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EXAMINING THE HETEROGENEOUS REGIMES OF STOCK MARKET IDENTIFIED WITH TWO VARIANTS OF B-B ALGORITHMS THAT DIFFER IN RIGIDNESS OF SPECIFICATION

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Abstract

This paper studies the more prolonged type of heterogeneous regimes in the stock market identified with the non-parametric Bry and Boschan (1971) (B-B) algorithm. Specifically, the paper extracts and examines the statistical properties of these durations derived using two variants of B-B algorithms, namely the Lunde and Timmerman (2004) B-B algorithm and the Candelon, Piplack and Straetmans (2008) B-B algorithm. These two algorithms are contrasting extremes in terms of specification rigidness. The results show that the Candelon et al. (2008) B-B algorithm which is less rigid between the two, detects more frequent switching of regimes, has lower standard deviation and yields higher values of cumulative return and loss. The greater sensitivity, however, may not imply superiority as the fundamental aim of stock market regimes dating is to clearly detect the unobserved long-run structure of the market.

JEL Classification: *G12, G14*
Keywords: *Stock market; Bull and bear markets; Heterogeneous regimes switching*

1. Introduction

In recent years, the trend of stock market declines is becoming less abrupt. Unlike the historic Black Monday crash which shaved off 20.47% of the S&P 500 Index (SP500 hereafter) in a single day on 19 October 1987, stock market declines in the last three decades have never recorded a single day loss of 10% or more (S&P 500 Historical Data, n. d.). These include the instances of major declines such as the burst of the 2000 Dot-com bubble and the 2007 subprime meltdown. The declines were devastating in the cumulative term as such that the drops tapered off for a prolonged period.

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In comparison with the 1987 crash which reached its throng in just one day, the SP500 peaked at 1508.31 on 24 August 2000 during the Dot-com bubble and reached its throng on 11 March 2003 (over 30 months later) at 800.73. Similarly, the SP500 closed at highest of 1562.47 on 10 October 2007 prior to the subprime crisis before tapering off for the next 14 months to 676.53 on 9 March 2009 (S&P 500 Historical Data, n. d.). The SP500 losses termed in percentage from peak to throng for both the later collapses were 46.8% and 56.7%, respectively. Thus both of the “slow burn” meltdowns were far more devastating compared to the more infamous 1987 crash. Scenarios as such compel researchers to redefine traditional specification for major stock market declines as they are not merely confined to sharp crashes.

On the other hand, it is long accepted among market participants that the more gradual type of stock market declines, i.e., bear markets, is very much prevalent in the stock market. The crude terms of bear and bull markets which are originated from the market only begin to gain considerable acceptance in the academic by the end of year 2000s. Nonetheless, literature in this area is still less extensive compared to the theme of stock market crashes. Despite the widespread agreement on the importance of “bull markets”, it is noteworthy that there still does not exist a general consensus as to the objective definition the term.

Studies in the bear and bull markets conventionally employ the ex-post dating technique for the identification of the local minima and maxima of price indices. Gonzalez et al. (2005) noted that the pioneering studies in this area such as the works by Lunde and Timmermann (2004) and Pagan and Sossounov (2003) were largely inspired by the business cycle dating approach introduced by Bry and Boschan (1971). Algorithms based on the Bry and Boschan (1971) approach (B-B algorithm hereafter) in the previous studies mainly differ in the rigidness of specification for the identification of the switching of regimes between the bear and bull markets.

The level of rigidness for the identification of regimes is adjusted arbitrarily to suit the objective of different studies in the past. For example, algorithm adopted by Candelon et al. (2008) (CPS B-B then after) is one of the less rigid and most simplified among others. The original CPS B-B algorithm was meant to measure the synchronisation of stock market regimes for selected East Asian countries. Reasonably, studies that encompass cross countries comparison would require a higher magnitude of sensitivity to detect the turning points in the market.

Likewise, for studies that compare the efficacy of predictive indicators. For example, Chen (2009) extracted the regime switching result derived with the CPS B-B algorithm to examine the relationship of bear markets across selected macroeconomic indicators. Lunde and Timmermann (2004) in the other end adopted a more rigid algorithm (LT B-B hereafter) with the motivation to clearly distinguish the latent long-run structure of the market from the short-term market fluctuation. An ensuing test for the relationship was conducted to examine the result derived, albeit with just a single macro variable, i.e., interest rates.

Comparing the two aforementioned studies, a more sensitive B-B algorithm (i.e., one with less rigid specification) is conceivably more ideal for relationship test between multiple macro variables as oppose to test on a single variable as the former would yield higher statistical significance compared to the latter. The specification of B-B algorithms in the past studies thus was discernibly calibrated in congruence to the motivation of studies.

This paper extracts the bear and bull markets of the SP500 for an extended period of 47 years, using the most and least rigid extremes of B-B algorithms (i.e., LT B-B and CPS B-B) as mentioned above. The identification of these unobserved heterogeneous regimes is important as it provides the foundation for interrelationship studies with market fundamentals. It also serves a practical function as a reference for market participants who do not have access to such market dating tools. Moreover, the examination of the statistical properties of the switching of regimes and their durations could yield crucial insight into the efficacy of algorithms with specifications that vary between two rigidness extremes.

2. Bear and Bull Markets Literature

The bull market is deemed synonymous with the “market rally” term that is commonly found in the literature. The stock market rally is defined as the ascendance of the indices or the stock prices (Shim & Siegel, 2001). Likewise, the general understanding of the term “bull market” is the occurrence of a persistent upward trend of stock market indices particularly after a period of downward trend or stagnancy. The run of positive returns during the bull market could stretch for months and commonly typified by the high volume of transactions in the market. On the contrary, a bear market is defined as the trend of extended decline of stock prices in the market. It is commonly typified by sweeping pessimism on the market outlook. Expectation to economic contraction is the most common catalyst to the occurrence of bear markets in the history (Downes & Goodman, 2010).

Tracing the origin, both the terms of “bear markets” and “bull markets” are regular jargons used by fund managers in the financial market to describe the directions of the market. These terms are later accepted as formal terms for studies in the subject area. In reference to Yanis (2002), one of the definitions from the common traders’ viewpoint (non-academic) of a bear market is a decline in the stock market index of at least 20% or beyond. Other addendums to the key specification include the precondition that the stock market has to go through three stages, i.e., stage one - a “routine decline” of 5% or more; stage two – a “moderate decline” of 10% or more; and stage three - a “severe correction” of a drop of 15% or more. Notwithstanding, it is notable that such specification as above is only one of the many informal examples found in the non-academic literature.

From the academic aspect, Gonzalez et al. (2005) argued that the notion of a random walk be ingrained too deeply in the most contemporary literature on the movement of stock prices that it has curtailed the development of other prospective hypotheses. Despite the unorthodoxy, studies on the cyclical heterogeneous durations of returns in the stock market are one area in the financial economics that is fast gaining prominence (Coakley & Fuertes, 2006; Perez-Quiros & Timmermann, 2000).

Pagan and Sossounov (2003) is one of the earliest studies to specify a set of the algorithm on the change of regimes of the bull and bear markets. Other more critical literature on the identification of bull and bear markets that emerged subsequently include Candelon et al. (2008), Cuñado et al. (2010), Gonzalez et al. (2005), Maheu et al. (2009), and Lunde and Timmerman (2004). Albeit the growing interest in this area, it is noteworthy that the formal definitions of the terms of 'bull market' and 'bear market' have yet to be agreed by consensus.

The design of the Pagan and Sossounov (2003) B-B variant is encapsulated in the steps as follows: 1) determine the turning points of peaks and troughs with an 8-month timeframe; 2) impose switching of phases through the removal of the lesser adjoining peaks and the greater of adjoining troughs; 3) remove phases that are fewer than 4 months except for changes which are over 20%; 4) remove cycles that are not more than 16 months. Maheu et al. (2009) followed the innovation by Lunde and Timmerman (2004) which recommended a shorter 6-month time frame and dated the bear and bull markets with the "value weighted including distributions (VWRETD) index returns for the NYSE+AMEX+NASDAQ stock exchanges".

Citing the October 1987 crash as the primary example, Pagan and Sossounov (2003) pointed out that the phase of the stock market decline only lasted for three months of which then after, the market began to recover. Setting the elimination rule for phases lasting less than four months would have filtered out the aforementioned crash. However, setting the threshold for phase switching at three months minimum would result in many spurious cycles. Thus, another additional restriction was imposed as such that the removal of phases that are fewer than four months can be overruled should the stock market falls by 20% or more within a month.

Cuñado et al. (2010) continued the work of Pagan and Sossounov (2003) with the same algorithm and extended the dating from the year 2000 to 2003. Gonzalez et al. (2005) examined the bull and bear market cycles of the NYSE with an algorithm that closely resembles the original specification introduced by Bry and Boschan (1971). Candelon et al. (2008) introduced a less rigid variant of the B-B algorithm to date the East Asian market.

3. Bear and Bull Markets Identification

3.1 Data

The paper uses the monthly SP500 to date the heterogeneous cycles because the broad market oscillation is more aptly identified with low-frequency data (Gonzalez et al., 2005). The observation period begins from April 1967 to June 2014 (beginning of second quarter of 1967 to end of second quarter of 2014). The LT B-B algorithm dates the heterogeneous regimes of the market with the SP500 in its original form. The CPS B-B algorithm, however, transforms the index into a percentage of return, i.e., *Rt100* for regimes identification.

Consider p_t as the nominal monthly SP500 closing price index at time t, where r is termed in percentage i.e., *Rt100*.

$$r_t = 100 * (lnp_{\mathrm{t}} - lnp_{\mathrm{t-1}}) \quad (1)$$

3.2 CPS B-B Algorithm

The CPS B-B algorithm which was also used in the study by Chen (2009) is more simplistic in relative to other B-B variants. The focus of algorithm is only for the identification of local minimum and the local maximum of $r_t$within a rolling 6 months window based on the original B-B algorithm.

Thus, a local maximum is identified at time t whenever:

$$r_{max} = \{r_t > r_{t\pm 6}\} \tag{2}$$

Likewise, a local minimum is identified at time t whenever:

$$r_{min} = \{r_t < r_{t\pm 6}\} \tag{3}$$

Once the local maximum/minimum, i.e., the turning points in the time series are ascertained, the r_{max} to r_{min} period is identified as bear regime ($D_t = 1$) and the r_{min} to r_{max} period is identified as bull regime ($D_t = 0$), where D_t is a binary dummy variable to denote the alternating regimes in series.

3.3 LT B-B Algorithm

It is important to note that the 20% rule for the decline is an arbitrary value for the algorithm. The in-depth justification can be found in the study by Pagan and Sossounov (2003). The 20% rule is also a convenient figure that is commonly cited as the threshold for sharp declines by market participants (Candelon et al., 2008; Lunde & Timmermann, 2004). Lunde and Timmermann (2004) nonetheless also suggested that other combinations of thresholds could be more sensitive for the identification regime switching, i.e., a 15% surge for bull market vis-a-vis a 15% decline for bear market or a 15% increase for bull market vis-a-vis a 10% decrease for bear market. The research thus chooses the 15% threshold for both the peak and throng turning points as recommended.

To determine local minimum or maximum with the 6-month time frame rule, consider a local maximum at time t_0, therefore $P_{t_0}^{max} = P_{t_0}$, where at the time of t_0, the $P_{t_0}$is the tracked price of stock of the stochastic process. The "time-stopping variables" for a run of bull market is expressed in the following:

$$\tau_{max}\left(P_{t_0}^{max}, t_0 |\, I_{t_0} = 0\right) = inf\left\{t_0 + \tau :\ \ P_{t_0+\tau} \geq P_{t_0}^{max}\right\} \tag{4}$$

$$\tau_{min}\left(P_{t_0}^{max}, t_0 |\, I_{t_0} = 0\right) = inf\left\{t_0 + \tau :\ \ P_{t_0+\tau} \leq 0.85 P_{t_0}^{max}\right\} \tag{5}$$

Next, a filter is imposed on phase switching if one of the scenarios as below occurs:

If $\tau_{max} < \tau_{min}$, the run of bull market remains, the new value of the peak is computed, $P_{t_0+\tau_{max}}^{max} = \ P_{t_0+\tau_{max}}$and the peak time prior at t_0 is replaced with set $I_{t_0+1} = \cdots\ I_{t_0+\tau_{max}} = 1$. Return to rule (4) and (5).

If $\tau_{max} > \tau_{min}$, a trough will commence at time $t_0 + \tau_{min}$, hence the bear market would have occurred from $t_0 + 1$ to $t_0 + \tau_{min}$, $I_{t_0+1} = \cdots\ I_{t_0+\tau_{min}} = 1$.

The value of $P_{t_0+\tau_{min}}^{min} = P_{t_0+\tau_{min}}$ is computed and the time at t_0 is identified as a peak. Next rule (6) and (7) is applied for bear market.

Vice versa, the "time-stopping variables" for a run of bear market is denoted in the following:

$$\tau_{min}\left(P_{t_0}^{min}, t_0 | \, I_{t_0} = 1\right) = inf\left\{t_0 + \tau : \; P_{t_0+\tau} \leq P_{t_0}^{min}\right\} \tag{6}$$

$$\tau_{max}\left(P_{t_0}^{min}, t_0 | \, I_{t_0} = 1\right) = inf\left\{t_0 + \tau : \; P_{t_0+\tau} \geq 1.15 P_{t_0}^{min}\right\} \tag{7}$$

If one of the scenarios as below occurs:

If $\tau_{min} < \tau_{max}$, the run of bear market remains, the new value of the trough is computed, $P_{t_0+\tau_{min}}^{min} = P_{t_0+\tau_{min}}$ and the trough time prior at t_0 is replaced with set $I_{t_0+1} = \cdots I_{t_0+\tau_{min}} = 1$. Return to rule (6) and (7).

If $\tau_{min} > \tau_{max}$, a peak will commence at time $t_0 + \tau_{max}$. Hence a run of bull market would have occurred from $t_0 + 1$ to $t_0 + \tau_{max}$, $I_{t_0+1} = \cdots I_{t_0+\tau_{min}} = 0$. The value of $P_{t_0+\tau_{max}}^{max} = P_{t_0+\tau_{max}}$ is computed and the time at t_0 is recorded as a trough. Return to rule (4) and (5) for bull market.

The binary dummy denotations for both regimes of bear and bull markets for the LT B-B algorithm as explained above are reversed from the original study (i.e., in the literature, bear = 0; bull = 1 were changed to bear = 1; bull = 0) to be standardised with CPS B-B algorithm used in the research.

4. Results

The dates for the heterogeneous switching of regimes between the bull and bear markets identified using the LT B-B and the CPS B-B algorithm are presented in Table 1 and Table 2 respectively. Charts generated from the result that illustrate the bear markets more clearly are shown in Figure 1 and Figure 2. Table 3 demonstrates the comparison of statistical properties between the two B-B algorithms.

Table 1: CPS B-B algorithm identification for bull and bear markets durations (April 1967 – June 2014).

Bull Markets Dates			Bear Markets Dates		
Dates	*Rt100* Mean	S.D.	Dates	*Rt100* Mean	S.D.
1967.04 - 1967.09	1.150	1.189	1967.10 - 1968.03	-1.212	2.610
1968.04 - 1968.12	1.983	2.552	1969.01 - 1970.06	-1.905	3.676
1970.07 - 1971.04	3.094	2.131	1971.05 - 1971.11	-1.493	2.060
1971.11 - 1973.01	1.742	2.372	1973.02 - 1974.12	-2.471	4.468
1975.01 - 1976.09	2.157	3.979	1976.10 - 1978.03	-0.956	1.761
1978.04 - 1978.09	2.614	3.057	1978.10 - 1978.11	-4.630	1.984
1978.12 - 1980.11	1.498	3.432	1980.12 - 1982.07	-1.077	3.348
1982.08 - 1983.10	2.848	3.331	1983.11 - 1984.07	-1.158	1.961
1984.08 - 1986.06	2.107	2.835	1986.07 - 1986.10	-0.818	2.120
1986.11 - 1987.08	3.275	2.562	1987.09 - 1987.12	-7.812	6.204
1988.01 - 1990.06	1.341	2.451	1990.07 - 1990.10	-3.999	3.543
1990.11 - 1994.01	1.107	2.306	1994.02 - 1994.04	-1.867	1.680
1994.05 - 2000.08	1.579	2.981	2000.09 - 2001.09	-2.708	4.601
2001.10 - 2002.03	1.656	3.238	2002.04 - 2003.02	-2.918	4.651

Table 1 (*continued*).

Bull Markets Dates			Bear Markets Dates		
Dates	*Rt100* Mean	S.D.	Dates	*Rt100* Mean	S.D.
2003.03 - 2004.02	2.599	2.020	2004.03 - 2004.08	-0.813	2.120
2004.09 - 2007.10	0.911	2.088	2007.11 - 2009.03	-4.175	6.142
2009.04 - 2010.04	3.525	3.568	2010.05 - 2010.07	-3.444	2.962
2010.08 - 2011.05	2.146	1.697	2011.06 - 2011.09	-3.277	5.943
2011.10 - 2014.06*	1.533	1.971			

*The run bull market continued as per the end date.

Table 2: LT B-B algorithm identification for bull and bear markets durations (April 1967 – June 2014).

Bull Markets Dates			Bear Markets Dates		
Dates	*Rt100* Mean	S.D.	Dates	*Rt100* Mean	S.D.
1967.04 - 1968.12	0.832	2.558	1969.01 - 1970.11	-1.017	3.800
1970.12 - 1973.01	1.307	2.844	1973.02 - 1975.01	-2.040	4.853
1975.02 - 1976.09	1.871	3.855	1976.10 - 1978.07	-0.373	2.281
1978.08 - 1980.11	1.192	3.734	1980.12 - 1982.09	-0.469	4.091
1982.10 - 1987.08	1.678	2.922	1987.09 - 1988.09	-1.587	5.807
1988.10 - 2000.08	1.198	2.869	2000.09 - 2003.06	-1.199	4.799
2003.07 - 2007.10	0.853	2.108	2007.11 - 2009.03	-3.313	6.992
2009.04 - 2014.06*	1.340	3.003			

*The run bull market continued as per the end date.

The bear and bull markets regimes objectively identified in Table 1 and Table 2 show the CPS B-B algorithm detects more frequent switching of regimes (19 times) compared to the LT B-B algorithm (8 times). Thus, the durations of bear markets dated with the CPS B-B algorithm is discernibly shorter. As noted prior, the *Rt100* is the nominal capital returns termed in percentage. Schwert (1990) pointed out that the difference of dividend returns are less significant compared to the fluctuation of stock prices. Gonzalez et al. (2005) concurred that dividend returns are negligible and studies on regimes switching are best examined solely with capital returns.

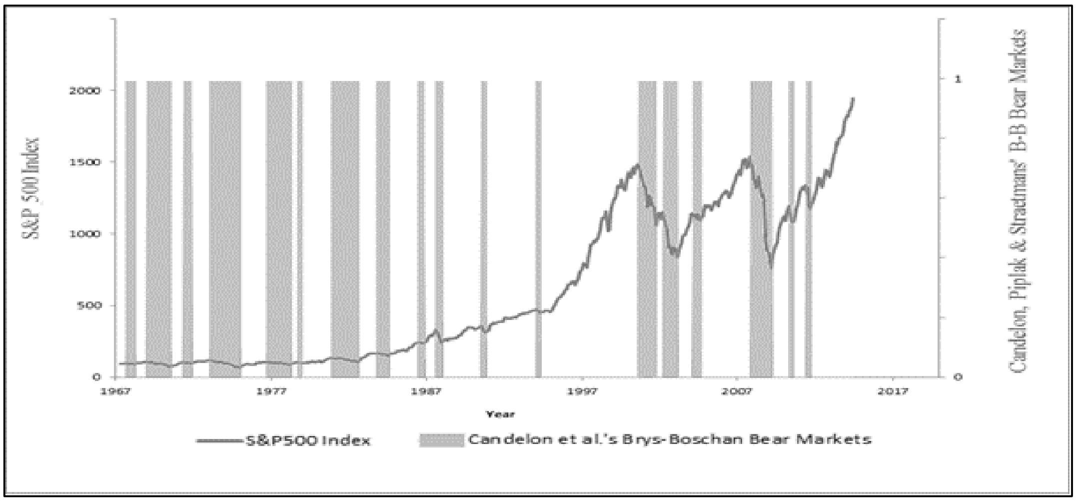

Figure 1: S&P 500 index vs. CPS B-B algorithm bear markets.

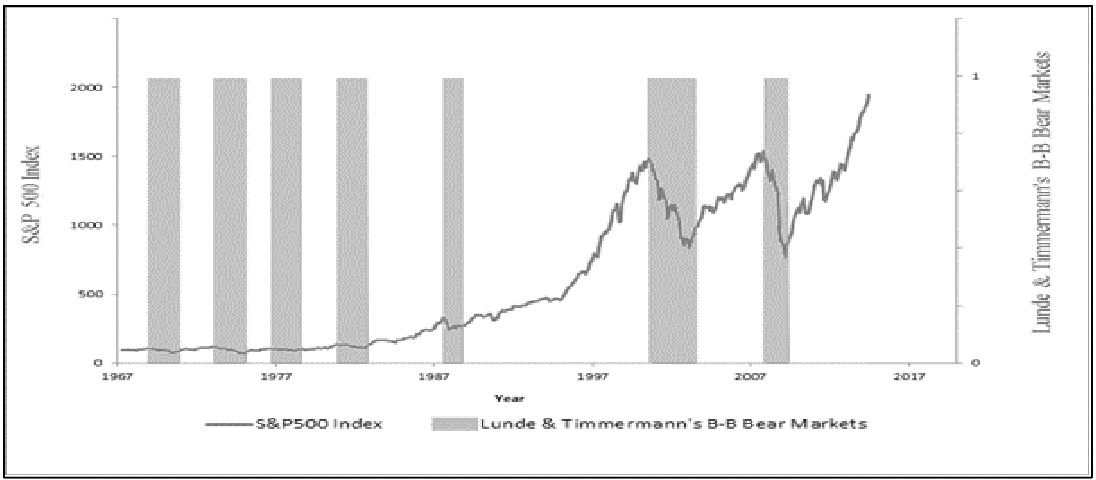

Figure 2: S&P 500 index vs. LT B-B algorithm bear markets.

Table 3: Comparison of Statistical Properties between the LT B-B and CPS B-B.

	LT B-B		*CPS B-B*	
	Bull Markets	Bear Markets	Bull Markets	Bear Markets
Mean	1.265	-1.358	1.767	-2.267
Standard Error	0.143	0.377	0.138	0.306
Median	1.387	-0.878	1.823	-1.729
Standard Deviation	2.907	4.710	2.750	4.011
Sample Variance	8.448	22.187	7.564	16.085
Kurtosis	1.689	2.721	1.680	3.966
Skewness	-0.316	-0.786	0.078	-1.290
Range	21.858	34.157	20.996	29.353
Minimum	-11.155	-22.804	-9.644	-22.804
Maximum	10.703	11.352	11.352	6.549
Sum	519.994	-211.919	698.061	-389.986
Count	411	156	395	172
Confidence Level (95.0%)	0.282	0.745	0.272	0.604

The CPS B-B algorithm which is less rigid in specification compared to the LT B-B algorithm, yields a larger average return (1.767) and average loss (-2.267); smaller standard deviation for return (2.750) and loss (4.011); and larger cumulative gain (698.061) and cumulative loss (-389.986) for the aggregated bull and bear regimes respectively. Overall, the LT B-B algorithm identified 411 months of bull markets vis-à-vis 395 months identified with the CPS B-B algorithm. The zero-sum nature of the heterogeneous regimes identification approach thus renders the LT B-B to identify lesser overall durations for bear markets (156 months) compared to the CPS B-B algorithm (172 months).

The distribution of bear markets for both the LT B-B and CPS B-B algorithms are leptokurtosis and have higher readings than their counterpart, i.e., the bull markets. This indicates the bear markets are inclined to go through greater movements and are more probable to outliers. It is noteworthy that the findings on kurtosis are in contrary to the previous study by Gonzalez et al. (2005). The difference could be due to the calibration of the "auto-trigger" regime switching threshold from a 20% fall or rise within a month in the original B-B algorithm to 15% in the LT B-B algorithm. The lowered threshold is justified as it was noted in previous study aforementioned that "fewer than half of the bear markets result in a market decline more than 20%". The CPS B-B algorithm, on the other hand, removed the threshold rule altogether (refer to Section 3) which in turn increases its sensitivity for turning-point detection. On another note, it is also plausible that the use of the different stock market index and observation period attributed to the unconformity of findings between this paper and the earlier related study.

5. Conclusion

The overall results indicate that the less rigid B-B variant of the CPS B-B algorithm detects more frequent changes of stock market regimes, has lower standard deviation but higher aggregated sum of return and loss. Notwithstanding, it is important to note that the indication of greater sensitivity does not imply superiority. The primary objective of studies in heterogeneous regimes switching is to identify distinctly the latent long-run structure of the market. The output of the LT B-B algorithms illustrated in the chart (Figure 2) shows a more patent and persistent long-term structure compared to the output of the CPS B-B algorithm.

The study does emancipate the impasse of dissension on the choicest algorithm for the ex-post modelling of bear and bull markets. The results nonetheless may provide valuable insight into the statistical properties of algorithms with a diverse spectrum of rigidness. This can be crucial for the methodological selection of future studies that examine the relationship between economic indicators and the heterogeneous market durations. The ex-post dates of the bear and bull markets provided in the paper are conceivably useful for market participants to analyse the long-term pattern of the movement for their future investment decision making.

References

Bry, G., & Boschan, C. (1971). Programmed selection of cyclical turning points. In *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs* (pp. 7-63). NBER.

Candelon, B., Piplack, J., & Straetmans, S. (2008). On measuring synchronization of bulls and bears: The case of East Asia. *Journal of Banking & Finance*, *32*(6), 1022-1035.

Chen, S. S. (2009). Predicting the bear stock market: Macroeconomic variables as leading indicators. *Journal of Banking & Finance*, *33*(2), 211-223.

Coakley, J., & Fuertes, A. M. (2006). Valuation ratios and price deviations from fundamentals. *Journal of Banking & Finance*, *30*(8), 2325-2346.

Cuñado, J., Gil-Alana, L. A., & de Gracia, F. P. (2010). Mean reversion in stock market prices: New evidence based on bull and bear markets. *Research in International Business and Finance*, *24*(2), 113-122.
Downes, J., & Goodman, J. E. (2010). *Dictionary of finance and investment terms*. New York: Barron's Educational Series.
Gonzalez, L., Powell, J. G., Shi, J., & Wilson, A. (2005). Two centuries of bull and bear market cycles. *International Review of Economics & Finance*, *14*(4), 469-486.
Lunde, A., & Timmermann, A. (2004). Duration dependence in stock prices: An analysis of bull and bear markets. *Journal of Business & Economic Statistics*, *22*(3), 253-273.
Maheu, J. M., McCurdy, T. H., & Song, Y. (2009). Extracting bull and bear markets from stock returns. *Journal of Business & Economic Statistics*, *18*(1), 100-112.
Pagan, A. R., & Sossounov, K. A. (2003). A simple framework for analysing bull and bear markets. *Journal of Applied Econometrics*, *18*(1), 23-46.
Perez-Quiros, G., & Timmermann, A. (2000). Firm size and cyclical variations in stock returns. *The Journal of Finance*, *55*(3), 1229-1262.
Shim, J. K., & Siegel, J. G. (2001). *Dictionary of international investment terms*. New York: Barrons Educational Series Incorporated.
S&P 500 Historical Data (n. d.). *Yahoo! Finance*. Retrieved May 10, 2017, from https://finance.yahoo.com/quote/%5EGSPC/history/.
Schwert, G. W. (1990). Stock volatility and the crash of '87, *The Review of Financial Studies*, 3(1), 103-106.
Yanis, E. M. (2002). *Riding the Bull, Beating the Bear: Market Timing for the Long-term Investor*. New York: Wiley.