

Supplementary Material to

Better Safe than Sorry?

Ex Ante and Ex Post Moral Hazard in Dynamic
Insurance Data

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A Main (Corrected) Sample without Young Drivers

Tables and figures numbered [A.1](#) and up report the results of redoing all analyses on a subsample of insurees of 28 years old and up of the main sample (see Section 4.1). Like in the main analysis, all claims observed to be withdrawn are excluded.

Table A.3: Contract Exposure Durations in the Sample

Number of years Y	Number of contracts observed		Total
	exactly Y years	between $Y - 1$ and Y years	
1	8,074	11,389	19,463
2	5,107	9,329	14,436
3	6,576	7,111	13,687
4	66,654	6,144	72,798
Total	86,411	33,973	120,384

Table A.4: Number of Contracts Observed for At Least One Full Contract Year, by Bonus-Malus Class and Number of Claims in the First Contract Year

BM class	Number of contracts with					Total
	no claim	1 claim	2 claims	3 claims	4 claims	
1	519	112	23	4	1	659
2	704	84	11	1		800
3	902	75	10			987
4	1,266	96	8			1,370
5	1,682	101	9	2		1,794
6	2,330	146	13	2		2,491
7	3,142	192	14			3,348
8	3,857	252	15			4,124
9	4,584	235	14	2		4,835
10	6,018	274	11		1	6,304
11	5,763	262	10	2		6,037
12	5,895	287	16			6,198
13	5,807	258	10			6,075
14	6,683	311	13			7,007
15	6,241	298	7			6,546
16	6,429	297	13	1		6,740
17	5,692	250	7			5,949
18	4,380	202	10			4,592
19	3,868	213	5			4,086
20	27,651	1,372	28	2		29,053
Total	103,413	5,317	247	16	2	108,995

Figure A.1: Distribution of Contracts Observed for At Least One Full Contract Year Across Bonus-Malus Classes; and Shares of Those Contracts with At Least One and At Least Two Claims at Fault in the First Contract Year, by Bonus-Malus Class

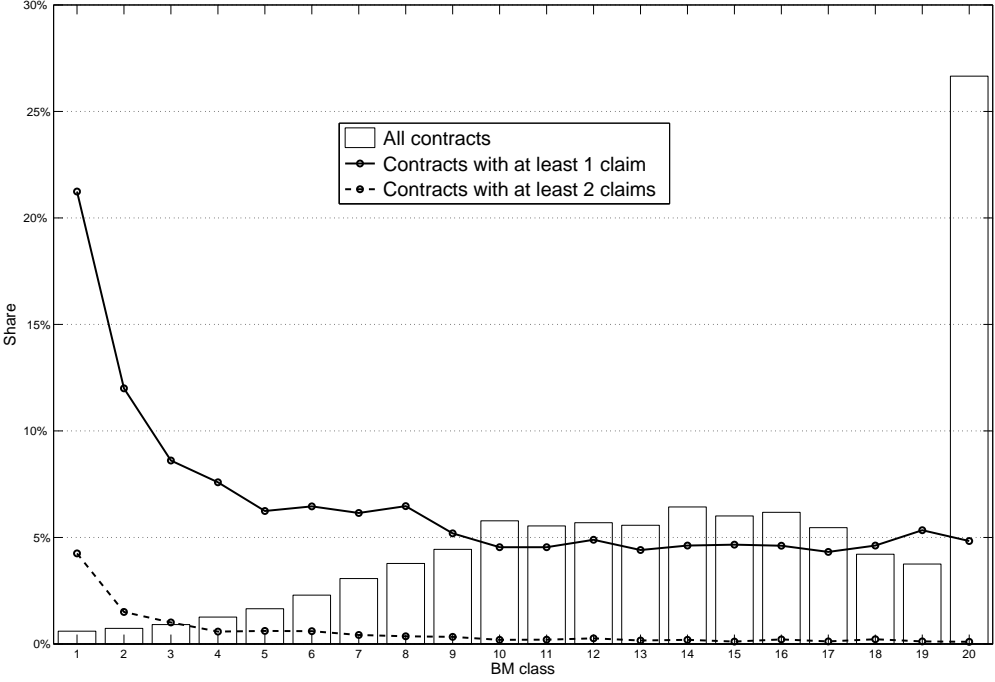


Figure A.2: Incentives to Avoid First, Second and Third Claim; at an Average Risk Level

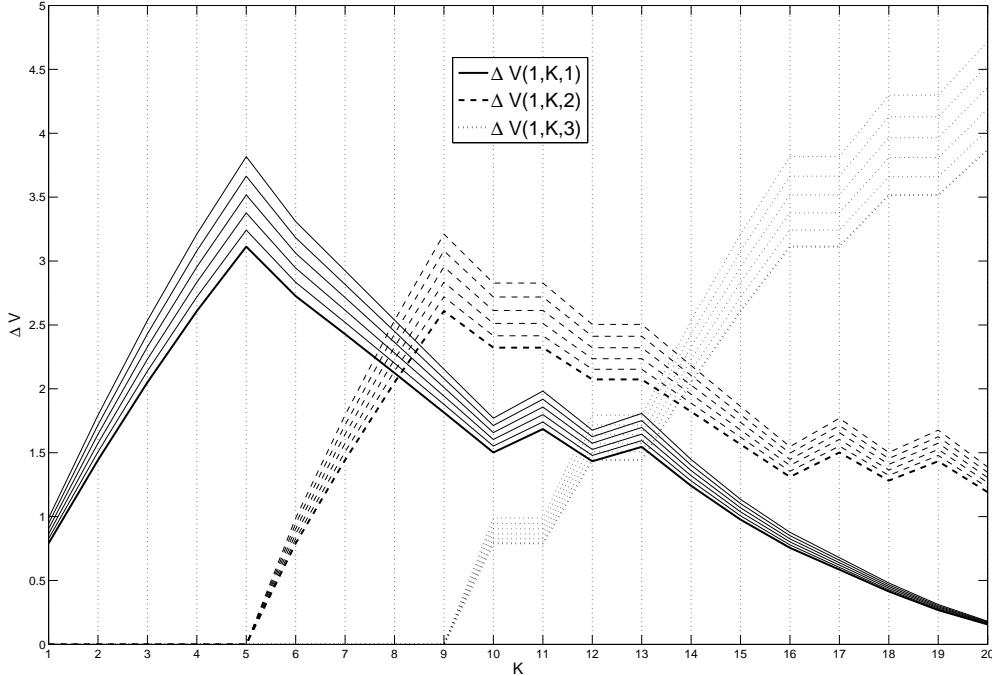


Figure A.3: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at an Average Risk Level

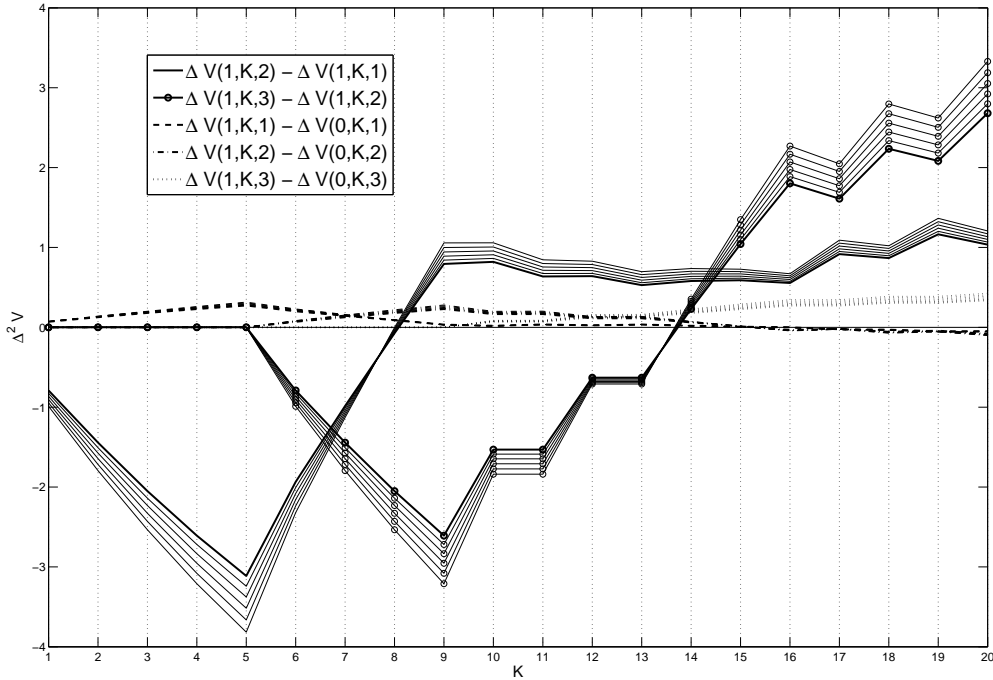


Figure A.4: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a Zero Risk Level

unchanged

Figure A.5: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a High Risk Level

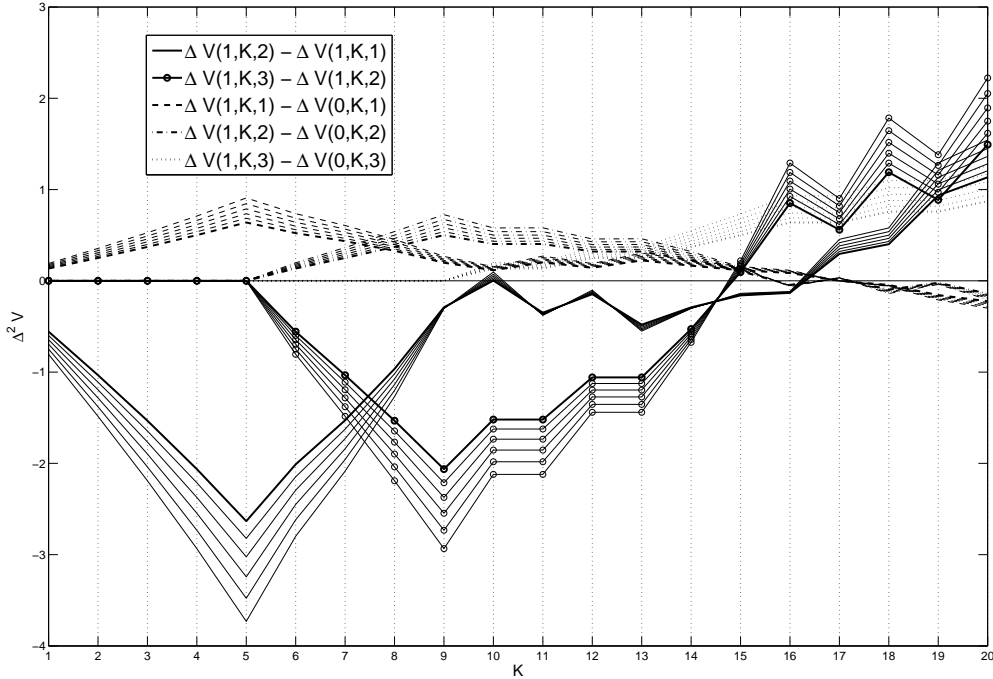


Table A.5: ML Estimation of the Auxiliary Model (14) with 3 and 4 Support Points

Three Support Points

Parameter	Estimate	Std. Error
β	0.4193	0.0390
λ_1	0.0393	0.0032
λ_2	0.2023	0.0197
λ_3	0.4172	0.0322

Tests of $\beta = 0$

- LM test: 120.11, p -value = 0.00
- LR test: 103.66, p -value = 0.00
- Wald test: 115.75, p -value = 0.00

Four Support Points

Parameter	Estimate	Std. Error
β	0.3795	0.0342
λ_1	0.0000	0.0000
λ_2	0.0551	0.0080
λ_3	0.2240	0.0124
λ_4	0.8919	0.1273

Tests of $\beta = 0$

- LM test: 57.25, p -value = 0.00
- LR test: 100.75, p -value = 0.00
- Wald test: 123.05, p -value = 0.00

Table A.6: Nonparametric Tests Based on Comparison of H_1 and H_2 for Different Bonus-Malus Classes

Kruskal - Wallis test	p -value
$H_1(K)$ equal for all K	0.736
$H_2(K)$ equal for all K	0.285
Wilcoxon test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.370
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.005
Kolmogorov - Smirnov test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.433
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.002

Figure A.7: Comparison of \hat{H}_1 with the Uniform Distribution for Low and High Bonus-Malus Classes

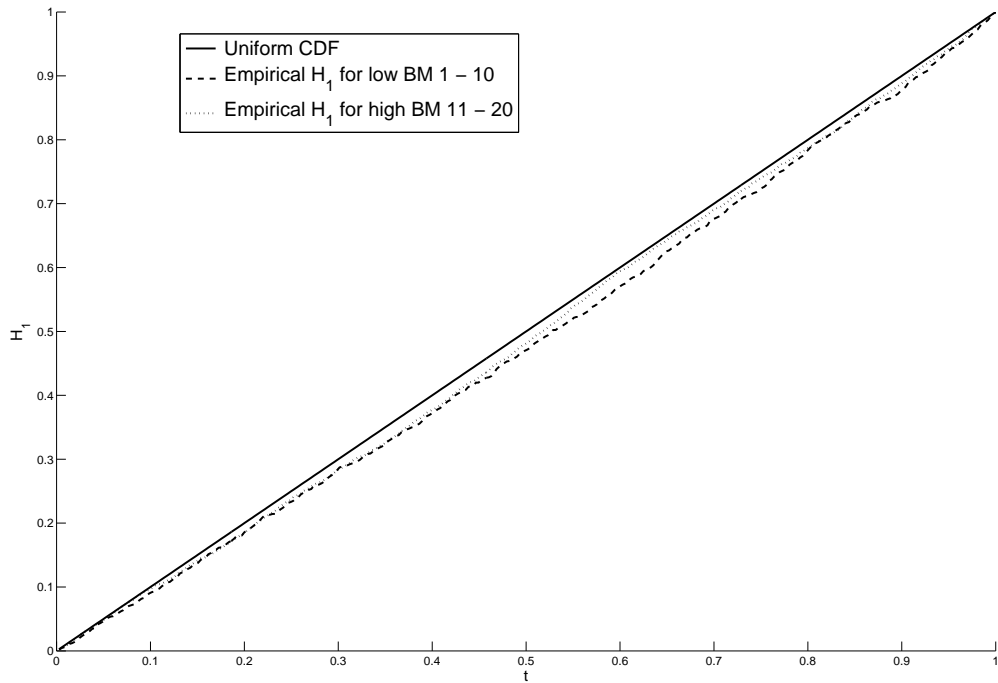


Table A.7: Kolmogorov-Smirnov Test Comparing H_1 with the Uniform Distribution and H_2 with H_1^2 for Different Bonus-Malus Classes

Kolmogorov - Smirnov test		p -value
$H_1(\text{all } K)$	$\sim \text{Uniform}$	0.003
$H_1(\text{low } K)$	$\sim \text{Uniform}$	0.052
$H_1(\text{high } K)$	$\sim \text{Uniform}$	0.018
$H_2(\text{all } K)$	$\sim H_1^2(\text{all } K)$	0.649
$H_2(\text{low } K)$	$\sim H_1^2(\text{low } K)$	0.055
$H_2(\text{high } K)$	$\sim H_1^2(\text{high } K)$	0.250
$H_2(\text{low } K)$	$\sim H_1^2(\text{high } K)$	0.107
$H_2(\text{high } K)$	$\sim H_1^2(\text{low } K)$	0.515

Figure A.8: Comparison of \hat{H}_1 with the Uniform Distribution and of \hat{H}_1^2 with \hat{H}_2 for Low and High Bonus-Malus Classes, with \hat{H}_1 and \hat{H}_2 Estimated on the Same Classes

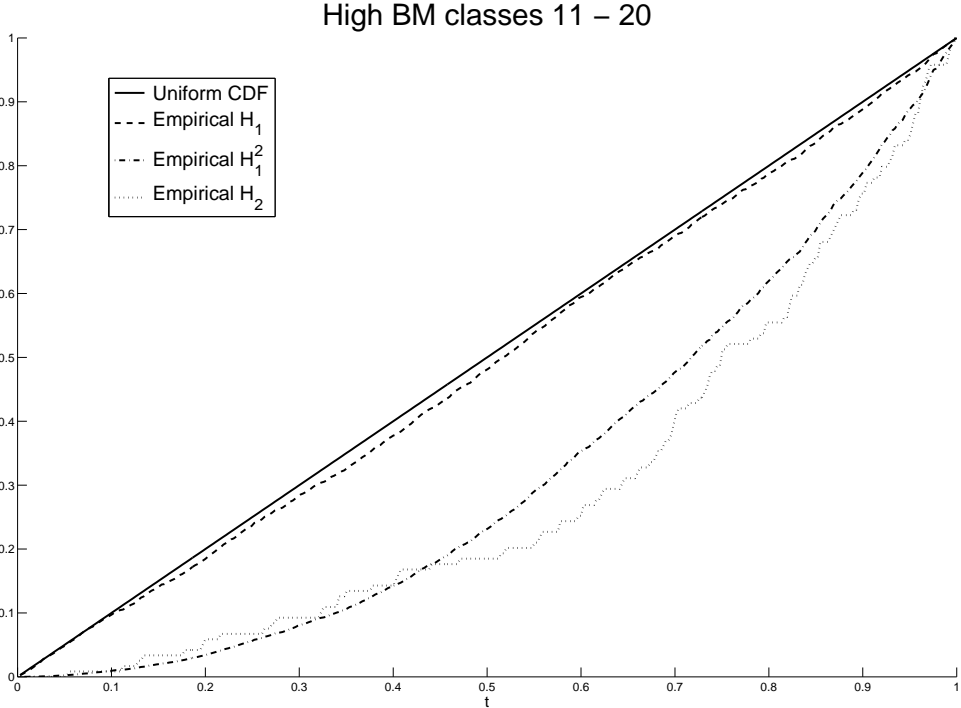
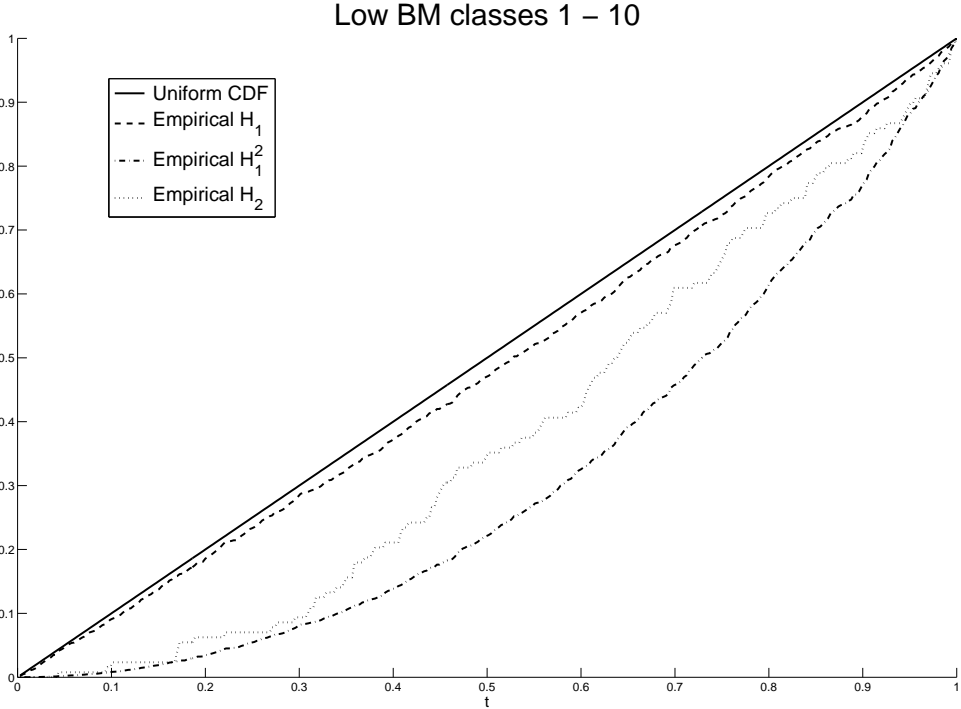


Table A.8: Tests Based on Comparison of First and Second Claim Durations, for Different Bonus-Malus Classes

BM classes	Test statistics (std. error)			
	$\hat{\pi}_n$	$\widehat{\ln \beta}_n$	$\hat{\pi}_n^*$ (all)	$\hat{\pi}_n^*$ (current)
1	60.9% (10.4%)	0.408 (0.378)	56.5% (10.4%)	56.5% (11.1%)
1 – 2	64.7% (8.6%)	0.586 (0.311)	61.8% (8.6%)	61.8% (9.1%)
1 – 3	61.4% (7.5%)	0.392 (0.273)	59.1% (7.6%)	59.1% (7.9%)
1 – 4	53.8% (6.9%)	0.196 (0.252)	51.9% (7.0%)	51.9% (7.3%)
1 – 5	54.1% (6.4%)	0.177 (0.232)	52.5% (6.4%)	54.1% (6.7%)
1 – 6	52.7% (5.8%)	0.033 (0.211)	51.4% (5.8%)	51.4% (6.0%)
1 – 7	51.1% (5.3%)	0.061 (0.193)	50.0% (5.4%)	50.0% (5.5%)
1 – 8	52.4% (4.9%)	0.090 (0.179)	51.5% (5.0%)	53.4% (5.1%)
1 – 9	52.1% (4.6%)	0.092 (0.168)	50.4% (4.7%)	49.6% (4.8%)
1 – 10	53.1% (4.4%)	0.117 (0.160)	51.6% (4.5%)	51.6% (4.5%)
All	53.4% (3.2%)	0.137 (0.115)	51.4% (3.2%)	51.4% (3.2%)
11 – 20	53.8% (4.6%)	0.158 (0.166)	51.3% (4.6%)	51.3% (4.6%)
12 – 20	52.3% (4.8%)	0.075 (0.174)	49.5% (4.8%)	49.5% (4.8%)
13 – 20	51.6% (5.2%)	0.117 (0.188)	49.5% (5.2%)	49.5% (5.2%)
14 – 20	51.8% (5.5%)	0.148 (0.199)	50.6% (5.5%)	50.6% (5.5%)
15 – 20	51.4% (6.0%)	0.124 (0.217)	50.0% (6.0%)	50.0% (6.0%)
16 – 20	47.6% (6.3%)	-0.042 (0.229)	46.0% (6.3%)	46.0% (6.4%)
17 – 20	44.0% (7.1%)	-0.192 (0.257)	42.0% (7.1%)	42.0% (7.1%)
18 – 20	46.5% (7.6%)	-0.109 (0.277)	44.2% (7.6%)	46.5% (7.7%)
19 – 20	42.4% (8.7%)	-0.060 (0.316)	39.4% (8.7%)	42.4% (8.8%)
20	39.3% (9.4%)	-0.118 (0.343)	39.3% (9.5%)	42.9% (9.5%)

Table A.9: Tests Based on Comparison of First and Second Claim Durations that Pool Low and High Bonus-Malus Classes

BM classes		Test statistics (std. error)			
low	high	$\hat{\pi}_n$	$\widehat{\ln \beta_n}$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	20	60.8% (7.0%)	0.249 (0.254)	58.8% (7.0%)	58.8% (7.1%)
1 – 2	20	62.9% (6.4%)	0.375 (0.230)	61.3% (6.4%)	61.3% (6.4%)
1 – 2	19 – 20	61.2% (6.1%)	0.327 (0.222)	61.2% (6.1%)	61.2% (6.2%)
1 – 2	18 – 20	58.4% (5.7%)	0.320 (0.207)	58.4% (5.7%)	59.7% (5.8%)
1 – 2	17 – 20	59.5% (5.5%)	0.352 (0.198)	59.5% (5.5%)	59.5% (5.5%)
1 – 3	19 – 20	59.7% (5.7%)	0.250 (0.207)	59.7% (5.7%)	59.7% (5.8%)
1 – 3	18 – 20	57.5% (5.4%)	0.252 (0.194)	57.5% (5.4%)	57.5% (5.4%)
1 – 4	17 – 20	54.9% (5.0%)	0.194 (0.180)	54.9% (5.0%)	54.9% (5.0%)
1 – 5	16 – 20	53.2% (4.5%)	0.108 (0.163)	53.2% (4.5%)	53.2% (4.6%)
1 – 6	15 – 20	50.7% (4.2%)	-0.043 (0.151)	50.7% (4.2%)	50.7% (4.2%)
1 – 7	14 – 20	49.7% (3.8%)	-0.040 (0.139)	49.7% (3.9%)	49.7% (3.9%)
1 – 8	13 – 20	50.5% (3.6%)	-0.008 (0.130)	51.0% (3.6%)	51.0% (3.6%)
1 – 9	12 – 20	50.0% (3.3%)	0.012 (0.121)	50.4% (3.4%)	50.4% (3.4%)
1 – 10	11 – 20	49.8% (3.2%)	-0.015 (0.115)	50.2% (3.2%)	50.2% (3.2%)

Table A.10: Comparison of First and Second Claim Sizes for Various Bonus-Malus Classes

BM classes	# obs.	Wilcoxon test <i>p</i> -value	Sign test $L_1 \sim L_2$ against		
			$L_1 \succ L_2$	$L_1 \prec L_2$	$L_1 \not\sim L_2$
1	28	0.466	0.092	0.956	0.185
1 – 2	40	0.628	0.437	0.682	0.875
1 – 3	50	0.490	0.556	0.556	1.000
1 – 4	58	0.667	0.448	0.653	0.896
1 – 5	69	0.888	0.595	0.500	1.000
1 – 6	84	0.656	0.707	0.372	0.744
1 – 7	98	0.570	0.760	0.307	0.614
1 – 8	113	0.371	0.827	0.226	0.452
1 – 9	129	0.344	0.811	0.241	0.481
1 – 10	141	0.446	0.750	0.307	0.614
All	265	0.075	0.987	0.018	0.037
11 – 20	124	0.099	0.996	0.007	0.015
12 – 20	112	0.092	0.995	0.009	0.018
13 – 20	96	0.078	0.991	0.016	0.032
14 – 20	86	0.064	0.989	0.020	0.040
15 – 20	73	0.100	0.991	0.017	0.034
16 – 20	66	0.056	0.998	0.005	0.009
17 – 20	52	0.131	0.982	0.035	0.070
18 – 20	45	0.185	0.964	0.068	0.135
19 – 20	35	0.534	0.845	0.250	0.500
20	30	0.688	0.708	0.428	0.856

B Cleaned Data

Tables and figures numbered [B.1](#) and up report the results of redoing all analyses with a sample that includes only observations with consistent raw information on claims and bonus-malus classes (see [Appendix C](#)). No corrections are applied to these data. Like in the main analysis, all claims observed to be withdrawn are excluded.

Table B.3: Contract Exposure Durations in the Sample

Number of years Y	Number of contracts observed		Total
	exactly Y years	between $Y - 1$ and Y years	
1	8,097	11,775	19,872
2	4,296	8,760	13,056
3	5,487	6,560	12,047
4	59,183	5,438	64,621
Total	77,063	32,533	109,596

Table B.4: Number of Contracts Observed for At Least One Full Contract Year, by Bonus-Malus Class and Number of Claims in the First Contract Year

BM class	Number of contracts with					Total
	no claim	1 claim	2 claims	3 claims	4 claims	
1	363	96	19	1		479
2	570	78	11	1		660
3	788	66	9			863
4	1,059	88	8			1,155
5	1,483	94	9	1		1,587
6	2,019	126	10	2		2,157
7	2,754	172	16			2,942
8	3,570	222	13			3,805
9	4,122	204	14	2		4,342
10	5,574	264	10		1	5,849
11	5,197	225	8	2		5,432
12	5,235	255	15			5,505
13	4,777	221	10			5,008
14	5,565	244	9			5,818
15	5,360	262	4			5,626
16	5,600	261	11			5,872
17	4,997	223	5			5,225
18	3,842	177	8			4,027
19	3,606	183	4			3,793
20	26,424	1,224	26	2		27,676
Total	92,905	4,685	219	11	1	97,821

Figure B.1: Distribution of Contracts Observed for At Least One Full Contract Year Across Bonus-Malus Classes; and Shares of Those Contracts with At Least One and At Least Two Claims at Fault in the First Contract Year, by Bonus-Malus Class

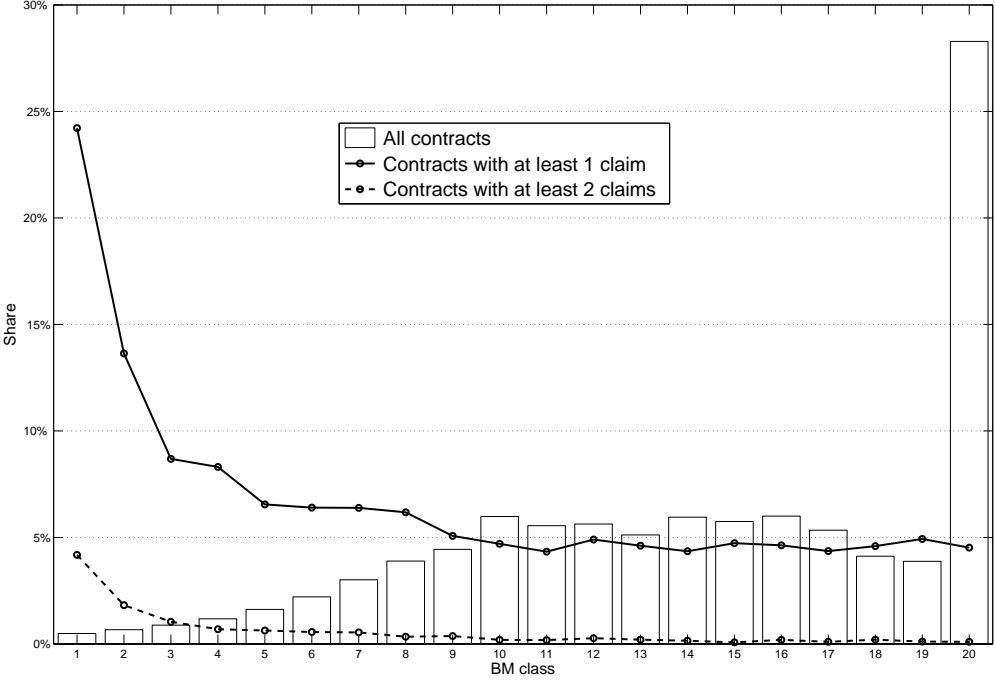


Figure B.2: Incentives to Avoid First, Second and Third Claim; at an Average Risk Level

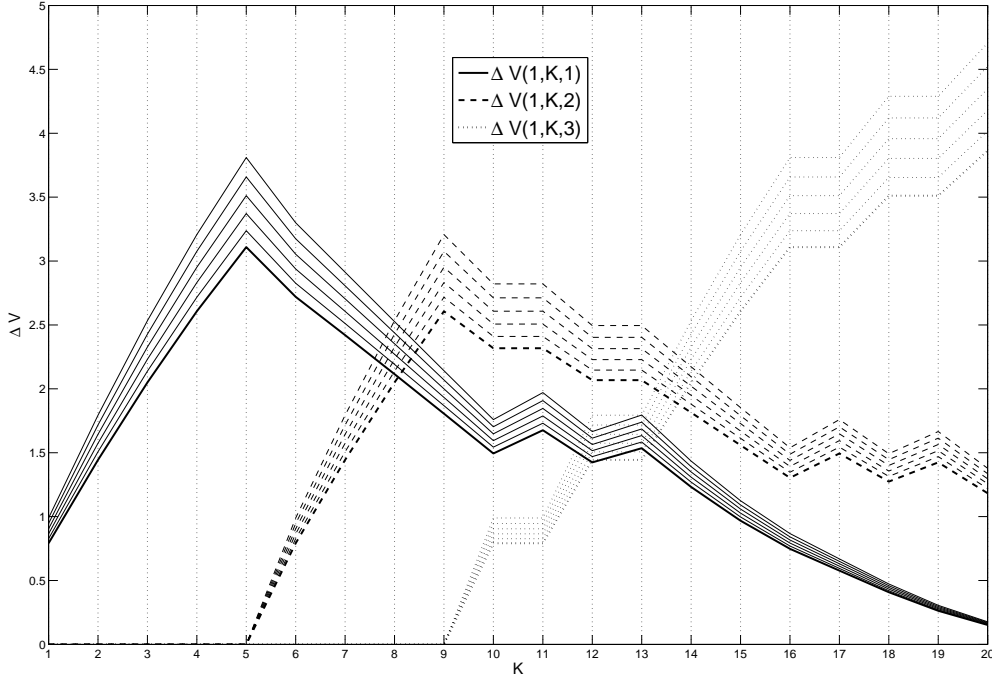


Figure B.3: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at an Average Risk Level

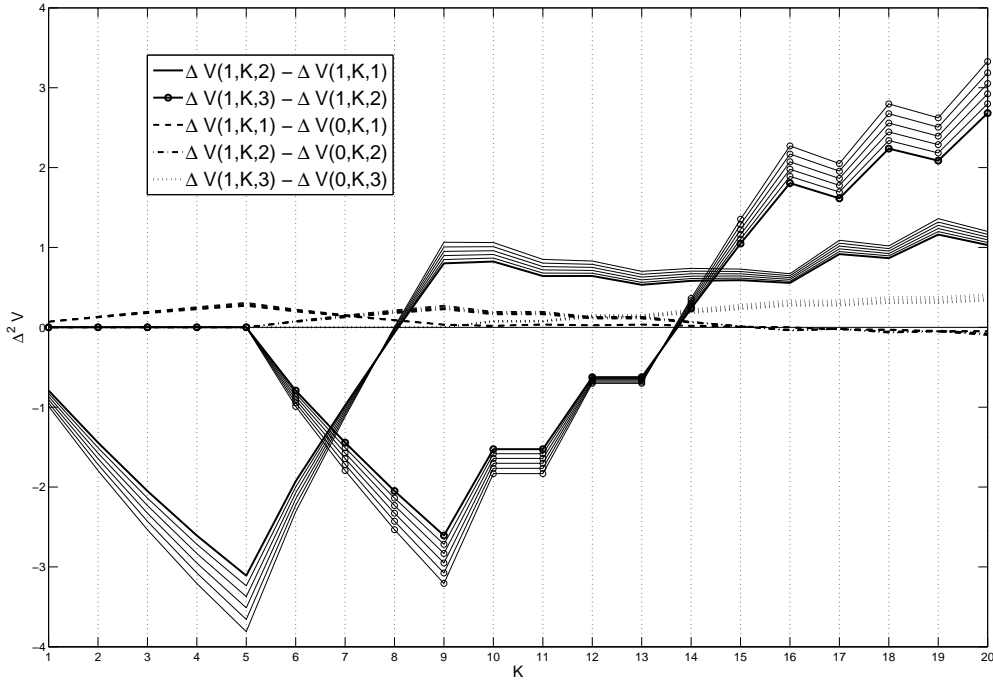


Figure B.4: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a Zero Risk Level

unchanged

Figure B.5: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a High Risk Level

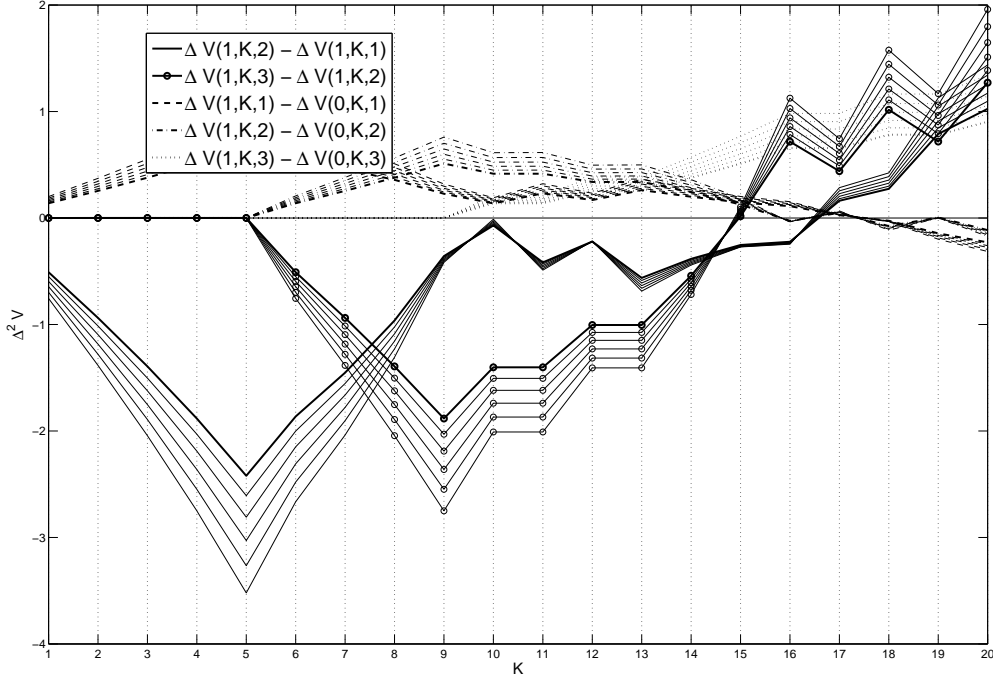


Table B.5: ML Estimation of the Auxiliary Model (14) with 3 and 4 Support Points

Three Support Points

Parameter	Estimate	Std. Error
β	0.4203	0.0528
λ_1	0.0268	0.0051
λ_2	0.1869	0.0375
λ_3	0.3023	0.0156

Tests of $\beta = 0$

- LM test: 5.70, p -value = 0.02
- LR test: 33.08, p -value = 0.00
- Wald test: 63.47, p -value = 0.00

Four Support Points

Parameter	Estimate	Std. Error
β	0.3688	0.0417
λ_1	0.0000	0.0000
λ_2	0.0843	0.0091
λ_3	0.1992	0.0147
λ_4	0.5643	0.0881

Tests of $\beta = 0$

- LM test: 16.13, p -value = 0.00
- LR test: 50.10, p -value = 0.00
- Wald test: 78.23, p -value = 0.00

Table B.6: Nonparametric Tests Based on Comparison of H_1 and H_2 for Different Bonus-Malus Classes

Kruskal - Wallis test	p -value
$H_1(K)$ equal for all K	0.406
$H_2(K)$ equal for all K	0.463
Wilcoxon test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.336
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.036
Kolmogorov - Smirnov test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.433
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.054

Figure B.7: Comparison of \hat{H}_1 with the Uniform Distribution for Low and High Bonus-Malus Classes

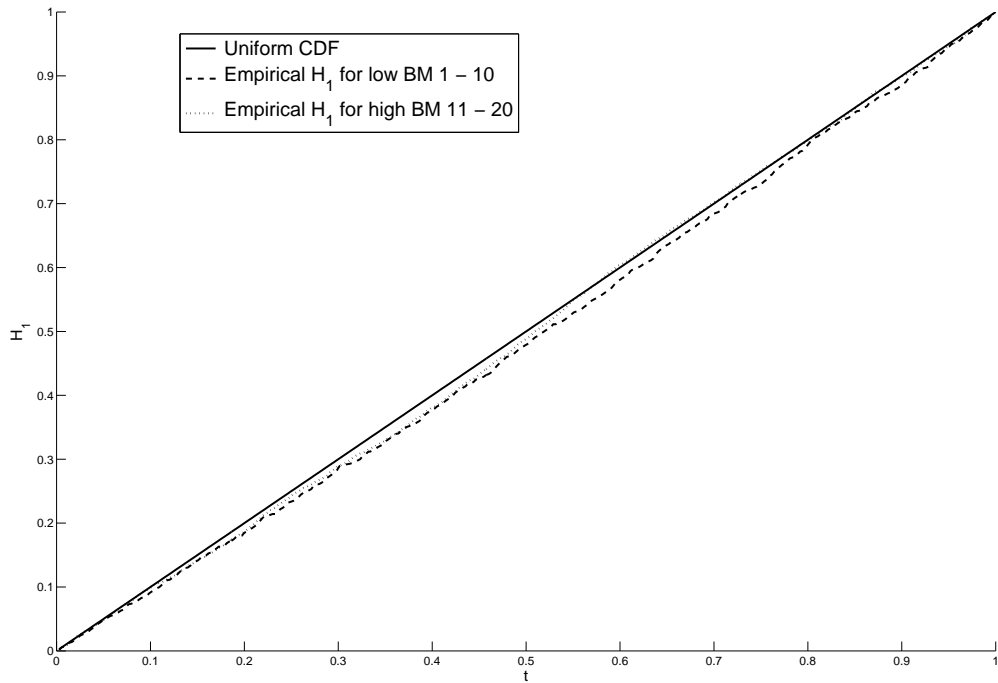


Table B.7: Kolmogorov-Smirnov Test Comparing H_1 with the Uniform Distribution and H_2 with H_1^2 for Different Bonus-Malus Classes

Kolmogorov - Smirnov test		p -value
$H_1(\text{all } K)$	$\sim \text{Uniform}$	0.012
$H_1(\text{low } K)$	$\sim \text{Uniform}$	0.219
$H_1(\text{high } K)$	$\sim \text{Uniform}$	0.082
$H_2(\text{all } K)$	$\sim H_1^2(\text{all } K)$	0.542
$H_2(\text{low } K)$	$\sim H_1^2(\text{low } K)$	0.109
$H_2(\text{high } K)$	$\sim H_1^2(\text{high } K)$	0.660
$H_2(\text{low } K)$	$\sim H_1^2(\text{high } K)$	0.215
$H_2(\text{high } K)$	$\sim H_1^2(\text{low } K)$	0.746

Figure B.8: Comparison of \hat{H}_1 with the Uniform Distribution and of \hat{H}_1^2 with \hat{H}_2 for Low and High Bonus-Malus Classes, with \hat{H}_1 and \hat{H}_2 Estimated on the Same Classes

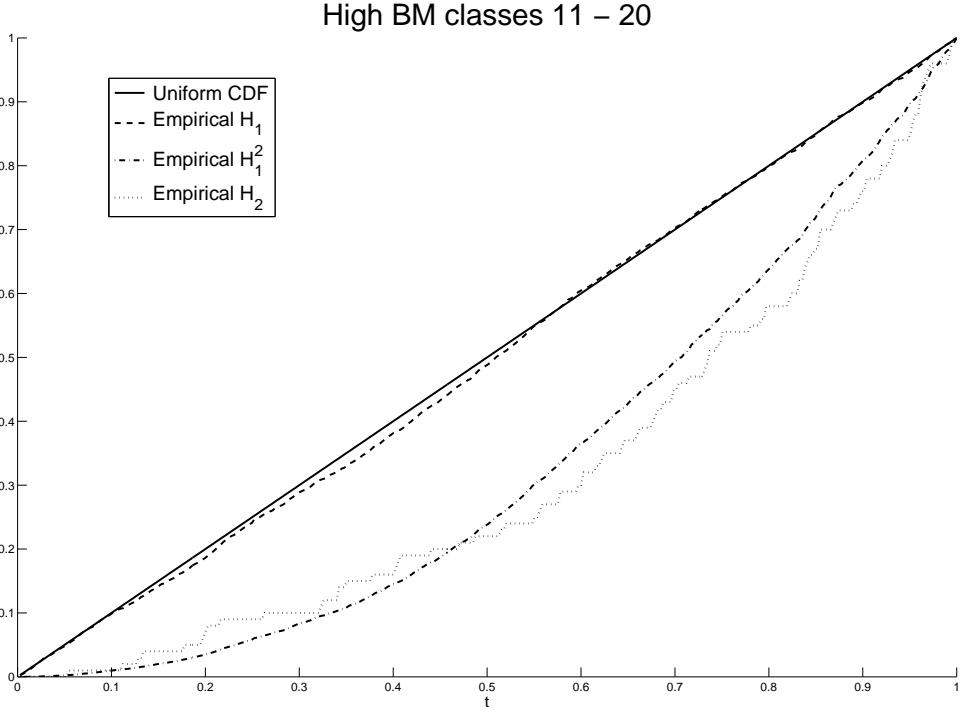
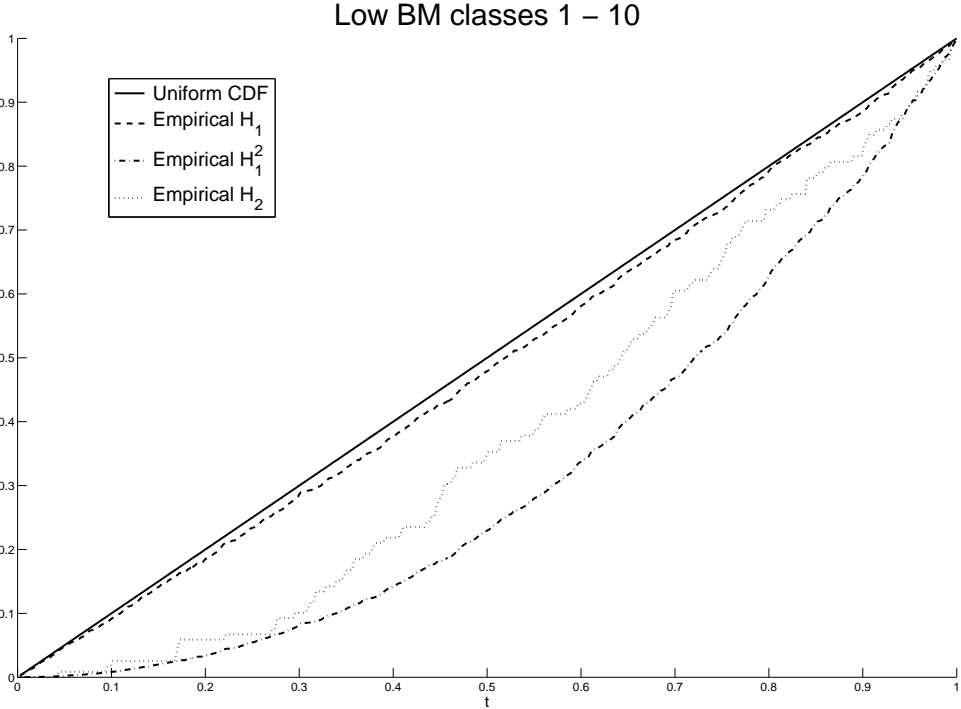


Table B.8: Tests Based on Comparison of First and Second Claim Durations, for Different Bonus-Malus Classes

BM classes	Test statistics (std. error)			
	$\hat{\pi}_n$	$\widehat{\ln \beta}_n$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	57.9% (11.5%)	0.356 (0.416)	47.4% (11.5%)	47.4% (12.2%)
1 – 2	63.3% (9.1%)	0.577 (0.331)	56.7% (9.1%)	56.7% (9.6%)
1 – 3	59.0% (8.0%)	0.361 (0.290)	53.8% (8.0%)	53.8% (8.4%)
1 – 4	53.2% (7.3%)	0.177 (0.265)	48.9% (7.3%)	48.9% (7.6%)
1 – 5	53.6% (6.7%)	0.141 (0.242)	50.0% (6.7%)	51.8% (7.0%)
1 – 6	50.0% (6.2%)	-0.042 (0.223)	47.0% (6.2%)	47.0% (6.4%)
1 – 7	50.0% (5.5%)	0.023 (0.200)	47.6% (5.6%)	48.8% (5.7%)
1 – 8	50.5% (5.1%)	0.082 (0.186)	48.4% (5.2%)	47.4% (5.3%)
1 – 9	50.5% (4.8%)	0.089 (0.174)	47.7% (4.8%)	46.8% (4.9%)
1 – 10	51.3% (4.6%)	0.113 (0.166)	48.7% (4.6%)	49.6% (4.7%)
All	51.6% (3.4%)	0.094 (0.123)	49.3% (3.4%)	49.3% (3.4%)
11 – 20	52.0% (5.0%)	0.072 (0.181)	50.0% (5.0%)	49.0% (5.1%)
12 – 20	52.2% (5.2%)	0.045 (0.189)	50.0% (5.2%)	50.0% (5.3%)
13 – 20	50.6% (5.7%)	0.088 (0.207)	49.4% (5.7%)	49.4% (5.8%)
14 – 20	52.2% (6.1%)	0.159 (0.222)	50.7% (6.1%)	50.7% (6.2%)
15 – 20	51.7% (6.6%)	0.111 (0.238)	50.0% (6.6%)	50.0% (6.6%)
16 – 20	50.0% (6.8%)	0.006 (0.247)	48.1% (6.8%)	48.1% (6.9%)
17 – 20	46.5% (7.6%)	-0.165 (0.277)	44.2% (7.6%)	44.2% (7.7%)
18 – 20	47.4% (8.1%)	-0.135 (0.294)	44.7% (8.1%)	47.4% (8.2%)
19 – 20	43.3% (9.1%)	-0.106 (0.331)	40.0% (9.1%)	43.3% (9.2%)
20	42.3% (9.8%)	-0.143 (0.356)	42.3% (9.8%)	42.3% (9.9%)

Table B.9: Tests Based on Comparison of First and Second Claim Durations that Pool Low and High Bonus-Malus Classes

BM classes		Test statistics (std. error)			
low	high	$\hat{\pi}_n$	$\widehat{\ln \beta_n}$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	20	57.8% (7.5%)	0.233 (0.270)	53.3% (7.5%)	55.6% (7.5%)
1 – 2	20	60.7% (6.7%)	0.375 (0.242)	57.1% (6.7%)	58.9% (6.8%)
1 – 2	19 – 20	60.0% (6.5%)	0.341 (0.234)	58.3% (6.5%)	60.0% (6.5%)
1 – 2	18 – 20	57.4% (6.1%)	0.330 (0.220)	55.9% (6.1%)	57.4% (6.1%)
1 – 2	17 – 20	57.5% (5.9%)	0.334 (0.212)	56.2% (5.9%)	56.2% (5.9%)
1 – 3	19 – 20	58.0% (6.0%)	0.250 (0.218)	56.5% (6.0%)	58.0% (6.1%)
1 – 3	18 – 20	55.8% (5.7%)	0.250 (0.207)	54.5% (5.7%)	55.8% (5.8%)
1 – 4	17 – 20	53.3% (5.3%)	0.171 (0.191)	52.2% (5.3%)	52.2% (5.3%)
1 – 5	16 – 20	51.8% (4.8%)	0.069 (0.173)	50.9% (4.8%)	50.9% (4.8%)
1 – 6	15 – 20	49.2% (4.5%)	-0.074 (0.163)	48.4% (4.5%)	48.4% (4.6%)
1 – 7	14 – 20	49.0% (4.1%)	-0.059 (0.149)	48.3% (4.1%)	48.3% (4.2%)
1 – 8	13 – 20	50.0% (3.8%)	0.005 (0.138)	49.4% (3.9%)	49.4% (3.9%)
1 – 9	12 – 20	49.3% (3.5%)	0.027 (0.128)	48.8% (3.6%)	48.3% (3.6%)
1 – 10	11 – 20	49.8% (3.4%)	0.029 (0.123)	49.3% (3.4%)	49.3% (3.4%)

Table B.10: Comparison of First and Second Claim Sizes for Various Bonus-Malus Classes

BM classes	# obs.	Wilcoxon test <i>p</i> -value	Sign test $L_1 \sim L_2$ against		
			$L_1 \succ L_2$	$L_1 \prec L_2$	$L_1 \not\sim L_2$
1	20	0.296	0.058	0.979	0.115
1 – 2	32	0.736	0.430	0.702	0.860
1 – 3	41	0.781	0.500	0.622	1.000
1 – 4	49	0.846	0.500	0.612	1.000
1 – 5	59	0.916	0.603	0.500	1.000
1 – 6	71	0.705	0.762	0.318	0.635
1 – 7	87	0.412	0.858	0.196	0.391
1 – 8	100	0.203	0.933	0.097	0.193
1 – 9	116	0.153	0.943	0.082	0.163
1 – 10	127	0.195	0.922	0.107	0.214
All	231	0.021	0.998	0.003	0.006
11 – 20	104	0.051	0.998	0.004	0.008
12 – 20	94	0.022	0.999	0.001	0.003
13 – 20	79	0.024	0.998	0.003	0.007
14 – 20	69	0.011	0.999	0.002	0.004
15 – 20	60	0.015	0.999	0.001	0.003
16 – 20	56	0.013	1.000	0.001	0.002
17 – 20	45	0.087	0.992	0.018	0.036
18 – 20	40	0.088	0.992	0.019	0.038
19 – 20	32	0.246	0.945	0.108	0.215
20	28	0.495	0.828	0.286	0.572

C Sample Corrected Based on Initial Bonus-Malus Class

Tables and figures numbered [C.1](#) and up report the results of redoing all analyses on a sample constructed using an alternative correction for inconsistent bonus-malus classes (see Appendix C). This alternative correction takes the initial bonus-malus class observed as given and constructs all further bonus-malus classes from observed claims and withdrawals data. Like in the main analysis, all claims observed to be withdrawn are excluded.

Table C.3: Contract Exposure Durations in the Sample

Number of years Y	Number of contracts observed		Total
	exactly Y years	between $Y - 1$ and Y years	
1	8,097	11,775	19,872
2	4,709	9,616	14,325
3	6,428	7,572	14,000
4	69,059	6,546	75,605
Total	88,293	35,509	123,802

Table C.4: Number of Contracts Observed for At Least One Full Contract Year, by Bonus-Malus Class and Number of Claims in the First Contract Year

BM class	Number of contracts with					Total
	no claim	1 claim	2 claims	3 claims	4 claims	
1	475	230	45	7	1	758
2	745	126	16	1		888
3	948	115	11			1,074
4	1,295	149	13			1,457
5	1,796	162	16	1		1,975
6	2,431	261	23	2		2,717
7	3,347	306	18			3,671
8	4,227	326	22			4,575
9	4,842	314	15	2		5,173
10	6,473	351	12		1	6,837
11	6,039	330	10	2		6,381
12	6,003	349	17			6,369
13	5,504	287	10			5,801
14	6,452	588	14			7,054
15	6,220	297	6			6,523
16	6,432	300	13	1		6,746
17	5,753	253	7			6,013
18	4,426	205	10			4,641
19	3,922	210	4			4,136
20	27,832	1,375	29	2		29,238
Total	105,162	6,534	311	18	2	112,027

Figure C.1: Distribution of Contracts Observed for At Least One Full Contract Year Across Bonus-Malus Classes; and Shares of Those Contracts with At Least One and At Least Two Claims at Fault in the First Contract Year, by Bonus-Malus Class

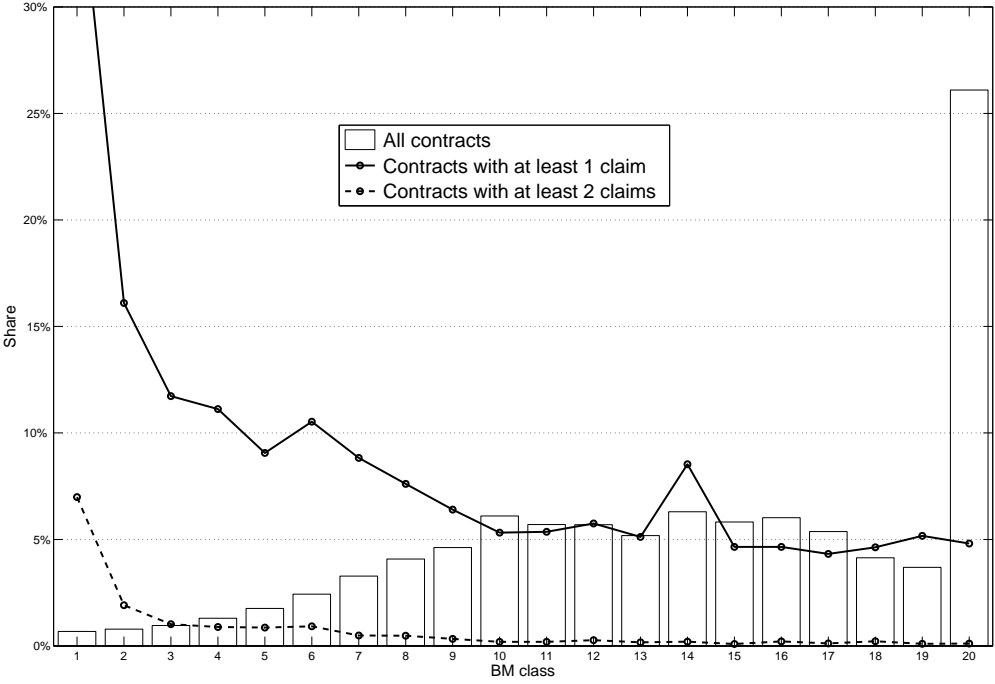


Figure C.2: Incentives to Avoid First, Second and Third Claim; at an Average Risk Level

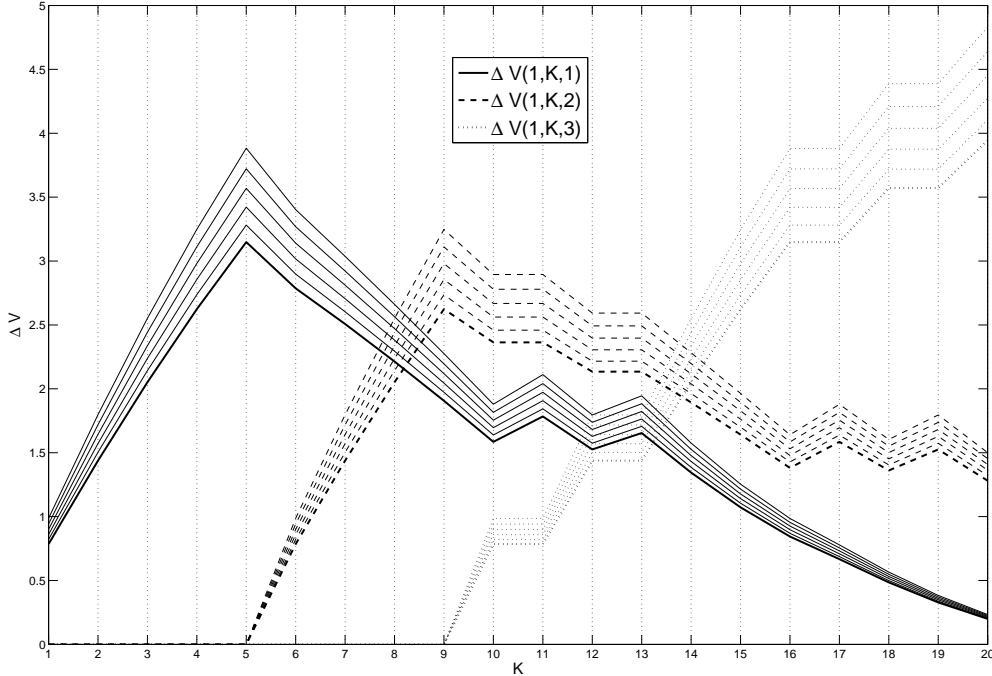


Figure C.3: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at an Average Risk Level

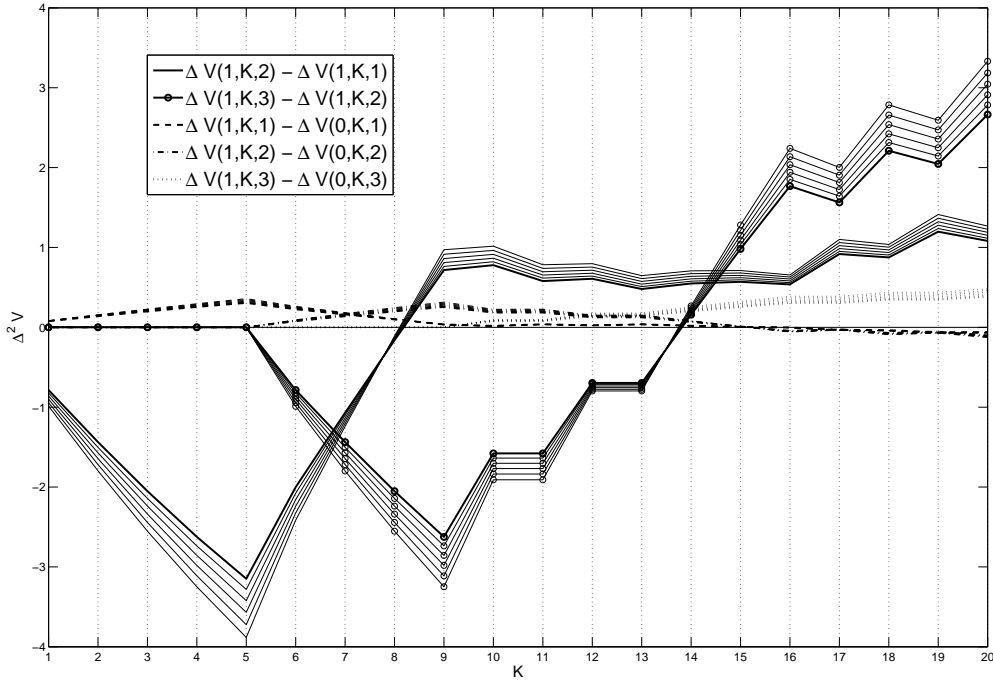


Figure C.4: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a Zero Risk Level

unchanged

Figure C.5: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a High Risk Level

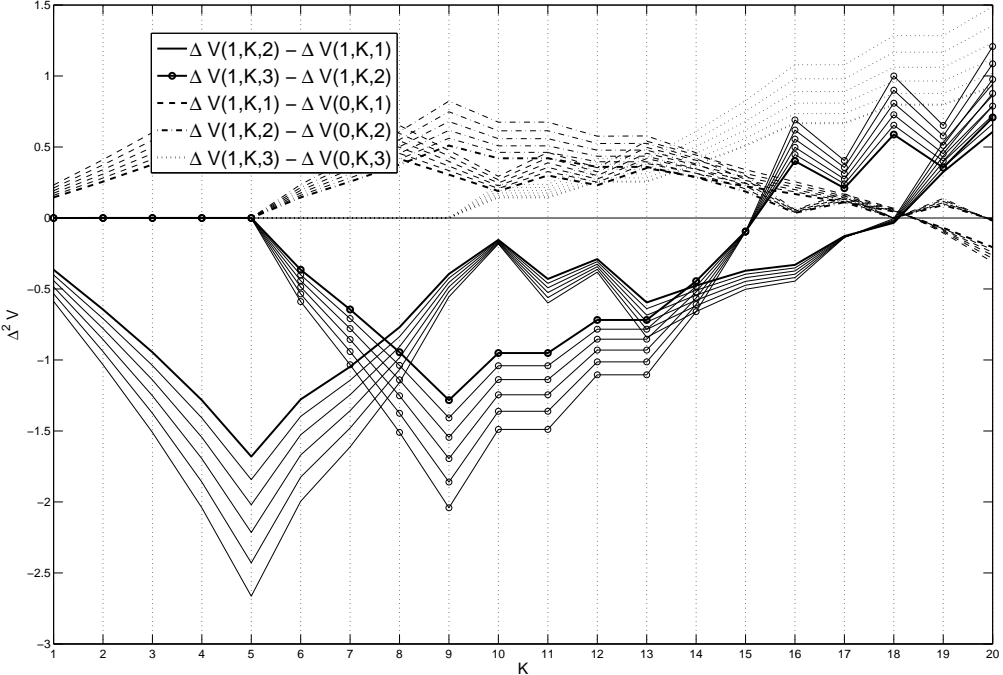


Table C.5: ML Estimation of the Auxiliary Model (14) with 3 and 4 Support Points

Three Support Points

Parameter	Estimate	Std. Error
β	0.3201	0.0435
λ_1	0.0512	0.0037
λ_2	0.1987	0.0240
λ_3	0.3319	0.0136

Tests of $\beta = 0$

- LM test: 5.47, p -value = 0.02
- LR test: 36.92, p -value = 0.00
- Wald test: 54.26, p -value = 0.00

Four Support Points

Parameter	Estimate	Std. Error
β	0.3356	0.0339
λ_1	0.0000	0.0000
λ_2	0.0644	0.0066
λ_3	0.2070	0.0117
λ_4	0.3376	0.0123

Tests of $\beta = 0$

- LM test: 21.79, p -value = 0.00
- LR test: 11.74, p -value = 0.00
- Wald test: 98.28, p -value = 0.00

Table C.6: Nonparametric Tests Based on Comparison of H_1 and H_2 for Different Bonus-Malus Classes

Kruskal - Wallis test	p -value
$H_1(K)$ equal for all K	0.619
$H_2(K)$ equal for all K	0.414
Wilcoxon test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.287
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.014
Kolmogorov - Smirnov test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.530
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.017

Figure C.7: Comparison of \hat{H}_1 with the Uniform Distribution for Low and High Bonus-Malus Classes

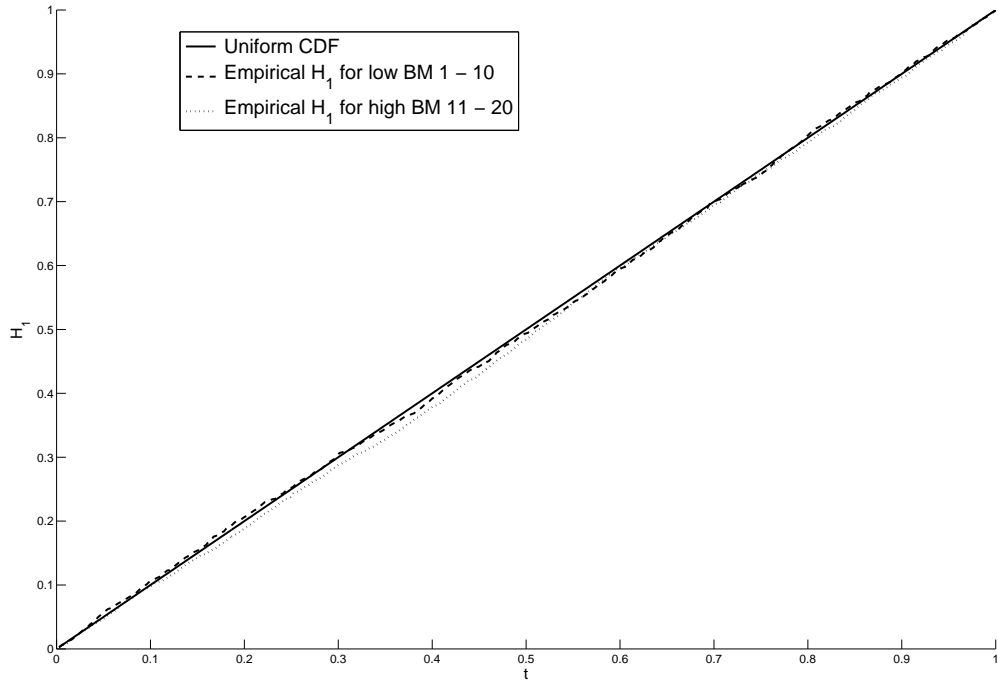


Table C.7: Kolmogorov-Smirnov Test Comparing H_1 with the Uniform Distribution and H_2 with H_1^2 for Different Bonus-Malus Classes

Kolmogorov - Smirnov test		p -value
$H_1(\text{all } K)$	$\sim \text{Uniform}$	0.014
$H_1(\text{low } K)$	$\sim \text{Uniform}$	0.867
$H_1(\text{high } K)$	$\sim \text{Uniform}$	0.015
$H_2(\text{all } K)$	$\sim H_1^2(\text{all } K)$	0.601
$H_2(\text{low } K)$	$\sim H_1^2(\text{low } K)$	0.152
$H_2(\text{high } K)$	$\sim H_1^2(\text{high } K)$	0.489
$H_2(\text{low } K)$	$\sim H_1^2(\text{high } K)$	0.133
$H_2(\text{high } K)$	$\sim H_1^2(\text{low } K)$	0.380

Figure C.8: Comparison of \hat{H}_1 with the Uniform Distribution and of \hat{H}_1^2 with \hat{H}_2 for Low and High Bonus-Malus Classes, with \hat{H}_1 and \hat{H}_2 Estimated on the Same Classes

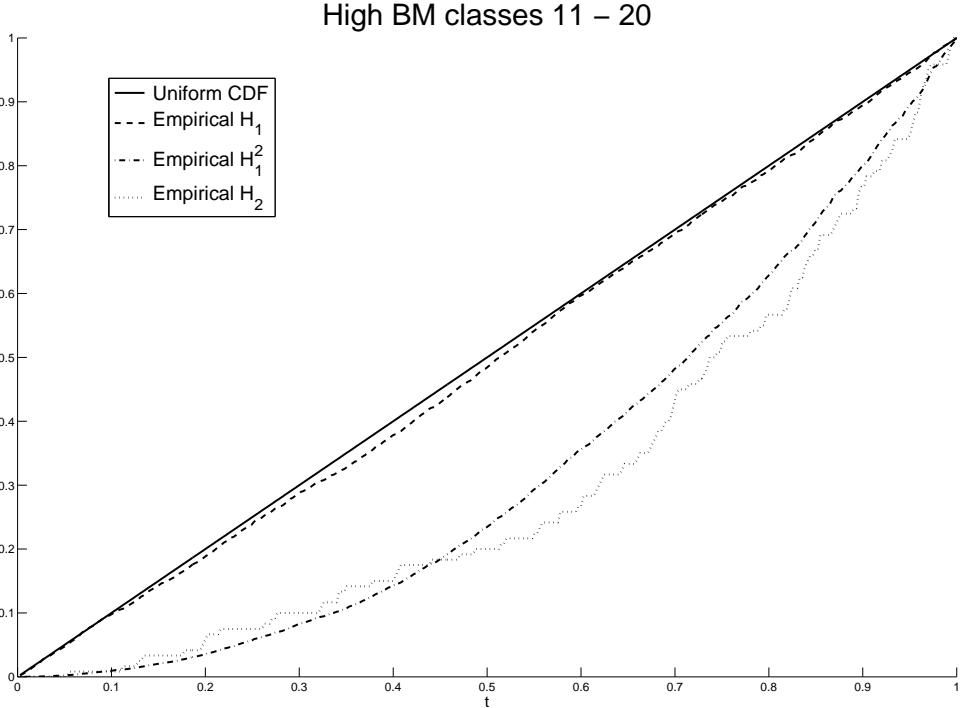
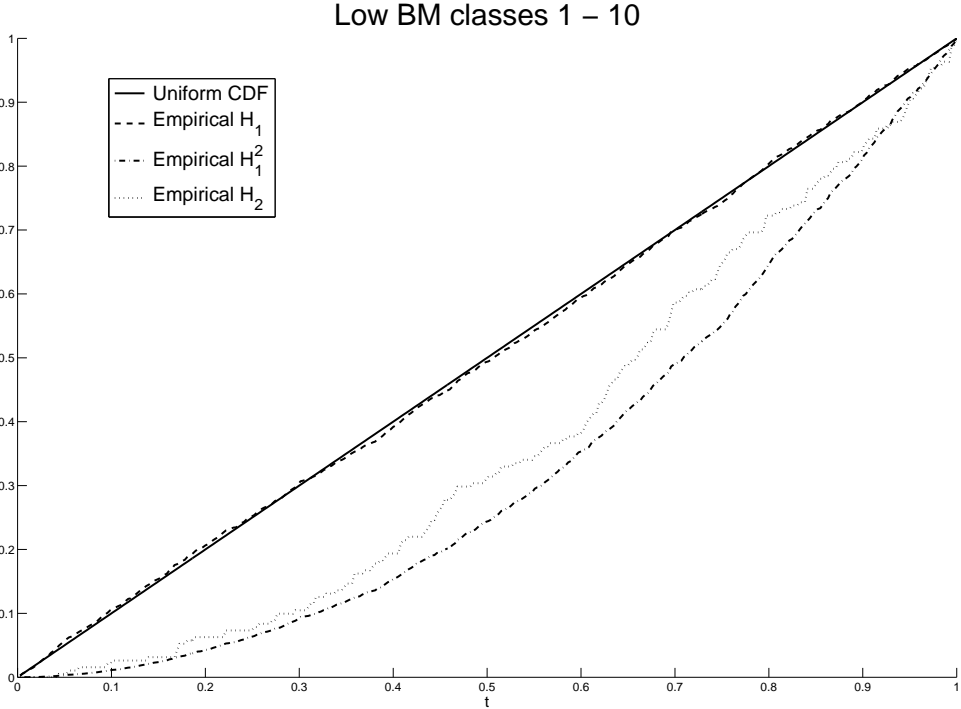


Table C.8: Tests Based on Comparison of First and Second Claim Durations, for Different Bonus-Malus Classes

BM classes	Test statistics (std. error)			
	$\hat{\pi}_n$	$\widehat{\ln \beta_n}$	$\hat{\pi}_n^*$ (all)	$\hat{\pi}_n^*$ (current)
1	62.2% (7.5%)	0.488 (0.270)	55.6% (7.5%)	64.4% (7.9%)
1 – 2	62.3% (6.4%)	0.418 (0.232)	57.4% (6.4%)	59.0% (6.8%)
1 – 3	61.1% (5.9%)	0.372 (0.214)	56.9% (5.9%)	59.7% (6.2%)
1 – 4	57.6% (5.4%)	0.326 (0.197)	54.1% (5.4%)	55.3% (5.7%)
1 – 5	56.4% (5.0%)	0.263 (0.180)	53.5% (5.0%)	56.4% (5.2%)
1 – 6	53.2% (4.5%)	0.082 (0.163)	50.0% (4.5%)	52.4% (4.7%)
1 – 7	52.8% (4.2%)	0.099 (0.152)	50.0% (4.2%)	53.5% (4.3%)
1 – 8	52.4% (3.9%)	0.107 (0.142)	50.0% (3.9%)	53.7% (4.0%)
1 – 9	52.0% (3.7%)	0.104 (0.136)	49.2% (3.8%)	54.2% (3.8%)
1 – 10	52.9% (3.6%)	0.123 (0.131)	50.3% (3.7%)	53.4% (3.7%)
All	52.4% (2.8%)	0.108 (0.103)	50.5% (2.9%)	50.5% (2.9%)
11 – 20	51.7% (4.6%)	0.084 (0.166)	50.8% (4.6%)	50.0% (4.6%)
12 – 20	51.8% (4.8%)	0.040 (0.173)	50.9% (4.8%)	50.0% (4.8%)
13 – 20	50.5% (5.2%)	0.046 (0.188)	50.5% (5.2%)	49.5% (5.2%)
14 – 20	51.8% (5.5%)	0.098 (0.199)	51.8% (5.5%)	50.6% (5.5%)
15 – 20	50.7% (6.0%)	0.091 (0.218)	49.3% (6.0%)	49.3% (6.1%)
16 – 20	47.6% (6.3%)	-0.053 (0.229)	46.0% (6.3%)	46.0% (6.4%)
17 – 20	44.0% (7.1%)	-0.207 (0.257)	42.0% (7.1%)	42.0% (7.1%)
18 – 20	46.5% (7.6%)	-0.126 (0.277)	44.2% (7.6%)	46.5% (7.7%)
19 – 20	42.4% (8.7%)	-0.082 (0.316)	39.4% (8.7%)	42.4% (8.8%)
20	41.4% (9.3%)	-0.112 (0.337)	41.4% (9.3%)	44.8% (9.3%)

Table C.9: Tests Based on Comparison of First and Second Claim Durations that Pool Low and High Bonus-Malus Classes

BM classes		Test statistics (std. error)			
low	high	$\hat{\pi}_n$	$\widehat{\ln \beta_n}$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	20	60.8% (5.8%)	0.341 (0.211)	56.8% (5.8%)	56.8% (5.9%)
1 – 2	20	61.1% (5.3%)	0.319 (0.191)	57.8% (5.3%)	60.0% (5.4%)
1 – 2	19 – 20	60.6% (5.2%)	0.300 (0.187)	58.5% (5.2%)	59.6% (5.2%)
1 – 2	18 – 20	58.7% (4.9%)	0.297 (0.178)	56.7% (4.9%)	58.7% (5.0%)
1 – 2	17 – 20	59.5% (4.7%)	0.323 (0.172)	57.7% (4.8%)	57.7% (4.8%)
1 – 3	19 – 20	60.0% (4.9%)	0.281 (0.177)	58.1% (4.9%)	59.0% (5.0%)
1 – 3	18 – 20	58.3% (4.7%)	0.28 (0.169)	56.5% (4.7%)	58.3% (4.7%)
1 – 4	17 – 20	57.0% (4.3%)	0.282 (0.156)	55.6% (4.3%)	56.3% (4.4%)
1 – 5	16 – 20	54.9% (3.9%)	0.183 (0.142)	53.7% (3.9%)	53.7% (4.0%)
1 – 6	15 – 20	51.8% (3.6%)	0.020 (0.131)	50.3% (3.6%)	50.3% (3.7%)
1 – 7	14 – 20	51.1% (3.3%)	0.026 (0.121)	49.3% (3.4%)	49.3% (3.4%)
1 – 8	13 – 20	51.4% (3.1%)	0.052 (0.113)	49.8% (3.2%)	49.8% (3.2%)
1 – 9	12 – 20	50.5% (2.9%)	0.049 (0.107)	49.1% (3.0%)	49.5% (3.0%)
1 – 10	11 – 20	51.1% (2.8%)	0.043 (0.103)	49.8% (2.9%)	49.8% (2.9%)

Table C.10: Comparison of First and Second Claim Sizes for Various Bonus-Malus Classes

BM classes	# obs.	Wilcoxon test <i>p</i> -value	Sign test $L_1 \sim L_2$ against		
			$L_1 \succ L_2$	$L_1 \prec L_2$	$L_1 \not\sim L_2$
1	53	0.780	0.392	0.708	0.784
1 – 2	70	0.706	0.640	0.452	0.905
1 – 3	81	0.596	0.672	0.412	0.824
1 – 4	94	0.612	0.697	0.379	0.757
1 – 5	111	0.897	0.776	0.285	0.569
1 – 6	136	0.246	0.928	0.099	0.198
1 – 7	154	0.201	0.937	0.085	0.171
1 – 8	176	0.104	0.979	0.030	0.059
1 – 9	193	0.086	0.978	0.030	0.061
1 – 10	206	0.148	0.959	0.054	0.109
All	331	0.019	0.998	0.003	0.006
11 – 20	125	0.060	0.994	0.010	0.020
12 – 20	113	0.030	0.998	0.004	0.008
13 – 20	96	0.030	0.995	0.009	0.018
14 – 20	86	0.017	0.997	0.006	0.013
15 – 20	72	0.031	0.997	0.006	0.013
16 – 20	66	0.020	0.999	0.002	0.004
17 – 20	52	0.049	0.991	0.018	0.036
18 – 20	45	0.068	0.982	0.036	0.072
19 – 20	35	0.238	0.912	0.155	0.311
20	31	0.493	0.763	0.360	0.720

D Main (Corrected) Sample Including Withdrawn Claims

Tables and figures numbered [D.1](#) and up report the results of redoing all analyses using the contract and bonus-malus information from the main (corrected) sample, but including all withdrawn claims as claim-at-fault events (see Appendix C).

Table D.3: Contract Exposure Durations in the Sample

Number of years Y	Number of contracts observed		Total
	exactly Y years	between $Y - 1$ and Y years	
1	8,097	11,775	19,872
2	4,709	9,616	14,325
3	6,261	7,385	13,646
4	68,808	6,501	75,309
Total	87,875	35,277	123,152

Table D.4: Number of Contracts Observed for At Least One Full Contract Year, by Bonus-Malus Class and Number of Claims in the First Contract Year

BM class	Number of contracts with					Total
	no claim	1 claim	2 claims	3 claims	4 claims	
1	562	119	24	4	1	710
2	746	95	11	1		853
3	957	83	11			1,051
4	1,308	100	9			1,417
5	1,876	112	13	1		2,002
6	2,509	162	14	2		2,687
7	3,360	209	17			3,586
8	4,232	272	16			4,520
9	4,882	252	16	2		5,152
10	6,486	298	11		1	6,796
11	6,056	282	12	2		6,352
12	6,002	287	16			6,305
13	5,874	269	11			6,154
14	6,663	313	13			6,989
15	6,161	302	9			6,472
16	6,375	298	14	1		6,688
17	5,669	252	7			5,928
18	4,366	207	11			4,584
19	3,854	214	7			4,075
20	27,651	1,374	29	2		29,056
Total	105,589	5,500	271	15	2	111,377

Figure D.1: Distribution of Contracts Observed for At Least One Full Contract Year Across Bonus-Malus Classes; and Shares of Those Contracts with At Least One and At Least Two Claims at Fault in the First Contract Year, by Bonus-Malus Class

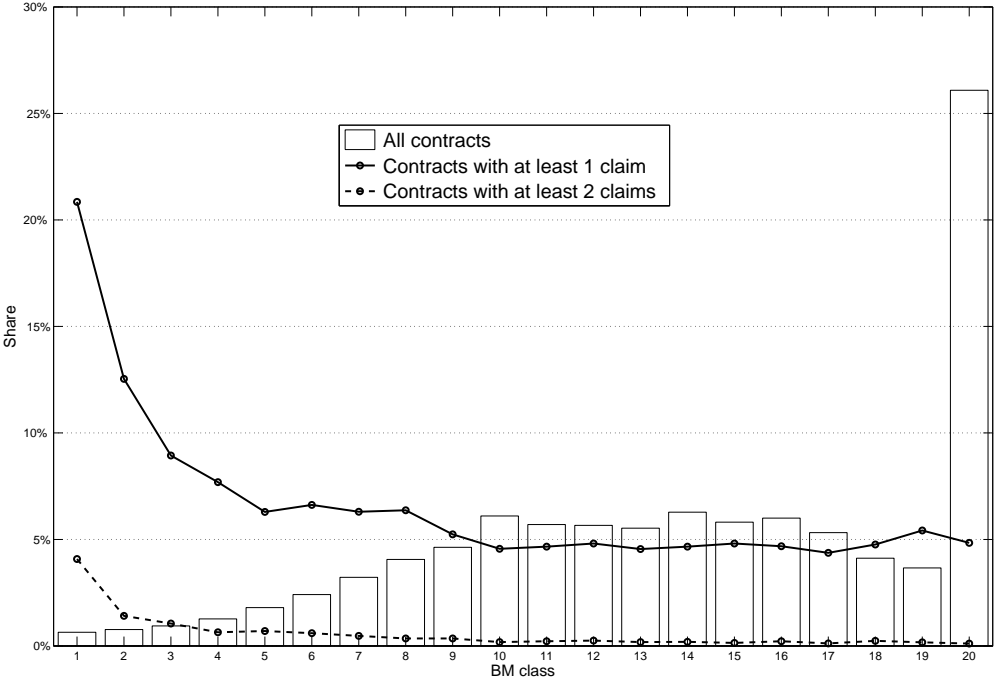


Figure D.2: Incentives to Avoid First, Second and Third Claim; at an Average Risk Level

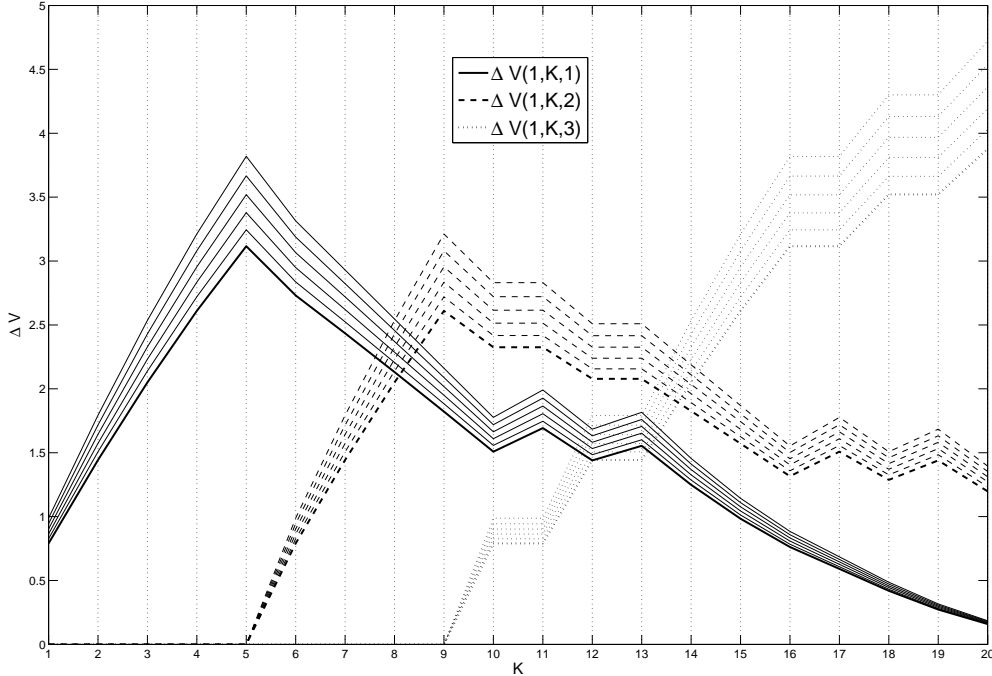


Figure D.3: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at an Average Risk Level

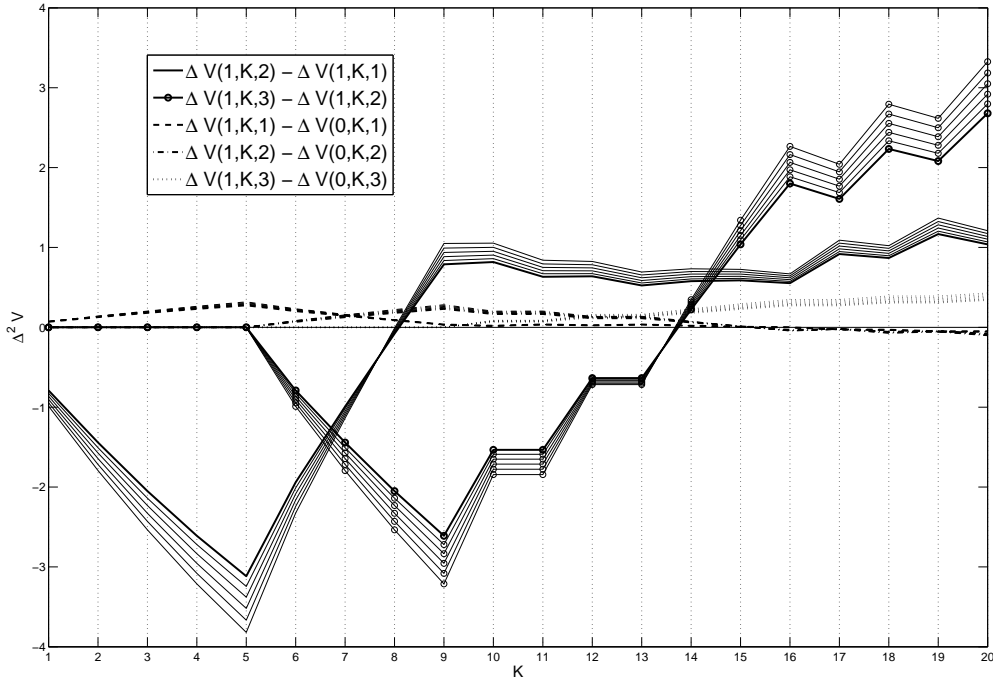


Figure D.4: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a Zero Risk Level

unchanged

Figure D.5: Change in Incentives to Avoid a Claim after a First and a Second Claim, and Changes in Incentives to Avoid a First, a Second and a Third Claim over the Course of a Contract Year; at a High Risk Level

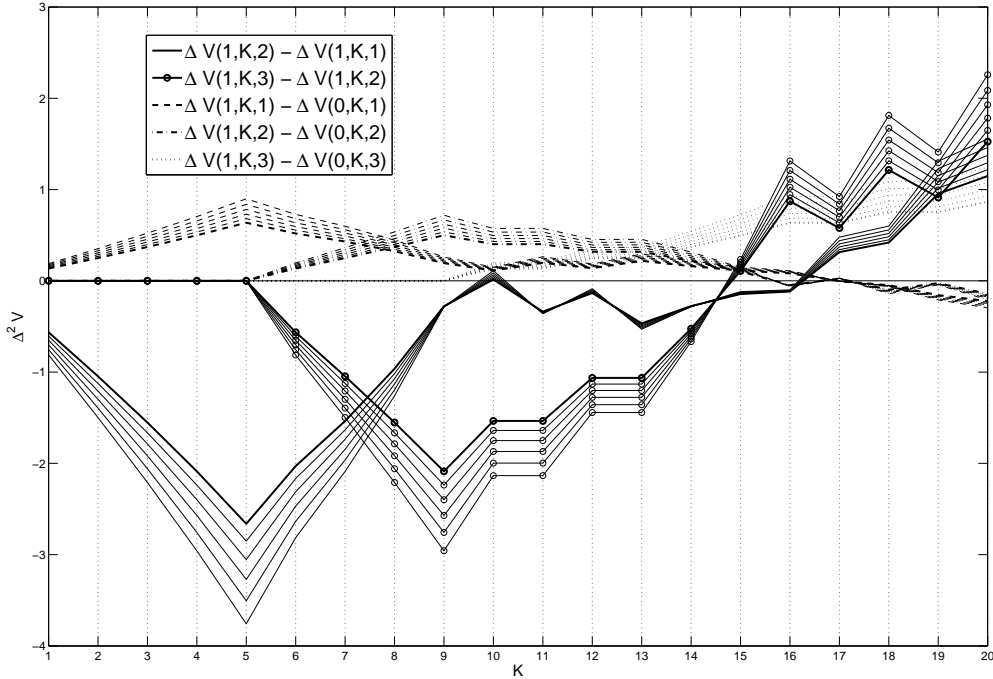


Table D.5: ML Estimation of the Auxiliary Model (14) with 3 and 4 Support Points

Three Support Points

Parameter	Estimate	Std. Error
β	0.4710	0.0353
λ_1	0.0435	0.0037
λ_2	0.2623	0.0110
λ_3	0.3560	0.0126

Tests of $\beta = 0$

- LM test: 9.22, p -value = 0.00
- LR test: 73.61, p -value = 0.00
- Wald test: 178.15, p -value = 0.00

Four Support Points

Parameter	Estimate	Std. Error
β	0.4692	0.0330
λ_1	0.0396	0.0036
λ_2	0.2481	0.0150
λ_3	0.2672	0.0105
λ_4	0.3611	0.0130

Tests of $\beta = 0$

- LM test: 229.96, p -value = 0.00
- LR test: 48.01, p -value = 0.00
- Wald test: 201.78, p -value = 0.00

Table D.6: Nonparametric Tests Based on Comparison of H_1 and H_2 for Different Bonus-Malus Classes

Kruskal - Wallis test	p -value
$H_1(K)$ equal for all K	0.667
$H_2(K)$ equal for all K	0.247
Wilcoxon test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.504
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.008
Kolmogorov - Smirnov test	p -value
$H_1(\text{low } K) \sim H_1(\text{high } K)$	0.528
$H_2(\text{low } K) \sim H_2(\text{high } K)$	0.003

Figure D.7: Comparison of \hat{H}_1 with the Uniform Distribution for Low and High Bonus-Malus Classes

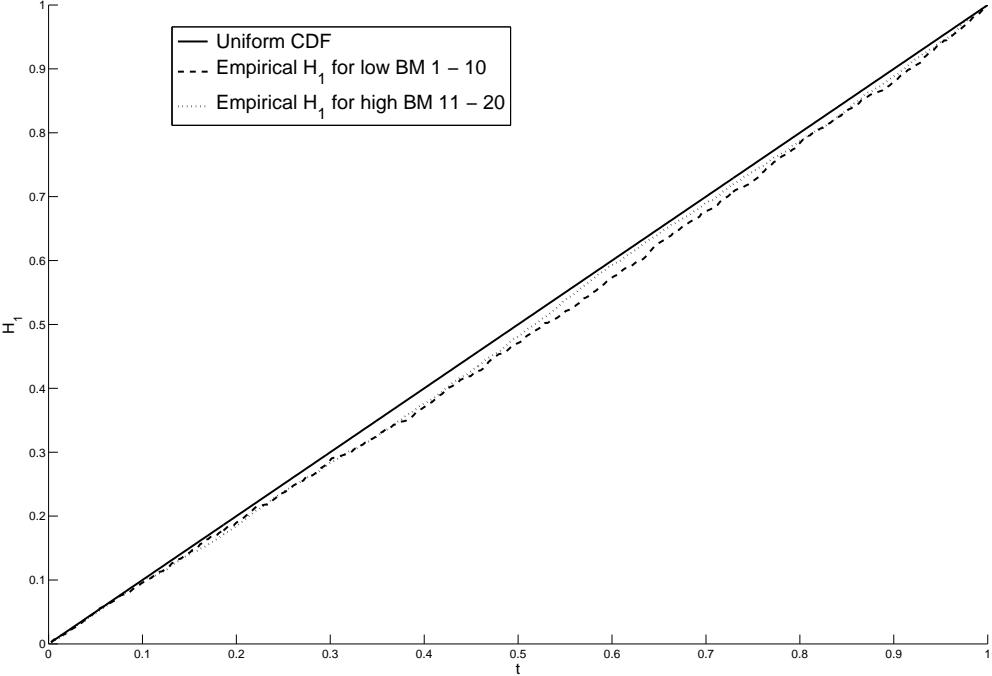


Table D.7: Kolmogorov-Smirnov Test Comparing H_1 with the Uniform Distribution and H_2 with H_1^2 for Different Bonus-Malus Classes

Kolmogorov - Smirnov test		p -value
H_1 (all K)	\sim Uniform	0.002
H_1 (low K)	\sim Uniform	0.052
H_1 (high K)	\sim Uniform	0.011
H_2 (all K)	\sim H_1^2 (all K)	0.545
H_2 (low K)	\sim H_1^2 (low K)	0.059
H_2 (high K)	\sim H_1^2 (high K)	0.389
H_2 (low K)	\sim H_1^2 (high K)	0.127
H_2 (high K)	\sim H_1^2 (low K)	0.658

Figure D.8: Comparison of \hat{H}_1 with the Uniform Distribution and of \hat{H}_1^2 with \hat{H}_2 for Low and High Bonus-Malus Classes, with \hat{H}_1 and \hat{H}_2 Estimated on the Same Classes

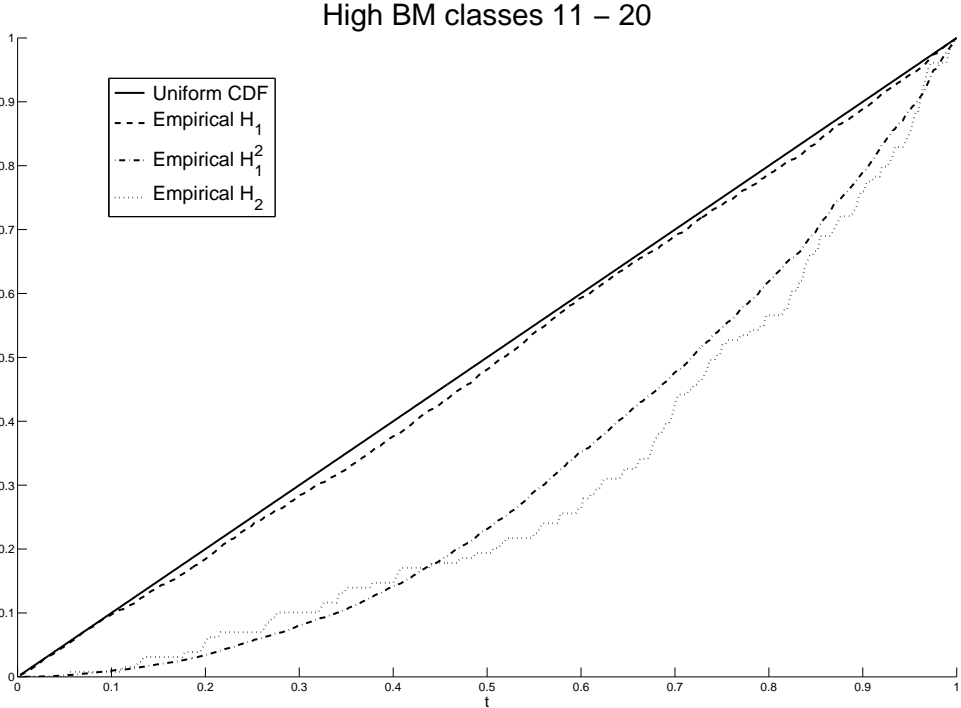
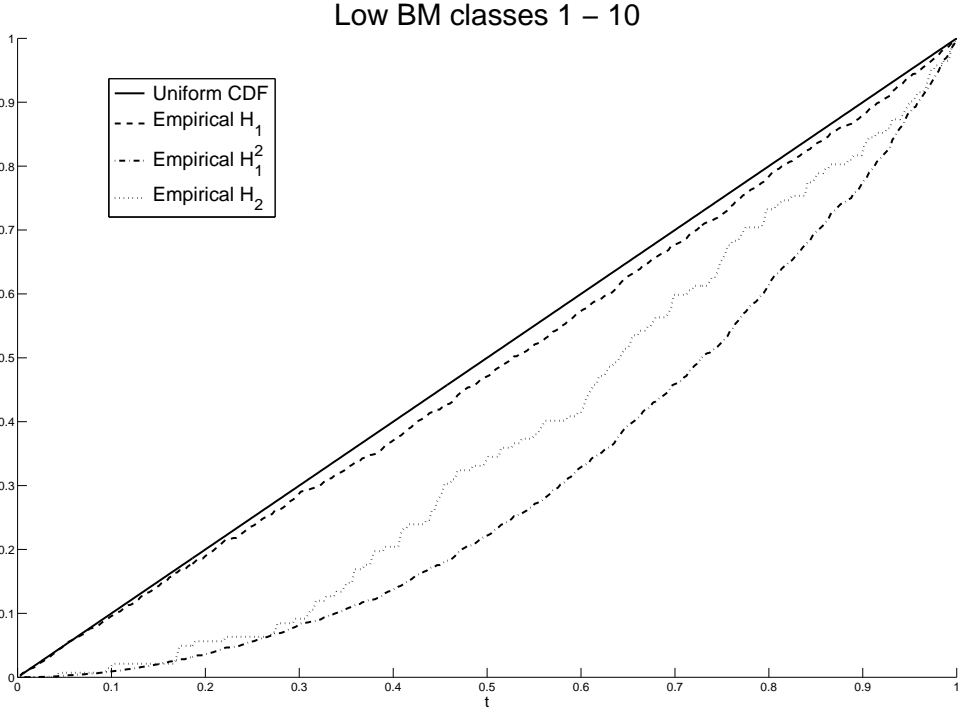


Table D.8: Tests Based on Comparison of First and Second Claim Durations, for Different Bonus-Malus Classes

BM classes	Test statistics (std. error)			
	$\hat{\pi}_n$	$\widehat{\ln \beta}_n$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	62.5% (10.2%)	0.392 (0.370)	54.2% (10.2%)	54.2% (10.9%)
1 – 2	65.7% (8.5%)	0.570 (0.307)	60.0% (8.5%)	60.0% (8.9%)
1 – 3	60.9% (7.4%)	0.346 (0.267)	56.5% (7.4%)	56.5% (7.7%)
1 – 4	54.5% (6.7%)	0.183 (0.245)	50.9% (6.8%)	52.7% (7.0%)
1 – 5	54.4% (6.1%)	0.157 (0.220)	51.5% (6.1%)	54.4% (6.3%)
1 – 6	53.7% (5.5%)	0.029 (0.200)	50.0% (5.5%)	53.7% (5.7%)
1 – 7	53.5% (5.0%)	0.080 (0.182)	50.5% (5.1%)	53.5% (5.2%)
1 – 8	53.0% (4.7%)	0.080 (0.169)	50.4% (4.7%)	53.0% (4.8%)
1 – 9	51.9% (4.4%)	0.064 (0.158)	48.9% (4.4%)	50.4% (4.5%)
1 – 10	52.8% (4.2%)	0.089 (0.152)	50.0% (4.2%)	50.7% (4.3%)
All	52.8% (3.0%)	0.090 (0.110)	50.2% (3.1%)	50.2% (3.1%)
11 – 20	52.7% (4.4%)	0.091 (0.160)	50.4% (4.4%)	51.2% (4.5%)
12 – 20	52.1% (4.6%)	0.020 (0.168)	49.6% (4.7%)	50.4% (4.7%)
13 – 20	51.5% (5.0%)	0.049 (0.180)	49.5% (5.0%)	50.5% (5.0%)
14 – 20	53.3% (5.3%)	0.104 (0.191)	51.1% (5.3%)	52.2% (5.3%)
15 – 20	51.9% (5.7%)	0.072 (0.207)	49.4% (5.7%)	50.6% (5.8%)
16 – 20	48.5% (6.1%)	-0.074 (0.220)	47.1% (6.1%)	47.1% (6.1%)
17 – 20	44.4% (6.8%)	-0.250 (0.247)	42.6% (6.8%)	42.6% (6.9%)
18 – 20	46.8% (7.3%)	-0.182 (0.265)	44.7% (7.3%)	46.8% (7.4%)
19 – 20	41.7% (8.3%)	-0.210 (0.302)	38.9% (8.4%)	41.7% (8.4%)
20	41.4% (9.3%)	-0.112 (0.337)	41.4% (9.3%)	44.8% (9.3%)

Table D.9: Tests Based on Comparison of First and Second Claim Durations that Pool Low and High Bonus-Malus Classes

BM classes		Test statistics (std. error)			
low	high	$\hat{\pi}_n$	$\widehat{\ln \beta_n}$	$\hat{\pi}_n^*(\text{all})$	$\hat{\pi}_n^*(\text{current})$
1	20	60.4% (6.9%)	0.239 (0.249)	56.6% (6.9%)	56.6% (6.9%)
1 – 2	20	62.5% (6.3%)	0.363 (0.227)	59.4% (6.3%)	59.4% (6.3%)
1 – 2	19 – 20	62.0% (5.9%)	0.387 (0.215)	60.6% (6.0%)	60.6% (6.0%)
1 – 2	18 – 20	58.5% (5.5%)	0.348 (0.200)	57.3% (5.5%)	58.5% (5.6%)
1 – 2	17 – 20	59.6% (5.3%)	0.376 (0.192)	58.4% (5.3%)	58.4% (5.4%)
1 – 3	19 – 20	59.8% (5.5%)	0.286 (0.200)	58.5% (5.5%)	58.5% (5.6%)
1 – 3	18 – 20	57.0% (5.2%)	0.263 (0.188)	55.9% (5.2%)	57.0% (5.3%)
1 – 4	17 – 20	55.0% (4.8%)	0.216 (0.174)	54.1% (4.8%)	54.1% (4.9%)
1 – 5	16 – 20	52.9% (4.3%)	0.116 (0.156)	52.2% (4.3%)	52.2% (4.4%)
1 – 6	15 – 20	50.9% (4.0%)	-0.020 (0.144)	50.3% (4.0%)	49.7% (4.0%)
1 – 7	14 – 20	50.3% (3.6%)	-0.008 (0.132)	49.7% (3.7%)	49.7% (3.7%)
1 – 8	13 – 20	50.9% (3.4%)	0.019 (0.123)	50.5% (3.4%)	50.0% (3.5%)
1 – 9	12 – 20	50.0% (3.2%)	0.025 (0.115)	49.6% (3.2%)	49.2% (3.2%)
1 – 10	11 – 20	50.2% (3.0%)	0.003 (0.110)	49.8% (3.1%)	49.8% (3.1%)

Table D.10: Comparison of First and Second Claim Sizes for Various Bonus-Malus Classes

BM classes	# obs.	Wilcoxon test <i>p</i> -value	Sign test $L_1 \sim L_2$ against		
			$L_1 \succ L_2$	$L_1 \prec L_2$	$L_1 \not\sim L_2$
1	29	0.336	0.068	0.969	0.136
1 – 2	41	0.791	0.378	0.734	0.755
1 – 3	52	0.649	0.445	0.661	0.890
1 – 4	61	0.815	0.399	0.696	0.798
1 – 5	75	0.941	0.500	0.591	1.000
1 – 6	91	0.755	0.662	0.417	0.834
1 – 7	108	0.413	0.807	0.250	0.501
1 – 8	124	0.195	0.911	0.121	0.243
1 – 9	142	0.121	0.923	0.104	0.208
1 – 10	154	0.174	0.887	0.147	0.295
All	288	0.021	0.994	0.008	0.016
11 – 20	134	0.070	0.994	0.010	0.019
12 – 20	120	0.050	0.996	0.007	0.013
13 – 20	104	0.042	0.993	0.012	0.024
14 – 20	93	0.035	0.994	0.011	0.022
15 – 20	80	0.068	0.995	0.009	0.018
16 – 20	71	0.043	0.998	0.004	0.009
17 – 20	56	0.119	0.978	0.041	0.081
18 – 20	49	0.171	0.957	0.076	0.152
19 – 20	38	0.335	0.872	0.209	0.418
20	31	0.493	0.763	0.360	0.720