Research in Practice (RIP?)

"In theory there is no difference between theory and practice. In practice there is".

Multiple attributions including Einstein and Yogi Berra

Robert Fildes

Centre for Forecasting, Lancaster University

Founding Editor, *Journal of Forecasting* and *International Journal of Forecasting*

Themes

- The objectives of the Forecasting Journals
  - The focus of forecasting research
  - Implications for the practice of forecasting
- Researching practice
  - Demand forecasting across the supply chain
- Role of practice in research

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The Objectives of the Forecasting Journal(s)

- Interdisciplinary
- Bridge the gap between theory and practice
  - ✓ Evaluation of different methodologies
  - ✓ Business, economics and management applications (BEM)
  - ✓ Judgement, econometrics and time series
  - ✓ Technological forecasting
  - ✓ Organisational aspects
  - ✓ Impact of uncertainty on decision making

Importance, competence, replicability
+ method of multiple hypotheses

Papers should include evaluation on real data!

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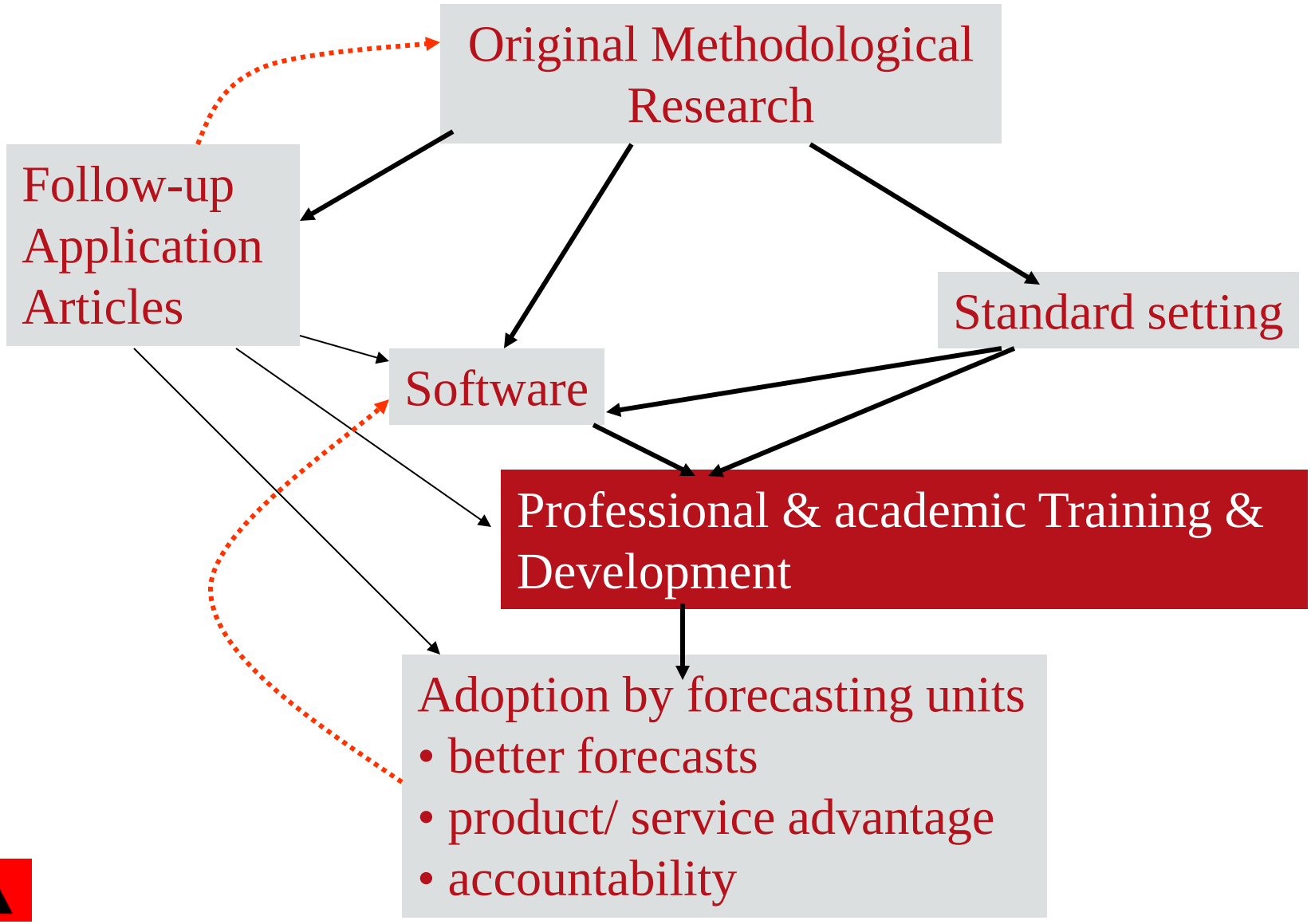
The aim in founding the journals:
'influential' research – what do we mean?

Affects

- Forecasting Practice
  - Applied researchers
  - Supply chain forecasters
  - Economic and market forecasters
- Software designers
- Standard setters
  - Earnings forecasters
  - 'best practice
- Other researchers

Note:
- some expert
- some technical novices

How forecasting knowledge diffuses?



The Experts' Views: Influential Articles – Pre 1980

PAPERS	Article	Citations
Makridakis S. & Hibon M.	(1979) Accuracy Of Forecasting - Empirical-Investigation J Royal Statistical Society A, 142, 97-145.	212
Kalman, R E	(1960) A new approach to linear filtering and prediction problems. ASME Transactions, J. Basic Engineering, 83-D, 95-108.	22060 (Google)
Holt, C C	(1957) Forecasting Seasonal and Trends by Exponentially Weighted Moving Average.Office of Naval Research, Memorandum No.52	127
Davidson, J E H, et al	(1978) Econometric Modeling of the aggregate time-series relationship between consumers expenditure and income.., Economic J. 88 (352): 661-692	276 (repec)
Bates, J M & Granger,C W J	(1969) The combination of forecasts, Opl. Res. Q, 253-260.	2613 (Google)
Tversky,A & Kahneman, D	(1974) Judgment under uncertainty: Heuristics and biases, Science 185, 1124-1131.	8783
Kahneman, D & Tversky, A	(1973) On the psychology of prediction' Psychological Review, 80, 237-251.	1859
Zellner, A	(1979) Statistical Analysis of econometric models. J. the Am. St. Assoc, 74, 628-651.	80
Newbold & Granger	(1974) Experience with forecasting univariate time series and the combination of forecasts J. the Royal Statistical Society, A, 137, 131-164.	369
Nelson, C R	(1972) The prediction performance of the FRB-MIT-PENN model of the US economy. American Economic Rev., 62, 902-917.	432 (Google)

+ books by Box & Jenkins, Brown, Klein, Theil, Morgenstern, Zarnowitz & Mincer

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Forecasting Research: what have we studied?

	2011 - 2015	2001 - 2004	1985 - 1988
Multiple hypotheses or evaluation	22.4%	62.5%	58.3%
Multiple hypotheses with conditions	2.2%	1.7%	4.5%
Articles making only a theoretical contribution	7.8%	2.8%	3.0%
Organisational aspects	0.8%	2.8%	3.8%
Forecaster behaviour	5.9%	7.4%	4.5%
Methods of forecast comparisons	4.8%	8.5%	10.6%
Univariate time series (either methodological or an evaluation)	13.7%	24.4%	22.0%
Causal and multivariate models (either methodological or an evaluation)	40.6%	17.6%	27.3%
Judgement (either methodological or an evaluation)	8.7%	8.0%	8.3%
Computer intensive methods (including non-linear statistical methods, neural nets and fuzzy methods)	9.2%	18.8%	3.0%
Combining	8.1%	3.4%	3.0%
Uncertainty	16.5%	11.4%	7.6%
Forecasting Support Systems	1.4%	0.0%	0.0%

Most Cited Articles from the Forecasting Journals

	Journal	Authors	Title	Year	Citations
1	IJF	G Zhang, BE Patuwo, MY Hu	Forecasting with artificial neural networks: The state of the art	1998	972
2	IJF	RT Clemen	Combining forecasts: A review and annotated bibliography	1989	684
3	JoF	S. Makridakis, A. Andersen, R. Carbone, R. Fildes, M. Hibon, R. Lewandowski, J. Newton, E. Parzen, R. Winkler	The accuracy of extrapolation (time series) methods: Results of a forecasting competition	1982	580
4	IJF	G Rowe, G Wright	The Delphi technique as a forecasting tool: issues and analysis	1999	424
1	IJF	RJ Hyndman, AB Koehler	Another look at measures of forecast accuracy	2006	366
5	IJF	S Makridakis, M Hibon	The M3-Competition: results, conclusions and implications	2000	356
6	JoF	Clive W. J. Granger, Ramu Ramanathan	Improved methods of combining forecasts	1984	346
7	IJF	D Harvey, S Leybourne, P Newbold	Testing the equality of prediction mean squared errors	1997	341
8	IJF	JS Armstrong, F Collopy	Error measures for generalizing about forecasting methods: Empirical comparisons	1992	318
9	JoF	E.S. Gardner	Exponential smoothing: The state of the art	1985	260
10	JoF	R.S. Tsay	Outliers, level shifts, and variance changes in time series	1988	256

The Top 10 Articles from 1980

	Journal	Authors	Title	Year	Citations	Topic
1	European Economic Review	Sims, CA	Interpreting the macroeconomic time-series facts - the effects of monetary-policy	1992	**2174**	Time series application
2	J. Business & Economic Statistics	Diebold, FX, Mariano, RS	Comparing predictive accuracy	1995	**1906**	Forecast evaluation
3	J. Finance	Glosten, LR, Jagannathan, R, Runkle, DE	On the relation between the expected value and the volatility of the nominal excess return on stocks	1993	**1172**	An extensions of GARCH Uncertainty model
4	J. Accounting Research	Ohlson, JA	Financial ratios and the probabilistic prediction of bankruptcy	1980	**807**	Forecasting application in finance
5	J. Econometrics	Engle, RF, Yoo, BS	Forecasting and testing in co-integrated systems	1987	**733**	Econometric innovation

The Top 10 Articles from 1980

	Journal	Authors	Title	Year	Citations	Topic
6	Management Science	Kahneman, D, Lovallo, D	Timid choices and bold forecasts - a cognitive perspective on risk-taking	1993	**526**	Judgement and uncertainty
7	Journal of American Statistical Association	Gneiting, Tilmann; Raftery, Adrian E.	Strictly proper scoring rules, prediction, and estimation	2007	**520**	Model estimation and validation
8	European Economic Review	Svensson, LEO	Inflation forecast targeting: Implementing and monitoring inflation targets	1997	**512**	Forecasting application
9	Strategic Management Journal	Rothaermel, FT; Deeds, DL	Exploration and exploitation alliances in biotechnology: A system of new product development	2004	**501**	New product development
10	Journal of Marketing Research	Bergkvist, Lars; Rossiter, John R.	The predictive validity of multiple-item versus single-item measures of the same constructs	2007	**488**	Consumer research. Multiple hypothesis

Dogs that bark

Strengths

- Causal (econometric) models
  - dynamics
- Nonlinearity
- Uncertainty
- **Forecast comparisons**
- Multiple hypotheses
  - **competitions**

Influence

- Standards, software & training
  - Widespread implementation
- Software
  - Neural nets diffused?
- Standards, software & training
- Standards: limited on software
- Limited impact

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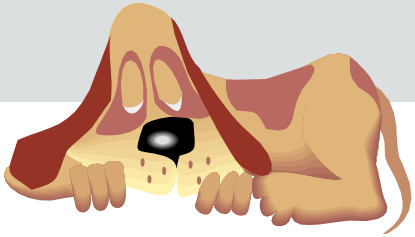
And those that haven't



- **Structured judgement**
  - ✕ In part
- Competitive situations
- **Organisational aspects**
  - ✕ Little org research
    - ✕ No focus on org improvement
  - Adoption of promising Practice
  - Design of systems
- Technology
  - ✕ Only diffusion
    - TFSC low contribution
- Long term forecasting
- **Grounded applications**

What is a grounded application?

Stylised application:

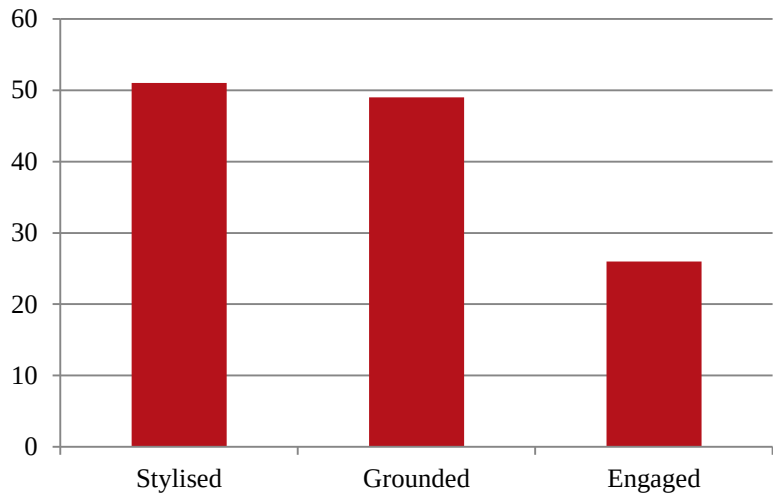
- Standardised context, e.g. macro forecasting
- Standard data set from external sources

Grounded application

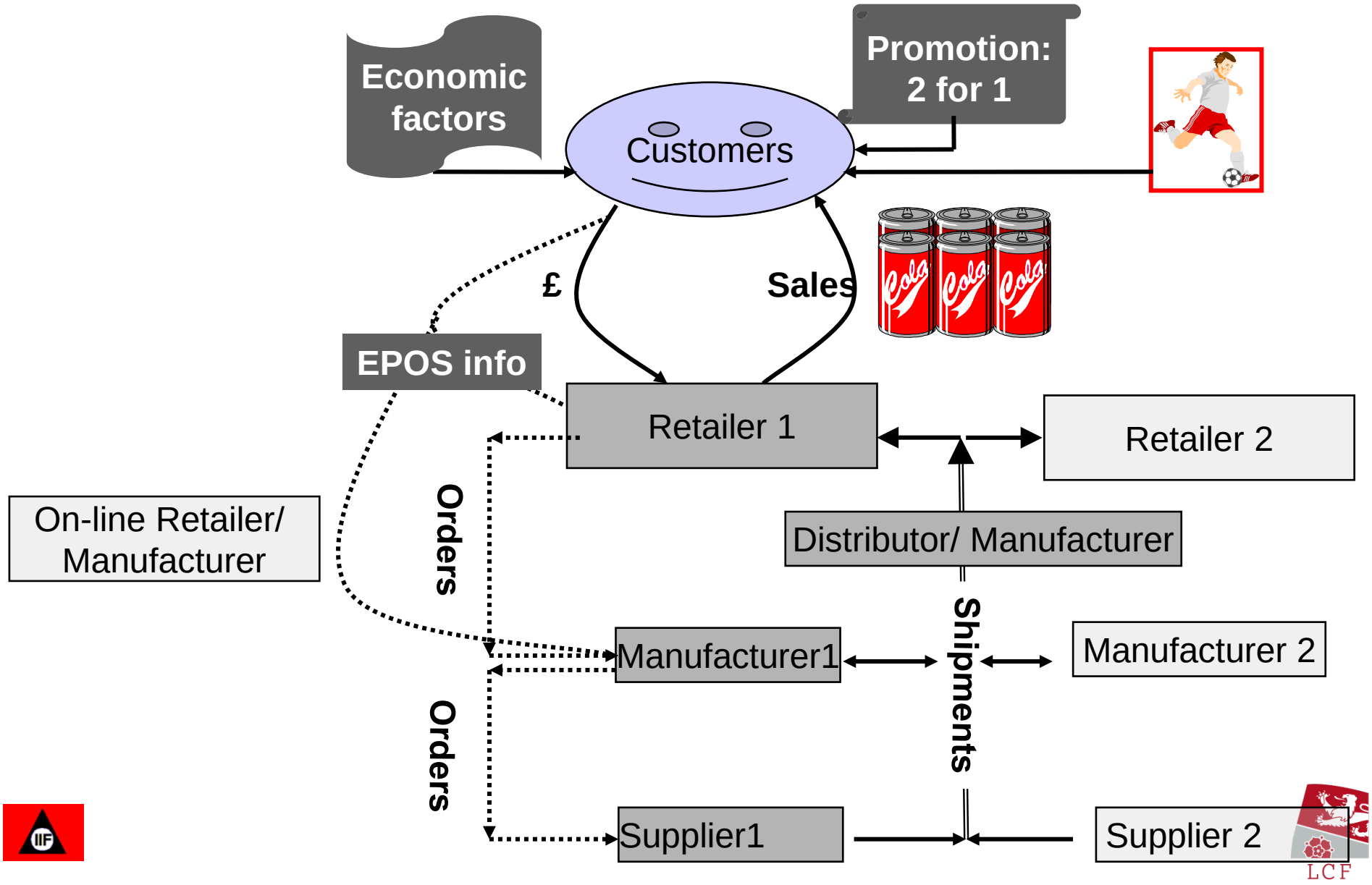
- Real client/ real context of application
  - Real-time data
- sensitivity to assumptions

Engaged

- Real client & organizational context
- Process issues
  - ✓ Data
  - ✓ Implementation
  - ✓ Policy sensitivity
  - ✓ judgment



Key industry application:
Supply Chain Forecasting



Key industry application:
Early influences in supply chain models

- ✓ **Brown,** R. G. (1963). *Smoothing, Forecasting and Prediction of Discrete Time Series.* Englewood Cliffs, NJ: Prentice-Hall.
- ✓ Brown, R. G. (1959). *Statistical forecasting for inventory control*. New York: McGraw-Hill.
- ✓ **Box, G. E. P., Jenkins**, G. M., Reinsel, G. C. & Ljung, G. (1994). *Time Series Analysis: Forecasting & Control* (3rd ed.). Upper Sadle River, NJ: Prentice Hall.
- ✓ **Holt,** C. C., & et al. (1960). *Planning production, inventories and work force*. Englewood Cliffs, New Jersey: Prentice Hall.
- ✓ **Muth**, J. F. (1960). Optimal properties of exponentially weighted forecasts. *Journal of the American Statistical Association, 55,* 299-306
- ✓ **Kalman, R E** (1960) A new approach to linear filtering and prediction problems. ASME Transactions, J. Basic Engineering, 83-D, 95-108.
- ✓ **Holt, C C** (1957) Forecasting Seasonal and Trends by Exponentially Weighted Moving Average.Office of Naval Research, Memorandum No.52
- ✓ **Bates, J M & Granger,C W J** (1969) The combination of forecasts, Opl. Res. Q, 253-260.

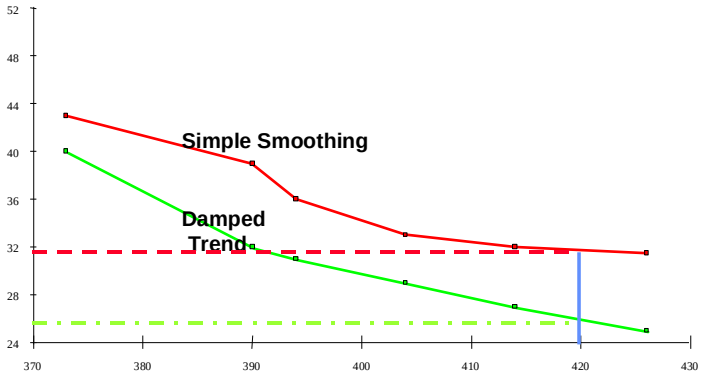
Key industry application:
Researching supply chain forecasting. The gaps (Syntetos et al, EJOR, 2016)

Objective: To improve supply chain performance through better forecasting

Service - inventory investment tradeoff curves

What do we now know!

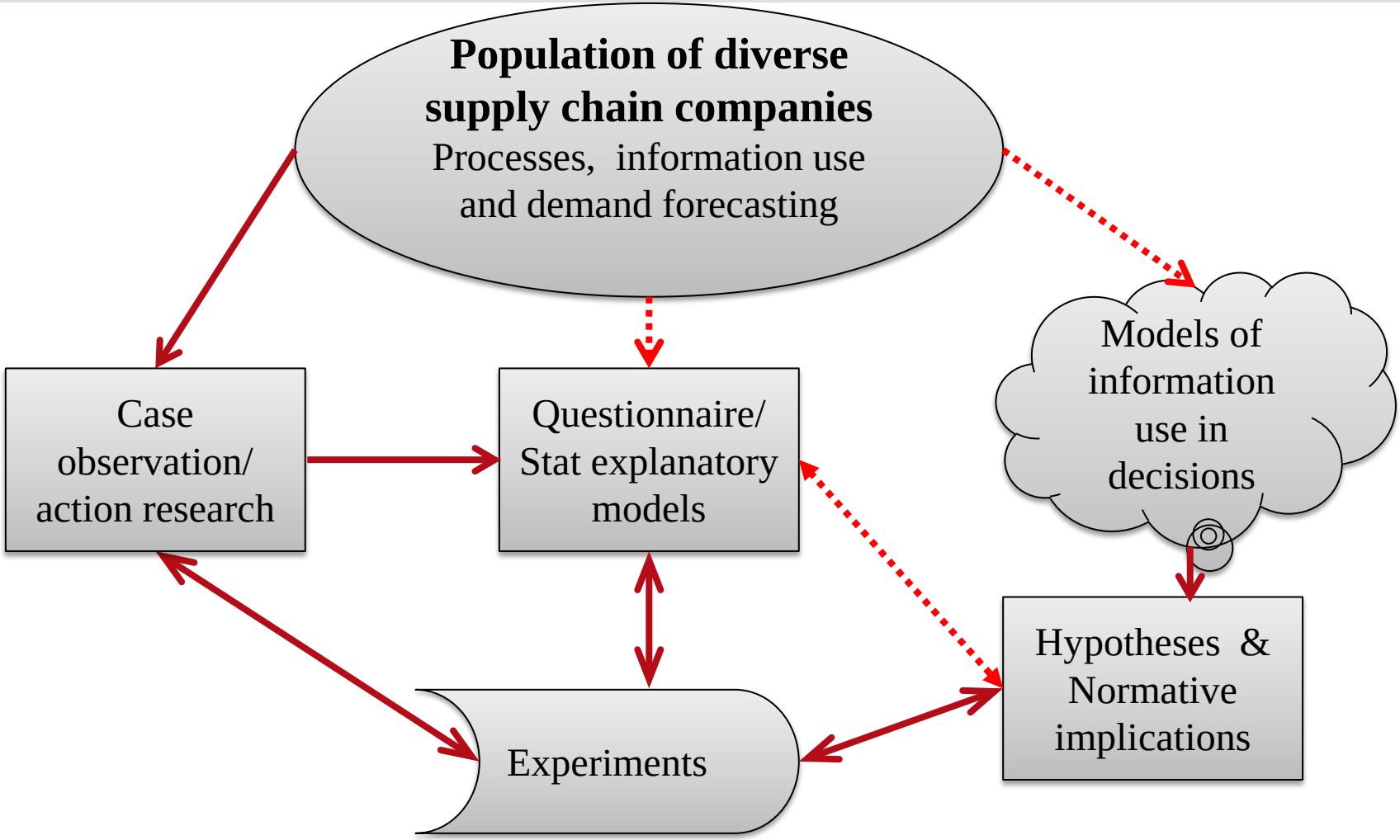
- Extensions to Brown and Box-Jenkins
  - Gardner, Hyndman, Taylor
  - Case evidence of value
    - Manufacturing & service examples
    - Inventory calculations: improvements saving €Ms
- Many theoretic models (of limited value and high citations!)



But what is typically practiced?

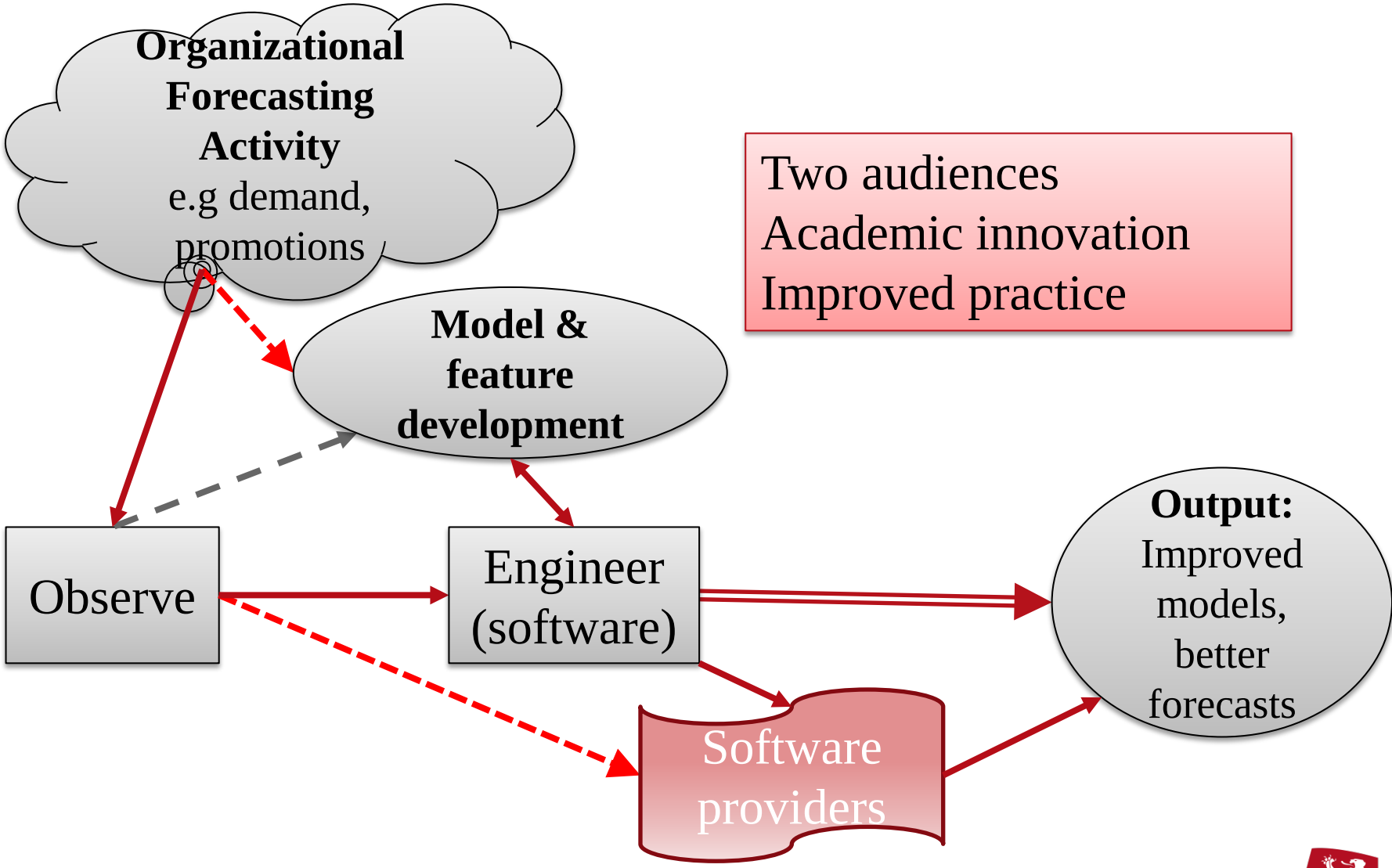
- Limited evidence in forecasting journals!
- Case evidence from research program from Mentzer and colleagues (U. Tennessee)
- How can improvements be achieved.

Researching grounded supply chain applications:
Methodological 'triangulation'



Experiments generate hypotheses to be further studied through survey and case
Also structure descriptive (normative?) models and improved processes

Learning from practice:
A virtuous circle? - researching supply chain forecasting



Two audiences
Academic innovation
Improved practice

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Learning from practice:
Supply chain forecasting – a case study in 'triangulation'

Objectives

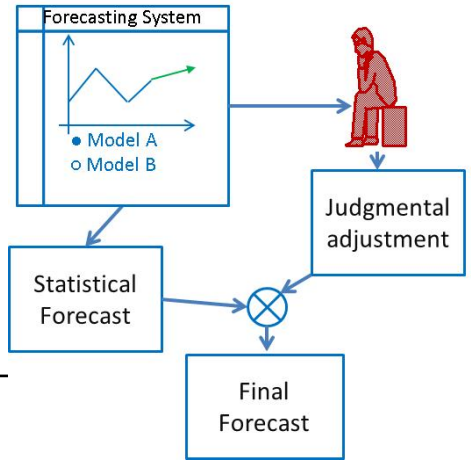
- To improve the effectiveness of Forecasting Support Systems, which are used extensively in supply chain planning.
- To develop a model that explains the behaviour of the users of forecasting support systems (FSS) to establish where serious deficiencies in current forecasting practice arise;
- To measure the extent to which errors in forecasts result from these deficiencies
- To design and test new features of FSSs suitable for supply chain planning using prototyping.
- To provide recommendations to software designers to improve the cognitive ergonomics of FSSs.

UK EPSRC funded

Learning from practice:
Supply chain forecasting – a case study

- Survey supply chain companies
- Observe 4 supply chain companies
  - Sales forecasts
    - Basic Exponential smoothing as the method of choice
    - Importance of judgment in producing the ‘final’ forecast
    - IMPORTANCE of promotional events
  - Interactions observed between actors
- Data structure
- Data on triples (Actual, statistical forecast, final) collected
  - Analysed & modelled
- Users and designers of software interviewed
  - New needed ‘features identified, e.g. notes

Survey: The Forecasting Process
How are forecasts typically produced?



	Fildes & Goodwin 2007	Lancaster 2013 survey
i) Judgment alone	25%	15.6%
ii) Statistical methods exclusively	25%	28.7%
iii) An average of a statistical forecast and management judgmental forecast(s)	17%	18.5%
iv) A statistical forecast judgmentally adjusted by the company forecaster(s)	34%	37.1%

The revelation:

Judgment plays a key role in most forecasting processes

- *It is unanalysed*

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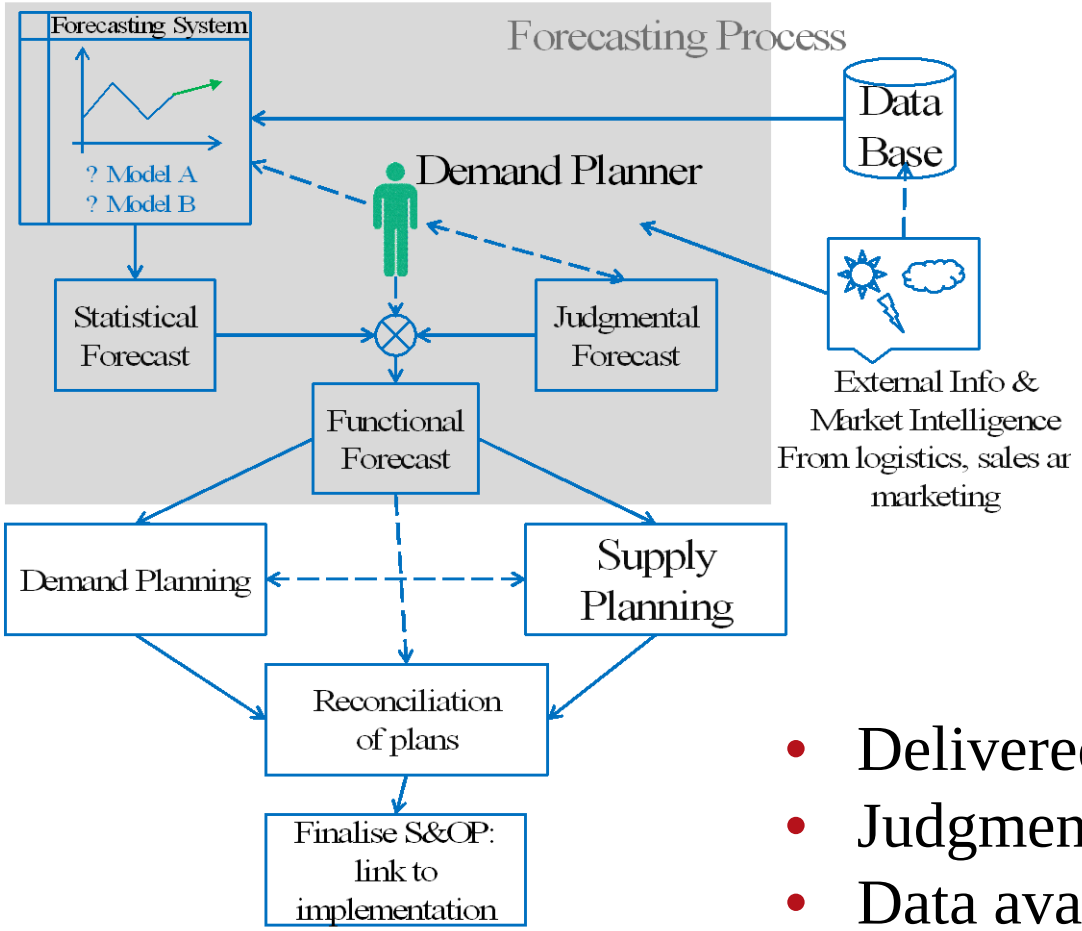
Case observation:
Sales and Operations Planning - Forecasting Process



- Statistical forecast (choice of statistical models)
- Information from sales, market research, planning, finance and logistics, interpreting information
- Incorporated into a final forecast from the forecasters

- Delivered back to interested parties
- Judgment a key component
- Data availability: downstream, market information e.g. promotions,
- Adjustment of model forecasts

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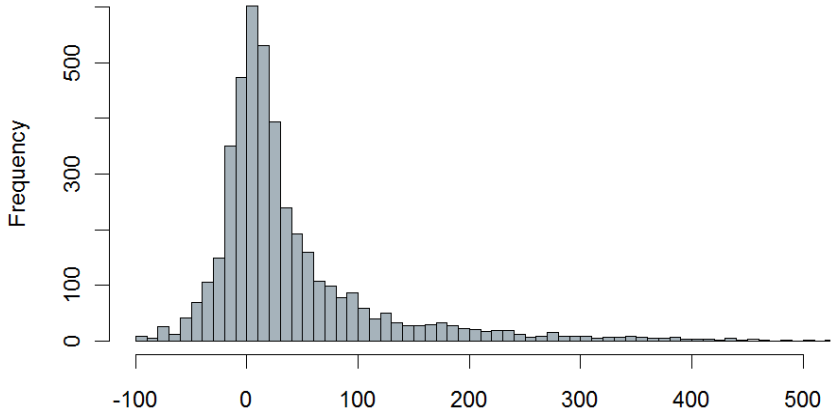
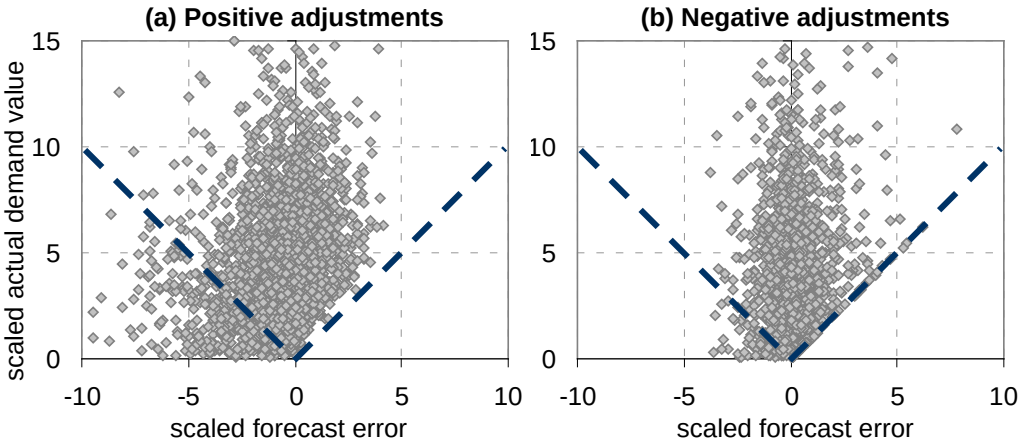
Case observation: Company data - on actuals, statistical forecasts and final adjusted forecasts



Standardised outcome distribution of sales



Scaled Forecast error distribution conditional on positive or negative information

$$e_{ijt} = \alpha_{ij,0} + \alpha_1 SysF_{ij,t-1} + \alpha_2 Adjust_{ij,t-1} + \beta_1 Act_{ij,t-1} + \beta_2 e_{ij,t-1} + \nu_{ijt}$$

Implications: for error measures, efficiency and bias and improving judgment

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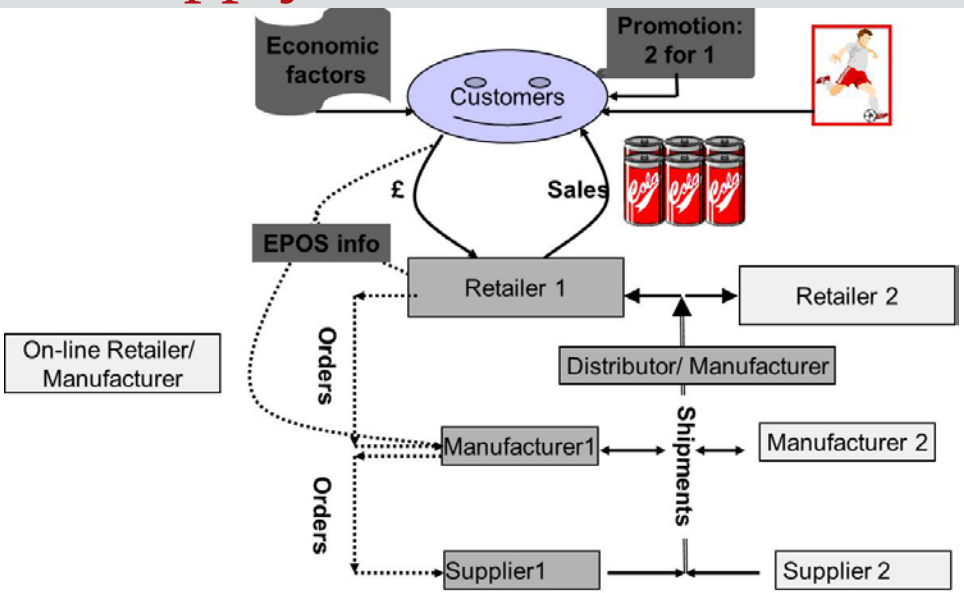
Case observation:
The structure of the supply chain



- Promotional effects
- Events (sporting, weather, holidays)
- Ordering rules
- EPOS data
- Collaboration and (forecast) information sharing
- Competition
  - between channels, products, companies

- Forecast value

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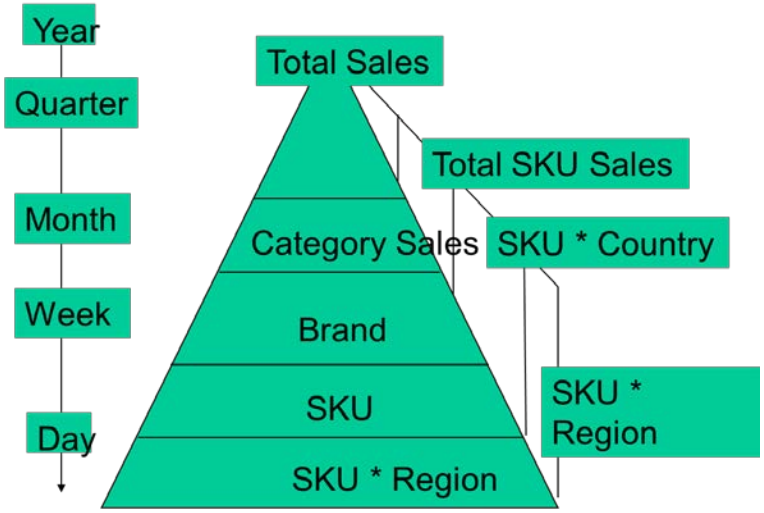
Case observation:
The data generation process

- Micro-data: sku x store x day (hour)
- Multiple hierarchies



- Double-seasonality
- Trend?
- Intermittent

- Short histories
- Missing observations

Case observation:
Research implications – data structure

- Hierarchies
  - Shared information: bottom-up and top-down forcing

    Hyndman et al
  - Time aggregation and Consistency

    Kourentzes, Petropoulos
  - Cross-sectional aggregation
    - Seasonality, common effects

- Data characteristics
  - Intermittency
    - Rediscovered by Johnston and Willemain arising from company engagement

➢ **Problems all derived from organizational data structures**
- operational in FSSs in 1970s
- Sporadic academic attention

➢ ***New models***

Case observation:
Research implications – observation and company data

- Conclusions (Fildes et al., Franses and Legerstree)
  - Supply chain forecasts are biased and inefficient
  - Judgment adds value sometimes
  - Mechanisms to guide judgment may help but….

  - Software ill-suited to forecasters' tasks
  - Algorithms poorly developed e.g. limited models and parameter optimisation

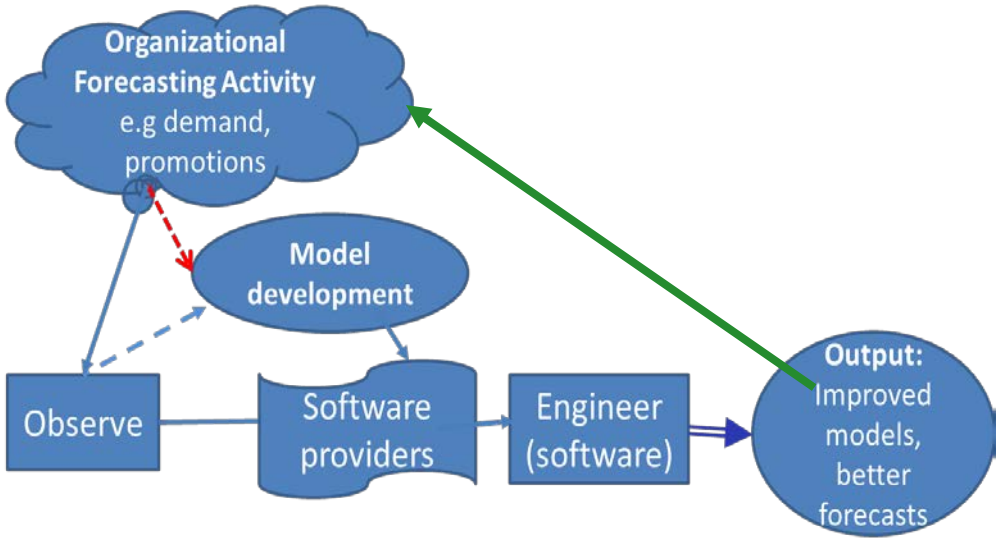
  - Software doesn't support judgmental interventions

  - Common error measures misleading (Davydenko & Fildes, IJF, 2012)

Case observation:
Research implications – data, structure, process

The need:

- Automatic model building capturing data structures
  - Robust (wrong signs, business rules)
- Forecasting Support Systems
  - Designed to match user process
  - Focus on judgment/ model interactions



Problems derived from supply chain structures

- ***New models***
- ***Redesigned FSSs***
- ***New organizational processes***

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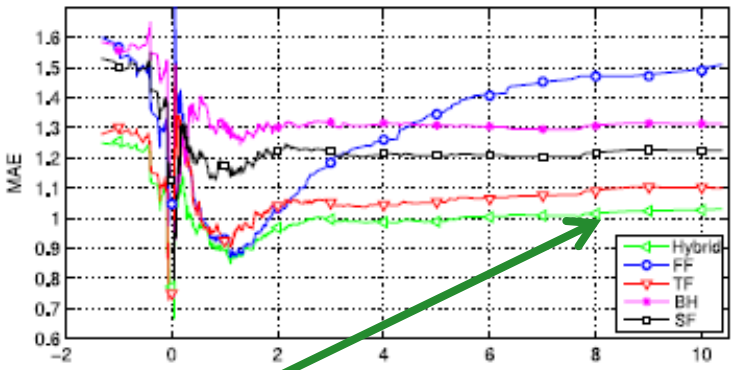
Model development. Engineer:
Novel methods – the benefits

Current readily available software

- Fails to incorporate external information (EPOS)
  - Is not competitive with best practice exponential smoothing
    Uses model selection routines which fail
- Novel methods

$$y_t = l_{t-1} + TF(\text{dummy\_promotion}_t) + e_t$$

$$l_t = l_{t-1} + \alpha e_t$$



✓ Exponential smoothing model with
- Promotional info; downstream info
- Automatic selection
- Combined with judgment

Size of judgmental adjustment

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Model development. Engineer:
Novel methods – the benefits II

- At manufacturer
  - **"Combined" model** delivers 42 % accuracy improvement
  - Company judgments add 6% (Trapero et al.)

- At retail store category level
  - Category and competitive info produces better forecasts (13% over own-sku promotional model,)
  - With promotional optimisation, 16% profit improvement

- Combined with price optimization for revenue management
  - 13% improvement in profit

Case observation & prototype solution:
Two stand-out issues

- Poor statistical models in use
  - New modelling approaches have potential to deliver
  - Barriers to improvements
    - e.g. complexity, software systems, training
- Process of incorporating additional information a key element
  - Judgment, not just models?
  - Biased, inefficient, unsupported
  - But key to organizational buy-in
- Improvements deliverable only through a holistic approach

Process improvements:
Improving the S&OP Process – the need for triangulation

Issue

- Understanding organizational processes
- Identification of biases, inefficiencies
  - In the results
  - In the processes
- Information and systems use
- Improving effectiveness

Methodology

- **Case studies**
- Inter-organisational survey
- Case and statistical survey
  - Statistical intraorg survey
  - **Case process analysis**
  - **Behavioural experiments**
- Inter-organisational survey
- **Statistical analysis**
- **Behavioural experiments**
- **Action Research**
- **Behavioural experiments**
- Normative models

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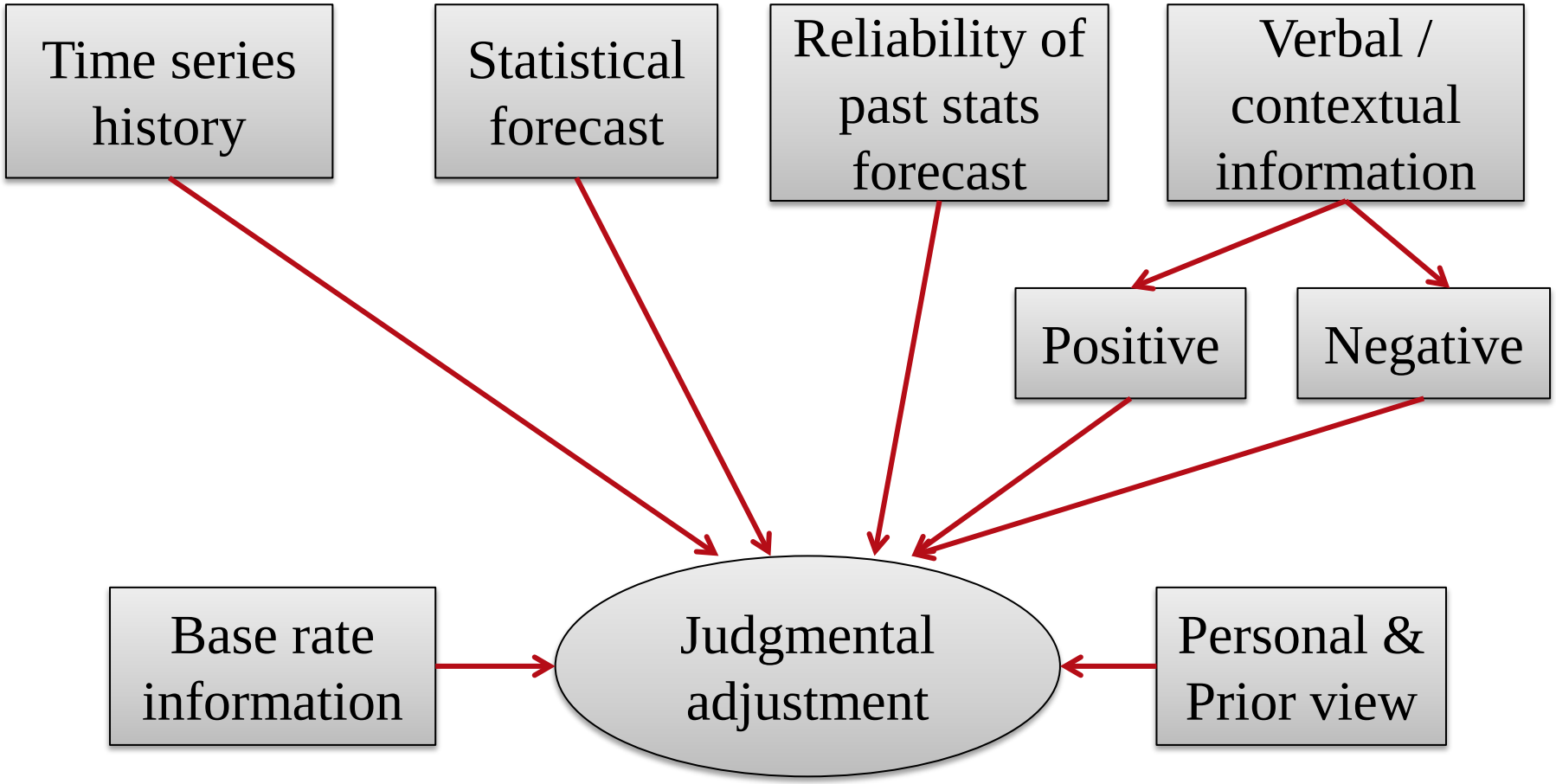
Process improvements:
Understanding information use.
Types of Information Available for Judgmental Adjustments in Experiment



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Process improvements:
Experiment

Aim:

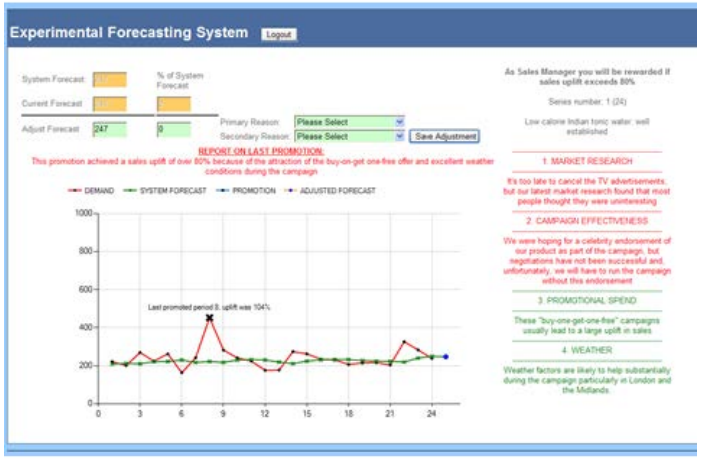
- To understand how the interactions between supply chain actors affect reliability and efficiencies
- The develop FSS support to test improvement strategies

Methods:

- Experiment with different forms of FSS and types of information
- Analyse driver interactions

Conclusions (so far):

- Interactions biased and highly inefficient
- FSS & S&OP likely to hinder
- Systems offering guidance can help



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Participate/ Analyse/ Improve

- Data collection
  - Actuals, statistical forecasts, final forecasts, available cues (e.g promotional events)
  - Process analysis: who does what with what and with whom
- Value added (SAS's terminology)
  - Does the forecast adjustment deliver accuracy improvements?
  - Is the statistical forecast 'optimal'
    - Based on off-line analysis using state of the art statistical software
  - Is cue information incorporated effectively?
    - Based on optimal models for including information

Engineer

- Re-calibration of existing systems
  - Important since SAP etc are dominant products
- Develop spreadsheet support
  - Most forecasting still done through spreadsheets
- Develop ‘advanced’ software
  - But……
- Improve processes
  - Reliability and validation of data and input assumptions
  - Trained staff

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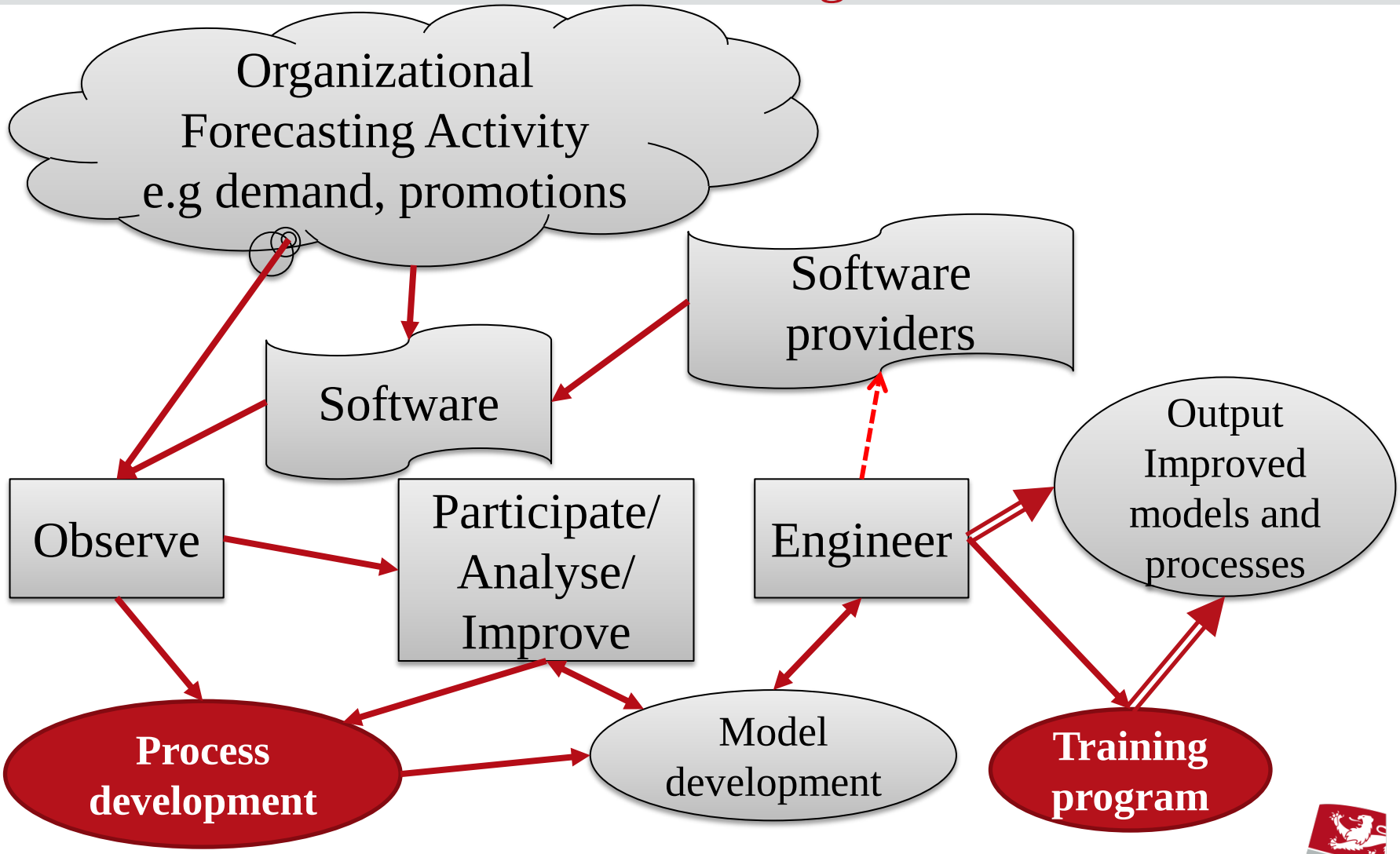
Learning from practice:
Extending the circle? - researching and improving supply chain forecasting



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A holistic research programme: interim results
New forecasting knowledge and impact

- Importance of judgment in forecasting practice
  - Heuristics and biases (Fildes & Goodwin)
- New methods & models
  - Temporal hierarchical models (Kourentzes and Petropoulos)
  - Feasibility and benefits of automatic promotions modelling

  (Trapero, Kourentzes, Shaohui)
- Use and value of collaborative information

  (Trapero, Weller & Crone, Boylan, Fildes et al)
- Software innovations
  - To guide and debias judgment, to interpret the information efficiently

  (Fildes & Goodwin)

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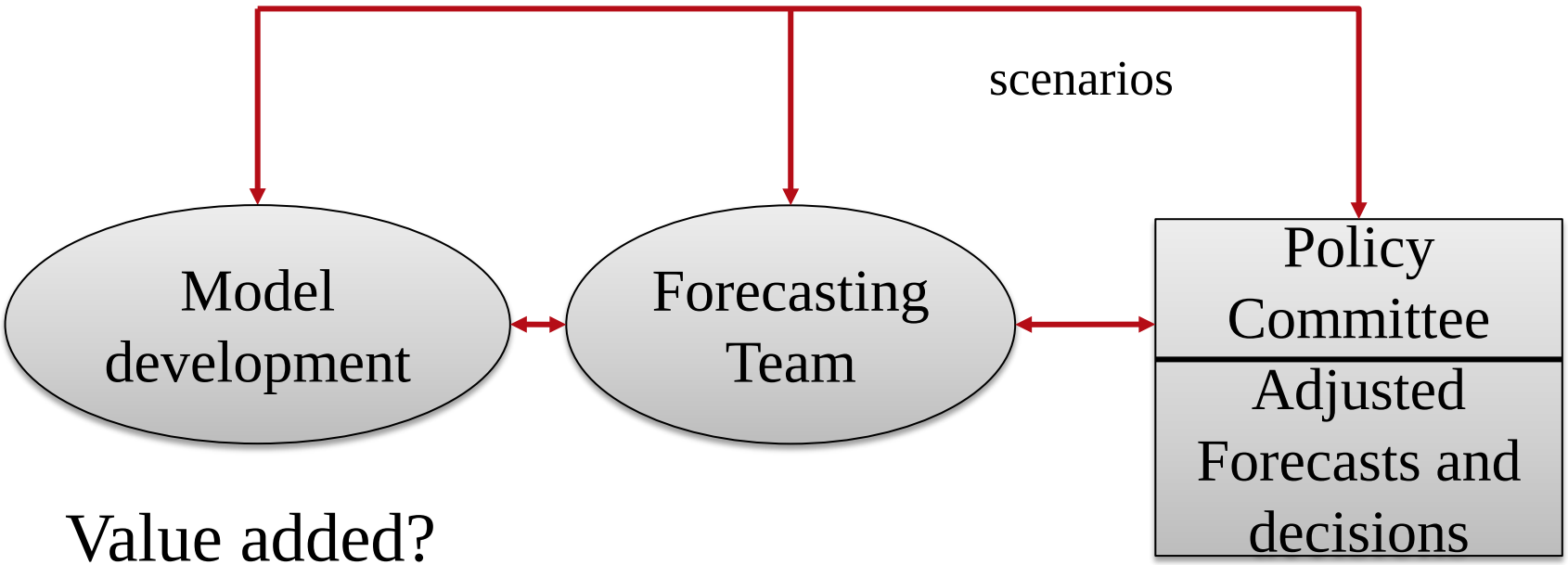
And this all applies to macroeconometric modelling!



Value added?

- Drivers of model innovation?
- Operationalising the model?
- Interactions with Policy Committee
  - ✓ Scenario choice?
- Judgments/ adjustments by PC
  - ✓ Judgmental adjustments **add value** (Franses)

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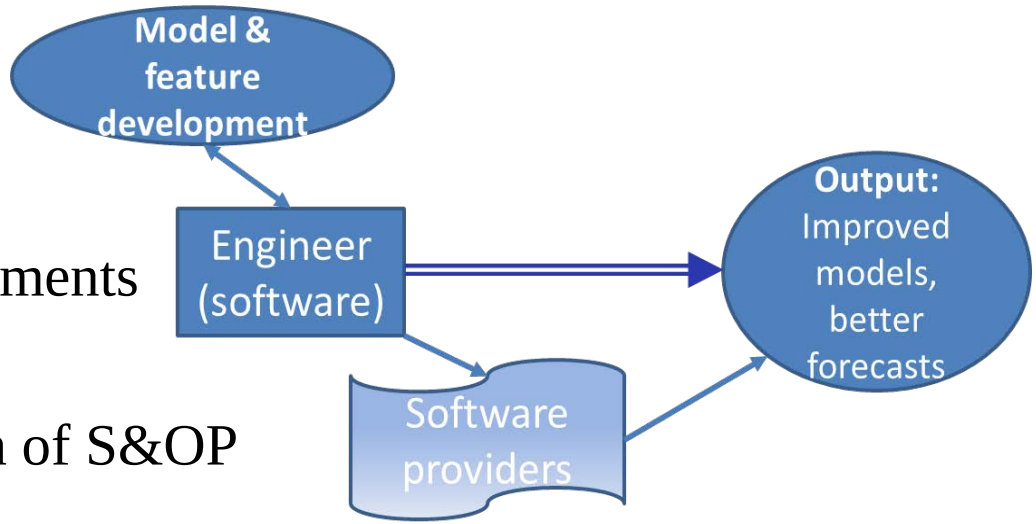
Conclusions: research in practice
what have we learnt?

- Academic research is often *just that!*
  - *No potential impact*
- Observing current processes reveal new problems and new constraints requiring new solutions
  - Case material and Action Research
- The assumptions in many theoretic models are unhelpful to practice
  - E.g. Mathematical models of the supply chain
- The ability of users to benefit from models is moot
- Empirical evidence on effectiveness in a multivariate context remains limited
  - Role of judgment critical

Conclusions: research in practice
what is needed?

Overall:

- More case studies
- In the supply chain
  - Hierarchical model developments
  - Model choice
  - Observation, data collection of S&OP
- In marketing
  - Barriers to using more complex models
  - Model design
- In macro
  - Focus on judgment calls (Stekler)
- In FSS
  - Design reliable robust software to support users



LCF

Conclusions: research in practice
Bridging the Gap

The Benefits

- Observing current processes reveal new problems and new constraints requiring new solutions
- Identification of the range and variety of problem structures
  - Simulation of novel DGPs/ Loss structures/ agent motivations
- Validation/ rejection of theoretical models
  - E.g. information sharing
- New data sources allow the development of contingent theories
- Impact:
  - implementing new ideas is fundamental to forecasting, an applied science

Conclusions: research in practice
Bridging the Gap

The Costs and the Barriers

- Access
  - Managers know little of methods and value
    - Lack of trust in models
    - Forecasts often political
    - Accuracy improvements unrewarded (not a KPI!)
- Empirical (plus theory) articles more demanding
- Higher risk: confidentiality, journal prestige
- Academic careers based on specialisms (e.g. econometric developments)

Questions?

In a phrase

- Hard to justify forecasting if there is no practical impact

Thanks to my colleagues:

Paul Goodwin, Dilek Onkal, Juan Trapero, Fotios Petropoulos, Sven Crone, Nikos Kourentzes, Kostas Nikolopoulos, John Boylan, Michael Lawrence, Shaohui Ma and ex-doctoral students, Stavros Assimopoullos, Wing Lee, Andrey Davydenko as well as Jon Prest, Charlotte Brown and Ivan Svetunkov, all of whom have worked on aspects of this research