BASS DIFFUSION AND GREY MODELS TO FORECAST NEW TOURISM PRODUCT: A CASE STUDY OF TANAH AINA RESORT IN MALAYSIA

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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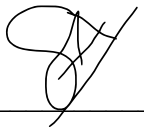
I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



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ABSTRAK

Ramalan permintaan pelancongan telah menerima perhatian daripada pihak penyelidik kerana industri pelancongan melibatkan pelaburan yang besar dan memberikan pulangan yang tinggi kepada sebuah organisasi dan kepada negara. Pelbagai kajian ramalan permintaan pelancongan yang telah diterbitkan, namun kurang tumpuan diberikan kepada ramalan permintaan produk pelancongan baru. Kajian ini memfokuskan kepada aplikasi model resapan Bass dan model ramalan grey Bass kepada ramalan permintaan produk pelancongan baru. Model resapan Bass adalah model yang berpengaruh dalam kalangan penyelidik untuk ramalan permintaan produk baru dan model ramalan grey terkenal dengan kebolehan mengendalikan sekurang-kurangnya empat data. Kombinasi kedua-dua model, model ramalan grey Bass digunakan untuk pertama kali dalam aplikasi ramalan permintaan produk pelancongan baru di Malaysia. Produk pelancongan baru yang dikaji adalah dua pusat peranginan ekopelancongan; Tanah Aina Fahad dan Tanah Aina Farrah Soraya. Data bulanan daripada Tanah Aina Fahad dan Tanah Aina Farrah Soraya telah dikumpulkan dari 2014 hingga 2018 dan ditukarkan kepada data tahunan untuk anggaran potensi pasaran. Tiga parameter yang terlibat dalam model-model berkaitan terdiri daripada potensi pasaran, m, koefisien inovasi, p, dan koefisien peneladanan, q. Kaedah anggaran parameter dan nilai potensi pasaran yang berbeza telah digunakan. Kajian ini mendapati model ramalan grey Bass mempunyai prestasi yang lebih baik berbanding model resapan Bass untuk set data Tanah Aina Fahad berdasarkan penilaian ramalan menggunakan purata peratusan ralat mutlak. Selain itu, untuk Tanah Aina Farrah Soraya, model resapan Bass menunjukkan prestasi yang lebih baik berbanding model ramalan grey Bass tetapi nilai parameter potensi pasaran, m memberikan kesan signifikan kepada prestasi ramalan. Kajian akan datang boleh ditambah baik dengan menggunakan kaedah anggaran parameter berlainan serta nilai p dan q untuk mendapatkan ramalan terbaik.

ABSTRACT

Tourism demand forecasting has been acknowledged by researchers as tourism industry involves a large investment and gives a high return to the organisations and to the countries. Among various tourism demand researches that have been published, yet little attention that focus on the new tourism product forecasting. This study focuses on the application of Bass diffusion model (BDM) and grey Bass forecasting model to the new tourism product demand forecasting. Bass diffusion model is an influential model among researchers in forecasting the new product and grey forecasting model is popular because of its ability to handle as low as four data. The combination of these two models, called grey Bass forecasting model is used for the first time in the application of forecasting the new tourism product demand in Malaysia. The new tourism products studied are ecotourism resorts; Tanah Aina Fahad and Tanah Aina Farrah Soraya. Monthly data from Tanah Aina Fahad and Tanah Aina Farrah Soraya are collected from 2014 until 2018 and are converted to yearly data for the estimation of potential market. There are three parameters involved in both models namely; potential market, m, coefficient of innovation, p and coefficient of imitation, q. Parameters estimation method and different value of potential market are employed. The study finds that the grey Bass forecasting model has a better performance compared to the basic BDM for Tanah Aina Fahad dataset based on the evaluation of forecast using mean absolute percentage error. Besides, for Tanah Aina Farrah Soraya, BDM shows a better performance than grey Bass forecasting model but the value of m gives a significant effect in the forecasting performance. Future research can be improved by using other methods in the estimation of parameters and applying the best values of p and q to achieve the best forecast.

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REFERENCES

Abu, N., & Ismail, Z. (2013). An improved parameter estimation of Bass model for forecasting new car demand. In *Prosiding seminar kebangsaan aplikasi sains dan matematik* (pp. 209–220).

Abu, N., & Ismail, Z. (2015). Forecasting sales of new vehicle with limited data using Bass diffusion model and grey theory. In *Aip conference proceedings* (pp. 467–475). https://doi.org/10.1063/1.4907482

Abu, N., & Ismail, Z. (2018). Forecasting sales demand of new proton car using Bass diffusion model. *Far East Journal of Mathematical Sciences (FJMS)*, *105*(1), 79–94. https://doi.org/10.17654/ms105010079

Athiyaman, A., & Robertson, R. W. (1992). Time series forecasting techniques: short-term planning in tourism. *International Journal of Contemporary Hospitality Management*, *4*(4), 8–11. https://doi.org/10.1108/09596119210018864

Bass, F. M. (1969). A new product growth for model consumer durables. *Management Science*, *15*(5), 215–227.

Bass, F. M. (2004). Comments on "A new product growth for model consumer durables". *Management Science*, *50*(12 SUPPL.), 1833–1840. https://doi.org/10.1287/mnsc.1040.0300

Brentan, B. M., Luvizotto, E., Herrera, M., Izquierdo, J., & Pérez-García, R. (2017). Hybrid regression model for near real-time urban water demand forecasting. *Journal of Computational and Applied Mathematics*, *309*, 532–541. https://doi.org/10.1016/j.cam.2016.02.009

Cao, Q., Leggio, K. B., & Schniederjans, M. J. (2005). A comparison between Fama and French's model and artificial neural networks in predicting the Chinese stock market. *Computers and Operations Research*, *32*(10), 2499–2512. https://doi.org/10.1016/j.cor.2004.03.015

Crawford, M., & Benedetto, A. D. (2010). *New products management* (10th ed.). New York: Mc-Graw Hill.

Dang H, H. S., Nguyen, T. M. T., Wang, C. N., Day, J. D., & Dang T, T. M. H. (2020). Grey system theory in the study of medical tourism industry and its economic impact. *International Journal of Environmental Research and Public Health*, *17*(3). https://doi.org/10.3390/ijerph17030961

Ding, S., Hipel, K. W., & Dang, Y.-g. (2018). Forecasting China's electricity consumption using a new grey prediction model. *Energy*, *149*, 314–328. https://doi.org/10.1016/j.energy.2018.01.169

Dunn, A. G., Braithwaite, J., Gallego, B., Day, R. O., Runciman, W., & Coiera, E. (2012). Nation-scale adoption of new medicines by doctors: An application of the Bass diffusion model. *BMC Health Services Research*, *12*(1), 248–257.

https://doi.org/10.1186/1472-6963-12-248

Ene, S., & Öztürk, N. (2017). Grey modelling based forecasting system for return flow of end-of-life vehicles. *Technological Forecasting and Social Change*, *115*, 155–166. https://doi.org/10.1016/j.techfore.2016.09.030

González Perea, R., Camacho Poyato, E., Montesinos, P., & Rodríguez Díaz, J. A. (2019). Optimisation of water demand forecasting by artificial intelligence with short data sets. *Biosystems Engineering*, *177*, 59–66. https://doi.org/10.1016/j.biosystemseng.2018.03.011

Grasman, J., & Kornelis, M. (2019). Forecasting product sales with a stochastic Bass model. *Journal of Mathematics in Industry*, *9*(1). https://doi.org/10.1186/s13362-019-0059-6

Gunter, U., & Önder, I. (2015). Forecasting international city tourism demand for Paris: Accuracy of uni- and multivariate models employing monthly data. *Tourism Management*, *46*, 123–135. https://doi.org/10.1016/j.tourman.2014.06.017

Hsiao, J. P. H., Jaw, C., & Huan, T. C. (2009). Information diffusion and new product consumption: A Bass model application to tourism facility management. *Journal of Business Research*, *62*(7), 690–697. https://doi.org/10.1016/j.jbusres.2008.08.002

Hyndman, R. J., & Athanasopoulos, G. (2018). *Forecasting: Principles and practice* (2nd ed.). Lexington: OTexts.

Hyndman, R. J., & Koehler, A. B. (2006). Another look at measures of forecast accuracy. *International Journal of Forecasting*, *22*(4), 679–688. https://doi.org/10.1016/j.ijforecast.2006.03.001

Intharathirat, R., Abdul Salam, P., Kumar, S., & Untong, A. (2015). Forecasting of municipal solid waste quantity in a developing country using multivariate grey models. *Waste Management*, *39*, 3–14. https://doi.org/10.1016/j.wasman.2015.01.026

Islam, T. (2014). Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. *Energy Policy*, *65*, 340–350. https://doi.org/10.1016/j.enpol.2013.10.004

Ismail, Z., & Abu, N. (2013). A study on new product demand forecasting based on Bass diffusion model. *Journal of Mathematics and Statistics*, *9*(2), 84–90. https://doi.org/10.3844/jmssp.2013.84.90

Ismail, Z., Abu, N., & Sufahani, S. (2016). New product forecasting with limited or no data. In *Aip conference proceedings.* https://doi.org/10.1063/1.4966099

Jaafar, M., & Maideen, S. A. (2012). Ecotourism-related products and activities, and the economic sustainability of small and medium island chalets. *Tourism Management*, *33*(3), 683–691. https://doi.org/10.1016/j.tourman.2011.07.011

Jha, P. C., Gupta, A., & Kapur, P. K. (2008). Bass model revisited. *Journal of Statistics and Management Systems*, *11*(3), 413–437. https://doi.org/10.1080/09720510.2008.10701320

Ju-Long, D. (1982). Control problems of grey systems. *Systems and Control Letters*, *1*(5), 288–294. https://doi.org/10.1016/S0167-6911(82)80025-X

Julong, D. (1989). Introduction to Grey System Theory. *The Journal of Grey System*, *1*, 1–24.

Ke, J., Zheng, H., Yang, H., & Chen, X. M. (2017). Short-term forecasting of passenger demand under on-demand ride services: A spatio-temporal deep learning approach. *Transportation Research Part C: Emerging Technologies*, *85*(October), 591–608. https://doi.org/10.1016/j.trc.2017.10.016

Klimberg, R. K., Sillup, G. P., Boyle, K. J., & Tavva, V. (2010). Forecasting performance measures - What are their practical meaning? *Advances in Business and Management Forecasting*, *7*, 137–147. Retrieved from http://dx.doi.org/10.1108/S1477-4070(2010)0000007012 https://doi.org/10.1108/S1477-4070(2010)0000007012

Kunc, M. H. (2009). Forecasting the development of wine tourism: A case study in Chile. *International Journal of Wine Business Research*, *21*(4), 325–338. https://doi.org/10.1108/17511060911004905

Law, R., Li, G., Fong, D. K. C., & Han, X. (2019). Tourism demand forecasting: A deep learning approach. *Annals of Tourism Research*, *75*(October 2018), 410–423. https://doi.org/10.1016/j.annals.2019.01.014

Leifer, E. M., Mahajan, V., & Wind, Y. (1987). Innovation diffusion models of new product acceptance. *Contemporary Sociology*, *16*(5), 764. https://doi.org/10.2307/2069859

Lewis, C. D. (1982). *Industrial and business forecasting methods : a practical guide to exponential smoothing and curve fitting*. London, Boston: Butterworth Scientific.

Li, G. D., Wang, C. H., Masuda, S., & Nagai, M. (2011). A research on short term load forecasting problem applying improved grey dynamic model. *International Journal of Electrical Power and Energy Systems*, *33*(4), 809–816. https://doi.org/10.1016/j.ijepes.2010.11.005

Li, S., Chen, H., & Zhang, G. (2017). Comparison of the short-term forecasting accuracy on battery electric vehicle between modified bass and Lotka-Volterra model: A case study of China. *Journal of Advanced Transportation*, *2017*(2013). https://doi.org/10.1155/2017/7801837

Li, X., Pan, B., Law, R., & Huang, X. (2017). Forecasting tourism demand with composite search index. *Tourism Management*, *59*, 57–66. https://doi.org/10.1016/j.tourman.2016.07.005

Li, Y., Ma, G., & Li, L. (2017). Development of a Generalization Bass Diffusion Model for Chinese Electric Vehicles Considering Charging Stations. *Proceedings - 2017 5th International Conference on Enterprise Systems: Industrial Digitalization by Enterprise Systems, ES 2017*, 148–156. https://doi.org/10.1109/ES.2017.31

Lim, J., Nam, C., Kim, S., Rhee, H., Lee, E., & Lee, H. (2012). Forecasting 3G mobile subscription in China: A study based on stochastic frontier analysis

and a Bass diffusion model. *Telecommunications Policy*, *36*(10-11), 858–871. https://doi.org/10.1016/j.telpol.2012.07.016

Mahajan, V., & Muller, E. (1979). Innovation diffusion and new product growth models in marketing. *Journal of Marketing*, *43*(4), 55–68. https://doi.org/10.2307/1250271

Mahajan, V., Muller, E., & Bass, F. M. (1990). New product diffusion models in marketing : A review and directions for research. *The Journal of Marketing*, *54*(1), 1–26.

Moro, S., & Rita, P. (2016). Forecasting tomorrow's tourist. *Worldwide Hospitality and Tourism Themes*, *8*(6), 643–653. https://doi.org/10.1108/WHATT-09-2016-0046

Ou, S. L. (2012). Forecasting agricultural output with an improved grey forecasting model based on the genetic algorithm. *Computers and Electronics in Agriculture*, *85*, 33–39. https://doi.org/10.1016/j.compag.2012.03.007

Pai, P. F., Hung, K. C., & Lin, K. P. (2014). Tourism demand forecasting using novel hybrid system. *Expert Systems with Applications*, *41*(8), 3691–3702. https://doi.org/10.1016/j.eswa.2013.12.007

Ren, Y., Suganthan, P. N., Srikanth, N., & Amaratunga, G. (2016). Random vector functional link network for short-term electricity load demand forecasting. *Information Sciences*, *367-368*, 1078–1093. https://doi.org/10.1016/j.ins.2015.11.039

Rice, W. L., Park, S. Y., Pan, B., & Newman, P. (2019). Forecasting campground demand in US national parks. *Annals of Tourism Research*, *75*(January), 424–438. https://doi.org/10.1016/j.annals.2019.01.013

Satoh, D. (2000). A discrete bass model and its parameter estimation. *Journal of the Operations Research Society of Japan*, *44*(1), 1–18. https://doi.org/10.15807/jorsj.44.1

Seol, H., Park, G., Lee, H., & Yoon, B. (2012). Demand forecasting for new media services with consideration of competitive relationships using the competitive Bass model and the theory of the niche. *Technological Forecasting and Social Change*, *79*(7), 1217–1228. https://doi.org/10.1016/j.techfore.2012.03.002

Silva, E. S., Hassani, H., Heravi, S., & Huang, X. (2019). Forecasting tourism demand with denoised neural networks. *Annals of Tourism Research*, *74*(October 2018), 134–154. https://doi.org/10.1016/j.annals.2018.11.006

Smith, S. L. (1994). The tourism product. *Annals of Tourism Research*, *21*(3), 582–595. https://doi.org/10.1016/0160-7383(94)90121-X

Sun X, X., Sun W, W., Wang, J., Zhang, Y., & Gao, Y. (2016). Using a Grey-Markov model optimized by Cuckoo search algorithm to forecast the annual foreign tourist arrivals to China. *Tourism Management*, *52*, 369–379. https://doi.org/10.1016/j.tourman.2015.07.005

Tang, C. F., & Tan, E. C. (2015). The determinants of inbound tourism demand in Malaysia: another visit with non-stationary panel data approach. *Anatolia*, *27*(2), 189–200. https://doi.org/10.1080/13032917.2015.1084345

Thomas, R. J. (1985). Estimating market growth for new products: An analogical diffusion model approach. *The Journal of Product Innovation Management*, *2*(1), 45–55. https://doi.org/10.1016/0737-6782(85)90015-3

Venkatesh, K., Ravi, V., Prinzie, A., & Van Den Poel, D. (2014). Cash demand forecasting in ATMs by clustering and neural networks. *European Journal of Operational Research*, *232*(2), 383–392. https://doi.org/10.1016/j.ejor.2013.07.027

Volchek, K., Liu, A., Song, H., & Buhalis, D. (2019). Forecasting tourist arrivals at attractions: Search engine empowered methodologies. *Tourism Economics*, *25*(3), 425–447. https://doi.org/10.1177/1354816618811558

Wang, Y., Wang, J., Zhao, G., & Dong, Y. (2012). Application of residual modification approach in seasonal ARIMA for electricity demand forecasting: A case study of China. *Energy Policy*, *48*, 284–294. https://doi.org/10.1016/j.enpol.2012.05.026

Wang, Z. X. (2013). A new grey Bass equation for modelling new product diffusion. *Applied Mechanics and Materials*, *291-294*(0), 3033–3036. https://doi.org/10.4028/www.scientific.net/AMM.291-294.3033

Xia, M., & Wong, W. K. (2014). A seasonal discrete grey forecasting model for fashion retailing. *Knowledge-Based Systems*, *57*, 119–126. https://doi.org/10.1016/j.knosys.2013.12.014

Yang, X., Pan, B., Evans, J. A., & Lv, B. (2015). Forecasting Chinese tourist volume with search engine data. *Tourism Management*, *46*, 386–397. https://doi.org/10.1016/j.tourman.2014.07.019