

University of Groningen

Asset liability management for pension funds using multistage mixed-integer stochastic programming

Drijver, S.J.

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

2005

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Drijver, S. J. (2005). *Asset liability management for pension funds using multistage mixed-integer stochastic programming*. [Thesis fully internal (DIV), University of Groningen]. s.n.

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Bibliography

- [1] Algemeen Burgerlijk Pensioenfonds. World Wide Web, <http://www.abp.nl>, 2002.
- [2] P. Bernstein. What rate of return can you reasonably expect... or what can the long run tell us about the short run? *Financial Analysts Journal*, vol. 53, no 2. March-April, 20-28, 1997.
- [3] J.R. Birge and F. Louveaux. *Introduction to stochastic programming*. Springer-Verlag, 1997.
- [4] G.O. Bierwag, G. Kaufman, and A. Toevs. Immunization strategies for funding multiple liabilities. *Journal of Financial and Quantitative Analysis*, 18:113-123, 1983.
- [5] F. Black and M. Scholes. The pricing of options and corporate liabilities. *Journal of Political Economy*, 81:637-659, 1973.
- [6] H. Blommestein. Ageing populations and the role of the financial system in the provision of retirement income. Research Report OECD, 1998.
- [7] C.G.E. Boender, P.C. van Aalst, and F. Heemskerk. Modelling and management of assets and liabilities of pension plans in The Netherlands. Research Report 9709, Erasmus University Rotterdam, 1997.
- [8] E. Bogentoft, H.E. Romeijn, and S. Uryasev. Asset/liability management for pension funds using CVaR constraints. Research report #2001 – 10, World Wide Web, http://ise.ufl.edu/uryasev/WP_multi_JRB.pdf, 2001.
- [9] T. Bollerslev. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31:307-327, 1986.
- [10] T. Bollerslev and J. Wooldridge. Quasi-maximum likelihood estimation and inference in dynamic models with time varying covariances. *Econometric Reviews*, 11:143-172, 1992.
- [11] T. Bollerslev, R.F. Engle, and D.B. Nelson. ARCH models. In: R.F. Engle and D. McFadden, editors, *Handbook of econometrics*, chapter 49, volume IV, pages 2959-3038, Elsevier, 1994.

- [12] S.P. Bradley and D.B. Crane. A dynamic model for bond portfolio management. *Management Science*, 19:139-151, 1972.
- [13] J. Campbell, A. Lo, and C. MacKinlay. *The Econometrics of financial markets*. Princeton University Press, 1997.
- [14] D.R. Cariño, T. Kent, D.H. Myers, C. Stacy, M. Sylvanus, A. Turner, K. Watanabe, and W.T. Ziemba. The Russell-Yasuda Kasai model: an asset liability model for a Japanese insurance company using multistage stochastic programming. *Interfaces*, 21:29-49, 1994.
- [15] D.R. Cariño and A.L. Turner. Multiperiod asset allocation with derivative assets. In: W.T. Ziemba and J.M. Mulvey, editors, *Worldwide asset and liability modeling*, chapter 9, pages 182-204. Cambridge University Press, 1998.
- [16] Centraal Bureau voor de Statistiek. World Wide Web, <http://www.cbs.nl>, 2002.
- [17] G. Consigli and M.A.H. Dempster. Dynamic stochastic programming for asset liability management. *Annals of Operations Research*, 81:131-162, 1998.
- [18] J.C. Cox, J.E. Ingersoll, and S.A. Ross. *A theory of the term structure of interest rates*, 53:385-407, 1985.
- [19] CRSP. Center for Research in Stock Prices. World Wide Web, <http://gsbwww.uchicago.edu/research/crsp/>, 2001.
- [20] Datastream. World Wide Web, <http://www.datastream.com>, 2001.
- [21] J.E.H. Davidson, D.F. Hendry, F. Srba, and S. Yeo. Econometric modeling of the aggregate time-series relationship between consumer's expenditure and income in the United Kingdom. *Economic Journal*, 88:661-692, 1978.
- [22] E.P. Davis. *Pension funds: retirement-income security, and capital markets, an international perspective*. Oxford University Press, 1995.
- [23] M.A.H. Dempster and A.M. Ireland. A financial expert decision support system In: G. Mitra et al., editors, *Mathematical models for decision support*, pages 415-440. Springer-Verlag, 1988.
- [24] C.L. Dert. *Asset liability management for pension funds: a multistage chance constrained programming approach*. PhD thesis, Erasmus University Rotterdam, The Netherlands, 1995.
- [25] D. Dickey and W. Fuller. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74:427-431, 1979.
- [26] De Nederlandsche Bank. World Wide Web, <http://www.dnb.nl>, 2001.
- [27] S.J. Drijver, W.K. Klein Haneveld, and M.H. van der Vlerk. Asset liability management modeling using multistage mixed-integer stochastic programming. In: B. Scherer, editor, *Asset and liability management tools: a handbook for best practice*, chapter 16, pages 309-324. Risk Books, London, 2003.

- [28] J. Dupačová, G. Consigli, and S.W. Wallace. Scenarios for multistage stochastic programs. *Annals of Operations Research*, 100:25-53, 2000.
- [29] J. Dupačová and J. Polívka. Asset-liability management for Czech pension funds using stochastic programming. Stochastic Programming E-Print Series, 2004-1, World Wide Web, <http://www.hera.rz.hu-berlin.de/speps/artikel/DuPo103.pdf>, 2004.
- [30] H.A. Eiselt and C.L. Sandblom. *Integer programming and network models*. Springer Verlag, 2000.
- [31] R.F. Engle. Autoregressive conditional heteroskedasticity with estimates of the variance of UK inflation. *Econometrica*, 50:987-1008, 1982.
- [32] F. Fabozzi and T.D. Fabozzi. *Bond markets, analysis and strategies*. Prentice Hall, 1989.
- [33] E. Fama and K. French. Dividend yields and expected stock returns. *Journal of Financial Economics*, 22:3-27, 1988.
- [34] K. French, G. Schwert, and R. Stambaugh. Expected stock returns and volatility. *Journal of Financial Economics*, 19:3-30, 1987.
- [35] J.M.G. Frijns and J.H.W. Goslings. Matching voor het pensioenbedrijf. *Economisch Statistische Berichten*, 868-871, 1989.
- [36] M. Gordon. *The investment, financing, and valuation of the corporation*. Irwin, 1962.
- [37] C.W.J. Granger and A.A. Weiss. Time-series analysis of error-correction models. In: S. Karlin, T. Amemiya, and L.A. Goodman, editors, *Studies in econometrics, time series and multivariate statistics*, Academic Press, New York, 1983.
- [38] J.M. Harrison and D.M. Kreps. Martingales and arbitrage in multiperiod securities markets. *Journal of Economic Theory*, 20:381-408, 1979.
- [39] R.A. Haugen. *Modern investment theory*. Prentice Hall, 1997.
- [40] R.S. Hiller and C. Schaack. A classification of structured bond portfolio modeling techniques. *The Journal of Portfolio Management*, 37-48, 1990.
- [41] P. Hilli, M. Koivu, T. Pennanen and A. Ranne. A stochastic programming model for asset liability management of a Finnish pension company. Stochastic Programming E-Print Series, 2003-9, <http://www.speps.info>, 2003.
- [42] K. Høyland, M. Kaut, and S.W. Wallace. A heuristic for moment-matching scenario generation. *Computational Optimization and Applications*, 24 (2-3):169-185, 2003.
- [43] R.G. Ibbotson and R.A. Sinquefeld. *Stocks, bonds, bills and inflation: the past and the future*. SBBI, 1996.

- [44] D. Jacob, G. Lord, and J. Tilley. A general framework for pricing contingent cash flows. *Financial Management*, 5-14, 1987.
- [45] R. Jagannathan, E.R. McGrattan, and A. Scherbina. The declining U.S. equity premium. *Federal Reserve Bank of Minneapolis Quarterly Review*, 24 (4):3-19, Fall 2000.
- [46] S. Johansen. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12:231-254, 1988.
- [47] P. Kall and S.W. Wallace. *Stochastic Programming*. Wiley, 1994.
- [48] J.G. Kallberg, R.W. White, and W.T. Ziemba. Short term financial planning under uncertainty. *Management Science*, 28:670-682, 1982.
- [49] P. Klaassen. *Stochastic programming models for interest-rate management*, PhD thesis, MIT, 1994.
- [50] P. Klaassen. Dcretized reality and spurious profits in stochastic programming models for asset/liability management. *European Journal of Operations Research*, 101:374-392, 1997.
- [51] H.A. Klein Haneveld. *Solvabiliteitscriteria voor pensioenfondsen*, PhD thesis, University of Groningen, The Netherlands, 1999.
- [52] H.A. Klein Haneveld. *Op weg naar solvabiliteitscriteria voor pensioenfondsen*. Stichting Pensioenwetenschap, 1998.
- [53] W.K. Klein Haneveld. *Duality in stochastic linear and dynamic programming*, volume 274 of *Lecture Notes in Economics and Mathematical Systems*. Springer-Verlag, Berlin, 1986.
- [54] W.K. Klein Haneveld and M.H. van der Vlerk. Integrated chance constraints: reduced forms and an algorithm. SOM Research Report 02A33, University of Groningen, 2000. To appear in *Computational Management Science*.
- [55] R. Kouwenberg. Scenario generation and stochastic programming models for asset liability management. *European Journal of Operations Research*, 134: 279-292, 2001.
- [56] M. Kritzman. What practitioners need to know ... about time diversification. *Financial Analysts Journal*, vol. 50, no. 1, January-February, pages 14-18, 1994.
- [57] M.I. Kusy and W.T. Ziemba. A bank asset and liability model. *Operations Research*, 34:356-376, 1986.
- [58] A. Laboul. Maintaining prosperity in an aging society: the OECD study on the policy implications of ageing. Working Paper OECD, 1998.
- [59] M. Lane and P. Hutchinson. A model for managing a certificate of deposit portfolio under uncertainty. In: M.A.H. Dempster, editor, *Stochastic programming*, pages 473-496, Academic Press, 1980.

- [60] G. Ljung and G. Box. On a measure of lack of fit in time series models. *Biometrika* 65:297-303, 1978.
- [61] A. Lo and A.C. MacKinlay. Stock market prices do not follow random walks: evidence from a simple specification test. *Review of Financial Studies*, 1:41-66, 1988.
- [62] F.R. Macaulay. *Some theoretical problems suggested by the movement of interest rates, bond yields, and stock prices in the United States since 1856*. Columbia University Press, 1938.
- [63] G.S. Maddala and In-Moo Kim. *Unit roots, cointegration, and structural change*. Cambridge University Press, 1998.
- [64] R.A.H. van der Meer. Matching bij pensioenfondsen van vitaal belang. *Tijdschrift voor Financieel Management*, september/oktober, 5:20-28, 1989.
- [65] N.G. Mankiw. *Macroeconomics*. Worth, New York, 2003.
- [66] Microsoft Visual C++. World Wide Web, <http://msdn.microsoft.com/visualc>, 2002.
- [67] J.M. Mulvey, S. Correnti, and J. Lummis. Total integrated risk management: insurance elements. *Princeton University Report*, SOR-97-2, 1997.
- [68] J.M. Mulvey and H. Vladimirov. Stochastic network optimization models for investment planning. *Annals of Operations Research*, 20:187-217, 1989.
- [69] P. Norris and S. Epstein. Funding the immunizing investment for insurance liabilities: the case of the SPDA. Study Note 380-22-91, Society of Actuaries, Schaumburg, Illinois, 1989.
- [70] Organisation for Economic Co-operation and Development. World Wide Web, <http://www.oecd.org>, 2001.
- [71] Optimization Solutions and Library (OSL). World Wide Web, <http://www.research.ibm.com/osl>, 2002.
- [72] Optimization Solutions and Library (OSL) Stochastic Extensions. World Wide Web, <http://www-3.ibm.com/software/data/bi/osl/features/stex.html>, 2002.
- [73] Pensioen- & Verzekeringkamer. *De uitgangspunten voor een financieel toetsingskader*, Koninklijke BDU Grafisch Bedrijf B.V., 2002.
- [74] Pensioen- & Verzekeringkamer. *Uitgangspunten voor de financiële opzet en de positie van pensioenfondsen*, 2002. World Wide Web, http://www.watsonwyatt.com/europe/netherlands/news/articles/2003_08.asp, 2002.
- [75] Pensioen- & Verzekeringkamer. World Wide Web, <http://www.pvk.nl>, 2002.

- [76] Pensioenfonds voor de Gezondheidszorg, Geestelijke en Maatschappelijke Belangen (PGGM). World Wide Web, <http://www.pggm.nl>, 2002.
- [77] G.C. Pflug. Scenario tree generation for multiperiod financial optimization by optimal discretization. *Mathematical Programming Series B*, 89:251-271, 2001.
- [78] S.R. Pliska. *Introduction to mathematical finance*, Blackwell, 1997.
- [79] J. Poterba and L. Summers. Mean reversion in stock returns: evidence and implications. *Journal of Financial Economics*, 22:27-60, 1988.
- [80] A. Prékopa. *Stochastic programming*. Kluwer Academic Publishers Group, 1995.
- [81] F.M. Redington. Review of the principle of life office valuations. *Journal of the Institute of Actuaries*, 18:286-340, 1952.
- [82] W. Römisch and R. Schultz. Multistage stochastic integer programs: an introduction. In: M. Grötchel, S.O. Krumke, and J. Rambau, editors, *Online Optimization of Large Scale Systems*, pages 581-600. Springer, Berlin, 2001.
- [83] M. Rudolf and H. Zimmermann. An algorithm for international portfolio selection and optimal currency hedging. In: W.T. Ziemba and J.M. Mulvey, editors, *Worldwide asset and liability modeling*, pages 315-340, Cambridge University Press, 1998.
- [84] J.D. Sargan. Wages and prices in the United Kingdom: a study in econometric methodology. In: P.E. Hart, G. Mills, and J.K. Whitaker, editors, *Econometric analysis for natural economic planning*, Butterworth, 1964.
- [85] R. Shiller, *Market volatility*, MIT Press, 1989.
- [86] A. Schrijver, *Theory of linear and integer programming*, Wiley, 1986.
- [87] G.W. Schwert. Indexes of United States stock prices from 1802 to 1987. *Journal of Business*, 63:399-426, 1990.
- [88] J.J. Siegel. *Stocks for the long run*, Norton, 1994.
- [89] C.A. Sims. Macroeconomics and reality. *Econometrica*, 48:1-48, 1980.
- [90] K.V. Smith. Increasing-stream hypothesis of corporate dividend policy. *California Management Review*, 15:56-64, 1971.
- [91] M.H. van der Vlerk. On multiple simple recourse models, SOM Research Report 02A06, University of Groningen, 2002. To appear in *Mathematical Methods of Operations Research*
- [92] M.H. van der Vlerk. Stochastic programming bibliography, World Wide Web, <http://mally.eco.rug.nl/spbib.html>, 1996-2003.
- [93] Vereniging van Gepensioneerden Elsevier-Ondernemingen. World Wide Web, <http://www.vgeo.nl/info/kkpensioen231102.htm>, 2002.
- [94] L.A. Wolsey. *Integer programming*, Wiley, 1998.

- [95] *Vette en magere jaren van de pensioenfondsen*. NRC Handelsblad, October 24, 2002.
- [96] *Spoed geboden: baby boomers gaan met pensioen*. NRC Handelsblad, October 1, 2002.
- [97] *Rutte: snel invloed ouderen op pensioen*. NRC Handelsblad, October 21, 2002.
- [98] *Kwart pensioenfondsen heeft te weinig in kas*. De Volkskrant, February 20, 2003.
- [99] *Korting op pensioen bij metaalbedrijven*. Trouw, October 30, 2002.
- [100] *Stevig ingrijpen in pensioenen geëist*. Trouw, October 1, 2002.

