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Final Year Project 2021/2022

Seminar Proceedings

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Final Year Project Coordinator I's Foreword

Assoc. Prof. Dr. Mohd Aminul Islam

Assalamu'alaikum wrt wbt

Alhamdulillah,
It is really an immense pleasure for me to know that CTS dept is going to publish its first issue of e-book of Final Year Projects (FYP) for batch 181 under the initiative of Dr. Hafizah and Dr. Farahain. I am informed that the first issue of FYP in the form of e-book to be published will be comprised of FYP abstracts (in Bahasa & English) and the posters presented in virtual exhibition. In fact, we have been in discussion quite for a long to publish FYP in the form of e-book as a source of reference for the future students who want to do FYP. But it was not happened to materialize due to lack of proper initiative.

Alhamdulillah, I am glad to see that finally under the initiative of Dr. Hafizah and Dr. Farahain, the long-awaited e-book of CTS department's FYP, even though in a concise form, is going to be materialized soon. I see this publication as a great need for guidance and very useful source of information for the future FYP students. I wish that more and more students will have the opportunity to read this e-book and get inspired to present their works to a much broader audience.

I wish to take this opportunity to congratulate Dr. Hafizah and Dr. Farahain for their relentless and talented efforts for the initiative. They have fulfilled the need for a e-book for FYP students to nurture their writing dreams. Lastly, not to forget the contributions of FYP students, supervisors, and the examiners. Thank you all for your cooperation and support.

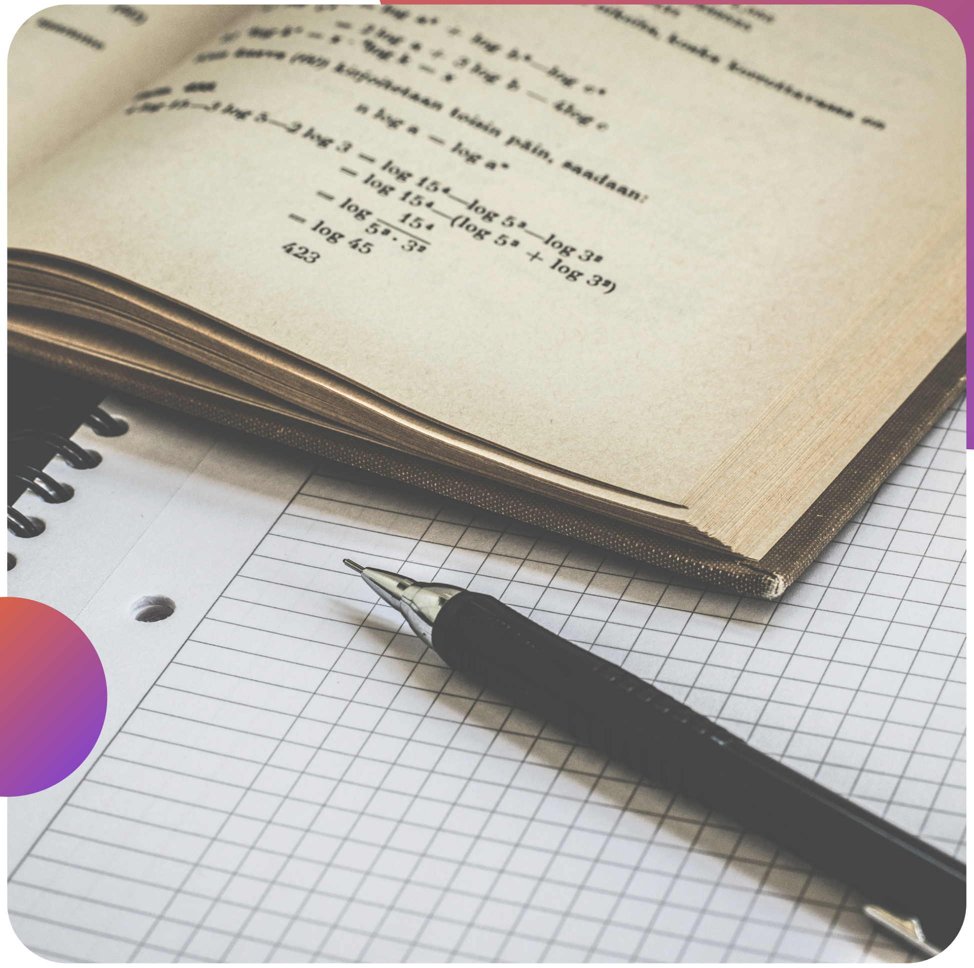
Wishing you all the best.

Final Year Project Coordinator II's Foreword

Asst. Prof. Dr. Hafizah Bahaludin

Alhamdulillah, we published the first e-book of final year project (FYP). I wanted to express my appreciation to Assoc. Prof. Dr. Aminul and Dr. Farahain for their continuous effort and support in completing this book. I believe this book will serve as a reference for other students to learn about previously completed projects. It is my sincere wish that all who read this book find it useful.
Thank you.

About Final Year Project



SMS 3401 Final Year Project I

- 4 Credit Hours
- Seminars
- Proposal Submission
- Proposal Presentation

SMS 4802 Final Year Project II

- 8 Credit Hours
- Virtual Poster Presentation
- Dissertation Submission
- Final Year Project Presentation

Presenting All the Projects

Geometry enlightens the intellect and sets one's mind right

~Ibn Khaldun~

Stability Analysis of Three Parameters of 2-Partition of Three Points Geometric Quadratic Stochastic Operator

Afiqah Binti Muhammed Najmuddin & Dr Nur Zatul Akmar Hamzah

Abstract

It is known that nonlinear operators can explain a wide range of systems. A quadratic stochastic operator is a system that is related to population genetics. In the nonlinear operator theory, the study of quadratic stochastic operators still has an open problem. Examples of the finite case can be found in many papers. However, there are only several papers mentioning infinite cases. Hence, in this research, we consider the quadratic stochastic operator defined on infinite state space, Geometric quadratic stochastic operator generated by 2-partition of consecutive three points with three different parameters. In this paper, we construct the Geometric quadratic stochastic operator, investigate the trajectory behaviour and its regularity, and analyse the operator's stability using graphical analysis. It is indicated that the Geometric quadratic stochastic operator is regular for some parameter values and non-regular for other parameter values through the convergence of the trajectory behaviour either to a unique fixed point or periodic point of period two. Furthermore, for stability, we get attracting hyperbolic fixed points as well as attracting and repelling hyperbolic periodic points. To conclude, the study of this operator is vital to understanding evolutionary phenomena or biological populations in a situation of the real world.

Abstrak

Diketahui bahawa pengendali tak linear dapat menerangkan pelbagai sistem. Pengendali stokastik kuadratik ialah satu sistem yang berkaitan dengan genetik populasi. Dalam teori pengendali tak linear, kajian pengendali stokastik kuadratik masih belum dapat diselesaikan. Contoh kes terhingga boleh ditemui dalam banyak kajian. Tetapi, hanya beberapa kajian yang mengkaji tentang kes tak terhingga. Maka, dalam penyelidikan ini, kami mempertimbangkan pengendali stokastik kuadratik bagi kes tak terhingga, iaitu pengendali stokastik kuadratik Geometri dijana oleh dua bahagian yang melibatkan tiga titik berturut-turut dengan tiga parameter yang berbeza. Dalam kajian ini, kami membina pengendali stokastik kuadratik Geometri tersebut, menyiasat tingkah laku trajektori dan ketetapannya, serta menganalisis kestabilannya dengan menggunakan analisis grafik. Ianya menunjukkan bahawa pengendali stokastik kuadratik Geometri ini tetap untuk beberapa nilai parameter dan tidak tetap untuk parameter yang lain menerusi penumpuan tingkah laku trajektori sama ada ke titik tetap yang unik atau titik berkala tempoh dua. Tambahan pula, untuk kestabilan, kami mendapati bahawa terdapat titik tetap tarikan hiperbolik serta titik berkala tarikan dan tolakan hiperbolik. Kesimpulannya, kajian pengendali ini penting bagi pemahaman fenomena evolusi atau populasi biologi dalam situasi dunia sebenar.

TITLE: STABILITY ANALYSIS OF THREE PARAMETERS OF 2-PARTITION OF THREE POINTS GEOMETRIC QUADRATIC STOCHASTIC OPERATOR

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Email: afiqahibnajmuddin@gmail.com | Email: zatulakmar@iium.edu.my

INTRODUCTION

In 1924, Bernstein introduced the study of quadratic stochastic operator (qso) and worked on mathematical investigation on population genetics [1]. Generally, there are two main cases from the study of qso: Volterra and non-Volterra qso. It is called Volterra qso if it has an additional condition, $P_{ij,k} = 0$ for $k \notin \{i, j\}$. In this research, we are motivated to study about the non-Volterra operator specifically on Geometric qso.

PROBLEM STATEMENT

The study of qso is still having an open problem in the nonlinear operator theory. Some of examples of researchers on finite case can be found in these papers [2,3]. Therefore, in this research, we consider the qso defined on infinite state space, that is Geometric qso generated by 2-partition of three points with three different parameters.

OBJECTIVE

1. To define and construct some classes of 2-partition Geometric qso of three points with three different parameters on countable state space.
2. To investigate the trajectory behavior and regularity of 2-partition Geometric qso of three points with three different parameters on countable state space.

METHODOLOGY

Let $A_1 = \{x_1, x_1+1, x_1+2 : x_1 \in X\}$ and $A_2 = X \setminus A_1$.

We define a family of functions $\{P_{ij,k} : i, j, k \in X\}$ as

$$P_{ij,k} = \begin{cases} (1-r_1)r_1^k & \text{if } (i,j) \in B_1 \\ (1-r_2)r_2^k & \text{if } (i,j) \in B_2 \\ (1-r_3)r_3^k & \text{if } (i,j) \in B_3 \end{cases}$$

Then, we will have

$$V^{n+1}\mu(k) = \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} P_{ij,k} V^n\mu(i) V^n\mu(j)$$

$$= (1-r_1)r_1^k \left[\sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]^2 + (1-r_2)r_2^k \left[1 - \sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]^2$$

$$+ (1-r_3)r_3^k \left\{2\sum_{i=x_1}^{x_1+2} V^n\mu(i) \cdot \left[1 - \sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]\right\},$$

where $n = 0, 1, 2, \ldots$

RESULT

In this research, we consider for two cases.

Case 1: $x_1 = 0$

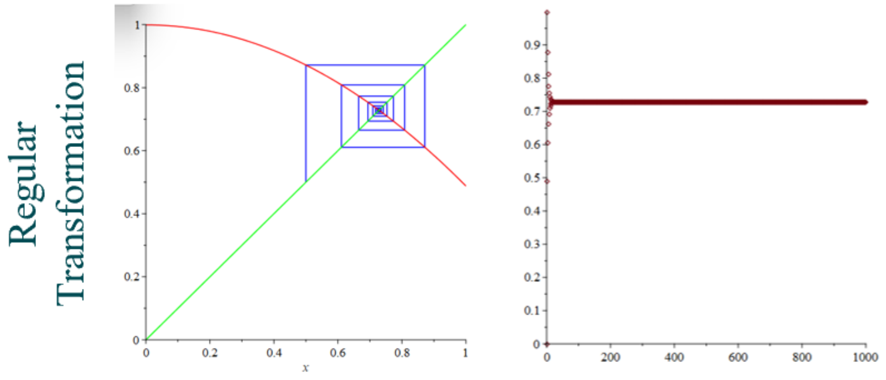

Figure 1: Orbit analysis for some fixed values $r_1 = 0.8$, $r_2 = 0.1$, and $r_3 = 0.05$ for $x_1 = 0$, $x_2 = 1$, and $x_3 = 2$.

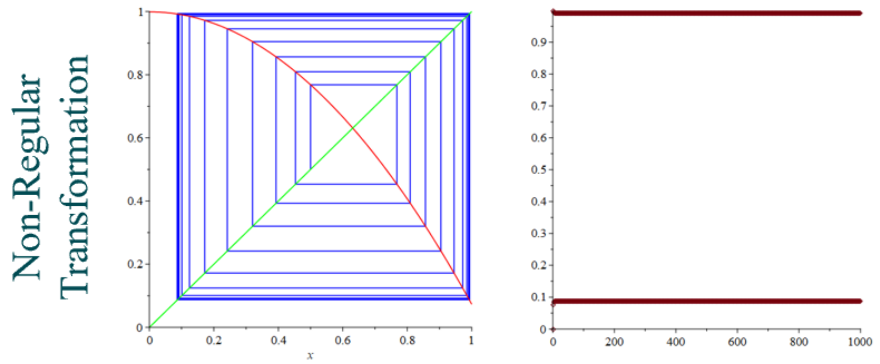

Figure 2: Orbit analysis for some fixed values $r_1 = 0.975$, $r_2 = 0.1$, and $r_3 = 0.05$ for $x_1 = 0$, $x_2 = 1$, and $x_3 = 2$.

Case 2: $x_1 \neq 0$

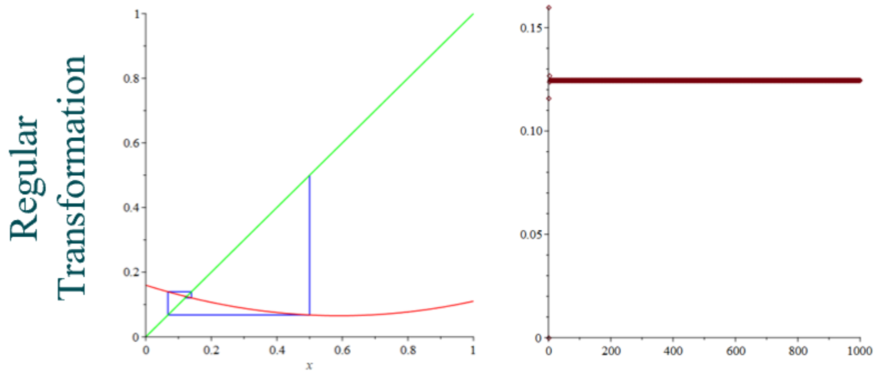

Figure 3: Orbit analysis for some fixed values $r_1 = 0.95$, $r_2 = 0.8$, and $r_3 = 0.2$ for $x_1 = 5$, $x_2 = 6$, and $x_3 = 7$.

CONCLUSION

From the graphical analysis, Geometric qso generated by 2-partition of three points with three different parameters is found to be regular and non-regular for some parameters.

REFERENCE

[1] Bernstein, S. N. (1924). The solution of a mathematical problem related to the theory of heredity. *Uchn Zapiski NI Kaf Ukr Otd Mat*, *1*, 83-115.

[2] Mukhamedov, F., & Ahmad Fadillah Embong. (2017). Extremity of b-bistochastic quadratic stochastic operators on 2D simplex. *Malaysian Journal of Mathematical Sciences*, *11*(2), 119-139.

[3] Abdulghafor, R., Shahrum Shah Abdullah, Turaev, S., & Raini Hassan. (2019). The nonlinear limit control of EDSQOs on finite dimensional simplex. *Automatika*, *60*(4), 404-412.

The Derivation of Chi-Square, Student's *t*, and *F* Distribution and a Simulation Study of Distribution of Sum of Two *F* Random Variables

Wan Muhammad Aqif Bin Wan Ahmad Sukri & Dr Siti Marponga Tolos

Abstract

The normal distribution and other special continuous distributions such as chi-square, student's *t* and *F* distribution are important for introductory statistics students. There are many methods of proofs and derivations for the probability density functions for these distributions. However, during the introductory statistic and probability class, these distributions were not derived comprehensively. Thus, in this study, the motivation is to make set of detail derivations for these probability distribution functions. The main purpose in this research is to derive chi-square from the standard normal as well as the proof for student's *t* and *F* distribution. In addition, we want to sketch and investigate the behavior of the probability density functions using the R studio and learn some properties of the mentioned distribution. Furthermore, the idea to derive of these distributions will be using some techniques and methods such as the cumulative distribution functions, the moment generating functions and the transformation technique. Besides, in later part of this study, we will do simulation on the sum of two *F* random variables. To sum up, this research is hoped to serve as a reference for the introductory statistics students who want to understand more on these continuous distributions.

Abstrak

Taburan normal dan taburan berterusan khas lain seperti khi kuasa dua, taburan *t* dan taburan *F* adalah untuk pelajar yang mengambil jurusan pengenalan kepada statistik. Terdapat banyak kaedah pembuktian dan terbitan bagi fungsi taburan kebarangkalian bagi taburan ini. Walau bagaimanapun, semasa kelas pengenalan kepada statistik dan kebarangkalian, fungsi taburan kebarangkalian ini tidak diperoleh secara terperinci. Oleh itu, motivasi untuk melakukan kajian ini adalah untuk membuat satu set yang terperinci untuk fungsi taburan kebarangkalian. Tujuan utama dalam penyelidikan ini adalah untuk mendapatkan khi kuasa dua daripada taburan normal serta pembuktian bagi taburan *t* dan *F*. Di samping itu, kami ingin melakar dan menyiasat kelakuan fungsi taburan kebarangkalian menggunakan studio R dan mempelajari beberapa sifat taburan yang disebutkan. Tambahan pula, idea pemperolehan bagi taburan ini akan menggunakan beberapa teknik dan kaedah seperti fungsi pengagihan kumulatif, fungsi penjanaan momen dan teknik transformasi. Selain itu, dalam bahagian akhir kajian ini, kami akan melakukan simulasi ke atas hasil tambah dua pembolehubah rawak bagi taburan *F*. Kesimpulannya, kajian ini diharap dapat menjadi rujukan kepada pelajar pengenalan kepada statistik yang ingin memahami lebih lanjut mengenai taburan ini.

TITLE: THE DERIVATION OF CHI-SQUARE, STUDENT'S *t*, AND F DISTRIBUTION AND A SIMULATION STUDY OF DISTRIBUTION OF SUM OF TWO F RANDOM VARIABLES

COMPUTATIONAL AND THEORETICAL SCIENCES

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ABSTRACT

The continuous distribution is important for the introductory statistics students such as Chi-square, Student's t and F. In this study, we will provide the derivation of PDF for these distributions, their test statistics as well as the simulation for sum of two F random variables.

OBJECTIVE

1)To derive the PDF of Chi-square from standard normal, Student's t and F distribution.
2) To investigate the behavior and characteristics of the PDF of Chi-square, Student's t and F distributions when the parameters are changed using R.

METHODOLOGY

Some of methods/techniques used:

CUMULATIVE DISTRIBUTION FUNCTION (CDF) TECHNIQUE

$$F_X(x) = P[X \leq x] = \int_{-\infty}^{x} f_X(u)du .$$

The CDF has the following properties:

1. $\lim_{x \to -\infty} F(x) = 0$
2. $\lim_{x \to \infty} F(x) = 1$
3. If f_X is continuous, then the PDF is the derivative of the CDF:
$$f_X(x) = \frac{dF_X(x)}{dx}.$$

TRANSFORMATION TECHNIQUE

Theorem 3.2. If X_1 and X_2 are two continuous-type random variables with joint PDF $f(x_1, x_2)$ and if $Y_1 = u_1(X_1, X_2)$, $Y_2 = u_2(X_1, X_2)$ has the single-valued inverse $X_1 = v_1(Y_1, Y_2)$, $X_2 = v_2(Y_1, Y_2)$, then the joint pdf of Y_1 and Y_2 is

$$g(y_1, y_2) = |J| f[v_1(y_1, y), v_2(y_1, y_2)]$$

where the Jacobian is the determinant and to find the Jacobian

$$J = \begin{vmatrix} \frac{\partial x_1}{\partial y_1} & \frac{\partial x_1}{\partial y_2} \\ \frac{\partial x_2}{\partial y_1} & \frac{\partial x_2}{\partial y_2} \end{vmatrix}.$$

PROBLEM STATEMENT

For the introductory students, the continuous distribution does not derive comprehensively. Therefore, this purpose of this project was to create a set of reference material for an introductory level statistics course.

RESULT 1 Derivation of χ^2 from standard normal

Let $Z \sim N(0,1)$, $Z = \frac{X-\mu}{\sigma}$, $f_Z(z) = \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}}$, $F_Z(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}} dz$.

Then we also let $Y = \frac{(X-\mu)^2}{\sigma^2} = Z^2$.

$$\begin{aligned} F_Y(y) &= P(Y \leq y) \\ &= P(Z^2 \leq y) \\ &= P(-\sqrt{y} \leq Z \leq \sqrt{y}) \\ &= P(Z \leq \sqrt{y}) - P(Z \leq -\sqrt{y}) \\ &= P(\sqrt{y}) - P(-\sqrt{y}) \\ &= F_Z(\sqrt{y}) - F_Z(-\sqrt{y}) \\ &= F_Z(\sqrt{y}) - [1 - F_Z(\sqrt{y})] \\ &= F_Z(\sqrt{y}) + F_Z(\sqrt{y}) - 1 \\ &= 2F_Z(\sqrt{y}) - 1. \end{aligned}$$

To compute the PDF, find the derivative of $F_Y(y)$,

$$\begin{aligned} f_Y(y) &= \frac{d}{dy} F_Y(y) \\ &= \frac{d}{dy}[2F_Z(\sqrt{y}) - 1] \\ &= \frac{d}{dy} 2F_Z(\sqrt{y}) - \frac{d}{dy} 1 \\ &= 2\frac{d}{dy} F_Z(\sqrt{y}) - 0 \quad (\textit{using chain rule}) \\ &= 2 f_Z(\sqrt{y}) \frac{1}{2} y^{-\frac{1}{2}} \\ &= f_Z(\sqrt{y})\, y^{-\frac{1}{2}}. \end{aligned}$$

Using the pdf of Normal distribution, where

$$f(x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}$$

then,

$$f_Y(y) = \frac{1}{\sqrt{2\pi}} e^{-\frac{y}{2}} y^{-\frac{1}{2}} \qquad y \geq 0.$$

Thus, the χ^2 distribution is a gamma distribution with parameter $\left(\frac{1}{2}, \frac{1}{2}\right)$. Then,

$$f_Y(y) = \frac{\frac{1}{2}^{\frac{1}{2}}}{\Gamma\left(\frac{1}{2}\right)} e^{-\frac{y}{2}} y^{\frac{1}{2}-1}$$

$$f_Y(y) = \frac{1}{2^{\frac{1}{2}}\Gamma\left(\frac{1}{2}\right)} e^{-\frac{y}{2}} y^{\frac{1}{2}-1}, \qquad y \geq 0.$$

CONCLUSION

This research hope to compile a set of comprehensive derivation for the continuous distribution. In short, this project can give an insight to the students to understand this topic more and give a guidance in their studies and research.

RESEARCH QUESTION

1) How to derive the PDF of Chi-square from standard normal, Student's t and F distribution?
2) How are the behavior and characteristics of Chi-square, Student's t and F distributions when the parameters are changed?

RESULT 2

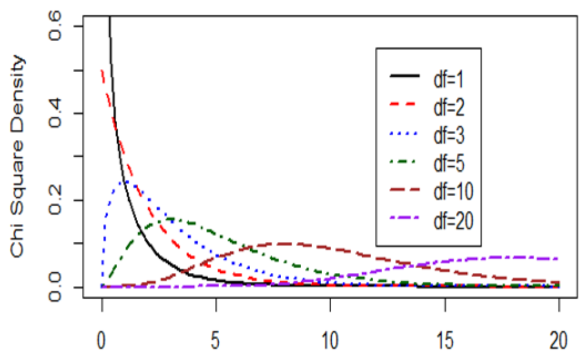

Figure 1:Pdf of χ^2

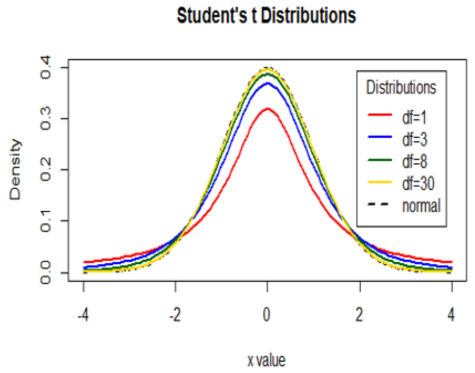

Figure 2: Pdf of Student's t

REFERENCES

1. Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (2010). *Probability and statistical inference* (Ninth Edition). Upper Saddle River, NJ, USA: Pearson/Prentice Hall.
2. Larsen, R. J., & Marx, M. L. (2012). *An introduction to mathematical statistics* (Fifth Edition). Prentice Hall.
3. Moser, W. R. (1996). *Linear models: A mean model approach*. Elsevier.

The Impact of COVID-19 Towards Health Care Sector by Using a Minimum Spanning Tree: A Case of Bursa Malaysia

Shakirah Bt Ahmad Suhaimi & Dr Hafizah Bahaludin

Abstract

Coronavirus disease (COVID-19) affected the global economy as well as the financial markets in which the market become more volatile. Financial market is known as a complex system due to the complexity and inexplicable interactions among stocks. The price fluctuations of numerous stocks lead to more intricate relationships which then can be described as a complex network. Therefore, this study is motivated to investigate the impact of COVID-19 on the health care sector in Bursa Malaysia. The timeline will cover from the year of 2019 until 2020. The financial network is constructed by applying a minimum spanning tree (MST) approach. The results demonstrated a significant change in the financial network in terms of its structure along with the domain nodes during those periods. The domain nodes in year 2019 were Supermax Corporation Berhad (Super) and Top Glove Corporation Bhd (Top). However, domain nodes in year of 2020 were Y.S.P. Southeast Asia Holding Berhad (YSP), Kossan Rubber Industries Berhad (Kossan) and Top Glove Corporation Bhd (Top).

Abstrak

Penyakit coronavirus 2019 (COVID-19) telah menjejaskan ekonomi dan pasaran kewangan secara keseluruhannya. Secara amnya, pasaran kewangan adalah dikenali sebagai satu sistem yang kompleks antara saham kerana kerumitan dan interaksi yang tidak dapat dijelaskan. Turun naik harga saham membawa kepada hubung kait yang lebih rumit yang kemudiannya boleh digambarkan sebagai jaringan kompleks. Oleh itu, kajian ini ingin mengkaji kesan COVID-19 terhadap sektor penjagaan kesihatan di Bursa Malaysia. Garis masa data yang diambil meliputi tahun 2019 sehingga 2020. Jaringan kewangan dirangka menggunakan pokok rentangan minimum. Hasil kajian menunjukkan perubahan yang nyata pada struktur jaringan kewangan seiring dengan nod domain semasa tempoh tersebut. Nod domain untuk tahun 2019 ialah Supermax Corporation Berhad (Super) dan Top Glove Corporation Bhd (Top). Walau bagaimanapun, pada tahun 2020, nod domain terdiri daripada Y.S.P. Southeast Asia Holding Berhad (YSP), Kossan Rubber Industries Berhad (Kossan) dan Top Glove Corporation Bhd (Top).

THE IMPACT OF COVID-19 TOWARDS HEALTH CARE SECTOR BY USING A MINIMUM SPANNING TREE: A CASE OF BURSA MALAYSIA

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OBJECTIVE

To **construct** the financial network of stock health care sector before and during the COVID-19 pandemic.

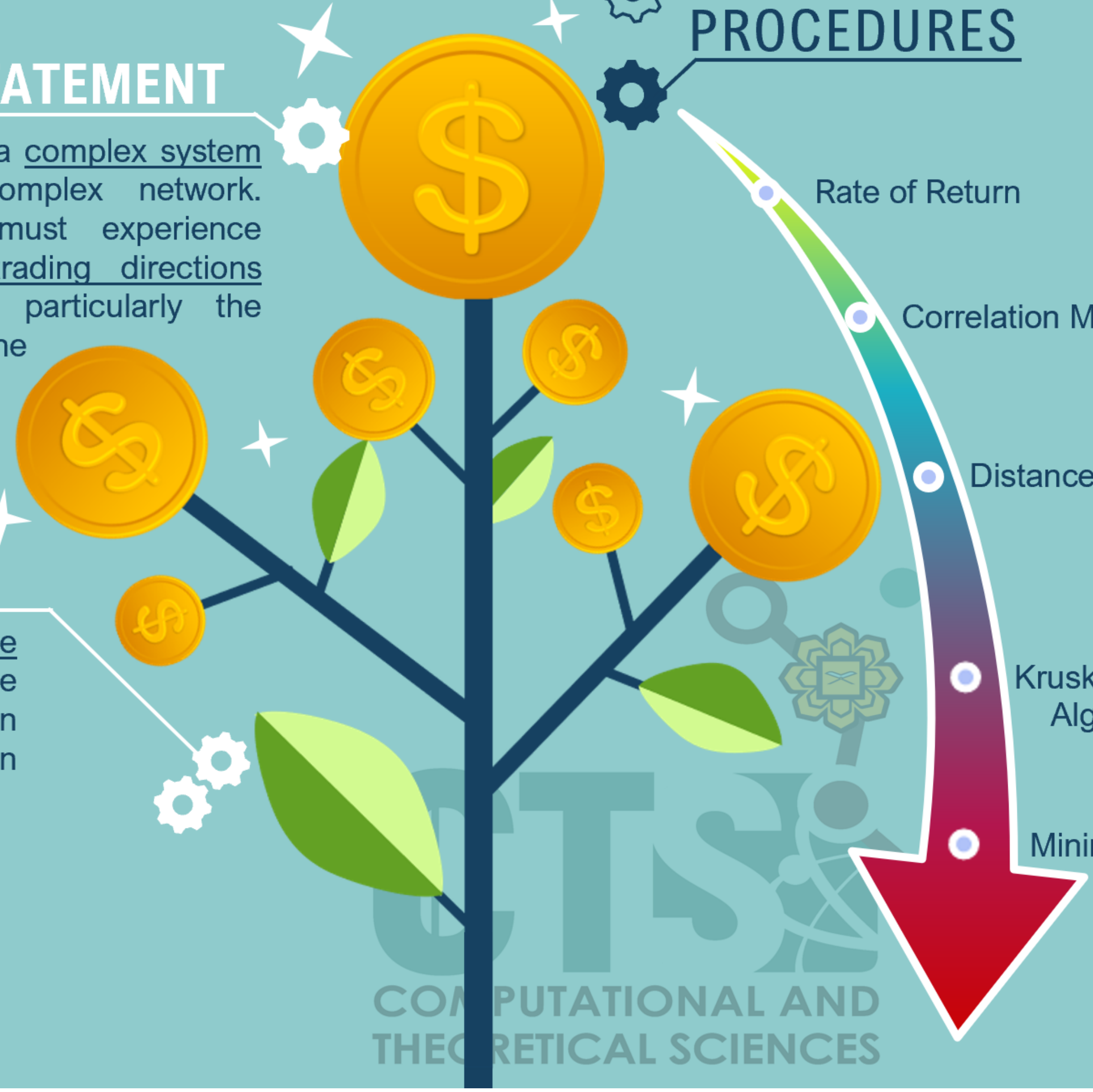
PROBLEM STATEMENT

The stock market is a complex system which leads to complex network. Financial markets must experience relatively different trading directions due to COVID-19, particularly the correlation between the stocks traded.

RESEARCH QUESTIONS

How to construct the graph that exhibits the correlation between the stocks listed in health care sector?

PROCEDURES

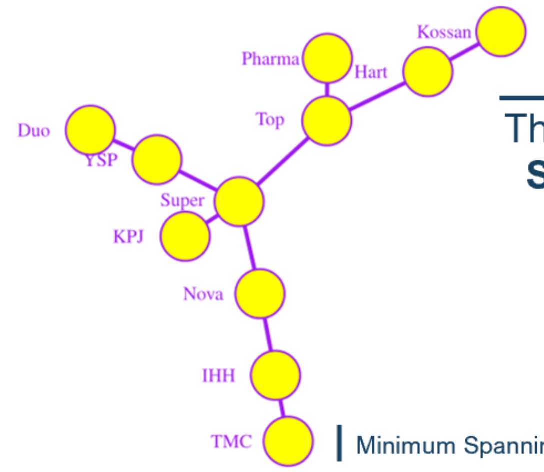


- Rate of Return
- Correlation Matrix
- Distance Matrix
- Kruskal Algorithm
- Minimum Spanning Tree

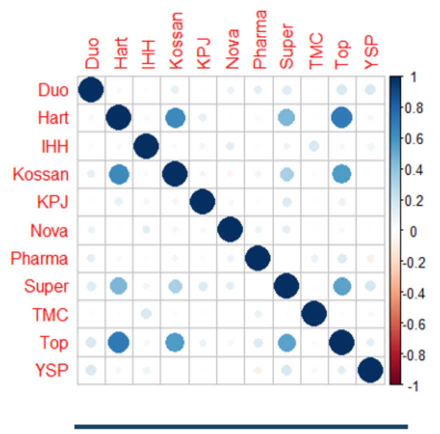
RESULT 1

2019

The most prominent stock: **Supermax Corporation Berhad (Super)**



Minimum Spanning Tree using iGraph

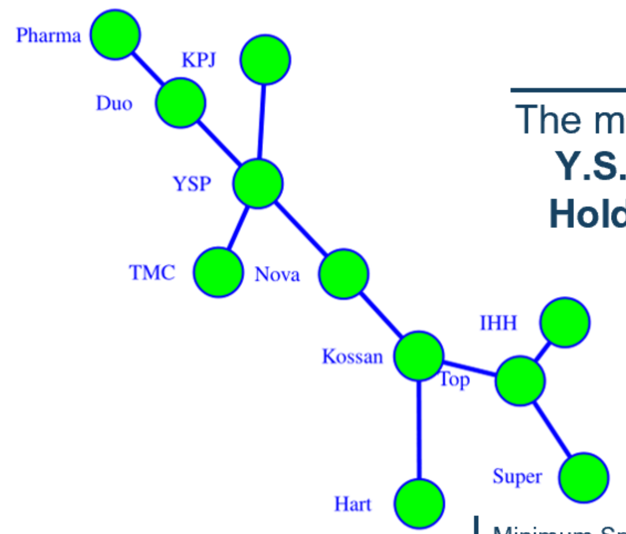


Correlation plot

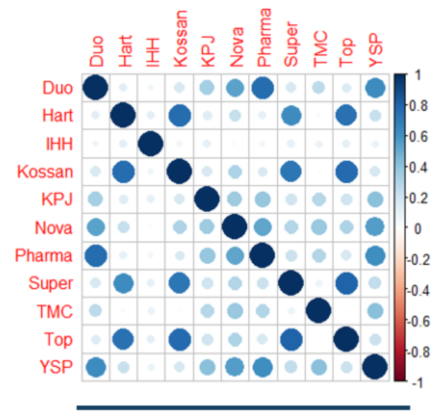
RESULT 2

2020

The most prominent stock: **Y.S.P.Southeast Asia Holding Berhad (YSP)**



Minimum Spanning Tree using iGraph



Correlation plot

CONCLUSION

Correlations between stocks in the health care sector are impacted by the COVID-19 pandemic. Before and during the COVID-19, the most prominent stocks changed their position.

REFERENCE

Bahaludin, H., & Syafiq, S. N. A. M. (2021). The Impact of COVID-19 on Industrial Products and Services Sector of Bursa Malaysia by using Minimum Spanning Tree. *Menemui Matematik (Discovering Mathematics), 43(2)*, 111-120.

Modelling Malaysia COVID-19 Case Using Quadratic Stochastic Operator

Mohd Yunus Bin Mohd Aisha Nuddin & Assoc. Prof. Dr Pah Chin Hee

Abstract

The Susceptible-Infected-Recovered (SIR) model is widely used in many countries to model the trend of coronavirus disease 2019 (COVID-19). In this research, we will apply a discrete-time version of SIR model without demography in which it will exclude the births and deaths cases. First, we will discretize the SIR and reduce it to Quadratic Stochastic Operators. This research intends to study the dynamics of the discretized SIR model using Quadratic Stochastic Operator. We will simulate the trajectory of the SIR-QSO model with different parameters. Then, we investigated the fixed point and its stability of the SIR-QSO using Jacobian and monotonicity. We found that the QSO to be a regular transformation and the fixed point consists of a set of boundary points. Next, we would model Malaysia COVID-19 trends during RMCO using discrete SIR-QSO. The method used was by finding the best fit parameters using Root Mean Square Error (RMSE). The best fit curve with the smallest RMSE was plotted. Then, we used the basic reproductive number, R_0 to determine the peak of infected density. We found out that this model is not good enough to be used in all type of cases. It can be improved by using better statistical analysis to get the best fit parameter.

Abstrak

Model “Susceptible-Infected-Recovered” (SIR) digunakan secara meluas di banyak negara untuk memodelkan arah pergerakan penyakit Coronavirus 2019 (COVID-19). Dalam penyelidikan ini, kami akan menggunakan versi masa diskret model SIR tanpa demografi di mana ia akan mengecualikan kelahiran dan kematian. Pertama, kami akan mendiskrisikan SIR dan mengurangkannya kepada Pengendali Stokastik Kuadratik. Penyelidikan ini bertujuan untuk mengkaji dinamik model SIR diskret menggunakan Pengendali Stokastik Kuadratik. Kami akan mensimulasikan trajektori model SIR-QSO untuk parameter yang berbeza. Kemudian, kita akan mencari titik tetap dan kestabilannya SIR-QSO menggunakan Jacobian dan “monotonicity”. Kami mendapati bahawa QSO adalah transformasi biasa dan titik tetap terdiri daripada satu set titik sempadan. Seterusnya, kami akan memodelkan arah pergerakan COVID-19 Malaysia semasa RMCO menggunakan SIR-QSO diskret. Kaedah yang digunakan ialah dengan mencari parameter kesesuaian terbaik menggunakan “Root Mean Square Error” (RMSE). Graf lengkung terbaik dengan RMSE terkecil diplotkan. Kemudian, kami menggunakan nombor pembiakan asas, R_0 untuk menentukan puncak ketumpatan yang dijangkiti. Kami mendapati bahawa model ini tidak cukup baik untuk digunakan dalam semua jenis kes. Ia boleh diperbaiki dengan menggunakan analisis statistik yang lebih baik untuk mendapatkan parameter kesesuaian yang terbaik.

TITLE: MODELLING MALAYSIA COVID-19 CASE USING QUADRATIC STOCHASTIC OPERATOR

COMPUTATIONAL AND THEORETICAL SCIENCES

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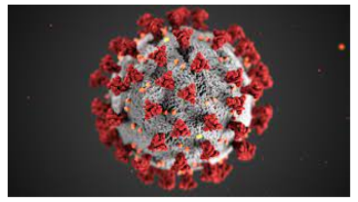
INTRODUCTION

Coronavirus diseases 19 or also known as COVID-19 was identified and has been spreading massively since its first case on 31st December 2019 in Wuhan, China. Malaysia also has been infected with it. We will use a discrete-time Susceptible, Infected, Recovered (SIR) Model and Quadratic Stochastic Operator (QSO) in this research. The discrete-time SIR Model will be reduced to QSO.



Data Collection

Phase	Movement Control Order (MCO)	Recovery Movement Control Order (RMCO)	National Recovery Plan (NRP)
Date	18th March – 3rd May 2020	13th January – 4th March 2021	1st June – 1st October 2021

PROBLEM STATEMENT

This research intends to find and study the threshold value R_0 of SIR-QSO model. There has been little study on how to simulate the trend and pattern of COVID-19 cases in Malaysia by using SIR-QSO model.

RESEARCH QUESTION

1) What is the trajectory of the SIR-QSO for different parameters?
2) What is the fixed point and its stability of the SIR-QSO and its regularity?
3) Can discrete SIR-QSO model capture the Malaysia COVID-19 trends during MCO, RMCO and NRP?

OBJECTIVE

1) To simulate trajectory of the SIR-QSO for different parameters.
2) To find the fixed point and stability of the SIR-QSO and check its regularity.
3) Modelling Malaysia COVID-19 trends during MCO, RMCO and NRP using discrete SIR-QSO.

METHODOLOGY

1 SIR MODEL:

$$\begin{cases} \frac{dS}{dt} = -aSI, \\ \frac{dI}{dt} = aSI - bI \\ \frac{dR}{dt} = bI. \end{cases}$$

2 DISCRETISATION OF THE SIR MODEL

We do the following substitutions to get the density of each S, I and R:

$$x = \frac{S}{N}, \quad y = \frac{I}{N}, \quad z = \frac{R}{N}$$

And we get

$$\begin{cases} \frac{dx}{dt} = -axy, \\ \frac{dy}{dt} = axy - by, \\ \frac{dz}{dt} = by, \end{cases} \quad (1)$$

3

We can define the discrete time dynamical system, associated to the system (1) that is generated by the operator V as

$$V: \begin{cases} x' = x - axy, \\ y' = y - by + axy, \\ z' = z + by. \end{cases} \quad (2)$$

4 REDUCTION TO QUADRATIC STOCHASTIC OPERATOR

Definition 1. The quadratic stochastic operator (QSO) is a mapping of the simplex

$$S^{m-1} = \left\{ x = (x_1, \dots, x_m) \epsilon \mathbb{R}^m : x_i \geq 0, \sum_{i=1}^{m} x_i = 1 \right\}$$

into itself, of the form

$$V: x'_k = \sum_{i=1}^{m} \sum_{j=1}^{m} P_{ij,k} x_i x_j, \qquad k = 1, \dots, m,$$

where the coefficients P_{ijk} satisfy the following conditions

$$P_{ij,k} \geq 0, \qquad P_{ij,k} = P_{ji,k}, \qquad \sum_{k=1}^{m} P_{ij,k} = 1, \qquad (i,j,k = 1, \dots, m).$$

Proposition 1. For the operator 2, we have $V(S^3) \subset S^3$ if and only if $a, b \epsilon [0,1]$.

5 THRESHOLD VALUE, $R_0 = \frac{a}{b}$

$R_0 > 1$	$R_0 < 1$ or $R_0 = 1$
An infection can spread throughout the population	Not infectious enough to infect most of the population

6 BEST FIT USING ROOT MEAN SQUARE ERROR (RMSE)

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (S_i - O_i)^2}$$

SIMULATION OF COVID-19 TREND WITH VARIOUS PARAMETERS

Note that x = Susceptible (S) density, y = Infected (I) density, z = Recovered (R) density

EXAMPLES WITH THE INITIAL VALUES FOR THE VARIABLES:

$x = 0.9999999375, y = 0.0000000625, z = 0.00000121875$

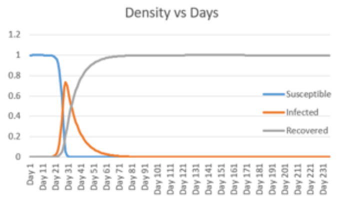


Figure 1

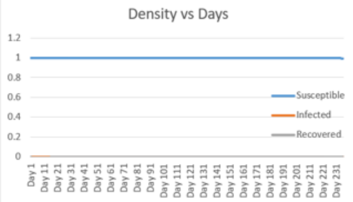


Figure 2

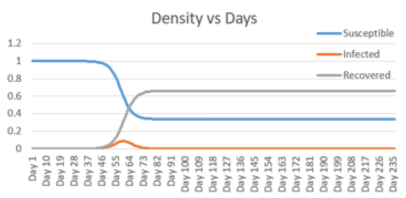


Figure 3

Figure	a	b	R_0
1	0.99	0.1	9.9
2	0.5	0.5	1
3	0.8	0.5	1.6

Theorem 1. The operator V has fixed points in the form of $(p, 0, 1-p) \in S^2$.

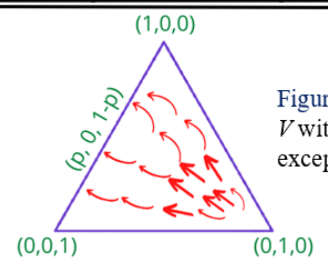


Figure 4: Trajectory of operator V with any initial value in S^2 except fixed point.

Theorem 2. For any $a, b \in [0,1]$, $x^{(n)} < \frac{b}{a}$, if and only if $y^{(n+1)} < y^{(n)}$.

Corollary 1. If $\frac{b}{a} > 1$, then $y^{(n+1)} < y^{(n)}$ for $n = 0,1,2, \dots$ and any value of x.

RESULT

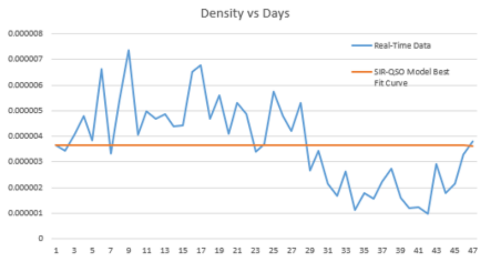


Figure 5: MCO

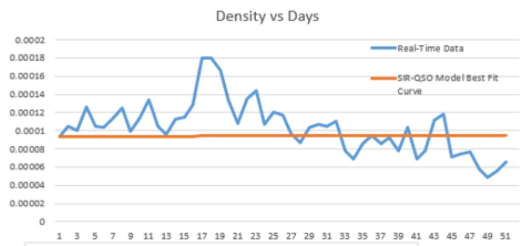


Figure 6: RMCO

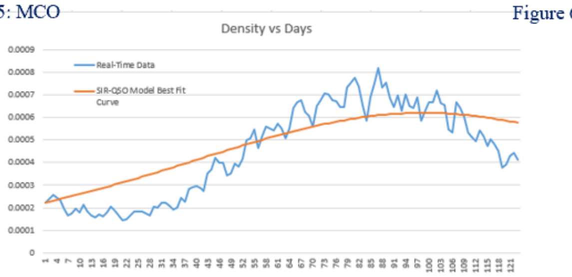


Figure 7: NRP

TABLE 1

Phase	Curve Fitting Result: a	b	R_0	RMSE
MCO	0.8	0.7999999	1.000000125	1.62013×10^{-6}
RMCO	0.4726	0.4699	1.05745903	2.96032×10^{-5}
NRP	0.6503	0.632	1.028955696	0.000105952

TABLE 2

Phase	Peak: Day of Simulation	Date of Simulation	Day of Actual Data	Date of Actual Data
MCO	1	18th March 2020	9	26th March 2020
RMCO	34	15th February 2021	87	30th January 2021
NRP	99	7th September 2021	18	26th August 2021

CONCLUSION

- COVID-19 infected density vanished after certain period of time.
- R_0 is not the sole indicator to predict the infectious of the disease as $x^{(n)} < \frac{b}{a}$ is the another indicator
- We did not get the results that we were hoping for every time which a and b are less than 1 and $a > b$.
- The Operator 2 is regular, the fixed points are $(p, 0, 1-p)$, where p is in [0,1].

REFERENCES

1) Córdova-Lepe, F., Gutiérrez, R., & Vilches-Ponce, K. (2020). Analysis of two discrete forms of the classic continuous SIR epidemiological model. *Journal of Difference Equations and Applications*, 26(1), 1-24.
2) Ndiaye, B. M., Tendeng, L., & Seck, D. (2020). Analysis of the COVID-19 pandemic by SIR model and machine learning technics for forecasting. *arXiv preprint arXiv:2004.01574*.
3) Rodrigues, H. S. (2016). Application of SIR epidemiological model: new trends. *arXiv preprint arXiv:1611.02565*.
4) Rozikov, U. A., & Shoyimardonov, S. K. (2021). An application of discrete-time SEIR model to the COVID-19 spread. *arXiv preprint arXiv:2105.00238*.

Optimizing Delivery Services Using Linear Programming and Monte Carlo Simulation

Nurfakhira Nublah Binti Mohamed Harith & Dr Norfaieqah Binti Ahmad

Abstract

The void in food industry during COVID-19 pandemic is worrying. It is harder for everyone to get food supplies. Hence, a local startup company is taking this opportunity to provide food delivery service. This research paper studies the optimization of food delivery service provided in the Kuala Lumpur city and its close regions. The idea is to solve a transportation problem by applying linear programming method and Monte Carlo simulation. The objectives are to find out the optimal routes for making deliveries within the range of area covered and to minimize the cost of deliveries. In order to obtain the desired results, firstly the optimization model is formulated and then, it is to be solved by using linear programming via Python software. Microsoft Excel is used to generate the sensitivity analysis. Python uses an open package named PuLP, while Microsoft Excel uses Solver add-in feature to solve linear programming problem. The results anticipated from this study are the minimum cost for deliveries and the optimal routes of deliveries. The optimal routes obtained pair the best sources with their respective destinations while fulfilling the demand and supply constraints. The total minimized value of the costs for deliveries will also be shown. Monte Carlo simulation is then applied to manipulate the model and the comparison between results from linear programming and Monte Carlo simulations were evaluated. This study is suitable for companies that offer similar services and wants to minimize their costs for deliveries so that they can save more money and gain more profit.

Abstrak

Kekosongan dalam industri makanan semasa wabak COVID-19 membimbangkan. Lebih sukar bagi setiap orang untuk mendapatkan bekalan makanan. Oleh itu, sebuah syarikat permulaan tempatan mengambil peluang ini untuk menyediakan perkhidmatan penghantaran makanan. Kertas penyelidikan ini mengkaji pengoptimuman perkhidmatan penghantaran makanan yang disediakan di Bandar Raya Kuala Lumpur dan kawasan berhampirannya. Ideanya adalah untuk menyelesaikan masalah pengangkutan dengan menggunakan kaedah pengaturcaraan linear dan simulasi Monte Carlo. Objektifnya adalah untuk mengetahui laluan optimum untuk membuat penghantaran dalam lingkungan kawasan liputan dan untuk meminimumkan kos penghantaran. Untuk mendapatkan hasil yang diingini, pertama sekali model pengoptimuman dirumuskan dan kemudian, ia perlu diselesaikan dengan menggunakan pengaturcaraan linear melalui perisian Python. Python menggunakan pakej terbuka bernama PuLP, manakala Microsoft Excel menggunakan ciri Solver Add-in untuk menyelesaikan masalah pengaturcaraan linear. Keputusan yang dijangkakan daripada kajian ini ialah kos minimum penghantaran dan laluan penghantaran yang optimum. Laluan optimum yang diperoleh akan menggandingkan sumber terbaik dengan destinasi masing-masing di samping memenuhi kekangan permintaan dan penawaran. Jumlah nilai minimum kos penghantaran juga akan ditunjukkan. simulasi Monte Carlo kemudiannya digunakan untuk memanipulasi model dan perbandingan antara hasil daripada pengaturcaraan linear dan simulasi Monte Carlo telah dinilai. Kajian ini sesuai bagi syarikat yang menawarkan perkhidmatan serupa yang ingin meminimumkan kos penghantaran mereka supaya dapat menjimatkan lebih banyak wang dan memperoleh lebih banyak keuntungan.

OPTIMIZING DELIVERY SERVICES USING LINEAR PROGRAMMING

INTRODUCTION

Food delivery and personal shopper services are always on high demand, even more so during this lockdown. According to Hwang (2020), consumers have started to favour meal delivery services at home rather than eating out since the COVID-19 outbreak. People find it easier and probably safer to use this service compared to them having to physically go to restaurants for food or getting groceries at the hypermarket which will make them more exposed to the virus.

RESEARCH QUESTION

How can we address the proposed problem systematically and minimize the cost of the offered services?

OBJECTIVE

- To figure out the optimal routes for making deliveries in a wide range of area.
- To explore the linear programming approach to minimize cost of the offered services.

PROBLEM STATEMENT

Individuals who wanted food prepared away from home began to request deliveries and takeout services through mobile applications (Botelho, Cardoso, & Canella, 2020). Because of how promising the online food businesses are during the pandemic, delivery services have become important and frequently used.

METHODOLOGY

- This study proposed the mathematical method of Linear Programming in solving a minimization problem.
- The computer software that are used to compute the problem are Microsoft Excel and Python.

RESULTS

01 Minimized Cost:
RM 7 380.28 for 4000 orders

02 Optimal Routes:

Kuala Lumpur	Sunway Putra Mall
Setapak	Setapak Central
Gombak	Wangsa Walk
Ampang	Melawati Mall
Ulu Kelang	Aeon Big

CONCLUSION

The mathematical model proposed in this study can help businesses to save cost and to further plan their optimal routes for making deliveries by applying Linear Programming. It can also cover a large scale of area that the service is available within.

REFERENCES

Botelho, L. V., Cardoso, L. d., & Canella, D. S. (2020). COVID-19 and the Digital Food Environment in Brazil: Reflections on the Pandemic's Influence on the Use of Food Delivery Apps. Reports in Public Health, 5.

Hwang, J. (2020). How to Form Behavioral Intentions in the Field of Drone Food Delivery Services: The Moderating Role of the COVID-19 Outbreak. Environmental Research and Public Health, 15.

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Stability Analysis of Three Parameters of 2-Partition of Three Points Poisson Quadratic Stochastic Operator

Anis Sulaikha Binti Samiun & Dr Nur Zatul Akmar Hamzah

Abstract

The theory of quadratic stochastic operator (QSO) defined on finite state space is well developed and nowadays there are many articles on the study that have been published worldwide. However, QSO defined on infinite state space is still not fully studied. Thus, it motivates us to study and introduce one of the classes of QSO defined on infinite state space. In this thesis, we constructed new class of Poisson QSO defined on infinite countable state space, that is, Poisson QSO generated by 2-partition of three points with three different parameters. This thesis also sought to investigate their trajectory behaviour as well as analysing the regularity and stability of such operator. The analysis is done graphically by considering two cases which are $x_1 = 0$ and $x_1 \neq 0$. It is shown that the constructed Poisson QSO is regular for some values of parameters and non-regular for other values of parameters. Moreover, it is figured out that all regular cases of the defined Poisson QSO have a unique fixed point which is attracting while all non-regular cases have hyperbolic periodic points which are attracting and repelling. The findings of this research may contribute to the further development of Poisson QSO since it may motivate future researchers to continue the study on Poisson QSO with different kind of points, partitions and parameters used.

Abstrak

Teori mengenai pengendali stokastik kuadratik (QSO) yang ditakrifkan pada ruang keadaan terhingga telah membangun dengan baik dan pada masa ini terdapat banyak artikel mengenai kajian tersebut telah diterbitkan di seluruh dunia. Walaubagaimanapun, QSO yang ditakrifkan pada ruang keadaan tak terhingga masih belum dikaji sepenuhnya. Oleh itu, ia mendorong kami untuk mengkaji dan memperkenalkan salah satu kelas QSO yang ditakrifkan pada ruang keadaan tak terhingga. Dalam tesis ini, kami membina kelas baharu Poisson QSO yang ditakrifkan pada ruang keadaan boleh dikira tak terhingga, iaitu, Poisson QSO yang dijana oleh 2-pembahagian tiga titik dengan tiga parameter berbeza. Tesis ini juga berusaha untuk menyiasat tingkah laku trajektori mereka serta menganalisis keteraturan dan kestabilan pengendali tersebut. Analisis dilakukan secara grafik dengan mengambil kira dua kes iaitu $x_1 = 0$ dan $x_1 \neq 0$. Ditunjukkan bahawa Poisson QSO yang dibina adalah teratur untuk beberapa nilai parameter dan tidak teratur untuk nilai parameter yang lain. Selain itu, didapati bahawa semua kes teratur bagi Poisson QSO yang ditakrifkan mempunyai titik tetap unik yang menarik manakala semua kes tidak teratur mempunyai titik berkala hiperbolik yang menarik dan menolak. Penemuan penyelidikan ini dapat menyumbang kepada pembangunan lanjut Poisson QSO kerana ia dapat mendorong penyelidik akan datang untuk meneruskan kajian tentang Poisson QSO dengan jenis titik, pembahagian dan parameter yang berbeza digunakan.

STABILITY ANALYSIS OF THREE PARAMETERS OF 2-PARTITION OF THREE POINTS POISSON QUADRATIC STOCHASTIC OPERATOR

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INTRODUCTION

QSO was introduced by Bernstein in 1924 as the mathematical solution to the problem arising from the evolution of a population over time. Ongoing era, QSO has become an important source of analysis to study various applied problems especially in mathematical genetics [1]. In fact, there are many classes of QSO that have been discovered such as Dissipative QSO [2], ℓ-Volterra QSO [3] and ξ^s-QSO [4]. All of these classes, however, would not be sufficient to cover all QSO. As a result, many other types of QSO have yet to be explored.

PROBLEM STATEMENT

In the present, the study of QSO defined on finite state space is well developed. The examples can be found in [5], [6] and [7]. According to [8], even though dynamical phenomena on higher dimensional systems are extremely significant, only a few studies on them are now understood. Therefore, this research emphasised on the QSO defined on infinite countable state space, specifically for three points Poisson QSO.

RESEARCH QUESTIONS

1. How to construct the classes of 2-Partition Poisson QSO of three points with three different parameters on infinite countable state space?
2. What is the trajectory behaviour and regularity of defined Poisson QSO?
3. How to analyze the stability of defined Poisson QSO using graphical analysis?

OBJECTIVES

1. To define and construct some classes of 2-Partition Poisson QSO of three points with three different parameters on infinite countable state space.
2. To investigate the trajectory behaviour and regularity of defined Poisson QSO.
3. To analyze the stability of defined Poisson QSO using graphical analysis.

METHODOLOGY

POISSON QSO GENERATED BY 2-PARTITION OF CONSECUTIVE THREE POINTS WITH THREE DIFFERENT PARAMETERS

Let the state space $X = \mathbb{Z}^*$, $A_1 = \{x_1, x_1+1, x_1+2 : x_1 \in \mathbb{Z}^*\}$ be the set of consecutive three points and $A_2 = \mathbb{Z}^* \backslash A_1$.

We consider Poisson distribution that is:

$$P_{ij,k} = \begin{cases} e^{-\lambda_1}\dfrac{\lambda_1^k}{k!} if\ (i,j) \in B_1 \\ e^{-\lambda_2}\dfrac{\lambda_2^k}{k!} if\ (i,j) \in B_2 \\ e^{-\lambda_3}\dfrac{\lambda_3^k}{k!} if\ (i,j) \in B_3 \end{cases}, \text{ for } i,j \in X$$

Then, for any initial measure, we have

$$V^{n+1}\mu(k) = \sum_{i=0}^{\infty}\sum_{j=0}^{\infty} P_{ij,k} V^n\mu(i) V^n\mu(j)$$

$$= e^{-\lambda_1}\frac{\lambda_1^k}{k!}\left[\sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]^2 + e^{-\lambda_2}\frac{\lambda_2^k}{k!}\left[1-\sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]^2 + e^{-\lambda_3}\frac{\lambda_3^k}{k!}\left\{2\left[\sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]\left[1-\sum_{i=x_1}^{x_1+2} V^n\mu(i)\right]\right\},$$

where $n = 0,1,2,\ldots$

Definition 1.
A QSO is called regular if the limit, $\lim_{n\to\infty} V^n\mu$, exists for any initial points $\mu \in S(X,F)$.

RESULTS AND DISCUSSION

RESULT 1: REGULARITY OF DEFINED POISSON QSO

Case 1: $x_1 = 0$

Regular Poisson QSO

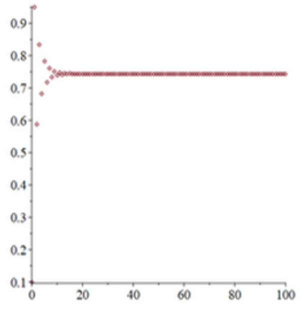

Fig 1 Plotorbit when starting point x=0.1, λ_1=2.5, λ_2=0.85, λ_3=0.0975

Non-regular Poisson QSO

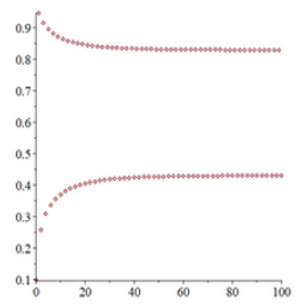

Fig 2 Plotorbit when starting point x=0.1, λ_1=4.5, λ_2=0.85, λ_3=0.0975

The operator is found to be regular for some parameters and non-regular for some other parameters.

Case 2: $x_1 \neq 0$

Regular Poisson QSO

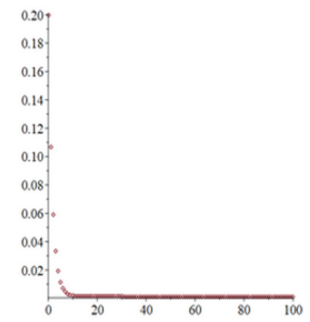

Fig 3 Plotorbit when starting point x=0.2, λ_1=4.5, λ_2=0.65, λ_3=3.75

The operator is found to be regular for all values of parameters.

RESULT 2: STABILITY OF DEFINED POISSON QSO

Regular Poisson QSO

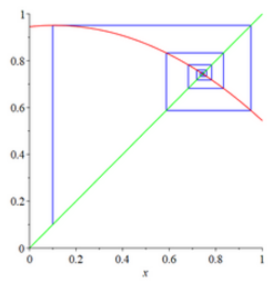

Fig 4 Cobweb when starting point x=0.1, λ_1=2.5, λ_2=0.85, λ_3=0.0975 for Case 1.

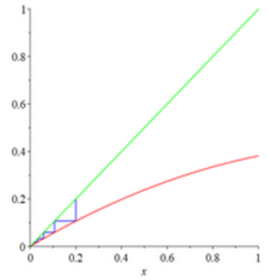

Fig 5 Cobweb when starting point x=0.2, λ_1=4.5, λ_2=0.65, λ_3=3.75 for Case 2.

All regular Poisson QSO generated by 2-partition of three points with 3 parameters have a hyperbolic fixed point which is attracting.

Non-regular Poisson QSO

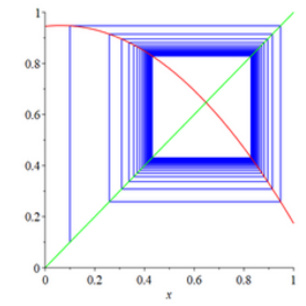

Fig 6 Cobweb when starting point x=0.1, λ_1=4.5, λ_2=0.85, λ_3=0.0975 for Case 1.

All non-regular Poisson QSO generated by 2-partition of three points with 3 parameters have hyperbolic periodic points which are attracting and repelling.

CONCLUSION

Poisson QSO generated by 2-partition of three points with three different parameters can be regular and non-regular for some cases, considering different values of parameters.
Also, it can be concluded that a free population under all regular cases for such operator will be eventually stable.

REFERENCES

[1] Ganikhodzhaev, R. et al. (2011). Infinite Dimensional Analysis, Quantum Probability and Related Topics.
[2] Shahidi, F. (2008). Applied Mathematics & Information Sciences - An International Journal.
[3] Rozikov, U. A., & Zada, A. (2010). International Journal of Biomathematics.
[4] Mukhamedov, F. et al. (2013). Abstract and Applied Analysis.
[5] Shahidi, F., & Abu Osman, M. T. (2013). Journal of Difference Equations and Applications.
[6] Abdulghafor, R. et al. (2016). Open Mathematics.
[7] Saburov, M. (2013). World Applied Sciences Journal.
[8] Mukhamedov, F., & Embong, A. F. (2015). Journal of Inequalities and Applications.

Approximation of 2D Ising Model Critical Point

Muhammad Aiman Arif Bin Ahmad Rushdi & Dr Siti Fatimah Binti Zakaria

Abstract

The Ising model is a mathematical model of ferromagnetic in statistical mechanics. This study focused on the two-dimensional Ising model in finite lattice that is 20×20 square lattice. The study aims to investigate the critical point of Ising model on finite lattice using some approximation methods. The methods used for approximation are Monte Carlo simulation method and curve-fitting techniques which are polynomial and cubic spline fitting. Our first step is to compute the partition function and plot the distribution of zeros of partition function in complex temperature plane. The partition function is computed using partition vector and transfer matrix approaches. Using Monte Carlo simulation method, we are able to simulate and observe the existence of phase transition in 2D Ising model. Then, we used the zeros in the first quadrant in the Argand plane to perform curve-fitting techniques. Monte Carlo simulation method simulate the model with chosen value of inverse temperatures β_c 2.4, 2.5 and $1+\sqrt{2}$. The simulation also supports with the additional graph of magnetization, susceptibility, and specific heat against temperature. The result showed the existence of critical point in phase transition. The polynomial fitting plotted the result with critical point at 2.49878282 and the cubic spline fitting at 2.5983984. Then, we referred to the Onsager's solution $1+\sqrt{2}$ for comparison. The approximated value chosen in Monte Carlo simulation and resulted from the curve fitting techniques are significant and closed to the Onsager's solution.

Abstrak

Model Ising adalah model matematik tentang ferromagnetik dalam mekanikal statistik. Kajian ini memberi tumpuan kepada model Ising dalam dua dimensi (2D). Kajian ini bertujuan untuk menyiasat titik kritikal ketika peralihan fasa dalam 20×20 kekisi persegi menggunakan beberapa kaedah penghampiran. Kaedah yang digunakan untuk penghampiran adalah kaedah simulasi Monte Carlo dan teknik pemasangan lengkung yang sesuai iaitu polinomial dan splin kiub. Pertama sekali kami perlu mencari fungsi partisi untuk 20×20 kekisi persegi dan plotkan semua sifar fungsi partisi dalam satah suhu kompleks. Fungsi partisi dikira menggunakan kaedah vektor partisi dan pendekatan matriks pemindahan. Dengan menggunakan kaedah simulasi Monte Carlo, kami dapat mensimulasikan dan memerhatikan 2D model Ising. Kemudian, kami menggunakan sifar di kuadran pertama dalam satah suhu kompleks untuk melakukan teknik pemasangan lengkung. Kami menggunakan solusi pertama dari Onsager untuk 2D model Ising sebagai penanda aras kami untuk kaedah penghampiran. Kaedah simulasi Monte Carlo mensimulasikan model dengan nilai suhu yang dipilih β_c 2.4, 2.5 dan $1+\sqrt{2}$. Simulasi ini juga disokong oleh dapatan dari graf magnetisasi, kerentanan, dan haba tertentu melawan suhu yang menunjukkan kewujudan titik kritikal dalam peralihan fasa. Lengkung polinomial menunjukkan titik kritikal pada 2.49878282 dan lengkung splin adalah 2.5983984. Kemudian, kami merujuk solusi dari Onsager yakni $1+\sqrt{2}$ sebagai perbandingan. Nilai anggaran yang dipilih dalam simulasi Monte Carlo dan keputusan dari teknik pemasangan lengkung adalah signifikan dan hampir kepada solusi dari Onsager.

TITLE: APPROXIMATION OF 2D ISING MODEL CRITICAL POINT

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ABSTRACT

We consider a 20 by 20 Ising model on square lattice to study its critical point of phase transition. Using Monte-Carlo simulation and curve fitting techniques, the critical point is approximated and compared with Onsager's solution.

PROBLEM STATEMENT

Many computational method have been introduced to investigate the critical point where the phase transition exhibit in 2D Ising model. Therefore, using approximation method, we would like to investigate the comparison between Onsager's solution and the approximated value.

RESEARCH QUESTION

1. How to approximate the critical point using Monte Carlo simulation?
2. How to approximate the critical point using extrapolation?
3. Can we get a good approximation as compared to the Onsager's exact solution?

OBJECTIVE

1. To approximate the critical point of Ising model on square lattice using Monte Carlo method and curve-fitting technique.
2. To compare the result of Onsager's solution with approximation of Monte Carlo method and curve-fitting technique.

METHODOLOGY

This research used Monte Carlo simulation method and curve fitting technique such as polynomial, least square and cubic spline.

RESULT 1

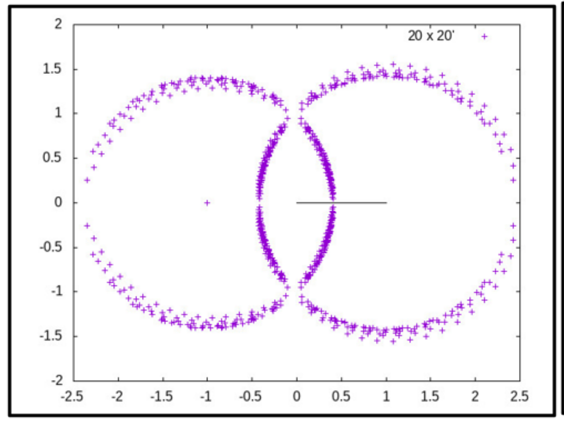

Figure 1: Zeros of partition function in the complex plane.

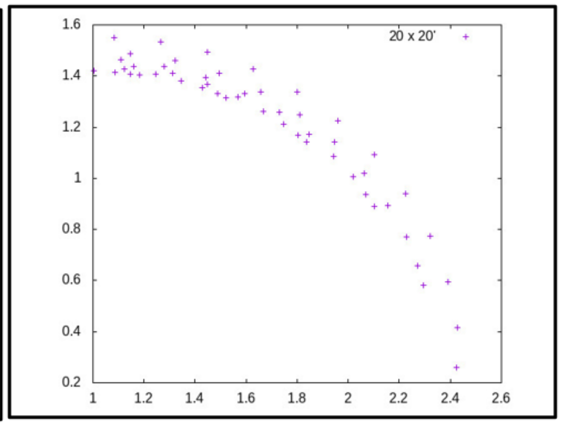

Figure 2: The first quadrant.

RESULT 2

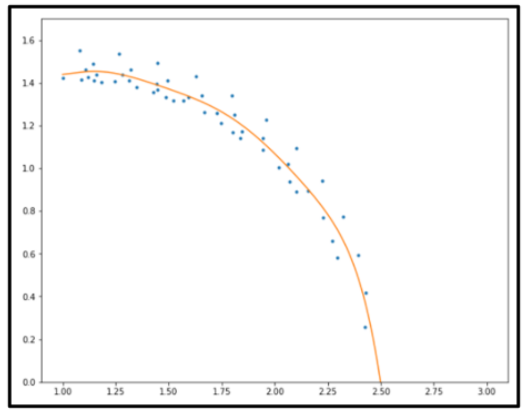

Figure 3: Extrapolation using polynomial method

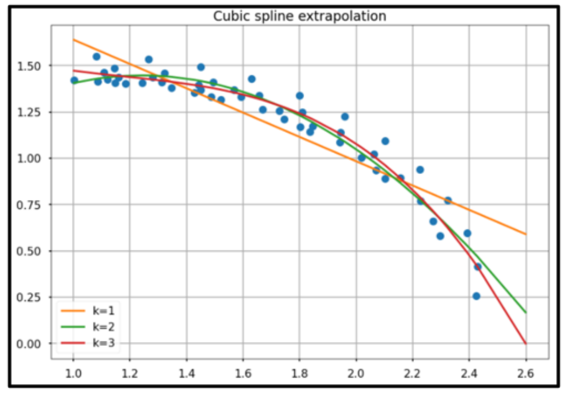

Figure 4: Extrapolation using cubic spline method

CONCLUSION

By plotting the zeros of partition function, the study consider the zeros in first quadrant only as the solution cross the real axis. In the Figure 2, there are 51 points plotted and use for extrapolation. Onsager's solution stated that critical point of phase transition in square lattice occur when $T_c = 1 + \sqrt{2} \approx 2.41421356$. Using polynomial technique, the approximated critical point is different depend on the degree of polynomial. The extrapolation in Figure 3 has the degree of polynomial equal to 7 and the critical point is approximated at 2.49878282. While using the cubic spline technique in the Figure 4, the approximated value is 2.5989999. For least square approximation, the result is still in investigation.

REFERENCES

1. Ferrenberg, A. M., Xu, J., & Landau, D. P. (2018). Pushing the limits of Monte Carlo simulations for the three-dimensional Ising model. Physical Review E, 97(4).
2. Ising, T., Folk, R., Kenna, R., Berche, B., & Holovatch, Y. (2017). The fate of Ernst Ising and the fate of his model. Journal of Physical Studies, 21(3).
3. Martin, P. P., & Zakaria, S. F. (2019). Zeros of the 3-state Potts model partition function for the square lattice revisited. *Journal of Statistical Mechanics: Theory and Experiment*, *2019*(8), 084003.
4. Valani, Y. P. (2011). On the Partition Function for the Three-dimensional Ising model. PhD thesis, Engineering and Mathematical Sciences.
5. Zakaria, S. F. (2016). Analytic Properties of Potts and Ising Model Partition Functions and the Relationship between Analytic Properties and Phase Transitions in Equilibrium Statistical Mechanics. (Doctoral dissertation, University of Leeds, UK).

Fundamentals of Spatial Agent-Based SIRD Model for Pandemic

Nurul Izzah Binti Ahamad Zambri & Dr Muhammad Salihi Abdul Hadi

Abstract

In this study, three models for simulating pandemic trends are presented. These models are based on the SIRD model. The first model is the compartmental SIRD model, the second is the agent-based SIRD model, and the last one is the spatial agent-based SIRD model. The aim of this study is to explain the fundamentals of the spatial agent-based SIRD model using two methods, building the program from scratch, and using the MESA library for Python in Jupyter Notebook. The spatial model is chosen as a better alternative compared to the compartmental model during early stages of a pandemic or for small populations. The model for this study is simulated for a period of 150 days. The results show the that the trends predicted by these simulations were similar in dynamics. However, there were differences in terms of the speed of pandemic growth, the infection peak, and more. This work is intended to help undergraduate students and starters who want to understand the underlying concepts of spatial agent-based SIRD model.

Abstrak

Kajian ini membentangkan tiga model untuk mensimulasi pola pandemik. Model-model ini adalah berdasarkan model SIRD. Model pertama ialah model SIRD kompartmen ataupun dikenali sebagai model SIRD analitik, yang kedua ialah model SIRD berasaskan ejen dan yang terakhir ialah model SIRD berasaskan ejen ruang. Matlamat kajian ini adalah untuk menerangkan asas model SIRD berasaskan ejen ruang menggunakan dua kaedah, membina program dari awal, dan menggunakan pustaka MESA untuk Python dalam perisian Jupyter Notebook. Model ruang dipilih sebagai alternatif yang lebih baik berbanding model kompartmen terutamanya pada peringkat awal pandemik ataupun untuk mensimulasi pandemik dalam populasi yang kecil. Model untuk kajian ini telah disimulasikan untuk tempoh 150 hari. Keputusan menunjukkan bahawa pola yang diramalkan oleh simulasi ini adalah serupa bagi ketiga-tiga model. Walau bagaimanapun, terdapat beberapa perbezaan dari segi kelajuan perkembangan pandemik, kemuncak jumlah jangkitan dan banyak lagi. Kajian ini diharapkan dapat membantu mahasiswa dan sesiapa yang ingin memahami konsep asas model SIRD berasaskan ejen ruang.

FUNDAMENTALS OF SPATIAL AGENT-BASED SIRD MODEL FOR PANDEMIC

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In epidemiology, many compartmental models have been used such as the SIR and the SEIRD model to study the spread of infectious diseases. This research utilizes a variant of the SIR model, which is the SIRD model that includes the number of deaths. To further improve this model, a stochastic model is introduced, which is the agent-based SIRD model. Then, a space can be added in order to mimic realistic situations where disease spread is highly affected by geography. This study focuses mainly on the fundamentals of spatial agent-based SIRD models.

OBJECTIVES

1. To compare the compartmental SIRD model with the corresponding agent-based model.
2. To investigate the descriptive statistics of the agent-based SIRD model.
3. To introduce a spatial agent-based SIRD model.

COMPARTMENTAL SIRD MODEL

This model will serve as a benchmark for the other models in this research.

It divides the population into 4 compartments, which flows into one another.

Figure 1: The flow of the population

This flow can then be represented by a set of odes:

$$\frac{dS}{dt} = \frac{-\beta IS}{N}$$
$$\frac{dI}{dt} = \frac{\beta IS}{N} - \gamma I - \mu I$$
$$\frac{dR}{dt} = \gamma I$$
$$\frac{dD}{dt} = \mu I$$

where β is the infection rate, γ is the recovery rate, μ is the mortality rate, and N is the population size.

Note that $$\frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} + \frac{dD}{dt} = 0$$

From above it follows that

$$S(t) + I(t) + R(t) + D(t) = N$$

Forward Euler's method is applied to solve the set of ODEs and obtain:

$$S_t = S_{t-1} - \frac{\beta\, I_{t-1}\, S_{t-1}}{N}$$
$$I_t = S_{t-1} + \frac{\beta\, I_{t-1}\, S_{t-1}}{N} - \gamma I_{t-1} - \mu I_{t-1}$$
$$R_t = R_{t-1} + \gamma I_{t-1}$$
$$D_t = D_{t-1} + \mu I_{t-1}$$

AGENT-BASED SIRD MODEL

This is a stochastic model concerned with approximating or mimicking a random or probabilistic element. Monte Carlo method is used hence each agent has a random probability to be infected, recover, or die.

There are two key components in agent-based models (ABM):

1. Agents (follows a set of rules and interacts with other agents and the environment)
2. Environment (the space where agents interact on)

SPATIAL AGENT-BASED SIRD MODEL

This model adds a conceptual space for agents' interaction with other agents but not with the space itself.

The agents are placed on a square lattice, in a torus space so each agent will have eight neigbours on their north, east, south, west, northeast, southeast, southwest, and northwest.

As an example, we will choose the total population to be 9 agents. The agents will be rearranged in a matrix with the size of the square root of the total population. Each agent will have eight neighbours to interact with. Then, agent 0 for instance will have such neighbours as illustrated below, the blue agents are put to visualize the torus space:

8	6	7	8	6
2	0	1	2	0
5	3	4	5	3
8	6	7	8	6
2	0	1	2	0

RESULTS & DISCUSSIONS

For all simulations, the parameters were kept constant as follows: γ = 0.225, μ = 0.01. Meanwhile β was set to 0.225 for first two cases and to 0.54 for the remaining cases. Initially, there are 100 infected patients set. The ABM and spatial models were each run 10 times and the median was calculated.

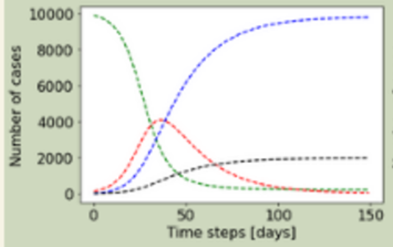

Figure 2: Compartmental SIRD model simulation

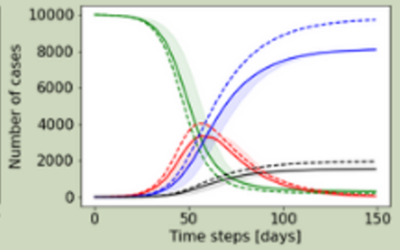

Figure 3: Agent-based SIRD model simulation

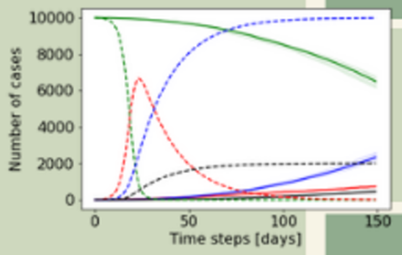

Figure 4: Spatial agent-based SIRD simulation; mode = random

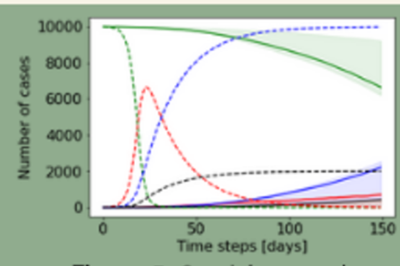

Figure 5: Spatial agent-based SIRD simulation; mode = lattice

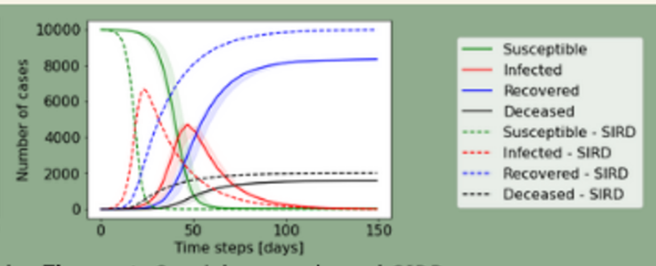

Figure 6: Spatial agent-based SIRD simulation; mode = lattice, random contacts = 1

For figure 2, the number of infected agents grow rapidly and peaks at around day 40, which is around the same time the susceptible agents drop significantly. After that, the infected cases slowly decreases because at this time, most agents have been infected. The deaths started at 0 and peak at around day 70 and remain stagnant until the end, while the number of infected cases reduces to 0. This model describes the average where it assumes homogenous mixing and social interaction.

Figure 3 shows the same dynamics as the compartmental model, albeit with some variances. The median is plotted as solid lines, while the shaded regions are the 25% to 75% quantile. This is due to the stochastic nature of the ABM that every simulation is different.

The mode for the simulation in figure 4 is set to random. It does not consider the population distribution like the agent-based model, but the results differ as the spread for this is significantly slower than the ABM. It was even necessary to increase the value of β to see any growth.

For figure 5, the agents are placed on a lattice. The trend observed is almost the same as before, but with a larger variance.

The spread of the disease in figure 6 is more rapid than the previous cases but is far from close to the compartmental model. To get similar results, fitting must be done, but it can be hard since we do not know the average parameters.

CONCLUSION

The parameter average for the ABM approaches the values for the compartmental model, while the average for the spatial models are very different. This lends to the fact that population distribution plays a significant role in the growth of disease spread.

REFERENCES

1. Cintra, P. H. (2020, June 5). Mathematical models for describing and predicting the COVID-19 pandemic crisis. doi:2006.02507v1 [physics.soc-ph] 3 Jun 2020
2. Columbia University. (2017). Agent-Based Modeling. Retrieved August 29, 2021, from Columbia Public Health: https://www.publichealth.columbia.edu/research/populationhealth-methods/agent-based-modeling
3. Graf, C. (2020, September 3). Modelling a Pandemic. Retrieved August 24, 2021, from Towards Data Science: https://towardsdatascience.com/modelling-a-pandemic-eb94025f248f
4. Norah, I. A., Eman, Y. A., & Muazzam, A. S. (2020, December 9). An agent-based simulation of the SIRD model of COVID-19 spread. International Journal of Biology and Biomedical Engineering, 14, 210-216. doi:10.46300/91011.2020.14.28

Susceptible-Exposed-Infected-Removed-Vaccinated (SEIRV) Model for COVID-19 in Malaysia

Nur Atifah Binti Baharuddin & Dr Nurul Farahain Mohammad

Abstract

In this project, the Susceptible-Exposed-Infected-Removed-Vaccinated (SEIRV) model for simulating COVID-19 in Malaysia is studied. Recently, the National COVID-19 Immunisation Programme (NIP) was implemented to protect Malaysians from COVID-19 through vaccination. However, the number of new infected cases in Malaysia remains high. Thus, the objectives of this study are to solve the SEIRV model, estimate parameters of SEIRV model together with basic reproduction number R_0 according to current COVID-19 situation in Malaysia, and build a dashboard for COVID-19 in Malaysia. The SEIRV model is solved numerically using built-in function odeint in Python. Then, for its parameter, COVID-19 infection rate, β and vaccination rate, α are estimated using built-in function minimize in Python. Built-in function least_squares which refer to Least-Squares minimization by using Trust Region Reflective method, is used in minimize. The data used for estimating parameters are filtered using built-in function savgol_filter. As for results, this project considers observation of infected and vaccinated population in SEIRV model for 14, 30, 100 and 300 days moving window after NIP. During 14 and 30 days moving window, approximately less than 10000 daily infected cases recorded when averagely more than 70000 people getting vaccinated in a day. Next, during 100 days moving window, vaccinated cases reduced to less than 70000 in June 2021 and infected cases showed less than 10000 people per day. Then, during 300 days moving window, vaccinated cases decreased to almost 50000 people in December 2021 since many people already vaccinated in this period. The infected cases still less than 10000 people per day. Therefore, based on our SEIRV model, we assume the daily infected cases is below 10000 when people are getting vaccinated. Lastly, a COVID-19 Dashboard in Malaysia is successfully executed using streamlit package in Python. The dashboard is able to reactively solve SEIRV model and perform parameter estimation.

Abstrak

Dalam projek ini, model SEIRV untuk COVID-19 di Malaysia telah dikaji. Baru-baru ini, Program Imunisasi COVID-19 Kebangsaan (NIP) telah dilaksanakan untuk melindungi rakyat Malaysia daripada jangkitan COVID-19 melalui vaksinasi. Walau bagaimanapun, jumlah kes jangkitan baharu di Malaysia kekal tinggi. Oleh itu, kajian ini bertujuan menyelesaikan model SEIRV, menganggarkan nilai parameter untuk model SEIRV serta kadar kebolehjangkitan R_0 berdasarkan situasi semasa COVID-19 di Malaysia, dan membina papan maklumat untuk COVID-19 di Malaysia. Model SEIRV diselesaikan secara berangka menggunakan fungsi terbina odeint dalam Python. Kemudian, kadar jangkitan COVID-19, β dan kadar vaksinasi, α dianggar menggunakan fungsi terbina minimize dalam Python. Fungsi terbina least_squares yang mana merujuk kepada peminimuman kuasa dua terkecil dengan pengecilan kuasa melalui kaedah pantulan kawasan dipercayai, digunakan dalam minimize. Data yang digunakan untuk menganggar parameter ditapis menggunakan fungsi terbina savgol_filter. Bagi keputusan kajian ini, pemerhatian dilakukan ke atas kelompok yang dijangkiti dan divaksin mengikut 14, 30, 100 dan 300 hari tetingkap bergerak selepas NIP dilaksanakan. Sepanjang tempoh 14 dan 30 hari tetingkap bergerak, anggaran kurang daripada 10000 kes jangkitan dicatat apabila purata lebih daripada 70000 orang mendapat vaksin dalam sehari. Seterusnya, dalam tempoh 100 hari, kes vaksinasi menurun kepada kurang daripada 70000 pada Jun 2021 dan kes jangkitan kurang daripada 10000 orang sehari. Kemudian, dalam tempoh 300 hari, kes vaksinasi berkurangan kepada hampir 50000 orang pada Disember 2021 memandangkan ramai orang telah divaksin dalam tempoh ini. Kes jangkitan masih juga kurang daripada 10000 orang setiap hari. Oleh itu, berdasarkan model SEIRV, kami menganggarkan kes jangkitan harian adalah di bawah 10000 apabila orang telah divaksinasi. Akhir sekali, papan maklumat COVID-19 di Malaysia berjaya dilaksanakan menggunakan pakej streamlit dalam Python. Papan maklumat ini dapat membantu menyelesaikan model SEIRV dan melaksanakan anggaran nilai untuk parameter secara automatik.

SEIRV MODEL FOR COVID-19 IN MALAYSIA

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INTRODUCTION

Vaccines distributed **BUT** → COVID-19 cases still high

The Susceptible-Exposed-Infectious- Removed-Vaccinated (SEIRV) model is used to investigate the impact of vaccination [1]

RESEARCH QUESTION

How to solve and simulate SEIRV Model for COVID-19 in Malaysia?

OBJECTIVE

To solve and simulate SEIRV Model for COVID-19 in Malaysia

MATHEMATICAL MODEL

Click here for more details about model

SEIRV Model from [2] :

$$S'(t)=\lambda-\frac{\beta S(t)I(t)}{N(t)}-\alpha S(t)-\mu S(t),$$

$$E'(t)=\frac{\beta S(t)I(t)}{N(t)}+\frac{(1-p)\beta V(t)I(t)}{N(t)}-\sigma E(t)-\mu E(t),$$

$$I'(t)=\sigma E(t)-\eta I(t)-\delta I(t)-\mu I(t),$$

$$R'(t)=pV(t)+\eta I(t)-\mu R(t),$$

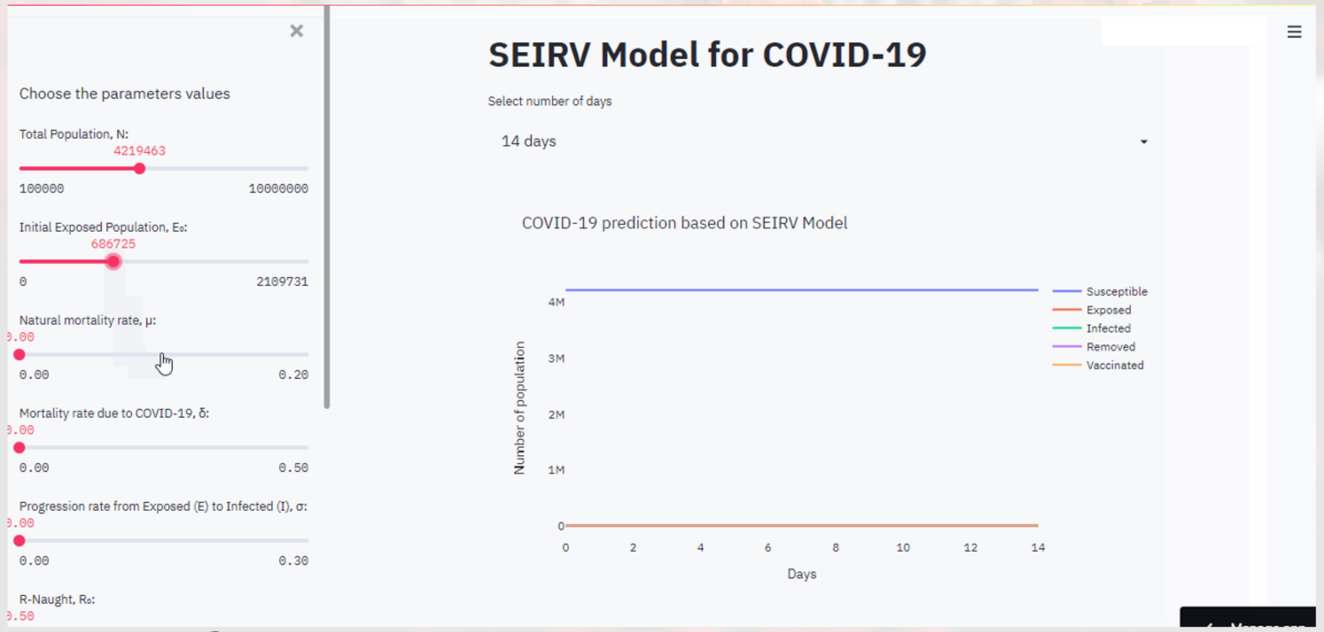
$$V'(t)=\alpha S(t)-\frac{(1-p)\beta V(t)I(t)}{N(t)}-pV(t)-\mu V(t)$$

Parameters description

- Recruitment rate of susceptible
- COVID-19 infection rate
- Progression rate from Exposed to Infected
- Mortality rate due to COVID-19
- Natural mortality rate
- Vaccination success rate
- Recovery rate from COVID-19
- Vaccination rate
- $N(t)=S(t)+E(t)+I(t)+R(t)+V(t)$

RESULT

SEIRV COVID-19 Dashboard



Click here to try the dashboard

METHODOLOGY

Solve SEIRV Model using *solve_ivp* — python — Build SEIRV dashboard using streamlit

CONCLUSION

SEIRV Model can be solved and simulated using Python

References:
[1] Li, W., et al. (2021). Epidemiology and Infection
[2] Alhamami, H. (2019). ProQuest Dissertations & Theses Global
[3] Tan, J., B., et al. (2020). International Journal of Environmental Research and Public Health

Utilizing an Online Epidemic Calculator for Estimating COVID-19 Growth Parameters in Malaysia

Umi Umairah Binti Mohd Azian & Dr Muhammad Salihi Abdul Hadi

Abstract

Since the COVID-19 pandemic's declaration in March 2020 by the World Health Organization (WHO), Malaysia has become critical as the daily confirmed cases of COVID-19 reach almost 26 thousand around August 2021. This study aims to explain how the Online Epidemic Calculator (Yap & Yong, 2020) works for tracking COVID-19 growth parameters and the methodologies behind it. Three analyses are carried out by including data of COVID-19 cases in Malaysia from early August 2021 until the end of the year: Firstly, the epidemic trend of COVID-19 for Malaysia is estimated by implementing the compartmental SEIR model, with the maximum log-likelihood estimation to calculate the basic reproduction number, R_0 . It showed that the estimated R_0 was allocated around 0.98. Secondly, statistical inference such as the Bayesian method is used to estimate the effective reproduction number, R_t . The result estimated that the median daily R_t of in Malaysia declined from 0.96 (95% CI 0.89–1.00) in early September 2021 to 0.75 (95% CI 0.71–0.89) by the end of the month. Finally, doubling time is measured to evaluate the infection rate in the country. It was found that there is an increase in doubling time from September until mid of December which indicates a slowing of the epidemic and flattening the epidemic curve. The calculator shows that the stringent measures imposed have an immediate effect of rapidly slowing down the spread of the coronavirus. However, the delay in reporting daily confirmed cases and the emergence of COVID-19 variants affect the dynamics of the simulations. Lastly, this study only required simple mathematical models that were used to simulate real-time epidemic situations; hence it is only hoped for interested learners and students.

Abstrak

Sejak pengisytiharan pandemik COVID-19 pada Mac 2020 oleh Pertubuhan Kesihatan Sedunia (WHO), Malaysia menjadi kritikal apabila kes harian COVID-19 yang disahkan mencecah hampir 26 ribu sekitar Ogos 2021. Kajian ini bertujuan untuk menerangkan cara menggunakan Internet Kalkulator Epidemik (Yap & Yong, 2020) untuk menjejak parameter pertumbuhan COVID-19 dan metodologi disebaliknya. Tiga analisis dijalankan dengan menggunakan data kes COVID-19 dari awal Ogos 2021 hingga akhir tahun: Pertama, trend wabak COVID-19 untuk Malaysia dianggarkan dengan melaksanakan model SEIR, dengan log-maksimum untuk mengira nombor pembiakan asas, R_0. Ia menunjukkan bahawa anggaran R_0 adalah sekitar 0.98. Kedua, inferens statistik seperti kaedah Bayesian digunakan untuk menganggarkan nombor pembiakan berkesan, R_t . Hasilnya median harian R_t di Malaysia menurun daripada 0.96 (95% CI 0.89–1.00) pada awal September 2021 kepada 0.75 (95% CI 0.71–0.89) menjelang akhir bulan. Akhir sekali, masa penggandaan diukur untuk menilai kadar jangkitan di negara ini. Didapati terdapat peningkatan masa penggandaan dari September hingga pertengahan Disember yang menunjukkan kadar jangkitan wabak yang perlahan. Kalkulator ini menunjukkan bahawa langkah ketat yang dikenakan mempunyai kesan serta-merta untuk memperlahankan penyebaran coronavirus. Walau bagaimanapun, kelewatan dalam melaporkan kes yang disahkan setiap hari dan kemunculan varian COVID-19 menjejaskan dinamik simulasi. Akhir sekali, kajian ini hanya memerlukan model matematik mudah yang digunakan untuk mensimulasikan situasi wabak masa nyata; justeru ia hanya diharapkan kepada pelajar dan pelajar yang berminat.

Utilizing an Online Epidemic Calculator for Estimating COVID-19 Growth Parameters in Malaysia

COMPUTATIONAL AND THEORETICAL SCIENCES

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1. INTRODUCTION

COVID-19 is a highly contagious virus that first appeared in China at the end of 2019. This study describes the methods used to develop a real-time, data-driven Online Epidemic Calculator (Yap & Yong, 2020) for tracking COVID-19 growth parameters to assist the general public in gaining a deeper understanding of the COVID-19 pandemic and evaluating the effectiveness of social intervention measures. These methods are demonstrated using Malaysia as a case study.

2. PROBLEM STATEMENT

To meet the need for timely, convenient, and accurate, yet easy to understand, risk assessments for COVID-19 epidemics at the national level, we aimed to develop a simple, intuitive coordinate SEIR model using case reporting data. However, the SEIR model is incapable of accurately forecasting the COVID-19 growth parameters on its own, making it difficult to tailor to the facts of the COVID-19 situation in Malaysia.

3. OBJECTIVES

To solve analytical SEIR model and by using the maximum log-likelihood method to estimate basic reproduction number, R_0.

Reference
Yap, F., & Yong, M. (2020). Implementation of An Online COVID-19 Epidemic Calculator for Tracking the Spread of the Coronavirus in Singapore and Other Countries. *Medrxiv.* https://doi.org/10.1101/2020.06.02.20120188

4. METHODOLOGY

R_0 can be estimated by fitting the data on reported infections to a basic SEIR model.

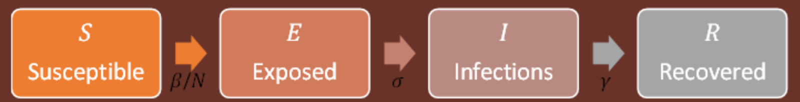

Figure 1. The progression of the SEIR model.

Which can then be represented by a set of ordinary differential equations:

$$\frac{dS}{dt} = -\beta\frac{S}{N}I$$
$$\frac{dE}{dt} = \beta\frac{S}{N}I - \sigma E$$
$$\frac{dI}{dt} = \sigma E - \gamma I$$
$$\frac{dR}{dt} = \gamma I$$

The ODEs of the SEIR model

Symbol	Description	Values
N	Size of population	32776195
$S(t=0)$	Number of susceptible individuals at time, $t=0$	31490716
$E(t=0)$	Number of latent individuals (infected but not infectious) at time, $t=0$	144589
$I(t=0)$	Number of infectious individuals at time, $t=0$	10468
$R(t=0)$	Number of removed or isolated individuals at time, $t=0$	1130422
$1/\sigma$	Mean latent period assuming an exponential distribution	2 days
$1/\gamma$	Mean infectious period assuming an exponential distribution	5 days

Table 1. Initial conditions of the SEIR model.

Given a set of initial conditions, the SEIR model can be calculated. The ODEs is solved numerically in Microsoft Excel by using Forward Euler's method:

$$S_t = -\beta\frac{S_{t-1}}{N}I_{t-1}$$
$$E_t = \beta\frac{S_{t-1}}{N}I_{t-1} - \sigma E_{t-1}$$
$$I_t = \sigma E_{t-1} - \gamma I_{t-1}$$
$$R_t = \gamma I_{t-1}$$

Forward Euler's method

$$\sum_{i=0}^{n-1} -\mu_i + x_i \ln \mu_i$$

The maximum log-likelihood function

Data on the total number of reported cases is then compared with the calculated values R class from the SEIR model. Maximum log-likelihood method is then used to further estimate the model parameters, by choosing the values of $I(t=0)$ and β that would maximise the log-likelihood function using Solver in Excel. Then, $R_0 = \beta/\gamma$ can be obtained.

5. RESULTS

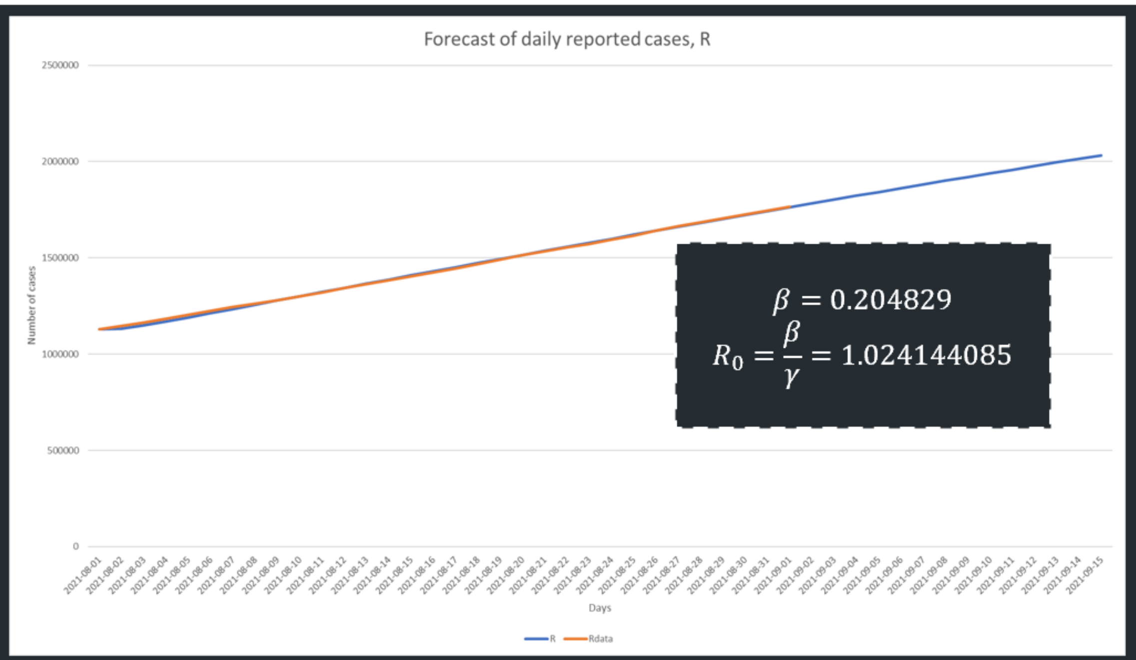

Figure 2. A screenshot from the Excel spreadsheet for forecasting the number of daily reported cases and for estimation of R_0.

6. CONCLUSION

The calculator and the associated graph on the Excel spreadsheet showed that the Movement Control Order, other non-pharmaceutical interventions (NPIs), and the National COVID-19 Vaccination Programme imposed from August 1st until September 1st, 2021, have an immediate effect on the spread of COVID-19. This can be seen that the estimated basic reproduction number, R_0, allocated at 1.0241. It almost coincided with the value of reproduction number reported by the Ministry of Health, which the contagion rate of COVID-19 by September 1st, 2021, for the whole country was 0.99. This also indicated that the infection rate among Malaysian is sustained during that time, thus herd immunity can be achieved by the end of this year. However, the new variant of COVID-19, so called the Omicron variant, is more likely to derive a new COVID-19 wave.

The Behaviour of Standard Map's Discrete Model

Muhammad A'dli Bin Rusli & Dr Wan Nur Fairuz Alwani Wan Rozali

Abstract

Many researchers have done the research about Chrikov-Taylor standard map. However, the studies that they did were in cylinder phase space. Not many people do research of this map in discrete space which we will use this space in our research. Our study focuses on the discrete model to investigate how the discrete points behave. Our objectives of this research are to reduce the 2-dimensional discrete standard map into 1-dimensional map and to investigate the behaviour of the discrete points of the discrete model. We use the Poincaré surface of section, Σ to reduce the 2-dimensional of discrete map to 1-dimensional map. The positive *X*-axis will be our Poincaré surface of section which will be used to investigate in deep of the points on that axis. We classify our map into 2 cases which are case $2\beta < \alpha$ and case $2\beta > \alpha$. Finally, we found that the map is interval-exchange transformation.

Abstrak

Ramai penyelidik telah membuat kajian tentang peta piawai Chrikov-Taylor. Walau bagaimanapun, kajian yang mereka lakukan adalah dalam ruang fasa silinder. Tidak ramai orang yang membuat penyelidikan peta ini dalam ruang diskret yang mana akan digunakan dalam penyelidikan kami. Kajian kami memberi tumpuan kepada model diskret untuk menyiasat bagaimana titik-titk diskret berkelakuan. Objektif kami penyelidikan ini adalah untuk menukar peta piawai diskret 2-dimensi kepada peta 1-dimensi dan untuk menyiasat kelakuan titik-titk diskret model diskret. Kami menggunakan permukaan Poincaré, Σ untuk menukar 2-dimensi peta diskret kepada peta 1-dimensi. Paksi-*X* yang positif akan menjadi permukaan keratan Poincaré kami yang mana akan digunakan untuk menyiasat titik pada paksi itu. Kami mengklasifikasikan peta kami kepada 2 kes iaitu kes $2\beta < \alpha$ dan kes $2\beta > \alpha$. Akhirnya, kami mendapati bahawa peta adalah transformasi pertukaran selang.

TITLE: THE BEHAVIOUR OF THE STANDARD MAP'S DISCRETE MODEL

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COMPUTATIONAL AND THEORETICAL SCIENCES

INTRODUCTION

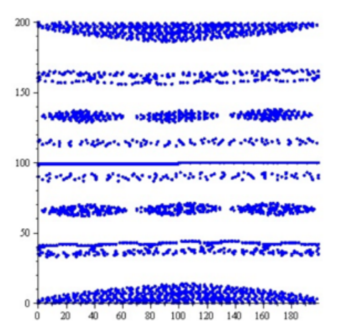
Our project use the standard map in discrete model which derived from a paper of Zhang and Vivaldi (1998) which is given by

$$\Upsilon : (\mathbb{Z}/N\mathbb{Z})^2 \rightarrow (\mathbb{Z}/N\mathbb{Z})^2,$$
$$\begin{cases} y_{t+1} \equiv y_t + \mathcal{V}(x_t) \ (mod\ N) \\ x_{t+1} \equiv x_t + y_{t+1} \ (mod\ N), \end{cases}$$

where the perturbation function V of the discrete map is defined as

$$\mathcal{V}(x) = \begin{cases} +1, & 0 \leq x < \left\lfloor \frac{N}{2} \right\rfloor; \\ -1, & \left\lfloor \frac{N}{2} \right\rfloor \leq x < N. \end{cases}$$

Discrete Model of Standard map



PROBLEM STATEMENT

Not many studies have been made about the standard map in discrete model. So what happens if the phase space is discrete?

RESEARCH QUESTION

- How are the points are bounded in the island chains in discrete model?
- What reasons that make the discrete points bounded in the island chains?

OBJECTIVE

To reduce the 2-Dimensional discrete $\sigma(1) = 2$ map into 1-Dimensional map.

METHODOLOGY

Poincaré Surface of Section:
The Poincaré section is the surface to present the trajectory or dynamics in n-Dimensional phase space in $(n-1)$-Dimensional. In our case, we will be using the intersections of non-negative X-axis which intersect α times as our Poincaré section, Σ. We use Poincaré section, Σ to reduce the 2-Dimensional of discrete map to 1-Dimensional map which can be defined as

$$\Sigma = \{ (X, 0):\ X \geq 0, X \in Z\_+ \}$$

RESULT

In one of the islands of standard map in discrete model, they have defined a local mapping

$$\Upsilon = (\mathbb{Z}/_N\mathbb{Z}^2) \rightarrow (\mathbb{Z}/_N\mathbb{Z}^2)$$

on doubly periodic lattice. The map is given by

$$\phi : \mathbb{Z}^2 \rightarrow \mathbb{Z}^2$$
$$\begin{cases} Y_{s+1} = Y_s - sign(X_s) \\ X_{s+1} = X_s + \alpha Y_{s+1} + \beta \end{cases}$$

$$\alpha \geq 1, \quad 0 \leq \beta < \alpha, \quad \alpha, \beta \in \mathbb{Z}_+$$

where

$$sign(X_s) = \begin{cases} +1, & if\ x \geq 0 \\ -1, & if\ x < 0 \end{cases}$$

By induction, we get to derive these equations where

$$F_+(X) = X + 2u_+\beta - \alpha u_+^2, \quad X \geq 0$$

where

$$u_+ = \lfloor U_+ + 1 \rfloor$$
$$U_+ = \frac{2\beta - \alpha + \sqrt{(2\beta - \alpha)^2 + 8\alpha X}}{2\alpha}$$

and

$$F\_(X) = X + 2u\_\beta + \alpha u\_^2, \quad X < 0$$

where

$$u\_ = \lfloor U\_ \rfloor$$
$$U_+ = \frac{-2\beta - \alpha + \sqrt{(2\beta + \alpha)^2 - 8\alpha X}}{2\alpha}$$

Composition of these two mappings yields

$$F(X) = X' = F\_(F_+) = X + 2\beta(u_+ + u\_) + \alpha(u\_^2 - u_+^2), \quad X \geq 0$$

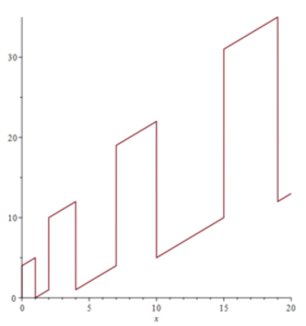
The map $F(X)$ is not well defined for some points of X near the origin.

Theorem 1. If we suitably extend the domain of $F\_$, then F represents the first-return map to non-negative X-axis for all parameters values F, we have that $F(X)$ is an interval-exchange transformation with infinitely many intervals.

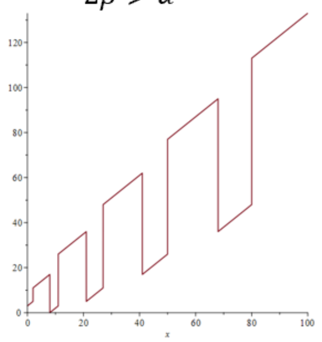
Using Maple Programming, graph of $F(X)$ was plotted for both cases $2\beta < \alpha$ and $2\beta > \alpha$.

Poincare Map

$2\beta < \alpha$



$2\beta > \alpha$



Let Δ_{2m+1} and Δ_{2m+2} be the odd and even-order intervals. Our interval exchange transformation is defined by

- Metric data which is length of intervals: $|\Delta_{2m+1}| = (\alpha - 2\beta)(m+1)$ and $|\Delta_{2m+2}| = \beta(2m+1), m \geq 0$.
- Combinatorial data (permutation of intervals):

For cases $2\beta > \alpha$,

$$\begin{cases} \sigma(1) = 2, & j = 1; \\ \sigma(2j) = 2j + 2, & j \geq 1; \\ \sigma(2j+1) = 2j - 1, & j \geq 1. \end{cases}$$

For cases $2\beta < \alpha$,

$$\begin{cases} \sigma(2j-1) = 2j + 1, & j \geq 1; \\ \sigma(2) = 1, & j = 2; \\ \sigma(2j) = 2j - 2, & j \geq 2. \end{cases}$$

CONCLUSION

The Poincaré map indeed the interval-exchange transformation.

REFERENCE

Alwani, F., & Vivaldi, F. (2018). Nonlinear rotations on a lattice. *Journal of Difference Equations and Applications*, 24(7), 1074–1104.
Zhang, X. S., & Vivaldi, F. (1998). Small perturbations of a discrete twist map. *In Annales de l'IHP Physique théorique* (Vol. 68, No. 4, pp. 507-523).

Exploring the Performance of Parametric Tests With Their Corresponding Nonparametric Tests for One Population and Two or More Populations

Syakirah Binti Mohd Khairul Bahri & Dr Siti Marponga Tolos

Abstract

It is well known that many researchers agreed that nonparametric tests are the alternative test for parametric tests when the parametric assumptions are violated since these tests do not rely on any distributional assumptions. However, some refuted this statement. Therefore, to study more about this topic, this research aims to explore the performance of parametric tests (one-sample and two-sample t-test, one-way ANOVA and Welch's ANOVA) and nonparametric tests (Wilcoxon Sign Rank test, Wilcoxon Rank Sum test and Kruskal Wallis test) in the hypothesis testing for one population, two and more than two populations. These tests are applied under the different conditions in which the normality and variances homogeneity are met and not met. Using R-Studio software, random samples were generated from normal, gamma and uniform distribution under the null hypothesis, at various sample sizes (small, moderate, and large). At $\alpha=0.05$ level of significance, their empirical Type I error rates were calculated. Tests with Type I error rates close to α will be considered as a good test. The results have shown that the parametric tests are robust to the violations of the parametric assumptions. Meanwhile, nonparametric tests are only recommended for small sample sizes and heterogeneous data. These tests also were heavily affected by the skewness of the distribution. To conclude, this research is important in understanding the performance of parametric and nonparametric tests when the parametric assumptions are met or not.

Abstrak

Ramai penyelidik bersetuju bahawa Ujian Bukan Parametrik adalah kaedah alternatif bagi Ujian Parametrik apabila andaian-andaian bagi Ujian Parametrik tidak dapat dipenuhi. Walaubagaimanapun, terdapat sebahagian penyelidik yang tidak bersetuju dengan kenyataan ini. Oleh itu, matlamat kajian ini adalah untuk mengkaji prestasi Ujian Parametrik (one-sample t-test, two-sample t-test, one-way ANOVA dan Welch's ANOVA) dan Ujian Bukan Parametrik (Wilcoxon Sign Rank test, Wilcoxon Rank Sum test dan Kruskal Wallis test) dalam ujian hipotesis bagi satu populasi, dua atau lebih dari dua populasi. Ujian-ujian ini akan diuji dengan beberapa situasi bebeza dimana andaian-andaian Ujian Parametrik akan dipenuhi dan tidak dipenuhi. Menggunakan perisian R-Studio, berdasarkan hipotesis nol, sampel rawak yang terdiri daripada beberapa saiz (kecil, sederhana, besar) akan diambil daripada taburan normal, taburan gamma dan taburan sekata. Pada tahap pengertian $\alpha=0.05$, tahap Kesalahan Jenis I bagi Ujian Parametrik dan Ujian Bukan Parametrik. Ujian yang mempunyai tahap Kesalahan Jenis I yang paling dekat dengan tahap pengertian akan dikategorikan sebagai kaedah yang bagus. Keputusan kajian mendapati bahawa prestasi Ujian Parametrik tidak terjejas walaupun andaian-andaiannya tidak dipenuhi. Sementara itu, Ujian Bukan Parametrik pula hanya disyorkan untuk sampel bersaiz kecil dan mempunyai varians yang sama. Taburan yang tidak simetri dan condong juga memberikan kesan yang buruk kepada prestasi Ujian Bukan Parametrik. Sebagai kesimpulan, kajian ini adalah penting dalam memahami prestasi Ujian Parametrik dan Ujian Bukan Parametrik apabila andaian-andaian parametrik dipenuhi dan tidak dipenuhi.

EXPLORING THE PERFORMANCE OF PARAMETRIC TESTS WITH THEIR CORRESPONDING NONPARAMETRIC TESTS FOR ONE POPULATION AND TWO POPULATIONS

CTS COMPUTATIONAL AND THEORETICAL SCIENCES

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INTRODUCTION

Parametric and nonparametric tests are statistical tests that may be used in hypothesis testing to determine whether the null hypothesis should be rejected or not. Generally, researchers prefer to use parametric tests since the tests are known as powerful tests than nonparametric tests. Parametric tests rely on the assumption of normality and homogeneity of the group variances. However, when the normality does not fit, the nonparametric tests or known as distribution-free tests, are usually employed and considered as the good alternative as they do not rely on normality assumption. Despite that, some of the nonparametric tests require a symmetric population for the test to be significant.

PROBLEM STATEMENT

Although many researchers claimed that the nonparametric tests perform better than the parametric tests when the assumption of normality is violated, there are also researchers that refute this statement. The nonparametric tests may perform worse than its parametric counterpart even for nonnormal distributions. Therefore, this research aims to study the performance of parametric and its corresponding nonparametric tests for one and two populations under certain distributional assumptions, especially under the case of nonnormal and heterogeneity of variance.

RESEARCH QUESTION

When testing the measure of central tendency for one population and two populations, which test should be used especially when the assumption of normality and homogeneity of variance are violated? In what circumstances does one test outperform the other?

OBJECTIVES

This research will study the performance of the following tests when the assumptions are violated and not violated

i. One sample t-test (parametric test) and Wilcoxon Sign Rank test (nonparametric test) for one population test

ii. Two-sample t-test (parametric test) and Wilcoxon rank-sum test (nonparametric test) for two populations test

METHODOLOGY

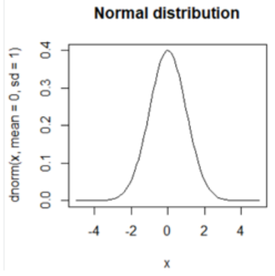
The simulation process in this research is performed using R software. At set.seed(100), the data are generated using the random function in R, for all simulation conditions including normal/non-normal distributions, and homogeneity/heterogeneity of variance and repeated 5000 times for each condition. For each repetition, the parametric test and its corresponding nonparametric test are assessed by calculating the observed p-value and the rejection rates. Throughout the repetition, the number of p-values that less than 0.05 will be divided by 5000 to get the rejection rates. At the significance level α=0.05, as the null hypothesis of equal means is true, the rejection rate of the null hypothesis will be considered as the empirical Type I error rate for the test. Hence, the test with the empirical Type I error rate closest to or less than α=0.05 is considered a good test.

RESULT

Tables below show the rejection rate for normal/nonnormal distributions, equal/unequal variance for one population and two populations.

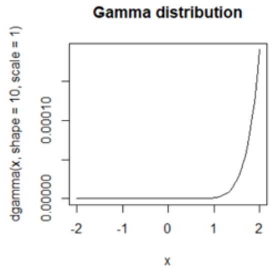
ONE POPULATION TEST

Normal distribution $(\mu = 0, \sigma = 1)$



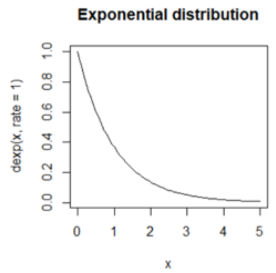
Sample size (n)	One sample t-test	Wilcoxon Sign rank test
10	0.053	0.051
20	0.051	0.050
30	0.055	0.054
40	0.051	0.052
50	0.052	0.050
100	0.049	0.051
200	0.049	0.050
300	0.047	0.049

Gamma distribution, $\alpha = 10,\ \beta = 1, (\mu = 10, \sigma = 10)$



Sample size (n)	One sample t-test	Wilcoxon Sign rank test
10	0.054	0.052
20	0.055	0.060
30	0.057	0.067
40	0.056	0.069
50	0.053	0.068
100	0.048	0.083
200	0.049	0.115
300	0.043	0.143

Exponential distribution, $\lambda = 1\ (\mu = 1, \sigma = 1)$

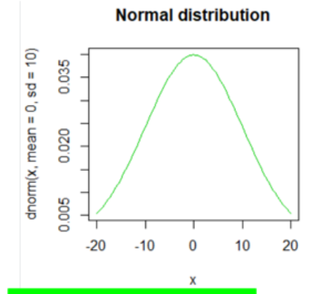


Sample size (n)	One sample t-test	Wilcoxon Sign Rank test
10	0.104	0.095
20	0.086	0.135
30	0.082	0.169
40	0.072	0.203
50	0.062	0.224
100	0.056	0.389
200	0.052	0.634
300	0.054	0.807

The Type I error rates obtained from the normal distribution are close to 0.05 for both tests and all sample sizes. For nonnormal distributions, the t-test perform better than the Wilcoxon test as the Type I error rates are closer to 0.05 and smaller than the Wilcoxon test, especially for the large sample sizes. Meanwhile, the Type I error rates of the Wilcoxon distributions are all greater than 0.05 and increased as the sample sizes increased because of the skewness of the distributions.

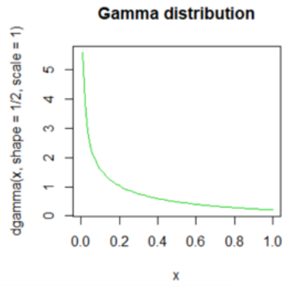
TWO POPULATION TEST (EQUAL VARIANCE)

Normal distribution $(\mu_1 = \mu_2 = 0, \sigma_1 = \sigma_2 = 10)$



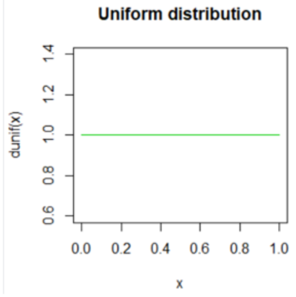
Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.050	0.039
6,6	0.053	0.043
9,27	0.049	0.046
18,18	0.049	0.045
27,81	0.052	0.047
54,54	0.049	0.046
100,200	0.050	0.049
300,300	0.044	0.047

Gamma distribution, $\alpha_1 = \alpha_2 = 1/2,\ \beta_1 = \beta_2 = 1,$ $(\mu_1 = \mu_2 = \frac{1}{2}, \sigma_1 = \sigma_2 = \frac{1}{2})$



Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.040	0.032
6,6	0.029	0.038
9,27	0.048	0.052
18,18	0.045	0.044
27,81	0.042	0.044
54,54	0.047	0.049
100,200	0.048	0.052
300,300	0.047	0.043

Uniform distribution, $a_1 = a_2 = 0,\ b_1 = b_2 = 1,$ $(\mu_1 = \mu_2 = 1/2, \sigma_1 = \sigma_2 = 1/12)$

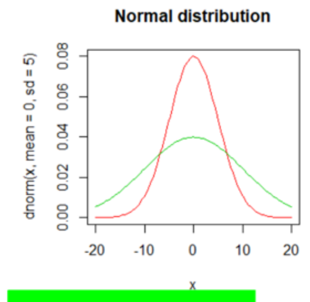


Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.048	0.034
6,6	0.058	0.046
9,27	0.053	0.050
18,18	0.049	0.047
27,81	0.049	0.047
54,54	0.049	0.048
100,200	0.050	0.050
300,300	0.048	0.048

Unlike the one population tests, the rejection rates calculated for two populations with equal variance are close to 0.05 and relatively consistent across the sample sizes and tests for the normal and nonnormal distributions hence no test is outperformed in rejection rate for all distributions.

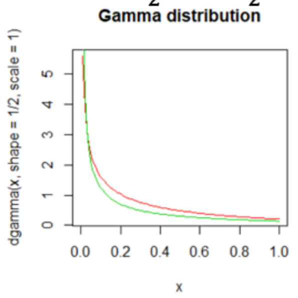
TWO POPULATION TEST (UNEQUAL VARIANCE)

Normal distribution $(\mu_1 = \mu_2 = 0, \sigma_1 = 10, \sigma_2 = 5)$



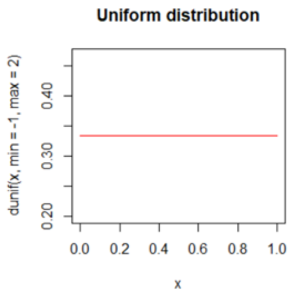
Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.073	0.096
6,6	0.054	0.050
9,27	0.054	0.097
18,18	0.048	0.051
27,81	0.050	0.093
54,54	0.053	0.056
100,200	0.045	0.083
300,300	0.046	0.057

Gamma distribution, $\alpha_1 = \frac{1}{2}, \alpha_2 = \frac{1}{4},\ \beta_1 = 1, \beta_2 = 2,$ $(\mu_1 = \mu_2 = \frac{1}{2}, \sigma_1 = \frac{1}{2}, \sigma_2 = 1)$



Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.027	0.034
6,6	0.026	0.076
9,27	0.050	0.115
18,18	0.057	0.177
27,81	0.052	0.345
54,54	0.061	0.454
100,200	0.044	0.839
300,300	0.053	0.991

Uniform distribution, $a_1 = 0, a_2 = -1,\ b_1 = 1, b_2 = 2,$ $(\mu_1 = \mu_2 = \frac{1}{2}, \sigma_1 = \frac{1}{12}, \sigma_2 = \frac{9}{12})$



Sample size (n1,n2)	Two sample t-test	Wilcoxon rank sum test
3,9	0.048	0.007
6,6	0.066	0.053
9,27	0.055	0.017
18,18	0.048	0.067
27,81	0.049	0.016
54,54	0.052	0.074
100,200	0.050	0.033
300,300	0.051	0.077

The two sample t-test performs better than the Wilcoxon test for all distributions. From the normal distributions, the rejection rates of the Wilcoxon test are worse under the unequal sample sizes. Meanwhile, the rejection rate of the Wilcoxon test from gamma distributions increased as the sample sizes increased. However, the test performs the best under the uniform distribution especially for unequal sample sizes.

CONCLUSION

The one sample t-test and two sample t-test (parametric tests) perform well for all conditions although the distributions are not normally distributed and have unequal variance. Hence, it can be concluded that the performance of the parametric tests is not affected given that the assumptions are satisfied or not.

On contrary, the rejection rates of the Wilcoxon test (nonparametric tests) were distorted larger than the t-test (parametric tests) particularly for the skewed distributions and unequal variance. In addition, the test also do not give better alternative for parametric tests even under the nonnormal distributions. Despite that, it can maintain the rejection rates close to the significance level under flat distribution and equal variance. Certainly, before employing any tests for hypothesis testing, the condition of the distributions should be taken into consideration because different tests may lead to different results.

REFERENCES

Amandeep, & Robin. (2015). Comparative Analysis of Parametric and Non-Parametric Tests. *Journal of Computer and Mathematical Sciences*, *6*(6), 336–342. www.compmath-journal.org

Imam, A., Mohammed, U., & Moses Abanyam, C. (2014). On Consistency and Limitation of paired t-test, Sign and Wilcoxon Sign Rank Test. *IOSR Journal of Mathematics*, *10*(1), 01–06. https://doi.org/10.9790/5728-10140106

Michael, R. (1988). Choosing between Parametric and Nonparametric Tests. *Journal of Counseling and Development*, *67*(1), 35.

Zimmerman, D. W. (1998). Invalidation of parametric and nonparametric statistical tests by concurrent violation of two assumptions. *Journal of Experimental Education*, *67*(1), 55–68. https://doi.org/10.1080/00220979809598344

Analysis of Greek Letters During a Pandemic Crisis Using Dow Jones Industrial Average (DJIA) Index Options – The Industrial Sector

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Abstract

Option is a financial derivative where a contract is sold by one party or option writer to another party or the option holder. By entering this contract, the buyer has the right, but not the obligation, to buy if call option or sell if put option the underlying asset at an agreed-upon strike price in certain duration or on a specific exercise date. Options are well-known derivatives in an exchange market. Involvement in option trading helps the investors to minimize their risk in an investment. The objective of this study focuses on analysing the DJIA index option pricing and its sensitivities towards the changes in the factors that influence option prices which are stock prices, time to maturity, interest rate, volatility, and strike price. Apart from that, this study also establishes another knowledge of the Greeks under the BSM model framework in determining the stock prices in future. The data collected from three different companies in the industrial sector which are The Boeing Company, 3M Company and Honeywell International. The Greek Letters used are Delta, Gamma, Theta, Vega, and Rho. Three-months treasury bills are used for each trading day to obtain the results. The results show that the BSM model and Greek letters are one of the best alternatives for option prices and measuring the sensitivity of option prices to certain basic parameters.

Abstrak

Opsyen ialah derivatif kewangan di mana kontrak dijual oleh satu pihak atau penulis opsyen kepada pihak lain atau pemegang opsyen. Dengan memasuki kontrak ini, pembeli mempunyai hak, tetapi bukan kewajipan, untuk membeli jika opsyen beli atau menjual jika opsyen jual aset asas pada harga mogok yang dipersetujui dalam tempoh tertentu atau pada tarikh pelaksanaan tertentu. Opsyen ialah derivatif yang terkenal dalam pasaran pertukaran. Penglibatan dalam perdagangan opsyen membantu pelabur meminimumkan risiko mereka dalam sesuatu pelaburan. Objektif kajian ini tertumpu kepada menganalisis harga opsyen indeks DJIA dan sensitivitinya terhadap perubahan faktor yang mempengaruhi harga opsyen iaitu harga saham, masa hingga matang, kadar faedah, turun naik, dan harga mogok. Selain itu, kajian ini juga mewujudkan satu lagi pengetahuan orang Greek di bawah kerangka model BSM dalam menentukan harga saham pada masa hadapan. Data yang dikumpul daripada tiga syarikat berbeza dalam sektor perindustrian iaitu Syarikat Boeing, Syarikat 3M dan Honeywell International. Huruf Yunani yang digunakan ialah Delta, Gamma, Theta, Vega, dan Rho. Bil perbendaharaan tiga bulan digunakan untuk setiap hari dagangan untuk mendapatkan keputusan. Keputusan menunjukkan bahawa model BSM dan huruf Greek adalah salah satu alternatif terbaik untuk harga opsyen dan mengukur sensitiviti harga opsyen kepada parameter asas tertentu.

COMPUTATIONAL AND THEORETICAL SCIENCES

TITLE: ANALYSIS OF GREEK LETTERS DURING A PANDEMIC CRISIS USING DOW JONES INDUSTRIAL AVERAGE (DJIA) INDEX

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INTRODUCTION

1.Option - Call and Put
▪A contract where the holder of an option has the right, but not an obligation to buy (for call) or sell (for put) an underlying asset at an agreed price (strike price) on a specified date.
2.Black-Scholes model
▪Black-Scholes is a pricing model used to determine the fair price or theoretical value for a call or a put option based on six variables such as volatility, type of option, underlying stock price, time, strike price, and risk-free rate.
3.Greek Letters
▪Measures the sensitivities of an option price with respect to the change in the value of a given underlying parameter.

PROBLEM STATEMENT

DJIA index option pricing and its sensitivities will give an effects towards the changes in the factors that influence stock prices.

RESEARCH QUESTION

How the changes in the value of the Greek letters affecting the option pricing

How the Greek letters affect the stock prices in the future.

OBJECTIVE

▪GENERAL OBJECTIVE
-To analyze the DJIA index option pricing and its sensitivities towards the changes in the factors that influence stock prices.

▪SPECIFIC OBJECTIVES
-To observe the changes in the value of the Greek letters affecting the option pricing
-To examine how the Greek letters affect the stock prices in the future.

METHODOLOGY

GREEK LETTERS

▪Each Greek letter measures a different dimension to the risk in an option position and the aim of a trader is to manage the Greeks so that all risks are acceptable.

1. DELTA Δ

- Delta of an option, Δ is defined as the rate of change of the option price with respect to the price of the underlying asset.
- It is the slope of the curve that relates the option price to the underlying asset price.
- Formula : D = e - q tN(d1)

2. GAMMA G

- Gamma represents the rate of change in delta or second derivative of option price with respect to underlying stock price.
- Risk for option writers of a sudden change in delta means drastic changes in the amount of stock required to hedge the options they have sold.
- G = 1/((Sttsσ√τ))N'(d1)

3. THETA Θ

- Theta decay of the option's value as time passes.
- θ = (Stss)/(2 √ t)·N^'(d"1")-rX ·"e - rt" N(d"1")

4. VEGA N

- Monetary risk measure of the impact that a change in the implied volatility will have on an option's value.
- v= St√t · N'(d"1")

5. RHO Ρ

- Measures the sensitivity of the option price to changes in the risk-free interest rate.
- ρ=Xτ·e"- rt" N'(d"2")

RESULT 1

Time (Year)	0.01984127	0.03968254	0.099206349	0.119047619	0.178571429
Interest Rate	0.0433	0.0433	0.0433	0.0433	0.0433
Cont. Int. Rate	0.042388766	0.042388766	0.042388766	0.042388766	0.042388766
Implied Volatility	0.218481541	0.361523151	0.153064251	0.149997234	0.14831686
Delta	0.0542	0.0821	0.07728	0.05299	0.06214

From table above, it is observed that the Honeywell International Inc. (HONS) call options provide the positive Delta values.These Deltas show the options is are slightly for in-the-money option since the values are above 0.5. This means for any increment of $1 of stock price, the options price might move around these range this range of values.

CONCLUSION

As the price of the options is also affected by the demand factors and the operation of the company itself, there will always exist the risks when dealing with it. Several factors like volatility which are stochastics put the investors in cautious behavior to always make strategy and stay alert for any changes in market that may affect their investments.

REFERENCES

C. Rajanikanth, & E. Lokanadha Reddy. (2015). Analysis of price using Black Scholes and Greek letters in derivative European option market. International Journal of Research in Management, Science & Technology, 3(1), 34-37. Retrieved on November 4, 2017, from www.ijrmst.org.

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