BAB 5

KESIMPULAN DAN SARAN

Setelah penelitian selesai dilakukan, bab ini memuat kesimpulan yang dapat ditarik berdasarkan hasil penelitian. Kesimpulan pada bab ini menjawab rumusan masalah yang tertera pada Bab 1. Selain itu, bab ini juga memuat beberapa saran yang dapat diberikan untuk penelitian lebih lanjut terkait pengembangan model serupa.

5.1 Kesimpulan

Berikut merupakan kesimpulan yang dapat ditarik dari hasil penelitian Pengembangan Model *Last-Mile Delivery Site-Dependent Vehicle Routing Problem with Priority and Time Windows* untuk Meminimalkan Total Jarak:

1. Model *vehicle routing problem* yang mempertimbangkan pemilihan jenis kendaraan untuk pelanggan tertentu (*site-dependent*), urutan prioritas, dan *time windows* telah berhasil dikembangkan. Model *mixed integer linear programming* (MILP) ini dikembangkan untuk mendekati keadaan nyata *last-mile delivery* yang dilakukan oleh jasa ekspedisi. Model dikembangkan untuk merancang rute perjalanan yang meminimalkan biaya perjalanan, yaitu biaya bahan bakar kendaraan. Batasan *site-dependent* menentukan penggunaan jenis kendaraan yang akan melayani suatu pelanggan. Penentuan penggunaan jenis kendaraan bergantung kepada ukuran barang yang akan dikirim. Barang dengan ukuran lebih kecil atau sama dengan 30 x 30 x 30 cm akan dikirim menggunakan motor sementara ukuran yang lebih besar dari batas akan

dikirim menggunakan *blind van*. Batasan prioritas menggambarkan kondisi nyata jasa ekspedisi yang memiliki layanan-layanan khusus dengan tarif yang berbeda. Layanan prioritas perlu dikirimkan terlebih dahulu karena batas waktu pengirimannya lebih ketat daripada layanan reguler. Batasan prioritas yang dikembangkan pada model ini adalah prioritas yang dapat diatur kelonggarannya dengan parameter *d*. Batasan *time windows* digunakan untuk memperketat urutan pengiriman pada rute. Batasan ini digunakan dengan mempertimbangkan adanya tempat-tempat yang memiliki jam buka tertentu, seperti contohnya kantor atau toko. Apabila barang diantar pada pelanggan saat tidak ada orang yang dapat menerima paket, barang akan kembali dibawa ke depot dan dikirimkan kembali keesokan harinya. Hal ini tentu tidak diinginkan karena membuang-buang biaya perjalanan dan waktu.

2. Model penelitian cocok digunakan pada kasus jasa ekspedisi di Indonesia. Penerapan model $d = 0$ cocok digunakan pada kasus tanggal-tanggal diskon seperti 1 Januari, 2 Februari, dst. dan musim-musim libur lebaran dan natal di mana transaksi pembelanjaan meningkat. Banyaknya paket yang dikirimkan menekan kurir untuk mengirimkan seluruh paket prioritas terlebih dahulu sehingga cocok dengan keadaan model $d = 0$.

   Penerapan model $d < p_{max} - 1$ cocok digunakan oleh jasa ekspedisi pada hari-hari normal. Secara intuitif, kurir akan mengirimkan barang-barang dengan alamat pengiriman searah selama waktunya memungkinkan. Penerapan model $d < p_{max} - 1$ akan menghasilkan rute yang memungkinkan pengiriman searah dan meminimalkan total biaya perjalanan.

Penerapan model $d = p_{max} - 1$ cocok digunakan saat tidak ada paket dengan prioritas tinggi seperti BEST yang perlu didahulukan.

5.2 Saran

Berdasarkan penelitian yang telah dilakukan, berikut merupakan saran yang dapat dilakukan untuk penelitian lebih lanjut:

1. Mengerjakan kasus dengan pelanggan yang lebih banyak untuk menggambarkan kondisi nyata *last-mile delivery* oleh jasa ekspedisi.
2. Mengerjakan model dengan menggunakan metode heuristik atau metaheuristik untuk mempercepat waktu pencarian solusi pada kasus yang besar.
3. Mengembangkan kompleksitas model dengan mempertimbangkan faktor kemacetan jalan agar model semakin mendekati kondisi nyata.

DAFTAR PUSTAKA

Adebayo, K. J., Aderibigbe, F. M., & Dele-Rotimi, A. O. (2019). On Vehicle Routing Problems (VRP) with a Focus on Multiple Priorities. *American Journal of Computational Mathematics, Vol. 9*, pp. 348-357.

Aktas, E., Bourlakis, M., & Zissis, D. (2021). Collaboration in the last mile: evidence from grocery deliveries. *International Journal of Logistics Research and Applications, Vol. 24*(No. 3), pp. 227–241. doi:10.1080/13675567.2020.1740660

Amer, H. H., Farouk, H. A., & El-Kilany, K. S. (2020). Heterogeneous Green Vehicle Routing Problem with Hierarchical Objectives: Case Study. *International Conference on Industrial Engineering and Operations Management* (hal. 1289-1300). Dubai: IEOM Society International.

Anas, M., Khan, M. N., Rahman, O., & Uddin, S. M. (2022). Why consumers behaved impulsively during COVID-19 pandemic? *South Asian Journal of Marketing*.

Ayough, A., Khorshidvand, B., Massomnedjad, N., & Motameni, A. (2020). An integrated approach for three-dimensional capacitated vehicle routing problem considering time windows. *Journal of Modelling in Management, Vol. 15*(No. 3), pp. 995-1015. doi:https://doi.org/10.1108/JM2-11-2018-0183

Ayu, T., & Nahry. (2021). Optimizing the Heterogeneous Fleet Vehicle Routing Problem with Time Window on Urban Last Mile Delivery. *IOP Conference Series: Earth and Environmental Science, Vol. 830*.

Batsyn, M. V., Batsyna, E. K., Bychkov, I. S., & M., P. P. (2021). Vehicle assignment in site-dependent vehicle routing problems with split deliveries. *Operational Research, Vol. 21*, pp. 399-423. doi:10.1007/s12351-019-00471-7

Carvalho, G. X. (2019). *Site-Dependent Vehicle Routing Problem with Hard Time Windows*. Lisbon: TÉCNICO LISBOA.

Chao, I.-M., Golden, B. L., & Wasil, E. A. (1997). A new algorithm for the site-dependent vehicle routing problem. *Conference: Advances in computational and stochastic optimization, logic programming, and heuristic search* (hal. pp. 301-312). New York: Springer Science+Business Media . doi:10.1007/978-1-4757-2807-1_12

Chu, C. W., & Hsu, H. L. (2019). A heuristic algorithm for multiple trip vehicle routing problems with time window constraint and outside carrier selection. *Maritime Business Review, Vol. 4*(No. 3), pp. 256-273. doi:10.1108/MABR-04-2019-0018

Dannenberg, P., Fuchs, M., Riedler, T., & Wiedemann, C. (2020). Digital Transition by COVID-19 Pandemic? The German Food Online Retail. *Tijdschrift voor Economische en Sociale Geografie, Vol. 111*(No. 3), pp. 543-560.

Dantzig, G., & Ramser, J. (1959). The Truck Dispatching Problem. *Management Science, 6, Vol. 6*, pp. 80-91.

Dhake, R. J., Rajhans, N. R., & Bhole, N. (2018). Jaya Algorithm + Savings + 2-Opt Heuristic for Multi-Objective Capacitated Vehicle Routing Problem

with Time Constraints & Heterogeneous Fleet of Vehicles. *International Journal of Applied Engineering Research, Vol. 13*(No. 5), pp. 2242-2250.

Doan, T. T., Bostel, N., & Ha, M. H. (2021). The vehicle routing problem with relaxed priority rules. *EURO Journal on Transportation and Logistics, Vol. 10*. doi:10.1016/j.ejtl.2021.100039

Ghannadpour, S. F. (2019). Evolutionary Approach for Energy Minimizing Vehicle Routing Problem with Time Windows and Customers' Priority. *International Journal of Transportation Engineering, Vol. 6*(No. 3), pp. 237-264.

Ghannadpour, S. F., Noori, S., & tavakkoli-Moghaddam, R. (2014). A multi-objective vehicle routing and scheduling problem with uncertainty in customers' request and priority. *Journal of Combinatorial Optimization, Vol. 28*, pp. 414-446.

González, O. M., Segura, C., Peña, S. I., & León, C. (2017). A Memetic Algorithm for the Capacitated Vehicle Routing Problem with Time Windows. *2017 IEEE Congress on Evolutionary Computation (CEC)*, pp. 2582-2589. doi:10.1109/CEC.2017.7969619

Guezouli, L., & Abdelhamid, S. (2018). Multi-objective optimisation using genetic algorithm based clustering for multi-depot heterogeneous fleet vehicle routing problem with time windows. *Int. J. Mathematics in Operational Research, Vol. 13*(No. 3), pp. 332-349. doi:10.1504/IJMOR.2018.094850

Jiang, J., Ng, K. M., Poh, K. L., & Teo, K. M. (2014). Vehicle routing problem with a heterogeneous fleet and time windows. *Expert Systems with Applications, Vol. 41*(No. 8), pp. 3748-3760. doi:10.1016/j.eswa.2013.11.029

Kang, H. Y., & Lee, A. H. (2018). An Enhanced Approach for the Multiple Vehicle Routing Problem with Heterogeneous Vehicles and a Soft Time Window. *Symmetry, Vol. 10*(No. 11). doi:10.3390/sym10110650

Komarudin, Gui, R., & Rahmawan, A. (2016). Green Vehicle Routing Problem with Heterogeneous Fleet and Time Windows. *2nd International Conference on Mechanical Engineering and Electrical Systems.* Hongkong.

Kritikos, M. N., & Ioannou, G. (2013). The heterogeneous fleet vehicle routing problem with overloads and time windows. *Int. J.ProductionEconomics, Vol. 144*(No. 1), pp. 68-75. doi:10.1016/j.ijpe.2013.01.020

Lightner-Laws, C., Agrawal, V., Lightner, C., & Wagner, N. (2016). An evolutionary algorithm approach for the constrained multi-depot vehicle routing problem. *International Journal of Intelligent Computing and Cybernetics, Vol. 9*(No. 1), pp. 2-22. doi:10.1108/IJICC-06-2015-0018

Liu, Y. (2017). *Optimization of Vehicle Routing Problem for Field Service.* Beijing: Beihang University.

Lubis, A., & Mawengkang, H. (2020). A capacitated heterogeneous vehicle routing problem for pharmaceutical products delivery. *Systematic Reviews in Pharmacy, Vol. 11*(No. 4), pp. 738-741.

Maghfiroh, M. F., & Hanaoka, S. (2018). Dynamic truck and trailer routing problem for last mile distribution in disaster response. *Journal of Humanitarian Logistics and Supply Chain Management, Vol. 8*(No. 2), pp. 252-278. doi:10.1108/JHLSCM-10-2017-0050

Molina, J. C., Salmeron, J. L., Eguia, I., & Racero, J. (2020). The heterogeneous vehicle routing problem with time windows and a limited number of

resources. *Engineering Applications of Artificial Intelligence, Vol. 94*. doi:10.1016/j.engappai.2020.103745

Mostafa, N., & Eltawil, A. (2017). Solving the Heterogeneous Capacitated Vehicle Routing Problem using K-Means Clustering and Valid Inequalities. *International Conference on Industrial Engineering and Operations Management Rabat* (hal. 2239-2249). Morocco: IEOM Society International.

Movarrei, R., Vessal, S. R., Vessal, S. R., & Aspara, J. (2021). The effect of type of company doing home delivery during a pandemic on consumers' quality perceptions and behavior. *International Journal of Physical Distribution & Logistics Management*. doi:10.1108/IJPDLM-08-2020-0272

Nucamendi-Guillén, S., Flores-Díaz, D., Olivares-Benitez, E., & Mendoza, A. (2020). A Memetic Algorithm for the Cumulative Capacitated Vehicle Routing Problem Including Priority Indexes. *Applied Sciences, Vol. 10*(No. 11). doi:10.3390/app10113943

Nufus, I. V. (2022). *Pengembangan Model dan Penyelesaian Capacitated Vehicle Routing Problem dengan Prioritas Pengiriman.* Bandung: Universitas Katolik Parahyangan.

Oloveze, A. O., Ogbonna, C., Ahaiwe, E., & Ugwu, P. A. (2022). From offline shopping to online shopping in Nigeria: evidence from African emerging economy. *IIM Ranchi Journal of Management Studies, Vol. 1*(No. 1), pp. 55-68. doi:10.1108/IRJMS-08-2021-0110

Onut, S., Kamber, M. R., & Altay, G. (2014). A heterogeneous fleet vehicle routing model for solving the LPG distribution problem: A case study. *Journal of*

Physics: Conference Series, Vol. 490. doi:10.1088/1742-6596/490/1/012043

Oran, A., Tan, K. C., Ooi, B. H., Sim, M., & Jaillet, P. (2012). Location and Routing Models for Emergency Response Plans with Priorities. *Future Security*, pp. 129-140. doi:10.1007/978-3-642-33161-9_20

Polas, M. R., Tabash, M. I., Jahanshahi, A. A., & Ahamed, B. (2021). Consumers' sustainable online purchase behaviour during COVID-19 pandemic: the role of relational benefit and site commitment. *Foresight*. doi:10.1108/FS-01-2021-0012

Rabbani, M., Pourreza, P., Farrokhi-Asl, H., & N., N. (2018). A hybrid genetic algorithm for multi-depot vehicle routing problem with considering time window repair and pick-up. *Journal of Modelling in Management, Vol. 13*(No. 3), pp. 698-717. doi:10.1108/JM2-04-2017-0046

Ramos, T. R., Gomes, M. I., & Póvoa, A. P. (2020). Multi-depot vehicle routing problem: a comparative study of alternative formulations. *International Journal of Logistics: Research and Applications, Vol. 23*(No. 2), pp. 103-120. doi:10.1080/13675567.2019.1630374

Ravly, A. (2021). *Pengembangan Model Multiple Traveling Salesman Problem dengan Mempertimbangkan Prioritas Pengantaran.* Bandung: Universitas Katolik Parahyangan.

Roohnavazfar, M., Pasandideh, S. H., & Tadei, R. (2022). A Hybrid Algorithm for the Vehicle Routing Problem with AND/OR Precedence Constraints and Time Windows. *Computers & Operations Research, Vol. 143*. doi:10.1016/j.cor.2022.105766

Saha, S. K., Zhuang, G., & Li, S. (2020). Will Consumers Pay More for Efficient Delivery? An Empirical Study of What Affects E-Customers' Satisfaction and Willingness to Pay on Online Shopping in Bangladesh. *Sustainability, Vol. 12*(No. 3). doi:10.3390/su12031121

Salhi, S., Imran, A., & Wassan, N. A. (2014). The multi-depot vehicle routing problem with heterogeneous vehicle fleet: Formulation and a variable neighborhood search implementation. *Computers & Operations Research, Vol. 52*, pp. 315-325. doi:10.1016/j.cor.2013.05.011

Salsabila, H. (2020). *Usulan Rute Kendaraan Dinas Perindustrian dan Energi Seksi Penerangan Jalan DKI Jakarta Menggunakan Genetic Algorithm*. Bandung: Universitas Katolik Parahyangan.

Sekretariat. (2022, Oktober 11). *Data Kependudukan*. Dipetik Agustus 27, 2023, dari Direktorat Jenderal Kependudukan dan Pencatatan Sipil Kementrian dalam Negeri Republik Indonesia: https://dukcapil.kemendagri.go.id/page/read/7/data-kependudukan

Setiawan, F., Masruroh, N. A., & Pramuditha, Z. I. (2019). On Modelling and Solving Heterogeneous Vehicle Routing Problem with Multi-Trips and Multi-Products. *Jurnal Teknik Industri, Vol. 21*(No. 2), pp. 91-104. doi:10.9744/jti.21.2.91-104

Shetty, V. K., Sudit, M., & Nagi, R. (2008). Priority-based assignment and routing of a fleet of unmanned. *Computers & Operations Research, Vol. 35*(No. 6), pp. 1813-1828. doi:10.1016/j.cor.2006.09.013

Sitompul, C., & Horas, O. M. (2021). A Vehicle Routing Problem with Time Windows Subject to the Constraint of Vehicles and Good's Dimensions.

International Journal of Technology, Vol. 12(No. 4), pp. 865-875. doi:10.14716/ijtech.v12i4.4294

Smith, S. L., Pavone, M., Bullo, F., & Frazzoli, E. (2010). Dynamic Vehicle Routing with Priority Classes of Stochastic Demands. *SIAM Journal on Control and Optimization, Vol. 48*(No. 5), pp. 3224-3245.

Snyder, L. V., & Shen, Z. J. (2019). *Fundamentals of Supply Chain Theory, Second Edition.* Hoboken: John Wiley & Sons, Inc.

Susilawati, E., Mawengkang, H., & Efendi, S. (2018). An Integer Programming Model For Solving Heterogeneous Vehicle Routing Problem With Hard Time Window considering Service Choice. *IOP Conf. Series: Materials Science and Engineering. 300.* Medan: IOP Publishing.

Taş, D., Jabali, O., & Woensel, T. V. (2014). A Vehicle Routing Problem with Flexible Time Windows. *Computers & Operations Research, Vol. 52*, pp. 39-54. doi:10.1016/j.cor.2014.07.005

Tirkolaee, E. B., Abbasian, P., Soltani, M., & Ghaffarian, A. (2019). Developing an applied algorithm for multi-trip vehicle routing problem with time windows in urban waste collection: A case study. *Waste Management & Research, Vol. 37*(No. 1), pp. 4-13. doi:10.1177/0734242X18801

Valizadeh, J. (2020). A novel mathematical model for municipal waste collection and energy generation: case study of Kermanshah city. *Management of Environmental Quality: An International Journal, Vol. 31*(No. 5), pp. 1437-1453. doi:10.1108/MEQ-02-2020-0027

Venkatesh, V., Speier-Pero, C., & Schuetz, S. (2022). Why do people shop online? A comprehensive framework of consumers' online shopping intentions and

behaviors. *Information Technology & People*. doi:10.1108/ITP-12-2020-0867

Wang, B., Qian, Q., Tan, Z., Zhang, P., Wu, A., & Zhou, Y. (2020). Multidepot Heterogeneous Vehicle Routing Problem for a Variety of Hazardous Materials with Risk Analysis. *Scientific Programming, Vol. 2020*, pp. 1-11. doi:10.1155/2020/8839628

WeAreSocial. (2023, Januari). *Digital 2023*. Diambil kembali dari We Are Social: https://wearesocial.com/id/blog/2023/01/digital-2023/

Zare-Reisabadi, E., & Mirmohammadi, S. H. (2015). Site dependent vehicle routing problem with soft time window: Modeling and solution approach. *Computers & Industrial Engineering, Vol. 90*, pp. 177-185. doi:10.1016/j.cie.2015.09.002

Zhang, W., Gajpal, Y., Appadoo, S. S., & Wei, Q. (2020). Multi-Depot Green Vehicle Routing Problem to Minimize Carbon Emissions. *Sustainability, Vol. 12*(No. 8). doi:10.3390/su12083500

Zhang, Y., Qi, M., Miao, L., & Wu, G. (2015). A generalized multi-depot vehicle routing problem with replenishment based on LocalSolver. *International Journal of Industrial Engineering Computations, Vol. 6*(No. 1), pp. 81-98. doi:10.5267/j.ijiec.2014.8.005

.