Insurance Supervision under Climate Change: A Pioneer Detection Method

Eric Vansteenberghe [a]

[a]Banque de France

Disclaimer

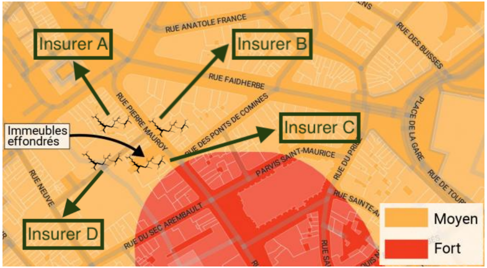
A storm is threatening
My very life today
If I don't get some shelter
I'm going to fade away

Michael Phillip Jagger and Keith Richards

The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of the his past, present or future employers.

Motivation 1/2

- November 12, 2022, two buildings collapsed in Lille city center
- Did insurers receive claims? (cracks as early warnings) illustration[b]
- Investigation to determine if collapse due to CC (will be public information)



[b] "La Voix du Nord" 30.11.2022 C. Canivez and J. Depelchin

Motivation 2/2

What are the optimal regulation and supervision actions?

1. Build own beliefs:
   - On-site ad-hoc inspections;
   - Stress tests;
   - Modeling;
   - Opinion pooling.
2. Information sharing in the form of:
   - Disclosures;
   - Announcements;
   - Regulatory constraints.

Contributions to the literature

- **Opinion pooling, combination forecast**: Stone [1961], Genest and Zidek [1986], Clemen [1989], Timmermann [2006], and Wang et al. [2022].
  - Gaussian context:
    - difficult to beat a mean excluding outliers.
  - Extreme Value context:
    - extremes do occur but rarely $\Longrightarrow$ hard to guess the tail;
    - $\Longrightarrow$ new Pioneers Detection Method.

- **Insurability** and **supervisor mandate**:
  - Berliner [1985], Charpentier [2008];
  - this is the first paper to suggest using insurance on-site inspection to gather and then pool expertise wrt climate change.

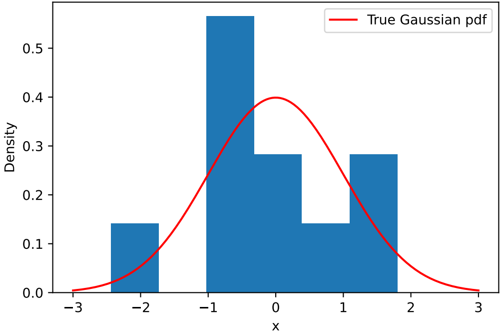
Pioneer Detection Method: illustration 1/3

- Risk-averse insurance buyer exposed to aggregated losses:
  - $x\left(\alpha^t\right)$;
  - x rv $\sim$ **Pareto** with unknown tail parameter α^t:
    - Kleiber [2003] Pareto, a parsimonious model effective for capturing the right-tail behavior of loss distributions.

- Climate change impacts the tail parameter over time t;
- The realization of α^t is never observable.

Pioneer Detection Method: illustration 2/3

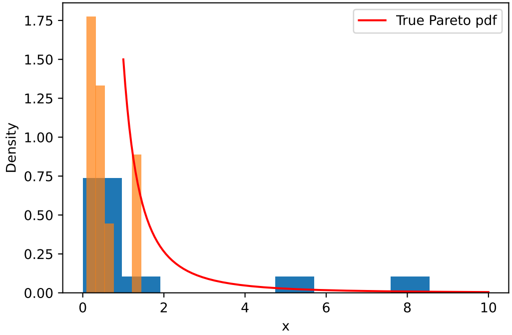
- In a Gaussian world, standard normal law, sample of 10 losses



- $\bar{x} \simeq 0$
- $Var(x) \simeq 1$

Pioneer Detection Method: illustration 3/3

- In an EVT, Pareto law ($\alpha = \mathbf{1.5}$), sample of 10 losses
- blue and orange fragmented information

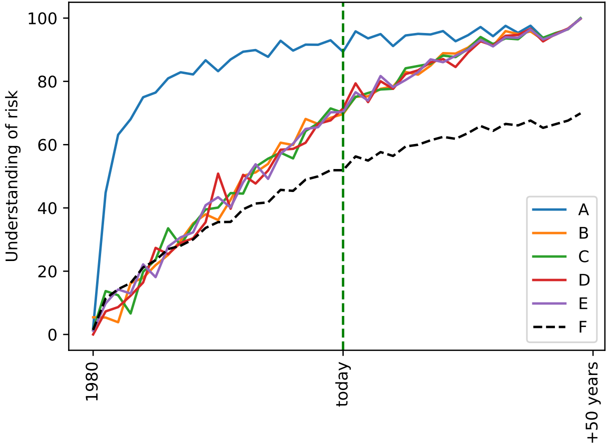


- $\hat{\alpha}_{\text{orange}} \simeq 5.5$
- $\hat{\alpha}_{\text{blue}} \simeq 1.2$
  - Granular information: $\hat{\alpha}_{\text{granular}} \simeq \mathbf{1.6}$, simple estimate average: $\hat{\alpha}_{\text{average}} \simeq 3.4$

Pioneer Detection Method

- can't observe α^t;
- extreme events have low probability of occurrence but do happen:
  - heterogeneous learning rate depending on (random) exposure.
- **Pioneers** are experts who deviate from the majority opinion but towards which other experts' opinions converge over time although experts do not cooperate nor observe other estimates.
- PDM: implicit inter-temporal voting among experts to identify pioneers.
- A convergence in direction is enough to identify a Pioneer.

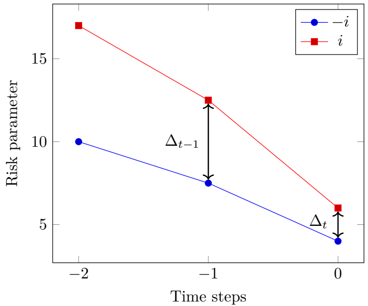
Pioneer Detection Method - time series



How to identify today that expert **A** is a pioneer?

Pioneer Detection Method - step 1 / 3

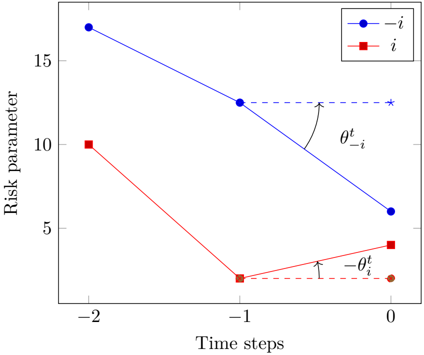
- **First step**: distance reduction dummy, $\delta^t_{\text{distance}} = \mathbb{1}_{\Delta_t < \Delta_{t-1}}$



- i represents the expert of interest
- $-i$ the average estimate of his competitors (i excluded).

Pioneer Detection Method - step 2/3

Second step: orientation change for convergence, $\delta^t_{\text{orientation}} = \mathbb{1}_{\theta^t_{-i} > \theta^t_i}$.

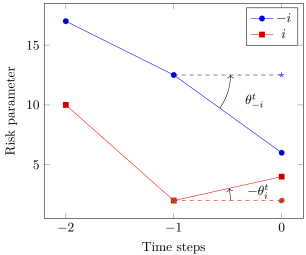


- i represents the expert of interest
- $-i$ the average estimate of his competitors (i excluded).

Pioneer Detection Method - step 3 / 3

Third step: proportion of the convergence attributed to each potential pioneer i:

$$w_i^t = \delta^t_{\text{distance}} \times \delta^t_{\text{orientation}} \times \frac{|\theta^t_{-i}|}{|\theta^t_{-i}| + |\theta^t_i|} \tag{1}$$



S subjective estimate:

$$\hat{\alpha}^t_S = \sum_i w^t_i \hat{\alpha}^t_i \tag{2}$$

New tool: alternatives competitors

1. Granger Causality (**GC**),
   [Granger, 1969] and [Toda and Yamamoto, 1995].
2. (lagged) **Correlation** [Pearson, 1895],
   as in Sakurai et al. [2005] and Forbes and Rigobon [2002].
3. Information transfer [Schreiber, 2000],
   similar to GC if the r.v. are Gaussian [Barnett et al., 2009].
4. Bayesian Model Averaging
   (BMA, Draper [1995]) but three challenges [Wang et al., 2022].

Comparison with Combination Forecast literature - Hog price

	prices	Econometric	ARIMA	Expert
date				
1976-03	47.90	48.55	48.54	47.00
1976-06	49.15	46.64	49.05	48.50
1976-09	43.53	47.76	46.81	45.00
1976-12	34.16	43.71	39.12	35.00
1977-03	38.96	45.32	35.27	35.00
...	...	...	...	...
1978-09	48.59	46.78	47.18	51.00
1978-12	50.03	52.08	47.28	45.00
1979-03	51.79	49.69	51.72	51.00
1979-06	43.07	51.01	50.05	48.00

- The data set is taken from Bessler and Brandt [1981].

Comparison with Combination Forecast literature - Hog price

	Expert	Econometric	AR	ARIMA	Median	L.Corr.	GC	Mean	Min. Var.	Pioneers
RMSE	1.35	1.22	1.00	0.64	0.64	0.56	0.55	0.52	0.48	0.42

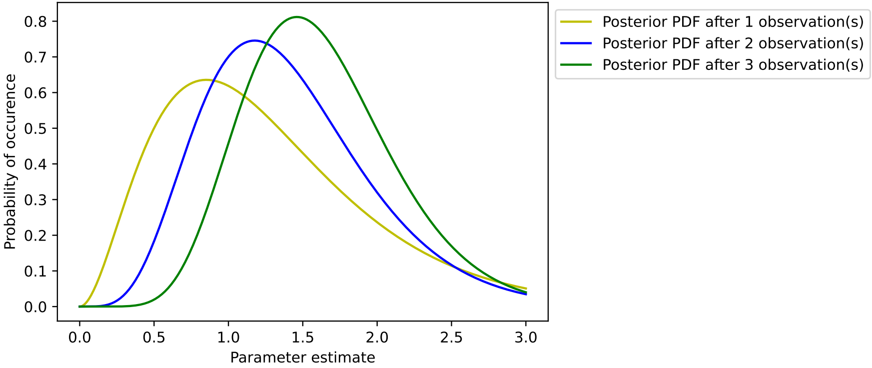
- Reported weights are the average when they are varying over time for the method:

Component	L.Corr.	GC	Mean	Min. Var.	Pioneers
Econometric	0.30	0.50	0.33	0.53	0.70
ARIMA	0.35	0.50	0.33	0.25	0.17
Expert	0.36	0.00	0.33	0.22	0.12

PDM validation - i.i. Bayesian experts

- Tipping point: stable α^- (unexpectedly) jumps to $\alpha = 1.5$ (then stable)
- Arnold and Press [1989] natural conjugate prior family for α is Gamma(s_i^t, r_i^t)
- start with vague prior $s_i^0 = r_i^0 = 10^{-3}$.

Bayesian expert posterior update with sample size



PDM validation - i.i. Bayesian experts

Time	Pioneers	Linear	Median	L.Corr.	GC
2	1.00	4.05	1.67	13.61	4.63
3	1.00	3.80	1.46	104.72	4.01
4	1.00	2.09	1.30	39.53	2.39
5	1.00	1.75	1.26	20.17	2.02
6	1.00	1.61	1.24	3.66	1.92
7	1.00	1.53	1.23	11.60	1.86
8	1.00	1.48	1.23	2.84	1.82
9	1.00	1.44	1.23	2.47	1.79

- Pareto type one distribution with $\alpha = 1.5$;
- 10^5 Monte Carlo simulations;
- m=5 non-cooperative Bayesian experts;
- robust to ranges of α and $m < \infty$.

S policy recommendation: welfare benefit

- Reminder: Pareto optimal contracts are solution of

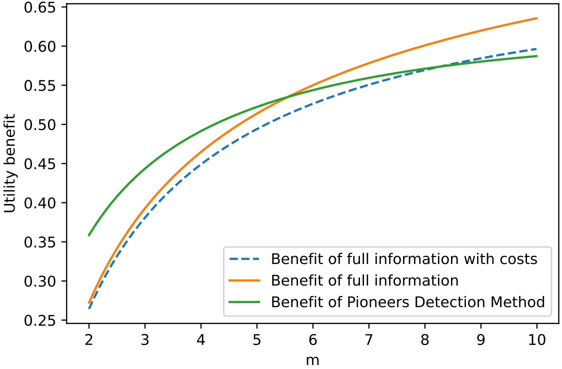
$$\begin{cases} \max_{I(x^t),\Pi} \mathbb{E}_{\hat{\boldsymbol{\alpha}}_{\boldsymbol{b}}^{\boldsymbol{t}}} \left[U \left(w - x^t + I(x^t) - \Pi \right) \right] \\ \text{subject to } \Pi(x^t) = \mathbb{E}_{\bar{\boldsymbol{\alpha}}^{\boldsymbol{t}}} \left[I(x^t) \right] \end{cases} \tag{3}$$

- Welfare gain substituting Π based on $\hat{\alpha}_i^t$ with $\hat{\boldsymbol{\alpha}}_{\boldsymbol{S}}^{\boldsymbol{t}} = \sum_i w_i^t \hat{\alpha}_i^t$?

- Logarithm utility as in Mossin [1968]:

$$\mathbb{E}_{\hat{\boldsymbol{\alpha}}_{\boldsymbol{S}}^{\boldsymbol{t}}} \left[\log \left(\text{constant} - \Pi \right) \right] \tag{4}$$

S policy recommendation: benefit, no data collection cost



- Even if claim collection would be costless, always more beneficial for S to use the PDM with less than five ICs.

Conclusion

- What can I advise an insurance supervisor to do if a tipping point introduces heterogeneous beliefs detrimental to welfare?

- Insurance market model to determine the form of indemnity:
    - Pareto type I where the tail parameter is never observable.

- I study optimal supervision actions and compare
    1. on-site inspections for information gathering;
    2. new Pioneers Detection Method for opinion pooling.

- My policy recommendation is to use the Pioneers Detection Method if small count of IC for an asset class.
- This conclusion in favor of the PDM is stronger when information collection and modeling costs are included.

Barry C Arnold and S James Press. Bayesian estimation and prediction for pareto data. *Journal of the American Statistical Association*, 1989.

Lionel Barnett, Adam B Barrett, and Anil K Seth. Granger causality and transfer entropy are equivalent for gaussian variables. *Physical Review Letters*, 2009.

Baruch Berliner. Large risks and limits of insurability. *The Geneva Papers on Risk and Insurance - Issues and Practice*, 1985.

David A Bessler and Jon A Brandt. Forecasting livestock prices with individual and composite methods. *Applied Economics*, 1981.

Arthur Charpentier. Insurability of climate risks. *The Geneva Papers on Risk and Insurance - Issues and Practice*, 2008.

Robert T Clemen. Combining forecasts: A review and annotated bibliography. *International journal of forecasting*, 1989.

David Draper. Assessment and propagation of model uncertainty. *Journal of the Royal Statistical Society: Series B (Methodological)*, 1995.

Kristin J Forbes and Roberto Rigobon. No contagion, only interdependence: measuring stock market comovements. *The Journal of Finance*, 2002.

Christian Genest and James V. Zidek. Combining probability distributions: A critique and an annotated bibliography. *Statistical Science*, 1986.

Clive WJ Granger. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: journal of the Econometric Society*, 1969.

C Kleiber. *Statistical Size Distributions in Economics and Actuarial Sciences*. John Wiley &Sons, Inc, 2003.

Jan Mossin. Aspects of rational insurance purchasing. *Journal of political economy*, 1968.

Karl Pearson. Note on regression and inheritance in the case of two parents. *Proceedings of the Royal Society of London*, 1895.

Yasushi Sakurai, Spiros Papadimitriou, and Christos Faloutsos. Braid: Stream mining through group lag correlations. In *Proceedings of the 2005 ACM SIGMOD international conference on Management of data*, 2005.

Thomas Schreiber. Measuring information transfer. *Physical review letters*, 2000.

Mervyn Stone. The opinion pool. *The Annals of Mathematical Statistics*, 1961.

Allan Timmermann. Forecast combinations. *Handbook of economic forecasting*, 2006.

Hiro Y Toda and Taku Yamamoto. Statistical inference in vector autoregressions with possibly integrated processes. *Journal of econometrics*, 1995.

Xiaoqian Wang, Rob J Hyndman, Feng Li, and Yanfei Kang. Forecast combinations: an over 50-year review. *International Journal of Forecasting*, 2022.