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The Effect of Liner Shipping Connectivity on Container Ports' Efficiency in The Middle East: Data Envelopment Analysis Approach

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References

[1] United Nations Conference on Trade and Development, "Developments in international seaborne trade," in Rev. Marit. Transp. 2014, pp. 1–25, 2014. doi: 10.18356/e9e3b605-en.
[2] A. S. Bergantino, E. Musso, and F. Porcelli, "Port management performance and contextual variables: Which relationship? Methodological and empirical issues," Res. Transp. Bus. Manag., vol. 8, pp. 39–49, 2013, doi: 10.1016/j.rtbm.2013.07.002.
[3] T. E. Notteboom and J.-P. Rodrigue, "Port regionalization: Towards a new phase in port development," Marit. Policy Manag., vol. 32, no. 3, pp. 297–313, 2005, doi: 10.1080/03088830500139885.
[4] T. E. Notteboom, "Towards a new intermediate hub region in container shipping? Relay and interlining via the Cape route vs. the Suez route," J. Transp. Geogr., vol. 22, pp. 164–178, May 2012, doi: 10.1016/j.jtrangeo.2012.01.003.
[5] C. Barros, "A benchmark analysis of Italian seaports using data envelopment analysis," Marit. Econ. Logist., vol. 8, pp. 347–365, 2006, doi: 10.1057/palgrave.mel.9100163.
[6] K. Bichou, "An empirical study of the impacts of operating and market conditions on container-port efficiency and benchmarking," Res. Transp. Econ., vol. 42, no. 1, pp. 28–37, 2013, doi: 10.1016/j.retrec.2012.11.009.
[7] C.-N. Wang, N.-A.-T. Nguyen, H.-P. Fu, H.-P. Hsu, and T.-T. Dang, "Efficiency assessment of seaport terminal operators using DEA Malmquist and epsilon-based measure models," Axioms, vol. 10, no. 2, p. 48, 2021, doi: 10.3390/axioms10020048.
[8] R. Kammoun and C. Abdennadher, "Seaport efficiency and competitiveness in European seaports," Transp. Policy, vol. 121, pp. 113–124, 2022, doi: 10.1016/j.tranpol.2022.04.003.
[9] G. Fancello, P. Serra, and D. M. Vitiello, "Evaluating the efficiency of Mediterranean container ports using data envelopment analysis," Compet. Regul. Netw. Ind., vol. 22, no. 3-4, 2021, doi: 10.1177/17835917211047837.
[10] K. Cullinane and D.-W. Song, "Estimating the relative efficiency of European container ports: A stochastic frontier analysis," Res. Transp. Econ., vol. 16, pp. 85–115, 2006, doi: 10.1016/S0739-8859(06)16005-9.
[11] E. Krmac and M. Mansouri Kaleibar, "A comprehensive review of data envelopment analysis (DEA) methodology in port efficiency evaluation," Marit. Econ. Logist., vol. 25, pp. 817–881, 2023, doi: 10.1057/s41278-022-00239-5.
[12] S. Sultana, M. M. Hossain, and M. N. Haque, "Estimating the potato farming efficiency: A comparative study between stochastic frontier analysis and data envelopment analysis," PLoS ONE, vol. 18, no. 4, p. e0284391, 2023, doi: 10.1371/journal.pone.0284391.
[13] J. D. Lamb and K. H. Tee, "Using stochastic frontier analysis instead of data envelopment analysis in modelling investment performance," Ann. Oper. Res., vol. 332, pp. 891–907, 2024, doi: 10.1007/s10479-023-05428-w.
[14] G. F. De Oliveira and P. Cariou, "The impact of competition on container port (in)efficiency," Transp. Res. Part A Policy Pract., vol. 78, pp. 124–133, 2015, doi: 10.1016/j.tra.2015.04.034.
[15] T. Serebrisky, J. Morales Sarriera, A. Suárez-Alemán, G. Araya, C. Briceño-Garmendía, and J. Schwartz, "Exploring the drivers of port efficiency in Latin America and the Caribbean," Transp. Policy, vol. 45, pp. 31–45, 2016, doi: 10.1016/j.tranpol.2015.09.004.
[16] R. E. Jamain, R. H. Zakaria, and N. H. M. Satar, "The importance of logistics variables on port performance analysis: A DEA approach to analyzing 57 ports in the World Port Ranking," J. Int. Bus. Econ. Entrep., vol. 7, no. 2, 2022, e-ISSN: 2550-1429, doi: 10.24191/jibe.v7i2.20718.

[17] B. T. H. Yen, M.-J. Huang, H.-J. Lai, H.-H. Cho, and Y.-L. Huang, "How smart port design influences port efficiency – A DEA-Tobit approach," Res. Transp. Bus. Manag., vol. 46, p. 100862, 2023, doi: 10.1016/j.rtbm.2022.100862.
[18] H. Schøyen et al., "Measuring the contribution of logistics service delivery performance outcomes and deep-sea container liner connectivity on port efficiency," Res. Transp. Bus. Manag., vol. 28, pp. 66–76, 2018, doi: 10.1016/j.rtbm.2018.03.002.
[19] P. M. Panayides, C. N. Maxoulis, T.-F. Wang, and K. Y. A. Ng, "A critical analysis of DEA applications to seaport economic efficiency measurement," Transp. Rev., vol. 29, no. 2, pp. 183–206, 2009, doi: 10.1080/01441640802260354.
[20] B. Tovar and A. Wall, "The relationship between port-level maritime connectivity and efficiency," J. Transp. Geogr., vol. 98, p. 103213, 2022, doi: 10.1016/j.jtrangeo.2021.103213.
[21] F. S. Mustafa, R. U. Khan, and T. Mustafa, "Technical efficiency comparison of container ports in Asian and Middle East region using DEA," Asian J. Shipp. Logist., vol. 37, no. 1, pp. 12–19, 2021, doi: 10.1016/j.ajsl.2020.04.004.
[22] E. S. Almawsheki and M. Z. Shah, "Technical efficiency analysis of container terminals in the Middle Eastern region," Asian J. Shipp. Logist., vol. 31, no. 4, pp. 477–486, 2015, doi: 10.1016/j.ajsl.2016.01.006.
[23] L. Lin, et al., "A new decision-making optimization approach for sustainable expressway pavement maintenance," Teh. Vjesn., vol. 31, no. 4, pp. 1119–1129, 2024, doi: 10.17559/TV-20221019112637.
[24] J. Zhu, Quantitative Models for Performance Evaluation and Benchmarking, Cham, Switzerland: Springer, 2014, doi: 10.1007/978-3-319-06647-9.
[25] J. D. Hong, "Application of the extended two-stage network DEA model for the biomass-biofuel logistics network design," Int. J. Ind. Eng. Manag., vol. 16, no. 1, pp. 76–89, 2025, doi: 10.24867/IJIEM-372.
[26] J. D. Hong, J. Mwakalonge, and K. Y. Jeong, "Design of disaster relief logistics network system by combining three data envelopment analysis-based methods," Int. J. Ind. Eng. Manag., vol. 13, no. 3, pp. 172–185, 2022, doi: 10.24867/IJIEM-2022-3-310.
[27] W. Meeusen and J. van Den Broeck, "Efficiency estimation from Cobb-Douglas production functions with composed error," Int. Econ. Rev., vol. 18, no. 2, pp. 435–444, 1977, doi: 10.2307/2525757.
[28] D. Aigner, C. A. K. Lovell, and P. Schmidt, "Formulation and estimation of stochastic frontier production function models," J. Econom., vol. 6, no. 1, pp. 21–37, 1977, doi: 10.1016/0304-4076(77)90052-5.
[29] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision-making units," Eur. J. Oper. Res., vol. 3, no. 4, pp. 339–338, 1979.
[30] R. D. Banker, A. Charnes, and W. W. Cooper, "Some models for estimating technical and scale inefficiencies in data envelopment analysis," Manag. Sci., vol. 30, no. 9, pp. 1078–1092, 1984, doi: 10.1287/mnsc.30.9.1078.
[31] W. D. Cook, K. Tone, and J. Zhu, "Data envelopment analysis: Prior to choosing a model," Omega, vol. 44, pp. 1–4, 2014, doi: 10.1016/j.omega.2013.09.004.
[32] K. Bichou, "An empirical study of the impacts of operating and market conditions on container-port efficiency and benchmarking," Res. Transp. Econ., vol. 42, no. 1, pp. 28–37, 2013, doi: 10.1016/j.retrec.2012.11.009.
[33] K. Cullinane and T. Wang, "The efficiency analysis of container port production using DEA panel data approaches," OR Spectr., vol. 32, pp. 717–738, 2010, doi: 10.1007/s00291-010-0202-7.
[34] D. S. da Costa, M. V. G. S. de Assis Carvalho, N. M. de Figueiredo, H. B. de Moraes, and R. C. B. Ferreira, "The efficiency of container terminals in the northern region of Brazil," Util. Policy, vol. 72, p. 101278, 2021, doi: 10.1016/j.jup.2021.101278.
[35] K. C. Iyer and V. P. S. N. Nanyam, "Technical efficiency analysis of container terminals in India," Asian J. Shipp. Logist., vol. 37, no. 1, pp. 61–72, 2021, doi: 10.1016/j.ajsl.2020.07.002.
[36] V. Chang and B. Tovar, "Metafrontier analysis on productivity for West Coast of South Pacific terminals," Transp. Res. Part A Policy Pract., vol. 103, pp. 118–134, 2017, doi: 10.1016/j.tra.2016.12.012.
[37] B. Tovar and A. Wall, "Are larger and more complex ports more productive? An analysis of Spanish port authorities," Transp. Res. Part A Policy Pract., vol. 121, pp. 265–276, Mar. 2019, doi: 10.1016/j.tra.2019.01.008.
[38] S. Lozano, G. Villa, and D. Canca, "Application of centralised DEA approach to capital budgeting in Spanish ports," Comput. Ind. Eng., vol. 60, no. 3, pp. 455–465, 2011, doi: 10.1016/j.cie.2010.07.029.
[39] P. N. Nguyen, S.-H. Woo, A. Beresford, and S. Pettit, "Competition, market concentration, and relative efficiency of major container ports in Southeast Asia," J. Transp. Geogr., vol. 83, p. 102653, 2020, doi: 10.1016/j.jtrangeo.2020.102653.
[40] A. M. R. Cabral and F. S. Ramos, "Efficiency container ports in Brazil: A DEA and FDH approach," Cerem. J., vol. 2, no. 1, pp. 43–64, 2018, doi: 10.29015/cerem.579.
[41] A. C.-L. Yuen, A. Zhang, and W. Cheung, "Foreign participation and competition: A way to improve the container port efficiency in China?," Transp. Res. Part A Policy Pract., vol. 49, pp. 220–231, 2013, doi: 10.1016/j.tra.2013.01.026.
[42] K. Cullinane, P. Ji, and T.-F. Wang, "The relationship between privatization and DEA estimates of efficiency in the container port industry," J. Econ. Bus., vol. 57, no. 5, pp. 433–462, 2005, doi: 10.1016/j.jeconbus.2005.02.007.
[43] V. de A. Guimarães, I. C. Leal Junior, and P. A. de A. Garcia, "Environmental performance of Brazilian container terminals: A data envelopment analysis approach," Procedia Soc. Behav. Sci., vol. 160, pp. 178–187, 2014, doi: 10.1016/j.sbspro.2014.12.129.
[44] L. Wang, Z. Zhou, Y. Yang, and J. Wu, "Green efficiency evaluation and improvement of Chinese ports: A cross-efficiency model," Transp. Res. Part D Transp. Environ., vol. 88, p. 102590, 2020, doi: 10.1016/j.trd.2020.102590.
[45] A. Hlali, "Efficiency analysis with different models: The case of container ports," J. Mar. Sci. Res. Dev., vol. 8, no. 2, pp. 1–10, 2018, doi: 10.4172/2155-9910.1000250.
[46] V. F. F. Valentine and R. Gray, "The measurement of port efficiency using data envelopment analysis," in Proc. 9th World Conf. Transp. Res., Seoul, South Korea, 2001.
[47] J. Wu, L. Liang, and M. Song, "Performance based clustering for benchmarking of container ports: An application of DEA and cluster analysis technique," Int. J. Comput. Intell. Syst., vol. 3, no. 6, pp. 709–722, 2010, doi: 10.1080/18756891.2010.9727734.
[48] H. Schøyen and J. Odeck, "Comparing the productivity of Norwegian and some Nordic and UK container ports – an application of Malmquist productivity index," Int. J. Shipp. Transp. Logist., vol. 9, no. 2, pp. 234–256, 2017, doi: 10.1504/IJSTL.2017.082526.
[49] S. Niavis and T. Tsekeris, "Ranking and causes of inefficiency of container seaports in South-Eastern Europe," Eur. Transp. Res. Rev., vol. 4, pp. 235–244, 2012, doi: 10.1007/s12544-012-0080-y.
[50] H.-S. Lee, M.-T. Chou, and S.-G. Kuo, "Evaluating port efficiency in Asia Pacific region with recursive data envelopment analysis," J. East. Asia Soc. Transp. Stud., vol. 6, pp. 544–559, 2005.

[51] V. Gökçek and Y. E. Şenol, "Efficiency analysis of Mediterranean container ports," J. ETA Marit. Sci., vol. 6, no. 2, pp. 129–140, 2018, doi: 10.5505/jems.2018.86648.
[52] J. H. A. Rosas and A. J. R. Torres, "Benchmarking of Mexican ports with data envelopment analysis," Int. J. Shipp. Transp. Logist., vol. 1, no. 3, pp. 276–295, 2009, doi: 10.1504/IJSTL.2009.027535.
[53] H. Itoh, "Efficiency changes at major container ports in Japan: A window application of data envelopment analysis," Rev. Urban Reg. Dev. Stud., vol. 14, no. 2, pp. 133–152, 2002, doi: 10.1111/1467-940X.00052.
[54] V. Charles and M. Kumar, Data Envelopment Analysis and Its Applications to Management, 1st ed. Newcastle upon Tyne, U.K.: Cambridge Scholars Publ., 2013, doi: 10.65325/EB2178.
[55] S. C. Kumbhakar, R. Ortega-Argilés, L. Potters, et al., "Corporate R&D and firm efficiency: Evidence from Europe's top R&D investors," J. Prod. Anal., vol. 37, pp. 125–140, 2012, doi: 10.1007/s11123-011-0223-5.
[56] T.-F. Wang, K. Cullinane, and D.-W. Song, Container port production and economic efficiency. Springer, 2005, doi: 10.1057/9780230505971.
[57] Z. H. Munim, "Does higher technical efficiency induce a higher service level? A paradox association in the context of port operations," Asian J. Shipp. Logist., vol. 36, no. 4, pp. 157–168, 2020, doi: 10.1016/j.ajsl.2020.02.001.
[58] X. B. Zheng and N. K. Park, "A study on the efficiency of container terminals in Korea and China," Asian J. Shipp. Logist., vol. 32, no. 4, pp. 213–220, 2016, doi: 10.1016/j.ajsl.2016.12.004.
[59] K.-C. Kuo, W.-M. Lu, and M.-H. Le, "Exploring the performance and competitiveness of Vietnam port industry using DEA," Asian J. Shipp. Logist., vol. 36, no. 3, pp. 136–144, 2020, doi: 10.1016/j.ajsl.2020.01.002.
[60] T. Q. M. Pham, G. K. Park, and K.-H. Choi, "The efficiency analysis of world top container ports using two-stage uncertainty DEA model and FCM," Marit. Bus. Rev., vol. 6, no. 1, pp. 2–21, 2021, doi: 10.1108/MABR-11-2019-0052.
[61] H. T. Sulaimani, Analysis of container throughput: Demand forecast and seaport competitiveness assessment, Ph.D. dissertation, New Jersey Inst. Technol., Newark, NJ, USA, 2021.
[62] W. K. Talley, M. W. Ng, and E. Marsillac, "Port service chains and port performance evaluation," Transp. Res. Part E Logist. Transp. Rev., vol. 69, pp. 236–247, 2014, doi: 10.1016/j.tre.2014.05.008.
[63] Y.-T. Chang and W. K. Talley, "Port competitiveness, efficiency, and supply chains: A literature review," Transp. J., vol. 58, pp. 1–20, 2019, doi: 10.5325/transportationj.58.1.0001.
[64] A. Suárez-Alemán, J. Morales Sarriera, T. Serebrisky, and L. Trujillo, "When it comes to container port efficiency, are all developing regions equal?," Transp. Res. Part A Policy Pract., vol. 86, pp. 56–77, 2016, doi: 10.1016/j.tra.2016.01.018.
[65] D. Nadarajan, S. A. M. Ahmed, and N. F. M. Noor, "Seaport network efficiency measurement using triangular and trapezoidal fuzzy data envelopment analyses with liner shipping connectivity index output," Math., vol. 11, no. 6, p. 1454, 2023, doi: 10.3390/math11061454.
[66] R. Färe, S. Grosskopf, B. Lindgren, and P. Roos, "Productivity developments in Swedish hospitals: A Malmquist output index approach," in Data Envelopment Analysis: Theory, Methodology, and Applications, Dordrecht, Netherlands: Springer, 1994, pp. 253–272, doi: 10.1007/978-94-011-0637-5_13.
[67] W. D. Cook and L. M. Seiford, "Data envelopment analysis (DEA) – Thirty years on," Eur. J. Oper. Res., vol. 192, no. 1, pp. 1–17, 2009, doi: 10.1016/j.ejor.2008.01.032.
[68] A. Grilo and J. Santos, "Measuring efficiency and productivity growth of new technology-based firms in business incubators: The Portuguese case study of Madan Parque," Sci. World J., vol. 2015, p. 936252, 2015, doi: 10.1155/2015/936252.