Simulation of Canadian S&P/TSX Composite Index for the First 20 Years in the 21st Century with Random Walk Model

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Abstract
The Canadian S&P/TSX Composite Index is a capitalization-weighted equity index that records the stock performance in Toronto Stock Exchange (TSX), which is the primary stock exchange in Canada. The S&P/TSX is closely monitored by investors and becomes a barometer for the health of the Canadian economy. The random walk model is an important tool to prove or disprove the efficient market hypothesis (EMH). Generally, the use of random walk model to test this hypothesis is conducted using statistical tests. Recently, we conducted a series of studies to use the random walk model to directly simulate/fit the major stock indices around the world. As a part of such an effort, we use the random walk model to simulate the S&P/TSX for the first 20 years in the 21st century in this study. The results show that the random walk model can satisfyingly simulate the S&P/TSX trend for the long period, but fails for short periods.

Keywords-*S&P/TSX Composite Index; random walk; simulation; finance and trade; stock market*

1. Introduction

The Canadian S&P/TSX Composite Index is a capitalization-weighted equity index that records the stock performance in Toronto Stock Exchange (TSX), which is the primary stock exchange in Canada. Thus, the S&P/TSX is closely monitored by investors and becomes a barometer for the health of the Canadian economy. Being important, the S&P/TSX is the topic of many studies on every aspect [1-3] including purely technical-oriented studies [2, 3].

The efficient market hypothesis (EMH) suggests that the prices at any given time reflect fully all available and relevant information in a stock market. However, this is often not the case. Therefore, the weak form of EMH suggests that stock returns follow a random walk because the available information is historic prices [4]. As a matter of fact, the issue of whether an individual stock follows the weak form of EMH is still unsolved and the issue of whether a stock index follows the random walk is controversial.

So far, a number of studies have been conducted to test whether a stock index follows a random walk on many indices around the world using statistical tests [5-10] and the random walk [11-15]. In the weak form of EMH, the trend in stock market is unpredictable. But the random walk simulation with a certain seed does generate a relatively predictable trend [11-15].

This conclusion needs more studies for analysis, exploration and tests. To the best of our knowledge, no random walk studies have been conducted on the S&P/TSX. Hence, it is important to test whether a random walk model can simulate the S&P/TSX by. This is designed as the goal of this study.

2. S&P/TSX Data and Random Walk Model

2.1. S&P/TSX data

The daily S&P/TSX for the first 20 years in the 21st century was obtained from Canadian Yahoo Finance [16]. This dataset from 2001 to 2020 includes 5025 daily open,

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high, low, close, adjusted close, and volume. We use the random walk to simulate the daily close. The simulations were grouped into five sub-periods, 2020 includes 252 trading days, 2016-2020 includes 1255 trading days, 2011-2020 includes 2509 trading days, 2006-2020 includes 3766 trading days, and 2001-2020 includes 2025 trading days.

2.2. Random Walk Model

Random walk by definition [17] is a path that is generated by tossing a fair coin continuously. Two faces of the coin are defined as 1 and –1, respectively. The addition of a series of tossing will generate a random walk along the time course. Because the outcome of tossing a coin is a random event, the record of a series of tossing is also a series of random events.

2.3. S&P/TSX as a Random Walk

The S&P/TSX can be converted into the form in the terms of random walk, i.e. if an S&P/TSX close in a trading day is higher or lower than that in its previous trading day, then we mark it as 1 or –1. These values then are added together along the time course, which is exactly a random walk. This rationale is workable because there are just six equal S&P/TSX closes between two sequential trading days: 8788.8 for October 15 and 18, 2004; 9122.6 for December 17 and 20, 2004; 11936.7 for August 3 and 4, 2006; 8724.1 for December 16 and 17, 2008; 11395 for September 29 and 30, 2009; and 13632 for May 4 and 5, 2016.

2.4. Random Walk in the Decimal Type

Although the random walk in the decimal type is not defined, we could expand the classical random walk, which is either 1 or –1, into a decimal type. This is because the modern random walk is made of random numbers generated by a computer program. The random numbers must be rounded to integral to fit the definition that each step in random walk is either 1 or –1. If we do not round the random numbers and add them together along the time course, then their addition will be a random walk in the decimal type. In reality, this is the case for any stock index and any individual stock.

2.5. Simulation

With the random walk in both 1/–1 and decimal types, we use the SigmaPlot [18] to generate a series of random numbers, whose addition results in a random walk simulation. The simulation should be as similar to the S&P/TSX as possible. The difference between a random work and the S&P/TSX is the measure to evaluate the simulation performance.

TABLE 1. BUILD RANDOM WALKS IN BOTH 1/–1 AND DECIMAL TYPES

Date	S&P/TSX Close	Compare Preceding Close	Random Walk in 1 or–1 Type	Generated Random Number	Compare Preceding Random Number	Random Walk in 1 or–1 Type	Generated Random Number	Random Walk in Decimal Type
Jan 2, 2020	17100		0					17100
Jan 3, 2020	17066.1	–1	–1	0.60981	1	1	–12.32222	17087.7
Jan 6, 2020	17105.5	1	0	0.18104	–1	0	33.77618	17121.5
Jan 7, 2020	17168.1	1	1	0.92326	1	1	244.56518	17366
Jan 8, 2020	17167.8	–1	0	0.62887	–1	0	–210.11105	17155.9
Jan 9, 2020	17235.6	1	1	0.79313	1	1	–9.22706	17146.7
Jan 10, 2020	17234.5	–1	0	0.79799	1	2	148.33497	17295
Jan 13, 2020	17293.4	1	1	–0.38158	–1	1	116.00793	17411
Jan 14, 2020	17352.9	1	2	–0.73407	–1	0	268.48064	17679.5
Jan 15, 2020	17415.2	1	3	0.83660	1	1	87.36547	17766.9

3. RESULTS AND DISCUSSION

Table 1 demonstrates how to build the random walk simulation in both 1/–1 and decimal types. Columns 1 and 2 are the date and its corresponding S&P/TSX close for the beginning of 2020. Column 3 lists whether the S&P/TSX is larger or smaller than that in its preceding day in terms of the 1/–1 type. For example, 17066.1, the S&P/TSX close on January 3, 2020 is smaller than 17100, the S&P/TSX close on January 2, 2020, so –1 is put into the second cell in column 3. Column 4 is the addition of each cell in column 3, and builds an S&P/TSX in the 1/–1 type. Column 5 is the first step to build a random walk, i.e. to generate as many random numbers as the size of column 3. Column 6 lists whether the generated random number is larger or smaller than its preceding random number in the 1/–1 type. Column 7 is the addition of each cell in column 6, and builds a random walk simulation for comparison with column 4. The last two columns demonstrate how to construct a random walk simulation in the decimal type. Column 8 is a series of random numbers generated according to the standard deviation of the S&P/TSX close in 2020 because the command for the generation of random numbers usually includes 4 terms, i.e. seed, the number to be generated, and upper and lower ranges. In our previous studies [11-15], we found that the standard deviation is more suitable for upper and lower ranges than the standard errors, 95% confident intervals, maximal and minimal closes. Column 9 is the random walk simulation by adding each random number in column 8 to the corresponding S&P/TSX close in column 2. Finally comparison can be made between columns 2 and 9.

In Figure 1, both S&P/TSX and random walk simulation are in the 1/–1 type. As both curves go up along the time course, we can understand that there are more uptrend trading days than downtrend trading days. Actually, there is always a chance to simulate the S&P/TSX perfectly because the chance is $(½)^{252}$ for 252 trading days in 2020.

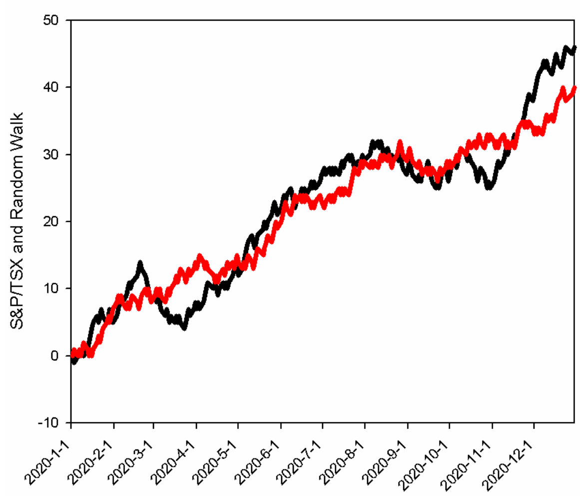

Figure 1. The S&P/TSX in 2020 in the 1/–1 type (black line) and its random walk simulation (red line) in the 1/–1 type using the seed of 0.83459.

In Figure 2, the simulation turns to the decimal type. The simulation has a great difficulty to reach the end of rapid decline from January to mid-March. In fact, we have met the same scenario many times and have no way to improve the simulation because the extreme could be judged as an outlier, which does not influence much on the standard deviation used in the generation of random numbers.

In Figure 3, the simulation appears powerless to catch the deep decline due to Covid-19 in spring 2020. Actually, this fall looks deeper than that in several major indices around the world. Clearly, a random number generator has no chance to produce a series of random numbers going in one direction.

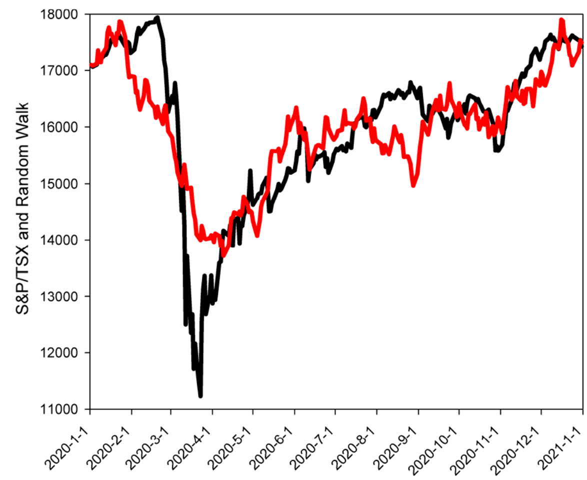

Figure 2. The S&P/TSX in 2020 (black line) and its random walk simulation (red line) in the decimal type using the seed of 0.6957.

In Figure 4, the simulation improves much before reaching the pandemic time in 2020, whose impact on overall dataset becomes less and less that the simulation ignores it. This raises the question of how to consider an outlier in random walk simulation.

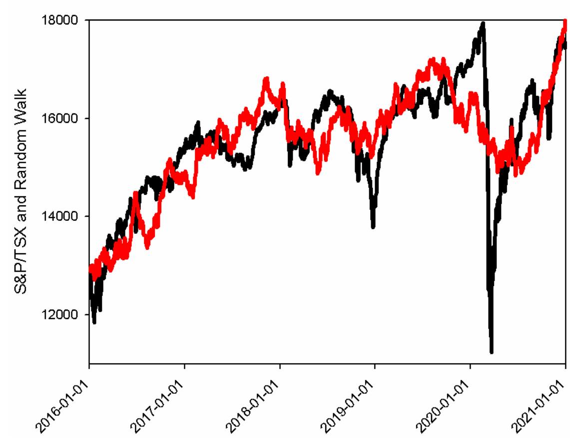

Figure 3. The S&P/TSX from 2016 to 2020 (black line) and its random walk simulation (red line) in the decimal type using the seed of 1.33519.

In Figure 5, the simulation has to deal with two crises between 2008 and 2009, and 2020. In fact, the simulation can somehow follow the first crisis but fails for the second one. Although we could search a larger scale to seeds, the simulations on several major indices around the world seem not to require doing so.

In Figure 6, the simulation furthermore improves. As can been seen, the simulation can generally follow the S&P/TSX trend although the exact definition of trend in terms of time length and scale has yet to be clear. In this sense, can we say that the weak form of EMH is met for this random walk simulation over the first 20 years in the

21st century in Figure 6? May be not, may be yes, perhaps this is why the statistical tests arrived at different conclusions. Therefore, a workout universally acceptable definition is in demand.

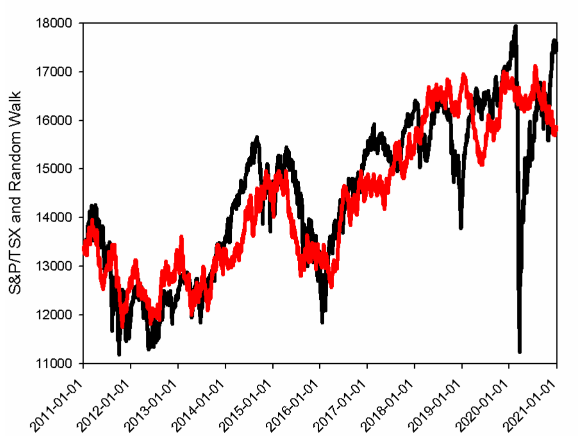

Figure 4. The S&P/TSX from 2011 to 2020 (black line) and its simulation (red line) generated by random walk in decimal type using the seed of 0.0822.

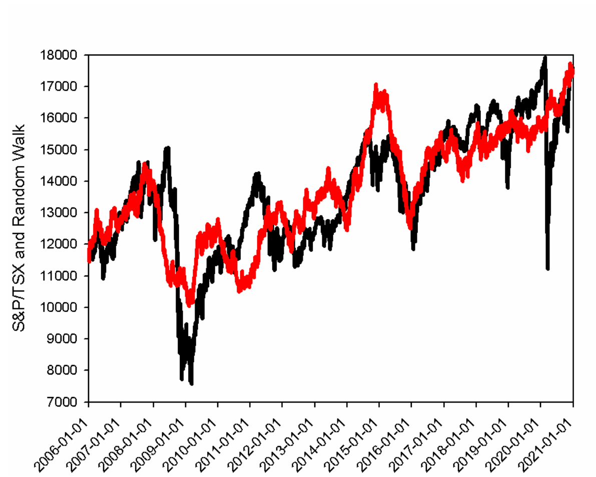

Figure 5. The S&P/TSX from 2006 to 2020 (black line) and its random walk simulation (red line) in the decimal type using the seed of 0.02083.

In this study, as we did in our previous studies [11-15], we use two types of random walk: (i) a classic random walk whose increment and decrement are defined as 1 and –1 shown in Figure 1, and (ii) a random walk whose increment and decrement are defined as decimals shown from Figures 2 to 6. We in fact use the terms, format, form and type, alternatively for description of two random walks although this practice leads to inconsistent. However, this is because the current software packages against plagiarism would warn us of plagiarizing and copying of our own papers.

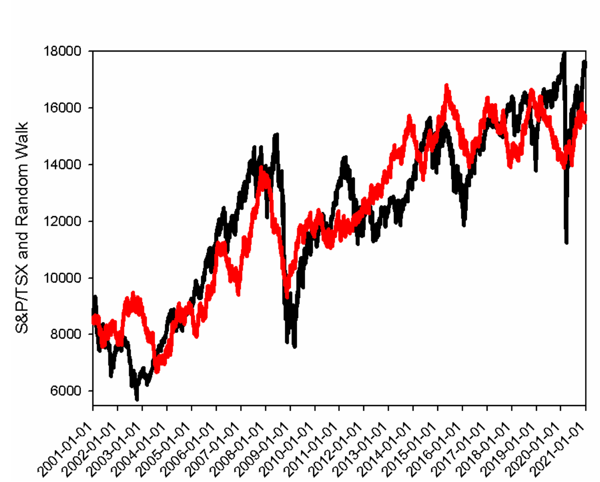

Figure 6. The S&P/TSX from 2001 to 2020 (black line) and its random walk simulation (red line) in the decimal type using any of 11 seeds of 0.13232, and from 7.55742 to 7.55751 with an increment of 0.00001.

The weak form of EMH as represented by a random walk is also different in developed and developing markets [19-21]. Recently, our focus is concentrated on the developed markets not only because the data availability is easier in the developed markets than in the developing markets, but also because the developed markets may be more prone to the weak form of EMH considering the information availability.

Practically, if a random walk can simulate the trend of an index or an individual stock with a certain seed and upper/lower ranges, can we use this seed and the upper/lower ranges to predict the market trend or the trend of an individual stock? If this could be the case, the random walk simulation will find the wide applications. As seen in our simulations, currently the seeds vary greatly and the upper/lower ranges change differently. Therefore, we need to address the issues of scopes of seeds and upper/lower ranges in our future studies.

In this study, our attention is directed to the Canadian S&P/TSX Composite Index, which in fact is heavily dependent upon the commodity prices and the development of world economy, especially the Chinese economy. Therefore, an interesting research line in the future would be to conduct the random walk simulation simultaneously for both Canadian and Chinese indices.

4. Conclusion

This study is the continuation of our series of studies in attempt to address the issue of whether a stock index fits the weak form of EMH by means of directly using the random walk model to simulate the Canadian S&P/TSX Composite Index. The results demonstrate that the random walk simulation can follow the trend of the S&P/TSX index, but how to define the trend in terms of its time length and scale of fluctuation has yet to come out. Still, the discussion on the limitation of random walk simulation is given, and the research directions in the future are also addressed.

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REFERENCES

[1] S. Alam, E. Asem, and S. Shams, “Converting TSX 300 index to S&P/TSX composite index: Effects on the indexâ€™s capitalization and performance,” Int. J. Econ. Finan., vol. 8, pp.250, 2016.

[2] S. Héroux, and A. Fortin, “Cybersecurity disclosure by the companies on the S&P/TSX 60 index,” Account. Perspect., vol. 19, pp. 73–100, 2020.

[3] N. Souissi, “The implied risk neutral density dynamics: Evidence from the S&P TSX 60 Index,,” J. Appl. Math., vol. 2017, pp. 1–10, 2017.

[4] A. Urquhart, and F. McGroarty, “Are stock markets really efficient? Evidence of the adaptive market hypothesis,” Int. Rev. Finan. Anal., vol. 47, pp. 39–49, 2016.

[5] H. Claessen, and S. Mittnik, “Forecasting stock market volatility and the informational efficiency of the DAX-index options market,” Euro. J. Finan, vol. 8, pp. 302–321, 2002.

[6] C. M. Boya, “From efficient markets to adaptive markets: Evidence from the French stock exchange,” Res. Int. Bus. Finan., vol. 49, pp. 156–165, 2019.

[7] B.M. Tabak, “The random walk hypothesis and the behaviour of foreign capital portfolio flows: the Brazilian stock market case,” Appl. Finan. Econ., vol. 13, pp. 369–378, 2003.

[8] A. Charles, and O. Darné, “The random walk hypothesis for Chinese stock markets: evidence from variance ratio tests,” Econ. Syst., vol. 33, pp. 117–126, 2009.

[9] D. Aggarwal, “Random walk model and asymmetric effect in Korean composite stock price index,” Afro-Asian J. Finan. Account., vol. 8, pp. 85–104, 2018

[10] L.F. Chaibi, “Testing the random walk: the case of Hong Kong stock exchange.” J. Empirical Studies, vol. 1, pp. 54–61, 2014..

[11] S. Yan, and G. Wu, “Fit Hang Seng index for 21st century with random walk model,” Conference Publication Series: CBFD pp. 66–69, 2021.

[12] S. Yan, and G. Wu, “Fitting of impact of COVID-19 pandemic on S&P 500 Index using random walk,” Conference Publishing Services: ICEMME vol. 4, pp. 1007–1011, 2020.

[13] S. Yan, and G. Wu, “Fitting of SSEC index (Shanghai composite) from January 2000 to July 2010 using random walk model,” Guangxi Sci vol. 18, pp. 92–96, 2011.

[14] S. Yan, and G. Wu, “Simulation of NIKKEI 225 index for 21st century using random walk,” 2nd International Conference on Big Data and Informatization Education (ICBDIE) pp. 330–33, 2021.

[15] S. Yan, and G. Wu, “Simulation of impact of COVID-19 pandemic on Dow Jones Index using random walk,” Proceedings in the 2nd International Conference on Computing and Data Science (CONFCDS), pp. 59–63, 2021.

[16] https://ca.finance.yahoo.com/

[17] W. Feller, An Introduction to Probability Theory and its Applications. 3rd ed., New York: John Wiley, 1968.

[18] SPSS Inc., SigmaPlot 2002 for Windows Version 8.02. (1986–2001).

[19] B.M. Tabak, “The random walk hypothesis and the behaviour of foreign capital portfolio flows: the Brazilian stock market case,” Appl. Finan. Econ., vol. 13, pp. 369–378, 2003.

[20] M.R. Borges, “Efficient market hypothesis in European stock markets.” Eur. J. Finan,, vol. 16, pp. 7, 711–726, 2010.

[21] M.C. Boya, “Testing capital market efficiency,” Global Bus. Econ Rev., vol. 19, pp. 194–224, 2017.