

Recoupling the forecasting and inventory management processes

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The 'decoupling' problem

- ❑ Demand forecasters often assume that forecasting is an end in itself; they have little knowledge of how their forecasts are used
- ❑ Inventory and supply chain managers have little knowledge about where the forecasts are coming from – in fact they often (implicitly) assume that demand is somehow known
- ❑ However, demand forecasts are simply an input into a stock control model
- ❑ And demand is not known, but rather it needs to be forecast
- ❑ Demand forecasting methods have been developed without considering inventory implications
- ❑ The entire inventory theory has been developed upon the assumption that either demand is deterministic or stochastic but known (a known demand distribution).

Inventory management: importance

- ❑ According to the 26th Annual State of Logistics report, the US alone was sitting (in 2015) on approximately \$2 trillion worth of goods held for sale
- ❑ According to the same report, the inventory carrying costs (taxes, obsolescence, depreciation and insurance) are currently estimated to be around \$0.5 trillion (i.e. an additional 25% of the value of the goods)
- ❑ In 2014 the total value of inventory in the US was equivalent to approximately 14% of the GDP
- ❑ Similar figures have been reported for many other countries
- ❑ Such statistics show that small improvements related to inventory control translate to tremendous amounts of money that can be released back in the economy
- ❑ The International Society for Inventories Research (ISIR) was founded in 1980 by Kenneth Arrow (Nobel laureate).

Outline

1 Inventory management

2 (Lack of) Interactions: why they matter?

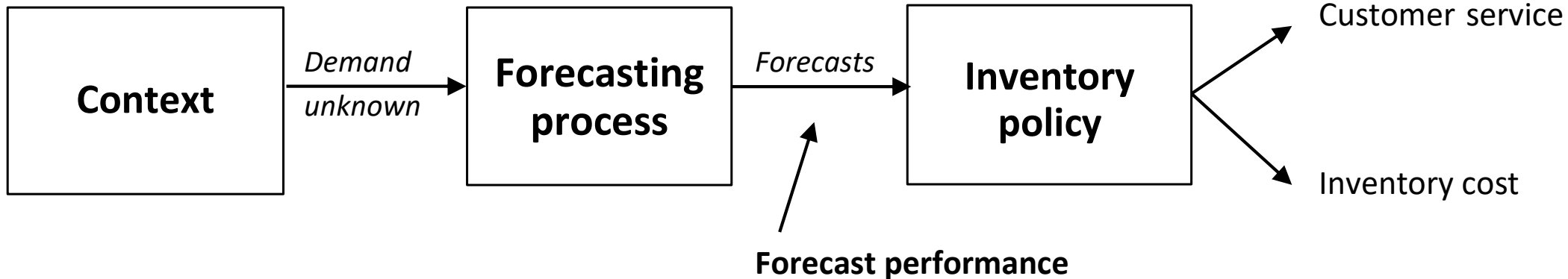
3 The forecasting perspective

4 The inventory perspective

5 Implementation missteps

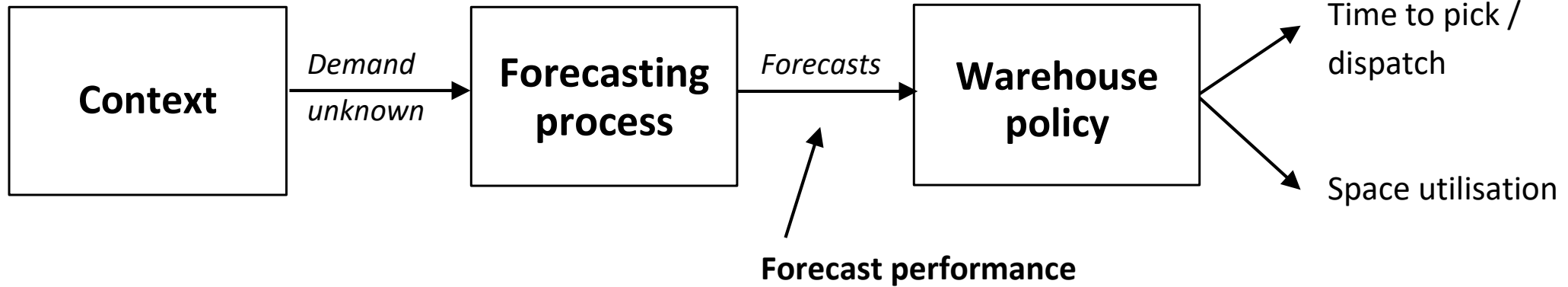
6 Suggestions for improving inventory forecasting systems

Forecasting is not an end in itself: inventory control



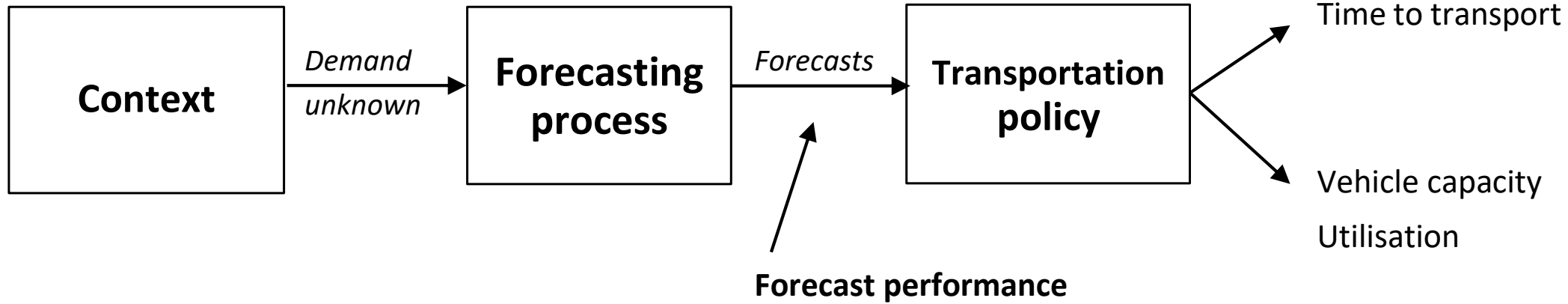
- ❑ We need to distinguish between forecast performance (forecast accuracy) and accuracy implications metrics
- ❑ We also need to emphasise that forecasting does not refer only to the *mean demand* (level of demand) but also to the *demand variance*, the latter determining our safety stocks

Forecasting is not an end in itself: warehousing

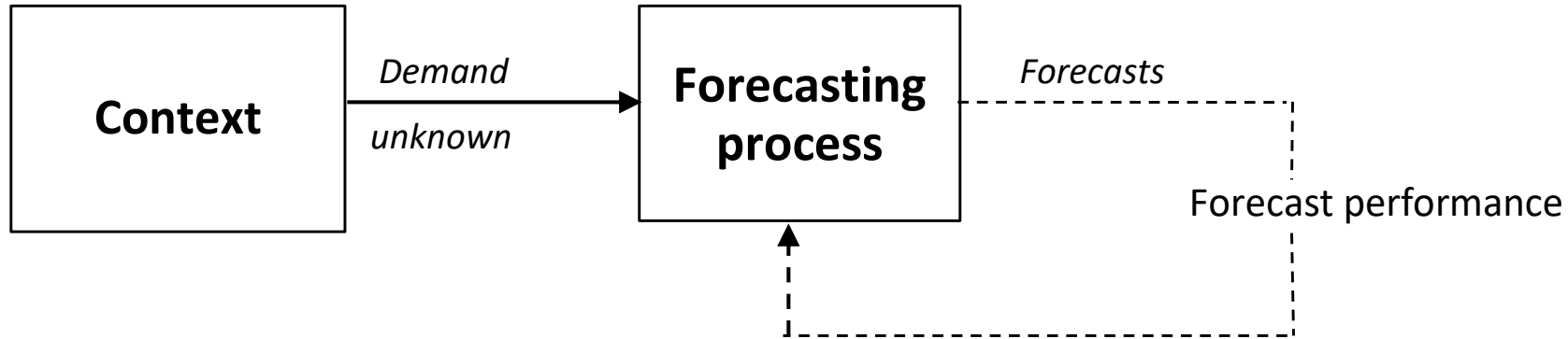


- The level of aggregation may vary but this does not change the fact that forecasts are always an input into a decision making process

Forecasting is not an end in itself: transportation



Interactions: why are they important?

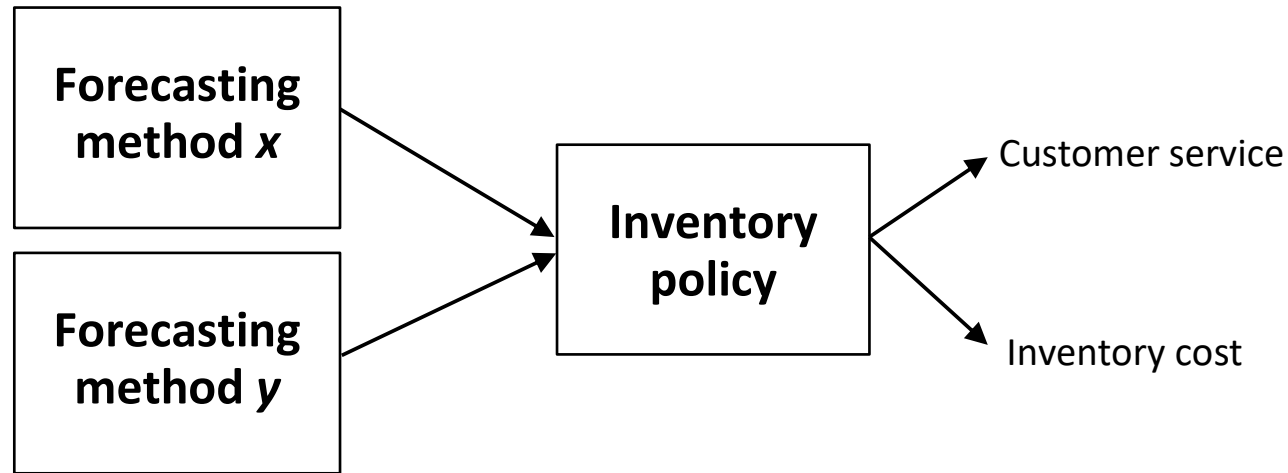


- ❑ **Forecasting as an end in itself**
- ❑ **Assuming no subsequent stages of computation**

Does this matter?

□ Evidence from the area of statistical demand forecasting

- The fact that method *x* performs better than method *y* in terms of forecast accuracy, does not mean that this will also be the case in terms of inventory performance; both for fast and slow (intermittent) demand forecasts



- We have recently examined (Syntetos et al, 2015) the inventory implications of various intermittent demand forecast methods on more than 7,000 items from the electronics and jewellery industries

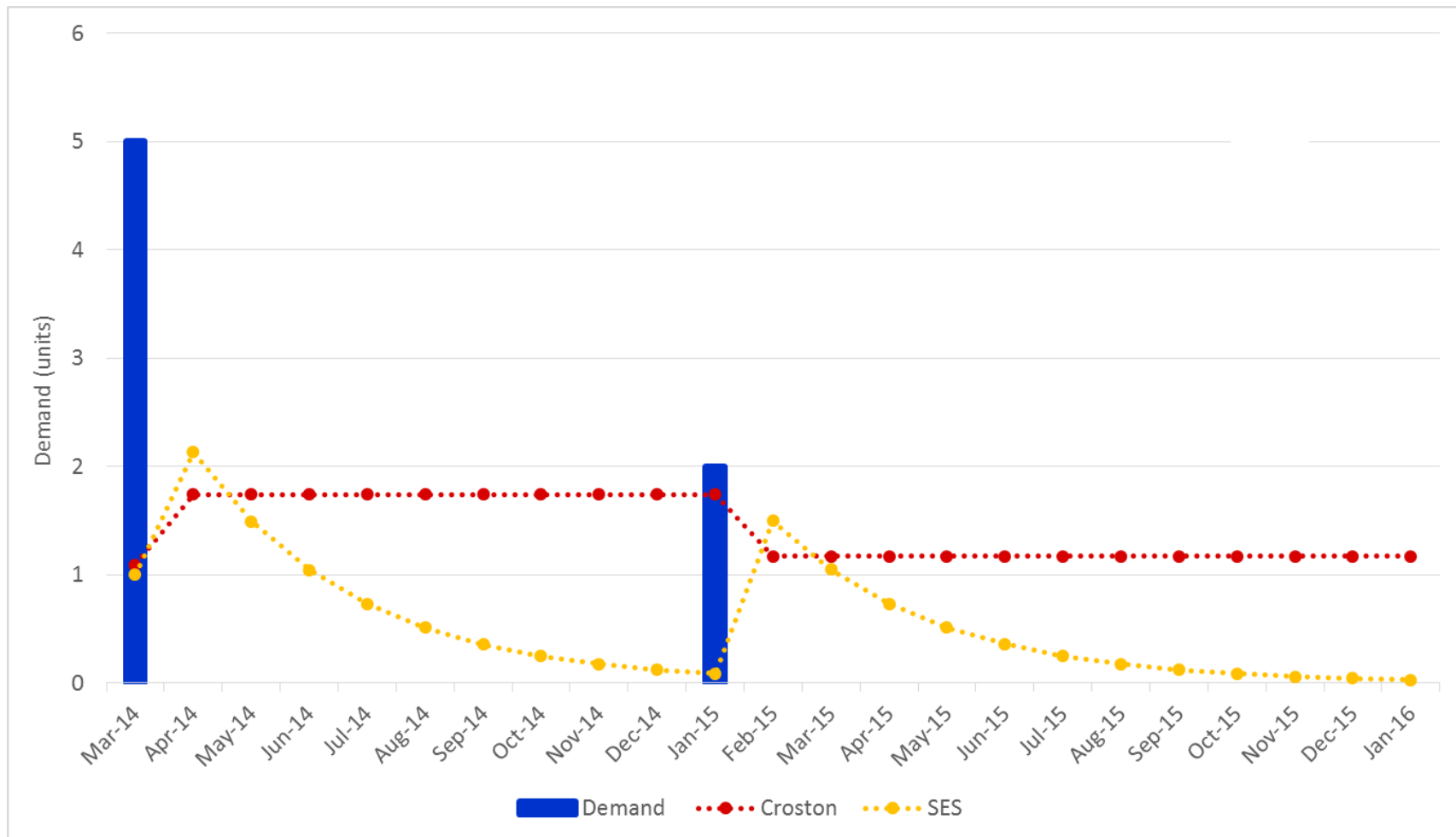
- Croston's method was found to perform worse than exponential smoothing (although the opposite should be expected based on forecast accuracy)

Does this matter?

- ❑ **Evidence from the area of judgemental adjustments of statistical forecasts**
 - ❑ **We have examined (Syntetos et al, 2010) the inventory implications of judgmentally adjusted statistical forecasts**
 - ❑ **Case study from the pharmaceutical industry**
 - ❑ **Forecast accuracy improvements (in the Mean Absolute Percentage Error) of 1% lead to inventory reductions that are of a different order of magnitude (15%-20%)**
 - ❑ **Most interestingly, this occurred while the service levels remained the same or even increased (by up to 1%)**
- ❑ **Pay attention also to double adjustment processes – stemming directly from a lack of appreciation of the interactions.**

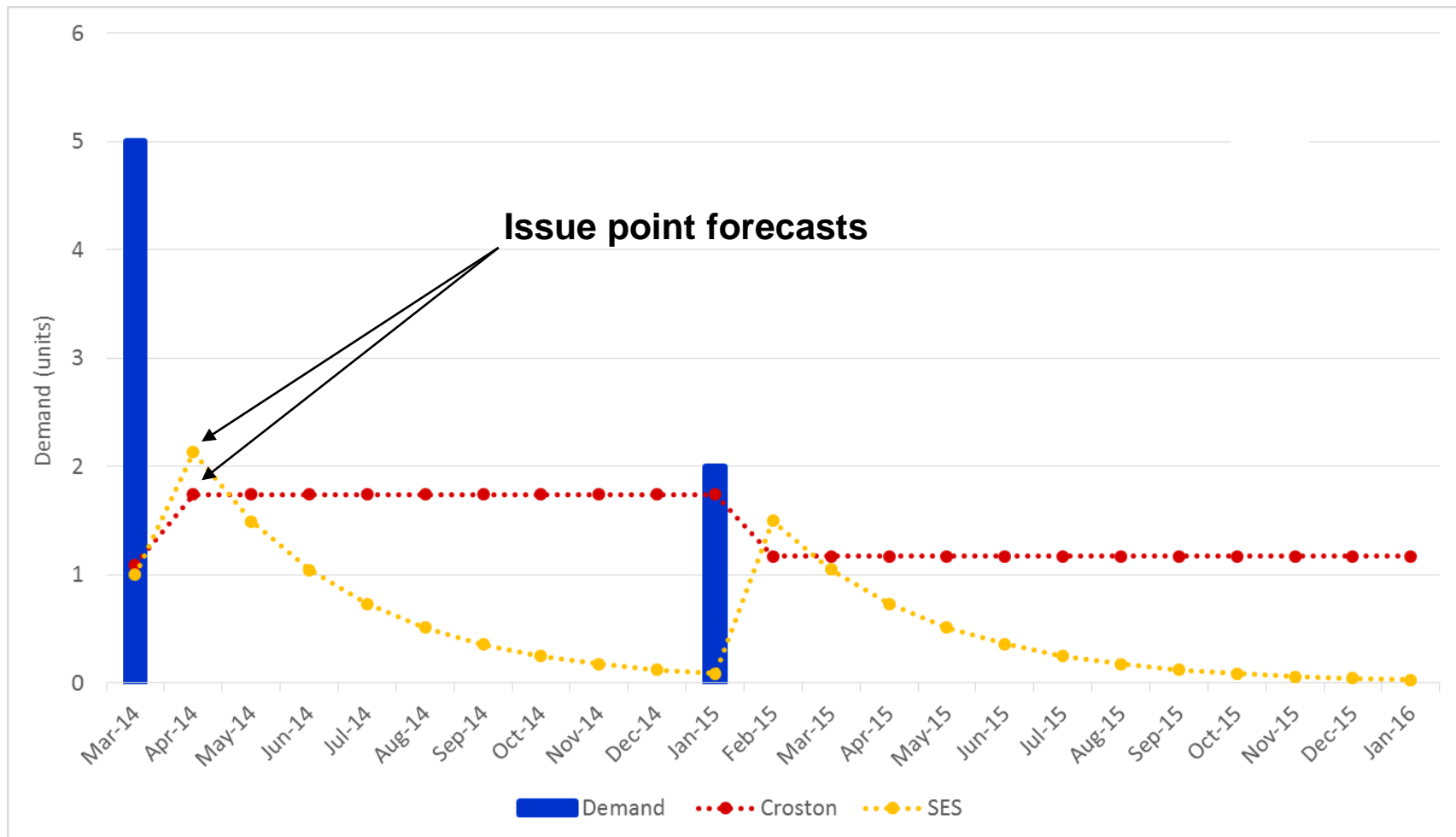
Does this matter?

- Appreciation of which forecasts are relevant for the forecasting task
 - The difference between all points in time and issue points only is a very important one for intermittent demand inventory forecasting



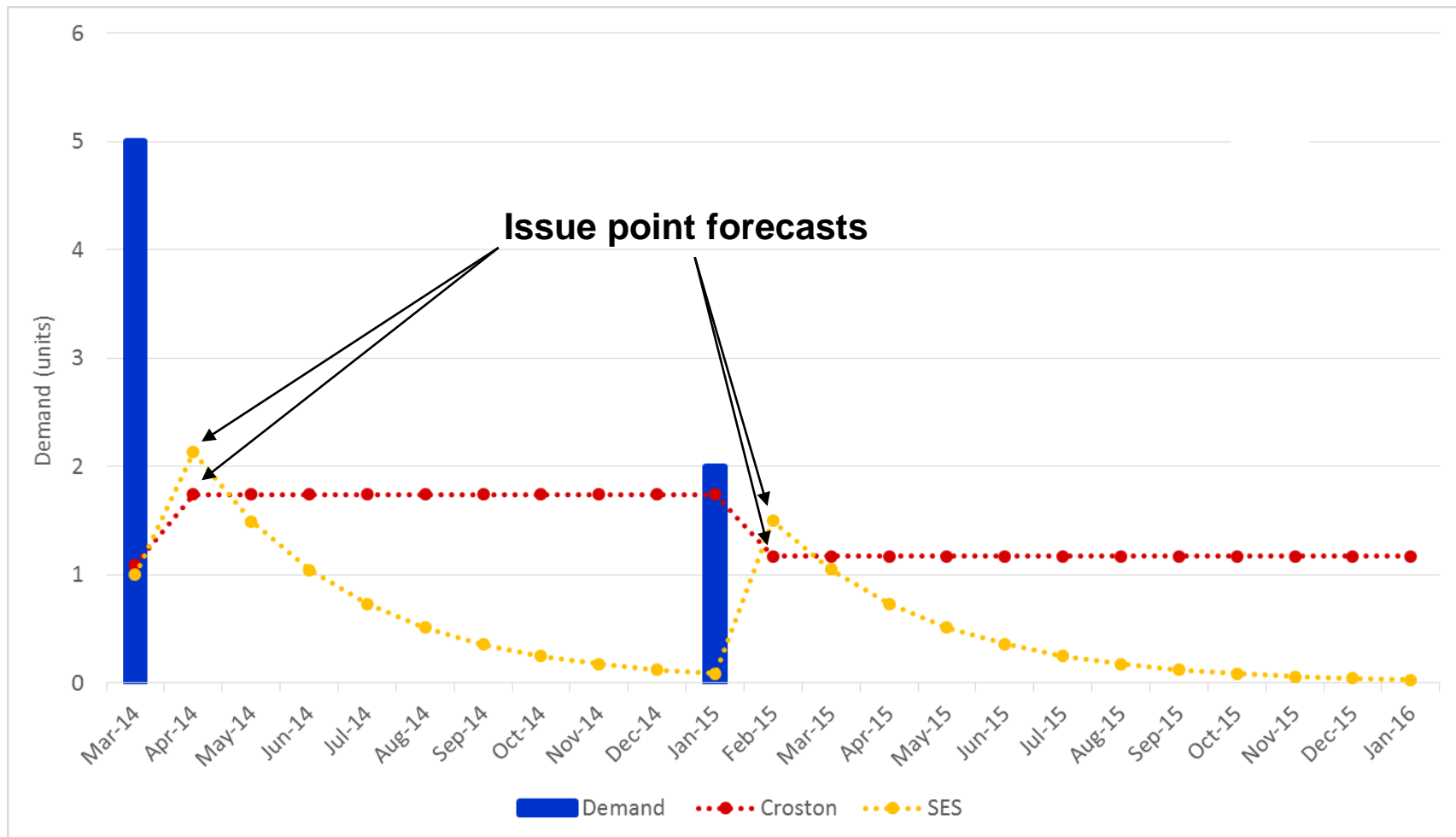
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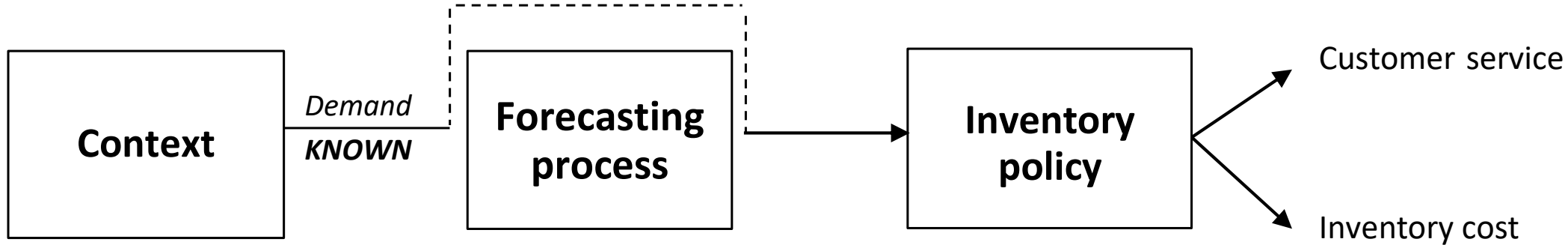
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Does this matter?

- ❑ **Development of new (mean demand) inventory forecasting methods**
 - ❑ **Perceiving forecasting as an end in itself does not facilitate the development of methods that reflect inventory concerns**
 - ❑ **A good example is the development of a forecasting method that reflects obsolescence related concerns – at the end of the life cycle (stock / non-stock decisions)**
 - ❑ **The method focuses on the probability of demand occurring which signifies whether an item has reached the end of its life cycle**
- ❑ **Consideration of the uncertainty underlying the demand variance**
 - ❑ **Safety stock = z * standard deviation of the lead time forecast error – see a recent FORESIGHT article by Steve Morlidge and Aris Syntetos.**

Interactions: why are they important?



- ❑ Demand assumed to be known
- ❑ Assuming no preceding stages of computation

Does this matter?

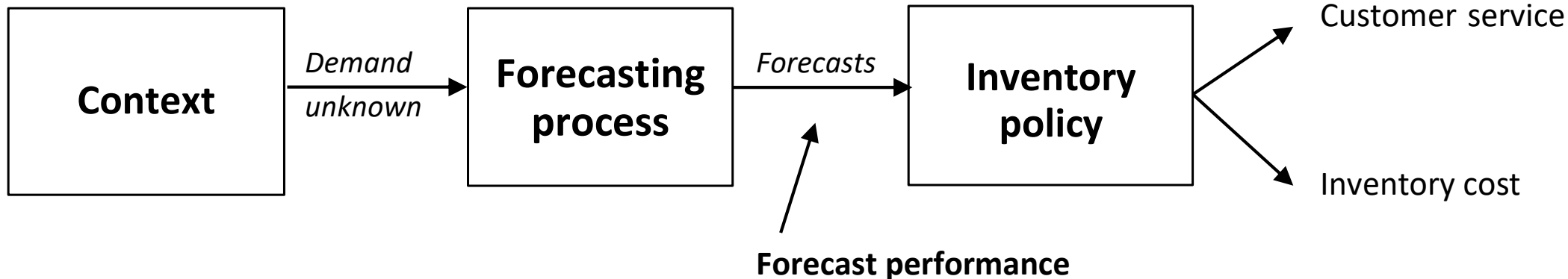
- ❑ Inventory theory is built around one main concern: decide when and how much to order so as to minimise the inventory investment subject to satisfying a target customer service level
- ❑ Different interpretations of this objective are available, but this does not change the fact that if we are to do what the inventory theory prescribes we should end up with achieved service levels that are more or less equal to the target ones
- ❑ It is well known though that invariably this is not the case
- ❑ This has been repeatedly shown empirically; especially for intermittent demand items and very high service levels
- ❑ But also analytically; in a recent study Prak et al (2016) show that failing to appropriately account for the variance of forecast errors leads to safety stocks that are up to 30% too low, and service levels that may be up to 10% below the target. Subsequently, they proposed appropriate safety stock adjustment (mark up) mechanisms.

- ❑ Consider a simple re-order point, order quantity (r, Q) inventory policy, where $r = \text{mean lead time demand forecast} + \text{safety stock}$
- ❑ **Safety stock = $z * \text{standard deviation of the lead time (L) forecast error}$**
- ❑ **Misstep 1: confusing the demand variance with the variance of the forecast error**
 - ❑ Consider $L = 1$, and stationary independent demand, then:
 - ❑ **Variance (forecast error) = Variance (demand) + Variance (forecasts)**
 - ❑ For exponential smoothing (with constant a), we know that:
 - ❑ **Variance (forecasts) = $[a/(2-a)] * \text{Variance (demand)}$**
 - ❑ **So we set safety stocks that are about 18% too low.**

- ❑ **Misstep 2**: using the Mean Squared Error (MSE) to calculate the variance of the lead time forecast error
 - ❑ A standard statistical result, regardless of the demand process or lead tie length is the following:
 - ❑ $MSE = \text{Variance (forecast error)} + \text{Bias}^2$
 - ❑ So, if there is bias, the MSE will overstate the forecast error variance and hence overstate the safety stock requirement
 - ❑ Safety stocks can be overstated by up to 40%
- ❑ **Misstep 3**: for lead time forecasts, assuming that period to period forecast errors are independent, and assuming that the size of the forecast error does not increase as the time lag increases:
 - ❑ Variance of forecast errors for L periods ahead = $L * \text{Variance of forecast error one period ahead}$.

Linkage between forecast and inventory performance

- ❑ Why focusing on the inventory performance does not solve the problem?
- ❑ Why forecast performance matters at all?
- ❑ For at least two reasons: i) Diagnosis; ii) Logical interpretations
- ❑ *Diagnosis*: change the parameters of the forecast model or change the model



Associations between forecast and inventory metrics

- ❑ Can we translate forecast performance into inventory performance?
- ❑ Can we explain inventory performance based on forecast performance?
- ❑ Only partly: this would work for example for the Mean Error (ME, Bias) and the Mean Squared Error (MSE)
- ❑ Bias (or the lack of) relates explicitly to service levels
- ❑ MSE relates to the variance of the forecast errors and thus to safety stocks
- ❑ However, it is rarely used for forecast accuracy reporting purposes (due to scale dependencies and inflation of large errors)

Where does the gap come from?

- ❑ **Forecasting and inventory control are two disciplines that have evolved separately**
- ❑ **This is evident through relevant (academic) conferences**
 - ❑ **International Symposium on Forecasting (ISF): supply chain and practitioner streams introduced only in the recent years**
 - ❑ **International Symposium on Inventories Research (ISIR): an inventory forecasting stream was introduced only in 2008**
- ❑ **This is also evident in the (academic) literature that remains fragmented**
 - ❑ **e.g. International Journal of Forecasting; Journal of Forecasting**
 - ❑ **e.g. International Journal of Production Economics**

Suggestions for improving inventory forecasting systems

- ❑ Treat inventory forecasting as a system rather than a set of disconnected modules**
- ❑ Consider the inventory implications of the forecasts: simulate inventory performance**
- ❑ Trace the origins of unexpected inventory problems by working backward to the forecasts**
- ❑ Not all forecasts are important depending on the inventory management task: distinguish between replenishment and stock-non/stock decisions**
- ❑ Consider the importance of appropriately estimating demand variance**

Suggestions for improving inventory forecasting systems

- ❑ Consider enhanced communication channels between demand forecasters and inventory planners**
- ❑ There is a need for training in both forecasting and inventory optimisation (for both forecasters and inventory planners)**
- ❑ Software developers should consider the adoption of relevant facilities (i.e. simulate inventory implications) and methods available**

References

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Thank you very much

Questions, discussion!

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