# การประยุกต์กระบวนการฮอร์คกับการวิเคราะห์ความเสี่ยงทางการเงิน
# AN APPLICATION OF HAWKES PROCESS TO FINANCIAL RISK ANALYSIS

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**บทคัดย่อ**

การค้นคว้าแบบอิสระฉบับนี้มีวัตถุประสงค์เพื่อศึกษาการนำเอากระบวนการฮอร์คมาประยุกต์ใช้กับตลาดหลักทรัพย์แห่งประเทศไทยในฐานะที่เป็นกระบวนการซึ่งนำไปสู่เครื่องมือในการตรวจวัดความเสี่ยงทางการเงิน ในการศึกษานี้เราได้รวบรวมข้อมูลอนุกรมเวลาของหุ้น 5 ตัวที่มีปริมาณการซื้อขายสูงที่สุดในวันที่ 6 มกราคม พ.ศ.2559 โดยข้อมูลได้ถูกบันทึกทุกๆวินาทีเป็นระยะเวลา 4,200 วินาทีในแต่ละวันตั้งแต่ 11 มกราคม พ.ศ.2559 ถึง 15 มกราคม พ.ศ.2559 เป็นเวลา 5 วัน วันละ 4,200 วินาที หุ้นที่ใช้ในการศึกษานี้ (เรียงลำดับจากปริมาณซื้อขายมากที่สุดไปน้อยที่สุด) ได้แก่ Advanced Info Service PCL, Intuch Holdings PCL, Jasmine International PCL, Bangkok Expressway and Metro PCL และ PTT PCL ผลการศึกษาถูกนำเสนอในรูปแบบของค่า mid-price และค่า branching ratio ของหุ้นแต่ละตัวเป็นระยะเวลา 5 วัน

จากข้อมูลที่ได้จากการวิเคราะห์จะเห็นได้ว่าไม่มีข้อบ่งชี้ถึงการ crash เนื่องจากค่า branching ratio ของหุ้นทั้ง 5 ตัวไม่ได้เข้าใกล้ค่า 1.00 เลย นอกจากนี้แล้วหุ้น Advanced Info Service PCL และหุ้น Intouch Holdings PCL ซึ่งมีค่าสัมประสิทธิ์ความแปรปรวน (CV) ของ branching ratio ต่ำและมีค่าเฉลี่ยของ branching ratio สูงมีความเหมาะสมกับการลงทุนแบบไม่เก็งกำไรมากกว่าหุ้นชอง Jasmine International PCL, Bangkok Expressway and Metro PLC และ PTT PCL ซึ่งมีพฤติกรรมที่ไม่แน่นอนมากกว่า เนื่องจากมีค่าสัมประสิทธิ์ความแปรปรวน (CV) ของ branching ratio ที่สูง
คำสำคัญ: กระบวนการฮอร์ค, ความเสี่ยงทางการเงิน, ค่า mid-price, ค่า branching ratio และการลงทุนแบบไม่เก็งกำไร

**ABSTRACT**

The objective of this independent study is to apply the Hawkes processes as a method of obtaining a mean to monitor financial risk for the Stock Exchange of Thailand (SET). Time series data of five (5) stocks that have the highest turnover on the day of January 6, 2016 are collected. The data are recorded every second for the duration of 4,200 seconds for each day from January 11, 2016 to January 15, 2016, i.e. 5 days with 4,200 seconds in each day. The stocks included in this study (from highest to lowest turnover) are: Advanced Info Service PCL, Intouch Holdings PCL, Jasmine International PCL, Bangkok Expressway and Metro PCL and PTT PCL, respectively. The results of each stock will be presented for the mid-price and the corresponding branching ratio in a consecutive manner, totally 5 days.

According to the analyzed data, there is no indication of crash, i.e. the branching ratio is less than 1 for all considered stocks. Besides, based on the low CV (Coefficient of Variation) and the high mean values of the branching ratios, Advanced Info Service PCL and Intouch

Holdings PCL are more suitable for the non-speculative investment than Jasmine International PCL, Bangkok Expressway and Metro PCL, and PTT PCL which exhibit higher uncertain reflective behaviors due to the higher CV (Coefficient of Variation) of the branching ratios.

Key word: Hawkes processes, financial risk, mid-price, branching ratio and non-speculative investment

## Background and Rational

One of the most crucial matters in financial risk management is the occurrence of a flash crash. Accordingly, the knowing of possible flash crash in advance is beneficial. Sornette (2003) concludes that computer trading, and the increased trading activities of derivative securities, illiquidity, trade and budget deficits, as well as overvaluation can initiate subsequent large negative price movements. More importantly, Sornette (2003) points out that speculative bubbles leading to crashes are likely to be a consequence of a positive herding behavior of investors. This positive herding behavior makes crashes locally self-enforcing. Hence, while bubbles can be ignited by an exogenous factor, instability grows endogenously. A stock market crash model should therefore be able to contain this self-excitation. Notably, such a self-excitation can also be detected in seismic behavior around earthquake sequences, where an earthquake usually engenders aftershocks which in turn can engender new aftershocks and so on. For many academics (and perhaps practitioners), earthquakes and stock markets therefore share characteristics typically detectable as the clustering of extremes and serial dependence.

One important class of self-excited processes is the so-called Hawkes Process. The Hawkes model (Hawkes, 1971) is a simple and powerful framework for simulating or modeling the arrival of the events which cluster over time (e.g., critical events and estimation of VaR, earthquake shock and aftershocks, high frequency price dynamics on financial market). In one dimension, the model is a Poisson process with an intensity which is the expected number of events per unit time and a self-exciting term which is a memory kernel function that weights how much past events influence the generation of future events, this self-exciting terms give rise event clustering and endogenous feedbacks.

In Hawkes processes, there is the so-called branching ratio. If the branching ratio of the change in the mid-price of a stock is greater than 1, the process becomes non-stationary and can be explode in finite time (Filimonov et al., 2013). Correspondingly, the Hawkes process and its branching ratio can be used to detect possible flash crash stocks. The financial risk management can be achieved via the analysis and monitoring of the temporal evolution of the branching ratio in the Hawkes process.

In 2011, there was the application of financial data with Hawkes processes. But it is 2012 that the processes were employed to high-frequency financial data. In 2014, there was analysis of a set of effect leading to significant biases in estimation of variable n (branching-ratio) that quantifies the degree of endogeneity that indicates how much level that past events trigger future events. Moreover, the Hawkes self-exciting processes can also be used to calculate to model risk in financial asset or to predict buy or sell order arrival times. Recently, in 2015, there was interpretation of financial crashes as earthquakes in the financial market. From the beginning, there has not been the application of these processes to the case of Thai stock yet. Therefore, we seek to explore the possibility of developing Hawkes model and obtain a means of monitoring financial risk management for the Stock Exchange of Thailand (SET).

This study is applied the method of Filimonov and Sornette (2012) in which a measure of activity of financial markets that provide a direct access to their level of endogeneity is introduced. From this measurement, branching ratio (n) is indicated as the indicator of financial market state regarding flash crash. Our study goes further by comparing this n value to a specific level of risk.

In this study, a framework of financial risk management using the Hawkes processes is proposed, where the periodic determination of the branching ratios of the changes in the mid-prices of stock is performed. Such a temporal evolution of the branching ratios will be used as a monitoring system of the stock state whether it approaches a flash crash or not.

## Purpose of the Study

To apply the Hawkes processes to financial risk analysis in the Stock Exchange of Thailand (SET).

## Research Methodology

This study employs the time series data of 5 stocks that have the highest turnover on the day of January 6, 2016. The data is daily data (read at every 1 second) for the period of 5 days from January 11, 2016 to January 15, 2016. The data is downloaded from program Reuters 2007's, Chiang Mai University.

In this study, we are going to employ the Hawkes process to the financial risk analysis. This can be done by monitoring the branching ratio of the process development by Filimonov and Sornette (2012) as follows:

1) Reading the time series data of total length T.

2) The periodic estimation of the branching ratio and its temporal monitoring of the estimation can inform the state of model and is thus a preventive measure of possible flash crash. The performer using estimation of the branching ratio of an event (Hardiman and Bouchaud, 2014) is the total event count $N_w$ in a window of length W. The mean and variance of $N_w$ is obtained from

$$\tilde{\mu}_W = W\frac{N_T}{T} \equiv \frac{1}{m}\sum_{i=1}^{m} N_W(i) \quad (1)$$

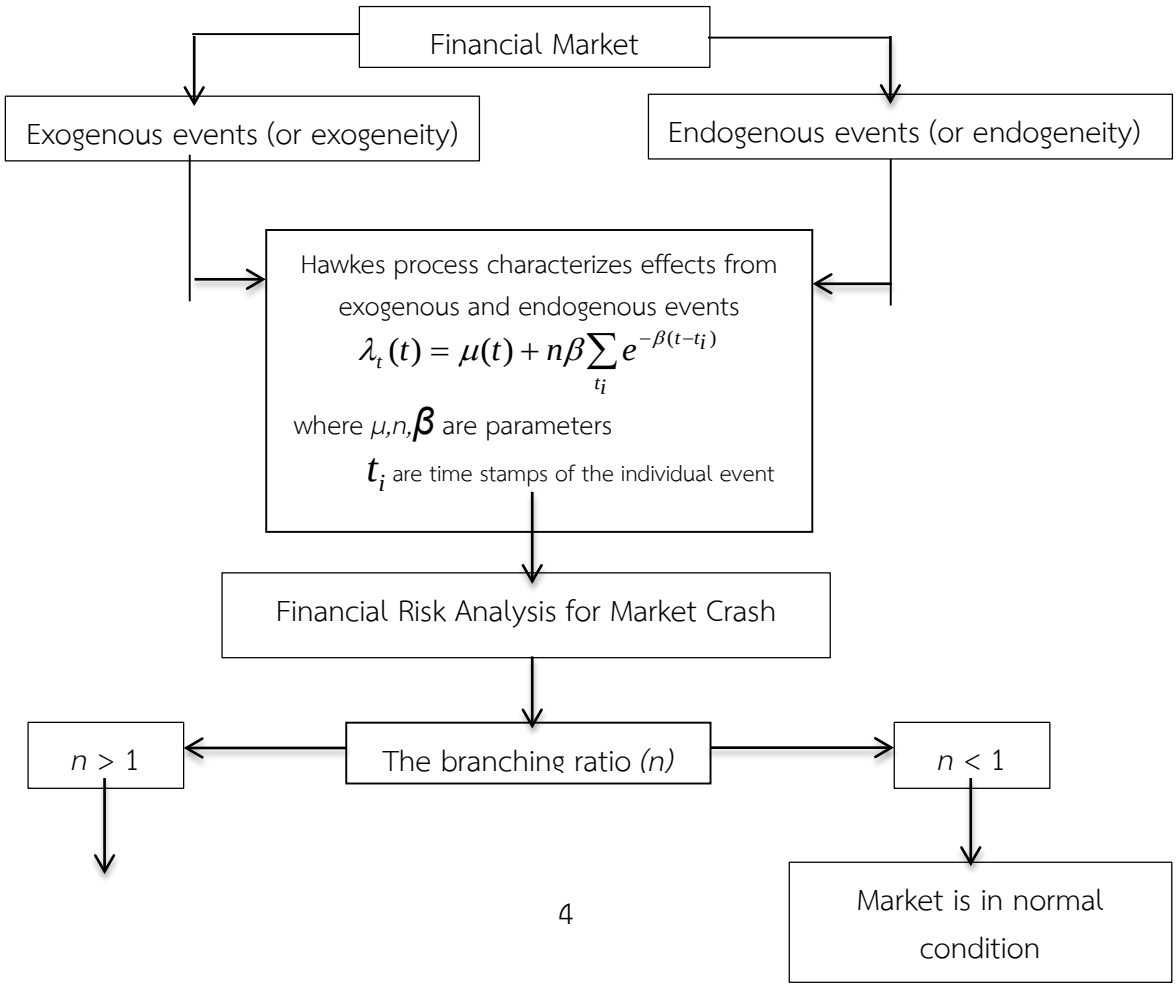
$$\tilde{\sigma}_W^2 = \frac{1}{m-1}\sum_{i=1}^{m}(N_W(i) - \tilde{\mu}_W)^2 \quad (2)$$

Finally, the branching ratio is obtained as

$$n \approx 1 - \sqrt{\frac{\tilde{\mu}_W}{\tilde{\sigma}_W^2}} \quad (3)$$

3) If the branching ratio of the change in the mid-price of a stock is greater than 1, the process becomes non-stationary and can be exploded in finite time.

**Research Design**




**Note:** Apply Hawkes process for risk management by monitoring the branching-ratio of the process as follows:

a) Assumption of Hawkes process: The simplest extension of the Poisson point process, in which past events influence future events trough a memory kernel.

b) Assumption of the branching ratio (*n*): Quantifies the degree of endogenous (endogeneity) of how much past events trigger future events.

**Figure 1** Research Method Design

## Empirical Results

### General

This study employs time series data of 5 stocks that have the highest turnover on the day of January 6, 2016. The data are record every second for the duration of 4,200 seconds in each day from January 11, 2016 to January 15, 2016, i.e. 5 days with 4,200 seconds in each day. The stocks include Advanced Info Service PCL, Intouch Holdings PCL, Jasmine International PCL, Bangkok Expressway and Metro PCL and PTT PCL. The results of each stock will be presented for the mid-price and the corresponding branching ratio in a consecutive manner, totally 5 days.

### Result Summary

The branching ratio with zero value indicates there is no change in the specific subinterval of the analysis. The statistics of the branching ratio for each stock within the 5-day period of analysis is reported in Table 1.

**Table 1:** Summary of statistics of branching ratio

| Stocks | Min | Max | Mean | SD | CV |
|---|---|---|---|---|---|
| Advanced Info Service PCL | 0.847823 | 0.913792 | 0.88101 | 0.018871 | 0.02 |
| Intuch Holdings PCL | 0.840011 | 0.913792 | 0.875707 | 0.020791 | 0.02 |
| Jasmine International PCL | 0 | 0.913792 | 0.584224 | 0.428425 | 0.73 |
| Bangkok Expressway PCL | 0 | 0.913792 | 0.642832 | 0.412626 | 0.64 |
| PTT PCL | 0 | 0.913792 | 0.812052 | 0.252868 | 0.31 |

Source: Computed Result

The obtained branching ratios and their statistics are given in Table 1. The results indicate that the crash does not take place in all stocks. Based on the low CV (Coefficient of Variation) and the high mean values of the branching ratios, Advanced Info Service PCL and Intouch Holdings PCL are persistently dominated by the endogenous effect while Jasmine International PCL, Bangkok Expressway and Metro PCL, and PTT PCL exhibit higher uncertain reflective behaviors due to the higher CV (Coefficient of Variation) of the branching ratios. In terms of risk management, Advanced Info Service PCL and Intouch Holdings PCL are more suitable for the non-speculative investment.

## Conclusions and Recommendation

### Conclusions

1) This study applies Hawkes processes to financial risk analysis, in particular of the Stock Exchange of Thailand (SET). This is done by monitoring the branching ratios of the process.

2) The proposed methodology has been used with time series data of 5 stocks that have the highest turnover on the day of January 6, 2016. The data are record every second for the duration of 4,200 seconds in each day from January 11, 2016 to January 15, 2016, i.e. 5 days with 4,200 seconds in each day. The stocks include Advanced Info Service PCL, Intouch Holdings PCL, Jasmine International PCL, Bangkok Expressway and Metro PCL and PTT PCL.

3) According to the analyzed data, there is no crash, i.e. the branching ratio is less than 1 for all considered stocks.

4) The branching ratio can be used as a tool to distinguish the types of investment to be speculative and non-speculative investments. The non-speculative investment is based on high values of branching ratio. In case of the given data, Advanced Info Service PCL and Intouch Holdings PCL are relatively more suitable for non-speculative investment than the others.

### Recommendation

Since the computation of branching ratios in this study is purely based on the methodology proposed by Hardiman and Bouchaud (2014). There should be a comparison of different computation methods in terms of accuracy and efficiency in the future.

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