

Modelling the risk surface of Outokumpu corporation using a generic HPC platform for cross-disciplinary R & D

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Table 1: The parameter space of the example firm at the minimum risk point (core 1408)

The parameter space Input	Historical accounts					Predicted accounts					Parametric variation for the risk surface					Low	High						
	2012	2013	2014	2015	2016	Mean	2017	2018	2019	2020	2021	range of linear variation (dp)	κ_1	$0.34969 d \kappa_1$	$-0.0225 dS \kappa_1$	$1.0707 dp$	range of stochastic variation (Δ)	κ_2	$0.00718 d \kappa_2$	$-0.0739 dS \kappa_2$	$1.1095 b_0$	Low	High
Outokumpu Oyj												average inflation: 2.00 %	cash tol. 0.100	b_0	0.2	b_1	10	t_0	0.5	kappaSwitch_point [0,1]	0.2000		
Balance sheet																							
1. Intangibles	0.6290	0.5700	0.5670	0.4980	0.5040	0.5536	0.5536	0.5536	0.5536	0.5536													
2. Other financial assets	1.9620	2.6130	0.4520	0.4910	0.7050	1.2446	0.7050	0.7050	0.7050	0.7050													
3. Other restricted equity	0.7140	0.7140	0.7140	0.7140	0.7140	0.7140																	
4. Accumulated depreciation difference																							
5. Reserves																							
6. Valuation items (liabilities)																							
7. Current liabilities ratio	0.6738	0.4548	0.2972	0.2753	0.3780	0.4158	0.3780	0.3780	0.3780	0.3780													
8. Sales price/unit	1.7468	1.3797	1.4395	1.5852	1.6880	1.5679	1.7218	1.7562	1.7913	1.8271													
9. Sales receivables ratio	0.1870	0.0833	0.0778	0.0646	0.0815	0.0989	0.0815	0.0815	0.0815	0.0815													
10. Max new issue ratio																							
11. Debt (t) $< k_2 * Eq(t)$	1.2228	2.0048	1.0610	0.7746	0.6315	1.1389	0.6315																
12. Amortization ratio					-0.1547	-0.0309	0.0300																
Statement of Income																							
13. Interest margin							7.9990 %																
14. Depreciation ratio	0.0906	0.1147	0.1106	0.1008	0.0839	0.1001	0.0950																
15. Fixed costs	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0400	2.0808	2.1224	2.1649	2.2082												
16. Interest rate ratio	0.0474	0.0852	0.0999	0.0881	0.0793	0.0800	7.9990 %	7.9990 %	7.9990 %	7.9990 %	7.9990 %												
17. Other financial income	0.0168	0.0042	0.0221	0.1181	0.0071	0.0337																	
18. Extraordinary income and expenses																							
19. Tax ratio	-0.0442	-0.0317	-2.2500	0.0899	-0.6856	-0.5843	0.1059																
Restrictions																							
20. Operating cost per unit	1.01	1.02	0.98	0.92	0.94	0.9754	1.0200	1.0404	1.0612	1.0824	1.1041												
21. Efficiency factor							0.9987																
22. Use factor cost (0/1)							1.0000																
23. Factor cost per unit							1.0000	1.0000	1.0000	1.0000	1.0000												
Other																							
24. Discount rate for present value (WACC)							0.1500																
25. Investment profile																							
26. Inertia							1.0000																
27. Dividend ratio							0.0100																
28. Default MC-iterations																							
29. Default number of local grid points (s)							1.0000																

use market share (0-4): 2

Market volume: 3.457230, 3.491802, 3.526720, 3.561988, 3.597607

Gross share: 100.00 %, 100.00 %, 100.00 %, 100.00 %, 100.00 %

SMI: 1.00, 1.00, 1.00, 1.00, 1.00

Market share: 100.00 %, 100.00 %, 100.00 %, 100.00 %, 100.00 %

Max sales: 3.457230, 3.491802, 3.526720, 3.561988, 3.597607

H_1 : parametric sales ceiling: 3.701572, 3.738587, 3.775973, 3.813733, 3.851870

sales price: 1.682933, 1.716591, 1.750923, 1.785942, 1.821660

κ_1

H_2 : capital structure: 0.700625

κ_2

H_2 : interest rate: 1.994004, 2.033884, 2.074562, 2.116053, 2.158374

κ_1 : 0.074077, 0.074077, 0.074077, 0.074077, 0.074077

adjust prod.cost: 1

κ_1 : 1.020000, 1.040400, 1.061208, 1.082432, 1.104081

κ_1 : 1.00

H_3 : factor cost: 0.890486, 0.890486, 0.890486, 0.890486, 0.890486

κ_1

Operations=Efficiency factor*Business driving assets

Factor cost per unit

Table 2: The optimal PC-solution based on the parameters of Cray XC40 core number 1408 presented on the previous page.

Outokumpu Oyj		CPU-secs: 0.98		Solved: 27.8.2018 20:24:21		CHECK					
Discounted:		Solve		CHANGE DEFAULTS	Save results	PERIOD:	2017	2018	2019	2020	2021
Net income	0.530452			Load data for Outokumpu Oyj		Optimal cash	2.042050	1.941612	2.057951	2.209969	2.398954
Dividends	0.01					Cash from statements	2.042050	1.941612	2.057951	2.209969	2.398954
Cash flow	2.94					Maximal Sales Volume	4.81	3.74	3.78	3.81	3.85
						Optimal Sales Volume	3.70	3.74	3.78	3.81	3.85
						Actual Sales Volume	3.70	3.74	3.78	3.81	3.85
						Maximal Operations	3.50	3.74	3.78	3.81	3.85
						Optimal Operations	2.39	3.74	3.78	3.81	3.85
						Actual Operations	2.39	3.74	3.78	3.81	3.85
						Minimal Depreciation	0.27	0.30	0.30	0.30	0.31
						Optimal Depreciation	0.25	0.27	0.27	0.28	0.28
						Actual Depreciation	0.25	0.27	0.27	0.28	0.28
						Minimal Equity/Assets	0.70	0.70	0.70	0.70	0.70
						Optimal Equity/Assets	0.40	0.41	0.42	0.43	0.45
						Actual Equity/Assets	0.40	0.41	0.42	0.43	0.45
						Maximal New Issues					
						Optimal New Issues					
						Actual New Issues					
						Maximal Dividend	1.58	1.68	1.81	1.98	2.18
						Minimal Dividend	0.00	0.00	0.00	0.00	0.00
						Optimal Dividend	0.00	0.00	0.00	0.00	0.00
						Actual Dividend	0.00	0.00	0.00	0.00	0.00
						Equal Amortization	0.05	0.04	0.04	0.04	0.04
						Optimal Amortization	0.04	0.04	0.04	0.04	0.04
						Actual Amortization	0.04	0.04	0.04	0.04	0.04
						Optimal fixed assets	2.62	2.84	2.87	2.91	2.94
						Actual fixed assets	2.62	2.84	2.87	2.91	2.94
						Optimal long-term debt	1.48	1.44	1.40	1.35	1.32
						Actual long-term debt	1.48	1.44	1.40	1.35	1.32
						Optimal new debt					
						Actual new debt					
						Optimal investments		0.49	0.31	0.31	0.31
						Actual Investments		0.49	0.31	0.31	0.31
						PERIOD:	2017	2018	2019	2020	2021
						Inventory volume		0.00	0.00	0.00	0.00
						PERIOD:	2012	2013	2014	2015	2016
						Inventory volume	2.28	1.19	1.55	1.36	1.31

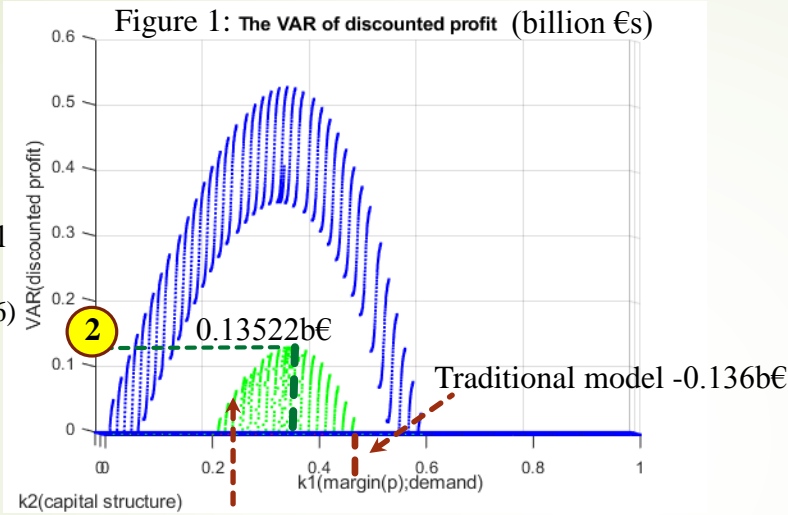
Table 3: Allocation of the first budget year for monthly follow-up. The first budget year is derived from the optimal risk minimizing solution of core nr 1408

FINANCIAL STATEMENTS Outokumpu Oyj	base year: 2016 scale: 1.E+06 units: giga€													PREDICTED ACCOUNTS								
	year in process: 2017 current calendar month: April first financial month: Jan													Cumu- lative	Expected total	budget 2017	Strategy					
	2016	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec				2017	2018	2019	2020	2021	
	monthly income 2017																					
Statement of income	monthly income 2017																					
Turnover	5.7780	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	1.5574	6.2295	6.2295	6.2295	6.4176	6.6114	6.8111	7.0168	
Variable operating costs	3.4230	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.9172	3.6687	3.6687	3.6687	3.8966	4.0071	4.1281	4.2528	
Fixed costs	2.0000	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.4985	1.9940	1.9940	1.9940	2.0339	2.0746	2.1161	2.1584	
Operating income	0.3550	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.1417	0.5668	0.5668	0.5668	0.4941	0.5298	0.5669	0.6056	
Depreciation	0.2520	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0623	0.2493	0.2493	0.2493	0.2698	0.2730	0.2762	0.2794	
Operating income after depreciation	0.1030	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0794	0.3174	0.3174	0.3174	0.2243	0.2568	0.2908	0.3263	
Interest expenses	0.1210	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0274	0.1097	0.1097	0.1097	0.1065	0.1034	0.1004	0.0974	
Other financial income	0.0050																					
Extraordinary income and expenses																						
Allocations (+/-)																						
Taxes	-0.1570	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0055	0.0220	0.0220	0.0220	0.0125	0.0162	0.0202	0.0242	
Net income	0.1440	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0464	0.1858	0.1858	0.1858	0.1054	0.1372	0.1702	0.2046	
Assets	cumulative positions 2017																					
Fixed assets	2.8740	2.8532	2.8324	2.8117	2.7909	2.7701	2.7493	2.7286	2.7078	2.6870	2.6662	2.6454	2.6247	2.8117	2.6247	2.6247	2.6247	2.8400	2.8733	2.9070	2.9410	
Intangible assets	0.5040	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536
Inventory	1.2320	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sales receivables	0.4710	0.4741	0.4771	0.4802	0.4833	0.4863	0.4894	0.4925	0.4955	0.4986	0.5017	0.5047	0.5078	0.4802	0.5078	0.5078	0.5078	0.5231	0.5389	0.5552	0.5720	
Cash	0.2040	1.4413	1.4962	1.5480	1.6029	1.6578	1.7127	1.7676	1.8225	1.8774	1.9323	1.9872	2.0421	1.5480	2.0421	2.0421	2.0421	1.9416	2.0580	2.2100	2.3990	
Other financial assets	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	
Financial assets	1.3800	2.6204	2.6783	2.7332	2.7911	2.8491	2.9071	2.9650	3.0230	3.0810	3.1389	3.1969	3.2549	2.7332	3.2549	3.2549	3.2549	3.1698	3.3019	3.4702	3.6759	
Total Assets	5.9900	6.0272	6.0644	6.0984	6.1356	6.1728	6.2100	6.2472	6.2844	6.3216	6.3587	6.3959	6.4331	6.0984	6.4331	6.4331	6.4331	6.5634	6.7288	6.9308	7.1705	
Shares equity and liabilities	cumulative positions 2017																					
Capital stock	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110	0.3110
Other restricted equity	0.7140																					
Dividends				0.0031										0.0031								
Monthly net income		0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.1858	0.1054	0.1372	0.1702	
Accumulated net income	0.1440	0.0310	0.0464	0.0619	0.0774	0.0929	0.1084	0.1238	0.1393	0.1548	0.1703	0.1858	0.0464	0.1858	0.1858	0.1858	0.1858	0.1858	0.1858	0.1858	0.1858	
Unrestricted equity	1.2460	2.1040	2.1040	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.1009	2.2835	2.3858	2.5199	2.6870	
Shareholders' equity	2.4150	2.4305	2.4460	2.4583	2.4738	2.4893	2.5048	2.5203	2.5357	2.5512	2.5667	2.5822	2.5977	2.4583	2.5977	2.5977	2.5977	2.6999	2.8340	3.0011	3.2026	
Accumulated depreciation difference																						
Reserves																						
Valuation items																						
Current liabilities	2.0500	2.0754	2.1008	2.1262	2.1516	2.1770	2.2024	2.2278	2.2532	2.2787	2.3041	2.3295	2.3549	2.1262	2.3549	2.3549	2.3549	2.4260	2.4993	2.5747	2.6525	
Long-term debt	1.5250	1.5213	1.5176	1.5139	1.5102	1.5065	1.5028	1.4991	1.4954	1.4917	1.4880	1.4843	1.4806	1.5139	1.4806	1.4806	1.4806	1.4375	1.3956	1.3549	1.3155	
Liabilities	3.5750	3.5967	3.6184	3.6401	3.6618	3.6835	3.7052	3.7269	3.7486	3.7703	3.7920	3.8137	3.8355	3.6401	3.8355	3.8355	3.8355	3.8634	3.8948	3.9297	3.9880	
Liabilities & shareholders' equity	5.9900	6.0272	6.0644	6.0984	6.1356	6.1728	6.2100	6.2472	6.2844	6.3216	6.3587	6.3959	6.4331	6.0984	6.4331	6.4331	6.4331	6.5634	6.7288	6.9308	7.1705	
Initial cash	0.1860	monthly cash flows 2017																				
Initial monthly cash 2017	0.2040	1.4413	1.4962	1.5480	1.6029	1.6578	1.7127	1.7676	1.8225	1.8774	1.9323	1.9872		0.2040	0.2040	0.2040	0.2040	2.0421	1.9416	2.0580	2.2100	
Turnover	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	1.5574	6.2295	6.2295	6.2295	6.4176	6.6114	6.8111	7.0168	
Sales receivables change	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0031	-0.0092	-0.0368	-0.0368	-0.0368	-0.0153	-0.0158	-0.0163	-0.0168	
Variable Operating Costs	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.3057	-0.9172	-3.6687	-3.6687	-3.6687	-3.8966	-4.0071	-4.1281	-4.2528	
Inventory change	1.2320													1.2320	1.2320	1.2320	1.2320	0.0000	0.0000	0.0000	0.0000	
Fixed costs	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.1662	-0.4985	-1.9940	-1.9940	-1.9940	-2.0339	-2.0746	-2.1161	-2.1584	
Other financial assets change																						
Other financial income																						
Extraordinary income & expenses																						
Interest expenses	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0274	-0.1097	-0.1097	-0.1097	-0.1065	-0.1034	-0.1004	-0.0974	
Taxes	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0018	-0.0055	-0.0220	-0.0220	-0.0220	-0.0125	-0.0162	-0.0202	-0.0242	
Operating cash flows	1.2652	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	0.0332	1.3316	1.6303	1.6303	1.6303	0.3598	0.3944	0.4301	0.4672	
Current liabilities change	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	0.0762	0.3049	0.3049	0.3049	0.0711	0.0733	0.0755	0.0778	
New debt																						
Repayment	-0.0037	-0.0037	-0.0037																			

Table 4: Monthly allocation keys for budget follow-up. The allocations correspond to standard items in the general ledger

FINANCIAL STATEMENTS	base year: 2016 Monthly allocation keys													PREDICTED ACCOUNTS						
	scale: 1.E+06 units: giga€													budget	2017	2018	2019	2020	2021	
	year in process: 2017 current calendar month: April first financial month: Jan																			
	2016	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec	total	2017	2017	2018	2019	2020	2021
(1) Investments and financing	monthly allocations 2017																			
New debt														0.0444	0.0444	0.0444	0.0431	0.0419	0.0406	0.0395
Repayment		0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0444	0.0444	0.0444	0.0431	0.0419	0.0406	0.0395
Long debt	1.5250	1.5213	1.5176	1.5139	1.5102	1.5065	1.5028	1.4991	1.4954	1.4917	1.4880	1.4843	1.4806	1.4806	1.4806	1.4806	1.4375	1.3956	1.3549	1.3155
Investments																	0.4851	0.3063	0.3098	0.3134
New Issues																				
Dividends				0.0031										0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
(2) Other asset components	cumulative positions 2017																			
Intangible assets	0.5040	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536	0.5536
Inventory	1.2320																0.0000			0.0000
Sales receivables	0.4710	0.4741	0.4771	0.4802	0.4833	0.4863	0.4894	0.4925	0.4955	0.4986	0.5017	0.5047	0.5078	0.5078	0.5078	0.5078	0.5231	0.5389	0.5552	0.5720
Other financial assets	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050	0.7050
(3) Other liability components	cumulative positions 2017																			
Other restricted equity	0.7140																			
Accumulated depreciation difference																				
Reserves																				
Valuation items																				
Current liabilities	2.0500	2.0754	2.1008	2.1262	2.1516	2.1770	2.2024	2.2278	2.2532	2.2787	2.3041	2.3295	2.3549	2.3549	2.3549	2.3549	2.4260	2.4993	2.5747	2.6525
(4) Statement of income	monthly allocations 2017																			
Turnover	5.7780	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	0.5191	6.2295	6.2295	6.2295	6.4176	6.6114	6.8111	7.0168
Variable operating costs	3.4230	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	0.3057	3.6687	3.6687	3.6687	3.8896	4.0071	4.1281	4.2528
Fixed costs	2.0000	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	0.1662	1.9940	1.9940	1.9940	2.0339	2.0746	2.1161	2.1584
Depreciation	0.2520	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.2493	0.2493	0.2493	0.2698	0.2730	0.2762	0.2794
Interest expenses	0.1210	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.1097	0.1097	0.1097	0.1065	0.1034	0.1004	0.0974
Other financial income	0.0050																			
Extraordinary income and expenses																				
Taxes	-0.1570	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0220	0.0220	0.0220	0.0125	0.0162	0.0202	0.0242

The profit profile and (green) 2.5% risk surface (billions of euros). 4096 dots in each figure, containing the numerical information presented below for core number 1408, $\{\kappa_1, \kappa_2\}^* = (3.496875e-01, 7.1875e-03)$.

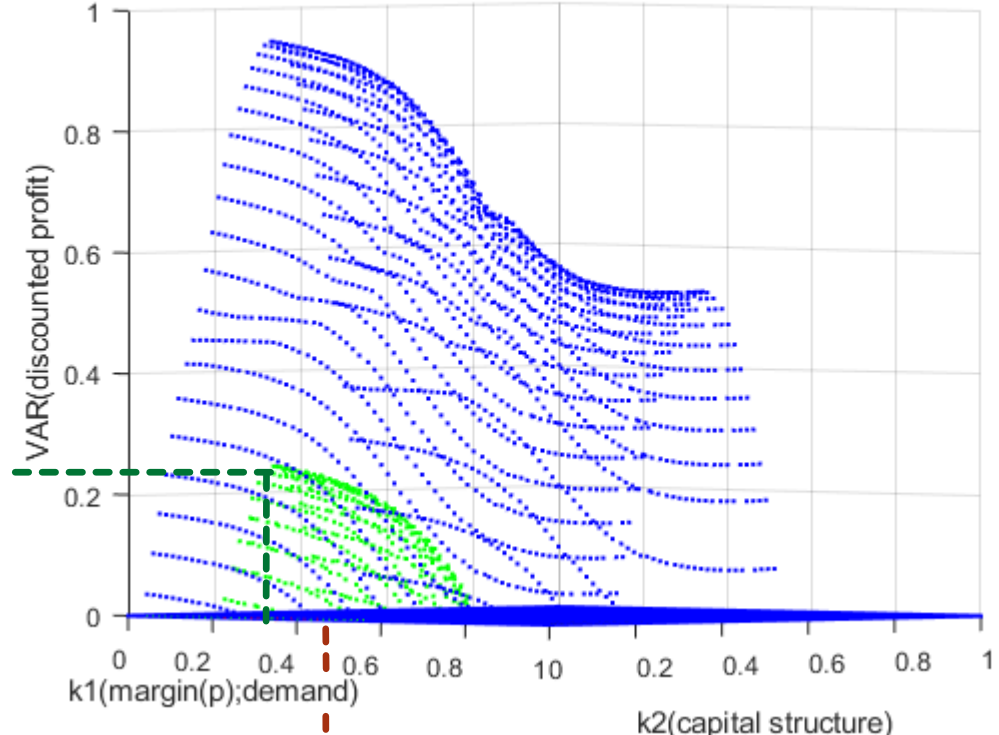


The maximum distance to the loss level of the HPC-model **2** is 0.135 billion euros and for the traditional model -0.136 billion euros: the difference is $0.135 - (-0.136) = 0.27b€$.
The best HPC-strategy is ~270 million euros safer.

stochastic variation 10% around optimum

The 100-year risk surface of the firm (best core 1408, $(m,n) = (2400, 3200)$, $\{\kappa_1, \kappa_2\}^* = (3.509375e-01, 1.2500e-03)$)

Figure 2: The VAR of discounted profit

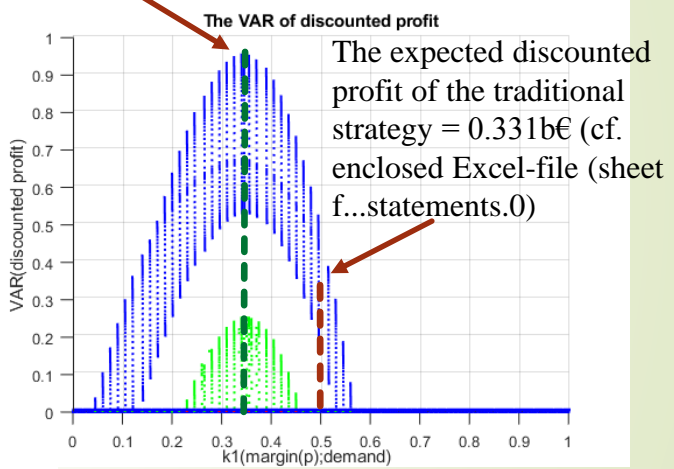


0.2521b€

Traditional risk analysis yields losses also over 100 years

Figure 3: Rotated view

The expected discounted profit of the HPC-strategy = 0.954b€ (cf. enclosed Excel-file (sheet f...statements.1408))



The expected discounted profit of the traditional strategy = 0.331b€ (cf. enclosed Excel-file (sheet f...statements.0))

The κ -space is the same in both the 5- and 100-year experiments:
 -0.075 -0.075 dp_L;dp_H (price_range(>0->linear,<0->sigmoidal activation))
 0.2 0.2 0.2 b_L;b_H;kappaSwitch_point

A note on the computational task

- ▶ In figure 1, the blue surface represents the discounted profit based on initial expectations of the key parameters without risk assessment. Usually, risk assessment is conducted on the best model obtained based on these expectations. Assuming that strategic adjustment is possible, **the downside risk of the safest strategy (2) is significantly lower than that of the traditional model.** Detecting this strategy requires HPC-techniques as commented below:
- ▶ In the above graphs, each dot involves $50 \times 50 = 2500$ optimization problems of size $(m,n) = (120,160)$ and 10000 simulations per optimization problem, in all cases with complete financial statements.
- ▶ Hence, the mesh of 4096 cores on the Cray XC40 supercomputer at CSC (Helsinki) solves 10 240 000 multi-period optimization problems in total for each surface.
- ▶ Each core computes $2500 \times 10000 = 25\,000\,000$ multi-period financial statements and the whole mesh 102.4 billion statements.
- ▶ CPU time absorbance on Cray XC40
 - 5-year problem: 1m 2.126s (~ 2.8 days with one computer)
 - 100-year problem: ~23m 14.691s (~ 66 days with one computer)

Valgrind check of heap memory usage in the firm model with 2500 optimizations and 10000 simulations per optimized model on a single core

- ▶ ==29016== Memcheck, a memory error detector
- ▶ ==29016== Copyright (C) 2002-2012, and GNU GPL'd, by Julian Seward et al.
- ▶ ==29016== Using Valgrind-3.8.1 and LibVEX; rerun with -h for copyright info
- ▶ ==29016== Command: ./supergha firm_mc
- ▶ ==29016== Parent PID: 1
- ▶ ==29016== HEAP SUMMARY:
- ▶ ==29016== in use at exit: 0 bytes in 0 blocks
- ▶ ==29016== total heap usage: 82,634 allocs, 82,634 frees, 980,289,413 bytes allocated
- ▶ ==29016==
- ▶ ==29016== All heap blocks were freed -- no leaks are possible
- ▶ ==29016==
- ▶ ==29016== For counts of detected and suppressed errors, rerun with: -v
- ▶ ==29016== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 8 from 6)