

## References

- Aaronson W.E., Zinn J.S. and M.D. Rosko (1994), "Do for-profit and not-for-profit nursing homes behave differently?" *The Gerontologist*, 34 (6), 775–777.
- Adams C.E. and Y. Michel (2001), "Correlation between home health resource utilization measures." *Home Health Care Services Quarterly*, 20 (3), 45–56.
- AHCPR (1994), "Clinical Practice Guideline No 12: Otitis Media with effusion in young children", Agency for Health Care Policy and Research, U.S. department of Health and Human Services Publication No. 94–0622.
- American Medical Association (1995), "*Current Procedural Terminology-1995, Evaluation and Management Services Guidelines*," AMA.
- Andersen P. and P.C. Petersen (1993), "A procedure for ranking efficient units in data envelopment analysis," *Management Science*, 39, 1261–1264.
- Athanassopoulos A. and C. Gounaris (2001), "Assessing the technical and allocative efficiency of hospital operations in Greece and its resource allocation implications." *European Journal of Operational Research*, 133 (2), 416–432.
- Bailey N.C. (1990), "How to control overcharging by physicians". *Business and Health*, August: 13–18.
- Banks D., Parker E. and J. Wendel (2001), "Strategic interaction among hospitals and nursing facilities: the efficiency effects of payment systems and vertical integration," *Health Economics*, 10 (2), 119–134.
- Bannick R.R. and Y.A. Ozcan (1995), "Efficiency analysis of federally funded hospitals: comparison of DoD and VA hospitals using data envelopment analysis," *Health Services Management Research* 8 (2), 73–85.
- Biorn E., Hagen T.P., Iversen T. and J. Magnussen (2003), "The effect of activity-based financing on hospital efficiency: a panel data analysis of DEA efficiency Scores 1992–2000," *Health Care Management Science*, 6 (4), 271–284.
- Björkgren M.A., Häkkinen U. and M. Linna (2001), "Measuring efficiency of long-term care units in Finland," *Health Care Management Science*, 4 (3), 193–200.
- Blank J.L.T. and E. Eggink (2001), "A quality-adjusted cost function in a regulated industry: The case of Dutch nursing homes," *Health Care Management Science*, 4 (3), 201–211.
- Brown III H.S. (2002), "Managed care and technical efficiency," *Health Economics*, 12 (2), 149–158.
- Buck D. (2000), "The efficiency of the community dental services in England: a data envelopment analysis," *Community Dentistry and Oral Epidemiology*, 28, 274–280.
- Burgess J.F. and P.W. Wilson (1993), Technical efficiency in veterans administration hospitals," in: *The Measurement of Productive Efficiency*, eds. H.O. Fried, C.A. Knox-Lovell and S.S. Schmidt, Oxford University Press, New York.

- Carter G.M., Newhouse J.P. and D.A. Relles (1990), "How much change in the case mix index is DRG creep", *Journal of Health Economics*, 9:411–428.
- Castle N.G. (2006), "Characteristics of nursing homes that close," *Health Care Management Review*, 31 (1), 78–89.
- Caves D.W., Christensen L.R. and W.E. Diewart (1982), "The econometric theory of index numbers and the measurement of input, and output productivity," *Econometrica*, 50 (6), 1393–1414.
- Cawley J., Grabowski D.G. and R.A. Hirth (2006), "Factor substitution in nursing homes," *Journal of Health Economics*, 25 (2), 234–247.
- Chang H.H. (1998), "Determinants of hospital efficiency: the case of central government-owned Hospitals in Taiwan," *Omega*, 26 (2), 307–318.
- Charnes A., Cooper W.W. and E. Rhodes (1978), "Measuring the efficiency of decision making units," *European Journal of Operational Research*, 2 (6), 429–444.
- Charnes A., Cooper W.W., Huang Z.M. and D.B. Sun (1990), "Polyhedral Cone-Ratio DEA Models with an illustrative Application to Large Commercial Banks," *Journal of Econometrics*, 46 (1), 73–91.
- Chattopadhyay S. and S.C. Ray (1998), "Technical, scale, and size efficiency in nursing home care: a nonparametric analysis of Connecticut homes," *Health Economics*, 5 (4), 363–373.
- Chilingerian J.A. (1995), "Evaluating physician efficiency in hospitals: A multivariate analysis of best practices," *European Journal of Operational Research*, 8 (3), 548–574.
- Chilingerian J.A. and H.D. Sherman (1997a), "Benchmarking physician practice patterns with DEA: a multi-stage approach for cost containment," *Annals of Operations Research*, 67, 83–116.
- Chilingerian J.A. and H.D. Sherman (1997b), "DEA and primary care physician report cards: deriving preferred practice cones from managed care service concepts and operating strategies," *Annals of Operations Research*, 73, 35–66.
- Chilingerian J.A., Glavin, M. and S. Bhalotra (2002), "Using DEA to profile cardiac surgeon efficiency," *Draft of Technical Report to AHRQ*, Heller School, Brandeis University.
- Chirikos T.N. and A.M. Sear (1994), "Technical efficiency and the competitive behavior of hospitals," *Socio-Economic Planning Sciences*, 28 (4), 219–227.
- Christensen E.W. (2003), "Scale and scope economies in nursing homes: a quantile regression approach," *Health Economics*, 13 (4), 363–377.
- Chu H.L., Liu S.Z. and J.C. Romeis (2004), "Does capitated contracting improve efficiency? Evidence from California hospitals," *Health Care Management Review*, 29 (4), 344–352.
- Cooper W.W., Seiford L.M. and K. Tone (2007), *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. Springer, Boston, MA.
- Coppola M.N. (2003), *Correlates of Military Medical Treatment Facility (MTF) Performance: Measuring Technical Efficiency with the Structural Adaptation to Regain Fit (SARFIT) Model and Data Envelopment Analysis (DEA)*. Ph.D. Thesis, Virginia Commonwealth University, Richmond, VA. University Microfilms Inc., Ann Arbor MI.
- Coppola M.N., Ozcan Y.A. and R. Bogacki (2003), "Evaluation of performance of dental providers on posterior restorations: does experience matter? A data envelopment analysis (DEA) approach," *Journal of Medical Systems*, 27 (5), 447–458.
- Coventry J.A., Weston M.S. and P.M. Collins (1996), "Emergency room encounters of pediatric patients with asthma: cost comparisons with other treatment settings," *Journal of Ambulatory Care Management*, 19 (2), 9–21.
- Creteur M., Pochet Y., Pouplier I. and M.C. Closon (2003), "Organisational performance evaluation: application to Belgian hospitals," *International Journal of Healthcare Technology and Management*, 1 (1/2), 148.
- Crivelli L., Filippini M. and D. Lunati (2002), "Regulation, ownership and efficiency in the Swiss nursing home industry," *International Journal of Health Care Finance and Economics*, 2 (2), 79–97.
- Dalmau-Atarrodona E. and J. Puig-Junoy (1998), "Market structure and hospital efficiency: evaluating potential effects of deregulation in a National Health Service," *Review of Industrial Organization*, 13 (4), 447–466.

- Dervaux B., Leleu H., Nogues H. and V. Valdmanis (2006), "Assessing French nursing home efficiency: an indirect approach via budget constrained DEA models," *Socio-Economic Planning Sciences*, 40, 70–91.
- Draper D.A., Solti I. and Y.A. Ozcan (2000), "Characteristics of health maintenance organizations and their influence on efficiency," *Health Services Management Research*, 13 (1), 40–56.
- Ersoy K., Kavuncubasi S., Ozcan Y.A. and J.M. Harris (1997), "Technical efficiencies of Turkish hospitals: DEA approach," *Journal of Medical Systems*, 21 (2), 67–74.
- Fare R. and S. Grosskopf (1983), "Measuring output efficiency," *European Journal of Operational Research*, 13, 173–179.
- Fare R., Grosskopf S. and C.A. Knox-Lovell (1994), *Production Frontiers*. London: Cambridge University Press.
- Fare R., Grosskopf S., Lindgren B. and P. Roos (1994), "Productivity developments in Swedish hospitals: a malmquist output index approach," in *Data Envelopment Analysis: Theory, Methodology, and Applications*, eds. A. Charnes, W. W. Cooper, A.Y. Lewin and L.M. Seiford. Boston: Kluwer.
- Farsi M. and M. Filippini (2004), "An empirical analysis of cost efficiency in non-profit and public nursing homes," *Annals of Public and Cooperative Economics*, 75 (3), 339–366.
- Ferrando A., Ivaldi C., Buttiglieri A., Pagano E., Bonetto C., Arione R., Scaglione L., Gelormino E., Merletti F. and G. Ciccone (2005), "Guidelines for preoperative assessment: impact on clinical practice and costs," *International Journal of Quality Health Care*, 17 (4), 323–329.
- Ferrier G.D. and V. Valdmanis (2004), "Do mergers improve hospital productivity?" *Journal of the Operational Research Society*, 55 (10), 1071–1080.
- Field K. and A. Emrouznejad (2003), "Measuring the performance of neonatal care units in Scotland," *Journal of Medical Systems*, 27 (4), 315–324.
- Fizel J.L. and T.S. Nunnikhoven (1993), "The efficiency of nursing home chains," *Applied Economics*, 25 (1), 49–55.
- Fried H.O., Schmidt S.S. and S. Yaisawarng (1998), "Productive, scale and scope efficiencies in U.S. hospital-based nursing homes," *INFOR Special Issue on Evaluating Performance in Public and Service Sector Organizations*, 36 (3), 103–119.
- Fried H.O., Schmidt S.S. and S. Yaisawarng (1999), "Incorporating the operating environment into a nonparametric measure of technical efficiency," *Journal of Productivity Analysis*, 12 (3), 249–267.
- Fulton L. (2005), *Performance of Army Medical Department Health Delivery Components, 2001–2003: A Multi Model Approach*, Ph.D. Thesis, University of Texas, Austin, TX. University Microfilms Inc., Ann Arbor MI.
- Gerdtham U.G., Rehnberg C. and M. Tambour (1999), "The impact of internal markets on health care efficiency: evidence from health care reforms in Sweden," *Applied Economics*, 31 (8), 935.
- Gertler P.J. and D.M. Waldman (1994), "Why are not-for-profit nursing homes more costly?" *DRU-723-NIA*, <http://www.rand.org/cgi-bin/health/hilite.pl?key=1994DRU-723-NIA&hi>
- Giokas D.I. (2001), "Greek hospitals: how well their resources are used," *Omega*, 29 (1), 73–83.
- Given R. (1996), "Economies of scale and scope as an explanation of merger and output diversification activities in the health maintenance organization industry," *Journal of Health Economics*, 15 (6), 685–713.
- Government Accounting Office (2000), "Medicare Home Health care: Prospective Payment System Could Reverse Recent Declines in Spending," Washington, D.C.: document GAO-HEHS-00-176. <http://www.gao.gov/new.items/he00176.pdf>.
- Grabowski D.C. (2001), "Medicaid reimbursement and the quality of nursing home care," *Journal of Health Economics*, 20 (4), 549–569.
- Grosskopf S. and V. Valdmanis (1987), "Measuring hospital performance: a non-parametric approach," *Journal of Health Economics* 6, 89–107.
- Grosskopf S., Margaritis D. and V. Valdmanis, (2001), "The effects of teaching on hospital productivity," *Socio-Economic Planning Sciences*, 35 (3), 189–204.
- Grosskopf S., Margaritis D. and V. Valdmanis (2004), "Competitive effects on teaching hospitals," *European Journal of Operational Research*, 154 (2), 515–525.

- Han B., Remsburg R.E., Lubitz J. and M. Goulding (2004), "Payment source and length of use among home health agency discharges," *Medical Care*, 42 (11), 1081–1090.
- Harrington C. and J. O'Meara (2004), "Report on California's nursing homes, home health agencies, and hospice programs," *California HealthCare Foundation*, <http://www.chcf.org/documents/hospitals/ReportOnNursingHomeHealthHospice.pdf>
- Harris J.M., Ozgen H. and Y.A. Ozcan (2000), "Do mergers enhance the performance of hospital efficiency?" *Journal of the Operational Research Society*, 51, 801–811.
- Harrison J.P. and C. Sexton (2006), "The improving efficiency frontier of religious not-for-profit hospitals," *Hospital Topics*, 84 (1), 2–10.
- Harrison J.P., Coppola M.N. and M. Wakefield (2004), "Efficiency of federal hospitals in the United States," *Journal of Medical Systems*, 28 (5), 411–422.
- Health, United States (2005), "Chartbook on trends in the health of Americans," *National Center for Health Statistics*. Hyattsville, MD (also, <http://www.cdc.gov/nchs/>).
- Helling D.K., Nelson K.M., Ramirez J.E. and T.L. Humphries (2006), "Kaiser permanente colorado region pharmacy department: innovative leader in pharmacy practice," *Journal of American Pharmacy Association*, 46 (1), 67–76.
- Helmig B. and L. Lapsley (2001), "On the efficiency of public, welfare and private hospitals in Germany over time: a sectoral data envelopment analysis study," *Health Services Management Research*, 14 (4), 263–274.
- Hicks L.L., Rantz M.J., Petroski G.F., Madsen R.W., Conn V.S., Mehr D.R. and R. Porter (1997), "Assessing contributors to cost of care in nursing homes," *Nursing Economics*, 15 (4), 205–212.
- Hollingsworth B. (2003), "Non-Parametric and parametric applications measuring efficiency in health care," *Health Care Management Science*, 6 (4), 203–218.
- Hollingsworth B., Dawson P.J. and N. Manidakis (1999), "Efficiency measurement of health care: a review of non-parametric methods and applications," *Health Care Management Science*, 2 (3), 161–172.
- HQA (200), [http://www.aha.org/aha\\_app/issues/HQA/index.jsp](http://www.aha.org/aha_app/issues/HQA/index.jsp)
- Hsia D.C., Ahern C.A., Ritchie B.P., Moscoe L.M. and W.M. Krushat (1992), "Medicare reimbursement accuracy under the prospective payment system, 1985 to 1988", *Journal of the American Medical Association* 268(7), 896–899.
- Javitt J.C., McBean A.M., Sastry S.S. and F. DiPaolo (1993), "Accuracy of coding in Medicare part B claims", *Archives of Ophthalmology* 111(5), 605–7.
- Kemper P., Komisar H.L. and L. Alexih (2005/2006), "Long-term care over an uncertain future: what can current retirees expect?" *Inquiry*, 42 (4), 333–350.
- Kirigia J.M., Emrouznejad A., Sambo L.G., Munguti N. and W. Liambila (2004), "Using data envelopment analysis to measure the technical efficiency of public health centers in Kenya," *Journal of Medical Systems*, 28 (2), 155–166.
- Kleinsorge I.K. and D.F. Karney (1992), "Management of nursing homes using data envelopment analysis," *Socio-Economic Planning Sciences*, 26 (1), 57–71.
- Knox K.J., Blankmeyer E.C. and J.R. Stutzman (2004), "Administrative compensation and organizational performance in Texas nursing facilities," *Small Business Economics*, 22 (1), 33–49.
- Kooreman P. (1994), "Nursing home care in the netherlands: a nonparametric efficiency analysis," *Journal of Health Economics*, 13 (3), 301–316.
- Laine J., Linna M., Häkkinen U. and A. Noro (2004), "Measuring the productive efficiency and clinical quality of institutional long-term care for the elderly," *Health Economics*, 14 (3), 245–256.
- Laine J., Linna M., Noro A. and U. Häkkinen (2005), "The cost efficiency and clinical quality of institutional long-term care for the elderly," *Health Care Management Science*, 8 (2), 149–156.
- Lee K. and T.T.H. Wan (2004), "Information system integration and technical efficiency in urban hospitals," *International Journal of Healthcare Technology and Management*, 1(3/4), 452.
- Linna M., Nordblad A. and M. Koivu (2003), "Technical and cost efficiency of oral health care provision in Finnish health centres," *Social Science & Medicine*, 56 (2), 343.
- Lynch J.R. and Y.A. Ozcan (1994), "U.S. hospital closures: an efficiency analysis," *Hospital and Health Services Administration* 39 (2), 205–220.

- Malmquist S. (1953), "Index numbers and indifference surfaces," *Trabajos de Estadística*, 4, 209–242.
- McCall N., Petersons A., Moore S. and J. Korb (2003), "Utilization of home health services before and after the balanced Budget Act of 1997: What were the initial effects?" *Health Services Research*, 38 (1), 85–106.
- McCallion G., Glass J.C., Jackson R., Kerr C.A. and D.G. McKilliop (2000), "Investigating productivity change and hospital size: a nonparametric frontier approach," *Applied Economics*, 32, 161–174.
- McKinney M.M., Begun J.W. and Y.A. Ozcan (1998), "Hospital development and OPO performance", *Journal of Transplant Coordination*, 8(2):74–80.
- MECON-Peer Guide (1995). San Ramon, CA.
- MedPAC. (2005a). *Report to the Congress: Medicare Payment Policy*. [http://www.medpac.gov/publications/congressional\\_reports/Mar05.Ch02D.pdf](http://www.medpac.gov/publications/congressional_reports/Mar05.Ch02D.pdf)
- MedPAC. (2005b). *A data Book: Healthcare Spending and the Medicare Program*. <http://www.medpac.gov/publications/chapters/Jun05DataBookSec10.pdf>
- Mobley L.R. and J. Magnussen (1998), "An international comparison of hospital efficiency: does institutional environment matter?" *Applied Economics*, 30 (8), 1089–1100.
- Mobley L.R. and J. Magnussen (2002), "The impact of managed care penetration and hospital quality on efficiency in hospital staffing," *Journal of Health Care Finance*, 28 (4), 24–43.
- Morey R.C., Ozcan Y.A., Retzlaff-Roberts D.L. and D.J. Fine (1995), "Estimating the Hospital-wide cost differentials warranted for teaching hospitals: an alternative to regression approaches." *Medical Care* 33 (5), 531–552.
- National Institutes of Health (1991), "*Guidelines for the Diagnosis and Management of Asthma.*" National Asthma Education Program; Office of Prevention, Education, and Control; National Heart, Lung, and Blood Institute; National Institutes of Health; Bethesda, Maryland; Publication No. 91-3042.
- Nunamaker T.R. and A.Y. Lewin (1983), "Measuring routine nursing service efficiency: a comparison of cost per patient day and data envelopment analysis models/comment," *Health Services Research*, 18 (2 (Part 1)), 183–208.
- Nyman J.A. and D.L. Bricker (1989), "Profit incentives and technical efficiency in the production of nursing home care," *Review of Economics and Statistics*, 71 (4), 586–594.
- Nyman J.A., Bricker D.L. and D. Link (1990), "Technical efficiency in nursing homes," *Medical Care*, 28 (6), 541–551.
- Office of Statewide Health Planning and Development (2006). *Find data – HHA and Hospices Annual Utilization Data*. <http://www.oshpd.state.ca.us/HQAD/HHA/hhautil.htm>
- O'Neal P.V., Ozcan Y.A. and Y. Ma (2002), "Benchmarking mechanical ventilation services in teaching hospitals," *Journal of Medical Systems*, 26 (3), 227–239.
- O'Neill L. (1998), "Multifactor efficiency in data envelopment analysis with an application to urban hospitals," *Health Care Management Science*, 1 (1), 19–27.
- O'Neill L. (2005), "Methods for understanding super-efficient data envelopment analysis results with an application to hospital inpatient surgery," *Health Care Management Science*, Nov 2005 8 (4), 291–298.
- O'Neill L. and F. Dexter (2004), "Market capture of inpatient perioperative services using DEA," *Health Care Management Science*, 7 (4), 263–273.
- O'Neill L., Rauner M., Heidenberger K. and M. Kraus (2007), "A cross-national comparison and taxonomy of DEA-based hospital efficiency studies." *Socio-Economic Planning Sciences*, doi:10.1016/j.seps.2007.03.001.
- Ouellette P. and V. Vierstraete (2004), "Technological change and efficiency in the presence of quasi-fixed inputs: A DEA application to the hospital sector," *European Journal of Operational Research*, 154 (3), 755–763.
- Ozcan Y.A. (1992–1993), "Sensitivity analysis of hospital efficiency under alternative output/input and peer groups: a review," *Knowledge and Policy*, 5 (4), 1–29.
- Ozcan Y.A. (1995), "Efficiency of hospital service production in local markets: the balance sheet of U.S. medical armament," *Socio-Economic Planning Sciences* 29 (2), 139–150.

- Ozcan Y. A. (1998), "Physician benchmarking: measuring variation in practice behavior in treatment of otitis media," *Health Care Management Science*, 1 (1), 5–17.
- Ozcan Y.A. (2005), *Quantitative Methods in Health Care Management: Techniques and Applications*, Jossey-Bass/Wiley: San Francisco, CA.
- Ozcan Y.A. and R.R. Bannick (1994), "Trends in department of defense hospital efficiency," *Journal of Medical Systems*, 18 (2), 69–83.
- Ozcan Y.A. and J.J. Cotter (1994), "An assessment of area agencies on aging in virginia through data envelopment analysis," *Gerontologist* 34 (3), 363–370.
- Ozcan Y.A., Jiang H.J. and C-W. Pai (2000), "Physician Efficiency in Treatment of Sinusitis: Do Primary Care Physicians or Specialist Provide More Efficient Care?" *Health Services Management Research*, 13(2): 90–96.
- Ozcan Y.A. and R.D. Luke (1993), "A national study of the efficiency of hospitals in urban markets," *Health Services Research*, 28 (6), 719–739.
- Ozcan Y.A. and J. Lynch (1992), "Rural hospital closures: an inquiry to efficiency," in eds. Scheffler R.M. and L.F. Rossiter, *Advances in Health Economics and Health Services Research*, 13: 205–224, 1992.
- Ozcan Y.A. and M.J. McCue (1996), "Financial performance index for hospitals," *Journal of Operational Research Society* 47, 18–26.
- Ozgen H. and Y.A. Ozcan (2002), "A national study of efficiency for dialysis centers: an examination of market competition and facility characteristics for production of multiple dialysis outputs," *Health Services Research*, 37 (3), 711–732.
- Ozgen H. and Y.A. Ozcan (2004), "Longitudinal analysis of efficiency in multiple output dialysis markets," *Health Care Management Science* 7 (4), 253–261.
- Ozcan Y.A., Luke R.D. and C. Haksever (1992), "Ownership and organizational performance: a comparison of technical efficiency across hospital types," *Medical Care*, 30 (9), 781–794.
- Ozcan Y.A., Yeh S.-C. and D. McCollum (1996a), "Trends in labor efficiency among American hospital markets," *Annals of Operations Research*, 67, 61–82.
- Ozcan Y.A., McCue M.J. and A.A. Okasha (1996b), "Measuring the Technical efficiency of psychiatric hospitals," *Journal of Medical Systems*, 20 (3), 141–150.
- Ozcan Y.A., Watts J., Harris J.M. and S.E. Wogen (1998a), "Provider experience and technical efficiency in the treatment of stroke patients: DEA approach," *Journal of Operational Research Society*, 49 (6), 573–582.
- Ozcan Y.A., Luu S.K., Glass K.W., Shasky C. and L. F. Rossiter (1998b) "Physician benchmarking for asthma cases with, INFORMS meeting, Montreal, Canada, April 25–27, 1998.
- Ozcan Y.A., Wogen S.E. and L.W. Mau (1998c), "Efficiency evaluation of skilled nursing facilities," *Journal of Medical Systems*, 22(4), 211–224.
- Ozcan Y.A., Begun J.W. and M.M. McKinney (1999), "Benchmarking organ procurement organizations (OPOs): a national study," *Health Services Research*, 34 (4), 853–872.
- Ozcan Y.A., Jiang H.J. and C.-W. Pai (2000), "Physician efficiency in treatment of sinusitis: do primary care physicians or specialist provide more efficient care?" *Health Services Management Research*, 13 (2), 90–96.
- Ozcan Y.A., Merwin E., Lee K. and J.P. Morrissey (2004), "Benchmarking using DEA: the case of mental health organizations," in eds. Brandeau M.L., Sainfort F., and W.P. Pierskalla, *Operations Research and Health Care: A Handbook of Methods and Applications*, Boston, MA: KluwerBoston.
- Pai C-W, Ozcan Y.A. and H.J. Jiang (2000), "Regional variation in physician practice pattern: an examination of technical and cost efficiency for treating sinusitis," *Journal of Medical Systems*, 24 (2), 103–117.
- Payne S.M., Donahue C., Rappo P., McNamara J.J., Bass J., First L., Kulig J., Palfrey S., Siegel B. and C. Homer (1995), "Variations in pediatric pneumonia and bronchitis/asthma admission rates. Is appropriateness a factor?" *Archives of Pediatrics & Adolescent Medicine*, 149(2), 170–173.
- Pina V. and L. Torres (1996), "Methodological aspects in efficiency evaluation of public hospitals," *Financial Accountability & Management*, 12 (1), 21–35.

- Ramanathan T.V., Chandra K.S. and W.M. Thupeng (2003), "A comparison of the technical efficiencies of health districts and hospitals in Botswana," *Development Southern Africa*, 20 (2), 307–320.
- Robinette B.A. and E.V. Helsel (1992), "Ambulatory care review: utilization management illustrated," *American Journal of Medical Quality*, 7 (1), 21–23.
- Rollins J., Lee K., Xu Y. and Y.A. Ozcan (2001), "Longitudinal study of health maintenance organization efficiency," *Health Services Management Research*, 14 (4), 249–262.
- Rosko M.D., Chilingirian J.A., Zinn J.S. and W.E. Aaronson (1995), "The effect of ownership, operating environment and strategic choices on nursing homes efficiency," *Medical Care*, 33 (10), 1001–1021.
- Rosenau P.V. and S.H. Linder (2001), "The comparative performance of for-profit and nonprofit home health care services in the US," *Home Health Care Services Quarterly*, 20 (2), 47–59.
- Rosenman R., Siddharthan K. and M. Ahern (1997), "Output efficiency of health maintenance organizations in Florida," *Health Economics*, 6 (3), 295–302.
- Sahin I and Y.A. Ozcan (2000), "Public sector hospital efficiency for provincial markets in Turkey," *Journal of Medical Systems*, 24 (6), 307–320.
- Schinnar A.P., Kamis-Gould E., Delucia N. and A.B. Rothbard (1990), "Organizational determinants of efficiency and effectiveness in mental health partial care programs," *Health Services Research*, 25 (2), 387–420.
- Schnelle J.F., Simmons S.F., Harrington C., Cadogan M., Garcia E. and B.M. Bates-Jensen (2004), "Relationship of nursing home staffing to quality of care," *Health Services Research*, 39 (2), 225–250.
- Sexton T.R., Leiken A.M., Sleeper S. and A.F. Coburn (1989), "The impact of prospective reimbursement on nursing home efficiency," *Medical Care*, 27 (2), 154–163.
- Sherman H.D. (1984), "Hospital efficiency measurement and evaluation: empirical test of a new technique," *Medical Care* 22 (10), 922–938.
- Sherman H.D. and J. Zhu (2006), *Service Productivity Management: Improving Service Performance Using Data Envelopment Analysis (DEA)*, Springer: Boston, MA.
- Singaroyan R., Seed C.A. and R.M. Egdell (2006), "Is a target culture in health care always compatible with efficient use of resources? A cost-effectiveness analysis of an intervention to achieve thrombolysis targets," *Journal of Public Health*, 28 (1), 31–34.
- Siwolop S. (1989), "Doctored Fees," *Financial World*, 158(16), 64–5.
- Sola M. and D. Prior (2001), "Measuring productivity and quality changes using data envelopment analysis: an application to catalan hospitals," *Financial Accountability and Management*, 17 (3), 219–246.
- Steinmann L. and P. Zweifel (2003), "On the (in)efficiency of Swiss hospitals," *Applied Economics* 35 (3), 361–370.
- Thompson R.G., Langemeier L.N., Lee C.T., Lee E. and R.M. Thrall (1990), "The Role of multiplier bounds in efficiency analysis with application to Kansas farming," *Journal of Econometrics*, 46, 93–108.
- Tyler L.H., Ozcan Y.A. and S.E. Wogen (1995), "Technical efficiency of community mental health centers," *Journal of Medical Systems* 19 (5), 413–423.
- U.S. Census 2000, [www.Allcountries.org](http://www.Allcountries.org)
- Valdmanis V. (1990), "Ownership and technical efficiency of hospitals," *Medical Care*, 28 (6), 552–561.
- Valdmanis V. (1992), "Sensitivity analysis for DEA models: an empirical example using public vs. NFP hospitals," *Journal of Public Economics*, 48 (2), 185–205.
- Valdmanis V., Kumanarayake L. and J. Lertiendumrong (2004), "Capacity in Thai public hospitals and the production of care for poor and non-poor patients," *Health Services Research*, 39 (6), S2117–2135.
- Vitaliano D.F. and M. Toren (1994), "Cost and efficiency in nursing homes: a stochastic frontier approach," *Journal of Health Economics*, 13 (3), 281–300.
- Wang B.B., Ozcan Y.A., Wan T.T.H. and J. Harrison (1999), "Trends in hospital efficiency among metropolitan markets," *Journal of Medical Systems*, 23 (2), 83–97.

- Weech-Maldonado R., Neff G. and V. Mor (2003), "Does quality of care lead to better financial performance? The case of the nursing home industry," *Health Care Management Review*, 28 (3), 201–216.
- White K.R. and Y.A. Ozcan (1996), "Church ownership and hospital efficiency," *Hospital and Health Services Administration*, 41 (3), 297–310.
- Wholey D., Feldman R., Christianson J. and J. Engberg (1996), "Scale and scope economies among health maintenance organizations," *Journal of Health Economics*, 15 (6), 657–684.
- Yeh J., White R.K. and Y.A. Ozcan (1997), "Efficiency evaluation of community-based youth services in Virginia," *The Community Mental Health Journal*, 33 (6), 487–499.
- Zhu J. (2003), *Quantitative Models for Performance Evaluation and Benchmarking: Data Envelopment Analysis with Spreadsheets and DEA Excel Solver*. International Series in Operations Research & Management Science; 51, Boston: Kluwer.



# Index

## A

Academic Medical Center application, 116–117  
Additive model, 71  
Ambulatory clinic visits, 121  
Ambulatory patient visits (APVs), 116  
American Hospital Association (AHA) data, 105  
Association of Organ Procurement Organizations (AOPO), 175  
Assurance regions (AR), 59  
    for inputs, conceptualization of, 60  
    for outputs, conceptualization of, 62  
    ratios with upper and lower bound restrictions for input, 61

## B

Basic frontier models, 23  
Benchmarks, for input-oriented CRS model, 32

## C

Case-mix adjusted admissions, 108  
Case mix adjusted discharges (CMAD), 116  
Center for Medicare and Medicaid Services (CMS), 105, 159, 169  
Community Based Youth Services (CBYS), 174  
Community mental health centers (CMHC), 172  
Cone ratio models, 59–61  
Constant returns frontier, conceptualization, 43, 44

Constant returns to scale (CRS), 23  
    fractional formulation, CRS model, 38  
    model, 24–25  
CRS and VRS models  
    efficiency scores, in basic envelopment models, 54  
    scale efficiency, 54–55  
CRS input-oriented model, results of, 28  
CRS output-oriented model formulation, 41

## D

Data Envelopment Analysis (DEA), 3, 12–15, 21  
    effectiveness measurement, 21  
    efficiency evaluations using, 17  
        allocative efficiency, 19–21  
        price efficiency, 18–19  
        scale efficiency, 17–18  
        technical efficiency, 17  
    efficiency measurement, 16–17  
    in health care, 15  
DEAFrontier envelopment model, 27  
DEAFrontier limited version, software  
    load Excel Solver in Excel 2007, 204  
    load Excel Solver in Excel 97, 2000 and 2003 (XP), 203  
    macro security, 200  
    organization of data, 205  
    run DEAFrontier Software, 204–205  
    Trust Center, check, 202  
DEA models  
    classifications, envelopment models, 24  
    combining efficiency, benchmarks and quality scores, 97–99  
    congestion DEA, 99  
    economies of scope, 99–100

- DEA models (*cont.*)  
 quality  
 as additional output, 93–95  
 incorporation of, 93  
 as independent output, 95–97  
 super efficiency DEA models, 99
- Decision making units (DMU), 15  
 fully efficient and weakly efficient, 40
- Diagnostic related groups (DRGs), 15, 108
- Durable medical equipment, 122
- E**
- Efficiency, defined as, 7
- Efficiency frontier, 22
- Emergency room (ER) visits, 122
- End-stage renal disease (ESRD), 169
- F**
- Federal government hospitals (VA and DoD), 115–116
- Fee-for-service (FFS), 172
- Fisher index, 11
- Full time equivalents (FTEs), 107
- G**
- Gamma-Knife technology, DEA, 17–18
- H**
- Health care  
 DEA in, 15  
 measurement difficulties, 13
- Health care, evaluation of performance, 3  
 comparative performance analysis, methods, 6  
 Data Envelopment Analysis (DEA), 12–13  
 least-squares regression (LSR), 9–11  
 ratio analysis, 7–9  
 Stochastic Frontier Analysis (SFA), 12  
 Total Factor Productivity (TFP), 11–12  
 components of performance, 4  
 measurement difficulties in, 13  
 multi-facility and multi-time performance comparison, 5  
 performance classification schema, 6  
 performance, to measure, 5
- Health Care Financing Administration (HCFA), 159
- Health care managers, 4  
 DEA, for assessment, 17
- Health care organizations, 4
- Health Maintenance Organizations (HMOs), 120, 155  
 evaluation for, 157  
 performance model for, 157  
 performance of, 156
- Home health agencies, 159  
 DEA model, outputs and inputs, 161  
 performance evaluations, data for, 162  
 performance model for, 161  
 performance studies  
 home health services, 160  
 non-profit home health agencies, 160
- Home health agency model  
 DEA analysis, 164–165  
 efficient and inefficient home health agencies, peer group, 165  
 inefficiencies, magnitude of, 166  
 variables by peer group, statistics of, 165  
 homogeneous groups and descriptive statistics, 164  
 inputs and outputs, 162–164
- Home health care industry, 159
- Hospital applications, 109
- Hospital inputs and outputs  
 capital investments, 106  
 inpatient services, 107–108  
 labor, 107  
 operating expenses, 107  
 outpatient visits, 108
- Hospitalization, 122. *See also* Physician practice
- Hospital performance, 10
- Hospital performance ratios, 8, 21. *See also* Data Envelopment Analysis (DEA)
- Hospital Quality Alliance (HQA), 93
- Hospital sector, service production process in, 104–105
- Hospital settings  
 DEA models, for evaluation  
 benchmarking mechanical ventilation services, 182–184  
 hospital closures, 187  
 hospital markets, labor efficiency in, 187–188  
 hospital mergers, 186–187  
 hospital service production, in local markets, 188–189  
 hospital service production, sensitivity analysis for, 189  
 inpatient perioperative services, market capture of, 184–185  
 physicians, hospital setting, 185–186  
 stroke patients treatment, efficiency of, 181–182
- Hospital, standardized efficiency ratios and ranking, 8

**I**

- Independent Renal Facility Cost Report Data (IRFCRD), 169
- Input orientation, 23
- Input-oriented CRS DEA model, 25–28
  - DEAFrontier data setup, 26
  - DEAFrontier run, 27
  - hospital inputs and outputs, 26
- Input-oriented CRS model, efficient target calculations, 40
- Input-oriented measure, specific model
  - efficient target calculations, 80
  - formulation, 79–80
- Input-oriented model
  - input and output efficient targets, 31
  - input and output slacks, 30
- Input-oriented multiplier model, formulation, 68
- Input-oriented VRS DEA model, 48–49
- Input-oriented VRS model, 47–49
  - benchmarks for, 50, 51
  - efficiency scores for, 48
  - efficient target calculations for, 56
  - envelopment model selections for, 48
  - increasing, constant and decreasing returns, 47
  - slacks and efficient targets for, 49–50
  - target report for the, 52
- Interim payment system (IPS), 159

**J**

- J.3 Adjustment Algorithm, 141–142
- J.2 CPT Code Creep, 141

**L**

- Laboratory tests, physician practice, 122
- Large size general hospital performance evaluation, 110–115
- Laspeyres index, 11
- Least-squares regression (LSR), 9
- Longitudinal (panel) evaluations, using DEA
  - Malmquist-DEA efficiency, 84
    - efficiency scores, 89
    - independent efficiency evaluation, 88
  - Malmquist-DEA index, calculations of, 90
  - Malmquist index period, 89
  - results for hospital, 87
  - selection of periods and orientation, 86
  - setup for, 86

**M**

- Malmquist index, 11, 12, 83–84. *See also* Longitudinal (panel) evaluations, using DEA
- Malmquist index based, DEA model, 170
- Measure specific models, 75–78
  - efficient target calculations for
    - input-oriented, 80
  - efficient targets for, 78
  - input-oriented, formulation, 79–80
  - output-oriented and efficient target calculation, 80–81
  - selections, 76
  - setup, 75
  - slacks for, 77
  - solution to measure, 76
- Medical Group Management Association (MGMA), 7
- Medicare beneficiaries, 160
- Medicare certified home health agencies, 160
- Medicare home health care, 160
- Multifactor efficiency (MFE), 104
- Multiplier models
  - results of, 59
  - setup, 58
  - specification, 59
- Multiplier (weight restricted) model, 64–68
  - basic and multiplier (weight) restricted models, comparison, 67
  - CRS input-oriented restricted multiplier model selection, 65
  - data setup for, 64
  - multiplier sheet for both output and input restrictions, 66
  - restricted multiplier solution –ratio 12, 66, 67

**N**

- Non-oriented (slack-based) models, 71–75
  - selections, 72
  - setup, 72
  - slack report, 73
  - solution, 73
  - solution targets, 74
- Non-radial super-efficiency (NRSE), 104
- Nursing homes
  - DEA results of, 151–152
  - evaluations, 148
  - homogeneous groups and descriptive statistics, 150–151
  - inputs of, 149

Nursing homes (*cont.*)  
 outputs of, 149–150  
 performance model for, 146–148  
 performance studies, 144–146

## O

Office of Statewide Health Planning and  
 Development (OSHDP), 162  
 Older Americans Act Funds, 177  
 Older Americans Act of 1965, 176  
 Organ procurement organizations (OPOs), 175  
 Output orientation, 23  
 Output-oriented CRS DEA model, 33–34  
 Output-oriented CRS model  
 efficiency and inefficiency, 35  
 efficient target calculations, 41  
 efficient targets for inputs and outputs, 36  
 slacks, 35–36  
 Output-oriented measure specific models, 80  
 efficient target calculation, 81  
 Output-oriented multiplier model formulation,  
 68–69  
 Output-oriented VRS model, 50–53  
 benchmarks for, 53  
 efficiency results for, 52  
 efficient target calculations, 56  
 slack report for, 52

## P

Pasche index, 11  
 PCP visits, 121  
 Performance, evaluation methods, 6  
 Performance measurement  
 constant returns to scale (CRS) model,  
 24–25  
 DEA frontier, and performance ratios,  
 21–23  
 DMUs consideration, 24  
 efficiency and effectiveness models, 15–21  
 frontier models, 23–24  
 input and output orientation, 23  
 input-oriented model benchmarks, 31–32  
 interpretation of results, 28  
 efficiency and inefficiency, 28–29  
 input and output efficient targets, 30–31  
 slacks, 29–30  
 output-oriented CRS DEA model, use of,  
 33–34  
 output-oriented CRS results, interpretation,  
 34–37  
 output-oriented models, 32–33  
 benchmarks, 37  
 using DEA, 15

Performance ratios, 7–8  
 Physician performance  
 asthma for, 132–137  
 limitations, 137–139  
 otitis media for, 124–126  
 behavior focus, 128–129  
 efficiency focus, 126–128  
 implication of weight restricted practice  
 styles, 129–130  
 sinusitis for, 130–131  
 Physician practice  
 applications, 124  
 inputs, 121  
 and production of services, 120–121  
 Primary care physician (PCP) models, 119  
 Prospective payment system (PPS), 141

## R

Radiology, physician practice inputs, 122  
 Relative value units (RVUs), 116  
 Relative weighted product (RWP), 116  
 Resource based relative value schedule  
 (RBRVS), 15  
 Returns to scale (RTS), 44  
 assessment, 47  
 constant returns frontier, 43  
 variable returns frontier, 43–47

## S

Scale efficiency (SE), 54  
 Scale models, 43  
 Selected health service providers, performance  
 models  
 aging agencies, 176–178  
 DEA model for, 178  
 community based youth services, 174–175  
 DEA model for, 174  
 community mental health centers, 171–174  
 DEA model for, 173  
 dental providers, 178–179  
 DEA model, performance on restorations,  
 179  
 dialysis centers, 169–171  
 CRS input-oriented model and evaluation,  
 171  
 DEA model for, 170  
 independent renal facility cost report data  
 files, 170  
 organ procurement organizations, 175–176  
 DEA model for, 176  
 Seriously mentally ill (SMI), 172  
 Skilled nursing, 159

Slack-based model, 71  
Slacks, mathematical details, 39–40  
Specialists visits, 121  
Stochastic Frontier Analysis (SFA), 12  
Stochastic frontier model, 12  
Supplemental security income (SSI), 172

**T**

TFP<sub>ab</sub> index, 11  
Tornqvist index, 11  
Total Factor Productivity (TFP), 11

**U**

United Network for Organ Sharing (UNOS),  
175  
Upper and lower bound weights, assessment,  
61–63

restriction ratio, 63

**V**

Variable returns frontier, 43–47  
  conceptualization of, 45  
Variable returns-to-scale (VRS), 23  
VRS input-oriented model  
  efficiency scores for, 48  
  envelopment model selections for, 48  
  formulation, 55  
VRS output-oriented model  
  envelopment model selections, 51  
  formulation, 56  
VRS production frontier, conceptualization, 45

**W**

Weights assessment, 38–39

## Running the DEA Frontier Limited Version

Before you run the DEA Frontier software .....	206
Load Excel Solver in Excel 97, 2000 and 2003 (XP) .....	209
Load Excel Solver in Excel 2007 .....	210
Run the DEA Frontier Software .....	210
Organization of the Data .....	211

© Joe Zhu

[www.deafrontier.com](http://www.deafrontier.com)

## Before you run the DEAFrontier software

Before you load the DEAFrontierFree software, the Excel program must be open/loaded first. And then the Solver Parameters dialog box must at least be displayed once in your Excel session. Otherwise, an error (shown in Figure 1) may occur when you run the software. This error message means that the Excel Solver is not found by the DEAFrontier software. *(If the DEAFrontier software is installed in the directory where the Excel Solver is installed, you may not need to load the Excel Solver first.)*

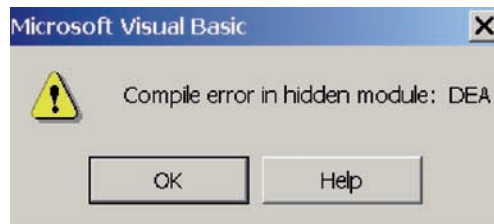
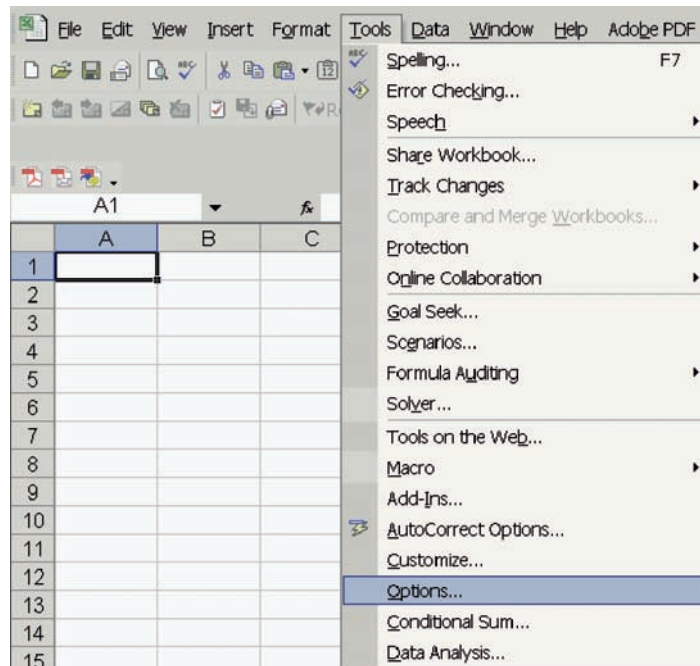
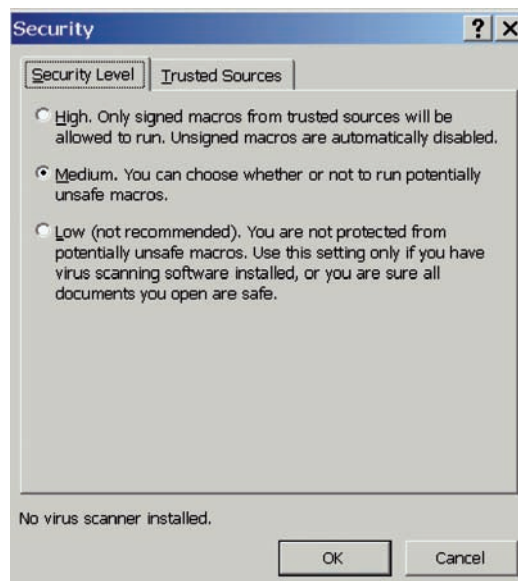
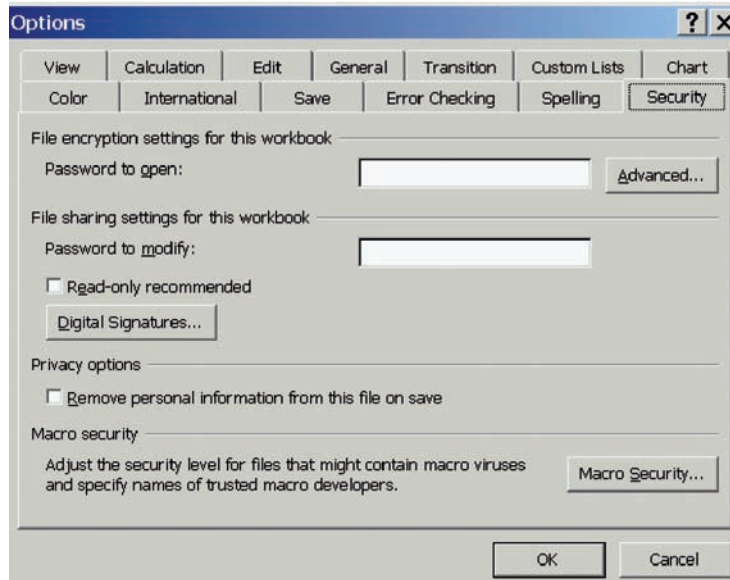


Figure 1

Please also set the Macro Security to Medium Level in the Excel. This can be done by selecting the Tools/Options menu item as shown in the following

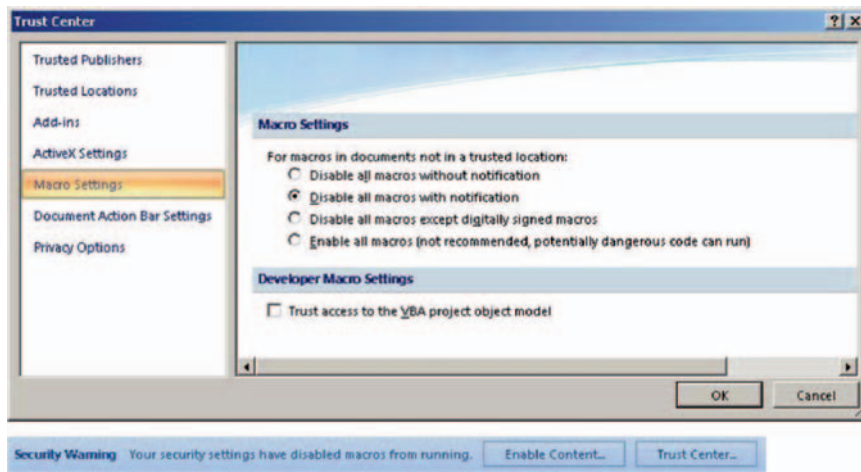


In the Option menu item, click the Macro Security button and then select the “Medium” option.





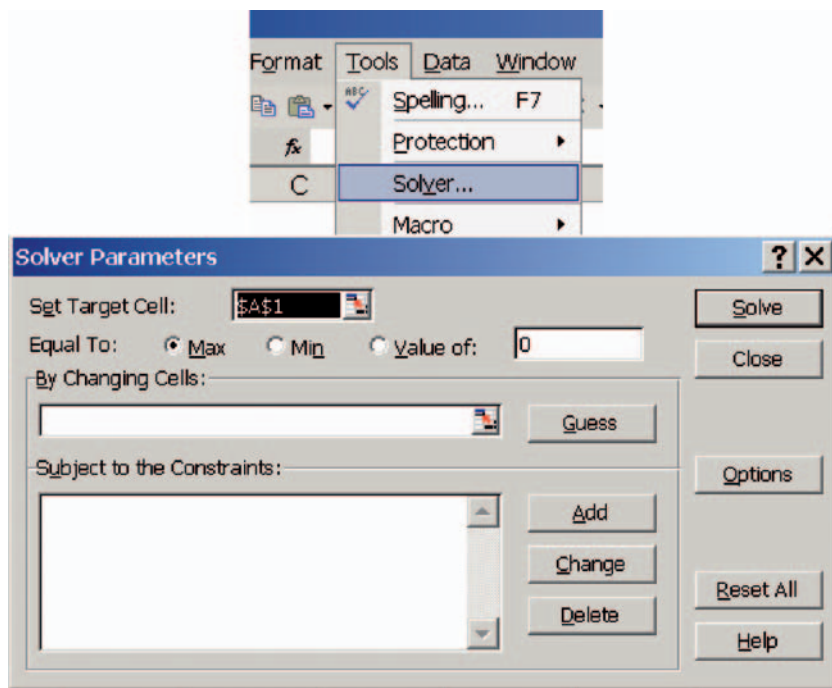
**If you are using Excel 2007**, you need to do this in the Trust Center: check (1) enable all macros and (2) Trust access to the VBA project object model. You may also need to specify the directory where the DEAFrontier software is located as “Trusted Locations”.



## Load Excel Solver in Excel 97, 2000 and 2003 (XP)

You may use the following steps. (Close the DEAFrontier if it is already opened using the “Quit” menu item.)

**Step 1:** Open Excel, and then load Solver parameters dialog box by using the Tools/Solver menu item.



**Step 2:** Click Close to close the Solver parameters dialog box. Now, the Solver has been loaded.

*If Solver does not exist in the Tools menu, you need to select Tools/Add-Ins, and check the Solver box, as shown in Figure 2. (If Solver does not show in the Add-Ins, you need to install the Solver first.)*

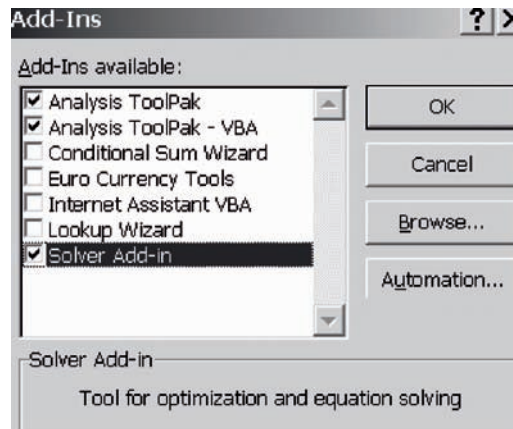



Figure 2

## Load Excel Solver in Excel 2007

1. Click the **Microsoft Office Button** , and then click **Excel Options**.
2. Click **Add-Ins**, and then in the **Manage** box, select **Excel Add-ins**.
3. Click **Go**.
4. In the **Add-Ins available** box, select the **Solver Add-in** check box, and then click **OK**.
 

**Tip:** If **Solver Add-in** is not listed in the **Add-Ins available** box, click **Browse** to locate the add-in.

If you get prompted that the Solver Add-in is not currently installed on your computer, click **Yes** to install it.
5. After you load the Solver Add-in, the **Solver** command is available in the **Analysis** group on the **Data** tab.

## Run the DEAFrontier Software

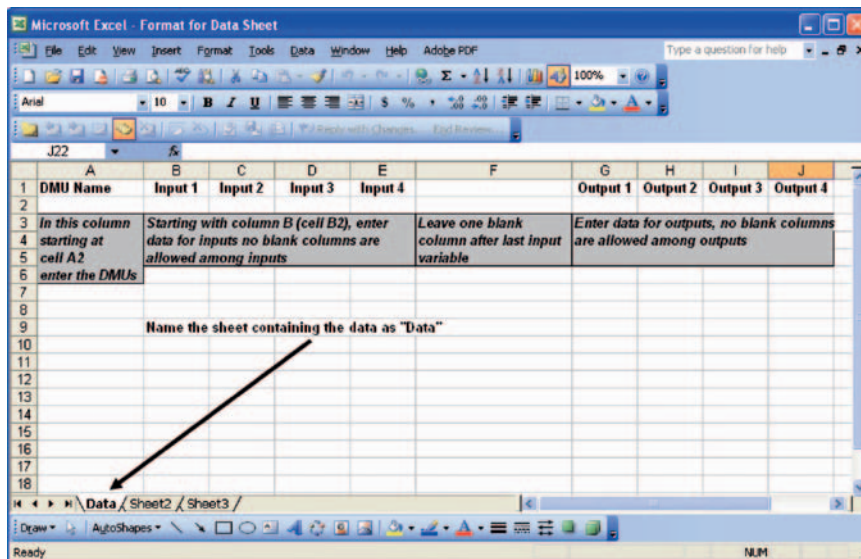
Load the DEA software by opening (i) "DEAFrontier Limited.xla" for Excel 97, 2000 and 2003, or (ii) "DEAFrontier Limited2007.xlam" for Excel 2007.

You will see a new Menu item “DEA” at the end of Excel Menu. Now, the software is ready to run. (Please see the Format for Data Sheet for proper setup of data sets.)

**For Excel 2007:** to locate the DEA Menu, Office 2007 users select the Add-Ins tab and navigate to the DEA menu option. The DEA menus will not always be visible, as they were in Office 2003. Users can move individual commands to a small Quick Access bar in Office 2007 to make them visible all the time.

*Please make sure that the Excel Solver works properly. One can use the file “solvtest.xls” to test whether the Excel Solver works. This test file is available at [www.deafrontier.com/solvtest.xls](http://www.deafrontier.com/solvtest.xls).)*

## Organization of the Data



## About the Author

*Yasar A. Ozcan, Ph.D.*  
*Professor,*  
*Department of Health Administration*  
*Virginia Commonwealth University*  
*Richmond, Virginia USA*  
*ozcan@vcu.edu*



Yasar A. Ozcan, Ph.D. is a Professor in the Department of Health Administration, Virginia Commonwealth University (VCU), where he has served as faculty member over 28 years. He teaches quantitative health care management courses in graduate professional programs in health administration, and methodology courses at the doctoral level, including data envelopment analysis (DEA).

Professor Ozcan's scholarly work is in the areas of health systems productivity, technical efficiency, financial efficiency, and effectiveness. Specifically, he has

applied DEA to measure efficiency across the range of health care facilities including hospitals, nursing homes, health maintenance organizations, mental health care organizations, physician practices, and other facilities. He has presented numerous research papers at professional meetings and published extensively. His work has been published in journals such as *Health Services Research*, *Medical Care*, *Health Care Management Science*, *Health Services Management Research*, *Journal of Medical Systems*, *Socio-Economic Planning Sciences*, *Annals of Operations Research*, *Journal of Operational Research Society* and the *Journal of Operational Research*. Professor Ozcan authored another text book *Quantitative Methods in Health Care Management: Techniques and Applications* (Jossey-Bass/Wiley, 2005) that is geared toward practicing health care managers and health care management students at the master's level.

He has served twice as President of the Health Applications Section in the Institute of Operations Research and Management Science (INFORMS). Professor Ozcan is the founding Editor in Chief of a highly regarded journal, *Health Care Management Science*, and co-editor of the *Journal of Central Asian Health Services Research*. He has been principal and co-principal investigator on various federal, state grants and international contracts. He has also provided management consultancy services to health care facilities and managed care organizations including: hospitals, physician practices and HMOs on reengineering and lean management. For further information on his research, please visit <http://www.had.vcu.edu/~ozcan/>.

**Early titles in the INTERNATIONAL SERIES IN OPERATIONS  
RESEARCH & MANAGEMENT SCIENCE**

**Frederick S. Hillier, Series Editor, Stanford University**

- Saigal/ *A MODERN APPROACH TO LINEAR PROGRAMMING*  
Nagurney/ *PROJECTED DYNAMICAL SYSTEMS & VARIATIONAL INEQUALITIES WITH APPLICATIONS*  
Padberg & Rijal/ *LOCATION, SCHEDULING, DESIGN AND INTEGER PROGRAMMING*  
Vanderbei/ *LINEAR PROGRAMMING*  
Jaiswal/ *MILITARY OPERATIONS RESEARCH*  
Gal & Greenberg/ *ADVANCES IN SENSITIVITY ANALYSIS & PARAMETRIC PROGRAMMING*  
Prabhu/ *FOUNDATIONS OF QUEUEING THEORY*  
Fang, Rajasekera & Tsao/ *ENTROPY OPTIMIZATION & MATHEMATICAL PROGRAMMING*  
Yu/ *OR IN THE AIRLINE INDUSTRY*  
Ho & Tang/ *PRODUCT VARIETY MANAGEMENT*  
El-Taha & Stidham/ *SAMPLE-PATH ANALYSIS OF QUEUEING SYSTEMS*  
Miettinen/ *NONLINEAR MULTIOBJECTIVE OPTIMIZATION*  
Chao & Huntington/ *DESIGNING COMPETITIVE ELECTRICITY MARKETS*  
Weglarz/ *PROJECT SCHEDULING: RECENT TRENDS & RESULTS*  
Sahin & Polatoglu/ *QUALITY, WARRANTY AND PREVENTIVE MAINTENANCE*  
Tavares/ *ADVANCES MODELS FOR PROJECT MANAGEMENT*  
Tayur, Ganeshan & Magazine/ *QUANTITATIVE MODELS FOR SUPPLY CHAIN MANAGEMENT*  
Weyant, J./ *ENERGY AND ENVIRONMENTAL POLICY MODELING*  
Shanthikumar, J.G. & Sumita, U./ *APPLIED PROBABILITY AND STOCHASTIC PROCESSES*  
Liu, B. & Esogbue, A.O./ *DECISION CRITERIA AND OPTIMAL INVENTORY PROCESSES*  
Gal, T., Stewart, T.J., Hanne, T. / *MULTICRITERIA DECISION MAKING: Advances in MCDM Models, Algorithms, Theory, and Applications*  
Fox, B.L. / *STRATEGIES FOR QUASI-MONTE CARLO*  
Hall, R.W. / *HANDBOOK OF TRANSPORTATION SCIENCE*  
Grassman, W.K. / *COMPUTATIONAL PROBABILITY*  
Pomerol, J-C. & Barba-Romero, S. / *MULTICRITERION DECISION IN MANAGEMENT*  
Axsäter, S. / *INVENTORY CONTROL*  
Wolkowicz, H., Saigal, R., & Vandenberghe, L. / *HANDBOOK OF SEMI-DEFINITE PROGRAMMING: Theory, Algorithms, and Applications*  
Hobbs, B.F. & Meier, P. / *ENERGY DECISIONS AND THE ENVIRONMENT: A Guide to the Use of Multicriteria Methods*  
Dar-El, E. / *HUMAN LEARNING: From Learning Curves to Learning Organizations*  
Armstrong, J.S. / *PRINCIPLES OF FORECASTING: A Handbook for Researchers and Practitioners*  
Balsamo, S., Personé, V., & Onvural, R./ *ANALYSIS OF QUEUEING NETWORKS WITH BLOCKING*  
Bouyssou, D. et al. / *EVALUATION AND DECISION MODELS: A Critical Perspective*  
Hanne, T. / *INTELLIGENT STRATEGIES FOR META MULTIPLE CRITERIA DECISION MAKING*  
Saaty, T. & Vargas, L. / *MODELS, METHODS, CONCEPTS and APPLICATIONS OF THE ANALYTIC HIERARCHY PROCESS*  
Chatterjee, K. & Samuelson, W. / *GAME THEORY AND BUSINESS APPLICATIONS*  
Hobbs, B. et al. / *THE NEXT GENERATION OF ELECTRIC POWER UNIT COMMITMENT MODELS*  
Vanderbei, R.J. / *LINEAR PROGRAMMING: Foundations and Extensions, 2nd Ed.*  
Kimms, A. / *MATHEMATICAL PROGRAMMING AND FINANCIAL OBJECTIVES FOR SCHEDULING PROJECTS*  
Baptiste, P., Le Pape, C. & Nuijten, W. / *CONSTRAINT-BASED SCHEDULING*  
Feinberg, E. & Shwartz, A. / *HANDBOOK OF MARKOV DECISION PROCESSES: Methods and Applications*  
Ramík, J. & Vlach, M. / *GENERALIZED CONCAVITY IN FUZZY OPTIMIZATION AND DECISION ANALYSIS*  
Song, J. & Yao, D. / *SUPPLY CHAIN STRUCTURES: Coordination, Information and Optimization*  
Kozan, E. & Ohuchi, A. / *OPERATIONS RESEARCH/ MANAGEMENT SCIENCE AT WORK*

**Early titles in the INTERNATIONAL SERIES IN OPERATIONS  
RESEARCH & MANAGEMENT SCIENCE**

*(Continued)*

- Bouyssou et al. / *AIDING DECISIONS WITH MULTIPLE CRITERIA: Essays in Honor of Bernard Roy*
- Cox, Louis Anthony, Jr. / *RISK ANALYSIS: Foundations, Models and Methods*
- Dror, M., L'Ecuyer, P. & Szidarovszky, F. / *MODELING UNCERTAINTY: An Examination of Stochastic Theory, Methods, and Applications*
- Dokuchaev, N. / *DYNAMIC PORTFOLIO STRATEGIES: Quantitative Methods and Empirical Rules for Incomplete Information*
- Sarker, R., Mohammadian, M. & Yao, X. / *EVOLUTIONARY OPTIMIZATION*
- Demeulemeester, R. & Herroelen, W. / *PROJECT SCHEDULING: A Research Handbook*
- Gazis, D.C. / *TRAFFIC THEORY*
- Zhu / *QUANTITATIVE MODELS FOR PERFORMANCE EVALUATION AND BENCHMARKING*
- Ehrgott & Gandibleux / *MULTIPLE CRITERIA OPTIMIZATION: State of the Art Annotated Bibliographical Surveys*
- Bienstock / *Potential Function Methods for Approx. Solving Linear Programming Problems*
- Matsatsinis & Siskos / *INTELLIGENT SUPPORT SYSTEMS FOR MARKETING DECISIONS*
- Alpern & Gal / *THE THEORY OF SEARCH GAMES AND RENDEZVOUS*
- Hall / *HANDBOOK OF TRANSPORTATION SCIENCE - 2<sup>nd</sup> Ed.*
- Glover & Kochenberger / *HANDBOOK OF METAHEURISTICS*
- Graves & Ringuest / *MODELS AND METHODS FOR PROJECT SELECTION: Concepts from Management Science, Finance and Information Technology*
- Hassin & Haviv / *TO QUEUE OR NOT TO QUEUE: Equilibrium Behavior in Queueing Systems*
- Gershwin et al / *ANALYSIS & MODELING OF MANUFACTURING SYSTEMS*
- Maros / *COMPUTATIONAL TECHNIQUES OF THE SIMPLEX METHOD*
- Harrison, Lee & Neale / *THE PRACTICE OF SUPPLY CHAIN MANAGEMENT: Where Theory and Application Converge*
- Shanthikumar, Yao & Zijm / *STOCHASTIC MODELING AND OPTIMIZATION OF MANUFACTURING SYSTEMS AND SUPPLY CHAINS*
- Nabrzyski, Schopf & Weglarz / *GRID RESOURCE MANAGEMENT: State of the Art and Future Trends*
- Thissen & Herder / *CRITICAL INFRASTRUCTURES: State of the Art in Research and Application*
- Carlsson, Fedrizzi, & Fullér / *FUZZY LOGIC IN MANAGEMENT*
- Soyer, Mazzuchi & Singpurwalla / *MATHEMATICAL RELIABILITY: An Expository Perspective*
- Chakravarty & Eliashberg / *MANAGING BUSINESS INTERFACES: Marketing, Engineering, and Manufacturing Perspectives*
- Talluri & van Ryzin / *THE THEORY AND PRACTICE OF REVENUE MANAGEMENT*
- Kavadias & Loch / *PROJECT SELECTION UNDER UNCERTAINTY: Dynamically Allocating Resources to Maximize Value*
- Brandeau, Sainfort & Pierskalla / *OPERATIONS RESEARCH AND HEALTH CARE: A Handbook of Methods and Applications*
- Cooper, Seiford & Zhu / *HANDBOOK OF DATA ENVELOPMENT ANALYSIS: Models and Methods*
- Luenberger / *LINEAR AND NONLINEAR PROGRAMMING, 2<sup>nd</sup> Ed.*
- Sherbrooke / *OPTIMAL INVENTORY MODELING OF SYSTEMS: Multi-Echelon Techniques, Second Edition*
- Chu, Leung, Hui & Cheung / *4th PARTY CYBER LOGISTICS FOR AIR CARGO*
- Simchi-Levi, Wu & Shen / *HANDBOOK OF QUANTITATIVE SUPPLY CHAIN ANALYSIS: Modeling in the E-Business Era*
- Gass & Assad / *AN ANNOTATED TIMELINE OF OPERATIONS RESEARCH: An Informal History*
- Greenberg / *TUTORIALS ON EMERGING METHODOLOGIES AND APPLICATIONS IN OPERATIONS RESEARCH*



***Early titles in the* INTERNATIONAL SERIES IN OPERATIONS  
RESEARCH & MANAGEMENT SCIENCE**

*(Continued)*

Weber/ *UNCERTAINTY IN THE ELECTRIC POWER INDUSTRY: Methods and Models for Decision Support*

Figueira, Greco & Ehrgott/ *MULTIPLE CRITERIA DECISION ANALYSIS: State of the Art Surveys*

Reveliotis/ *REAL-TIME MANAGEMENT OF RESOURCE ALLOCATIONS SYSTEMS: A Discrete Event Systems Approach*

Kall & Mayer/ *STOCHASTIC LINEAR PROGRAMMING: Models, Theory, and Computation*

Sethi, Yan & Zhang/ *INVENTORY AND SUPPLY CHAIN MANAGEMENT WITH FORECAST UPDATES*

Cox/ *QUANTITATIVE HEALTH RISK ANALYSIS METHODS: Modeling the Human Health Impacts of Antibiotics Used in Food Animals*

Ching & Ng/ *MARKOV CHAINS: Models, Algorithms and Applications*

Li & Sun/ *NONLINEAR INTEGER PROGRAMMING*

Kaliszewski/ *SOFT COMPUTING FOR COMPLEX MULTIPLE CRITERIA DECISION MAKING*

***\* A list of the more recent publications in the series is at the front of the book \****