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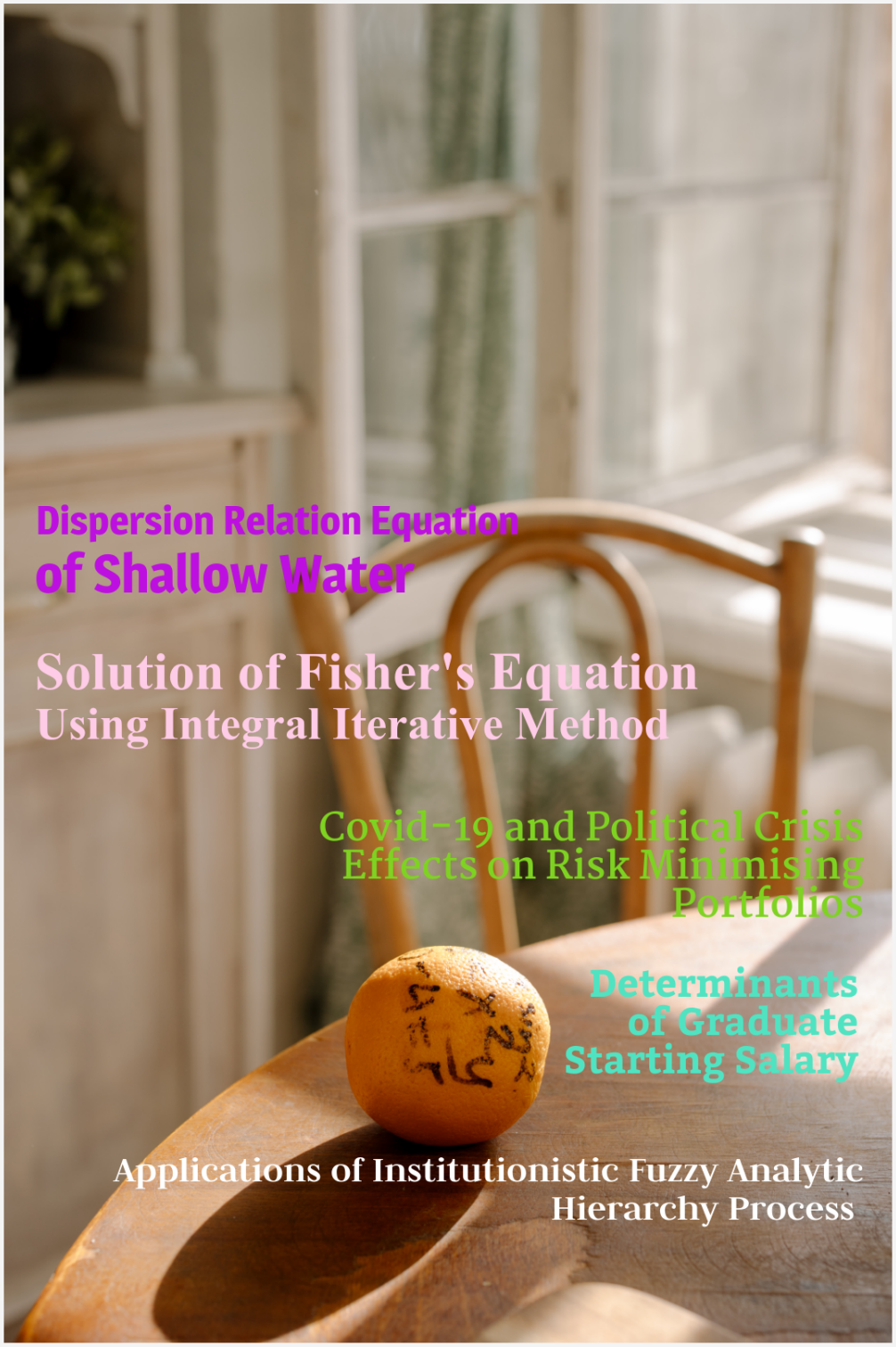

MATHEMATICS
IN APPLIED RESEARCH

BULETIN RASMI
KOLEJ PENGAJIAN PENGKOMPUTERAN, INFORMATIK, DAN MEDIA, UITM CAWANGAN NEGERI SEMBILAN KAMPUS SEREMBAN
EDISI NOVEMBER 2022

PENAFIAN:

Sebarang maklumat yang terkandung dalam majalah ini merupakan pengetahuan dan pendapat peribadi penulis artikel. Pembaca dinasihatkan untuk mendapatkan pandangan profesional sebelum mengikuti mana-mana maklumat dalam majalah ini. Pihak universiti, penerbit, dan sidang redaksi tidak akan bertanggungjawab dan menanggung sebarang risiko atas kerugian secara langsung atau tidak langsung atas maklumat yang dipaparkan.

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Majalah ini diterbitkan dua kali setahun

ALUAN KETUA EDITOR

Al-Hamdulillah bersyukur kita ke hadrat Allah swt, dengan penerbitan edisi ketiga makalah Mathematics in Applied Research terbitan Kolej Pengajian Pengkomputeran, Informatik, dan Media UiTM kampus Seremban. Penerbitan ini merupakan satu usaha untuk menonjolkan hasil penyelidikan pelajar bersama pensyarah dalam Projek Tahun Akhir program ijazah sarjana muda di KPPIM Seremban.

Semenjak tahun 2014, mahasiswa tahun akhir KPPIM (sebelumnya dikenali FSKM) Seremban telah menghasilkan banyak penyelidikan yang berpotensi untuk diketengahkan dalam dunia akademik. Akan tetapi tidak banyak yang berjaya diterbitkan dalam jurnal atau pun prosiding konferensi akademik kerana halangan tertentu seperti kualiti penyelidikan dan penulisan ilmiah. Oleh itu, penerbitan makalah ini diharapkan dapat menambahkan lagi ruang bagi penerbitan hasil penyelidikan warga KPPIM Seremban

Disamping itu, pihak KPPIM Seremban mengharapkan makalah ini akan menjadi rujukan dan pemangkin kepada usaha menghasilkan penyelidikan Projek Tahun Akhir yang lebih bermutu tinggi. Makalah ini juga adalah batu asas kepada perkongsian penyelidikan terkini daripada pelajar dan pensyarah KPPIM Seremban.

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- Profesor Madya Dr. Nur Azlina Abd Aziz
- Dr. Nor Azni Shahari

semoga kecemerlangan perkhidmatan yang ditunjukkan oleh kedua editor-editor ini akan menjadi pendorong kepada editorial board yang seterusnya.

Sekian. Terima kasih.

SIDANG REDAKSI

Thank You!

for being with us,

Dr. Nor Azni Shahari
Editor

MiAR 2021, 2022

Dr. Nur Azlina
Editor

MiAR 2021, 2022

for all the dedications and

Happy Retirement

From:
MiAR, Editorial Board

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Contents

KMV MODEL IN PREDICTING SOVEREIGN DEBT DEFAULT

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Keywords: Sovereign Debt, Default Risk, KMV Model

1. Introduction

Extensive research recognized that Greece is one of the countries that faced sovereign debt default due to its bankruptcy in 2009 (Arghyrou & Tsoukalas, 2011). The failure of a government to manage well its sovereign debt in the earlier stage can harm a country. According to the Ministry of Finance Malaysia (2018), Malaysia's sovereign real debt and liabilities amounted to RM1,065 billion by the end of June 2018, almost RM350 billion higher than the officially approved estimation of the previous government. This led to many concerns about the country's financial position. KMV model is one of the successful default models initiated to give an early precaution on default risk. However, the application of the KMV model is primarily focusing on the default risk of firms. Therefore, this study attempts to adapt the KMV model to the case of predicting the default risk of sovereign debt. Samples of data from Malaysia and Greece from 2007 to 2016 are utilized to predict the probability of default (PD) in one-year advance and at once to test the model's ability.

2. Restructuring the KMV Model

The KMV model is restructured to predict the default risk of sovereign debts. Here, default risk is defined as the probability that the value of the sovereign's asset falls below the value of the sovereign liability, and this is expressed as:

$$P_t = \Pr\left[V_t \le L \middle| V_0 = V_t\right] \tag{1}$$

where P_t is the probability of default (PD) at any time t, V_t is the total value of the sovereign asset at time t, V_0 is the initial total value of the sovereign asset, and L is the total value of sovereign liabilities (Crosbie & Bohn,2003).

According to Merton (1974), the asset behaved as a log-normal random walk function that follows the Geometric Brownian Motion as below:

$$dV_t = \mu V_t\, dt + \sigma\, dV_t dW_t \tag{2}$$

where dV_t is the asset changes, μ is the drift rate, σ is volatility, and dW_t is the Wiener process that describes the randomness of asset return. By using the Ito lemma's process, V at any time t is defined as:

$$V_t = V_0\, e^{\left(\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t\right)} \tag{3}$$

Therefore Eq. (1) is expressed as

$$P_t = \Pr\left[V_t e^{\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t} \leq L \right] \tag{4}$$

Rearranging Eq. (4) until it becomes

$$P_t = \Pr\left[W_t \leq -\left(\frac{\ln\left(\frac{V_t}{L}\right) + \left(\mu - \frac{1}{2}\sigma^2\right)t}{\sigma\sqrt{t}} \right) \right] \tag{5}$$

Let

$$\frac{\ln\left(\frac{V_t}{L}\right) + \left(\mu - \frac{1}{2}\sigma^2\right)t}{\sigma\sqrt{t}} = d \tag{6}$$

where d is the distance to default (DD). Since P_t can be written as a standard normal cumulative distribution function of d (Merton, 1974), thus Eq. (1) is rewritten as

$$P_t = \Pr\left[W_t \leq -d\right] = N\left(-d\right) = \int_{-\infty}^{-d} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}z^2}\, dz \tag{7}$$

According to Zieliński (2013), the PD for any time t is related to DD. The larger the DD, the smaller the PD, which means the less likely the entity will default.

3. Data Descriptive

Samples of monthly data from Malaysia and Greece are obtained from the websites of Bank Negara Malaysia (BNM) and the National Bank of Greece from 2007 until 2016. The data obtained are described in Tables 1 and 2.

Table 1: The components of Malaysia data

Asset	Liability
• Gold and Foreign Exchange and Other Reserves including SDR • Malaysian Government Paper • Deposits with Financial Institutions • Loans and Advances • Land and Buildings • Other Assets	• Currency in Circulation • Deposits by: Financial Institutions, Federal Government and Others • Bank Negara Papers • Allocation of Special Drawing Rights • Other Liabilities

Table 2: The components of Greece data

Asset	Liability
• Gold and gold receivables	• Bank notes in circulation
• Claims on non-euro area residents dominated in foreign currency	• Liabilities to euro area credit institutions related to monetary policy operations denominated in euro
• Claims on euro area residents dominated in foreign currency	• Other liabilities to euro credit institutions denominated in euro
• Claims on non-euro area residents dominated in euro	• Liabilities to other euro area residents denominated in euro
• Lending to euro area credit institutions related to monetary policy operations denominated in euro	• Liabilities to non-euro area residents denominated in euro
• Other claims on euro area credit institutions denominated in euro	• Liabilities to euro area residents denominated in foreign currency
• Securities of euro area residents denominated in euro	• Liabilities to non-euro area residents denominated in foreign currency
• General government long-term debt denominated in euro	• Counterpart of special drawing rights allocated by the IMF

4. Results

The PD of Malaysia and Greece are predicted for 2008 to 2017. The PD and the primary inputs to predict the PD are presented in Table 3 and Table 4.

Table 3: The drift rate, volatility, DD, and PD for Malaysia from 2008 to 2017

Year	Drift Rate	Volatility	Distance to Default (DD)	Probability of Default (PD)
2008	0.6424	0.709886	0.6639	0.2533861
2009	0.6861	0.082565	9.6385	2.75E-22
2010	0.6929	0.032801	25.3276	7.93E-142
2011	0.6959	0.039431	18.6229	1.047E-77
2012	0.7031	0.066579	11.6315	1.425E-31
2013	0.6926	0.011698	63.6269	0
2014	0.6931	0.023154	35.1434	7.32E-271
2015	0.6897	0.018586	44.1883	0
2016	0.6944	0.082196	13.1461	8.96E-40
2017	0.6908	0.034422	30.0277	2.14E-198

Table 4: The drift rate, volatility, DD, and PD for Greece from 2008 to 2017

Year	Drift Rate	Volatility	Distance to Default (DD)	Probability of Default (PD)
2008	0.6309	0.6951	0.6629	0.2537095
2009	0.7183	0.1275	5.9842	1.087E-09
2010	0.7044	0.1179	6.3382	1.162E-10
2011	0.7183	0.0969	7.7956	3.205E-15
2012	0.7040	0.0719	10.4021	1.212E-25
2013	0.6931	0.1320	5.6274	9.15E-09
2014	0.6727	0.0669	11.5022	6.433E-31
2015	0.6865	0.0705	11.4116	1.83E-30
2016	0.7230	0.2098	3.6570	0.0001276
2017	0.6857	0.0266	29.0706	4.22E-186

Table 3 and Table 4 show the drift rate, volatility, DD, and PD for Malaysia and Greece from 2008 to 2017. The PD is predicted between the range 0 (lowest PD) to 1 (highest PD). Based on Tables 3 and 4, Figure 1 is presented.

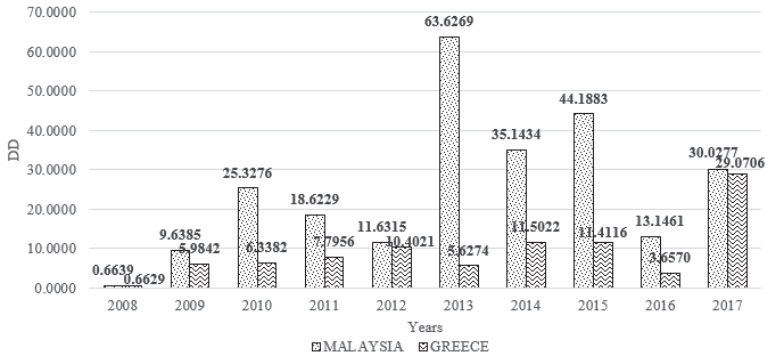

Figure 1: The comparison of DD of Malaysia and Greece

Figure 1 presents the comparison of DD of Malaysia and Greece. Overall, the DD of Malaysia is found to be greater than the DD of Greece. This means the possibility of Malaysia defaulting on its sovereign debt is lower than Greece.

6. Conclusion

Adapting the KMV model to the case of sovereign debt default gets this paper to the two main results. Firstly, the overall default risk of Malaysia is found to be lower than the default risk of Greece. Secondly, PD is predicted to be low every year for both countries except in 2008; the default risk for both countries is 25% which is the highest compared to the other selected years. This is parallel to the fact that the world financial crisis occurred during the years of 2007 to 2009 (Nastase et. al, 2010). All of these imply that the KMV model could predict the default risk of sovereign debt during normal and financial crisis conditions in one-year advance. In addition, the information contained in the KMV model on default risk is useful and valuable to be used in many cases, such as sovereign debt.

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