

INFORMS 2017

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Fat-tails in hospital costs: Evidence and implications for tariff-based compensation systems

Joint work with:

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Inpatient prospective payment system

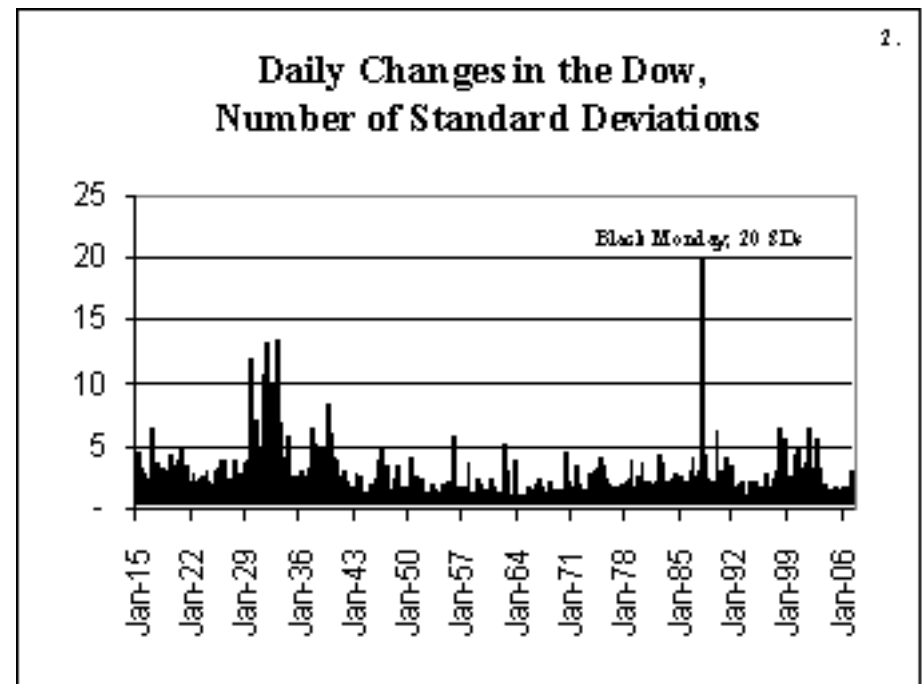
- IPPS: Patient visits classified into diagnosis-related groups (DRGs) and **hospitals receive a fixed per-visit payment**
- DRG payments are based on **average cost per patient visit** for the same DRG in the past
- Economic theory of **yardstick competition** (Shleifer 1985)
- **Basic assumption:** if hospitals don't change, then past system-average cost is a good predictor of future system-average costs

The basic assumption

- **Central limit theorem:** for a large enough sample size n , the distribution of the sample mean will approach a normal distribution
 - Assuming sufficiently large n , then sample means will be clustered close to the population mean
 - If the underlying cost distribution for a DRG does not change much from one year to the next, then past sample mean is good approx. of future population mean
- **Caveat:** True for a sample of independent random variables from any population distribution, as long as the population has a *finite variance*

Black swans

- A **black swan event** is such an extreme outlier that it should not “normally” happen
- The normal distribution (and its relatives) have rapidly decaying (exponentially) tails → black swan events rare
- **Fat-tailed distributions** don't, and their tails typically decay according to a power law → extremes happen much more often than under “normal” conditions



What if some DRGs have fat-tailed cost distributions?

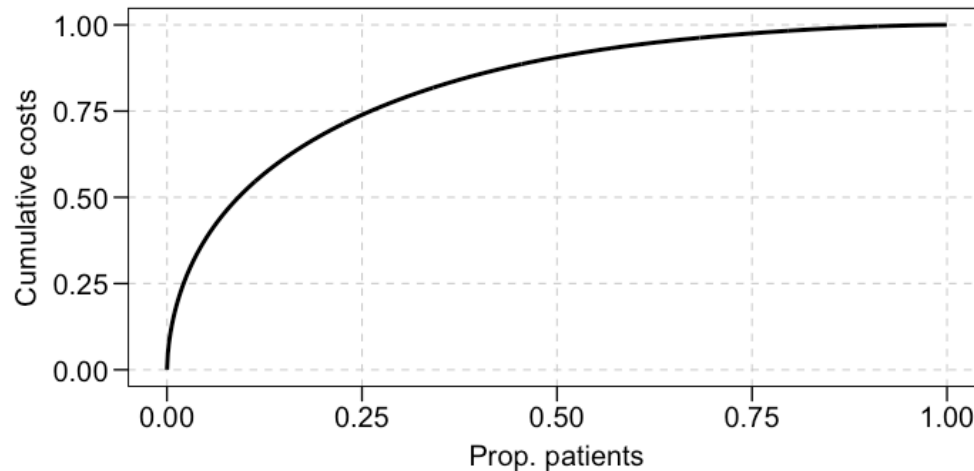
- **Fat-tailed distribution:** The chance of an extreme event is so large that it can completely derail the concept of “estimating an average” from a sample
 - Confidence intervals for sample averages are basically $[-\infty, +\infty]$
- **System-level:** Last year’s average cost is a very poor estimate for next year’s average cost
 - *The most basic assumption for tariff-setting is undermined*
- **Hospital-level:** If a hospital has a large proportion of patients in fat-tailed DRGs, then its financial performance last year is a very poor predictor for its performance next year

Study data

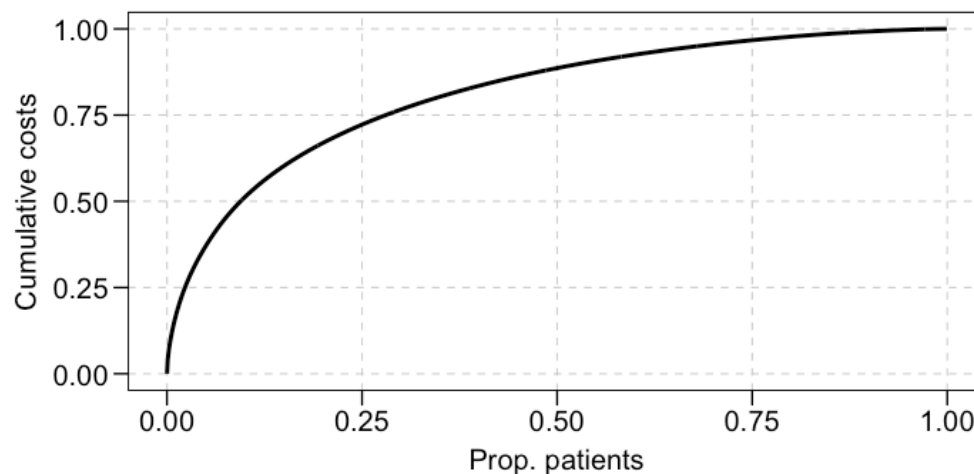
- Patient-visit-level costing data for FYs 2012/13 and 2013/14 for 61 (~40% of all) hospital trusts in the UK
- Each patient visit assigned to a dominant HRG (the UK equivalent of the DRG)
- Focus on HRGs corresponding to major body systems (chapters A to Q)
- Sample:
 - 4.4 million emergency visits in 1235 HRGs
 - 5.1 million elective visits in 1333 HRGs

Distribution of costs

Emergency costs



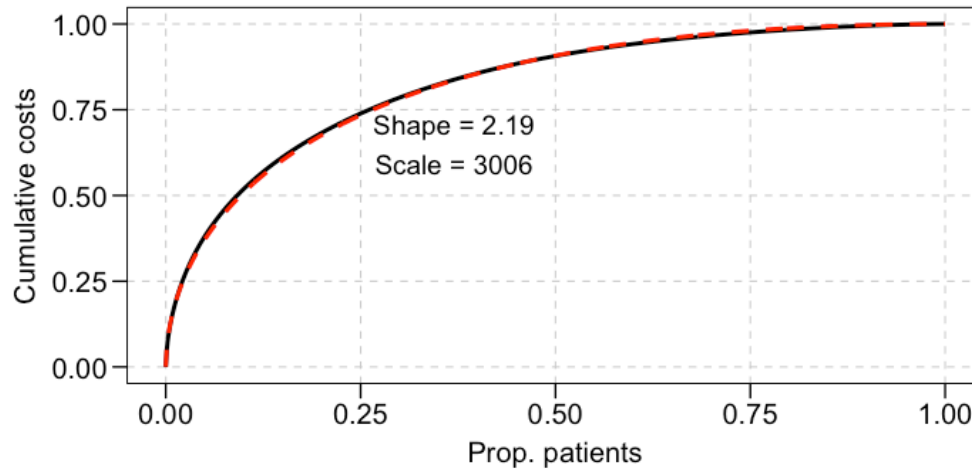
Elective costs



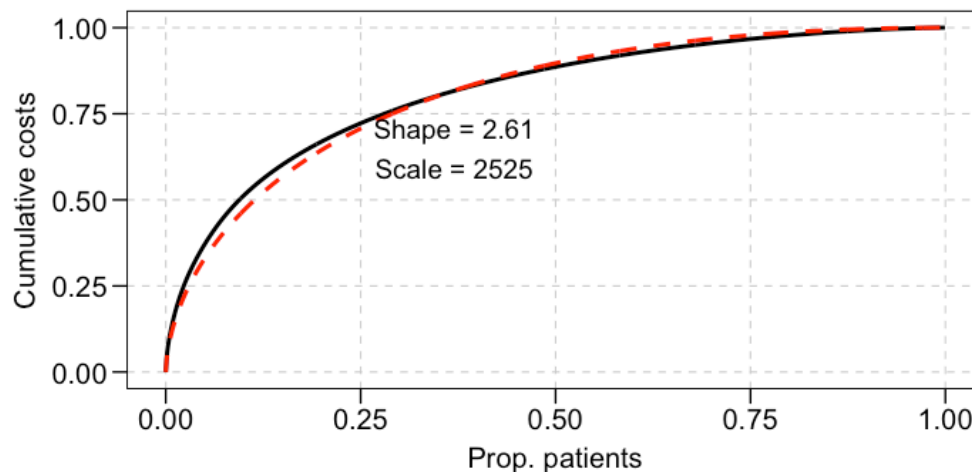
- High proportion of costs incurred by relatively small % of population
- Approx. 75-25 rule:
 - 75% of costs attributable to 25% of the population

Pareto distribution

Emergency costs



Elective costs

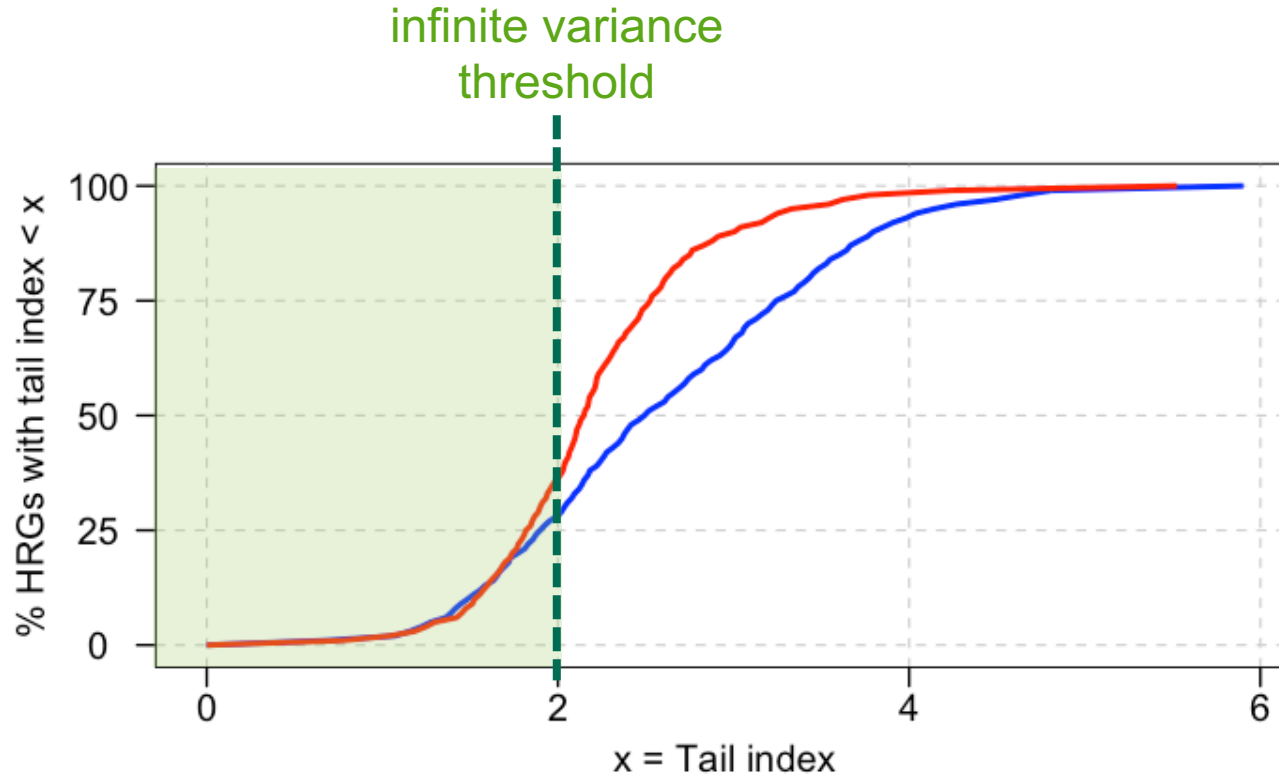


- Pareto distribution characterized by shape parameter, α , and scale parameter, β
 - α also known as the **tail index**
- α describes the “fatness” of the tail, smaller $\alpha \rightarrow$ fatter tail

$\alpha < 1 \rightarrow$ infinite mean

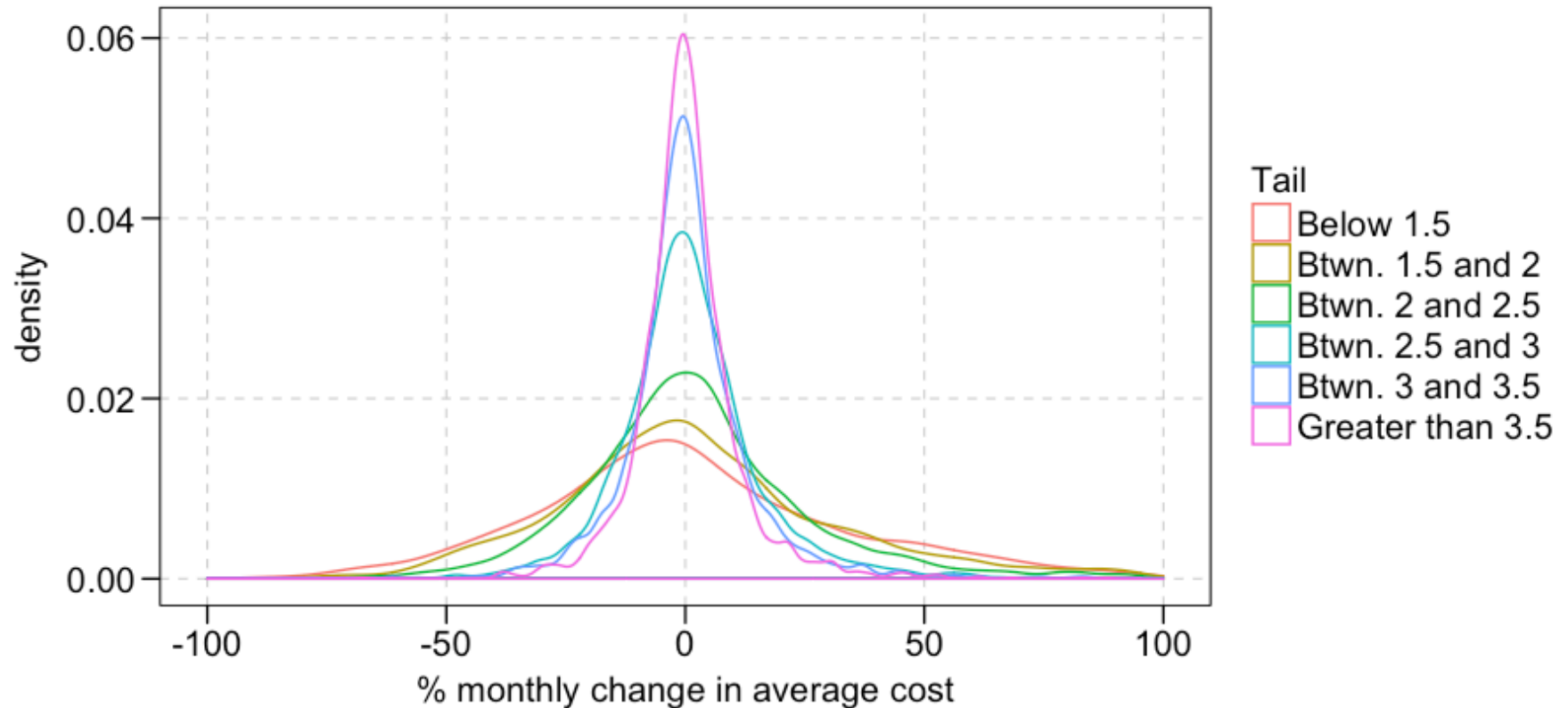
$\alpha < 2 \rightarrow$ infinite variance

Distribution of tail indices



- Surprise: 30-40% of cost distributions for elective and emergency HRGs have “infinite variance”

Volatility of sample averages by tail index

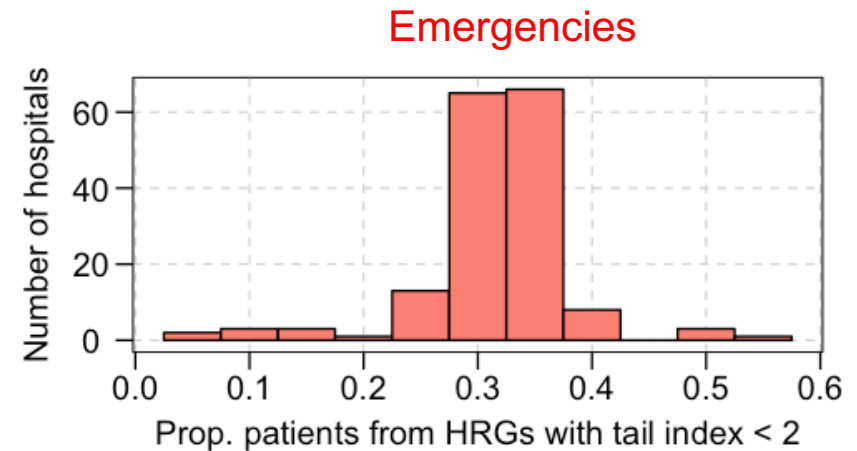
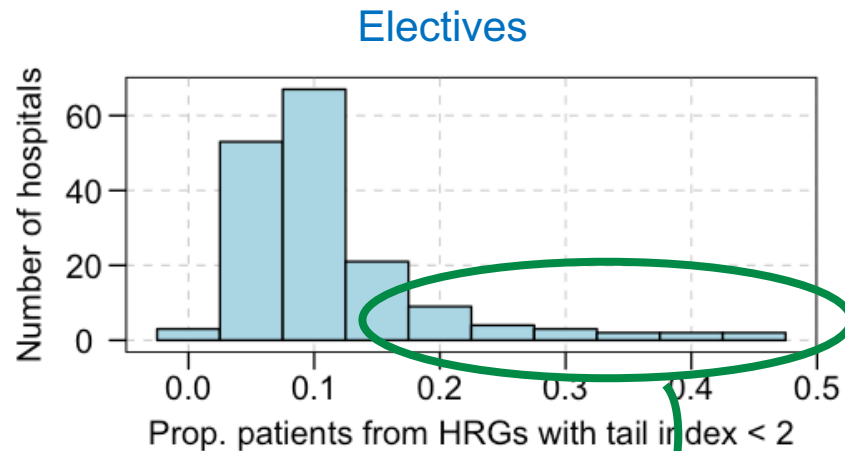


- **Insight:** The lower the tail index, the poorer last month's sample average cost is as a predictor of next months average cost

Interim summary

- PPS predicated on the assumption that past system average costs is a good predictor of future costs
- We have seen that for a large number of DRGs (30-40%), this assumption may be flawed
- As a consequence, future hospital income (= past cost) and future hospital cost may differ significantly
 - ➔ Hospital financial position unstable from year-to-year
- **Next:** How are patients from fat-tailed DRGs distributed across hospitals, and what are the implications?

“Black swan” type patients not randomly distributed



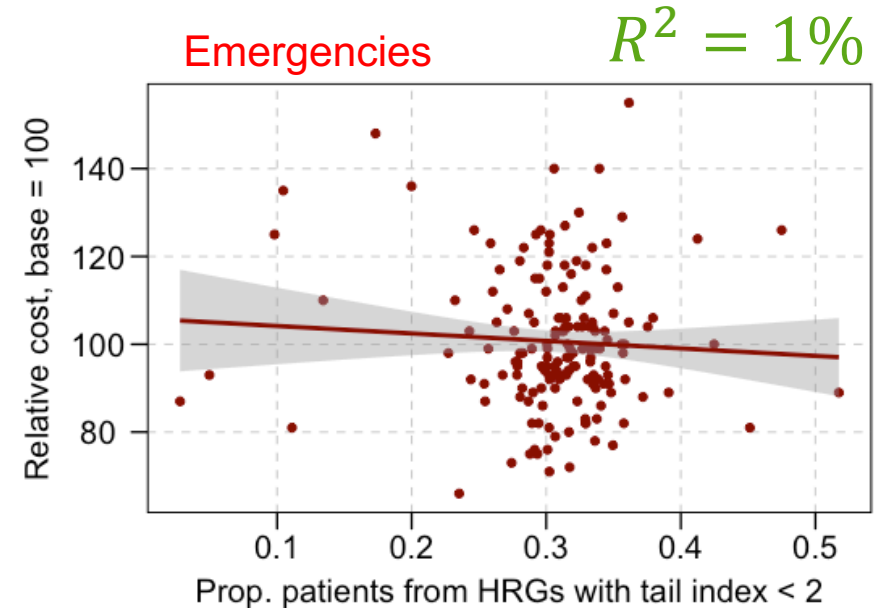
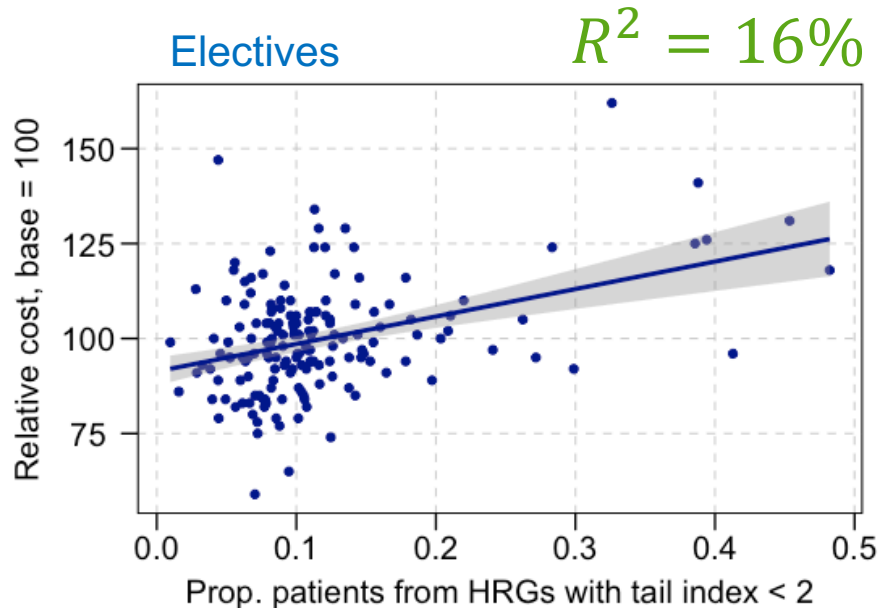
- Some hospitals have a high proportion of elective patients from fat-tailed DRGs
→ these hospitals also likely to have more “black swan” patients
- Hospitals have similar exposure to emergency black swans

Types of hospital more predisposed to black swans

	% elective patients from fat-tailed HRGs	% emergency patients from fat-tailed HRGs
Small acute	7.9%	32.2%
Medium acute	8.0%	31.8%
Large acute	9.8%	32.9%
Teaching	15.9%	32.2%
Specialist	23.6%	31.9%

- Teaching and specialist hospitals more likely to treat patients from fat-tailed HRGs
 - This is stable: correlation between % of fat-tailed patients at a hospital in FY 2010/11 and 2011/12 = 0.93

Worse financial performance with more black swan HRGs



- % of patients from fat-tailed HRGs explains a significant proportion of deviation from expected cost
 - Not for emergencies, since black swans equally likely at any hospital

- PPS predicated on the assumption that past system average costs is a good predictor of future costs
- We have seen that for a large number of DRGs (30-40%), this assumption may be flawed
- As a consequence, future hospital income (= past cost) and future hospital cost may differ significantly
 - ➔ Hospital financial position unstable from year-to-year
- Some (esp. teaching and specialist) hospitals treat disproportionately more patients from fat-tailed DRGs
 - These hospitals also have worse financial performance

The background is a green-tinted collage of various business school scenes. It includes a large crowd of students in a lecture hall, a modern glass-fronted building with 'INSEAD' signage, a classroom with students at computers, and silhouettes of people in a meeting.

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