Forecasting with SAP® APO DP?

The Gap between Theory and Practice?

Disclaimer
Slagging of IT is always in fashion ...

... but it's too simple!
Functionality is only one of many aspects in ERP/APS implementation.

**Objectives of ERP Systems**

- Relative importance to value chain activities
  - Data Integration
  - New ways of doing Business
  - Global capacities
  - Flexibility / Agility

- Relative importance to support activities
  - External buy-in of knowledge & processes

**Corporate benefits**

- IT benefits
  - IT purchasing benefits
  - IT architecture cost reduction

**IT**

- Benefits
  - Benefits of IT purchased
  - Benefits of IT architecture cost reduction

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**Disclaimer**

[Martin et al. (2002) p.182]
System Design Objectives

- ERP / APS systems offer >3000% functionality
- Functionality is accessible in 1000+ “best practice” processes → customise → normal implementation aims at 80%-85% coverage!
SAP APO is more than just a forecasting tool
• Holistic integrated planning suite
• Communication with legacy systems

need to evaluate overall SAP® APO based on total functionality
Customised Mercedes-Benz SL600s, studded with 300,000 Swarovski crystal glass,
“Buying the most expensive **Hammer** ...

...does not make you the best **Carpenter**!”

→ A forecasting system is only a *tool* in the hands of a forecaster!
→ Yields very different results by Craftstman vs. Novice (DP/IT)
Not today!
1. Disclaimer

2. How do companies use APO DP?
   - Evidence from a survey
   - System(s), Orga, Setup, Methods ...

3. “Best Practices” in APO DP?
   - Forecasting Science as benchmark
   - Data Exploration, Model Selection ...
   - Promo Forecasting, New Products ...
• **Questionnaire Design**
  - Pilot study in 2011 (to ensure validity)
  - Final version pre-tested with 18 FMCG forecasters
  - Questionnaire implemented online
  - Conducted January 2012-August 2012

• **Survey Sample Design**
  - Specified target group: demand planning & forecasting professionals (in manufacturing)
  - LCF Mailing list, forecasting lists / blogs (ISF, SAS)
  - 100s of LinkedIn Groups
  - 2000+ personalised LinkedIn invites
  - Multiple reminders sent

• **Response**
  - 540 responses
    • 260 incomplete (reminders send, to only speculative interest, unwilling to give email address (although not mandatory), Atrophy (number of repeated questions), unsuitable respondent (industry sector & position)
    • 15 complete responses discarded (Consultants/academics, rushed surveys (10-15 mins), highly inconsistent answers, middle-clicking {same answer for every question in groups})

→ **263 complete surveys** with usable forecasting systems information
→ **200 surveys from forecasters in Manufacturing** → representative!
Study Results
Systems use of Respondents

Group responses by a forecasting software – plus average response!

Classification:  
- APO  
- APO+  
- ERP/APS  
- Excel  
- SAP  
- Specialist  
- AVERAGE

Number of responses in each category

- AVERAGE
  - SAP
  - Specialist
  - APO+
  - Excel
  - APO
  - ERP/APS

- NON-MFR
  - SAP
  - Specialist
  - APO+
  - Excel
  - APO
  - ERP/APS

→ APO and APO+ (incl. specialists FSS add-ons) dominate today’s market!
Group responses by a forecasting software – plus average response!

Classification: APO  APO+  ERP/APS  Excel  SAP  Specialist  AVERAGE

Breakdown of responses by sector:

- Food & Beverage: 55
- Industrial/other: 43
- Other consumer goods: 33
- Electronics & computing: 20
- Consumer healthcare & beauty: 17
- Pharmaceuticals: 14
- Mixed: 13
- Clothing & Apparel: 5

Interpret whether forecasting practices are influenced by SAP APO DP system?

Interpret general forecasting practices and use of systems?

→ mostly large manufacturers active in the FMCG / CPG industry
→ Allows insight into different forecasting practices by systems → APO DP!!
Which Systems?
Heterogeneous market of ERP/APS vs. stand-alone FSS & combination

- SAP based solutions dominate all of ERP usage (100 v. 89 users or 38% v. 34% in %)
- Majority (72%) of respondents use an ERP/APS system (incl. SAP APO etc.)
- 23 respondents use APO DP plus an extra FSS Specialist system
- 14 respondents still use SAP with no APO modules (e.g. R/3 MM ...)

Study Results
Systems use of Respondents

- Excel only 17%
- SAP APO only 21%
- SAP APO + Other FSS 12%
- SAP (non APO) 5%
- ERP/APS 34%
- FSS Specialist Only 11%
Study Results
Systems use of APO+ Respondents

23 users apply SAP APO DP plus an additional Specialist FSS

Additional tool indicate shortcomings of SAP APO DP
No clear market leader / equal share of additional FSS tools used
Study Results
Systems use of Respondents

ERP/APS SYSTEMS (NON-SAP)

- JDA 23%
- Demand Solutions 14%
- Demantra 10%
- add*one, ASW, COMPASS, Epicor, iScala, GPAO/Oracle, Kinaxis, M3 (Lawson), MXB PRMS, NeoGrid, Reflex, Rockysoft, Ross/scp, Servigistics, Syspro, TecCMI 17%
- MfgPro/QAD 7%
- Logility 9%
- Infor 3%
- Oracle 3%
- Arkieva/Zemeter 5%
- Steelwedge 2%
- Futurmaster 2%
- Microsoft Dynamics AX 3%
- ERP/APS 34%
- SAP APO only 21%
- SAP APO + Other FSS 12%
- SAP (non APO) 5%
- FSS Specialist Only 11%
- SAP APO only 21%
- Excel only 17%
- Excel only 17%
- ERP/APS+ Demantra
- ERP/APS+Futurmaster
- ERP/APS+Forecast Pro

BUT: 4 non SAP users of ERP/APS also use extra FSS specialist software (ForecastPro, eTXT, Steelwedge etc.)

Classification:
- APO
- APO+
- ERP/APS
- Excel
- SAP
- Specialist
- AVERAGE

→ Large variety of ERP/APS systems led by JDA & Demand Solutions
Large variety of software packages, led by ForecastPro

Study Results
Systems use of FSS Specialist Respondents

SPECIALIST FSS SYSTEMS

Forecast Pro 21%
SAS 10%
Forecast X 7%
R 7%
Excel only 17%
SAP APO + Other FSS 12%
SAP (non APO) 5%

ERP/APS 34%

Apollo Data Technologies, Applix Tm1, Avercast, Demand Solutions, Eviews, GMT, Infor, Predicast/Aperia, Project i, Remira LogoMate, Retail Express AMP2, SAF, SPSS, Stata, TORA, TXT...

Classification: APO APO+ ERP/APS Excel SAP Specialist AVERAGE
Companies use multiple software together → lack of functionality!
Adoption of standard packages (ERP/APS/FSS) → individual dies out

**Study Results (all industries)**
Use of Software Packages

- **Excel & FSS users** don’t use ERP/APS systems
- **APO DP users use MS Excel as well** to make forecasts!
- **APO DP users use APO DP most frequently to make forecasts**
- **Demand Sensing & CPFR systems** are rarely used by anyone!
- **Few companies today still use a custom made (in-house) solution**

→ Companies use multiple software together → lack of functionality!
→ Adoption of standard packages (ERP/APS/FSS) → individual dies out
Planners use SAP APO and Excel and FSS ... 
... all in parallel!

(requires additional data exchange, process coordination, extra time & effort ...)

... indicates some lack of functionality!
What systems do you use?
Which Organisation?
Study Results (all industries)
Organisational Setup

- Smaller number of items likely to drive use of MS Excel
- All companies more likely to use SAP APO DP
- Number of forecasters is independent of use of system(!?)
- Most companies predict 1000 items across systems
- Larger companies more likely to use SAP APO DP
- APO+ users with more #items than APO users ➔ drives system?

→ # of items & company turnover drives APO DP adoption
→ # of Forecasters seems independent of #SKUs and # of revenue?
Study Results (all industries)
Forecasting Setup

What level of supply chain aggregation do you use?

- Item level
- Account Level
- DC Level
- Store Level

% of customers forecast what extent do you forecast

- Daily
- Weekly
- Never
- Rarely
- Sometimes
- Often

Classification: APO APO+ ERP/APS Excel SAP Specialist AVERAGE

APO DP normally forecast at item or account level, never store / DC
APO DP+ FSS forecast also at DC level (VMI functions?)
Users forecast at multiple time buckets at the same time!

Daily forecasts are still rare (!)

Similar setup: companies forecast on multiple levels & time buckets
How is this (best) supported by SAP APO DP?
Market complexities impact all business equally, regardless of system.

Study Results (all industries)

Drivers of Forecasting

Users of SAP R/3 (MM etc.) face the least impacts (lucky them!)

Most companies & system users face the same relative impact

Classification: APO APO+ ERP/APS Excel SAP Specialist AVERAGE
What organisation do you use?
Which Tools?
Typical SAP APO usage employs 25% only stats, 25% only judgment
... and 50% a combination of Statistics & Judgment

APO DP users forecast with Stats + Judgment (S&OP process?)

Specialist FSS users apply mainly Stats (without Judg. !)

Excel users apply mainly judgment (without Stats !)
Study Results (all industries)
Use of Forecasting Methods

- **Exp.Smoothing** is the single most used method family in APO DP.
- Only marginal use of Linear Regression in SAP APO DP.
- Only limited use of advanced methods across any systems!
- Only 10% of the methods used can integrate causal drivers (Promos, DC stock …)
- 72% use simplest methods only for level time series (28% MA+15% Naïve)

→ APO DP: 78% (45% ETS + 22% Av+ 11% Naïve) use simple methods!
→ APO drives use of simpler methods than average software packages
What algorithms do you use?
All users are only moderately happy with their forecast accuracy

APO DP not worse off than SAP R/3, ERP or Specialist software
Users seem satisfied that better systems will not improve accuracy!

BUT: will more customer data not require new system (functions)?
Users seem generally satisfied with their systems

Tricky interpretation, as ERP/APS/Excel can be customised!
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NON-Disclaimer
Forecasting & its technology are well established!
Advances in Forecasting
25 years of Scientific Insights!

• Founding of the International Institute of Forecasters → “unify the field and bridge the gap between theory & practice”

• Publication of 2 core interdisciplinary journals – Peer Reviewed!
  – Various publications in Operational Research, Management Science, Finance, Econometrics, Economics, Marketing, Retailing journals

• Publication of Practitioner oriented journals – Peer Reviewed!
  – Foresight – The Journal of Practical Forecasting (JBF to a lesser extent)

• Annual conferences
  – The International Symposium on Forecasting (ISF) → Peer Review
  – Professional conferences (Forecasting Summit, commercial IBF, iE, SAS, Terra etc.) are typically non-peer review

• 4 Nobel Prices for research in forecasting & related areas
  – Clive Granger & Robert Engle
  – Daniel Kahneman

Forecasting has developed as a scientific discipline of its own right
State of the art know-how from 25 years of R&D plus practice !!!
The Forecasting Process

Statistical Modelling: Model Application

- Maintain master data & link with predecessors
- Analyse & understand assortment (ABC / XYZ)
- Decision on automated forecasting
- Analyze time series & clean data
- Identify suitable models & parameters
- Apply statistical / manual forecasting
- Evaluate forecast quality
- Adjust & release forecast
- Finalization of forecast
- Initialization via overall analysis

Monthly statistical forecasting
The Forecasting Process
Statistical Modelling: Model Application

Initialization via overall analysis

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- Monthly statistical forecasting
41.4% of profit comes from 20% of products

59.8% of forecasting error comes from 20% of products

Now also available in SAP APO DP in master data (VARCOEFF)
No provision of process know-how on how to use & apply it ...

A-Narts
- Important for the business
- Fewer NARTs (20%)
- Cannot use Neural Nets as it can't be explained in e.g. ISF

X-Narts
- Simple to forecast NARTs
- Avoid Neural Nets → similar high accuracy → use the simplest method

BY, BZ, CY, & CZ -Narts
- Less important
- Many time series (50%)
- Neural Nets can be used

Interactive MoSel for decision support
Exponential Smoothing & SLR

Automatic Exponential Smoothing & SLR

Automatic Exponential Smoothing & SLR

Analysing Assortments
ABC-XYZ ... Analysis
The Forecasting Process

Data Analysis & Exploration

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- Maintain master data & link with predecessors
Data analysis and exploration in SAP® APO DP is very flexible. Customization of key-figures to be displayed on screen is possible.
Data Analysis & Exploration
Graphics in Interactive Forecasting

Visualisation is needed for Model Selection & Outlier Detection

Baseline

- Level time series
- Seasonal time series
- Trend time series

What is this?
- No distinction between “Null” and “0” → distorts

Standard colours are poor & often not changeable due to setup

No distinction between “Null” and “0” → distorts
Together with data transformations (detrend / deseasonalise, log transforms etc.)

Seasonal Plots
ACF Plots
Spectral Plots

Statistical tests, e.g. F-Test
Compare distributions using F-test (parametric) or Freidman’s (nonparametric)

Many others exist:
- Trend (Kendall’s Test, Spearman's Rho, Cox-Stuart), Linear Coefficient, Noether's Cyclical)
- Seasonality (Kruskal Wallis Test, Chi-Squared-Mod-Test, F-Test, ACF-Heuristic)
- Noise (Cox-Stuart Dispersion, Runs (Mean), Runs (Median), Runs (Up-Down))
- Model form (Level Shifts, Outliers, nonlinearity ...)
- Series Characteristics (Zero Values → Intermittent Demand, Length → New Products)
Create simple seasonal diagram as planning book

Program interactive "graphics container" with multiple diagrams for APO

Together with data transformations (detrend / deseasonalise, log transforms etc.)
Together with data transformations (detrend / deseasonalise, log transforms etc.)
Data Analysis & Exploration
Graphics in other software packages

Forecast Pro

→ Not every “fancy” visualisation is helpful!
Underdeveloped Graphics!
The Forecasting Process

Model Selection & Parameterisation

- Maintain master data & link with predecessors
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- Adjust & release forecast
- Apply statistical / manual forecasting
- Maintain master data & link with predecessors
Model Selection

Why Model Selection?
Various selections required in SAP APO DP:

- **Methods:** Exponential Smoothing: Single, Trend, Seasonal, Trend-Seasonal, Linear regression, Seasonal Linear Reg., ...
  - **Choice of “98” forecasting methods in SAP APO DP!**

- **Parameters:** Alpha [0,...,1], Beta [0,...,1], Gamma [0,...,1]
  - **Choice of 100x100x100 parameter combinations!**

- 14 ETS models x 100 x 100 x 100 parameters
  - **offer 14.000.000 choices per time series for each planner!**

Supports mainly a *manual* Model Selection by Forecaster.

2 options for a *fully automatic* Model Selection.
2 Options for Automatic Model Selection in SAP APO DP (2 magic buttons?)

- Option 1 NOR Option 2 always work (➔ after testing)

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<th>Mean Improvement</th>
<th>average</th>
<th>for</th>
</tr>
</thead>
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<td>Judgmental FC</td>
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<td>X</td>
</tr>
<tr>
<td>FC Pro</td>
<td>-1%</td>
<td>X</td>
</tr>
<tr>
<td>Intelligent Forecaster</td>
<td>-1%</td>
<td>X</td>
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<td>X</td>
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<tr>
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<td>3%</td>
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</tr>
</tbody>
</table>

Automatic Model Selection in SAP APO DP does NOT work robustly!

➔ Works sometimes, but not always … cannot trust the system!
➔ Cannot run automatically in the background!
Solutions exist

- Train demand planners in model selection
- Use bolt-on systems for model selection

→ Can train demand planners (preferred!)
→ Can integrate systems to do model selection for you
Poor Model Selection!
The Forecasting Process
Model Application

Initialization via overall analysis

- Maintain master data & link with predecessors
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- Finalization of forecast

SAP® APO DP includes some models which don’t work
SAP® APO DP excludes some important models

Monthly statistical forecasting
Model Application
Models in APO not functional

Forecasting Methods

Statistical

Time Series
- Double ETS (2nd order ETS)
- Linear Trend ETS
- Linear Regression
- Trend-Seasonal ETS (multiplic.)
- Seasonal Linear Regression
- Naive Methods
- Moving Average
- Single ETS
- Seasonal ETS (multiplicative)
- Median Method

Causal
- Causal Dynamic Regression (ARX)

Judgemental
- Individual
- Expert Opinion

Baseline
Exponential Smoothing require an “Initialisation” to forecast → poor “Naïve” Initialisation will impair forecast

3 years in-sample not enough to forget bad initialisation, requires higher smoothing parameters → Filter noise adequately?

→ Initialisation problem for ETS trend models is significant → better avoid them!
→ Similarly: avoid 2nd order Exponential Smoothing
Exponential Smoothing Models in APO DP
-Seasonal Models

In APO DP there is only multiplicative seasonal exponential smoothing. When there is no trend or level shifts there is little difference between additive and multiplicative models; however, this is not the case for trended time series.

This restricts the valid usage of the seasonal trend model in APO DP.
Very small values break down multiplicative seasonal models → use additive
Choose method according to forecasting problem & data
→ Simple methods often perform equally well
→ Problem dependent
That can get more complicated...

\[ \hat{y} = 25.36 + 0.40y_{t-1} + 0.42y_{t-2} - 0.24y_{t-3} + 98.23(\text{Promo1}) + 46.98(\text{Promo2}) \]
The ScanPRO model

\[ Q_{kjt} = \left[ \prod_{r=1}^{n} \left( \frac{p_{krt}}{\overline{p}_{krt}} \right)^{\beta_{ij}} \prod_{l=1}^{3} \gamma_{lrj}^{D_{ikrt}} \prod_{t=1}^{T} \delta_{jt}^{Xt} \prod_{k=1}^{K} \lambda_{kj}^{Zk} \right] e^{\varepsilon_{kjt}} \]

Cross-effects between products \(\rightarrow\) Interactions & cannibalism

Cross-effects between promotions \(\rightarrow\) Interactions, support & cannibalism

Cross-effects between stores \(\rightarrow\) Spatial cannibalisation & competition

![Graph showing sales over periods with positive and negative effects]
Croston method is designed to deal with these type of products.

Advanced Intermittent methods are missing, e.g. neural nets, Bootstrapping, Zero-inflated demand.
Limited Model Functionality!
The Forecasting Process
Statistical Modelling: Model Application

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No explicit systems support of judgmental decision making in system!
Support Judgement with Analogous Information

→ Improve Forecasting Support Systems (FSS)

HUMAN CAUSES

Rational Human Causes
- e.g. biases from company policy

Irrational Human Causes
- limited information processing capacity

THE PROBLEM

Sub-optimal sales forecast accuracy from Human Judgment

• How to avoid systematic errors in final forecast?

THE REMEDIES

Training
Decompose
Don’t adjust
Use Analogies
Develop systems
FSS features to support judgment
FSS features to constrain judgement

Side effects:
Lower user acceptance
Test what type of support works best using ANOVA.

Interactively select & store similar promotional cases.
Limited Support of Judgment!
The Forecasting Process

Statistical Modelling: Model Application

- **Initialization via overall analysis**
- **Maintain master data & link with predecessors**
- **Analyse & understand assortment (ABC / XYZ)**
- **Decision on automated forecasting**
- **Analyse time series & clean data**
- **Evaluate forecast quality**
- **Identify suitable models & parameters**
- **Apply statistical / manual forecasting**
- **Adjust & release forecast**
- **Finalization of forecast**
- **Monthly statistical forecasting**
Assess accuracy correctly: out of sample, rolling, good measures!

1 forecast origin
→ only 1 measurement
→ low confidence in the measurement accuracy
→ BUT: more data (24) is available
Fit **all possible models** and measure the errors:

- **MSE**:
  \[
  MSE = \frac{1}{n} \sum_{i=1}^{n} (A_i - F_i)^2
  \]

- **MAPE**:
  \[
  MAPE = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{A_i}{F_i} - 1 \right|
  \]

- **MAE**:
  \[
  MAE = \frac{1}{n} \sum_{i=1}^{n} |A_i - F_i|
  \]

- **sMAPE**:
  \[
  sMAPE = \frac{1}{n} \sum_{i=1}^{n} \frac{|A_i - F_i|}{(|A_i| + |F_i|)/2}
  \]

- **RE_t**:
  \[
  RE_t = \frac{A_i - F_t}{A_i - F_{Naive}}
  \]

- **GMRAE**:
  \[
  GMRAE = \left( \prod_{i=1}^{n} \frac{|A_i - F_i|}{|A_i - F_{Naive}|} \right)^{1/n}
  \]

- **MASE**:
  \[
  MASE = \frac{1}{n} \sum_{i=1}^{n} \frac{|A_t - F_t|}{\text{MAE}_{in-sample1-step-ahead Naive}}
  \]

Robust versions of MAPE exist.

Relative Errors missing.

... use **Information Criteria** for model selection?

- **AIC**:
  \[
  AIC = n \ln(L) - 2 \ln(L)
  \]

- **BIC**:
  \[
  BIC = -2 \ln(L) + k \ln(n)
  \]

**Assess accuracy correctly:** out of sample, rolling, good measures!
Visualisation of error distributions to check for errors and bias for relevant lead time!

Assess accuracy correctly: out of sample, rolling, good measures!
The Forecasting Process
Triage of Baseline | Promo | New
Take aways

• Companies are using SAP APO with multiple other systems and still use simple methods & little data → does not reflect Marketing hype & S.o.t.A.!
• Data exploration can be enhanced → poor graphics & visualisation – customisable?
• Model Selection can be enhanced → enough model selection & models for you?
• Judgmental Adjustments are not supported well → smart notes to support & constrain judgment!
• Review your SAP APO DP setup → possibly new releases / customisation flawed?

... making SAP APO DP work for you!
Questions?
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