

# Identifying the major reversals of the BIST-30 index by extreme outliers

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## Abstract

**Purpose** – The purpose of this paper is to show that major reversals of an index (specifically BIST-30 index) can be detected uniquely on the date of reversal by checking the extreme outliers in the rate of change series using daily closing prices.

**Design/methodology/approach** – The extreme outliers are determined by checking if either the rate of change series or the volatility of the rate of change series displays more than two standard deviations on the date of reversal. Furthermore, wavelet analysis is also utilized for this purpose by checking the extreme outlier characteristics of the A1 (approximation level 1) and D3 (detail level 3) wavelet components.

**Findings** – Paper investigates ten major reversals of BIST-30 index during a five year period. It conclusively shows that all these major reversals are characterized by extreme outliers mentioned above. The paper also checks if these major reversals are unique in the sense of being observed only on the date of reversal but not before. The empirical results confirm the uniqueness. The paper also demonstrates empirically the fact that extreme outliers are associated only with major reversals but not minor ones.

**Practical implications** – The results are important for fund managers for whom the timely identification of the initial phase of a major bullish or bearish trend is crucial. Such timely identification of the major reversals is also important for the hedging applications since a major issue in the practical implementation of the stock index futures as a hedging instrument is the correct timing of derivatives positions.

**Originality/value** – To the best of the author's knowledge; this is the first study dealing with the issue of major reversal identification. This is evidently so for the BIST-30 index and the use of extreme outliers for this purpose is also a novelty in the sense that neither the use of rate of change extremity nor the use of wavelet decomposition for this purpose was addressed before in the international literature.

**Keywords** BIST-30, Outliers, Wavelet approximation and wavelet details, Volatility, Doubechies

**Paper type** Research paper

## I. Introduction

This paper is about the timely identification of the major reversals of the BIST-30 index which is the leading stock index of the Borsa Istanbul. A major reversal is a change in the direction of the stock prices (indices) from a bullish trend to a bearish trend (or vice versa) which is followed by a substantial rise or fall in the prices. Though it is not easy to differentiate a minor reversal from a major reversal in the financial markets; we may define, as a rule of thumb, a major reversal as a change in the direction of the prices (indices) which is followed by at least a 10 percent increase or decrease in the subsequent days. The importance of early detection of such reversals for the fund managers is evident.

The identification of major reversal points is a major issue in technical analysis with a plethora of different tools (bullish/bearish patterns, moving averages, etc.) used for this purpose. The validity of technical analysis, however, is quite a debatable issue with an inevitable subjective element. Moreover, some of the benchmarks used to identify the



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change in the primary trend such as 100-day or 200-day moving averages are quite late in signaling the change.

The academic literature on reasons for propelling the major rallies or crashes is relatively meager but still includes some interesting attempts for the explanation of the aberrant behavior in the financial markets. According to the orthodox view which assumes efficiency of markets; a crash or a major reversal is the result of the announcement of a dramatic and unexpected piece of information. Earlier work which focused on a rational expectations model of bubbles and crashes such as Blanchard (1979) and Blanchard and Watson (1982) admits that the observed prices may deviate significantly from the fundamental prices for extended periods of time but these deviations are still explained in terms of rational expectations. An alternative approach ascribes these deviations to the behavioral and psychological mechanisms such as herding by arguing that investors are not fully rational but rather are characterized by bound rationality (Thaler, 1993; Shefrin, 2000). There is also increasing awareness of the fact that financial data sets often display empirical evidence of the regime shifts (Van Norden and Schaller, 1993).

An interesting viewpoint for the explanation of the financial market crashes is adopted by Sornette (2003) who borrows his ideas heavily from the behavior of complex systems in physics which are known to display certain critical points (reversal points). Such systems with a large number of mutually interacting parts have the ability to self-organize their internal structures leading to emergent properties over time. These systems are characterized by coherent large-scale collective behaviors resulting from the non-linear interactions among its constituents. Sornette argues that big rallies are caused by local self-reinforcing imitation between the traders which leads to bubbles. This process leading to the bubbles, however, is also characterized by an increasing potential of instability due to the amplification of the non-linear feedback chains eventually culminating in critical points with an eventual regime shift (crash). Furthermore; he also argues that the timing of a crash in advance is possible by using certain log-periodic precursory signals (Sornette, 2003).

The search for certain mathematical or statistical signals accompanying the market crashes and major reversals is not limited by Sornette's log-periodic signals. Extreme value theory (Embrechts *et al.*, 1997; Bassi *et al.*, 1998) employs peak over threshold distributions in the form of Generalized Pareto distributions for this purpose. Lillo and Mantegna (2000) shows that the shape of the return distributions display significant distortions (both in tails and center) in the extreme trading days compared to normal days. L'vov *et al.* (2001) argues that extreme events in the financial markets is not simply a magnified version of usual normal scale fluctuations but rather the overall return distribution is made of two different populations of the body and of the tail which have different physical properties and different scaling. Most significantly, turbulences exhibit outliers.

The gist of this paper shares the essential idea in the literature cited above and argues that the major reversals in a financial market are characterized by certain unique statistical footprints. The paper, however, does not try to explain the reasons leading to a rally or crash though I personally believe that herding plays some role in these processes with some dose of irrationality. What the paper aims to accomplish is to identify a set of fairly reliable statistical tools which signal that the market is changing its mood from a bullish rally to a major bearish tone or vice versa. It implicitly assumes that such a change is characterized by emotional excesses which statistically lead to extreme price moves on the day of reversal. In other words; major reversal days are characterized by outliers. These outliers can easily be determined by employing fairly simple tools. We observe a more than two standard deviation in the daily price rate of change (daily return) in a major reversal day which we do not see in earlier days. We may also occasionally see a sudden volatility burst in such days. However; these outliers may be more disguised in some cases whose identification may require a more sophisticated approach such as searching these

outliers in the wavelet components of the series. The paper is about the test of this proposition in the context of the BIST-30 index and is motivated by an earlier research of us (Oztürk *et al.*, 2016) which demonstrated that the use of extreme volatility estimators (which incorporates day's extreme prices) substantially improves the daily BIST-30 volatility forecasts.

The rest of the paper follows the usual format. Section 2 deals with data and methodology. Section 3 presents the empirical evidence and Section 4 concludes.

## II. Data and methodology

The data are the daily closing prices of the BIST-30 index from January 4, 2010 to June 15, 2016 with a total of 1,627 observations derived from Bloomberg. The major emphasis is to identify the major reversals (from bullish to bearish and vice versa) in the latter part of that period and then to check if these reversal days are characterized by statistical outliers.

The price series itself (closing prices of the BIST-30 index) is not a suitable instrument to detect relevant outliers, information wise[1]. What we search for is an outlier that uniquely characterize the major reversal day which is defined as a more than two standard deviation in the series considered. This outlier must also be unique in the sense that it is not observed in the days prior to reversal but shows itself only at the point of reversal. One such candidate is the daily returns. Relevant outliers can be observed in the daily return series (which simply is the day's rate of change) when the market reverses itself from a major bullish (bearish) trend to a major bearish (bullish) trend. Another candidate is the volatility which may demonstrate a sudden burst during major reversal days. The outlier identification at reversal days may also utilize the volatility series. However; such unique outliers are observed essentially in the volatility of the rate of change rather than the volatility of price series[2].

The two tools mentioned above are easy to implement and can effectively be utilized by fund managers. Some major reversals, however, are harder to detect using the above mentioned tools though they represent a minority of the cases considered. They do not reveal a more than two standard deviation outlier in either the daily return (rate of change) or the volatility of daily return series. In such cases; detection of outliers may require a more sophisticated approach. An effective tool to use in such disguised cases may be to analyze the wavelet components of the daily rate of change (daily return) series. As it will be evident in the next section; the wavelet components of daily return series have a good record for revealing outliers at the reversal days. Even when daily return or volatility of return series does not display outliers at the critical major reversal days; such behavior may be detected by checking the wavelet components of the daily return series.

Wavelet analysis provide a complete representation of a data series from both time and frequency perspectives simultaneously. Thus they permit to break down the market activity into different frequency components and to study the dynamics of each of these components separately. This analysis is especially useful to analyze nonstationary data (data whose mean and variance change over time) which is a typical characteristic of financial data.

A wavelet is essentially a small wave which grows and decays in a limited time frame. This small wave is characterized by a mathematical function  $\psi(t)$  which is called a mother wavelet. There is a variety of different functions which may be used to characterize the small wave. The chosen function  $\psi(t)$  can be dilated and translated as:

$$\Psi_{u,s}(t) = 1/\text{sqrt}(s)\psi(t-u/s) \quad (1)$$

where  $u$  and  $s$  are the location and the scale parameters, respectively and  $\text{sqrt}(s)$  is the square root of  $s$ . The wavelet coefficients  $W(u, s)$  which is a function of  $u$  and  $s$  are

obtained by projecting the original function  $x(t)$  or the data set onto the mother wavelet  $\psi_{u,s}(t)$  yielding:

$$W(u, s) = \int x(t) \psi_{u,s}(t) dt \quad (2)$$

The  $W(u, s)$  is a continuous wavelet transform of the original data. In financial applications; we rather use the discrete wavelet transform (DWT). The DWT uses only a limited number of translated and dilated versions of the mother wavelet to decompose the original signal (Masset, 2008). DWT selects  $u$  and  $s$  so that information contained in the signal (data) can be summarized by a minimum of wavelet coefficients. This is achieved by setting  $s = 2^{-j}$  and  $u = k2^{-j}$  where  $j$  and  $k$  are integers representing the set of discrete translations and discrete dilatations. The DWT can only be applied to series of dyadic length (the number of observations used must be equal to the powers of 2).

The DWT is based on two discrete wavelet filters which are the mother wavelet and the father wavelet. The mother wavelet (differencing function) is a high-pass filter which measures the deviations from the smooth components. The father wavelet (scaling function) captures the long scale (low frequency) components of the series and generates the scaling coefficients. The application of both the mother and the father wavelets allow separating the low frequency components of the time series from the high frequency components. The wavelet and scaling coefficients at the first level of decomposition are obtained by convolution of the data series with the mother and father wavelets. After having applied the mother and father wavelets on the original data series, one has a series of high frequency components and a series of lower frequency components. The low frequency components (scaling coefficients) can be further decomposed into high and low frequency components by recursive application of a pyramid algorithm up to scale  $J = [\log_2(T)]$ .

In this study; the wavelet Daubechies-3 is used to obtain the DWTs. Choosing a level of 3 with dyadic data is sufficient for our purpose. This DWT generates three levels of approximation coefficients which display the average behavior of BIST-30 index and three levels of detail coefficients which indicate short bursts in the data and being more responsive to the jumps generated by new information. Rather than focusing on all approximation and detail levels; I primarily used A1 (approximation level 1) and D3 (detail level 3) to detect the outliers of the reversal days. Empirical tests showed that the type of wavelet chosen for the analysis has only a minor impact on the results.

### III. Empirical results

In what follows; I presented evidence of extreme outliers at major reversal points by analyzing several different cases. The cases presented cover almost all of the major reversal points of BIST-30 index during the period from November 22, 2013 to June 15, 2016. I also tested if such extreme outliers are detected in case of minor reversals. The purpose here was to highlight the fact that the extreme outliers are a specific footprint characterizing only the major reversals. Then a brief evaluation follows which discusses the importance of outlier information for the fund managers.

#### *Case 1 – Observation 775 (Date: January 24, 2013)*

This is the end of a major bullish move which started on observation 730 (date: November 22, 2013) when the BIST-30 index was 86,993. The index value of observation 773 (daily close) was 108,090 representing a gain of 24.3 percent during the bullish rally. It is technically the first head of a major double top. In fact; it was the latter part of a bigger bullish move which started on observation 609 (date: May 30, 2012) when the index value was 65,956 thus representing a significant gain of 63.8 percent. The market closed down

next day at 105,800 with a daily decline of 2.8 percent at which point a downward move started that continued until observation 794 (date: February 22, 2013) leading to a loss of 13.3 percent. The chart in Figure 1 with a small square at reversal point illustrates vividly the transition from a major bullish trend to a bearish trend.

The change from the bullish phase to the bearish phase is signaled by the close of observation 775 (after a further drop to 101,110). When we enter the observations (closes of the BIST-30) from 1 to 775 and calculate the daily rate of changes (daily returns); we see that the last entry corresponding to the daily rate of change from observation 774 to 775 represents a more than 2 standard deviation change (an extreme outlier)[3]. Please take note of the fact that the most recent outlier (represented by a more than two standard deviation change in the rate of change series of the BIST-30) prior to the one at observation 775 is recorded at observation 648 which was in fact also a reversal point from a bearish trend to a bullish trend[4].

The aberrant behavior of observation 775 is also confirmed by further evidence. When I enter first 775 observations, calculate the daily return (rate of change) of the closing prices and then calculate the volatility of the returns; it is observed that the last entry (observation 774)[5] is an extreme outlier with a deviation of more than 3 standard deviations. The most recent outlier prior to observation 774 is detected at observation 479 of the volatility series which actually corresponds to a major bullish reversal. Furthermore; when we enter the first 775 observations; calculate the daily rate of changes, delete the first 262 observations and extract the A1 (approximation level 1) and D3 (detail level 3) wavelet transforms from the remaining dyadic series of 512 observations; we observe that the last entry[6] displays extreme outliers (a deviation greater than two standard deviations) both in A1 and D3 components[7]. The reversal from a major bullish rally to a major bearish rally is signaled effectively by the aberrant behavior of rate of change series, by the volatility of the rate of change series as well as by the A1 and D3 wavelet transforms. This aberrant behavior displays itself as more than two standard deviations (as extreme outliers) in all of these series[8].

Is that extreme behavior unique in the sense of characterizing only the reversal points? A simple test can clarify this issue. I entered ten previous observations of daily closes starting with observation 764[9]. The market during this period was displaying a strong uptrend without any corrections. Neither the rate of change of closing prices nor the

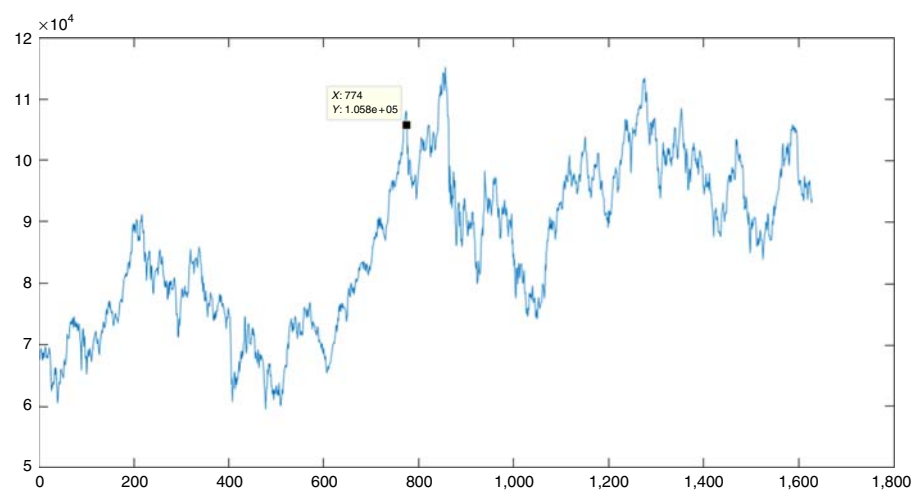


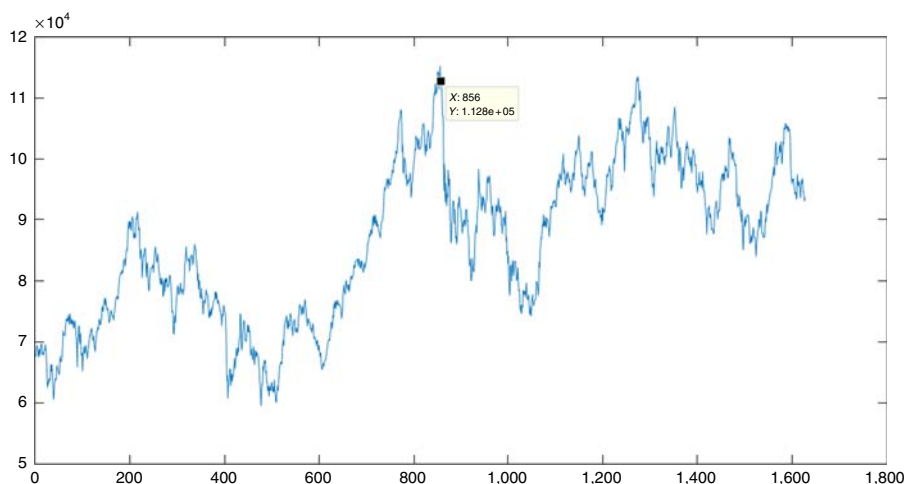
Figure 1.  
Case 1

volatility of the rate of changes displayed any extreme outlier during this ten day period. The D3 (detail level 3) displayed an outlier for observation 765 but it can be ignored given the highly responsive nature of high frequency data to daily changes. An interesting case is the case of observation 774 which displayed more than two standard deviation outliers in both A1 and D3 series but unable to find an extreme outlier in either the rate of change or the volatility series. The observation 774 corresponds to the first reversal day after the strong bullish move with index dropping from 108,090 to 105,800. The major reversal was confirmed one day later by rate of change and volatility series after a further drop to 101,100. This suggests that the wavelet components may identify a major reversal earlier than the rate of change or volatility series in some cases. The essential point, however, is the fact that the series used for outlier detection reveal extreme behavior at the point of reversal but not before.

#### *Case 2 – Observation 860 (Date: May 29, 2016)*

The bearish reversal that started after observation 775 continued until observation 794 (February 22, 2013) after which a new bullish rally started that continued until observation 855 (May 22, 2013). The index value moved up from 93,664 to 115,341 representing a gain of 23.1 percent (see Figure 2). The market started to reverse at observation 856 with a daily decline of 2.2 percent. The downward move that started at this point continued until observation 922 (August 27, 2013). The index fell from 115,341 to 79,952 with a loss of 30.6 percent.

The extreme outliers detect this major reversal at the slightly later date of May 29, 2013 when the index value is 107,136[10]. The rate of change series displays a deviation of more than two standard deviations on this date though volatility series do not display extreme behavior. The wavelet components A1 and D3, however, confirm the aberrant behavior displaying deviations of more than two standard deviations on that particular day. The most recent outlier prior to observation 860 is detected by both rate of change series and wavelet components at observation 840 which was the starting point of a strong rally. In fact; wavelet component A1 signals an extreme behavior (a deviation of more than two standard deviations) at observation 856 (the first day of reversal). A test of previous days starting with observation 849 do not reveal any extreme behavior prior to observation 860 (or observation 856 in case of A1).



**Figure 2.**  
Case 2

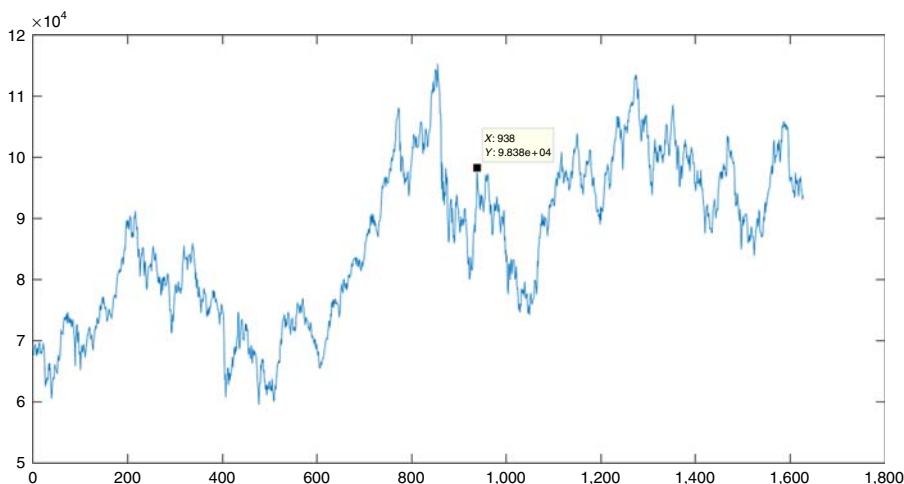
*Case 3 – Observation 938 (Date: September 19, 2013)*

This case represents the end of a strong bullish move which started on August 27, 2013 (observation 922) when index value was 79,952 and reaching to a value of 98,375 (at observation 938) with an overall gain of 23 percent (see Figure 3). The observation 938 represents the end of the bullish rally and corresponds to the first head of a significant double top (see Figure 3). The index then declined to 91,670 on September 27, 2013 (observation 944). A second rally to 97,333 on September 27, 2013 (observation: 961) created the second top after which index fell down to 77,856 on December 27, 2013 (observation: 1,004).

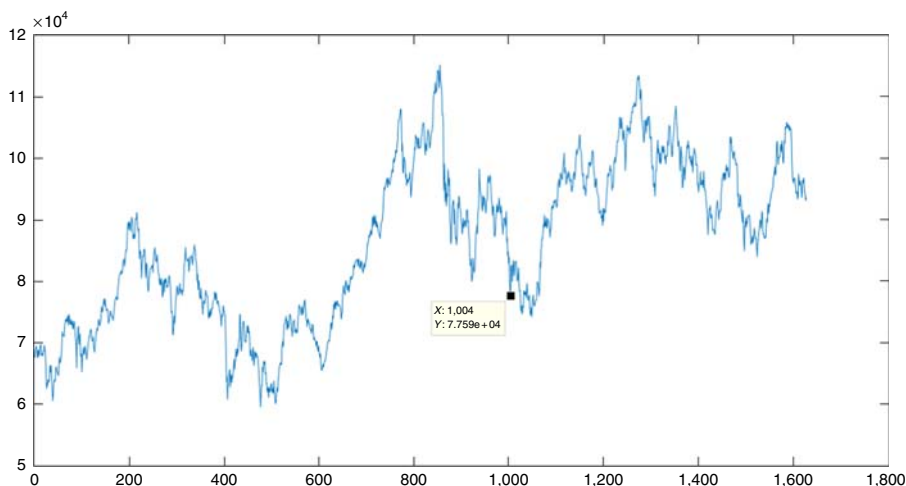
All the series signal a major reversal of index at observation 938. The rate of change series display a more than three standard deviation on that particular day and volatility series confirm the extremity by a more than two standard deviation in the same day. The A1 series display a more than three standard deviation on that particular day and D3 series also signal aberrant behavior represented by a more than two standard deviation change. The extreme outlier characteristic of all the four series on September 19, 2013 is quite unique since the previous days starting with observation 930 do not display such a character (the only exception is observation 935 with extreme outliers in the rate of change series and A1 series but not in the other two series. This date, in fact, was also a bullish reversal day after a correction)[11].

*Case 4 – Observation 1,005 (Date: December 30, 2013)*

A very sharp decline started on December 16, 2016 (observation 995). The index value plummeted from 91,399 on December 16, 2016 to 77,586 by December 27, 2013 (observation 1,004)[12]. The index then turned up sharply on December 30, 2013 with a 6.5 percent daily gain starting a rally which continued until January 7, 2014 (observation 1,010). The rally led to a 7.4 percent gain in six days (see Figure 4). This strong bullish reversal is typically characterized by extreme outliers. The rate of change series, volatility series and A1 series displayed more than three standard deviations on that date (the previous outliers detected by the data set ending at observation 1,005 were at observations 938 and 995). The previous entries starting with observation 996 do not display any extreme outliers with the exception of observation 997 where more than two standard deviations are observed in the rate of change and A1 series (observation 997 corresponds to a neckline breakdown plausibly confirming the onset of the bullish trend).



**Figure 3.**  
Case 3

Figure 4.  
Case 4

#### Case 5 – Observation 1,050 (Date: March 4, 2014)

A major bearish move started on October 28, 2013 (observation 961) when the index value was 97,333. The bearish move continued until March 3, 2014 when the index close was 74,173 representing a loss of 23.7 percent. We then see a typical double bottom signifying the end of the major bearish move after which a big bullish rally started eventually leading to an index value of 103,953 on July 25, 2014 (observation 1,150) representing a gain of 40.1 percent[13].

The observation 1,049 is the dip of the second bottom. The bullish rally started on March 4, 2014. The bullish rallies, however, seem to be more subtle than the bearish ones in the sense that their major reversal points are not characterized by easily recognizable footprints. The reversal that started on March 4, 2014 fails to display extreme outliers (deviations exceeding two standard deviations) in the rate of change or the volatility series. We do not observe such outliers at observation 1,050 or at the three consecutive observations (also not in the preceding ones). In such cases; wavelet components which are more responsive to reversals may provide valuable information about the impending change in the market.

When we check the outlier status of the entries starting with observation 1,041; we do not observe any outliers in A1 and D3 components in the first four days. Observation 145 corresponds to a minor bearish reversal and this reversal generates outliers (deviations exceeding two standard deviations) on that day. Following two more quiet days; we observe an extremity (a deviation of more than two standard deviations) of D3 series at observation 1,048. Then we also observe an extremity (a deviation of more than two standard deviations) in the A1 series at observation 1,049. Following these early signals; the reversal day 1,050 is characterized by extreme behavior (deviations exceeding two standard deviations) in both A1 and D3 series.

#### Case 6 – Observation 1,276 (Date: January 28, 2015)

The bullish trend that started on December 16, 2014 (observation 1,246) when the index value was 97,978 continued until January 26, 2015 (observation 1,274) reaching to a value of 113,614 with a gain of 15.9 percent. The market reversed and the downward trend continued until March 13, 2015 (observation 1,308). The index declined from 113,614 to 93,828 with a loss of 17.4 percent.



The footprints of this major reversal are detected at observation 1,276 which was characterized by a strong daily decline. This reversal, however, cannot be detected by extreme behavior of daily rate of change or volatility series. The latest outlier detected in these series is at observation 1,245 which in fact was a significant bullish reversal. As in the previous case (case of observation 1,050); the reversal is signaled by extremity of wavelet components. The A1 approximation and D3 detail series display outliers at observation 1,276 with deviations exceeding two standard deviations on that particular day. It is a noteworthy fact that none of the previous observations starting with observation 1,266 display any outliers in the A1 and D3 wavelet components. The aberrant behavior of wavelet components is detected only and uniquely at the major reversal point (at observation 1,276).

*Case 7 – Observation 1,366 (Date: June 8, 2015)*

A bearish trend that started on May 18, 2015 when the index value was 108,609 ended on June 8, 2016 when the index value was 95,205 after a 12.8 percent decline. The bullish reversal started on June 9, 2015 (observation 1,367) leading to a value of 102,928 on June 24, 2015.

The immediate bullish reversal was signaled by the significant daily decline (5.71 percent) on June 8, 2015 which led to observations of extreme outliers in all the relevant series. The daily rate of change series and the volatility series display a change of more than three standard deviations on that day. The wavelet components A1 and D3 also display changes of more than three standard deviations on that day confirming an aberrant behavior at the point of bullish reversal. Such an aberrant behavior is not observed in the previous observations (in consecutive data sets starting with observation 1,360). The more responsive A1 and D3 series detect an outlier at observation 1,362 which was a minor (though quite significant) bearish reversal of 8.33 percent though the extreme outlier characteristics of all the four major series is uniquely confined to the observation 1,366 which is immediately followed by the onset of a bullish reversal.

*Case 8 – Observation 1,420 (Date: August 24, 2015)*

A significant bearish move started on May 18, 2015 (observation 1,352) when the index value was at 108,609. The index then declined 19.3 percent reaching to a dip value of 87,545 which is observed on August 24, 2015. This dip was immediately followed by a bullish reversal which continued until November 2, 2015 (observation 1,467). This bullish reversal carried the index to the peak value of 103,595 with a significant gain of 18.3 percent.

The bullish reversals are harder to detect on the basis of the outlier information as we had also seen in the case of observation 1,050. The observation 1,420 is characterized by the same problem. Neither the rate of change series nor the volatility series exhibit an outlier character (deviations of more than two standard deviations) on August 24, 2015 despite a daily decline of 3.13 percent (outliers are not detected in the following three bullish days as well).

The immediate bullish reversal, however, can be detected by the more responsive wavelet components. The A1 (approximation) component of daily rate of changes display a typical outlier at observation 1,420 with more than three standard deviation change which is also confirmed by a more than two standard deviation change in the D3 series. This outlier characteristic of wavelet components signaling the impending bullish reversal and the termination of bearish trend is not observed in the preceding days starting with observation 1,414. It is only detected at observation 1,413 (both A1 and D3 displaying more than two standard deviations on that day) which in fact was the initial day of a sharp decline[14].

*Case 9 – Observation 1,467 (Date: November 2, 2015)*

A bullish trend that started on September 14, 2015 (observation 1,435) when the index value was 87,593 continued until November 2, 2015 by reaching to a peak value of 103,593 on that day.

This bullish move was characterized by a gain of 18.2 percent from the dip to the peak. The observation 1,467 is the final day of the bullish rally marked with a significant daily return of 5.33 percent. The index turned bearish by the next day (March 11, 2015) initiating a long decline until December 14, 2015 (observation 1,497) on which day it reached to the dip value of 84,893 after a loss of 18.05 percent.

All the four series display outliers on November 2, 2015 signaling the major bearish reversal. The rate of change series and volatility series display more than three standard deviation changes on November 2, 2015. More than three standard deviation changes on that day are also observed in the A1 and D3 components. These very significant outliers uniquely characterize the point of major reversal since they are not observed in any of the preceding days starting with observation 1,459. Neither the rate of change and volatility series nor the wavelet components display any aberrant behavior (deviations of more than two standard deviations) in any of these preceding days.

#### *Case 10 – Observation 1,498 (December 15, 2015)*

The bearish move that started on March 11, 2015 continued until December 14, 2015 as mentioned above. The observation 1,497 is the first dip of a big double bottom that formed in the consequent days. The major bearish move effectively ended on December 14, 2015 and the market started reversing itself by a daily up move of 4.26 percent on December 15, 2015 which was the starting point of a new bullish rally which eventually reached to a value of 105,912 on April 18, 2016.

The bullish reversal in this case deviates from the previously analyzed bullish cases and displays outliers in all the four relevant series. The rate of change series and the volatility series display more than two standard deviations on December 15, 2015. Similarly; the A1 and D3 components also display more than three standard deviations on that particular day. This observation of outliers in all the four series on December 15, 2015 is a distinctive event since such behavior is not observed in any of the precedent days starting with observation 1,487. The wavelet components A1 and D3 however start signaling a possible reversal at earlier days by starting to display outliers after observation 1,495 due to their higher sensitivity (we detect wavelet outliers in observations 1,496 and 1,497 but not before).

The analysis so far reveals a close relationship between the major reversal points of the index and the extreme outliers. Extreme outliers emerge at the end of a major bullish (bearish) trend or at the initial stages of a major bearish (bullish) trend. They can be detected in the rate of change and/or volatility series. They are also detected in the A1 (approximation) and/or D3 (detail) components of the rate of change series. All the four series may be characterized by extreme outliers in some major reversal points. There are, however, also cases (mostly in the case of bullish reversals) in which only the outliers of the A1 and D3 components signal a possible reversal. The A1 and D3 wavelet components seem to be more sensitive to reversals in the market. An important point is the fact that the outliers are observed at the major reversal points but not in the previous observations.

Are these outliers a unique event characterizing only the major reversal points? A partial answer was provided in the ten cases analyzed above. They do emerge at major reversal points but not before. A further test may clarify the issue better. In what follows; I randomly selected six minor reversals and repeated the same procedure to find outliers at these minor reversal points if there are any. The selected reversals have the common property of being preceded by a relatively limited price move and also displaying only a limited price move after the reversal. They are generally temporary corrections or reactions observed during a major bullish or bearish rally.

The first one is observation 719 which is a minor correction that was observed during a major bullish rally. The index fell from 90,659 on November 8, 2012 (observation 719) to 86,932 on November 22, 2012 (observation 729) after a small triple top. The bullish trend

then resumed after the limited downward move of 4.11 percent. The observation 890 represents a minor upward reaction observed during a major bearish move (from observation 856 to observation 922). It is the second dip of a double bottom which however failed to lead to a bullish rally. It was the end of a limited bearish move from 93,228 on July 1, 2013 to 85,912 on July 10, 2013. This downward move of 7.8 percent reversed on July 10, 2013 leading to a reaction reaching to 93,886 on July 17, 2013 after a gain of 9.2 percent. Bearish trend then resumed with a further 14.6 percent drop. The observation 1,085 was a minor correction during a major bullish rally characterized by a fall from 89,460 on April 22, 2014 (observation 1,085) to 87,118 on April 25, 2014 (a downward move of 2.6 percent).

The fourth case is observation 1,214 which is a minor correction during a major bullish rally. This correction led only to a limited downfall from 98,957 on October 31, 2014 (observation 2,014) to 94,749 on November 6, 2014 (observation 1,218). Bullish trend resumed after this downward move of 4.2 percent. The observation 1,425 corresponds to the top of a double bottom (after the completion of which a major bullish rally started). The major bearish episode was terminated at observation 1,420 (case 8). A bullish reversal that started on August 24, 2015 when the index value was 87,545 led only to a 5.5 percent increase reaching to 92,360 on August 31, 2015 (observation 1,425) at which point it turned bearish leading to a downward move of 5.1 percent at the end of which it marked the second dip of the double bottom on September 14, 2015 (observation 1,435) with an index value of 87,593. The observation 1,508 also corresponds to the top of another double bottom. The observation 1,497 was the end of a major bearish rally (case 10). A bullish reversal that started on December 15, 2015 (observation 1,498) carried the index to 90,785 on December 28, 2015 (observation 1,508) representing an upward move of 6.9 percent but went out of steam fairly quickly and was followed by a downward move from 90,785 to 85,981 on January 4, 2016 (observation 1,512). The downward move (a 5.3 percent decline) was a limited one as the preceding upward move[15].

The rather detailed description of these six cases above serves the purpose of highlighting an important point. The previous ten cases are major reversals in the sense of being preceded by substantial changes in the index value (usually over 10 percent) which are followed by a substantial change in the opposite direction. All of them are characterized by a significant mark at the reversal points which is fairly easy to identify. The rate of change in the prices displays outliers either at the final day of the previous bullish/bearish trend or at the first day of the opposite trend. In some cases; these outliers are also detected in the volatility of the daily returns. If both of them fail to identify a reversal, the A1 and D3 components of the daily returns (price rate of changes) display such outliers which are important warning signals of the impending change in the market mood.

The minor reversals covered by the six cases above are different in the sense of being preceded by rather limited changes in the index value and also followed by a limited change in the opposite direction. The outlier characteristics of these minor reversals show a remarkable difference from the major reversals. They do not display outlier characteristics at all. We cannot detect outliers in any of the four series (in rate of changes, volatility of returns and wavelet components). This negative result is valid for all the six cases considered (except for an outlier in the highly responsive D3 component detected at observation 890). The empirical evidence so far seems to indicate that there may be a way of distinguishing major reversals from the minor reversals at the reversal point (at least in the context of the BIST-30 index)[16].

The importance of identifying the major reversals at the initial stage of such a reversal is quite evident. Its importance for portfolio management may easily be demonstrated by the following two simple cases. During the bullish rally from December 15, 2015 to April 18, 2016; the price of Akbank (a stock trading in Istanbul Stock Exchange) increased from 6.42 (closing price on December 15, 2015) to 8.48 (closing price on April 18, 2016) which is an increase of 32 percent. Akenerji (another stock trading in Istanbul Stock Exchange)

increased from 0.86 to 1.19 (an increase of 38.3 percent). During the bearish phase from March 11, 2015 to December 14, 2015; Akbank's price dropped from 7.70 to 6.16 (20 percent) and the price of Akenerji dropped from 1.00 to 0.85 (15 percent).

There is another important aspect regarding the importance of identifying the major reversals on time. Index futures is an essential hedging instrument for the portfolio managers. The hedging operation requires assuming short positions in index futures when a major drop in the index is anticipated. The rules for choosing the correct number of contracts to be shorted for a given portfolio is well established[17]. The major problem in the implementation of a hedging operation by using the index futures is to determine the correct time for shorting the index futures which usually is not an easy task in the volatile environment of the markets. Identification of a major bearish reversal by outliers at a peak point signaling the high probability of an impending substantial drop in the index value may be important to choose the correct time for initiating the hedge position (as well as for the correct timing of covering the shorts).

#### IV. Conclusion

This paper is about the identification of the major reversal points in the context of the BIST-30 index. The empirical analysis based on daily data for a six year period strongly suggests that the major reversal points of the BIST-30 index are characterized by extreme outliers. The extreme outliers are defined as more than two standard deviation changes observed in the vicinity of major reversal days. Major reversal days are interpreted as days when a substantial bullish (bearish) move in the index is reversed leading to a substantial move in the opposite direction. Such outliers can be detected in the daily return (rate of change) series, volatility of return series and in the level 1 approximation (A1) and detail level 3 (D3) wavelet components of the daily return series. Wavelet decomposition is achieved by using dyadic observations and Daubechies-3 wavelet. Such outliers seem to emerge on the day of the major reversal and not before.

A plausible explanation of this observation may be the following: A major reversal day is a day when the mood and expectations of the market suddenly change probably due to some new information. It seems that such a change is also characterized by emotional excesses coupled with some degree of herding behavior leading to aberrant price volatility and outliers. The empirical analysis also suggests that such outliers characterize the major reversals rather than the minor reversals (with the possible exceptions of highly responsive D3 outliers which may indicate the minor reversals as well).

This empirical fact detected in the BIST-30 index may be important for fund managers. When the market changes direction; it is generally very difficult to judge if the observed reversal is a short-term phenomenon or the starting point of a long-term major trend in the opposite direction. The empirical tools suggested in this paper may provide an answer to this question. Apparently; a more robust conclusion requires further analysis and the extension of this kind of analysis to the prices or values of other indices and financial asset prices. The preliminary evidence, however, implies the importance and possible benefits of considering the outliers in the somewhat chaotic environment of financial markets.

#### Notes

1. When markets are characterized by a strong rally prior to reversal; prices exhibit a successive series of outliers whose information value is negligible. What we search for is a unique footprint (outlier) which characterizes the major reversal day but is not detected before the reversal day while the rally continues.
2. That simply means that we check if the squared deviation of the daily rate of change from its mean value is a more than two standard deviation change (an outlier) during the reversal day.

3. Please take notice of an important fact. I do not use a backward analysis such as entering all the data (1,627 observations) and then checking for extreme outliers. I enter only the data up to observation 775 and search outliers on the basis of this data set which has 775 observations. This procedure is also used in all the remaining cases. Apparently this is what a fund manager will be faced with in the real life. Another brief note is in order. The first reversal considered was the one at observation 775. There were other major reversals before that date. However; this type of analysis requires a fairly long data set to be statistically robust. Also the use of discrete wavelet transforms compels us to use dyadic data. In the case of observation 775; I used the dyadic 512 observations (by deleting the first 263 observations of the data set and thus considering the 512 observations prior to observation 773). The number 512 is dyadic since it is equal to  $2^9$ . The discrete wavelet approach also requires a fairly long series to be robust enough.
4. The list of previous extreme outliers detected by using a data set of 775 observations are at observations 486, 488, 504, 521 and 525 all being earlier reversal points.
5. The last entry of the series is 774 instead of 775 because the price rate of change operation automatically deletes the first observation. The entry 774 corresponds to the rate of change from the close of observation 774 to the close of the observation 775.
6. The last observation in the dyadic series of 512 observations corresponds to the rate of change from the close of observation 774 to the close of observation 775 whose wavelet transforms A1 and D3 are extreme outliers.
7. They also represent a behavior quite unique to the entry 512 since the earlier most recent outliers are detected at observations 386 and 388.
8. All the statistical operations and wavelet analysis is evaluated in MATLAB environment.
9. As usual; I entered only the observations from 1 to 764 in order to search the extreme outliers and conducted the tests on this observation set to see if the last entry qualify as an extreme outlier. Then I entered the data set from 1 to 765 repeating the test with this data set and so on.
10. The 100-day moving average which is commonly used in technical analysis to identify the changes in the primary trend gives the signal (price crosses below moving average) on March 6, 2013 when the index value (close) is 94,827.
11. The bullish move that ended on September 19, 2013 actually started on September 19, 2013 (at observation 930) when the index value was 85,434. The fact that a bullish rally started on that date is also signaled by extreme outliers since rate of change series display a more than two standard deviation on that date confirmed by more than three standard deviation change in A1 and more than two standard deviation change in D3 series.
12. Though it is not covered in the main body of the text, the sharp drop that started on December 16, 2016 is also signaled by the extreme outliers detected on that date. The rate of change series and the volatility series both display deviations in excess of three standard deviations as well as the A1 component.
13. The charts after Figure 4 are not displayed for the sake of brevity. They are available upon request.
14. The index following an indecisive horizontal period during which a small double top formed started to decline on August 13, 2015. The index value declined sharply in a few days from 94,589 on August 13, 2015 to 87,545 on August 24, 2015. The wavelet components by revealing outliers on August 13, 2015 successfully signal the sharp decline at its initial stage.
15. A more detailed analysis of two cases may further illustrate the benefit of checking outliers. When a major bearish trend is over, this is usually signaled by an early bullish reversal. Then the market enters into a horizontal phase during which certain formations (e.g. double bottoms) are formed. A strong bullish rally starts after the neckline of the double bottom is broken (usually after a neckline test). In case 8; major bearish trend was over on August 24, 2015 with an initial bullish reaction. The outliers successfully detected this change. In fact; outliers detected on August 24, 2015 were signaling the end of major bearish move rather than identifying a new

bullish episode. The first initial bullish move led only to a limited upward move reversing direction on August 31, 2015. As indicated in the main text; this reversal is not characterized by any outliers implying that the reversal was a minor one. The index initiated a second bullish move on September 15, 2015 (corresponding to the second dip of the double bottom). The A1 and D3 components remarkably identify the starting point of this second bullish move by displaying deviations of more than two standard deviations in both components on that day. The preceding four days, for example, do not display such an event. The onset of a really strong bullish move was, however, somewhat later starting on October 5, 2015 (observation 1,448) which roughly corresponds to the date when the prices crossed over the neckline of the double bottom. The outliers successfully detected the onset of this strong rally by displaying outliers (deviations exceeding two standard deviations in the rate of change series and deviations exceeding three standard deviations in the A1 and D3 components). The outliers appeared exactly on October 5, 2015 but not in the previous five days. The rally carried the index from 94,671 to 103,593 in less than one month. Another major bearish move was over on December 15, 2015 (case 10). The initial bullish reaction was rather limited reversing on December 28, 2015. This led to a minor bearish move whose onset was not accompanied by outliers. The index turned bullish again on January 22, 2016 after forming the second dip of the double bottom. The A1 and D3 components displayed outliers exactly on that date though they are not observed in the previous days. Following a possible neckline test; a strong bullish rally started on February 17, 2016 (observation 1,543). That particular day is characterized by outliers of both A1 and D3 components though we do not observe them in the five previous days. The result was an upward move from 87,104 to 105,912 in nearly two months.

16. Though I analyzed only six cases in the main body of the paper; I also checked seven additional reversals which may qualify as minor reversals in addition to the six reversals already mentioned. These reversals were located at observations 884, 1,040, 1,083, 1,520, 1,535, 1,567 and 1,623. We do not observe outliers of rate of change or volatility at the reversal points in any of them. Only one of them displayed an A1 outlier while five of them displayed D3 outliers. It seems that an outlier detected only in the highly responsive D3 series but not in the other three series (or if we do not observe any outlier at all during a reversal) tend to mark a minor reversal while the additional observation of outliers in A1 and daily return (price rate of change) series point out to the high likelihood of a major reversal.
17. The formula used to determine the number of contracts to be shorted is  $(\text{portfolio value} / (\text{index futures price} \times \text{contract multiplier}) \times \text{portfolio } \beta)$  (Erol, 2014). A hedging based on this formula guarantees perfect hedging (a gain in short futures fully compensating the loss in the portfolio value) if the difference between the index futures price and the spot index value (basis) remains unchanged during the hedging period.

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