Production Variability in Sales & Operations Planning: A Data-Driven Approach

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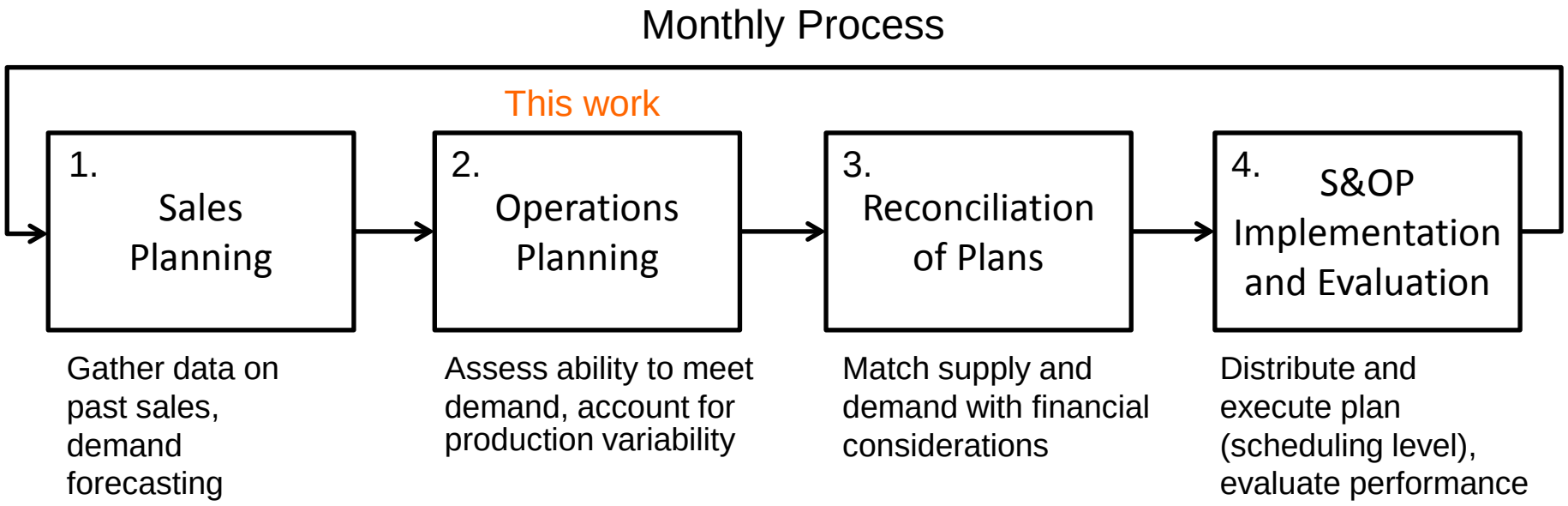
Motivation

- **Sales & Operations Planning (S&OP)**
  - Business and decision-making process.
  - Tactical plans in every business area.
  - Goal: balance demand and supply for products.
- Stages in the S&OP process



Adapted from Ling & Goddard (1988)

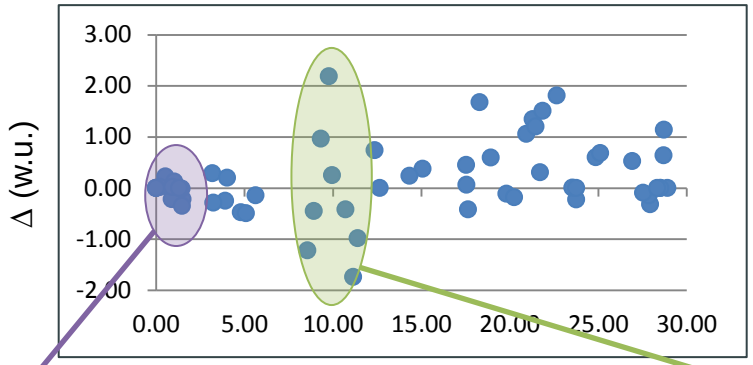
Problem Statement

- Production planning of a network of chemical plants
- **Given**
  - Deterministic monthly product demand,
  - Maximum installed capacity of each plant,
  - Transportation, production, and inventory costs.
  - Optional: current production plan (production targets)
- **Goals**
  ① Propose a new production plan by incorporating historical production variability,
  ② Evaluate the performance of the proposed plan using tradeoff average return vs. risk.
- Schematic of proposed approach

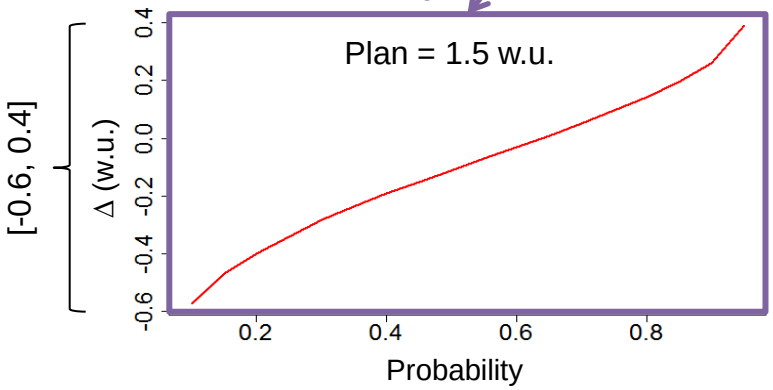
Deviation from Plan

- Given historical operational data (planned and actual production rates).
- Define deviation: Δ = Plan – Actual ➔ Production Variability
- Use quantile regression to model distribution of Δ conditional on a particular Plan value.
- Example:

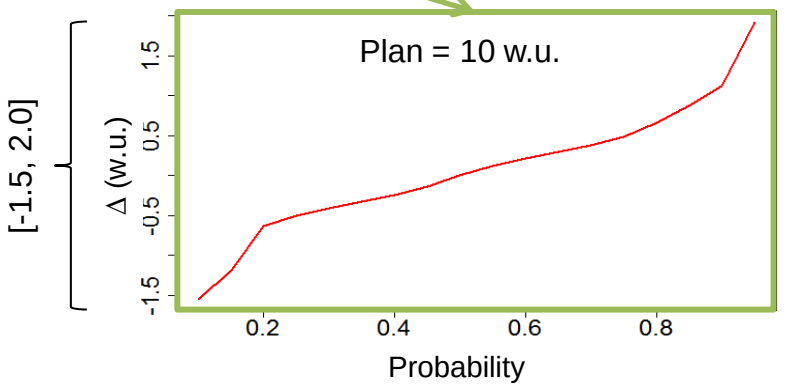
w.u.: weight units



Less variability

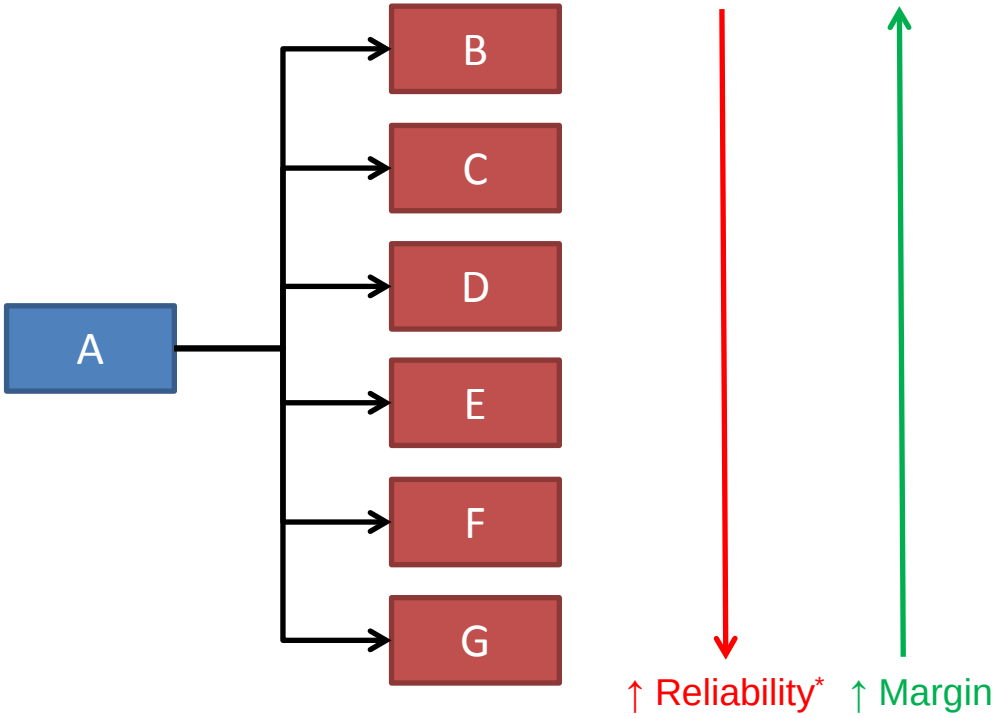


More variability



Motivating Example

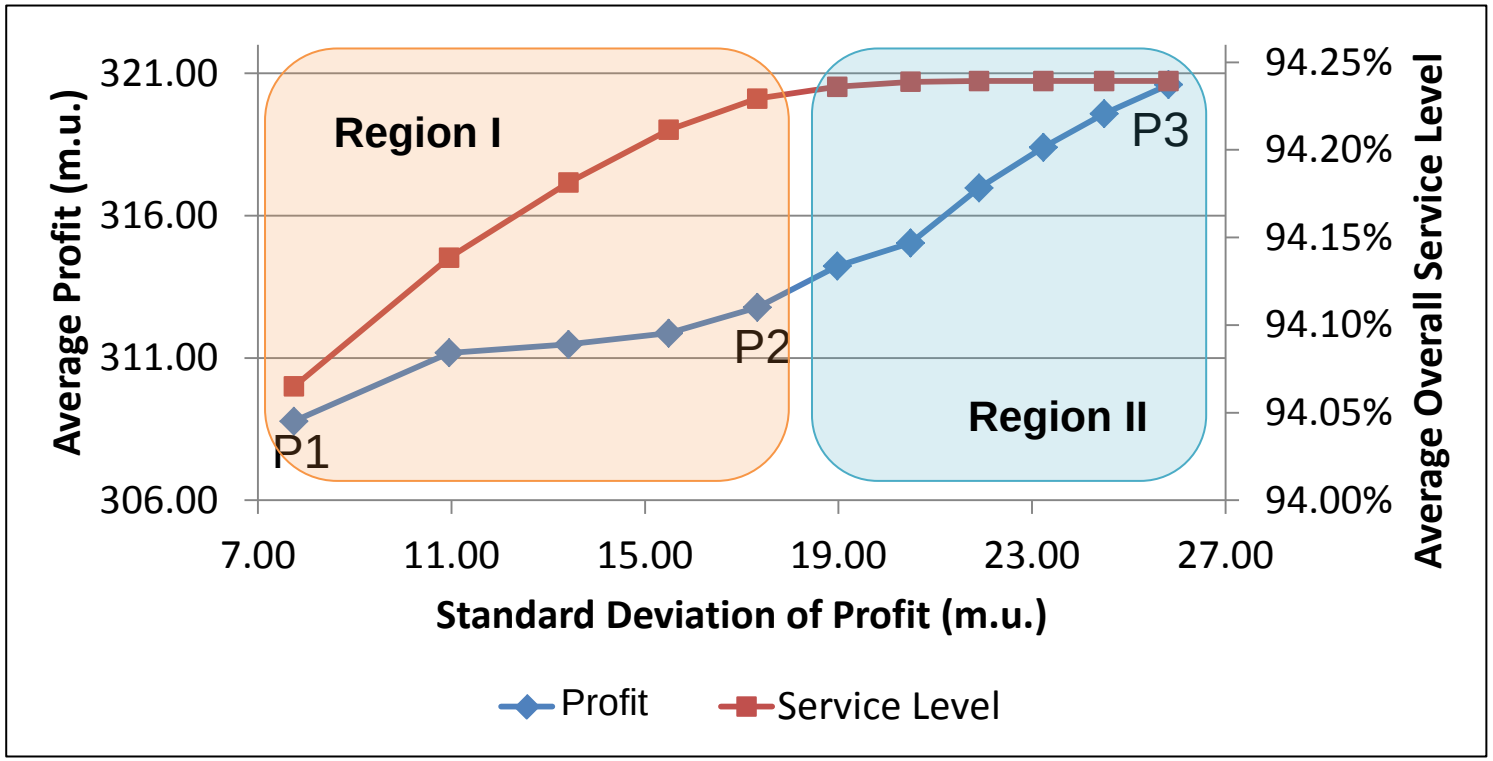
- Process network structure



* ↑ Spread of Δ around 0 ➔ ↑ Variability ➔ ↓ Reliability

- Main objective
  - Demonstrate the different allocation schemes as a function of financial risk tolerated.

Efficient Frontier

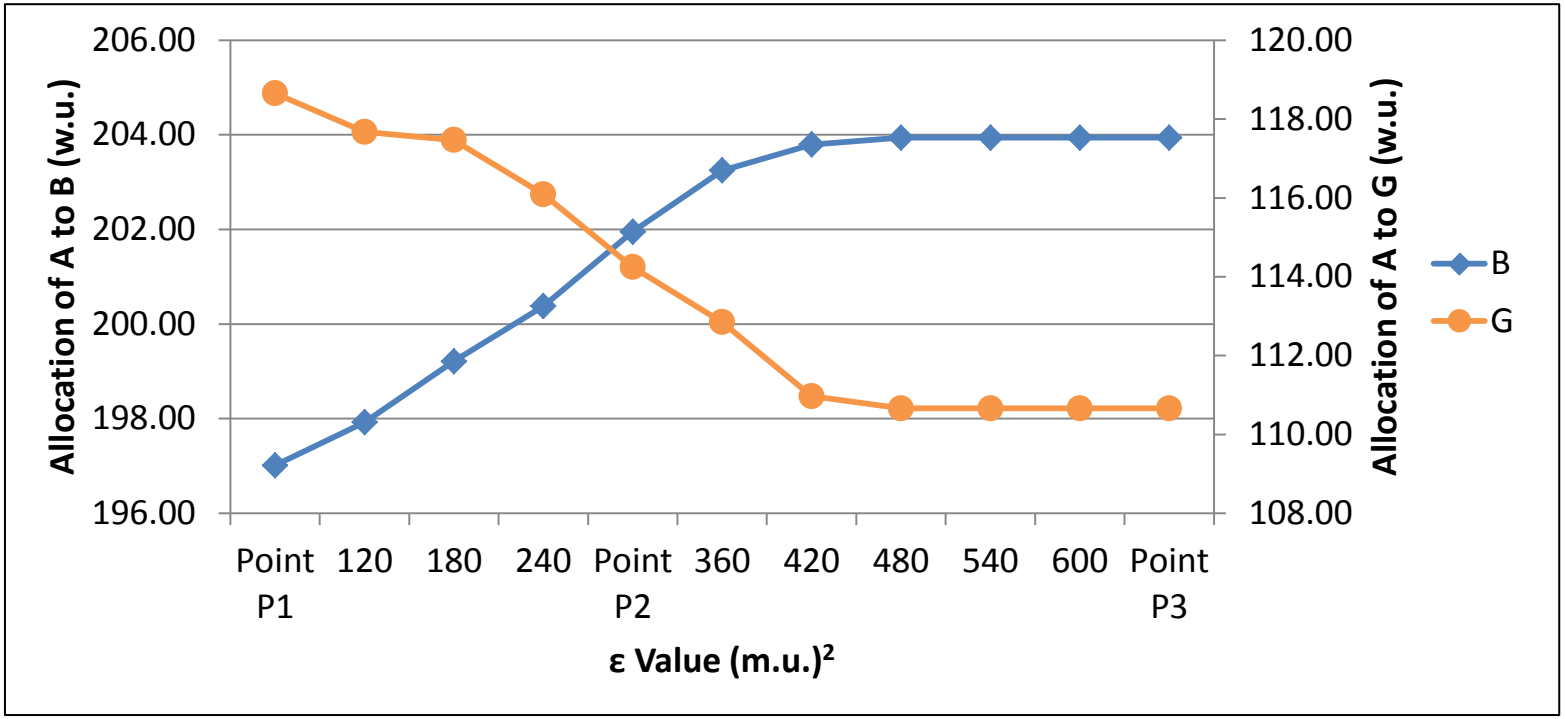


- Average overall service level does not increase after point P2.
- Increase in overall expected margin is accompanied by increase in financial risk
  - More A is allocated to less reliable, high-margin plants (next slide).

m.u.: money units

Allocation

- Total average allocation of A to highest-margin and lowest-margin plants.



- Overall allocation of A from **Region I** (less risk) to **Region II** (more risk)
  - ↓ low-margin plants
  - ↑ high-margin plants

Contributions and Conclusions

- **General framework to model production variability conditional on production Plan.**
  - Historical deviation from plan: Δ = Plan − Actual.
  - Quantile regression to generate scenarios.
- **Trade-off analysis for different material allocation schemes.**
- **Optimization-based approach**
  - \+ Simultaneously minimizes risk and accounts for production variability,
  - \+ Directly accounts for constraint violations,
  - − Difficult or impossible to use explicit model for Δ given Plan.
- **Implementation considerations**
  - Data analysis framework can be used to profile Plan-Actual mismatches.
  - Possible memory limitation for larger instances (more scenarios).

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