# What gets measured gets managed

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# Outline

- Introduction
- Aggregate Inventory Measures
- SKU Level Inventory Measures
- Forecasting Measures
- Conclusions

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# What gets measured gets managed

## Who said it?

Usually attributed to Peter Drucker, but …

We're not really sure.

## Objections

Not everything that matters can be measured.

Not everything that we can measure matters.

# High Level Inventory Measures

## Inventory Levels

Average Inventory

Inventory turnover (or ‘turn’)

Obsolescent / Dead Stock

## Inventory Availability

- Orders
- Order Lines
- Units / Value

# How to measure Availability?

| SKU | Ordered | Filled | Ordered (£) | Filled (£) |
|---|---|---|---|---|
| A | 5 | 5 | 500 | 500 |
| B | 10 | 8 | 1000 | 800 |
| C | 4 | 0 | 500 | 0 |
| D | 1 | 1 | 3000 | 3000 |
| E | 5 | 4 | 1000 | 800 |
| Total | 25 | 18 | 6000 | 5100 |

- Order-line Fill Rate = 2 / 5 = 40%
- Volume Fill Rate = 18 / 25 = 72%
- Value Fill Rate = 5100 / 6000 = 85%

# Availability Measures: Pitfalls

**Over-reliance on one measure**

1. Complete order-fulfilment desirable

   *but*

   if retailers submit many order-lines in a single order, then difficult to achieve complete order-fulfilment

2. High unit fill rates can be ‘gamed’ by stocking huge quantities of cheap item (eg nuts, bolts, washers).

# SKU Level Measures

**P1: Cycle Service Level**.

Fraction of replenishment cycles in which all of the demand can be met directly from stock.

**P2: Unit Fill Rate**

The fraction of the total volume of demand that can be satisfied directly from stock.

*Choice can be guided by costs of stockouts*
*(Fixed leads to P1; variable leads to P2)*

# Cycle Service Level: Pitfall for Intermittence

Suppose:

- No stock held
- Demand occurrence once every ten weeks

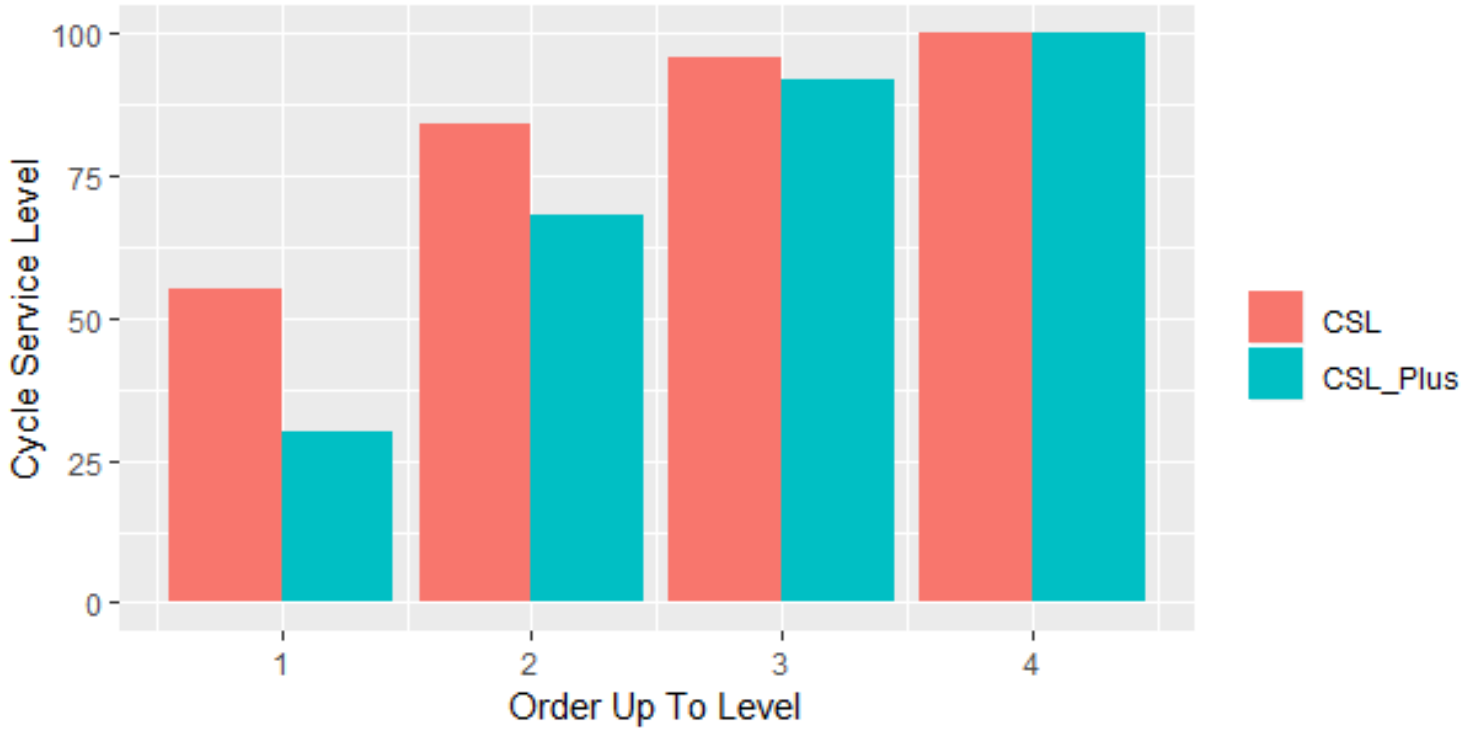
Then:

- No stock outs in 90% of the weeks
- CSL = 90%, but:

***With no stock, there is no service!***

# Alternative Measure: CSL Plus

- Restrict attention to cycles with some demand
- Same as Classic CSL for non-intermittent demand
- Example: Lead-Time =2; P(0)=0.5, P(1)=0.3, P(2)=0.2

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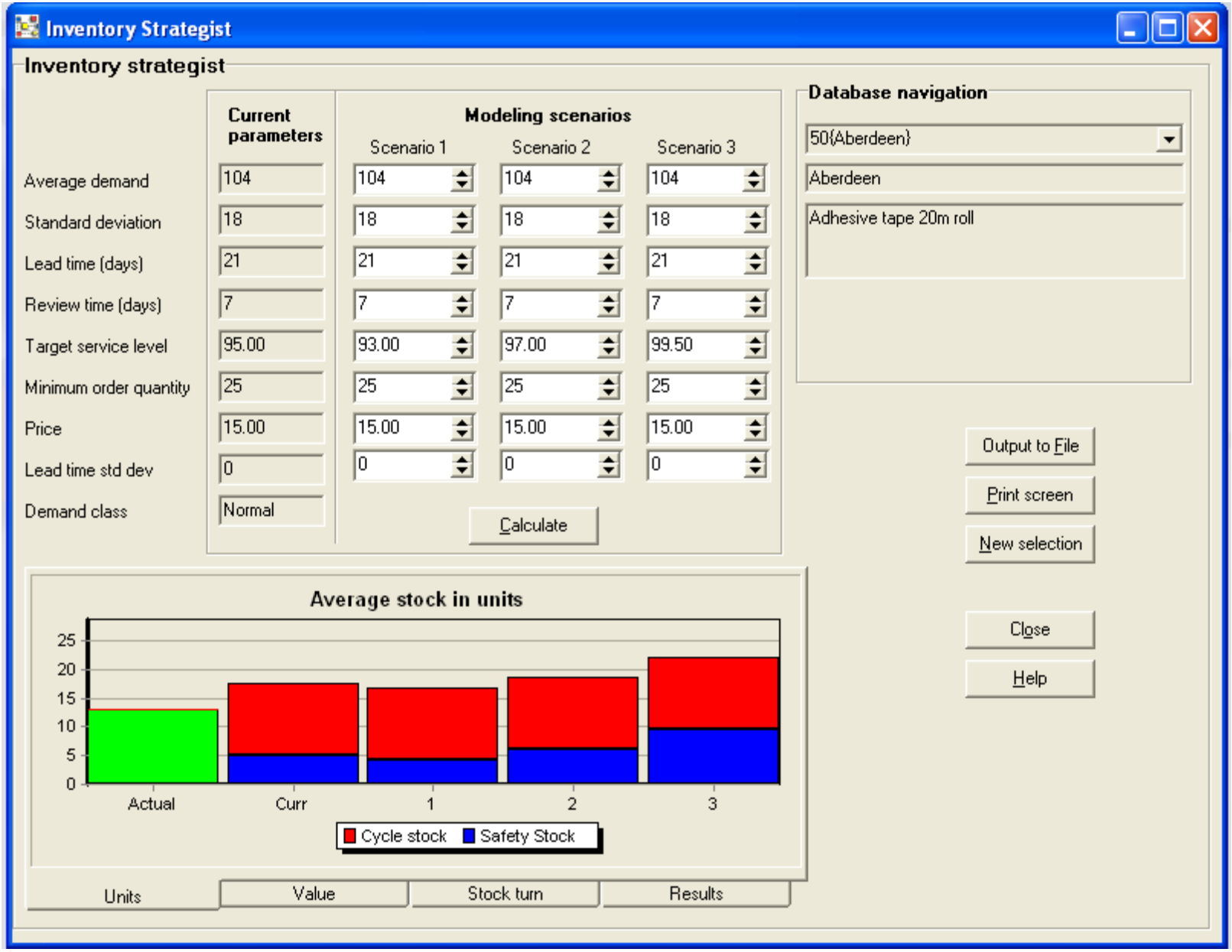
# Setting Appropriate Targets: What If Analysis

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# Service Level Agreements

**Client**

- Define measures that relate as directly as possible to business needs.
- Determine penalty clauses that discourage ‘gaming’ by the supplier.

**Supplier**

- Need clarity on measures, particularly relating to stock availability.
- Ensure that link between aggregate and SKU measures is well understood.

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# Understanding of Measures

**Silver, Pyke and Thomas (2017)**

"… an inventory manager, when queried, may say the company policy is to provide a certain level of service (say 95%) and yet not be able to articulate exactly what is meant by service".

This is a common pitfall, easily remedied by appropriate training and development (often under-resourced in practice).

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# What makes a good forecast accuracy measure?

**1. Interpretability**

Easy to understand and communicate.

**2. Robustness to Outliers**

Not unduly affected by 'unusual' observations.

**3. Scale Independence**

Not dominated by a small number of series in a collection.

*Davydenko and Fildes (2013)*

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# Mean Absolute Percentage Error (MAPE)

**Calculation**

1. Find absolute error (treat all errors as positive)
2. Divide by actual value
3. Take average for a single SKU
4. Average across all SKUs

**Strengths**

- Easy to understand
- Reasonably robust to outliers – but see next slide
- Not too sensitive to small amount of high volume series

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# Weaknesses of the MAPE

**Weaknesses**

- Cannot be calculated for intermittent demand (because of zeroes)
- For higher volume data, sensitive to occasional very low observations
- Scale independence comes at the cost of allocating the same weight to low volume series as high volume series.

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# MAPE Alternatives

- **Symmetric MAPE (sMAPE)**
  Divide by average of Actual and Forecast
  Introduces own asymmetries
  (Goodwin & Lawton, 1999).

- **Relative Mean Absolute Error (MAE)**
  Divide MAE of method by MAE of benchmark method
  Reduces sensitivity to low values.

- **Weighted MAPE (wMAPE)**
  Divide total absolute errors by total actuals
  Addresses problem of lack of weighting.

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# Intermittent Demand: Problem with Absolute Errors

| Period | Actual | Forecast | Error | Abs Error |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 10 | 0 | 10 | 10 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |
| 5 | 5 | 0 | 5 | 5 |
| 6 | 0 | 0 | 0 | 0 |
| 7 | 1 | 0 | 1 | 1 |
| Mean | 2.29 | 0 | 2.29 | 2.29 |

- For this data, Median = 0, but Mean = 2.29
- Zero forecasts minimise the Absolute Errors
- But we want to forecast the mean!

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# Alternative to MAPE for Intermittence

**Scaled Mean Squared Error**

1. Find error
2. Divide by average demand
3. Square this quantity
4. Average (as appropriate)

Petropoulos and Kourentzes (2015)

**Application - as for other measures**

- Demand in an individual periods (eg 1-step, 2-step)
- Demand over several periods – usually more appropriate for inventory management.

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# Bias Measures

**Origins of Bias**

- ***Human***: eg optimism bias from judgemental adjustment of forecasts
- ***Statistical***: using an inappropriate forecasting method

**Measurement of Bias**

- Mean Error: Average of all errors (positive and negative)
- Scaled Mean Error: Divide Mean Error by Mean Demand

**Diagnostic Capacity**

- Can go beyond comparing Method A with Method B. Helps to diagnose optimism bias or mis-specified methods.

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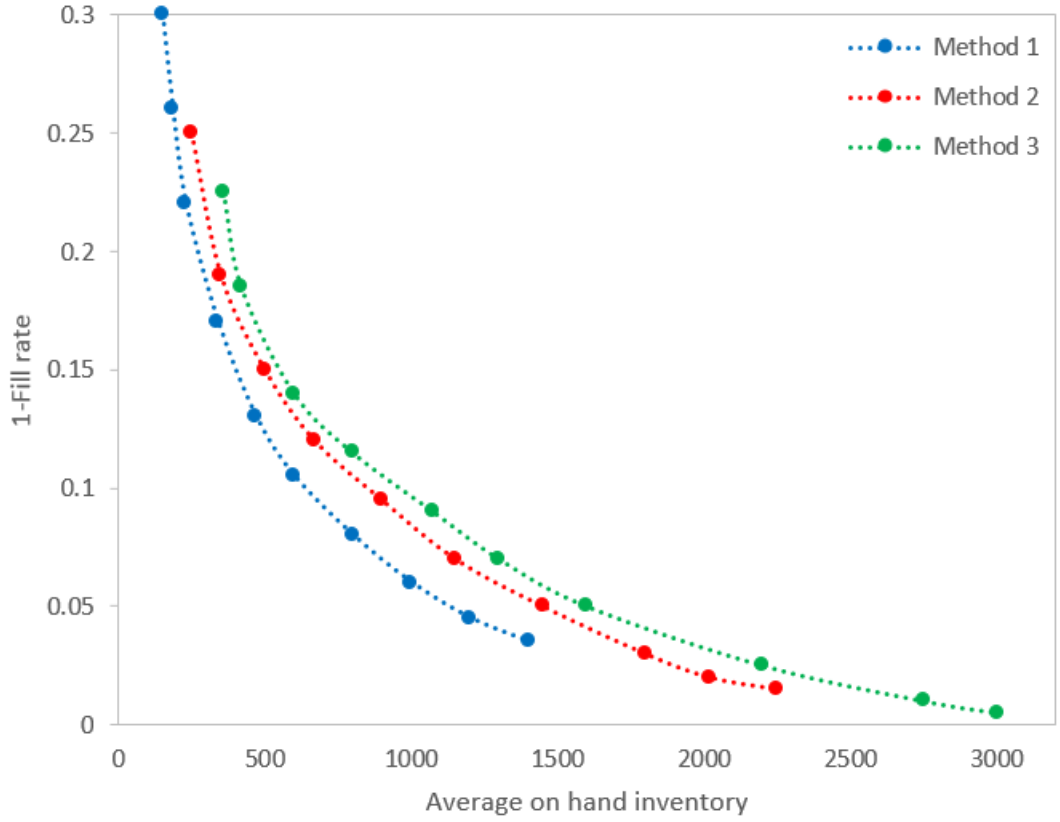
# Simulation of Effect on Inventories

Allows an assessment of the effect of forecasting accuracy

Can experiment with forecasting methods and/or inventory policies

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# Summary

## Inventory

- Choose availability measures strategically
- Avoid over-reliance on one measure!
- Adapt Cycle Service Level measure for intermittence.
- Ensure measures are well understood by supply chain people

## Forecasting

- Use MAPE but also consider alternatives
- Avoid all measures based on absolute errors for intermittence
- Measure forecast bias too!
- Ensure error measures are understood by demand planners
- Simulate effect of improved forecasting to assess inventory benefits.

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# References


Davydenko A and Fildes R (2013) Measuring forecast accuracy: the case of judgmental adjustments to SKU-level demand forecasts. International Journal of Forecasting, 29, 510-522.

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