2000) suggest that the important thing is if the firms are uncorrelated in the extreme events. According to them it is important to focus on the correlation at the tails of the distribution of the returns. We suggest that by defining the partitions weighting more the extreme situations (High negative and positive returns and high volume trading) we can obtain a tree showing the cluster of companies with the same dynamic in extreme situations, therefore it should be not convenient to put all the asset of the same cluster in the portfolio.
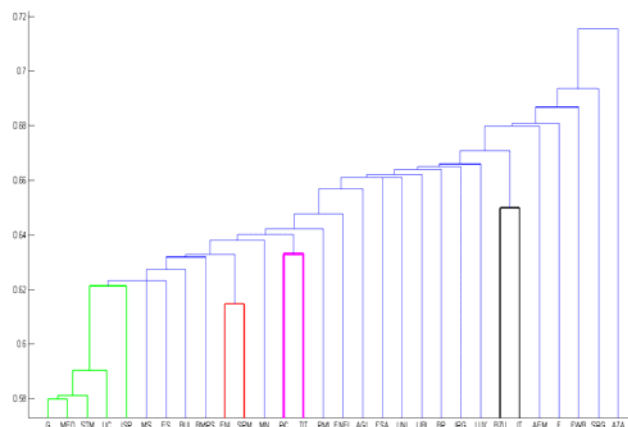

Figure 5: HT for Italy in Extreme Situation

4. Conclusions

Asset returns and volume trading are the main variables to study the financial market. Moreover, the positive correlation between volume trading and asset returns is a stylized fact but only few works use both variables in their studies of the market. In this paper we apply a multidimensional clustering methodology to characterize the Italian stock market both in normal and extreme situation. The MST methodology provides a parsimonious way to examine patterns of linkages between different firms in the market. Applied dynamically, it allows us to observe both consistencies and evolution in relationships between companies over time. We detect a net connecting four clusters (finance, media, energy and cement) sharing a common economic activity. The financial firms (representing more than the 30% of the Italian market capitalization) are in central position; i.e., their performance affects the rest of the clusters. In particular Generali (with a capitalization of 31 billion Euros) is situated in the center of the MST showing that it is very well connected with the rest of the companies in the sample. The central role of financial firms (and in particular of Generali) shows that dynamics of asset returns and volume trading of these companies affect dynamics of the rest of the firms in the market. This fact can be used for policy implications.

The present methodology could be useful in portfolio construction and management. Markowitz (1952) establishes that rational investors will diversify to optimize his returns. They can reduce portfolio risk simply by holding combinations of instruments which are not perfectly correlated. This idea is the base in many portfolios constructed by many investment funds. In portfolio construction and management many different strategies are applied in order to allocate assets. We suggest an strategy could be to consider the MST weighting the extreme situations (high negative and positive returns and high volume trading) studying the cluster formation in these situations. Therefore, to reduce the risk we should not put together assets within the same clusters because in critical situations they would likely move in the same direction.

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