





**HERMES**  
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on Computational Finance & Economics

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**The PROMETEIA model for  
managing endowments with guarantees**



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## OBJECTIVE



- The team:
  - PROMETEIA Calcolo, Flavio Cocco
  - University of Palermo, Andrea Consiglio
  - *HERMES* Center
- Integrative asset and liability modeling for endowments with minimum guarantees

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## OUTLINE



- The issues
  - Scenario optimization modeling
  - The PROMETEIA model
  - Results for the Italian insurance industry
  - Conclusions
- Application to Personal Financial Planning**

<http://fic.wharton.upenn.edu/fic/wfic/papers/00/p0041.html>

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## • The issues



- Products with return
- “Smoothing”
  - Household
  - Life insurance
  - Investment
- In the 1990’s could hardly
- Competitive
- Regulatory r



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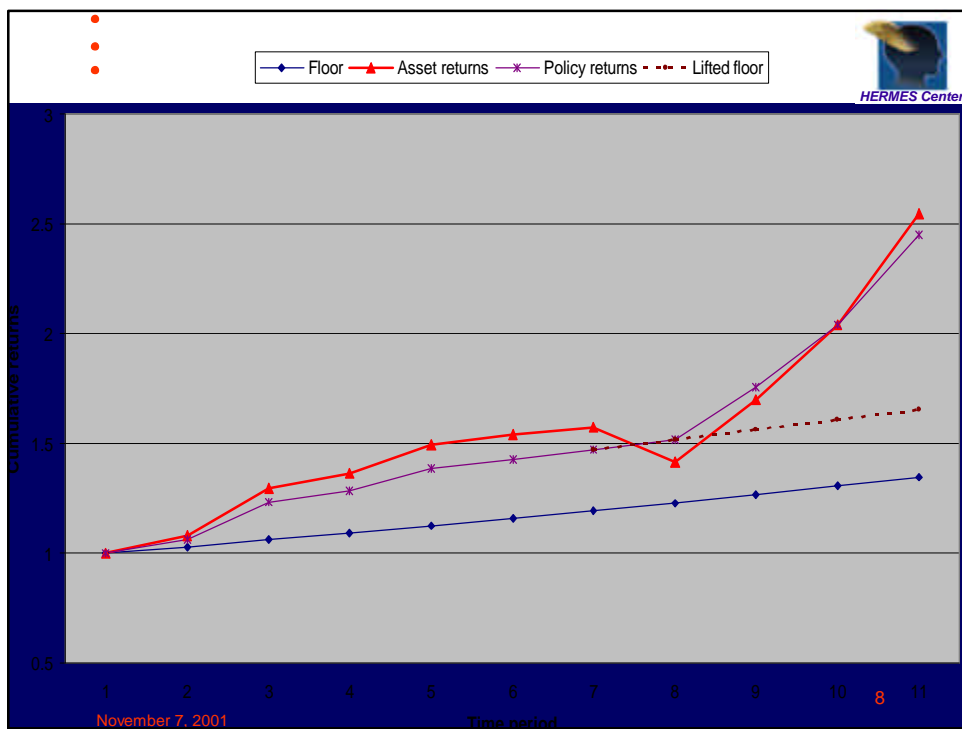
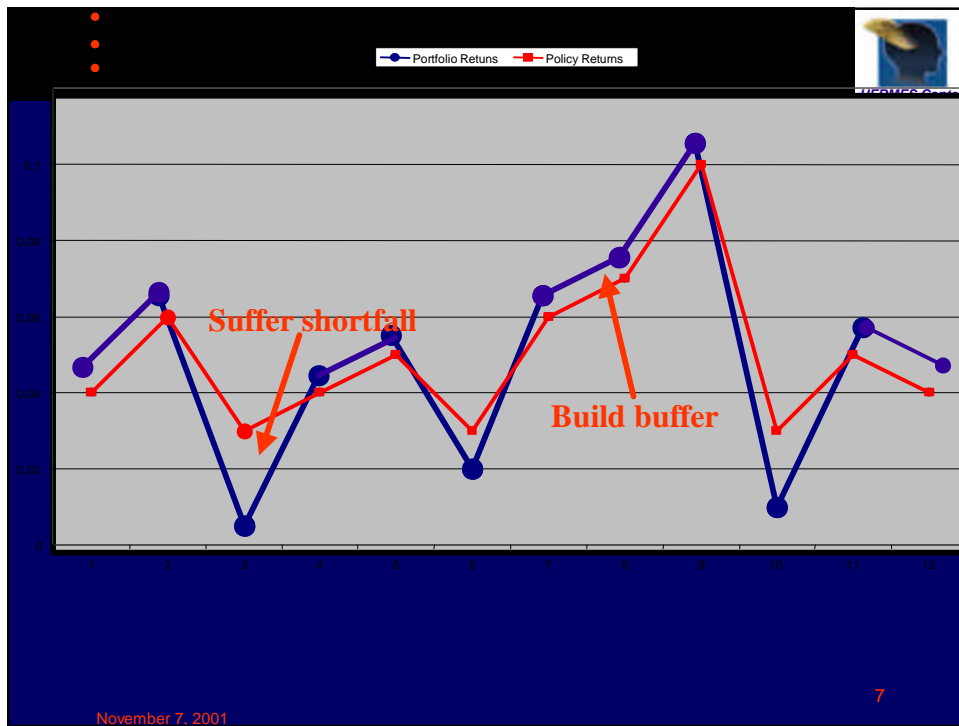
## • Participating policies



- Sum insured payable if event occurs before  $T$
- Otherwise the insured sum capitalized at the rate of an asset portfolio
  - *bonus policy*
- Minimum guaranteed rate of return
- Lapse option to surrender the policy

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## Modeling issues



- Pricing the options
  - guarantee (bond)
  - bonus (European option)
  - lapse (American option)
- Brennan and Schwartz (1976), Boyle and Schwartz (1977)  
Grosen and Jorgensen (1999), Bacinello (1999)  
Giraldi et al. (2000), Siglienti (2000)

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## Further modeling issues



- Capitalizing the product
- Satisfy regulatory requirements (leverage)
- Design competitive policies
- *Integrated financial product management.*  
Holmer and Zenios, *Operations Research*, 43, 1995.

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# Stochastic Programming



- Optimization under uncertainty
- Dynamic: decisions are revised with time as more information is received
- *Anticipate* uncertainty and *adapt* with it

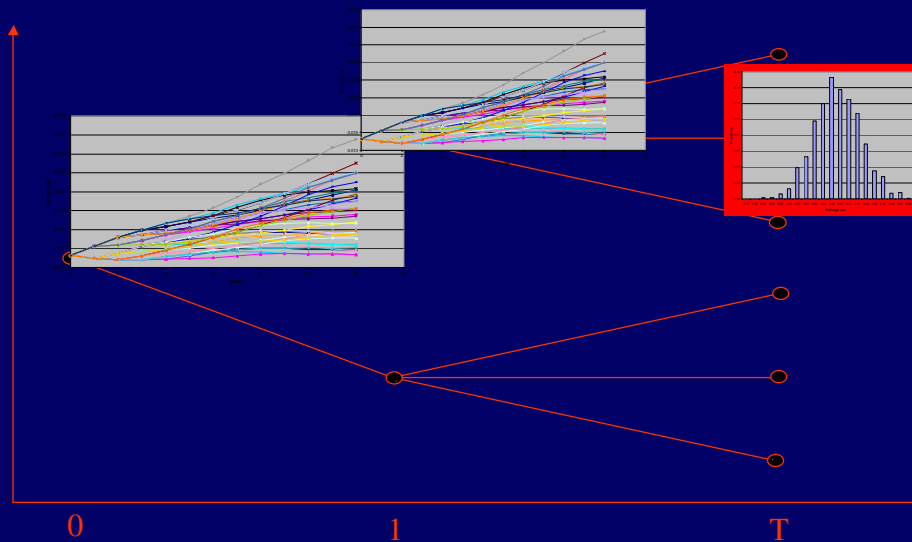
G.B. Dantzig (1955), R. J-B. Wets (1966)  
J.R. Birge and F. Louveaux, (1997)

Y. Censor and S.A. Zenios,  
*Parallel Optimization: Theory, Algorithms and Applications*,  
Oxford University Press, 1997.

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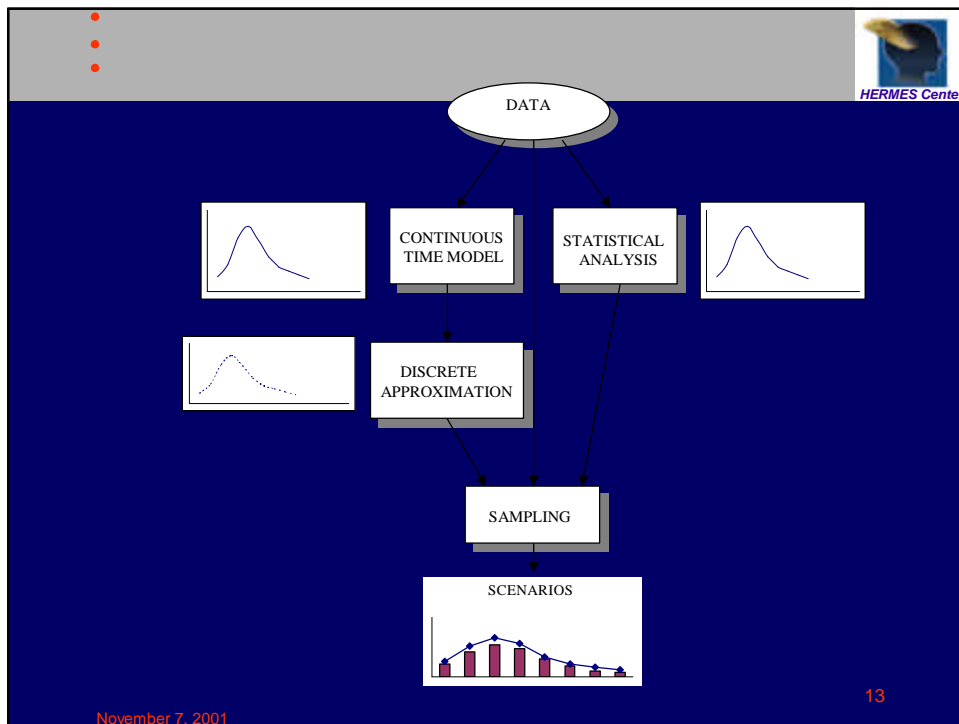
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# Scenario tree



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- ## Model Definition
- Integrate the *option pricing* problem with the *asset allocation* problem
  - Determine optimal asset allocation and debt structures
  - Analyze different policies
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## Asset portfolio characteristics

- Robust portfolios to face uncertainty
- “Minimize” shortfalls due to portfolio returns below the minimum guarantee
- Equity-to-liability regulatory ratios

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## State-of-the-art



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- Ziemba et. al., The Frank Rusell Model, *Interfaces*, 1994
- Mulvey et al., The Towers Perrin Model, 1998.
- Dempster et al., The CALM Model, 1998.
- Nielsen and Zenios, *Mathematical Programming*, 1996.  
– **METLIFE Insurance Co.**
- Consiglio and Zenios, *J. Econ. Dynamics and Control*, 1997.  
– **Federal National Mortgage Association**
- Consiglio and Zenios, *Mathematical Programming*, 2001.  
– **Banca della Svizzera Italiana**

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## • The PROMETEIA model



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## • Results for the Italian insurance industry

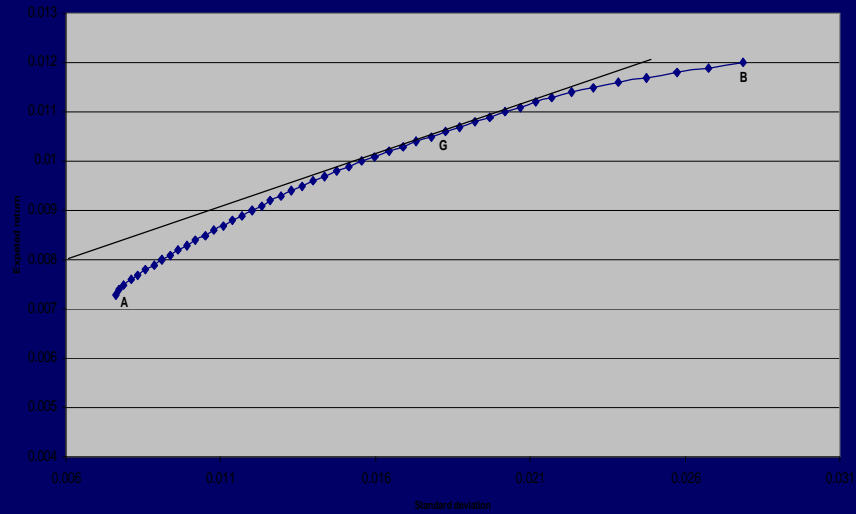


- Are mean-variance portfolios efficient?
- How far can the industry push its policies?
- Tradeoffs in portfolio structure
- Competitive policies
- 23 stock indices and 3 bond indices (IT)
- Stock and bond indices (UK, USA, JP)
- Corporates (USA)

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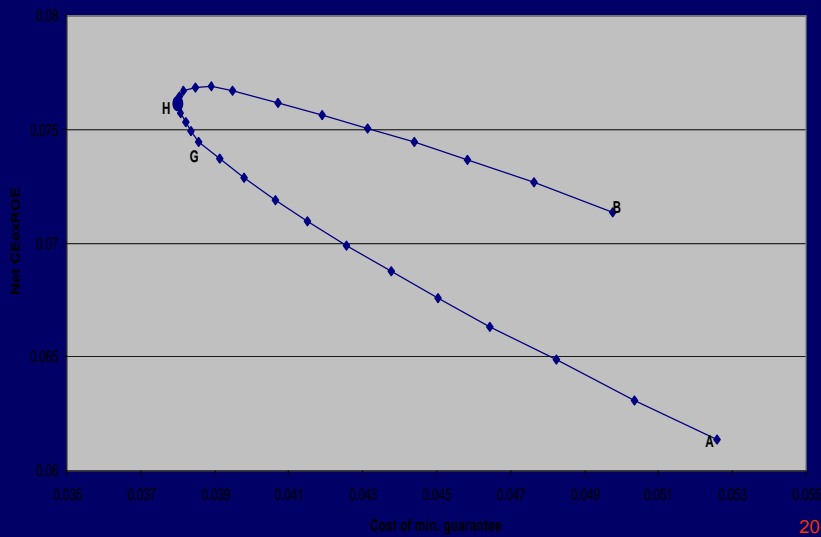
• Are mean-variance portfolios efficient?



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• Cost of guarantee and CExROE of mean-variance portfolios

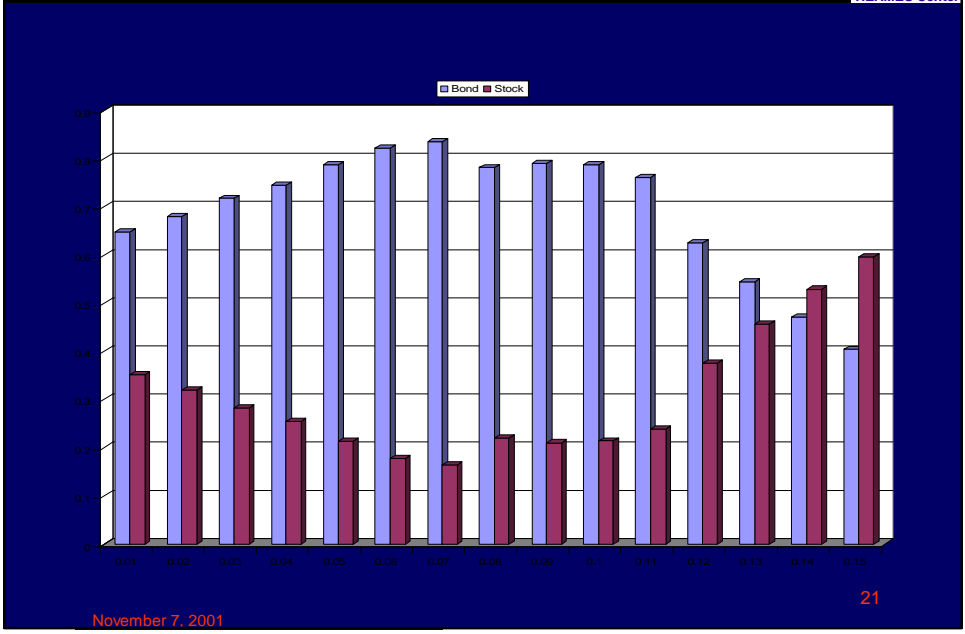


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# Optimal portfolio structures

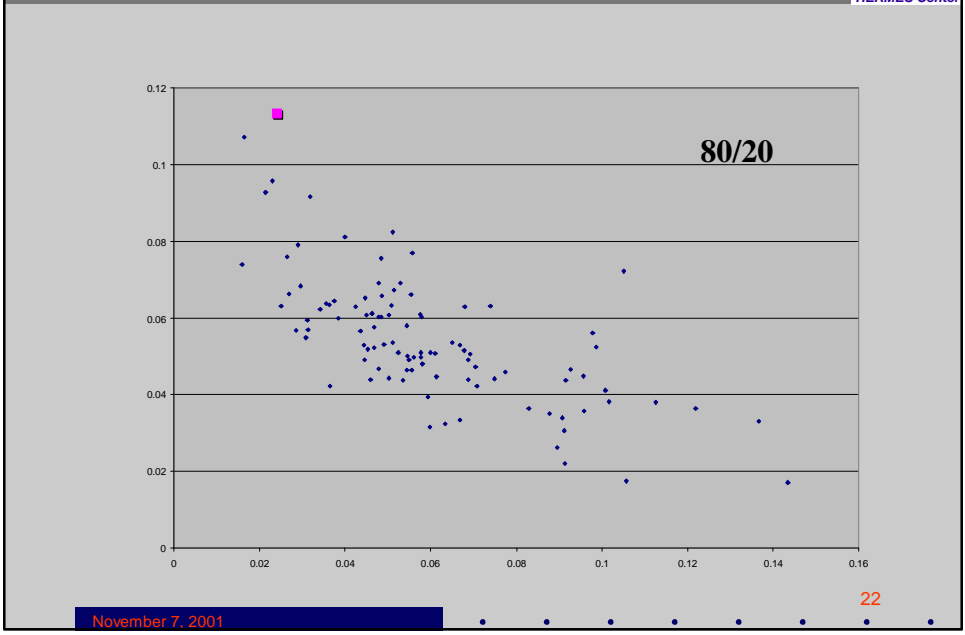


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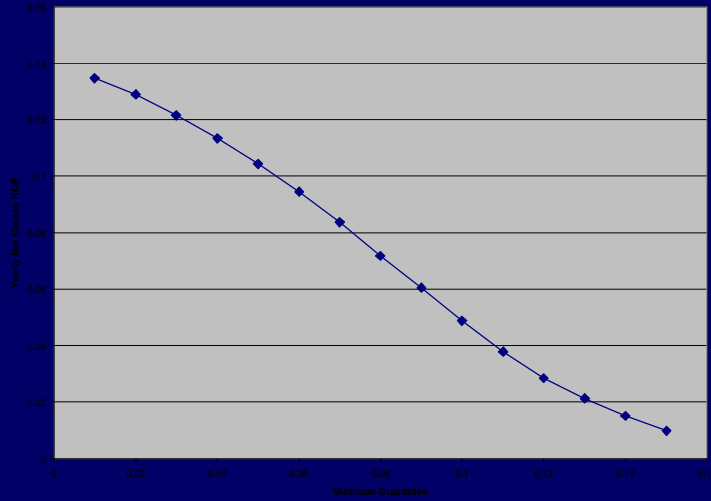
- Establish credibility of the model:
- comparisons with benchmark portfolios



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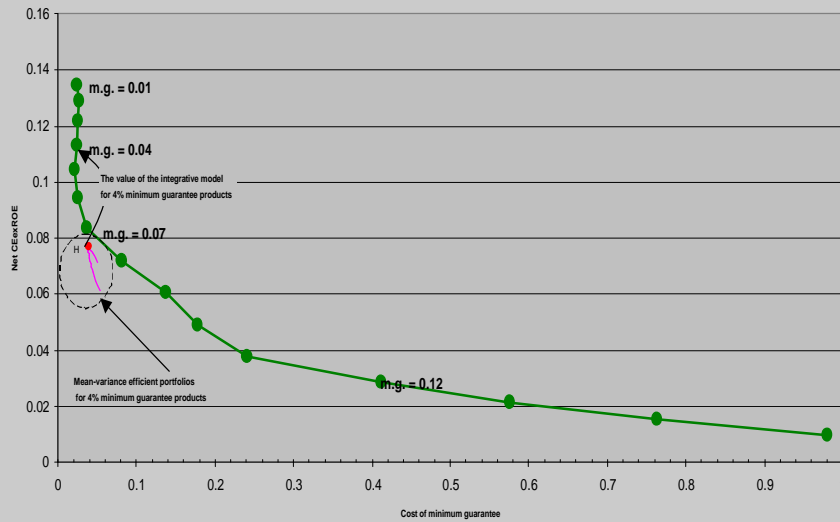
- How far can the industry push its policies?
- Net CExROE vs min. guarantee



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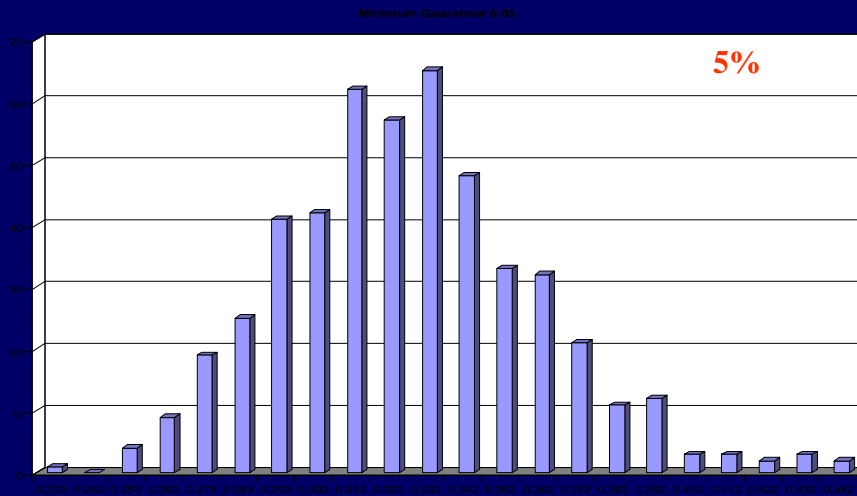
- How far can the industry push its policies?
- Cost of min. guarantee vs net CExROE



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# Satisfying the regulators



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- Competitive policies:
- CEexROE, guarantees, costs



		Minimum Guarantee							
		0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08
Policyholder Charges	0	0.144564	0.139163	0.135832	0.13177	0.130433	0.120909	0.110348	0.099402
	0.01	0.148057	0.142648	0.139726	0.136197	0.136011	0.126397	0.115193	0.102442
	0.02	0.151703	0.146281	0.143803	0.140857	0.141965	0.132226	0.120278	0.105562
	0.03	0.155517	0.150077	0.148086	0.145783	0.148361	0.138457	0.125641	0.10877
	0.04	0.15952	0.154056	0.152599	0.151014	0.155289	0.145166	0.131326	0.112075
	0.05	0.163732	0.158239	0.157375	0.156599	0.162863	0.152453	0.13739	0.115487
	0.06	0.168182	0.162651	0.162452	0.162599	0.171238	0.16045	0.143903	0.119017
	0.07	0.1729	0.167323	0.167876	0.169089	0.180626	0.169337	0.150957	0.122676
	0.08	0.177925	0.172291	0.173703	0.176169	0.191338	0.17937	0.15867	0.126479
	0.09	0.183304	0.177599	0.180007	0.183968		0.190924	0.167202	0.130443
	0.1	0.189093	0.183304	0.18688	0.192664			0.176778	0.134586

Leverage 0.05, confidence = 1%

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- Competitive policies:
- CEexROE, guarantees, costs



		Policyholder Charges									
		0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Debt over equity	0	0.121125	0.124595	0.128295	0.132256	0.136515	0.141118	0.146123	0.151602	0.15765	0.164391
	0.125	0.123946	0.127684	0.131656	0.135891	0.14043	0.145317	0.150612	0.156387	0.16274	0.169795
	0.25	0.126654	0.13064	0.13486	0.139346	0.144137	0.14928	0.154834	0.160873	0.167495	0.174827
	0.375	0.12926	0.133474	0.137923	0.142638	0.147659	0.153033	0.158821	0.165097	0.17196	0.179538
	0.5	0.13177	0.136197	0.140857	0.145783	0.151014	0.156599	0.162599	0.169089	0.176169	0.183968
	0.625	0.134193	0.138817	0.143673	0.148794	0.154219	0.159997	0.16619	0.172875	0.180151	0.188151
	0.75	0.136533	0.141343	0.146381	0.151682	0.157285	0.163242	0.169612	0.176475	0.183932	0.192114
	0.875	0.138798	0.143781	0.148989	0.154458	0.160227	0.166348	0.172882	0.179909	0.18753	0.195879
	1	0.140991	0.146137	0.151505	0.15713	0.163053	0.169327	0.176013	0.183191	0.190964	0.199468

Guarantee 4%, confidence = 1%<sup>27</sup>

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- Shareholder risks of competitive policies



		Policyholder Charges									
		0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Debt over equity	0	0.58	0.522	0.462	0.4	0.344	0.278	0.208	0.148	0.096	0.042
	0.125	0.534	0.478	0.416	0.366	0.302	0.242	0.172	0.112	0.072	0.02
	0.25	0.508	0.444	0.394	0.338	0.274	0.212	0.15	0.1	0.06	0.012
	0.375	0.476	0.416	0.368	0.306	0.252	0.188	0.134	0.092	0.042	0.012
	0.5	0.444	0.396	0.346	0.284	0.226	0.162	0.118	0.076	0.032	0.006
	0.625	0.418	0.374	0.322	0.266	0.212	0.152	0.106	0.068	0.022	0.004
	0.75	0.404	0.366	0.304	0.258	0.198	0.144	0.098	0.056	0.016	0.002
	0.875	0.4	0.354	0.286	0.234	0.184	0.136	0.092	0.05	0.012	0.002
	1	0.378	0.33	0.28	0.224	0.162	0.124	0.088	0.04	0.012	0.002

Guarantee 4%, confidence = 1%<sup>28</sup>

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## • Current developments

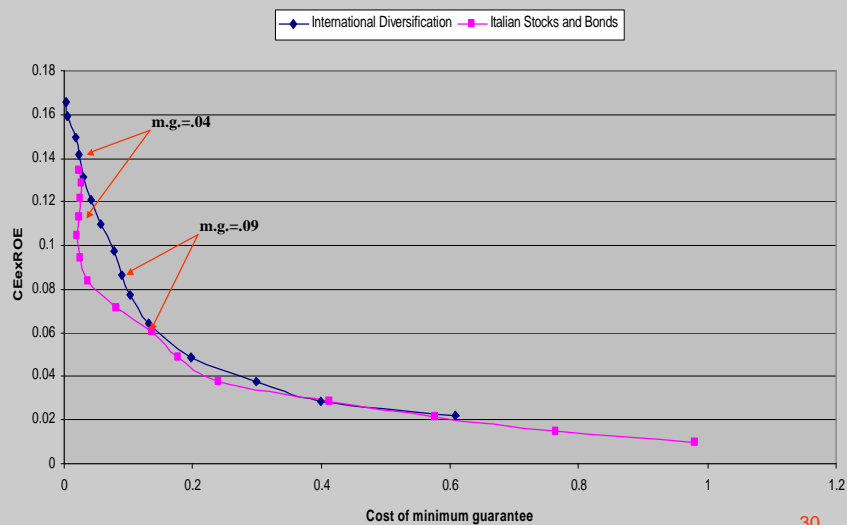


- Expand asset base:
  - Corporate bonds
  - International
  - Mutual funds (!): benchmarking
- Forward-looking scenario generation
- Multi-stage, multi-period optimization
- Lapse and bonus policies

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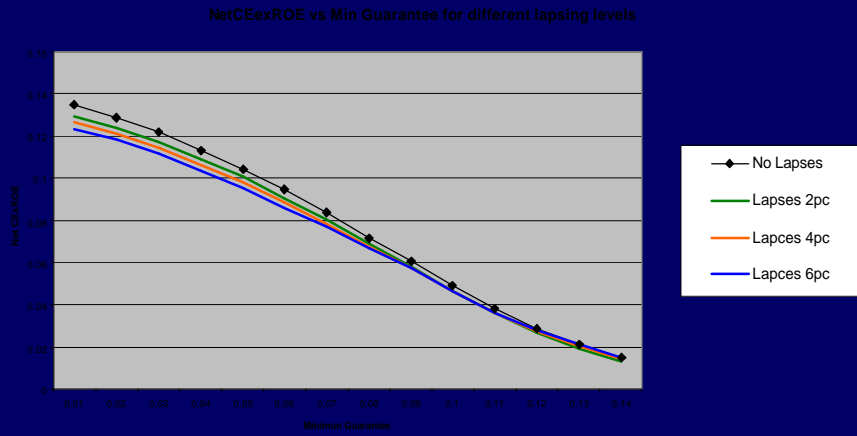
## • Integrated domestic and international portfolios



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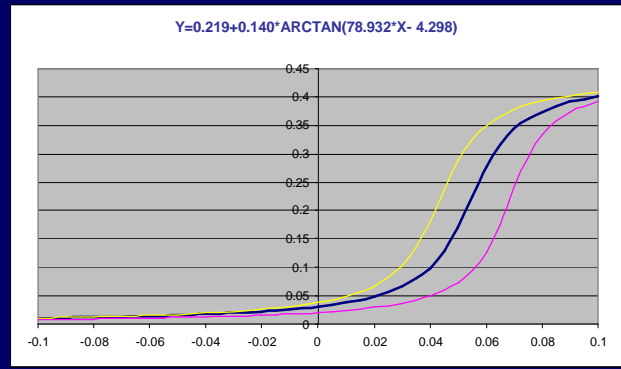
- The effects of lapse



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- Modeling the lapse option

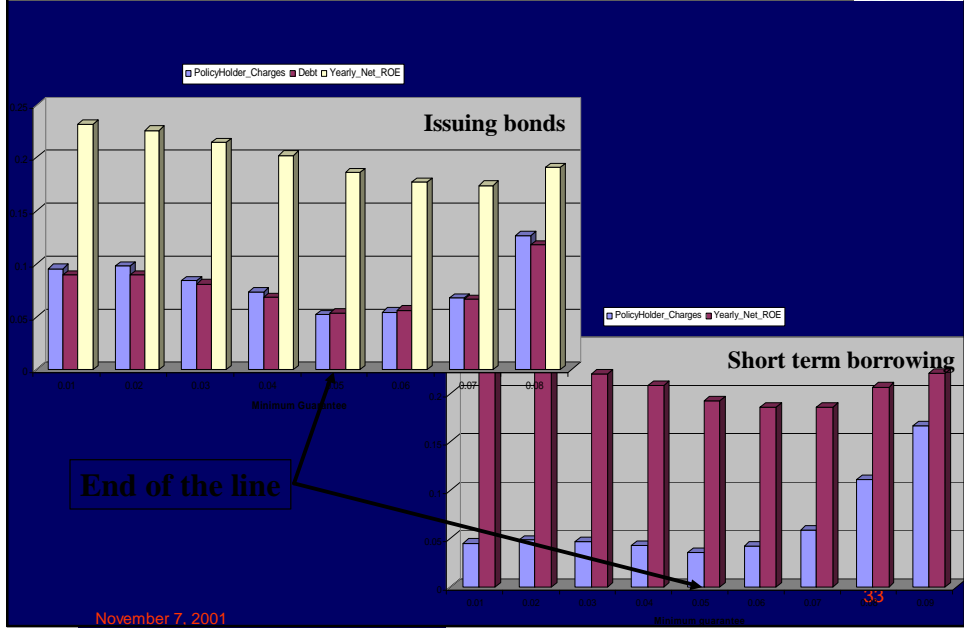


Independent variable: Differential to 10-yr benchmark

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- Reserving Methods:
- Long term debt vs short term borrowing



- Web based financial services



Personal financing →

## CONCLUSIONS



- Satisfy tradeoffs *efficiently*:
  - competitive policies
  - return to shareholders
  - regulatory restrictions
- Analyze debt structures:
  - equity, short-debt, or long-debt
- Financial engineering and the Web

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## REFERENCES



A Consiglio, F. Cocco and S.A. Zenios, The value of integrative risk management for endowments with guarantees, *Journal of Risk Finance*, pp.1—11, Spring 2001.

A Consiglio, F. Cocco and S.A. Zenios, Scenario based optimization for endowments with guarantees, *Journal of Risk and Insurance*, (to appear).

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