New Trends and Issues Proceedings on Humanities and Social Sciences

Volume 5, Issue 2 (2018) 19-28

www.prosoc.eu

ISSN 2547-8818

Selected Paper of 7th World Conference on Business, Economics and Management (BEM-2018), 28-30 April 2018, Ephesus – Kusadasi, Turkey

Mixed integer programming approach for seasonal anomalies in stock markets: A case study for BIST

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Suggested Citation:

Arik, O. E. (2018). Mixed integer programming approach for seasonal anomalies in stock markets: a case study for BIST. *New Trends and Issues Proceedings on Humanities and Social Sciences.* [Online]. *5*(2), pp 19–28. Available from: www.prosoc.eu

Selection and peer review under responsibility of Prof. Dr. Cetin Bektas, Gaziosmanpasa University, Turkey

Abstract

This paper proposes a mixed integer programming approach for seasonal anomalies in stock markets and presents a case study for the XU030 index in the stock market of Istanbul Stock Exchange (BIST). Stock markets are significant for economies of countries all over the world. Investors get economical wealth or lose some of their investment by selling and buying stocks. Therefore, buying and selling times of stocks are so important. This paper investigates a well-known effect called as 'Sell in May and Go Away' by proposing a MIP approach that searches best times for buying and selling of stocks in a year. Furthermore, this paper includes a numerical example of XU030 stock prices for the past 5 years and shows that most of the XU030 stocks have seasonal anomalies.

Keywords: First keyword, second keyword, third keyword, forth keyword.

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1. Introduction

Stock markets are one of the significant economic indicators of countries and they present opportunities and risks for both of domestic and international investors. 'Sell in May and Go Away' means that potential investors should sell their stock in May and rebuy them in September. Bouman and Jacobsen (2002) stated that the month of May signals the start of a bear market so that investors are better off selling their stocks and holding cash. There are two different endings to the saying. The first of these is: 'but remember to come back in September'; the second is: 'but buy back on St. Leger Day'. Most of the studies about this effect have investigated seasonal anomalies with regression analyses.

This paper proposes a mixed integer linear program that maximises total profit by buying and selling stocks on the right time in a year. The mathematical models in this paper assume that stock prices are equal for buying and selling prices for those stocks and there is no limitation for the buying and selling of those stocks. That means an investor can buy or sell stocks without waiting and transaction costs for stocks are ignored. These assumptions are necessary for putting out seasonal anomalies within an optimisation problem. In the proposed model, if a stock is bought, then that stock must be sold within 12 months after its buying time. Thus, seasonal anomalies can be easily determined by the models.

2. Literature review

It is difficult to explain the stock market in a classical framework. It is widely accepted that markets exhibit many seasonal irregularities or anomalies. The literature mainly focuses on time periods with seasonal effects. Rozeff and Kinney (1976) presented the evidence on the existence of seasonality in monthly rates of return on the New York Stock Exchange from 1904–1974. Bouman and Jacobsen (2002) examined whether stock returns are indeed significantly lower during the May–October period than during the remainder of the year. They reported that results for the month of October, results are similar when they use September instead. They showed the sell in May effect is present in 36 of the 37 countries in their sample. Furthermore, they showed that the effect tends to be particularly strong and highly significant in European countries. Andrade, Chhaochharia and Fuerst (2013) reported that all countries involved in the study by Bouman and Jacobsen (2002) also performed better than the rest of the year from November to April (1998–2012). As the seasonality of Halloween cannot be explained with rational effects, they have come to the conclusion that stock markets could be more stable in order to earn more than expected. Jones and Lundstrum (2009) investigated 40 countries' stock markets for 'Sell in May' or January effect. They showed that 38 of 40 countries have January effect in their stock markets.

Guo, Luo and Zhang (2014) investigated historical data of Chinese stock market from 1997 to 2013 and they showed that there is a strong indicator for the existence of robust 'Sell in May and Go Away' effect. Coakley, Kuo and Wood (2012) provided evidence of a new seasonal anomaly during the school vacation or school's out period in nine East Asia and five Mediterranean stock markets. One of the characteristics of this new seasonal anomaly was that many investors are distracted by child care activities in family-oriented economies where the school vacations last for at least 5 weeks. The other characteristic they figured out was that retail investors play a prominent role in these markets. Frey, Rieskamp and Hertwig (2015) investigated physiological reasons of 'Sell on May and go away' or January effect in stock markets. They also considered learning and risk-taking in non-monotonic decision problems that are related to buying and selling stocks in the markets.

Dichtl and Drobetz (2014) implemented regression models as well as Hansen's (2005) 'Superior Predictive Ability' test to analyse whether stock markets are really so inefficient. Their results reject the hypothesis that a trading strategy based on the Halloween effect significantly outperforms. In another study by Dichtl and Drobetz (2015), they examined whether the 'Sell in May and Go Away' (or

Halloween) trading strategy still offers an opportunity to earn abnormal returns. They found that the Halloween effect strongly weakened or even disappeared in recent years. They claimed that their results are robust across different markets and against various parameter variations.

Jacobsen and Marquering (2008) tried to find strong evidence on a summer–winter seasonality in stock returns buy they found that it is premature to conclude that this effect is caused by weather-induced mood changes of investors. Their analysis showed that it is simply not enough to link temperature and seasonal affective disorder directly to stock returns on the assumption that these variables affect mood and therefore, affect stock returns. We showed that other variables with a strong seasonal pattern do at least as well; the Sell in May/Halloween variable. Constantine and Ziemba (2010) investigated anomalies such as the January effect, January barometer and Sell in May effect. They stated that the anomalies remain, but with some changes in days of the occurrence. In the past, some anomalies, such as the turn-of-the-month and January effects had very high prediction accuracy. Furthermore, they stated that the January barometer and Sell in May effects, which deal with longer-range predictions, have similar reliability as in the past.

Degenhardt and Auer (2018) investigated Sell in May effect on stock and commodity markets. They found that the Sell in May effect has become weaker (stronger) in the stock (commodity) market since it has become part of the public information set and that the effectiveness and persuasiveness of standard investment strategies based on the effect are limited. Arendas (2017) investigated the Halloween effect on the agricultural commodities markets and tested price series of 20 major agricultural commodities over the 1980–2015-time period price series of 20 major agricultural commodities over the 1980–2015-time period. His research studies showed that 15 out of the 20 commodities recorded a higher average winter period than summer period returns and in 10 cases, the differences are statistically significant. His research studies also showed that out of the five commodities with higher summer period returns, only in the case of poultry the differences are statistically significant. Caporale and Plastun (2017) investigated the Ukrainian stock market for following anomalies: day-of-the-week effect; turn-of-the-month effect; turn-of-the-year effect; month-of-the-year effect; January effect; holiday effect and Halloween effect. They used multiple statistical techniques and a trading simulation approach. They showed some of the indices in the Ukrainian stock market has Halloween effect. Carrazedo, Curto and Oliveira (2016) presented economically and statistically empirical evidence that the Halloween effect is significant. In their study, a trading strategy based on this anomaly worked persistently and outperformed the buy and hold strategy in 8 out of 10 indices in their sample. They presented evidence that the Halloween strategy works two out of every three calendar years and if an investor followed it ‘blindly’, it would yield an annual average excess of return of approximately 2.4%, compared to the buy and hold strategy and further ensure a significant reduction in risk in all indices. Sakakibara, Yamasaki and Okada (2015) compared Sell in May effect and Dekansho-bushi effect on the Japanese stock market. The Dekansho-bushi effect distinguished from the Sell in May effect, since Japanese stocks perform well in June and poorly in November and December. They found that Dekansho-bushi effect exists, regardless of a company’s size or book-to-market ratio. Gebka, Hudson and Atanasova (2015) studied the benefits of trading based on combinations of three of the best-known effects: the moving average rule, the turn of the month effect and the Halloween effect. They showed that the rules can be combined effectively, giving significant levels of returns predictability with low risk and offering the possibility of profitable trading. Gulseven (2014) examined the monthly returns in Turkish and American stock market indices to investigate whether these markets experience abnormal returns during some months of the calendar year. Gulseven stated that there is a strikingly negative May effect on the Turkish stocks following a positive return in April. Furthermore, Gulseven stated that one can claim a positive return for the months of April, July and December, and negative returns for the months of May and August for the BIST 30 data. Other papers about Sell in May effect are conducted by Ferraro (2014), Lean (2011), Lucey and Zhao (2008), Doeswijk (2008), Cooper, McConnell and Ovtchinnikov (2006) and Maberly and Pierce (2005).

3. Mathematical model for single stock

This model is to check seasonal anomalies and determine best buying and selling times in view of monthly closing data for each of all stocks in the index. The model is as follows:

Indices:

i : *index for months*

j : *index for months*

Parameters:

N : *number of years*

M : *number of months in a year*

$B_{i,j}$: *Buying price of that stock on month i in year y*

$B_{i,j}$: *Seling price of that stock on month i in year y*

Decision variables:

B_j : *Buying price of that stock in year y*

S_j : *Seling price of that stock in year y*

P_j : *profit gained from that stock in year y*

$$X_i : \begin{cases} 1, \textit{if that stock is buyed on month i in each year} \\ 0, \textit{othervise} \end{cases}$$

$$Y_i : \begin{cases} 1, \textit{if that stock is sold on month i in each year} \\ 0, \textit{othervise} \end{cases}$$

Mathematical Model:

$$Max\ z = \sum_{j=2}^{N} P_j \tag{1}$$

Subject to:

$$\sum_{i=1}^{M} X_i = 1 \tag{2}$$

$$\sum_{i=1}^{M} Y_i = 1 \tag{3}$$

$$P_j = S_j - B_{j-1} \; j = 2 \ldots N \tag{4}$$

$$B_j = \sum_{j=1}^{N} B_{i,j} * X_i \forall j \tag{5}$$

$$S_j = \sum_{j=1}^{N} S_{i,j} * Y_i \forall j \tag{6}$$

$$\sum_{i=1}^{M} (12+i) * Y_i - \sum_{\substack{k=1 \\ k \neq i}}^{M} k * X_k \leq 11 \tag{7}$$

$$X_i, Y_i \in \{0,1\} \; \forall i \tag{8}$$

$$B_j, S_j \geq 0 \forall j \tag{9}$$

$$P_{t,j} \in R \tag{10}$$

The objective function (Eq. (1)) is to maximise profits for all years except the first year. Constraints Eqs. (2) and (3) ensure that only one month can be used for selling and buying transactions in a year. Constraint (Eq. (4)) shows that the profit values P_i are calculated by subtracting the buying price of the year *j*–1 from selling prices of the year *j*. Constraints Eqs. (5) and (6) are to determine each year's unique buying and selling prices. Constraint (Eq. (7)) ensures that time interval between buying time in the year *j*–1 and selling time in the year *j* is not longer than 12 months. Eqs. (8)–(10) define the neccesary domains of the decision variables.

4. Mathematical model for multiple stocks

This model is to check seasonal anomalies and determine best buying and selling times in view of monthly closing data for all stocks in the index. This model is also an extension of the first model. The model is as follows:

Indices:

i : *index for months*

j : *index for years*

t : *index for stocks*

Parameters:

N : *number of years*

$M: number\ of\ months\ in\ a\ year$

$O: number\ of\ stocks$

$B_{t,i,j}: Buying\ price\ of\ stock\ t\ stock\ on\ month\ i\ in\ year\ y$

$S_{t,i,j}: Seling\ price\ of\ stock\ t\ stock\ on\ month\ i\ in\ year\ y$

Decision variables:

$B_{t,j}: Buying\ price\ of\ stock\ t\ stock\ in\ year\ y$

$S_{t,j}: Seling\ price\ of\ stock\ t\ stock\ in\ year\ y$

$P_{t,j}: profit\ gained\ from\ stock\ t\ stock\ in\ year\ y$

$$X_i : \begin{cases} 1, if\ all\ stocks\ are\ buyed\ on\ month\ i\ in\ each\ year \\ 0, othervise \end{cases}$$

$$Y_i : \begin{cases} 1, if\ all\ stocks\ are\ sold\ on\ month\ i\ in\ each\ year \\ 0, othervise \end{cases}$$

Mathematical Model:

$$Max\ z = \sum_{j=2}^{N} \sum_{t=1}^{O} P_{tj} \tag{11}$$

Subject to:

$$\sum_{i=1}^{M} X_i = 1 \tag{12}$$

$$\sum_{i=1}^{M} Y_i = 1 \tag{13}$$

$$P_{t,j} = S_{t,j} - B_{t,j-1} j = 2 \ldots N \ \& \ \forall t \tag{14}$$

$$B_{t,j} = \sum_{j=1}^{N} B_{t,i,j} * X_i \forall j \ \& \ \forall t \tag{15}$$

$$S_{t,j} = \sum_{j=1}^{N} S_{t,i,j} * Y_i \forall j \,\&\, \forall t \tag{16}$$

$$\sum_{i=1}^{M} (12+i) * Y_i - \sum_{\substack{k=1 \\ k \neq i}}^{M} k * X_k \leq 11 \tag{17}$$

$$X_i, Y_i \in \{0,1\} \forall i \tag{18}$$

$$B_{t,j,} S_{t,j} \geq 0 \forall j \tag{19}$$

$$P_{t,j} \in R \tag{20}$$

The objective function (Eq. (11)) is to maximise profits of all years except the first year. Constraints (Eqs. (12) and (13)) ensure that only one month can be used for selling and buying transactions in a year. Constraint (Eq. (14)) shows that the profit values P_j are calculated by subtracting the buying price of the year j–1 from selling prices of the year j. Constraints (Eqs. (15) and (16)) are to determine each year's unique buying and selling prices. Constraint (Eq. (17)) ensures that time interval between buying time in the year j–1 and selling time in the year j is not longer than 12 months. Eqs. (18)–(20) define the neccesary domains of the decision variables.

5. A case study for the XU030 index in BIST

The models introduced in this paper assume that stock prices are equal for buying and selling prices for those stocks and there is no limitation for buying and selling of those stocks. That means an investor can buy or sell stocks without waiting, and transaction costs for stocks are ignored. These assumptions are necessary for putting out seasonal anomalies within an optimisation problem. The test data is obtained from stocks in the XU030 index (dated on 29.09.2017) from 2011 to 2016. Stock prices are monthly closing prices of stocks in the XU030 index. In order to execute the second model for all stocks, a common earliest January when all stocks are available in BIST is needed. This common earliest January is 01.01.2011 for all stocks in this example. The historical data of XU030 index has an increasing trend as seen in Figure 1. For each of 30 stocks in XU030 index, the first model is executed with CPLEX 12.6 solver and the summary of best pair months for buying and selling each stock is given in Table 1.

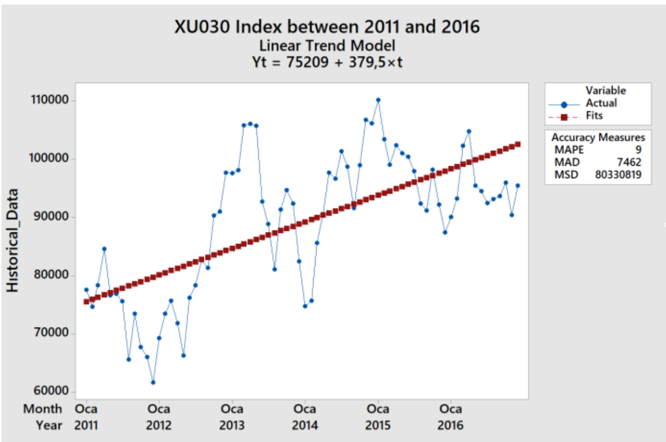

Figure 1. Historical data of XU030 index between 2011 and 2016

The first model is executed for 30 stocks' prices between 2011 and 2016. 19 of 30 stocks have the same result, buy in the month August and sell in the month April. The stock prices in this paper are historical closing prices of stocks in XU030 index between 2011 and 2016. Table 1 shows that more than 60% of stocks in the XU030 index have the same pattern that buying in August and selling in April. When the first model is executed by considering only XU030 own monthly closing prices in Figure 1, closing prices of August and April are found as best months for buying and selling, respectively. This situation directly indicates there is a pattern including selling in April and buying in August for XU030 monthly closing prices.

Table 1. The summary of the first model

For Buying	# of repeat	For selling	# of repeat
August	19	April	19
June	2	July	6
November	4	May	2
May	2	August	1
		March	1
		October	1
Total	30	Total	30

The study in this paper does not intend to suggest investors for buying and selling certain stocks between certain time periods. Thus, the result for each stock is not given in this paper, but Table 2 shows the names of stocks in the XU030 index when the date was 29.09.2017. When the second model is executed by CPLEX 12.6 solver for all stock in the XU030 index at the same time, closing prices of August and April are found as best months for buying and selling, respectively.

Table 2. Names of stocks in XU030 on 29.09.2017

No:	Stock name	No:	Stock name
1	GARAN	16	ASELS
2	AKBNK	17	TOASO
3	TUPRS	18	YKBNK
4	TCELL	19	SISE
5	BIMAS	20	TTKOM
6	EREGL	21	ENKAI
7	ISCTR	22	TAVHL
8	KCHOL	23	ULKER
9	SAHOL	24	TKFEN
10	HALKB	25	SODA
11	THYAO	26	KRDMD
12	EKGYO	27	METRO
13	VAKBN	28	KOZAL
14	PETKM	29	DOHOL
15	ARCLK	30	OTKAR

6. Conclusion

This paper proposes mixed integer programming models that use monthly closing prices of stocks in the XU030 index in order to determine seasonal anomalies and best time periods for buying and selling for a year. All historical data on stock closing prices are between 2011 and 2016. The models introduced in this paper assume that stock prices are equal for buying and selling prices for those stocks and there is no limitation for buying and selling of those stocks. That means an investor can buy or sell stocks without waiting. This assumption is necessary for putting out seasonal anomalies within an optimisation problem. The result of each model shows that there is a buying–selling pattern that suggests the month of August for buying and the month of April for selling. Future research can investigate these models for other BIST indices or all stocks in BIST or even other countries' stock markets.

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