Pricing Insurance Risk

Module C: Historical US Property-Casualty Profitability and Volatility

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Stephen J. Mildenhall

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convex risk

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Module C Contents

C.01. Premium to GDP Ratio, 1923-2020

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Premium to GDP Ratio

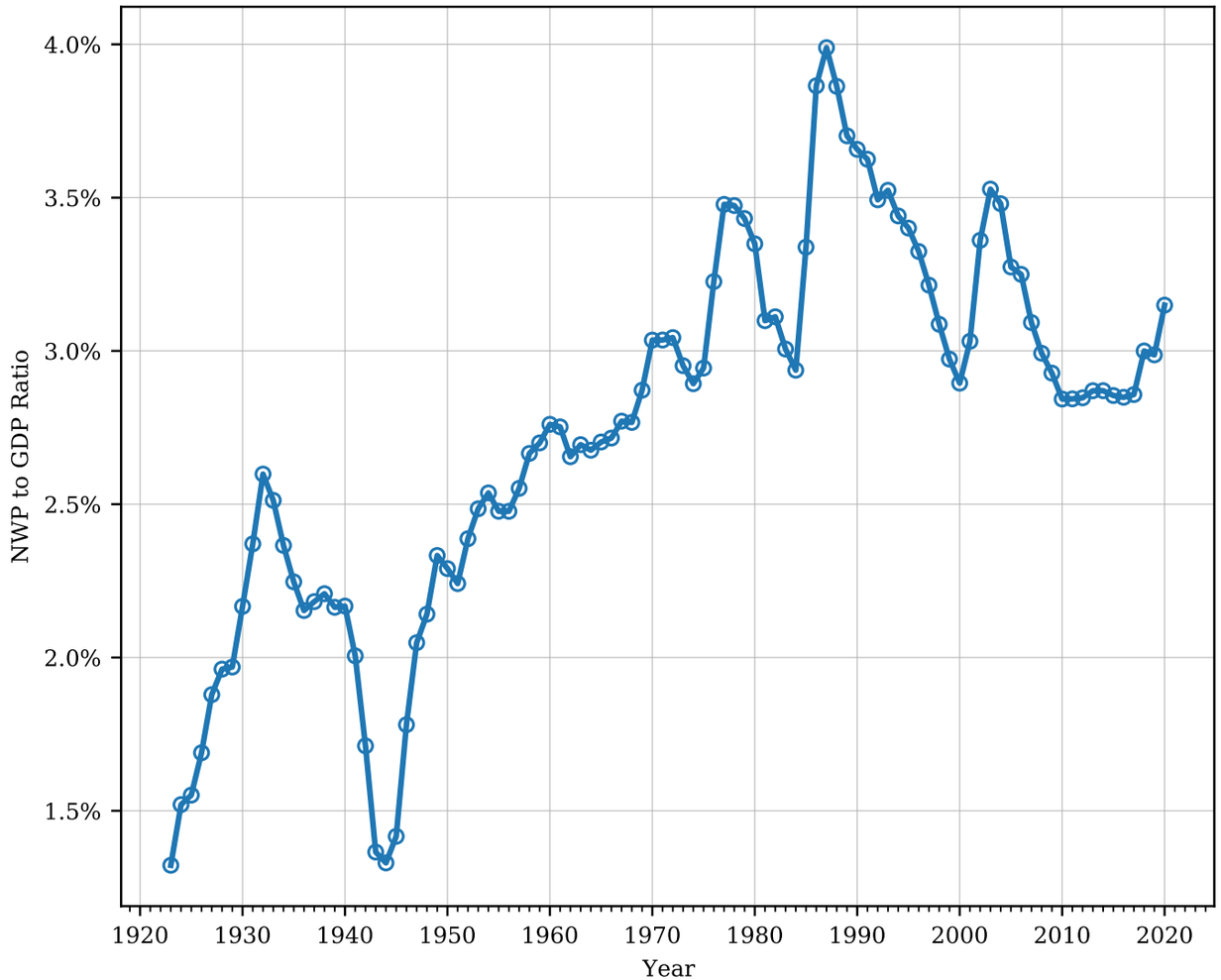

Figure 1: The ratio of US statutory net written premium (NWP) to nominal gross domestic product (GDP) gives a good measure of the insurance market cycle. It measures the penetration of the insurance industry into the economy. 2020 NWP estimated based on Q3 YTD actual and average full year to Q3 YTD; actual GDP. GDP and NWP are both are on a nominal basis; inflation cancels in the ratio. If GDP in 2020 had grown inline with 2019 over 2018, then premium to GDP ratio in 2020 would be unchanged. Source: NAIC US Statutory Compbined P&C Industry premium and GDP from FRED.

Premium to GDP Ratio: Cyclical Growth Between 1947 and 1997

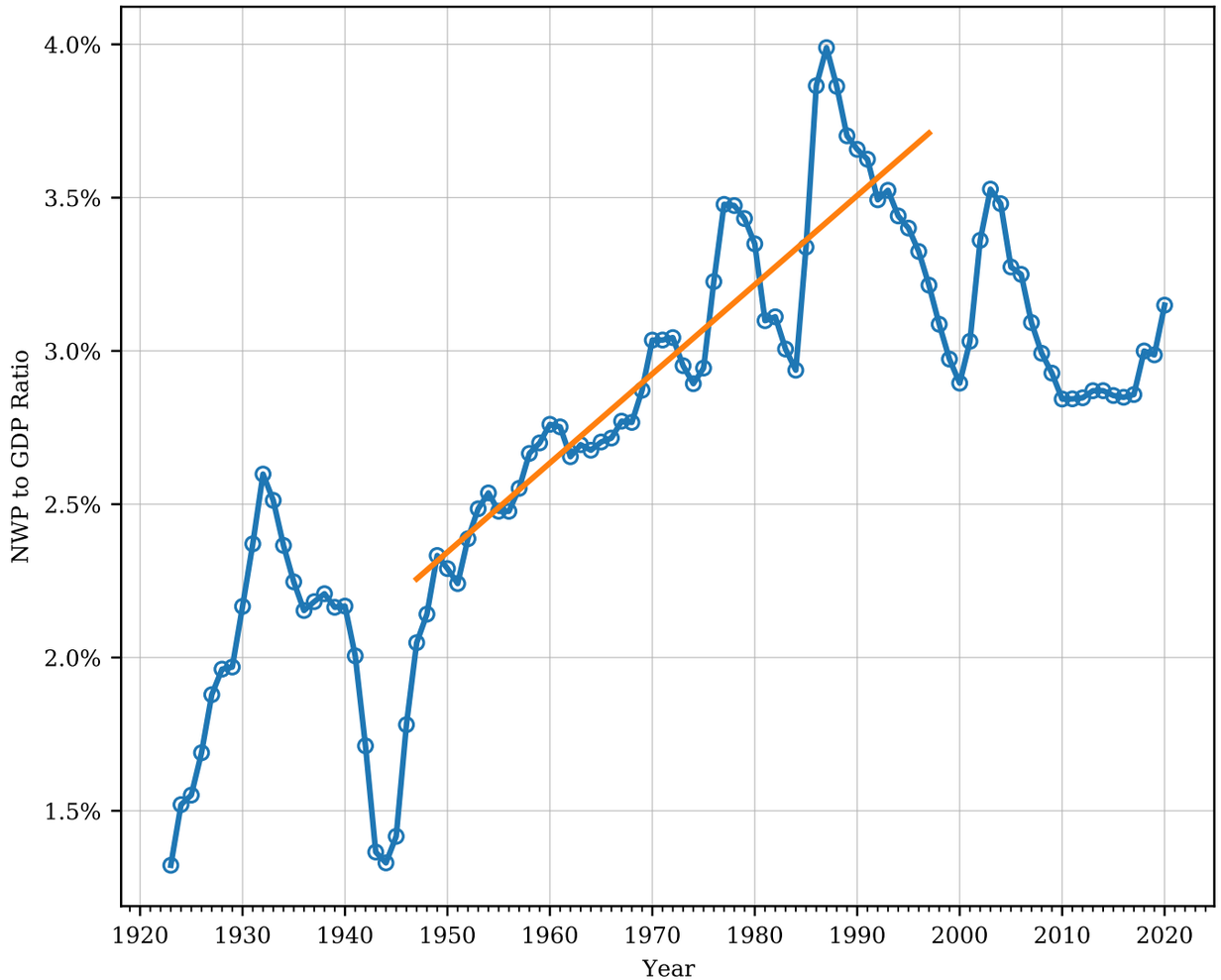

Figure 2: Secular growth from the end of WW2 through 1986 has given way to retrenchment and stabilization. The 1986 watershed saw tax reform, which introduced loss reserve discounting for tax purposes, as well as the claims-made form and absolute pollution exclusion. The period since 2008 is particularly stable.

Premium to GDP Ratio: 1968 Watershed

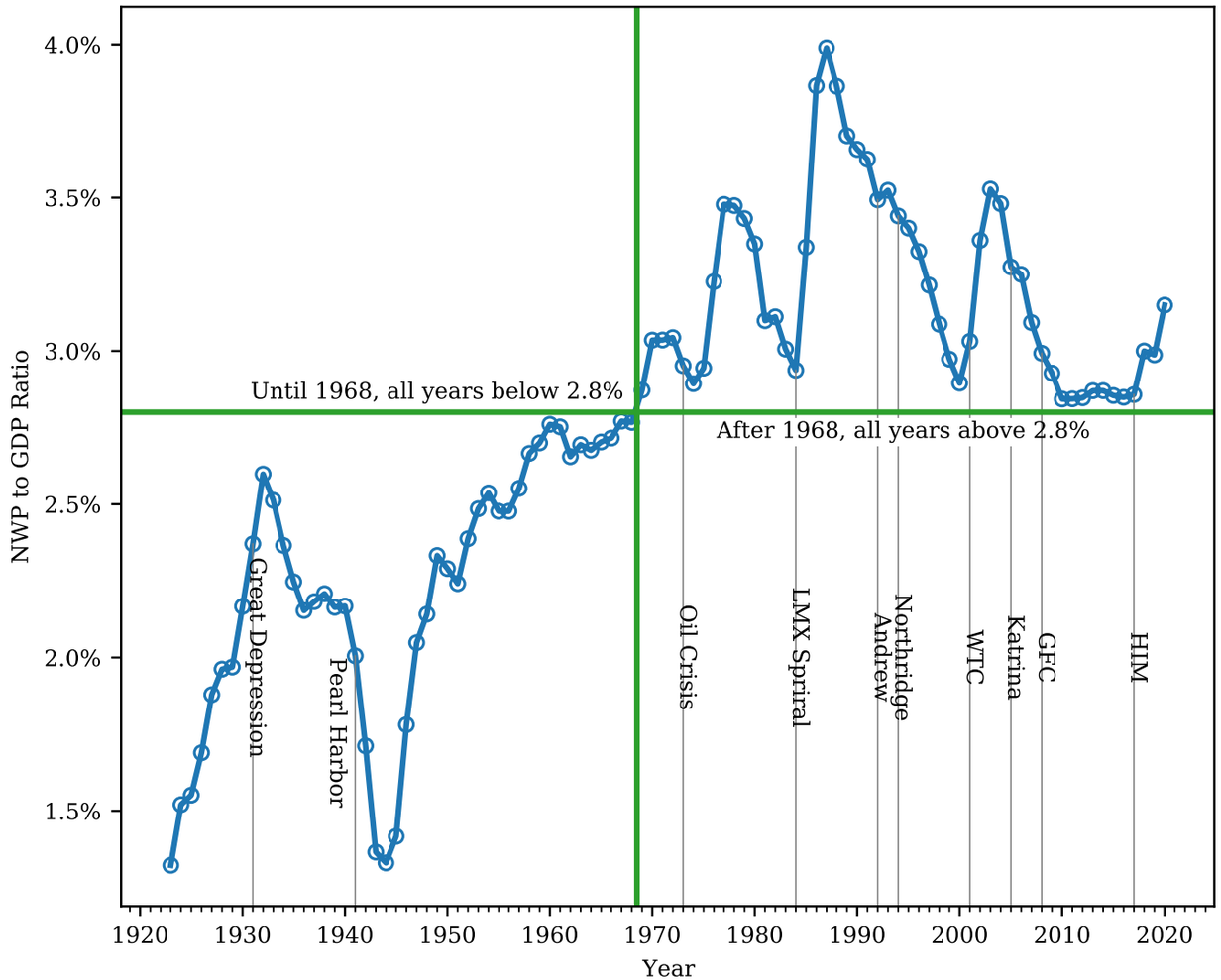

Figure 3: The 2.8 percent level (green lines) separates 1968 and prior from all subsequent years. The ratio was less than 2.8 percent in every year until 1968, while it has been greater than 2.8 percent in every year since. Significant insurance-related events are called out on the x-axis.

Annual Change in Statutory Surplus, 1932 to 2020

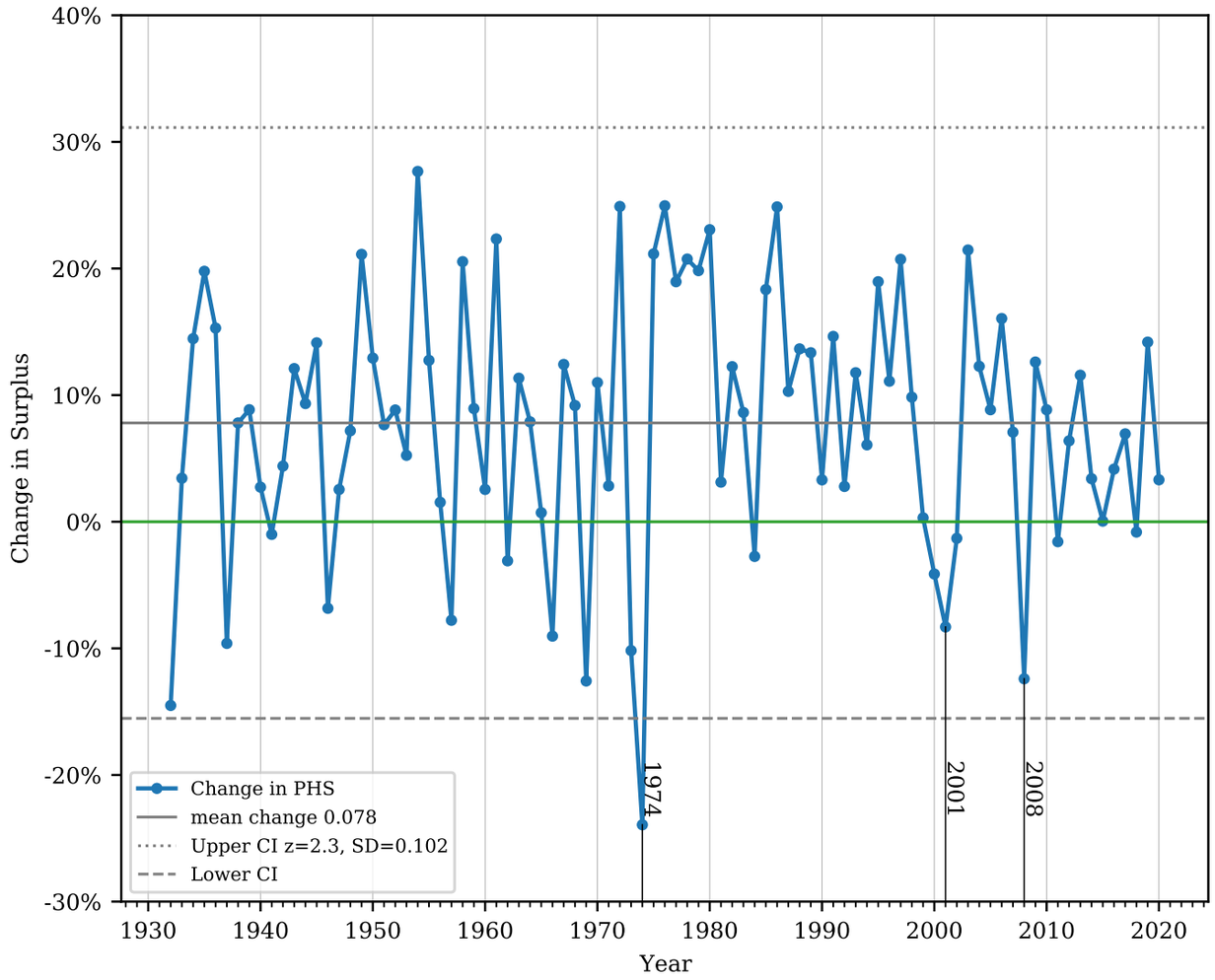

Figure 4: The three most significant post-1968 surplus declines have coincided with significant asset value declines: 1974, 2001 and 2008. 2000-02 is the only consecutive three year decline.

Annual Change in Statutory Surplus, 1932 to 2020 With 10- And 25-Year Rolling SD

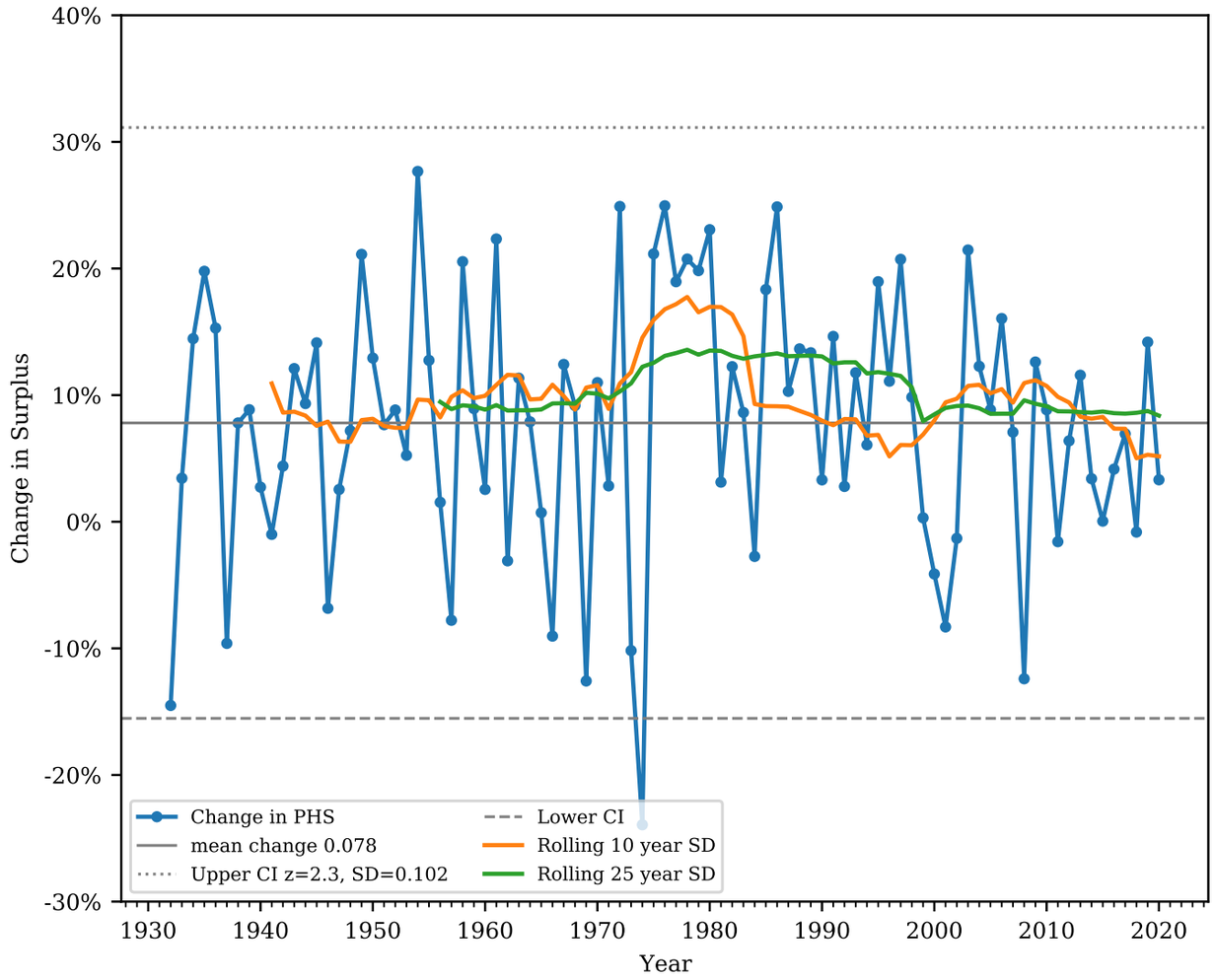

Figure 5: Rolling standard deviation reasonably steady over long-term history, and currently at historically low levels.

Multi-Year Change in Statutory Surplus, 1932 to 2020

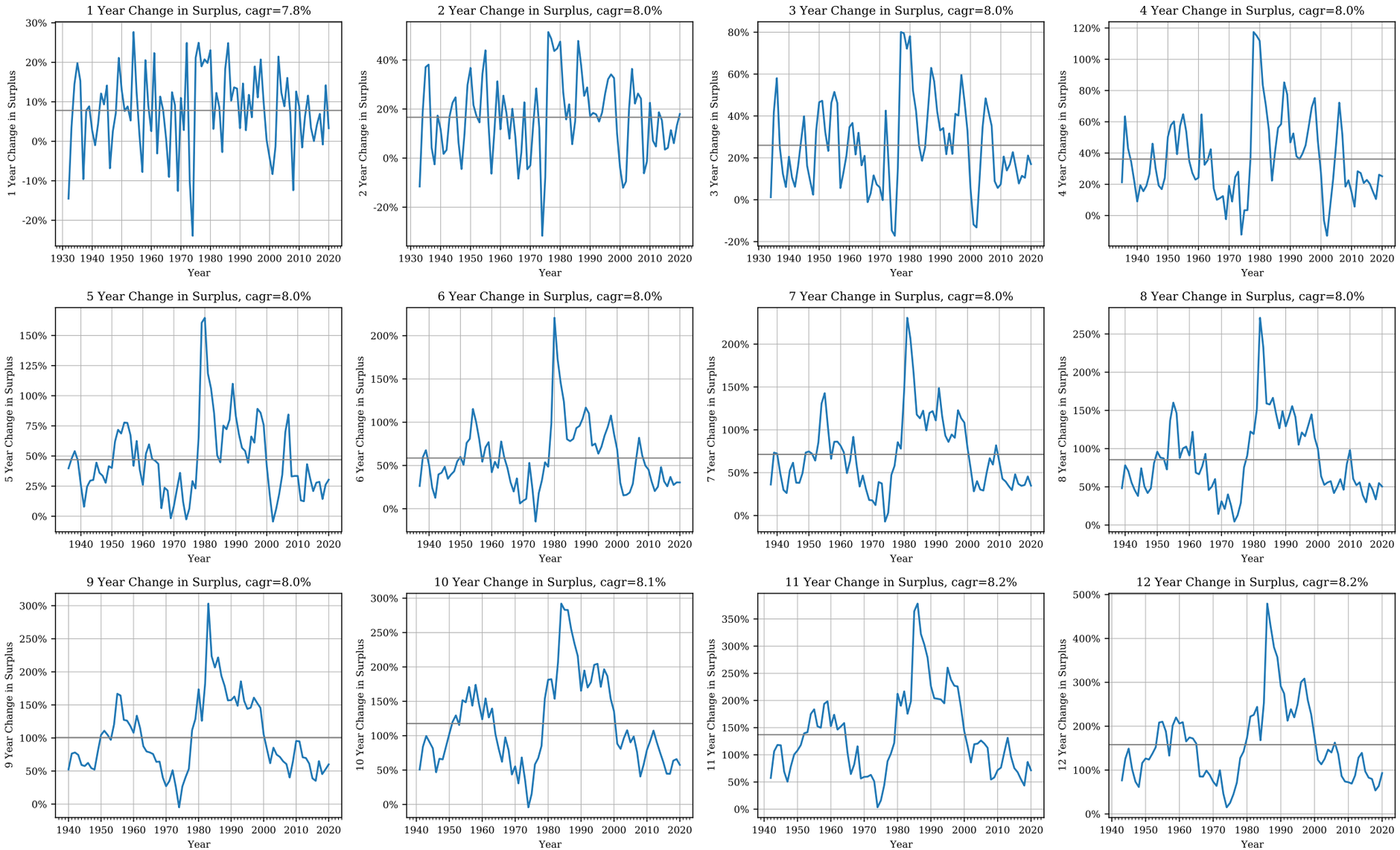

Figure 6: Surplus doubles every nine years, on average. Current period shows historically low long-term growth rates. Not adjusted for inflation.

Premium to Surplus Ratio, 1932 to 2020

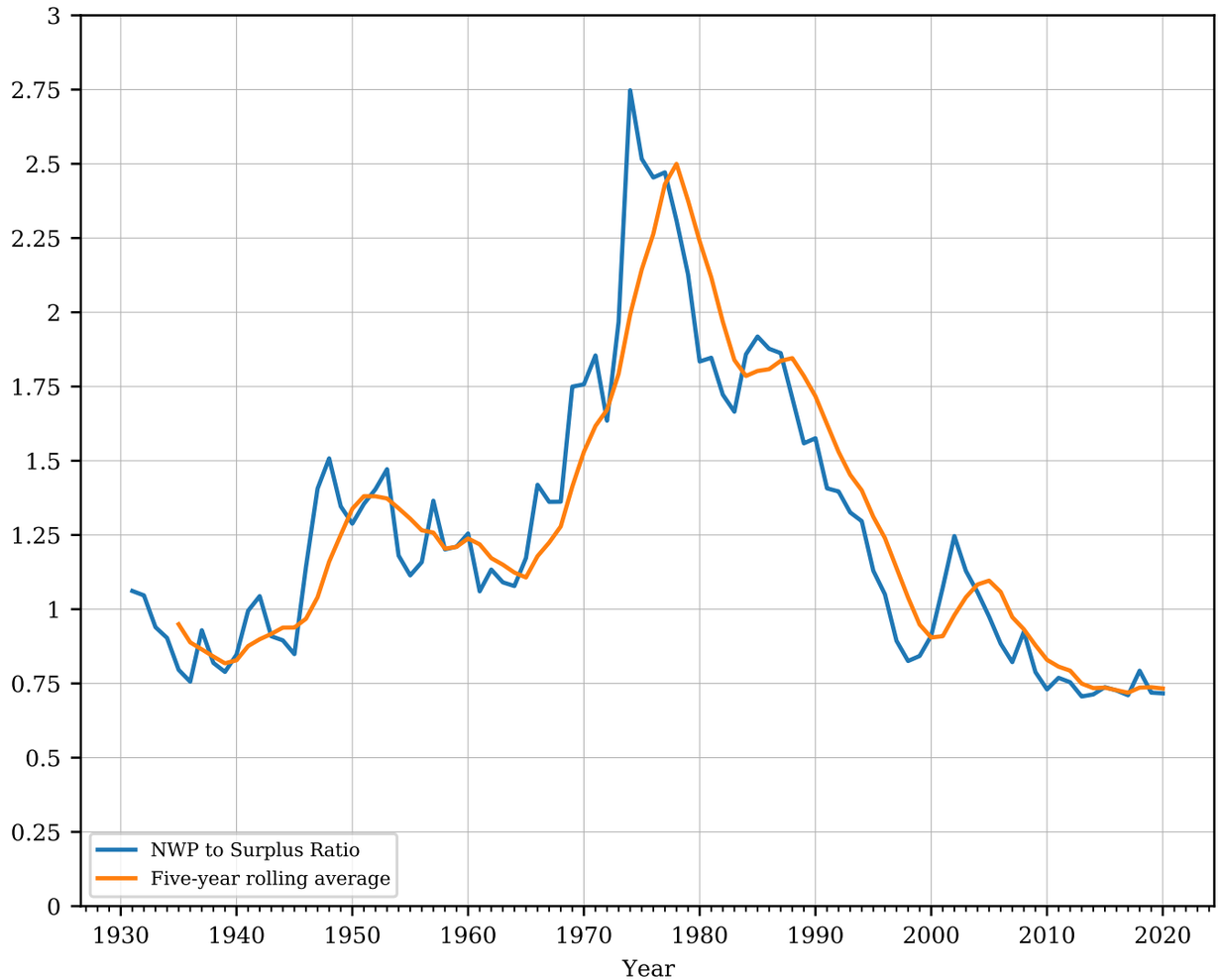

Figure 7: Industry leverage ratios have been decreasing since their mid-1970s high of 2.7 to 1. They have been remarkably stable over the last decade. Current leverage ratios were also seen in the 1930s.

Premium to GDP vs. Suprlus to GDP

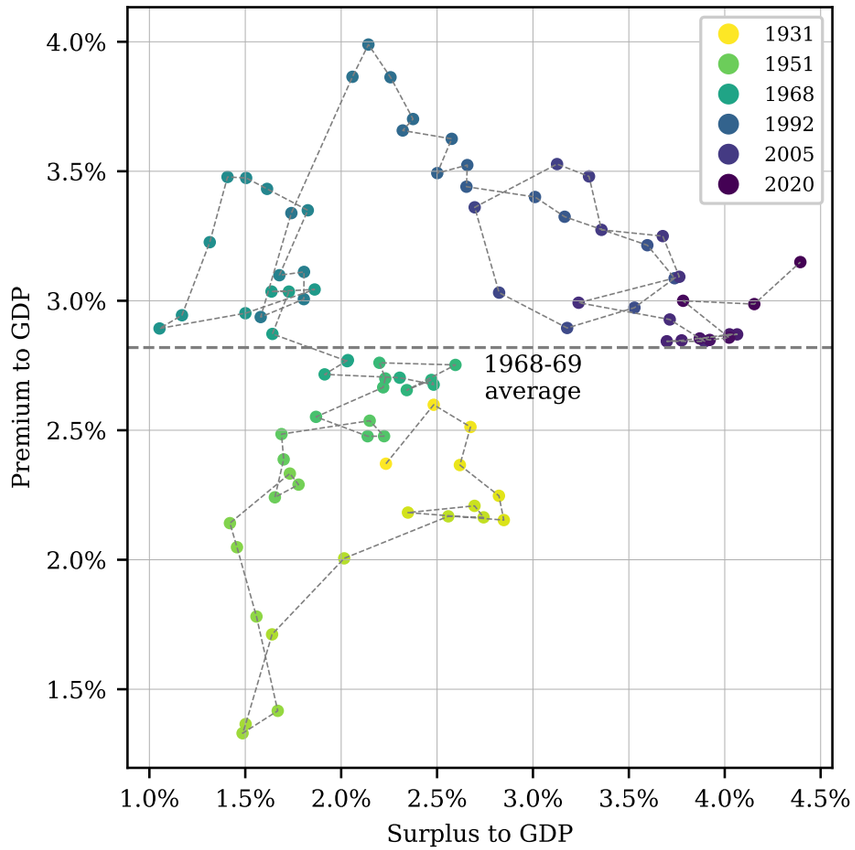

Figure 8: Period since 1968, above the dotted line, has seen much greater swings in surplus to GDP (east west direction) than the earlier period. Current premium penetration is below historical highs but current surplus to GDP ratios are at historic highs. Note relatively high surplus levels in 1930s (yellow): the industry did not return to 1930s levels of relative capitalization until 1995.

Three Phases of the Market 1931-2020

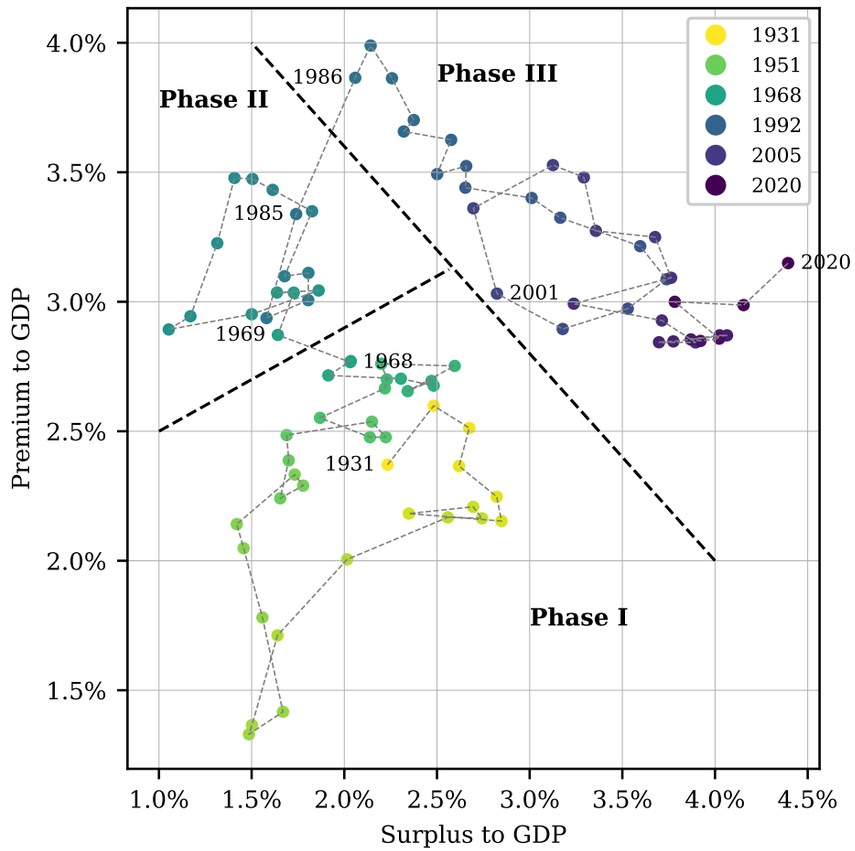

Figure 9: Phase I, 1931-1968: establishment, depression, WW2, and recovery. Phase II, 1969-1985: growth and expansion, industry looking for ways to find coverage. Tax code and high interest rate favorable to casualty business. Phase III, 1986-present: retrenchment and responsibility, secular decline in interest rates and revised tax code emphasize underwriting profits, and growing casualty reserves increase capital intensity.

Market Dynamics Since 1986 Explained by Prior Year Surplus Levels

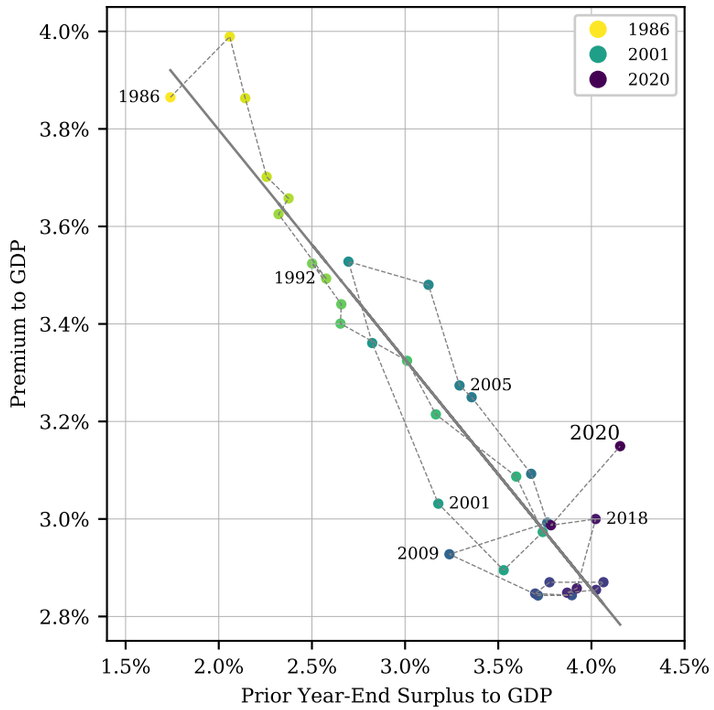

Figure 10: Regression of premium to GDP on prior year surplus to GDP. Anticlockwise cycle between 1994 and 2008!

Results: Ordinary least squares

Model:	OLS	Adj. R-squared:	0.860
Dependent Variable:	PG	AIC:	-364.7150
Date:	2021-04-06 12:14	BIC:	-361.6043
No. Observations:	35	Log-Likelihood:	184.36
Df Model:	1	F-statistic:	209.4
Df Residuals:	33	Prob (F-statistic):	7.60e-16
R-squared:	0.864	Scale:	1.6516e-06

	Coef.	Std.Err.	t	P>|t|	[0.025	0.975]
Intercept	0.0474	0.0011	44.3933	0.0000	0.0452	0.0496
pSG	-0.4710	0.0326	-14.4694	0.0000	-0.5373	-0.4048

Omnibus:	3.967	Durbin-Watson:	1.027
Prob(Omnibus):	0.138	Jarque-Bera (JB):	2.689
Skew:	0.424	Prob(JB):	0.261
Kurtosis:	4.060	Condition No.:	150

- Very strong correlation of premium penetration against prior year-end surplus ratio, regression $R^2 = 0.86$
- Suggests current premium levels will persist while industry capitalization remains strong

C.02. Surplus to GDP Ratio, 1931-2020e

Surplus to GDP Ratio, 1931-2020e

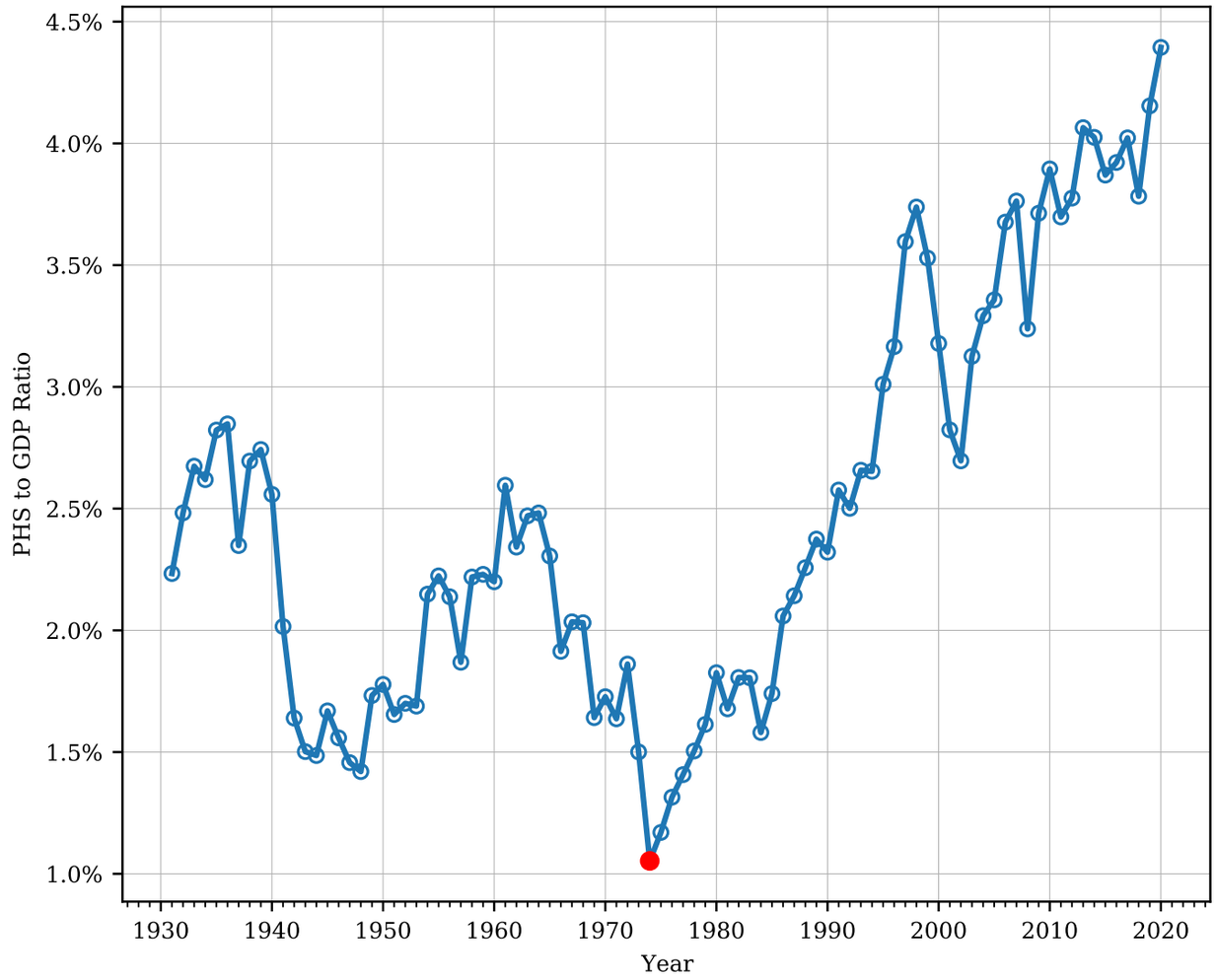

Figure 11: The surplus to GDP ratio shows that relative surplus levels have steadily increased since their recorded low in 1974 of 1.1% (red dot). YE 2020 surplus estimated at 2 percent above Q3. Last year's level is the all-time high of 4.4%.

The Surplus to GDP Ratio Has Increased During the Modern Period, 1968-2020

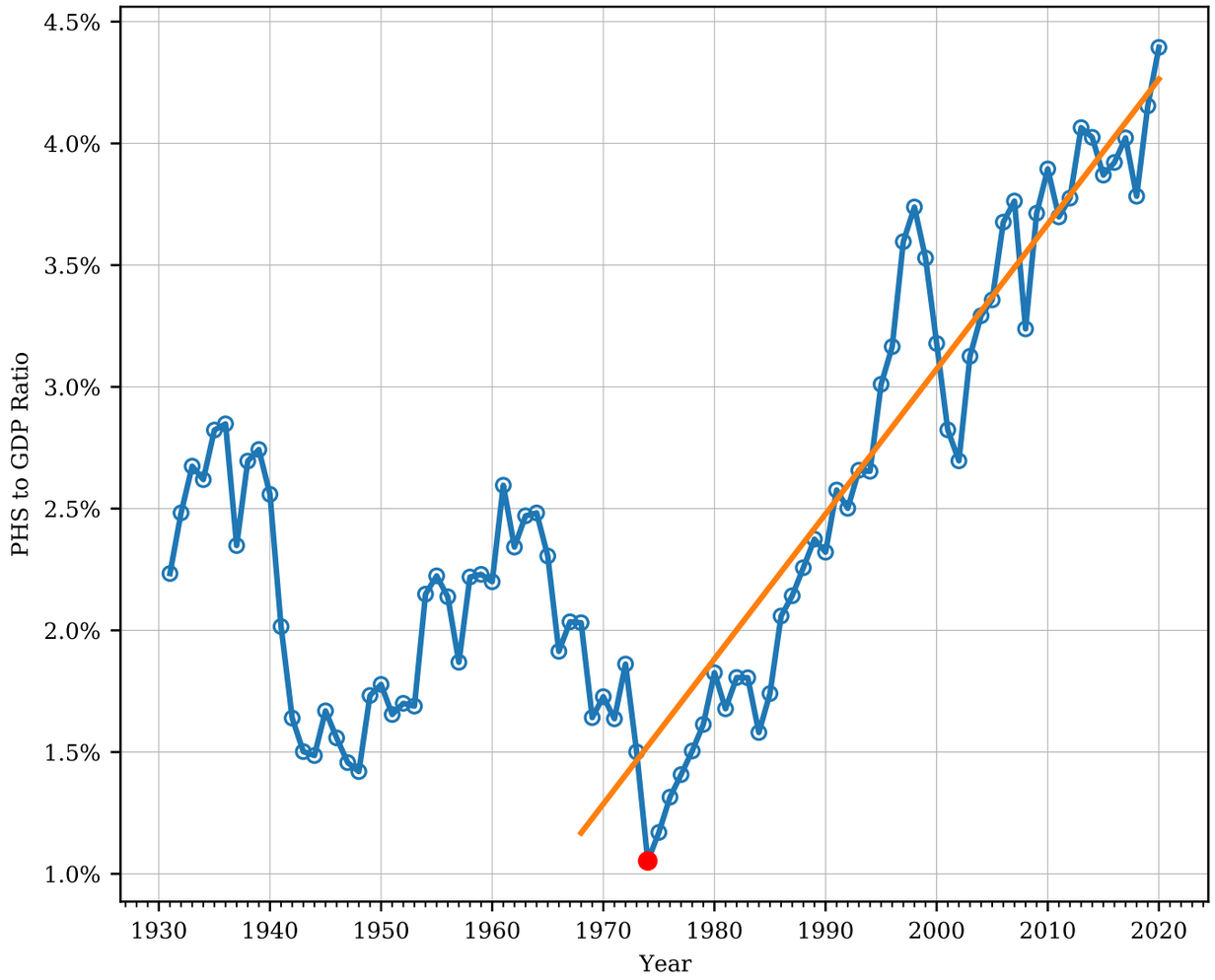

Figure 12: Linear regression has $R^2 = 0.892$, though horrible error auto-correlation until the mid-2000s.

C.03. Industry Volatility and Profitability Metrics, 1985-2019

Industry Net Volatility and Profitability Metrics, 1985-2019

Table 1: Industry operating and profitability metrics

Quantity	Kind	Full Name	Definition
NEP	USD000	Net earned premium	
NIL	USD000	Net incurred loss	
Exp	USD000	Expenses	All underwriting expenses and other income, excluding LAE
UWGain	USD000	Underwriting gain	
NII	USD000	Net Inv Inc	Net investment income, excluding gain or losses
OP	USD000	UW Operating result	UW Gain plus net inveestment income
GL	USD000	Inv Gain or Loss	Realized and unrealized investment gain, pre-tax 2005-19
NI	USD000	Net income	Statutory net income, page 4
DF	USD000	Dividends and Fin.	Dividends net of capital contributions (generally negative)
PHS	USD000	Polholder Surplus	Policyholder surplus, page 4
NIIR		Net Inv Income Ratio	Net investment income to earned premium
LR, ER	ratio	Loss, Expense Ratio	Loss and expense ratio, to earned premium
CR, OR	ratio	Combined, Operating Ratio	UW Gain, operating result to earned pmreium
NII_PHS	ratio	Net Inc Inc / PHS	NII / PHS
TIG_PHS	ratio	Total Inv Gain / PHS	Total investment income and GL to PHS (tax mis-match)
NI_PHS	ratio	Net Inc / PHS	NI / PHS, quasi-ROE, includes realized gains
OP_PHS	ratio	Op Res / PHS	Operating result to PHS, "operating-ROE"
ROEci	ratio	Comp Inc / PHS	Change in PHS net of dividends and financing / PHS, a comprehensive income ci ROE

Insurance Volatility and Profitability Metrics: Underwriting and Operating

statistic	Net Earned Premium	Net Incurred Loss	Expenses	Undewriting Gain	UW Operating Result	Net Inv Income Ratio	Loss Ratio	Expense Ratio	Combined Ratio	Operating Ratio
min	133.342G	118.572G	39.761G	-50.309G	-11.448G	0.0899	0.652	0.263	0.929	0.8
mean	355.207G	266.940G	100.591G	-9.396G	32.478G	0.124	0.767	0.283	1.05	0.916
max	628.054G	446.017G	178.723G	34.753G	88.101G	0.154	0.889	0.3	1.19	1.04
sd	132.584G	87.619G	38.096G	17.286G	23.868G	0.0206	0.0585	0.00937	0.0592	0.0487
cv	0.373	0.328	0.379	-1.84	0.735	0.166	0.0762	0.0331	0.0564	0.0531
growth	-0.0436	-0.0366	-0.0427	-0.512	1.12	0.017	0.00855	0.00161	0.00625	0.00525
r2	0.967	0.956	0.981	0.168	0.48	0.713	0.484	0.0434	0.427	0.138
rse0	24.555G	18.565G	5.360G	16.006G	17.466G	0.0112	0.0426	0.0093	0.0455	0.0459
rse	24.966G	18.876G	5.450G	16.274G	17.758G	0.0114	0.0434	0.00946	0.0462	0.0466
slope	0.0358	0.0313	0.0366	-0.0735	0.0497	-0.0136	-0.00517	673.605u	-0.0036	-0.00193
year	-25.114T	-16.474T	-7.271T	-1.393T	-3.199T	3.52	8.71	-0.0986	8.61	4.45
ar r2	0.989	0.962	0.992	0.237	0.495	0.824	0.414	0.61	0.412	0.236
ar rse0	13.549G	16.809G	3.321G	15.427G	16.882G	0.00876	0.043	0.00578	0.0428	0.0404
ar rse	13.549G	16.809G	3.321G	15.427G	16.882G	0.085	0.171	0.112	0.168	0.183
ar slope	1.02	1	1.02	0.49	0.699	0.932	0.608	0.749	0.595	0.449
ar intercept	7.921G	8.880G	1.694G	-4.148G	11.503G	0.00681	0.296	0.0705	0.42	0.501

Table 2: Statistics shown for the total US statutory industry. Columns are described on previous slide. Rows are described below. Source: S&P Global Market Intelligence, Statutory Accounts page 4.

Insurance Volatility and Profitability Metrics: Investments and Returns

statistic	Net Inv Income	Inv Gain or Loss	Net Income	Dividends and Fin.	Polholder Surplus	Net Inc Inc / PHS	Total Inv Gain / PHS	Net Inc / PHS	Op Res / PHS	Comp Inc / PHS
min	19.508G	-98.513G	-5.786G	-35.801G	75.511G	0.0652	-0.0976	-0.0192	-0.0435	-0.0996
mean	41.874G	15.737G	30.240G	-9.492G	396.357G	0.136	0.179	0.0783	0.0823	0.0882
max	56.981G	121.267G	70.061G	9.159G	866.615G	0.258	0.4	0.136	0.176	0.246
sd	10.225G	34.331G	21.215G	14.426G	227.435G	0.06	0.0984	0.0359	0.0483	0.0807
cv	0.244	2.18	0.702	-1.52	0.574	0.44	0.549	0.459	0.587	0.914
growth	-0.0283	-2.01	0.151	0.0379	-0.0664	0.0452	0.0755	0.167	1.2	-0.72
r2	0.856	0.0559	0.536	0.731	0.97	0.901	0.51	0.0369	0.00322	33.097n
rse0	3.941G	33.860G	14.672G	7.592G	40.136G	0.0191	0.0699	0.0358	0.0489	0.0819
rse	4.007G	34.426G	14.918G	7.720G	40.807G	0.0194	0.0711	0.0364	0.0497	0.0834
slope	0.022	0.0503	0.0501	0.127	0.0551	-0.0408	-0.0382	-0.0086	-0.00325	-16.705u
year	-1.806T	-1.569T	-3.004T	2.400T	-43.362T	11.26	13.91	1.43	0.617	0.0912
ar r2	0.902	0.028	0.454	0.726	0.981	0.967	0.3	0.0807	0.156	0.00486
ar rse0	3.046G	34.877G	15.721G	7.623G	31.606G	0.0105	0.0781	0.0343	0.0407	0.0819
ar rse	3.046G	34.877G	15.721G	7.623G	31.606G	0.041	0.214	0.198	0.186	0.263
ar slope	0.907	-0.198	0.681	0.872	1.03	0.94	0.505	0.275	0.352	0.0704
ar intercept	4.947G	18.385G	11.144G	-2.343G	12.220G	0.00261	0.0826	0.0583	0.0569	0.0799

Table 3: Statistics shown for the total US statutory industry. Columns are described on above. Rows are described below. Source: S&P Global Market Intelligence, Statutory Accounts page 4.

Insurance Volatility and Profitability Metrics

Gloss for rows

- `growth` is the average anuual growth rate
- `r2`, `rse0`, `slope`, `year` are the R^2, residual square error, slope and intercept for a regression of each variable against time (year)
- `rse` equals `rse0` plus the standard error of the slope parameter, giving a better indication of uncertainty
- `ar_r2`, `ar_rse0`, `ar_rse`, `ar_slope`, `ar_intercept` are the same statistics for an AR(1) autoregressive model

Time Series of Volatility and Profitability Metrics

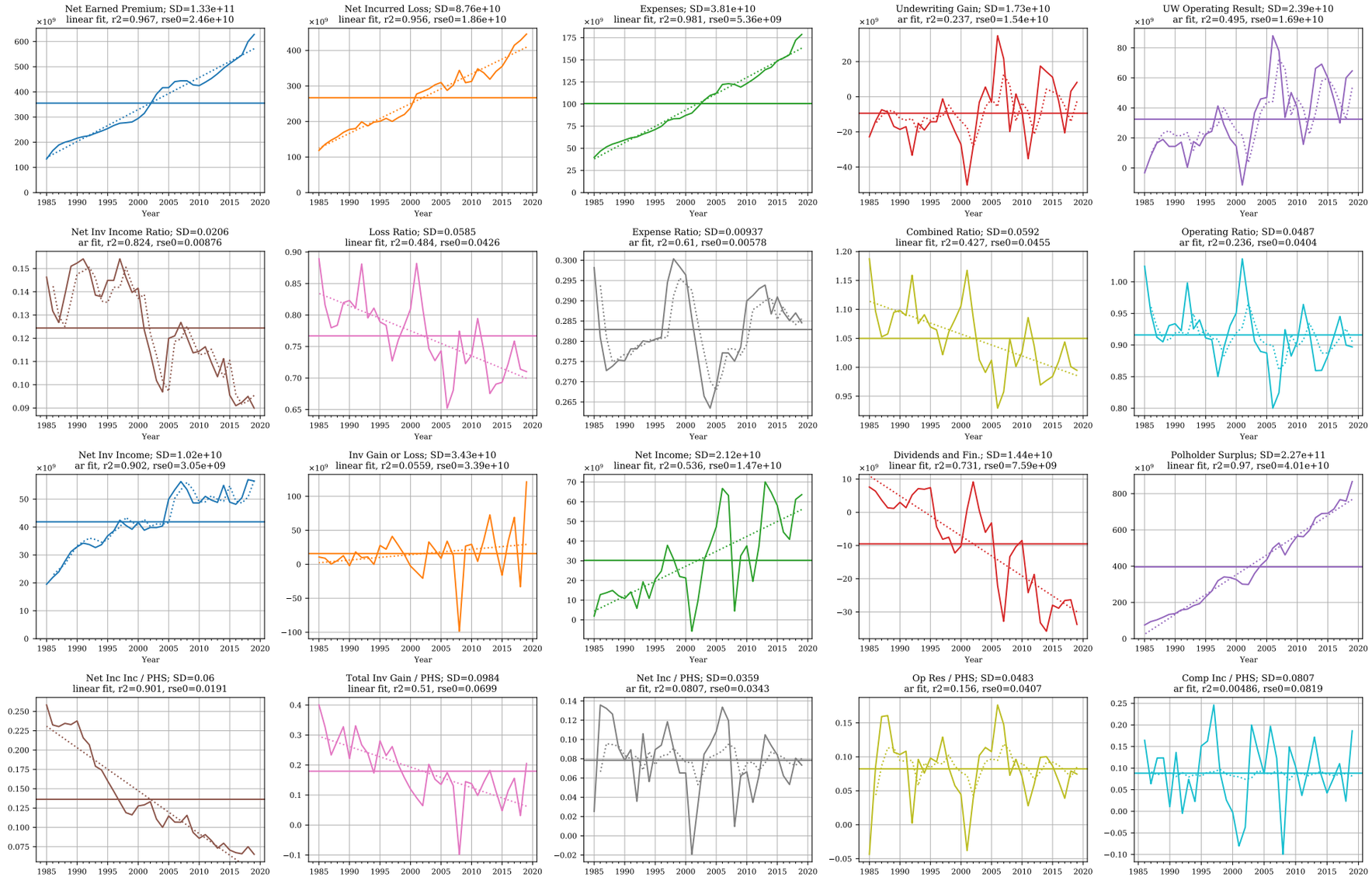

Figure 13: Time series of the variables from the previous table. Declining investment income and increasing volatility of gains and loss are particularly evident. See gloss on next slide.

Time Series of Volatility and Profitability Metrics

Title decoder: `Net Earned Premium; SD=1.33e+11 linear fit, r2=0.967, rse0=2.46e+10`

- `CR` is the variable name, e.g., combined ratio
- `SD` standard deviation
- If the variable appears to have a `linear` trend show the R^2 and residual standard error of a regression against time
- If it appears autoregressive `ar` show statistics for a fit against the lagged variable
- Linear trend is selected if the linear model R^2 is > 0.9 or is greater than the `ar` model R^2

Line legend

- Solid line is the statistic
- Horizontal line is its mean value
- Dotted line is the `linear` (straight) or `ar` fit (not straight, and appears lagging)

Interpretation

- `rse` significantly less than `SD` suggests potentially explainable variation
- Expenses (`Exp`) and surplus (`PHS`) have a much lower uncertainty than their `SD` suggests because they have a clear trend
- Almost all the variability in `UWGain` is unexpected
- `CR` may have a slightly predictable component—corresponding to the autoregressive underwriting cycle

C.04. Direct and Net Volatility and Profitability by Major Line, 1992-2019

Direct and Net Calendar Year Loss Ratio Average, Standard Deviation, Coefficient of Variation, Skewness, and Kurtosis by Major Line

	Direct					Net					Diff				
Line	Average	SD	CV	Skew	Kurt	Average	SD	CV	Skew	Kurt	Average	SD	CV	Skew	Kurt
Personal Auto	0.772	0.036	0.047	0.022	0.454	0.769	0.035	0.046	0.005	0.136	0.004	0.001	0.001	0.017	0.318
total	0.754	0.066	0.087	0.414	0.454	0.755	0.057	0.075	0.471	0.146	-0.000	0.009	0.012	-0.057	0.308
Other Comm	0.649	0.073	0.113	0.677	1.23	0.651	0.055	0.084	0.761	0.309	-0.002	0.019	0.029	-0.084	0.918
Comm Auto	0.751	0.082	0.11	-0.010	-1.028	0.75	0.074	0.099	-0.061	-1.076	0.001	0.008	0.011	0.051	0.049
Inland Marine	0.546	0.079	0.145	0.769	0.271	0.566	0.059	0.104	0.043	-1.124	-0.020	0.021	0.042	0.726	1.4
Workers Comp	0.778	0.103	0.133	0.012	-0.323	0.773	0.097	0.125	-0.139	-0.390	0.005	0.007	0.008	0.152	0.067
CMP	0.716	0.111	0.155	0.439	-0.017	0.716	0.090	0.126	0.206	-0.936	-0.001	0.021	0.029	0.233	0.918
Homeowners	0.763	0.166	0.218	1.62	4.1	0.765	0.133	0.174	1.63	4.99	-0.002	0.033	0.044	-0.012	-0.891
Liability	0.86	0.162	0.189	0.652	-0.599	0.835	0.161	0.193	0.728	-0.703	0.025	0.001	-0.004	-0.075	0.103
Med Mal	0.837	0.218	0.261	0.725	-0.363	0.834	0.204	0.244	0.826	-0.047	0.004	0.015	0.016	-0.100	-0.316
Comm Property	0.69	0.32	0.463	1.55	1.9	0.675	0.191	0.284	1.6	4.06	0.015	0.128	0.18	-0.052	-2.165
Reinsurance	nan	nan	nan	nan	nan	0.812	0.324	0.399	2.18	7.35	nan	nan	nan	nan	nan
Fin Guaranty	0.638	0.721	1.13	2.26	5.19	0.632	0.638	1.01	2.01	3.8	0.006	0.083	0.121	0.247	1.39

Table 4: The average, standard deviation, coefficient of variation, skewness and kurtosis of direct and net loss ratio, by major line. Sorted by Net CV. Exact grouping of statutory lines shown on next slide. Source: Industry Combined Direct Statutory IEE, 1996-2017.

Direct and Net Calendar Year Combined Ratio Average, Standard Deviation, and Coefficient of Variation by Major Line

	Direct			Net			Diff		
Line	Average	SD	CV	Average	SD	CV	Average	SD	CV
Personal Auto	1.01	0.041	0.041	1.01	0.036	0.036	0.002	0.005	0.005
Other Comm	0.937	0.074	0.079	0.974	0.047	0.048	-0.037	0.027	0.031
total	1.02	0.069	0.067	1.04	0.057	0.055	-0.014	0.011	0.012
Comm Auto	1.04	0.085	0.082	1.05	0.078	0.074	-0.008	0.008	0.008
CMP	1.05	0.116	0.111	1.08	0.096	0.089	-0.027	0.020	0.021
Inland Marine	0.85	0.092	0.108	0.916	0.082	0.089	-0.066	0.010	0.018
Workers Comp	1.05	0.115	0.109	1.06	0.099	0.093	-0.006	0.016	0.016
Homeowners	1.06	0.17	0.161	1.07	0.138	0.128	-0.015	0.033	0.033
Liability	1.14	0.165	0.145	1.14	0.158	0.138	-0.000	0.007	0.006
Med Mal	1.06	0.214	0.203	1.07	0.192	0.18	-0.013	0.022	0.023
Comm Property	0.985	0.326	0.331	1.01	0.208	0.205	-0.029	0.118	0.126
Reinsurance	nan	nan	nan	1.16	0.377	0.324	nan	nan	nan
Fin Guaranty	0.819	0.905	1.11	0.925	0.612	0.661	-0.106	0.294	0.444

Table 5: The average, standard deviation, and coefficient of variation of direct combined ratio, by major line. For most lines combined ratio SD is higher than loss SD, indicating pro-cyclical expenses. LAE included with loss. Sorted by Net CV. Direct minus net equals assumed minus ceded, and so does only proxies ceded. Broadly, expect net CR to be greater than direct, reflecting the cost of reinsurance, and SD to be lower, reflecting its volatility reduction. This is true for all lines execpt Personal Auto. Personal Auto cessions tend to involve high loss ratio business ceded to residual market pools. Exact grouping of statutory lines shown on next slide. Source: Industry Combined Direct Statutory IEE, 1996-2017.

Direct and Net Average Loss Ratio and Combined Ratio by Line

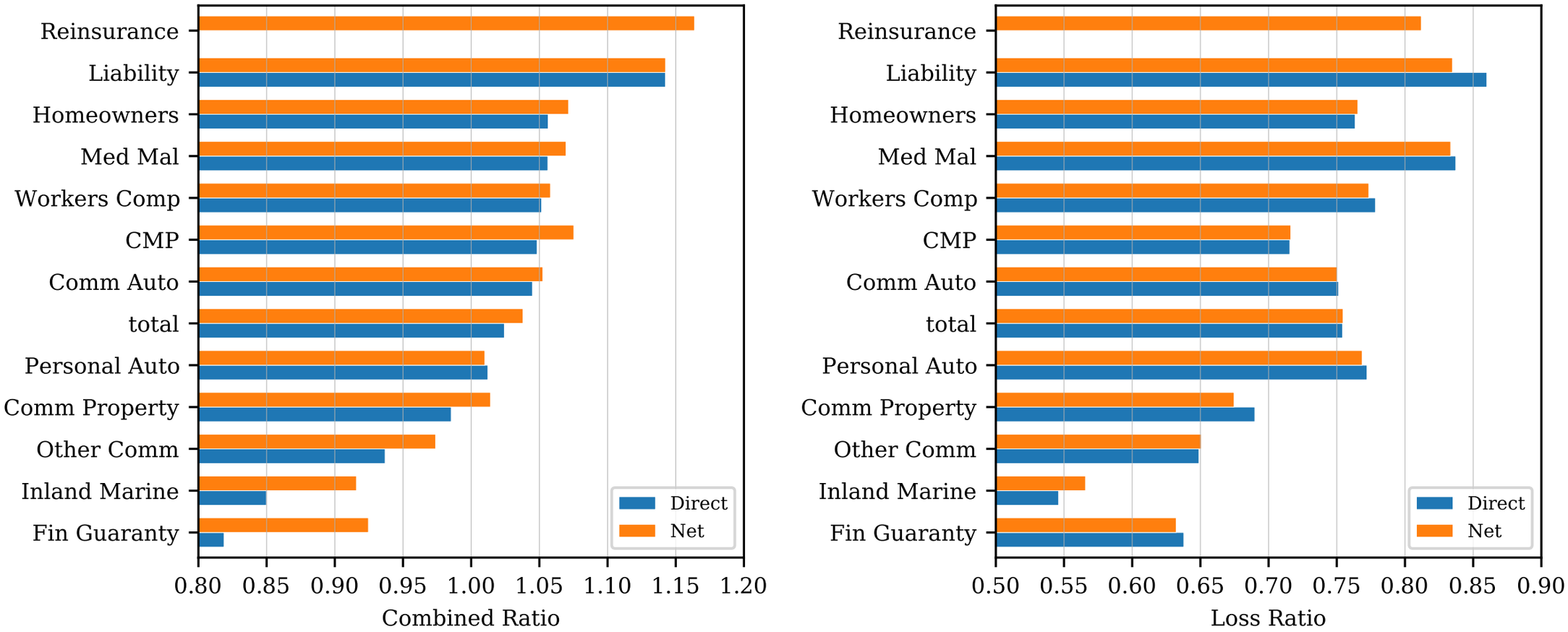

Figure 14: Lines sorted by descending net combined ratio.

Direct and Net Average Combined Ratio vs. Standard Deviation Combined Ratio

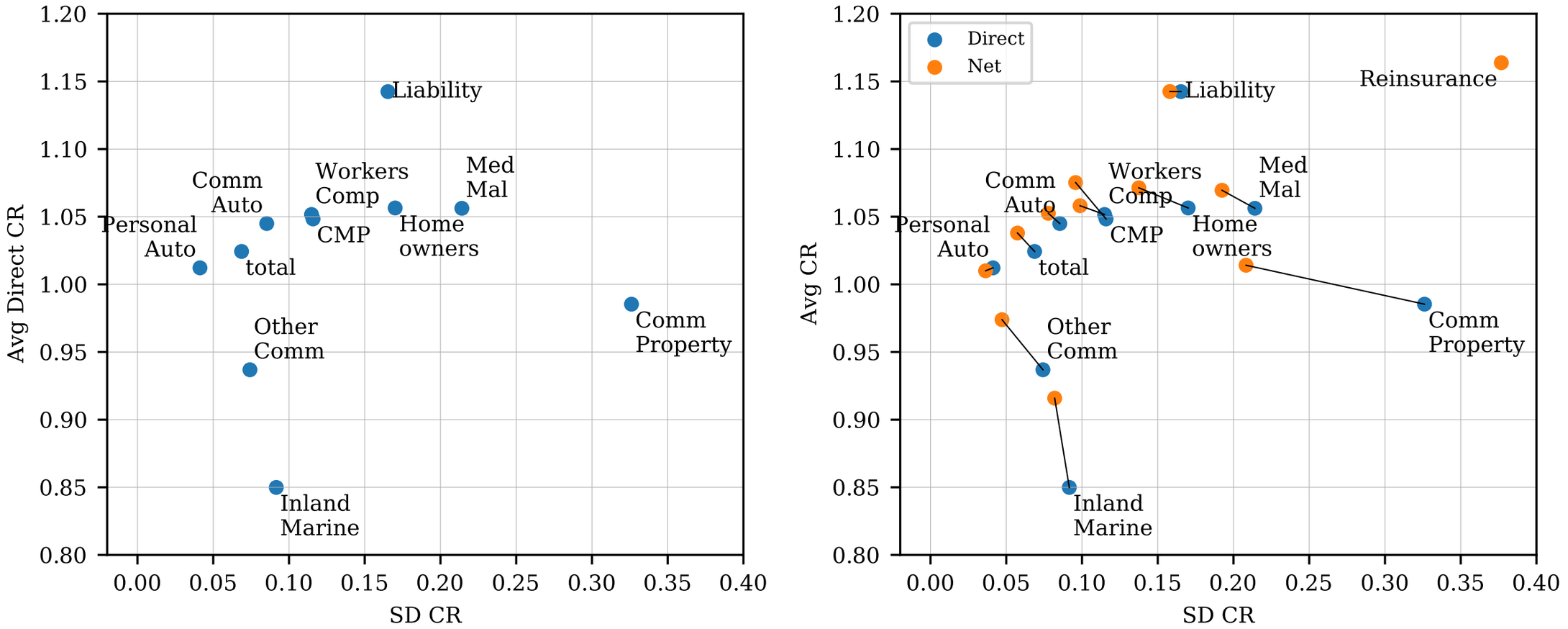

Figure 15: Left: direct, right: direct and net, with joining line. Expect imppact of reinsurance to be in the northwest direction: lower standard deviation but higher combined ratio. This is the case for most lines. Risk benefit most evident for commercial property.

Mapping Statutory Lines to Major Lines

US Statutory lines grouped as follows

- CMP
  - Commercial Multiple Peril (Liability Portion), Commercial Multiple Peril (Non-Liability Portion)
- Comm Auto
  - Commercial Auto Liability, Commercial Auto Physical Damage
- Comm Property
  - Allied Lines, Earthquake, Fire, Glass
- Fin Guaranty
  - Financial Guaranty, Mortgage Guaranty
- Homeowners
  - Farmowners Multiple Peril, Federal Flood, Homeowners Multiple Peril
- Inland Marine
  - Inland Marine
- Liability
  - Other Liability, Other Liability - Claims-Made, Other Liability - Occurrence, Products Liability
- Med Mal
  - Medical Professional Liability
- Other Comm
  - Aggregate Write-Ins For Other Lines Of Business, Aircraft (All Perils), Boiler And Machinery, Burglary And Theft, Credit, Credit A & H, Fidelity, Group A&H, International, Multiple Peril Crop, Ocean Marine, Other A&H, Private Crop, Surety, Warranty
- Personal Auto
  - Private Passenger Auto Liability, Private Passenger Auto Physical Damage
- Reinsurance
  - Reinsurance-Nonproportional Assumed
- Workers Comp
  - Excess Workers' Compensation, Workers' Compensation
- total
  - Totals (Lines 1 Through 34)

- Federal Flood included with Homeowners
- Liability computed as total minus all other lines owing to Occurrence vs. Claims Made coding change in original data source
- Earthquake with Comm Property: Northridge was a personal lines event but the CEA greatly reduced personal lines quake premium

Loss Ratio Correlation by Major Line

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Workers Comp	total
CMP	1	0.539	0.731	-0.211	0.756	0.688	0.593	0.65	0.537	0.386	0.452	0.915
Comm Auto	0.539	1	0.306	-0.480	0.022	0.222	0.287	0.544	0.391	0.693	0.086	0.412
Comm Property	0.731	0.306	1	-0.195	0.635	0.772	0.353	0.347	0.353	0.271	0.134	0.723
Fin Guaranty	-0.211	-0.480	-0.195	1	0.017	-0.072	-0.379	-0.539	-0.225	-0.111	0.106	-0.067
Homeowners	0.756	0.022	0.635	0.017	1	0.679	0.384	0.307	0.282	0.068	0.322	0.774
Inland Marine	0.688	0.222	0.772	-0.072	0.679	1	0.278	0.296	0.468	0.249	0.339	0.72
Liability	0.593	0.287	0.353	-0.379	0.384	0.278	1	0.812	0.546	0.238	0.491	0.7
Med Mal	0.65	0.544	0.347	-0.539	0.307	0.296	0.812	1	0.664	0.323	0.544	0.67
Other Comm	0.537	0.391	0.353	-0.225	0.282	0.468	0.546	0.664	1	0.307	0.564	0.618
Personal Auto	0.386	0.693	0.271	-0.111	0.068	0.249	0.238	0.323	0.307	1	0.323	0.482
Workers Comp	0.452	0.086	0.134	0.106	0.322	0.339	0.491	0.544	0.564	0.323	1	0.605
total	0.915	0.412	0.723	-0.067	0.774	0.72	0.7	0.67	0.618	0.482	0.605	1

Table 6: Pearson correlation coefficient between direct loss ratios by major line.

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Reinsur-ance	Workers Comp	total
CMP	1	0.542	0.637	-0.145	0.794	0.776	0.62	0.559	0.603	0.473	0.352	0.38	0.876
Comm Auto	0.542	1	0.322	-0.492	0.133	0.303	0.111	0.443	0.305	0.719	-0.020	-0.154	0.357
Comm Property	0.637	0.322	1	-0.089	0.522	0.566	0.446	0.195	0.273	0.308	0.488	-0.003	0.606
Fin Guaranty	-0.145	-0.492	-0.089	1	0.19	0.255	-0.308	-0.541	-0.315	-0.215	-0.193	0.225	0.016
Homeowners	0.794	0.133	0.522	0.19	1	0.696	0.574	0.332	0.391	0.326	0.383	0.507	0.87
Inland Marine	0.776	0.303	0.566	0.255	0.696	1	0.386	0.202	0.388	0.336	0.374	0.448	0.741
Liability	0.62	0.111	0.446	-0.308	0.574	0.386	1	0.652	0.723	0.266	0.681	0.37	0.753
Med Mal	0.559	0.443	0.195	-0.541	0.332	0.202	0.652	1	0.884	0.403	0.39	0.439	0.611
Other Comm	0.603	0.305	0.273	-0.315	0.391	0.388	0.723	0.884	1	0.346	0.447	0.569	0.694
Personal Auto	0.473	0.719	0.308	-0.215	0.326	0.336	0.266	0.403	0.346	1	-0.062	0.189	0.58
Reinsurance	0.352	-0.020	0.488	-0.193	0.383	0.374	0.681	0.39	0.447	-0.062	1	0.214	0.476
Workers Comp	0.38	-0.154	-0.003	0.225	0.507	0.448	0.37	0.439	0.569	0.189	0.214	1	0.582
total	0.876	0.357	0.606	0.016	0.87	0.741	0.753	0.611	0.694	0.58	0.476	0.582	1

Table 7: Pearson correlation coefficient between net loss ratios by major line.

Loss Ratio, Premium Change, and Loss Change Correlation

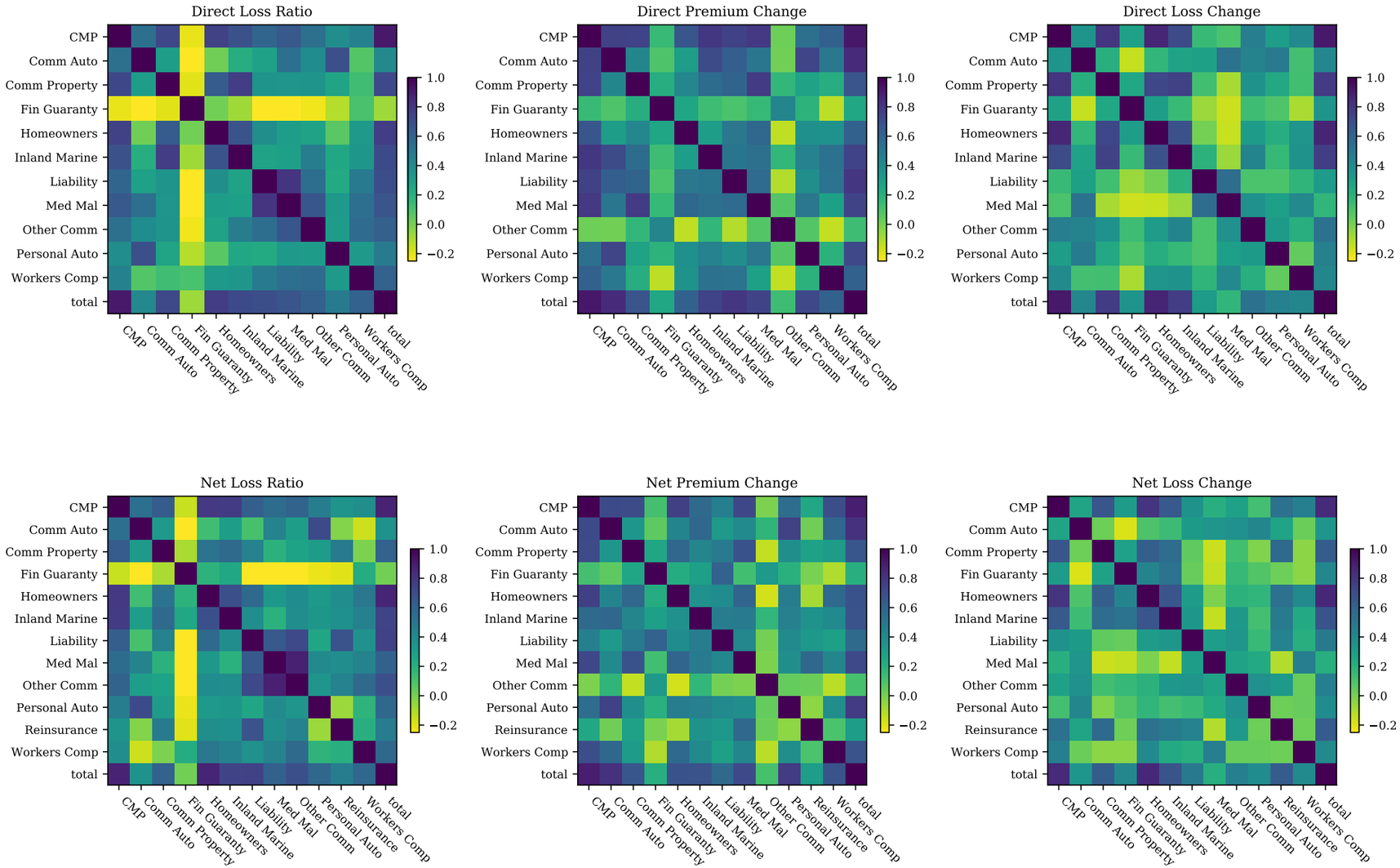

Figure 16: Premium and loss change is year over year change in total losses. It is another measure of the degree to which the cycle for a line is correlated with the overall market. Numerical values given below. Direct and net views.

Correlation Between Annual Change in Losses, by Major Line

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Workers Comp	total
CMP	1	0.351	0.813	0.284	0.865	0.715	0.153	0.106	0.465	0.304	0.4	0.913
Comm Auto	0.351	1	0.21	-0.140	0.17	0.28	0.29	0.529	0.442	0.485	0.123	0.42
Comm Property	0.813	0.21	1	0.254	0.731	0.753	0.129	-0.086	0.357	0.247	0.129	0.784
Fin Guaranty	0.284	-0.140	0.254	1	0.305	0.156	-0.064	-0.156	0.14	0.092	-0.090	0.353
Homeowners	0.865	0.17	0.731	0.305	1	0.691	0.012	-0.146	0.31	0.223	0.347	0.869
Inland Marine	0.715	0.28	0.753	0.156	0.691	1	0.195	-0.061	0.434	0.162	0.364	0.772
Liability	0.153	0.29	0.129	-0.064	0.012	0.195	1	0.553	0.103	0.105	0.182	0.313
Med Mal	0.106	0.529	-0.086	-0.156	-0.146	-0.061	0.553	1	0.366	0.296	0.411	0.176
Other Comm	0.465	0.442	0.357	0.14	0.31	0.434	0.103	0.366	1	0.319	0.218	0.527
Personal Auto	0.304	0.485	0.247	0.092	0.223	0.162	0.105	0.296	0.319	1	0.052	0.458
Workers Comp	0.4	0.123	0.129	-0.090	0.347	0.364	0.182	0.411	0.218	0.052	1	0.428
total	0.913	0.42	0.784	0.353	0.869	0.772	0.313	0.176	0.527	0.458	0.428	1

Table 8: Pearson correlation between annual change in direct losses, by major line.

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Reinsur-ance	Workers Comp	total
CMP	1	0.27	0.666	0.313	0.808	0.649	0.358	0.212	0.286	0.123	0.533	0.461	0.851
Comm Auto	0.27	1	0.026	-0.185	0.097	0.144	0.32	0.349	0.37	0.425	0.268	0.033	0.341
Comm Property	0.666	0.026	1	0.285	0.623	0.552	0.057	-0.150	0.128	-0.011	0.572	-0.035	0.63
Fin Guaranty	0.313	-0.185	0.285	1	0.436	0.523	0.041	-0.136	0.164	0.091	0.026	-0.034	0.42
Homeowners	0.808	0.097	0.623	0.436	1	0.672	0.308	-0.002	0.196	0.177	0.533	0.401	0.857
Inland Marine	0.649	0.144	0.552	0.523	0.672	1	0.341	-0.135	0.333	0.125	0.48	0.236	0.677
Liability	0.358	0.32	0.057	0.041	0.308	0.341	1	0.298	0.349	0.154	0.446	0.213	0.496
Med Mal	0.212	0.349	-0.150	-0.136	-0.002	-0.135	0.298	1	0.281	0.237	-0.106	0.463	0.216
Other Comm	0.286	0.37	0.128	0.164	0.196	0.333	0.349	0.281	1	0.368	0.325	0.040	0.458
Personal Auto	0.123	0.425	-0.011	0.091	0.177	0.125	0.154	0.237	0.368	1	0.027	0.041	0.391
Reinsurance	0.533	0.268	0.572	0.026	0.533	0.48	0.446	-0.106	0.325	0.027	1	0.028	0.634
Workers Comp	0.461	0.033	-0.035	-0.034	0.401	0.236	0.213	0.463	0.040	0.041	0.028	1	0.403
total	0.851	0.341	0.63	0.42	0.857	0.677	0.496	0.216	0.458	0.391	0.634	0.403	1

Table 9: Pearson correlation between annual change in net losses, by major line.

Correlation Between Annual Change in Premium, by Major Line

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Workers Comp	total
CMP	1	0.757	0.75	0.151	0.667	0.799	0.753	0.793	0.027	0.538	0.614	0.92
Comm Auto	0.757	1	0.427	0.093	0.306	0.716	0.628	0.512	0.016	0.739	0.497	0.844
Comm Property	0.75	0.427	1	0.221	0.423	0.558	0.599	0.784	0.174	0.282	0.221	0.673
Fin Guaranty	0.151	0.093	0.221	1	0.263	0.138	0.106	0.161	0.433	0.193	-0.124	0.256
Homeowners	0.667	0.306	0.423	0.263	1	0.302	0.505	0.581	-0.132	0.371	0.361	0.613
Inland Marine	0.799	0.716	0.558	0.138	0.302	1	0.515	0.54	0.174	0.447	0.535	0.749
Liability	0.753	0.628	0.599	0.106	0.505	0.515	1	0.562	-0.105	0.38	0.524	0.802
Med Mal	0.793	0.512	0.784	0.161	0.581	0.54	0.562	1	0.086	0.502	0.287	0.746
Other Comm	0.027	0.016	0.174	0.433	-0.132	0.174	-0.105	0.086	1	0.086	-0.136	0.14
Personal Auto	0.538	0.739	0.282	0.193	0.371	0.447	0.38	0.502	0.086	1	0.195	0.726
Workers Comp	0.614	0.497	0.221	-0.124	0.361	0.535	0.524	0.287	-0.136	0.195	1	0.611
total	0.92	0.844	0.673	0.256	0.613	0.749	0.802	0.746	0.14	0.726	0.611	1

Table 10: Pearson correlation between annual change in direct premium, by major line.

name	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Reinsur-ance	Workers Comp	total
CMP	1	0.718	0.71	0.116	0.763	0.568	0.463	0.727	-0.001	0.552	0.25	0.7	0.897
Comm Auto	0.718	1	0.343	0.062	0.438	0.584	0.33	0.403	0.18	0.76	0.021	0.581	0.823
Comm Property	0.71	0.343	1	0.262	0.586	0.432	0.481	0.687	-0.133	0.38	0.287	0.314	0.666
Fin Guaranty	0.116	0.062	0.262	1	0.226	0.297	0.607	0.128	0.329	0.207	-0.000	-0.102	0.209
Homeowners	0.763	0.438	0.586	0.226	1	0.369	0.39	0.594	-0.164	0.471	-0.080	0.571	0.684
Inland Marine	0.568	0.584	0.432	0.297	0.369	1	0.471	0.49	0.171	0.455	0.364	0.409	0.679
Liability	0.463	0.33	0.481	0.607	0.39	0.471	1	0.419	0.013	0.403	0.334	0.291	0.569
Med Mal	0.727	0.403	0.687	0.128	0.594	0.49	0.419	1	-0.003	0.383	0.576	0.426	0.726
Other Comm	-0.001	0.18	-0.133	0.329	-0.164	0.171	0.013	-0.003	1	0.045	0.031	-0.120	0.115
Personal Auto	0.552	0.76	0.38	0.207	0.471	0.455	0.403	0.383	0.045	1	-0.036	0.381	0.782
Reinsurance	0.25	0.021	0.287	-0.000	-0.080	0.364	0.334	0.576	0.031	-0.036	1	0.104	0.304
Workers Comp	0.7	0.581	0.314	-0.102	0.571	0.409	0.291	0.426	-0.120	0.381	0.104	1	0.677
total	0.897	0.823	0.666	0.209	0.684	0.679	0.569	0.726	0.115	0.782	0.304	0.677	1

Table 11: Pearson correlation between annual change in net premium, by major line.

Direct Loss Ratio Statistics by Major Line of Business

index	CMP	Comm Auto	Comm Property	Fin Guaranty	Home-owners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Workers Comp	total
min	0.543	0.624	0.365	0.0791	0.565	0.393	0.678	0.548	0.522	0.696	0.577	0.639
mean	0.716	0.751	0.69	0.638	0.763	0.546	0.86	0.837	0.649	0.772	0.778	0.754
max	0.964	0.897	1.59	3.21	1.33	0.74	1.24	1.34	0.853	0.853	0.993	0.921
sd	0.111	0.0823	0.32	0.721	0.166	0.0794	0.162	0.218	0.0734	0.0362	0.103	0.0658
cv	0.155	0.11	0.463	1.13	0.218	0.145	0.189	0.261	0.113	0.0469	0.133	0.0872
growth	-0.00243	0.00511	0.121	0.136	775.919u	0.0122	-0.00457	-0.00284	0.00404	-503.049u	-0.0145	-0.00483
r2	0.33	0.00256	0.0927	0.0242	0.181	0.0959	0.567	0.304	0.155	624.063u	0.274	0.33
rse0	0.0924	0.0837	0.31	0.726	0.154	0.0769	0.109	0.186	0.0688	0.0369	0.0896	0.0549
rse	0.0945	0.0857	0.318	0.743	0.157	0.0787	0.112	0.19	0.0704	0.0378	0.0917	0.0562
slope	-0.00774	-506.209u	-0.0118	0.0136	-0.0086	-0.00299	-0.0149	-0.0146	-0.00351	109.988u	-0.00656	-0.00459
year	16.23	1.77	24.42	-26.69	18.01	6.54	30.66	30.17	7.68	0.552	13.94	9.96
ar r2	0.268	0.798	17.679u	0.472	0.00946	0.00225	0.661	0.79	0.269	0.497	0.658	0.215
ar rse0	0.089	0.0384	0.329	0.543	0.128	0.0797	0.0968	0.101	0.0644	0.0267	0.06	0.0559
ar rse	0.244	0.129	0.528	0.69	0.278	0.273	0.212	0.191	0.234	0.169	0.181	0.221
ar slope	0.468	0.904	0.00418	0.692	0.0731	-0.046	0.804	0.866	0.513	0.708	0.837	0.433
ar intercept	0.371	0.0753	0.679	0.193	0.686	0.567	0.161	0.104	0.314	0.225	0.115	0.422

Table 12: Direct calendar year Loss ratio statistics by major line of business. See below for gloss.

Net Loss Ratio Statistics by Major Line of Business

index	CMP	Comm Auto	Comm Property	Fin Guaranty	Homeowners	Inland Marine	Liability	Med Mal	Other Comm	Personal Auto	Reinsurance	Workers Comp	total
min	0.568	0.633	0.387	0.0657	0.589	0.451	0.623	0.574	0.575	0.697	0.374	0.582	0.653
mean	0.716	0.75	0.675	0.632	0.765	0.566	0.835	0.834	0.651	0.769	0.812	0.773	0.755
max	0.895	0.873	1.33	2.77	1.24	0.658	1.17	1.32	0.787	0.838	2.05	0.971	0.884
sd	0.0899	0.0741	0.191	0.638	0.133	0.0586	0.161	0.204	0.0547	0.0353	0.324	0.0966	0.0569
cv	0.126	0.0988	0.284	1.01	0.174	0.104	0.193	0.244	0.084	0.0459	0.399	0.125	0.0754
growth	-0.00523	0.00464	0.0476	0.138	-0.00946	882.304u	-0.00346	-0.00163	-0.00128	-779.430u	0.06	-0.0158	-0.0059
r2	0.456	0.00141	0.0748	0.0173	0.306	0.203	0.5	0.25	0.362	0.014	0.0926	0.23	0.388
rse0	0.0676	0.0755	0.188	0.645	0.113	0.0534	0.116	0.18	0.0445	0.0357	0.314	0.0864	0.0454
rse	0.0692	0.0772	0.192	0.66	0.116	0.0546	0.119	0.184	0.0455	0.0365	0.322	0.0884	0.0464
slope	-0.00738	-338.097u	-0.00636	0.0102	-0.00895	-0.00321	-0.0138	-0.0124	-0.004	-507.031u	-0.012	-0.00563	-0.00431
year	15.51	1.43	13.43	-19.84	18.71	7	28.59	25.65	8.67	1.79	24.84	12.06	9.39
ar r2	0.477	0.782	0.015	0.443	0.131	0.0577	0.478	0.731	0.663	0.529	0.0601	0.645	0.355
ar rse0	0.0622	0.0359	0.196	0.495	0.0918	0.0577	0.117	0.107	0.0326	0.0251	0.324	0.0548	0.0428
ar rse	0.196	0.131	0.393	0.646	0.225	0.249	0.257	0.208	0.148	0.162	0.517	0.172	0.189
ar slope	0.638	0.898	0.122	0.673	0.259	0.237	0.669	0.833	0.806	0.727	0.244	0.793	0.543
ar intercept	0.252	0.0793	0.588	0.198	0.548	0.429	0.266	0.131	0.124	0.209	0.607	0.147	0.339

Table 13: Net calendar year Loss ratio statistics by major line of business. See below for gloss.

Loss Ratio Statistics by Major Line of Business

Key

- `min`, `mean`, `max`, `sd`, and `cv` are the minimum, mean, maximum, standard deviation and coefficient of variation of loss ratio
- `growth` is the arithmetic average annual growth rate
- `r2`, `rse0`, `slope`, and `year` are the R^2, residual standard error, slope coefficient and year (time) coefficient for a regression of loss ratio against time; `rse` equals `rse0` plus the standard error of the slope parameter
- `ar r2`, `ar rse0`, `ar intercept`, and `ar slope` are the R^2, residual standard error, slope coefficient and year (time) coefficient for an autoregression with lag 1; `ar rse` equals `ar rse0` plus the standard error of the auto regressive parameter

Direct Loss Ratio Time Series by Major Line

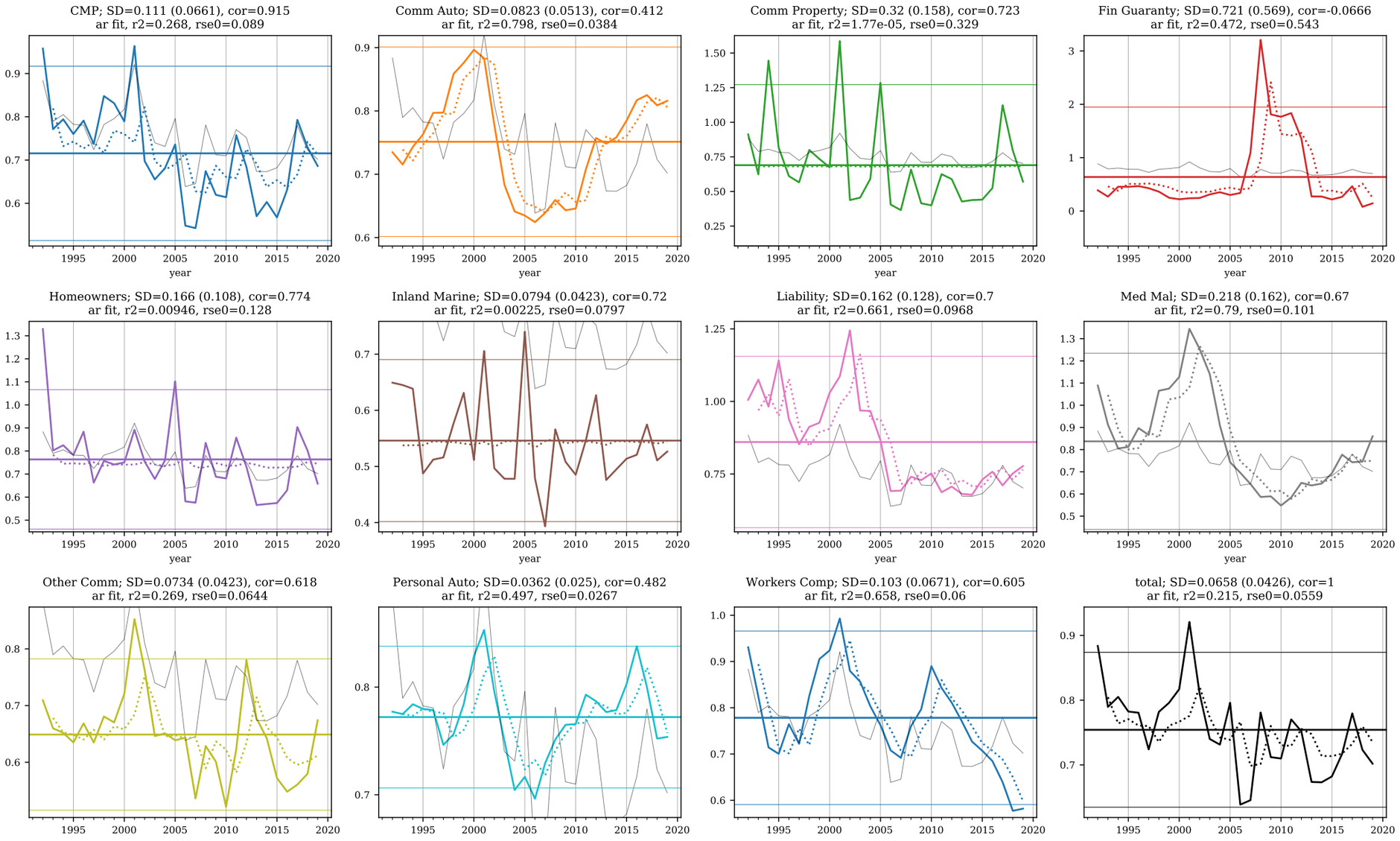

Figure 17: Direct calendar year Loss ratio time series by major line. See gloss below.

Net Loss Ratio Time Series by Major Line

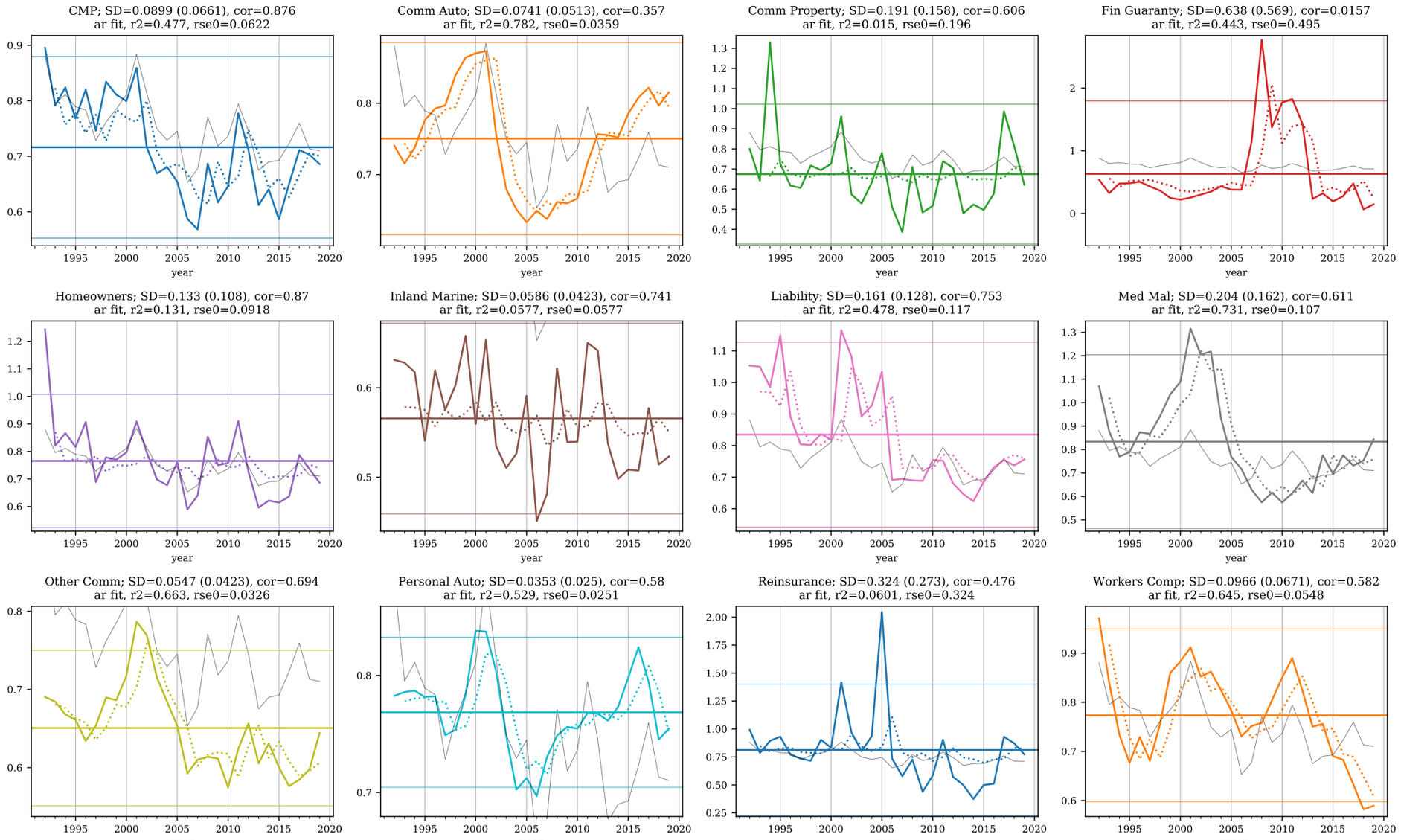

Figure 18: Net calendar year Loss ratio time series by major line. See gloss on next slide.

Loss Ratio Time Series by Major Line

Title decoder: `CMP; SD=0.111 (0.0661), cor=0.915 ar fit, r2=0.268, rse0=0.089`

- Line; standard deviation
- Down-side semi-deviation is shown in parenthsis (explain)
- Correlation of the line with total on the first line
- (second line) shows the R^2 and residual standard error of an autoregressive loss ratio model

Interpretation

- When the `rse` is much lower than `SD` it suggests the market cycle is predictable
- Tends to occur in casualty lines (e.g., commercial auto, medical malpractice, private passenger auto, and workers compensation)
- The cycle for property lines tends to be idiosyncratic, for obvious reasons.

Line Legend

- Thin gray line in each plot shows the `total` loss ratio, for context
- The horizontal lines show the mean (thicker) and mean $\pm\Phi^{-1}(22/23) = \pm 1.71$ standard deviations
  - If the loss ratios were normally distributed we expect all observations from 22 years (1996-2017) to fall within these tram lines
  - They provide a surprisingly good estimate of the range of loss ratio, except for `Financial Lines` (which uses a different tick spacing, note).

Total Loss Ratio Time Series, Direct and Net

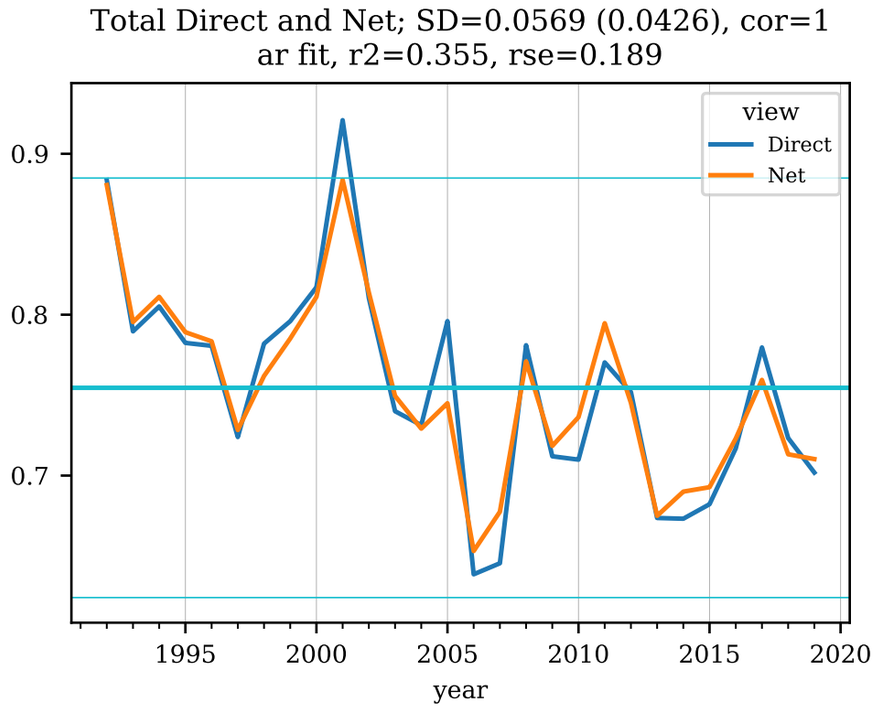

Figure 19: Average direct loss ratio is 0.754 with standard deviation 0.066. Average net loss ratio is 0.755 with standard deviation 0.057. Remember gross equals direct plus assumed minus ceded, so the difference between direct and net is not the same as ceded.

Direct Loss Ratio Time Series by Major Line, Loss Ratio Scale 0 to 150 Percent

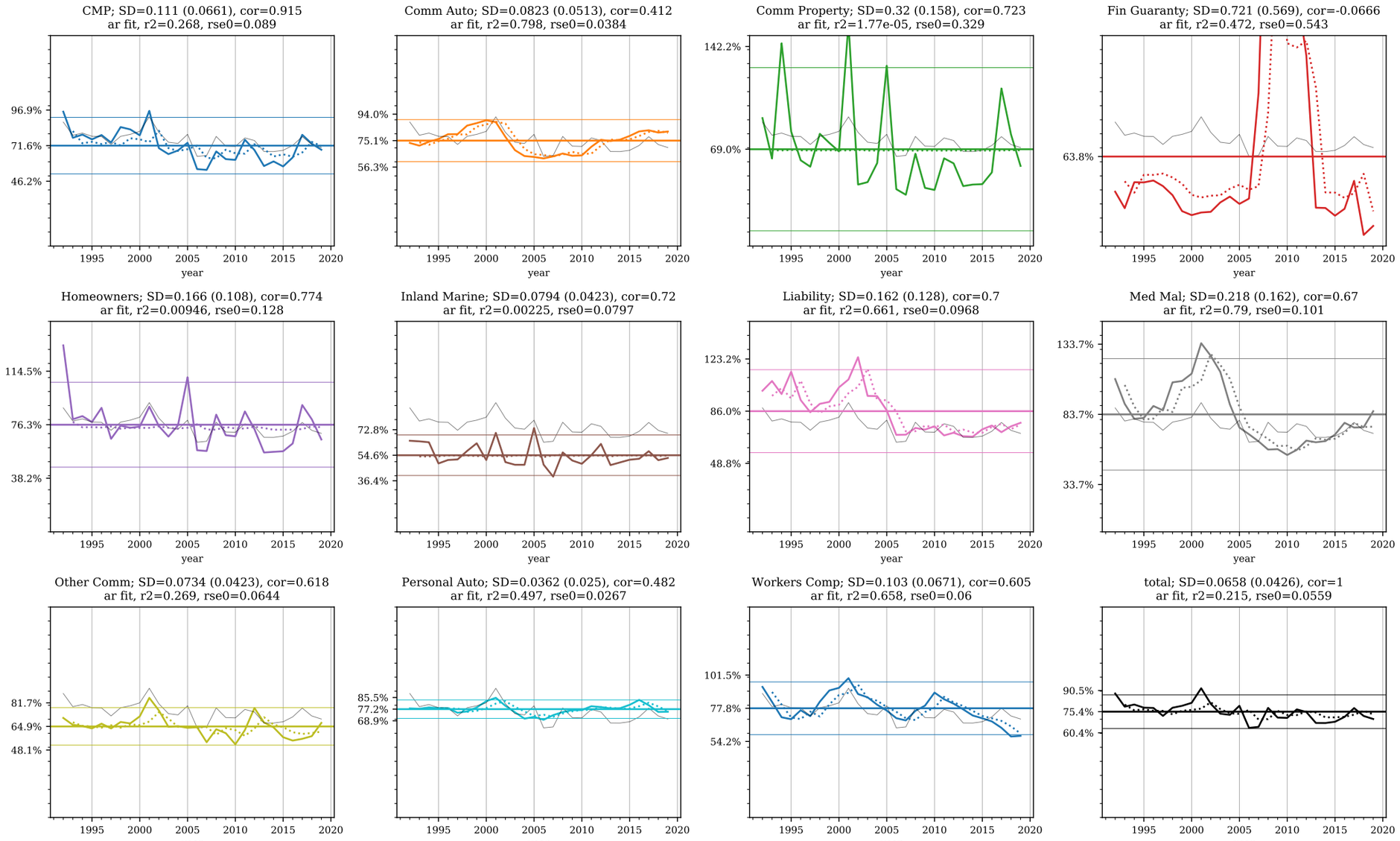

Figure 20: Same as the previous plot, but using the same *y* axis scale on all plots, to emphasize inter-line behavior.

Net Loss Ratio Time Series by Major Line, Loss Ratio Scale 0 to 150 Percent

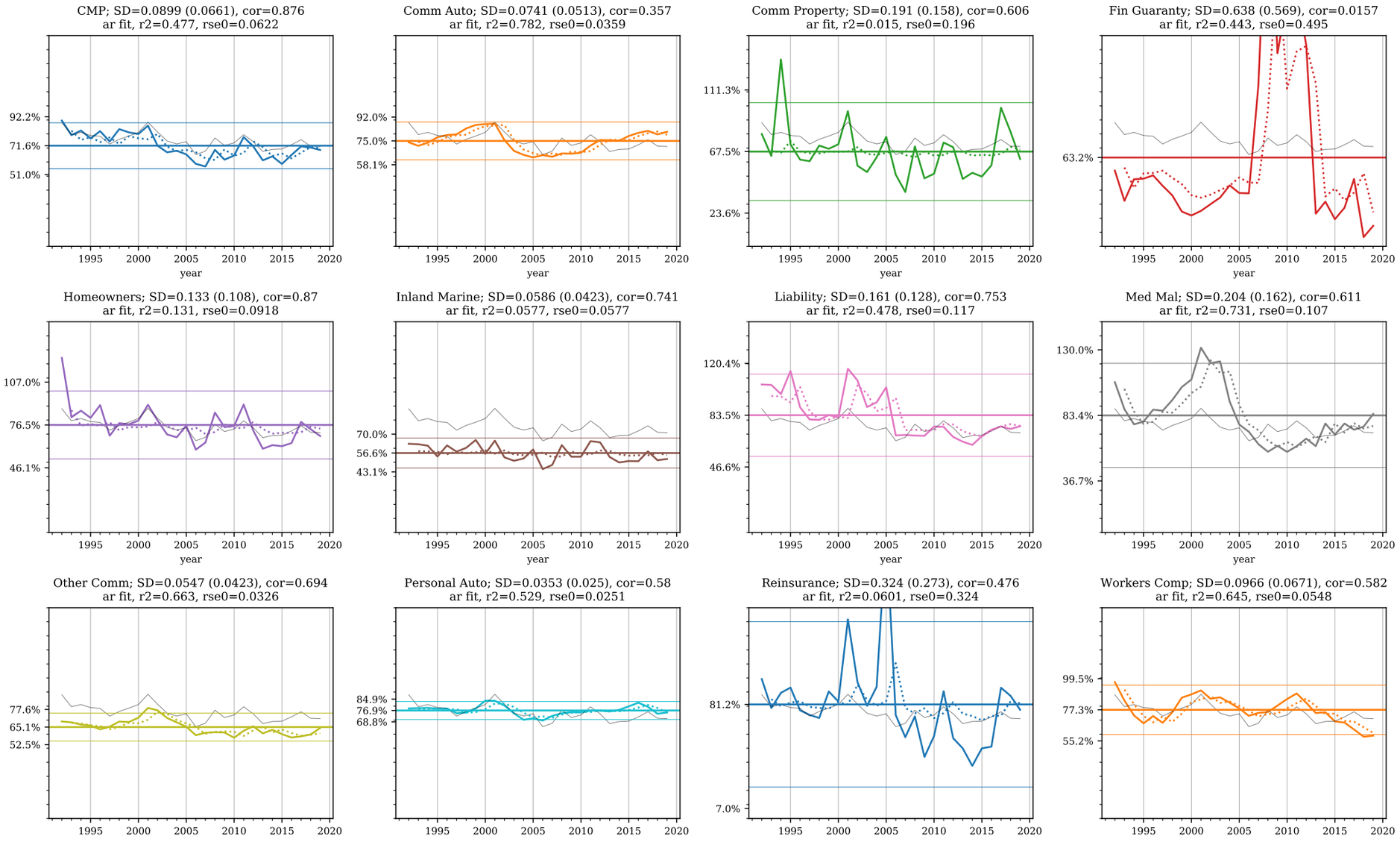

Figure 21: Same as the previous plot, but using the same *y* axis scale on all plots, to emphasize inter-line behavior.

Some Lines Are More Volatile Than Others...

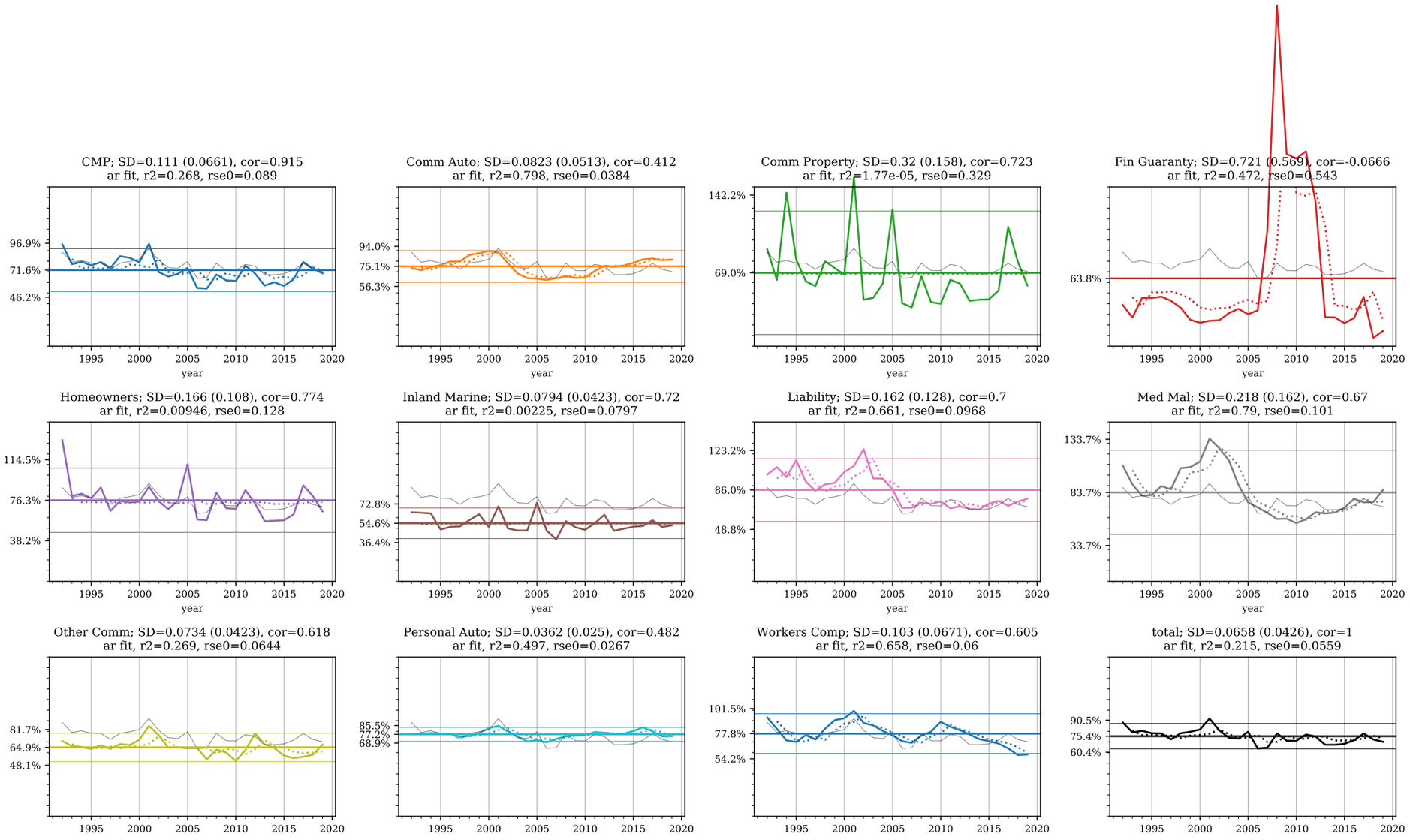

Figure 22: Same as the previous plot, but not clipping loss ratios at 150 percent for Commercial Property, Liability and Fin Guaranty.

Reinsurance More Effective for Some Lines Than Others. . .

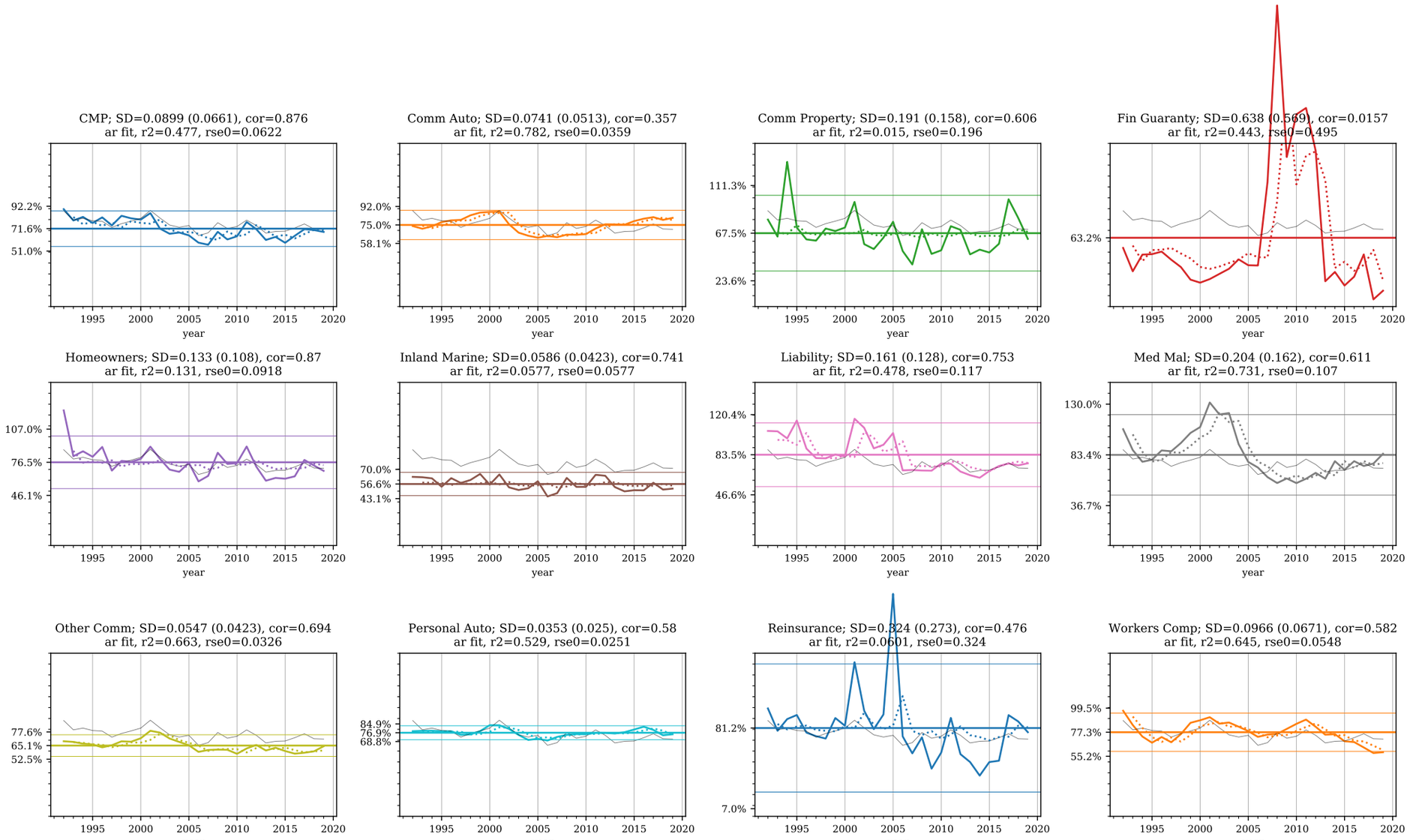

Figure 23: Reinsurance on Commercial Property, typically excess, reduces volatility very effectively whereas net loss more volatile for liabiltiy lines, often protected with quota shares.

Direct Premium and Loss Dynamics

Figure 24: See below for gloss. `rse` is residual standard error without parameter uncertainty, normalized by the mean.

Net Premium and Loss Dynamics

Figure 25: See below for gloss. `rse` is residual standard error without parameter uncertainty, normalized by the mean.

Direct Premium and Loss Dynamics

	CMP		Comm Auto		Comm Property		Fin Guaranty		Home-owners		Inland Marine	
index	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL
cv	0.265	0.214	0.262	0.286	0.404	0.486	0.393	1.597	0.463	0.448	0.444	0.431
cvlr	0.152	0.152	0.108	0.108	0.455	0.455	1.110	1.110	0.214	0.214	0.143	0.143
r2	0.931	0.741	0.722	0.658	0.918	0.366	0.454	0.045	0.989	0.797	0.932	0.856
rse	0.071	0.111	0.141	0.170	0.118	0.394	0.296	1.590	0.050	0.206	0.118	0.166
ar r2	0.981	0.611	0.944	0.959	0.972	0.107	0.888	0.376	0.998	0.679	0.987	0.797
ar rse	0.036	0.137	0.062	0.059	0.068	0.471	0.126	1.304	0.022	0.261	0.051	0.197

	Liability		Med Mal		Other Comm		Personal Auto		Workers Comp		total	
index	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL
cv	0.390	0.309	0.268	0.274	0.248	0.264	0.280	0.283	0.253	0.188	0.310	0.274
cvlr	0.185	0.185	0.256	0.256	0.111	0.111	0.046	0.046	0.130	0.130	0.086	0.086
r2	0.864	0.609	0.487	0.039	0.834	0.481	0.940	0.945	0.809	0.602	0.961	0.908
rse	0.147	0.197	0.196	0.273	0.103	0.194	0.070	0.067	0.113	0.121	0.063	0.085
ar r2	0.951	0.825	0.916	0.742	0.925	0.617	0.989	0.984	0.944	0.834	0.990	0.890
ar rse	0.087	0.130	0.077	0.142	0.064	0.159	0.029	0.035	0.062	0.080	0.031	0.091

Table 14: See below for gloss.

Net Direct Premium and Loss Dynamics

	CMP		Comm Auto		Comm Property		Fin Guaranty		Home-owners		Inland Marine	
index	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL
cv	0.259	0.193	0.233	0.255	0.388	0.415	0.372	1.421	0.444	0.396	0.341	0.304
cvlr	0.123	0.123	0.097	0.097	0.278	0.278	0.991	0.991	0.171	0.171	0.102	0.102
r2	0.933	0.872	0.707	0.637	0.941	0.660	0.502	0.052	0.986	0.892	0.927	0.893
rse	0.068	0.070	0.129	0.157	0.096	0.247	0.268	1.410	0.053	0.132	0.094	0.102
ar r2	0.975	0.768	0.936	0.953	0.964	0.483	0.893	0.400	0.996	0.842	0.967	0.831
ar rse	0.041	0.095	0.059	0.056	0.073	0.304	0.116	1.137	0.027	0.161	0.062	0.125

	Liability		Med Mal		Other Comm		Personal Auto		Reinsur-ance		Workers Comp	
index	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL	EP	IL
cv	0.373	0.308	0.273	0.261	0.214	0.223	0.280	0.279	0.155	0.314	0.235	0.188
cvlr	0.189	0.189	0.240	0.240	0.082	0.082	0.045	0.045	0.392	0.392	0.123	0.123
r2	0.878	0.617	0.633	0.155	0.712	0.340	0.933	0.930	0.144	0.038	0.768	0.495
rse	0.133	0.194	0.168	0.244	0.117	0.185	0.074	0.075	0.146	0.314	0.115	0.136
ar r2	0.910	0.848	0.938	0.696	0.885	0.711	0.988	0.985	0.061	0.338	0.925	0.824
ar rse	0.110	0.118	0.067	0.147	0.068	0.114	0.031	0.033	0.145	0.265	0.066	0.081

Table 15: See below for gloss.

Premium and Loss Dynamics

- **Loss ratio** uncertainty combines **loss** uncertainty and **premium** uncertainty
  - Loss uncertainty = event risk, catastrophes, unexpected trends, estimation error, etc.
  - Premium uncertainty = market or cycle uncertainty; ability to charge technical rate in market
  - `rse` is residual standard error without parameter uncertainty
- Looking at premium and loss time series separately illuminates the particular dynamics of each line
- Each plot shows premium and loss time series (thicker) and a linear or AR(1) fit (thinner)
- Cat-driven loss dynamics stand-out for CMP, Comm Property, Homeowners, Other Commercial and to a lesser extent, Inland Marine
- Non-cat losses tend to be smoother, as events bleed in through development: Comm Auto and Workers Comp
- A priori expect premium in most lines to grow smoothly, approximately with GDP, as seen in Homeowners
- However, most lines exhibit excess premium volatility
  - Personal Auto and Workers Comp premium are more uncertain than loss as measured by regression residual standard error
  - Comm Auto premium exhibits huge cyclic behavior
- Loss ratio uncertainty is a multifaceted and subtle pheneomenon

Calm Surface Masks Inner Turmoil

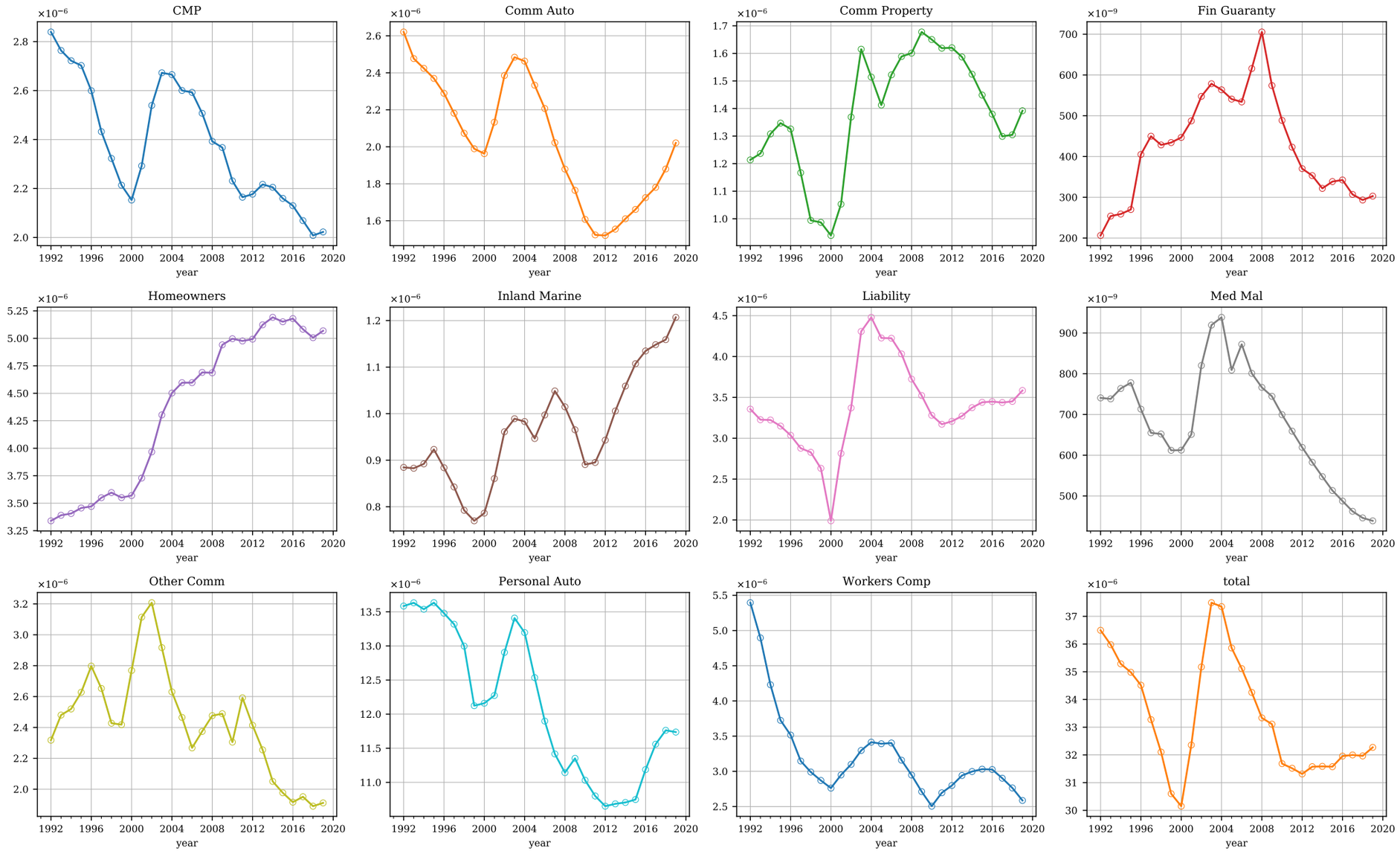

Figure 26: Direct premium to GDP by major line shows a wide variety of behaviors. Broadly, property has increased, while liability coverages have decreased.

The Underwriting Cycle Is Driven by Commercial Lines

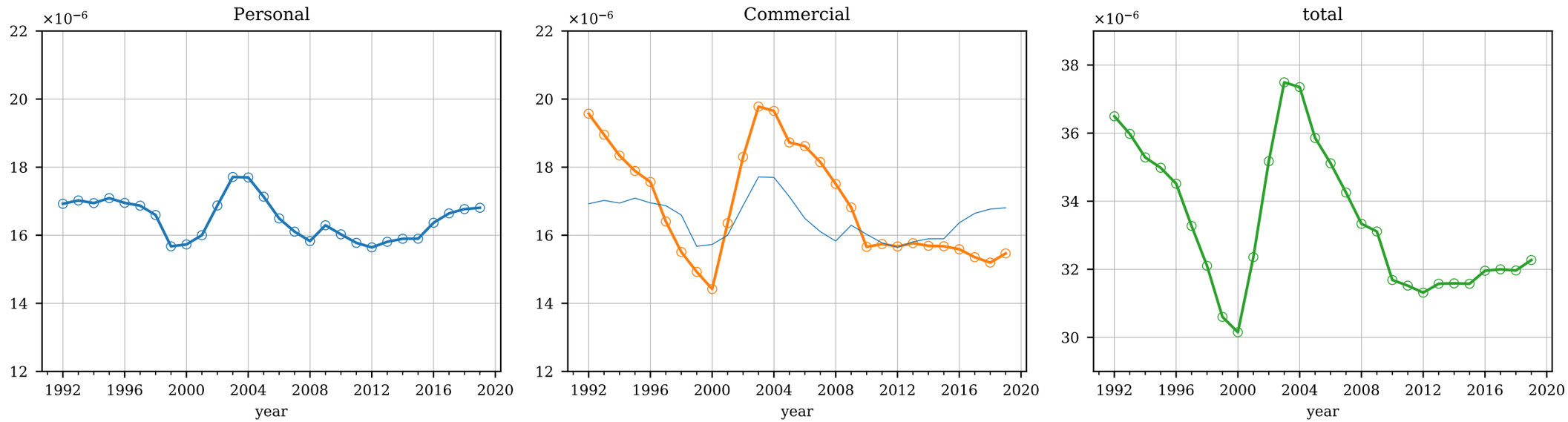

Figure 27: Premium to GDP for personal lines vs. commerical shows the cycle is more driven by commercial. All y axes have the same range but different locations. Personal lines (blue) shown on commerical plot to compare relative sizes. Commercial lines has been bigger than personal since 2001

Direct and Net Premium and Loss

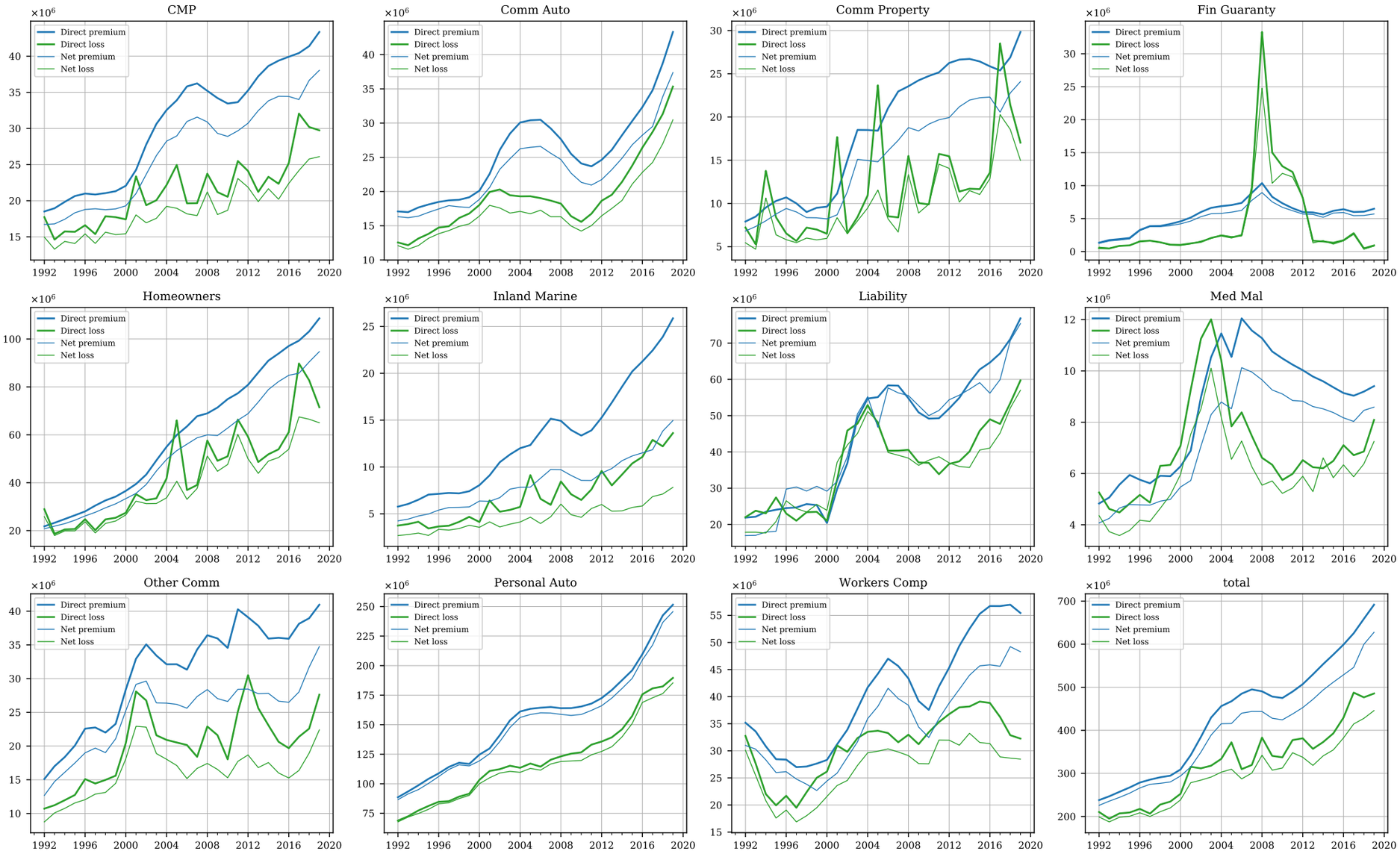

Figure 28: Direct and net premium and loss by major line.

Direct and Net Combined Ratio and Loss Ratio by Line by Year

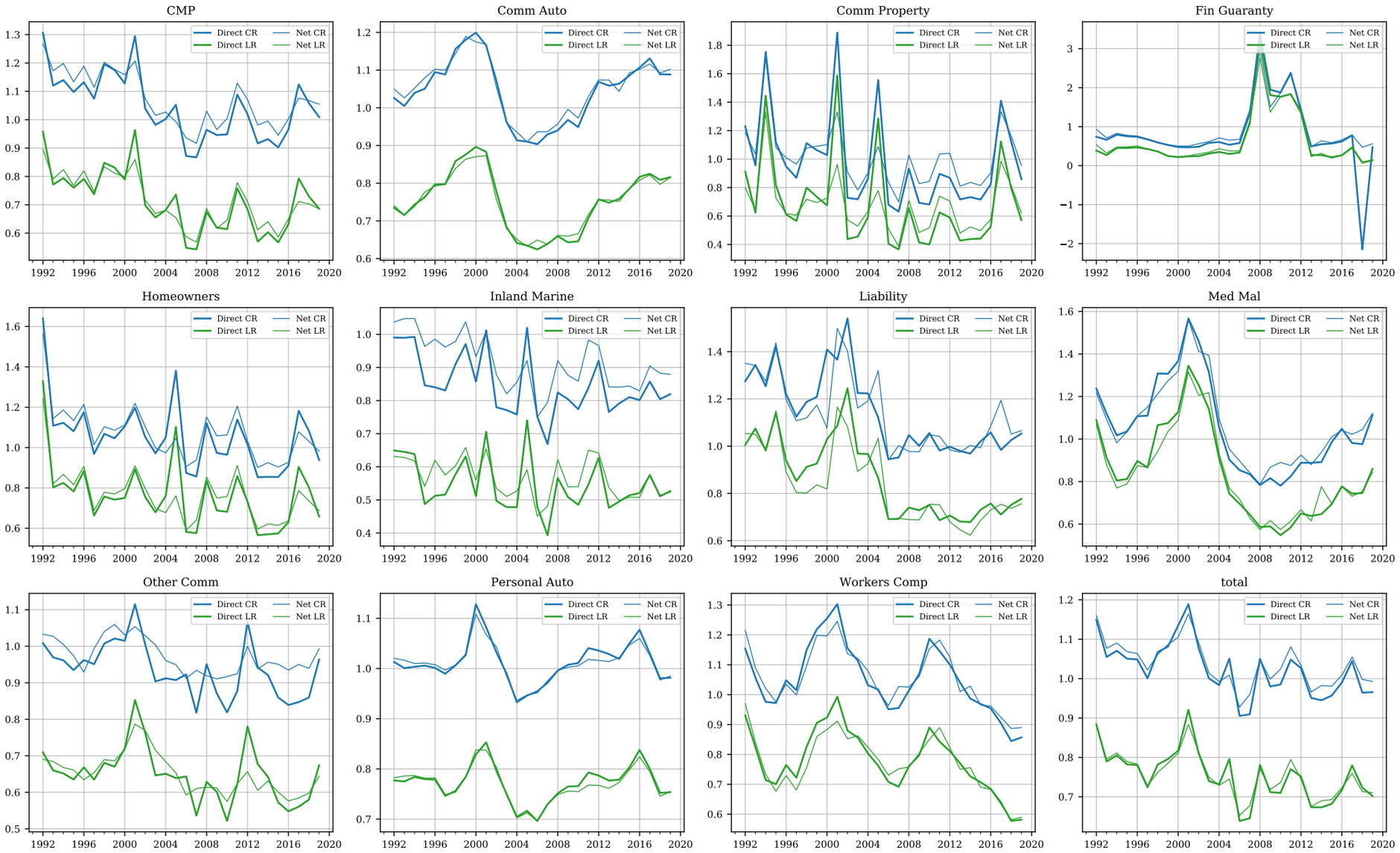

Figure 29: Direct and Net Combined Ratio and Loss Ratio by Line by Year.

Net Operating Results

name	Avg UW Margin	Wtd Avg UW Margin	SD UW Margin	Avg Op Margin	Wtd Avg Op Margin	SD Op Margin	Avg II	MSD	Adj Op Margin
Fin Guaranty	0.075	-0.036	0.612	0.194	0.067	0.626	0.118	0.309	0.281
Med Mal	-0.070	-0.041	0.192	0.121	0.133	0.183	0.191	0.660	0.160
Inland Marine	0.084	0.101	0.082	0.107	0.123	0.080	0.023	1.338	0.160
Workers Comp	-0.058	-0.043	0.099	0.083	0.095	0.095	0.142	0.877	0.117
Liability	-0.143	-0.105	0.158	0.038	0.061	0.150	0.180	0.250	0.054
total	-0.038	-0.028	0.057	0.025	0.031	0.061	0.063	0.420	0.035
Personal Auto	-0.010	-0.008	0.036	0.024	0.024	0.038	0.034	0.640	0.032
Comm Property	-0.014	0.019	0.208	0.020	0.052	0.206	0.034	0.096	0.021
Reinsurance	-0.164	-0.138	0.377	0.014	0.035	0.347	0.177	0.039	-0.595
Comm Auto	-0.053	-0.049	0.078	0.009	0.010	0.074	0.062	0.125	0.013
Other Comm	0.026	0.030	0.047	-0.006	-0.016	0.521	-0.032	-0.012	-0.014
CMP	-0.075	-0.057	0.096	-0.006	0.007	0.080	0.069	-0.080	-0.011
Homeowners	-0.071	-0.037	0.138	-0.041	-0.010	0.132	0.030	-0.314	-0.061

Table 16: Insurance operating result, with allocated investment income from policyholder funds, by major line. Weighted `Wtd` average margins are higher than straight `Avg` averages because bad results are followed by increasing rates and volume, thus good years receive relatively greater weight. Weighted also biases towards the most recent year. The straight average is a more appropriate measure of average achieved profitability. Sorted by descending average operating margin, most profitable first. `Avg II` shows implied investment income. `MSD` shows (straight) average to standard deviation ratio for operating margin. `Adj Op Margin` shows the operating margin adjusted for average expenses in the line.

Average Margins, All Lines Combined

Historical average margins

index	UW Margin	Op Margin	IEE Op Ins Funds	IEE Total Op	Inc Stmt Pre-Tax Total Return	Adj Op Margin
Average	-0.0381	0.0901	0.0282	0.105	0.108	0.126
Wtd Avg	-0.0278	0.0947	0.0325	0.11	0.111	0.132
Drag	0.0104	0.0046	0.00427	0.00528	0.00394	0.00642

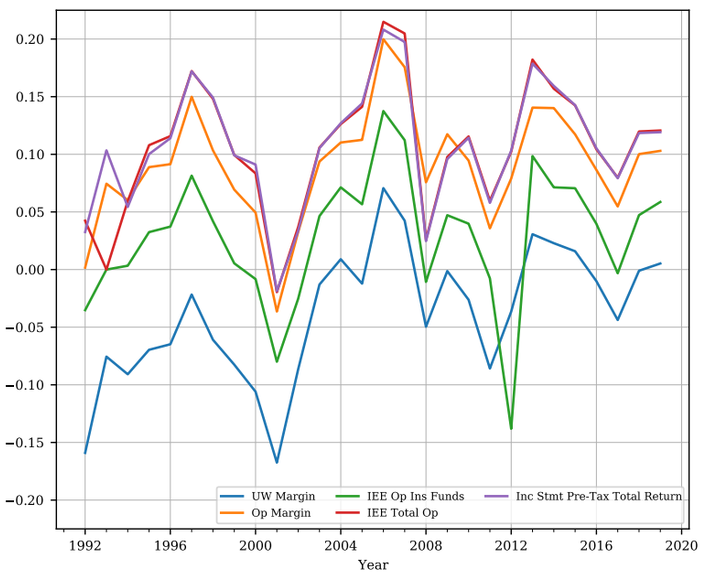

Figure 30: Average margins over time, all lines combined

Target average margins

- Table shows historical average pre-tax margin to earned premium
  - UU margin, with no investment income
  - Op margin, with income but no gains
  - IEE margin, with investment gains on insurance funds
  - IEE margin, wtih all invsetment gains
  - Income statement, with all gains
  - THe last two should be the same
- Weighted return greater than average because of cycle effect
- `Adj Op Margin` adjusts for expenses

C.05. Direct Premium Growth by Major Line, 1992-2019

Average Direct Premium Growth Rates by Line (Percent)

index	Mean	SD	CAGR	Adj
Workers Comp	1.90	6.46	1.70	1.69
Med Mal	2.80	8.30	2.50	2.46
CMP	3.27	3.93	3.20	3.19
Comm Auto	3.66	5.84	3.50	3.49
Personal Auto	3.98	2.83	3.94	3.94
Other Comm	4.01	7.43	3.76	3.74
total	4.08	3.36	4.03	4.03
GDP	4.52	1.80	4.51	4.51
Comm Property	5.39	9.10	5.04	4.98
Liability	5.41	12.44	4.76	4.63
Inland Marine	5.84	5.19	5.72	5.71
Homeowners	6.17	2.75	6.13	6.13
Fin Guaranty	6.94	15.00	6.00	5.81

Table 17: Average direcet premium growth rates by line of business, with (nominal) GDP included for reference. Lines sorted from slowest to fastest growth. Insurance grows broadly with the economy, as the premium to GDP analysis showed. Since 1992, premium growth has slightly lagged GDP growth. `Mean` shows the average annual growth rate and `SD` its standard deviation. `CAGR` is the compound average growth rate. `Adj` shows the arithmetic mean adjusted for volatility using the lognormal $\mu + \sigma^2/2$ formula. It is very close to the actual compound rate. Source: GDP from FRED.

Annual Change in Direct Premium by Line

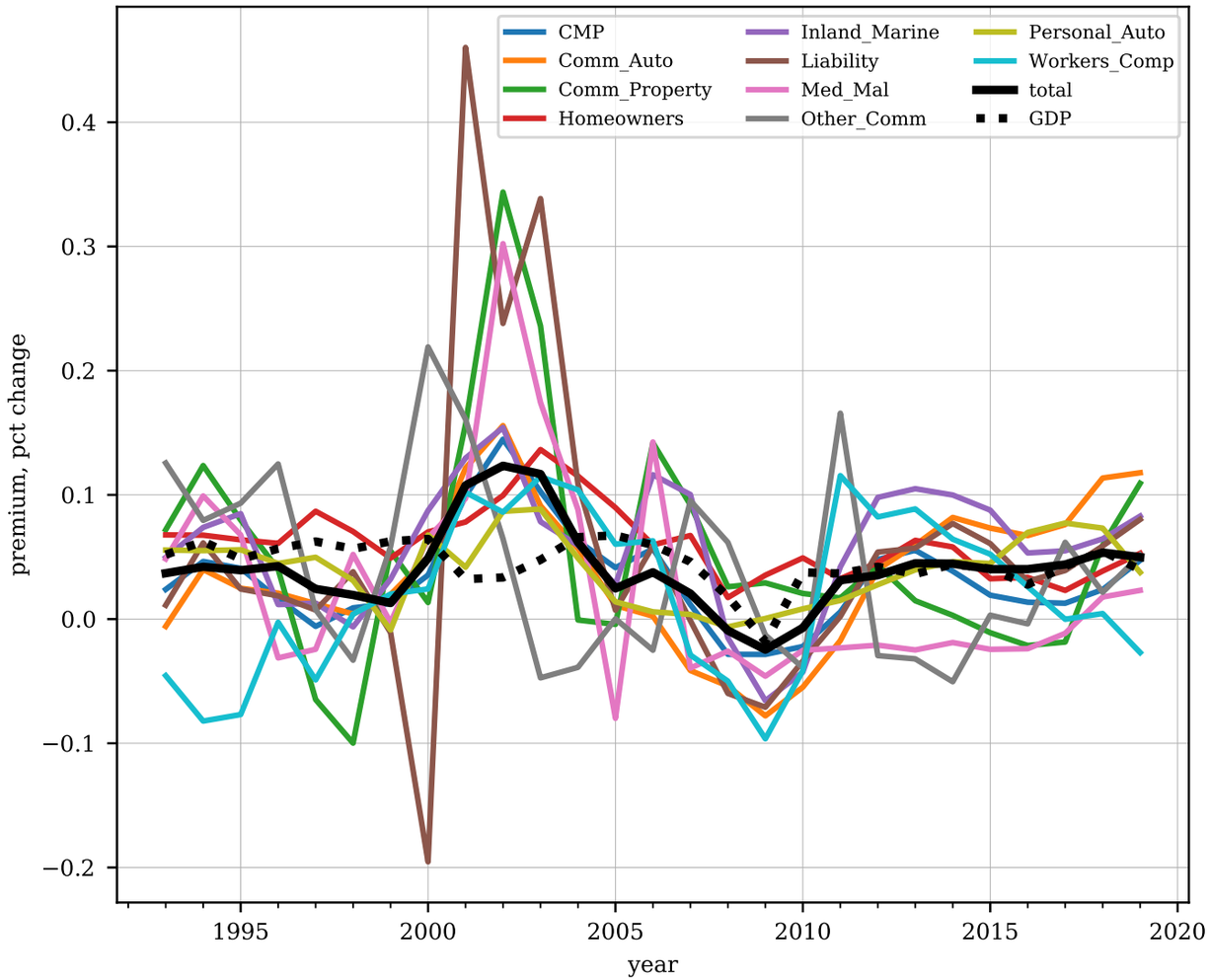

Figure 31: Change by line correlated to the economy (GDP), but displays considerable variation by line.

Annual Change in Direct Premium Detailed by Line

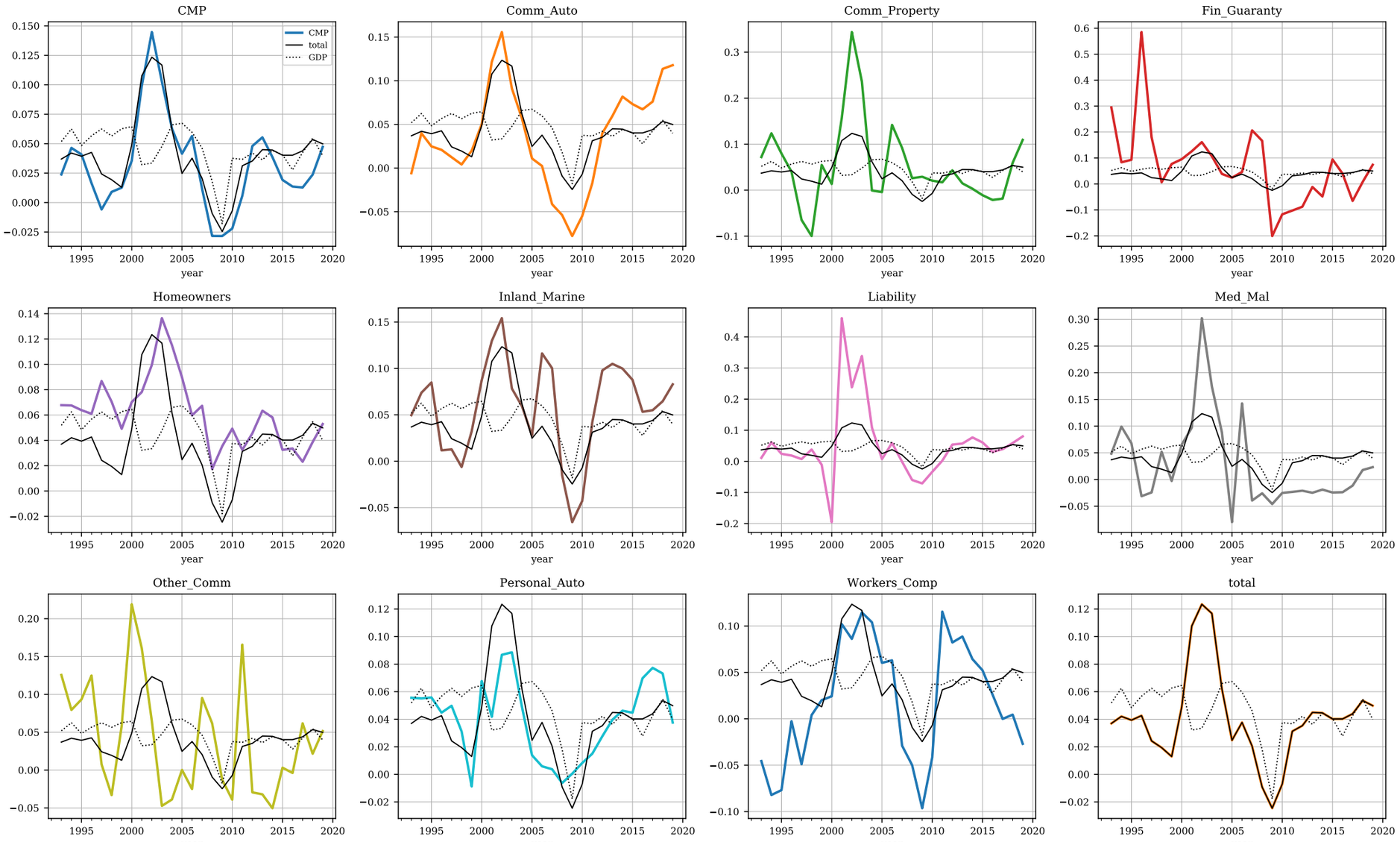

Figure 32: Degree of correlation to the economy (GDP) varies by line.

Annual Change in Direct Premium by Line Common Scale

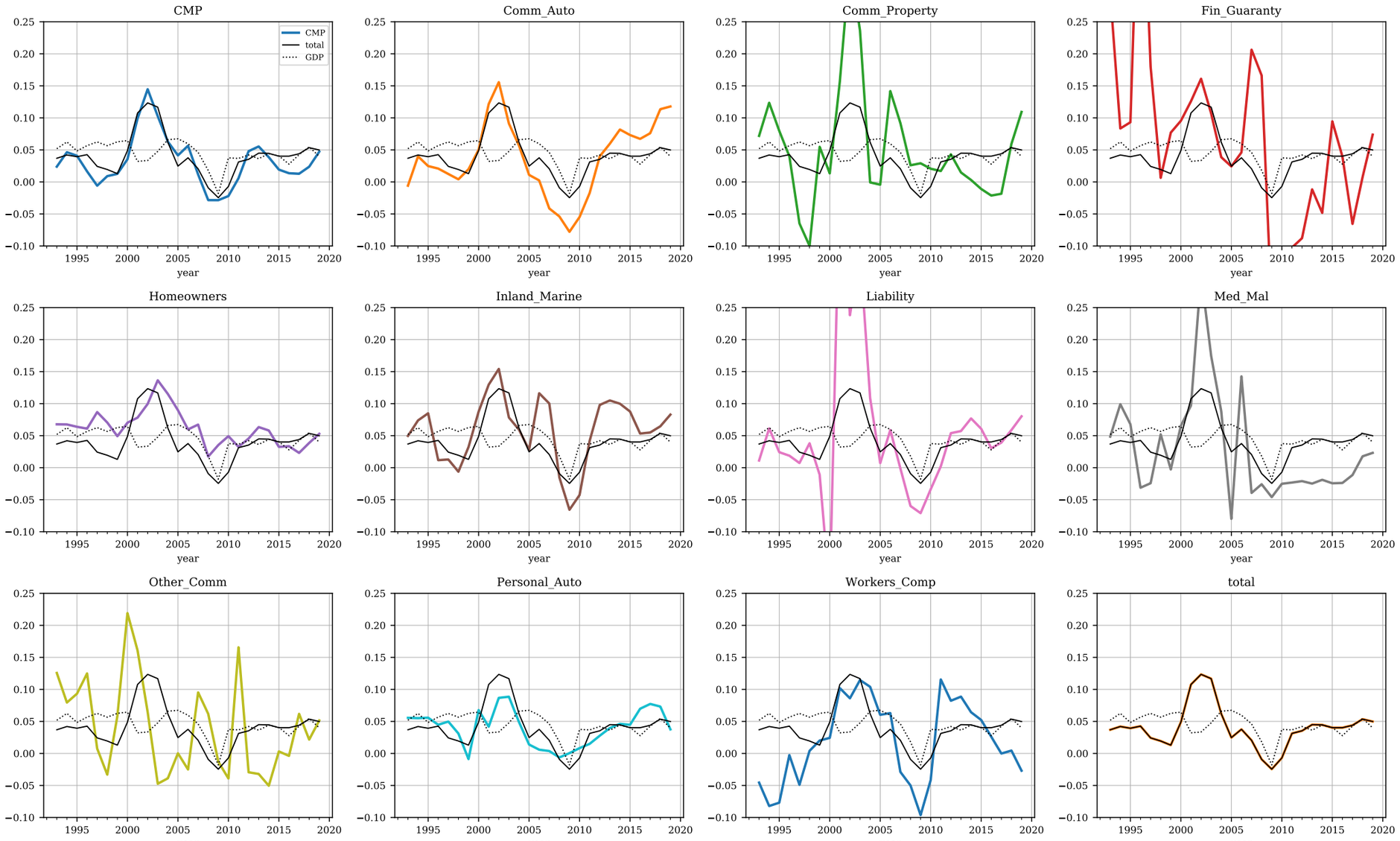

Figure 33: Magnitude of premium changes varies considerably by line.

Premium and GDP Growth Since 1992 (1992=1.0)

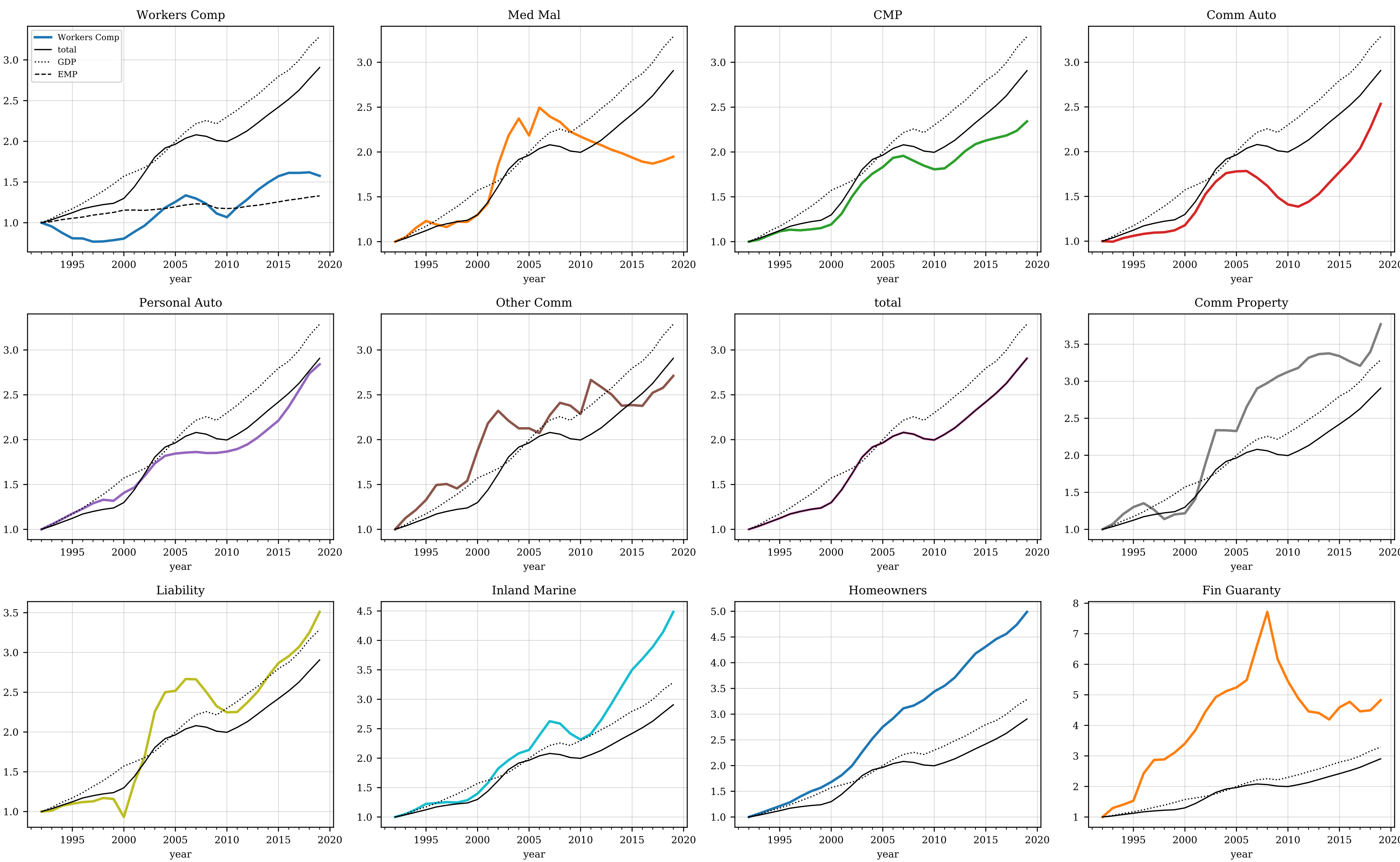

Figure 34: Lines sorted from slowest to fastest average growth rate, since 1992. The workers compensation plot includes the overall level of employment EMP from the FRED series CE16OV. WC premium has declined as productivity has improved. Broadly, labor inputs have become less important in higher-risk segments of the economy. Commercial auto is particularly interesting.

C.06. Implications

Implications

Loss ratio and margin expectations

- Adjusted Insurance Operating Ratios averages 13%
  - Net basis
  - Pre-tax
  - Including all investment income
- Considerable variation in underlying loss ratio by line
- By line asymptotic (large portfolio) direcet loss ratio CVs range from 5% for personal auto to 46% for commercial property
- Smaller portfolios will have larger CVs
- Total industry loss ratio CV is 9% direct and 8% net

Margin expectations

- Average historical pre-tax, net margin based on industry data 1992 to 2019
  - -4% underwriting income to net earned premium
  - 9% excluding capital gains and
  - 11% including all capital gains
- Over period, investment income declined from over 20% to less than 10% of net earned premium
- A pricing model producing a gross margin of 8 to 10% is consistent with realized experience 1996-2019