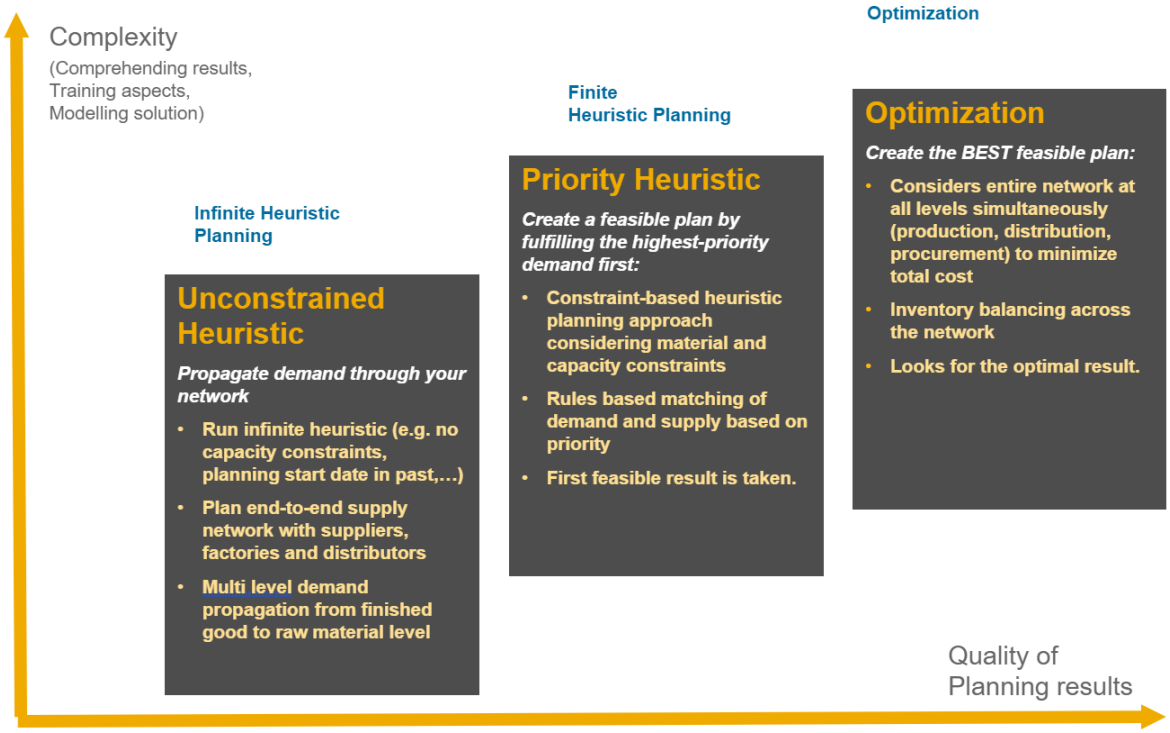
Optimizer – Best Practices, Do’s and Don’ts

Contents

1 Why Supply Optimization

Typical reasons for choosing optimization over other planning methods:

- Large, multi-level supply chain networks
- Multi-sourcing scenarios
- Production and distribution closely related
- Fair-share requirements across products and locations/regions
- 'Cost-based' planning requirements



Challenges/Issues with Supply Optimization:

- More complex setup than heuristic based solutions
- Potentially longer run times, especially if discrete optimization is used

- Results can be harder to understand

2 How does the optimization work?

The optimizer enables cost-based planning. Independent of the use case, it always minimizes the total cost of the supply plan. During the optimizing process, it searches through all feasible solutions to find the most cost-effective one in terms of total costs.

A solution is feasible for the optimizer when it respects all the planning constraints, for example, the source of supply options and available resource capacities. A feasible solution can contain non-deliveries, that is, not fully satisfied demands, safety stock constraint violations, or violate other constraints.

The most prominent costs are the ones for the source of supply decisions (production, transportation, and procurement) and the non-delivery costs for demands.

The output is a feasible production, distribution, and procurement plan for the selected supply chain network.

When used in order-based planning, the planning run writes order results and pegging.

To find the cost-optimal solution, the optimizer transforms the IBP for Supply model into a mathematical representation. This representation is called Mixed-Integer Linear Program (MILP, see also Linear programming – Wikipedia, the free encyclopedia). This MILP can be solved to a mathematical proven optimal solution. For additional details you can refer to blog IBP for Supply Optimizer: the mathematics behind.

3 How to address complexity in Supply Optimization - Best Practice

- General advisory: Keep unnecessary complexity out of the model!
  - ✓ Remember, it's mid-term planning in most of the cases.
- Careful use of discretization (lot sizes, fixed cost, setup):
  - ✓ Use discretization only in short-term horizon.
  - ✓ Use minimum lot sizes instead of integral lot sizes (rounding values) where possible.
  - ✓ Avoid using integral lot sizes on several levels (e.g. production and transportation).
  - ✓ If multi-level lot sizing cannot be avoided, make sure lot sizes are aligned.
- Reduce model scope:
  - ✓ Use shorter time periods and/or time aggregation.
  - ✓ Only plan relevant location levels in network. Consider propagating demand using heuristic for certain network levels.

- ✓ Only plan relevant SKUs. Components/Raw materials may not be required.

- Split Optimization scope into separate runs:
  - ✓ Plan by product group.
  - ✓ Identify bottleneck resources – non-bottleneck resources can be part of multiple runs.
  - ✓ This also improves planner experience / usability / fail safeness!
- Take care modeling alternative sourcing:
  - ✓ Avoid using 'exception only' alternatives in automated planning. Handle exceptions via alerts and manual planning.
  - ✓ Avoid modeling 'don't care' options (identical cost for alternative sources). Use 'virtual' priorities if necessary, to avoid strong fluctuations in optimizer results.
  - ✓ Consider restricting multi-sourcing to selected products (e.g. fast movers).

- Shift part of complexity to short-term distribution and/or production planning
  - ✓ Distribution planning – use of Deployment (optimization)
    - Plan part of the distribution network in deployment only
    - Consider transport lot sizing only in deployment
    - Planning in daily periods only in deployment
    - Allows consideration of additional constraints (e.g. storage, handling)
    - Fair-share considerations (location/region level) may only be considered in deployment
  - ✓ Production planning
    - Use PP/DS for detailed production planning
    - Alternative: Use ‚production-only'Supply Optimizer model in short term
    - Consider production lot sizes etc. only in short-term planning
    - Consider raw materials/component only in short-term planning
- Do not consider Optimizer as a black box! Build understanding of working principles of optimizer:
  - ✓ It's not rocket science…
  - ✓ Build a 'formal' tool translating business rules into an optimizer cost model
  - ✓ Especially useful if there are complex business requirements

- ✓ Involve (power) users in design of optimizer cost model

- Set up 'How-to' guides for analyzing / addressing frequent issues
  - ✓ In most scenarios, the same issues come up again and again
  - ✓ Document approach for new issues as they occur
  - ✓ Document resolutions provided by the experts in a way that non-experts can understand

4 Optimizer Expert Parameters – Frequently Asked Questions

1) Why expert parameters instead of optimizer profile parameters?

➢ Some features / parameters are not suitable to be part of the optimizer profile for the following reasons

- Some features are only required or relevant for a small number of customers / scenarios
- Some features are incompatible with other features or only work in certain scenarios and need to be used with caution
- Some features are not yet ready for general availability
- Some (custom) features are not free to use but only available as part of a custom enhancement / consulting solution

2) Is there a comprehensive list of expert parameters?

➢ No, there is no such list, mostly for the same reasons as given above.

3) When is it ok to use expert parameters in a project?

➢ As a general rule, expert parameters should only be used when recommended by SAP optimization consulting or SAP optimization development / support

4) Are expert parameters covered by standard SAP support?

➢ For parameters provided by SAP optimization development / support / consulting, customers are entitled to support. An exception may be performance-related parameters as performance tuning is not a support issue. In these cases, SAP optimization consulting should be involved. If customers use parameters not provided by SAP, they may not receive support.

5 Optimizer Run Explanations

5.1 What is it?

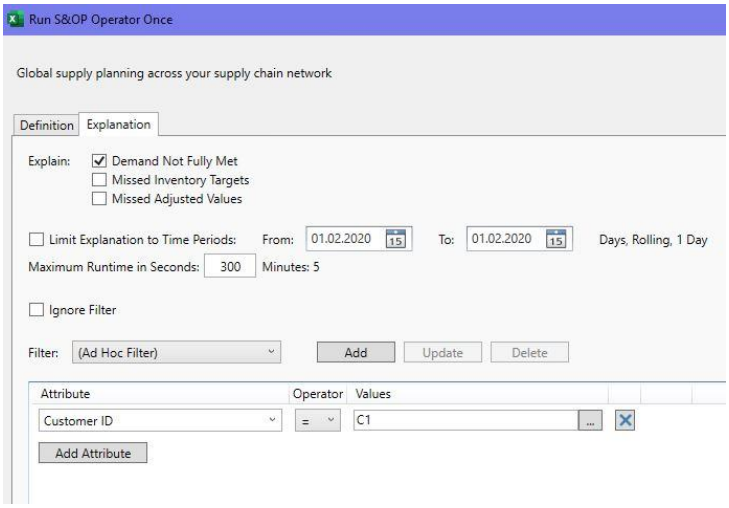
- Optimizer can explain following types of issues:
  - Demands not fully met.
  - Missed inventory target.
  - Missed adjusted values.

- What optimizer does not explain:
    - Why demand X is fulfilled and not demand Y?
    - Why some transport or production is used and not others?
    - Why some demand is fulfilled late?

5.2 How to Enable it?

- Prerequisites to run explanation:
    - Optimizer Profile must have enabled explanation
    - Explanation is only possible in batch processing mode
    - Create job (batch call) with enabled explanation

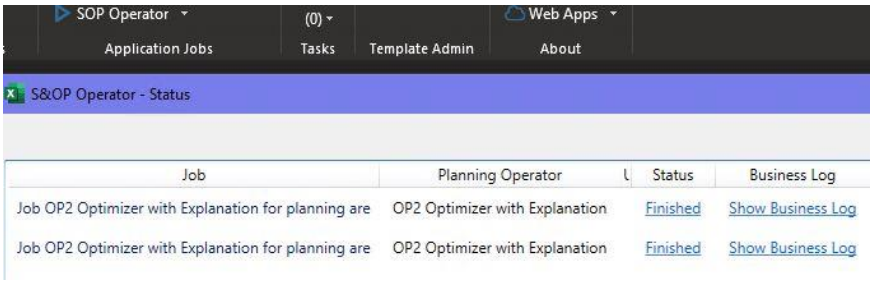
- For the explanation run specify:
    - What to be explained (demand, safety stock…)
    - Runtime for explanation run, in addition to main optimization
    - Optional (but highly recommended): filter what to explain
        - Periods with issues to explain
        - Location/customer products with issues to explain

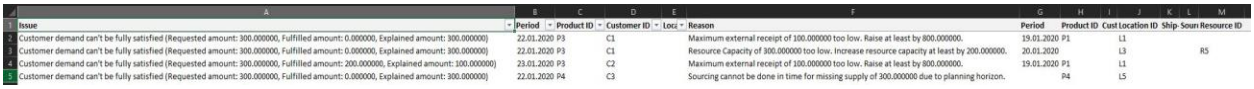


- Explanation should not be called with entire scenario
    - Runtime would increase drastically as scenario to be explained is huge
    - Results most likely are not usable because it is not possible to assign reasons uniquely to issues
    - Output excel could be too large to work efficiently with the results
- If issues are detected in an optimizer run:
    - Select a small number of location/customer products
    - Restrict to a small number of periods where issues should be explained (most likely first X periods)
    - Re-run the optimizer with explanation and filter

5.3 How to see Explanation Results

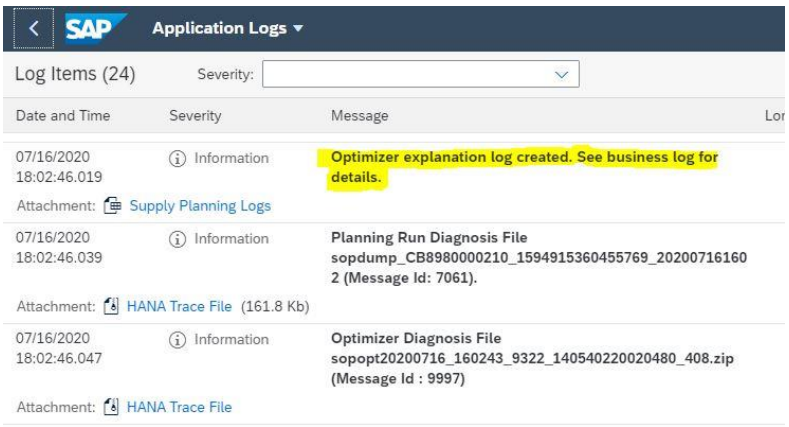
- Access result from Excel: SOP Operator => Status => Show Business Log

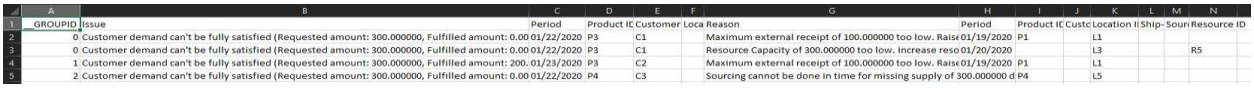




Issue	Period	Product ID	Customer ID	Loca	Reason	Period	Product ID	Cust Location ID	Ship- Sour	Resource ID
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P3	C1		Maximum external receipt of 100.000000 too low. Raise at least by 800.000000.	19.01.2020	P1	L1		
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P3	C1		Resource Capacity of 300.000000 too low. Increase resource capacity at least by 200.000000.	20.01.2020		L3		R5
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 200.000000, Explained amount: 100.000000)	23.01.2020	P3	C2		Maximum external receipt of 100.000000 too low. Raise at least by 800.000000.	19.01.2020	P1	L1		
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P4	C3		Sourcing cannot be done in time for missing supply of 300.000000 due to planning horizon.		P4	L5		

- Access result from Application: Application Logs => Select Log => Supply Planning Logs

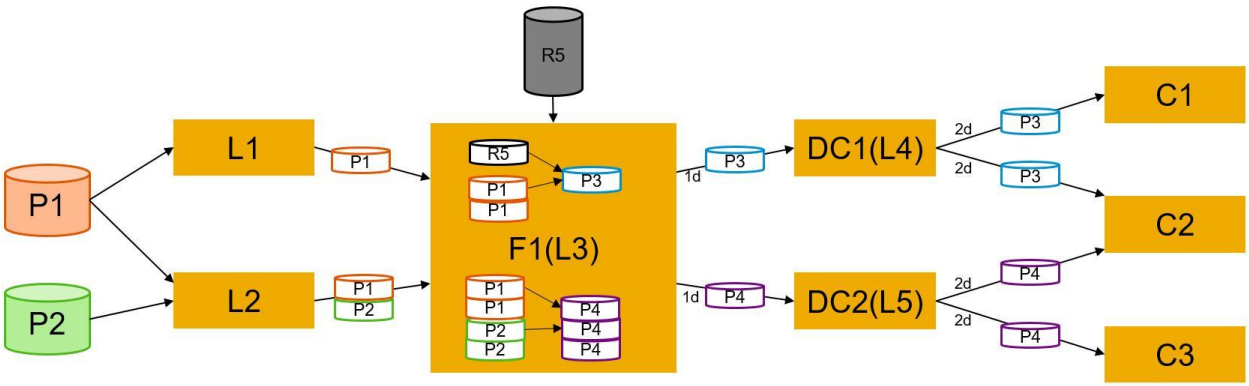




GROUPID	Issue	Period	Product ID	Customer	Loca	Reason	Period	Product ID	Custc	Location ID	Ship- Sour	Resource ID
0	Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.00	01/22/2020	P3	C1		Maximum external receipt of 100.000000 too low. Raise	01/19/2020	P1		L1		
0	Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.00	01/22/2020	P3	C1		Resource Capacity of 300.000000 too low. Increase reso	01/20/2020			L3		R5
1	Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 200.	01/23/2020	P3	C2		Maximum external receipt of 100.000000 too low. Raise	01/19/2020	P1		L1		
2	Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.00	01/22/2020	P4	C3		Sourcing cannot be done in time for missing supply of 300.000000 d		P4		L5		

5.4 Example for Optimizer Explanation

Sample supply chain network: Two finished products (P3&P4) produced in factory F1 at location L3. P1 and P2 are used as input components coming from location L1 and L2 respectively. P1 is used for both P3 and P4. Product P3 has valid resource R5 at L3. Lead time of 1 day from factory to DC and 2 days from DC to customers. 1 day of lead time from L1/L2 to L3.



Constraints or Restrictions:

- Capacity restrictions – 300 on 1/20/2020, 100 on 1/21/2020.
- External receipt restrictions - Only 100 each on 1/20/2020 and 1/21/2020
- Lead times – Total of 3 days lead time from factory (L3) to customers.
- Limited late delivery options – Only one period late delivery allowed for P3. No late delivery for P4.

Customer Demands: Input to Optimizer

You can see from the planning view below,

- There are total of three customer demands for products P3 and P4
- P3 has total of 600 demand on 1/22/2020 and 1/23/2020.
- P4 has total of 300 demand on 1/22/2020

Customer ID	Location ID	Product ID	Resource ID	Key Figure	01/19/2020	01/20/2020	01/21/2020	01/22/2020	01/23/2020	01/24/2020	01/25/2020	0
(None)	L1	P1	(None)	Maximum External Receipts	100	100						
	L2	P1	(None)	Maximum External Receipts	100	100						
		P2	(None)	Maximum External Receipts	100							
	L3	(None)	R5	Capacity Supply	1.000	300	100	100	1.000	1.000		
		P1	(None)	Maximum External Receipts								
		P2	(None)	Maximum External Receipts								
		P3	(None)	Maximum External Receipts								
		P4	(None)	Maximum External Receipts								
	L4	P3	(None)	Maximum External Receipts								
	L5	P3	(None)	Maximum External Receipts								
		P4	(None)	Maximum External Receipts								
C1	(None)	P3	(None)	Customer Demand				300				
				Late Delivery Max Periods	1	1	1	1	1	1	1	
C2	(None)	P3	(None)	Customer Demand					300			
				Late Delivery Max Periods	1	1	1	1	1	1	1	
		P4	(None)	Customer Demand								
				Late Delivery Max Periods	0	0	0	0	0	0	0	
C3	(None)	P4	(None)	Customer Demand				300				
				Late Delivery Max Periods	0	0	0	0	0	0	0	

Customer Receipts: Output of Optimizer

Optimizer can only fulfil total of 200 quantity for product P3. This is due to multiple constraints that were passed as input.

Demand fulfillment situation:

- P3@C1 not fulfilled
- P3@C2 partly fulfilled

  - 1/3 fulfilled in time
  - 1/3 fulfilled late
  - 1/3 not fulfilled
- P4@C3 not fulfilled

Customer ID	Location ID	Product ID	Resource ID	Key Figure	01/18/2020	01/19/2020	01/20/2020	01/21/2020	01/22/2020	01/23/2020	01/24/2020	01/25/2020
(None)	L1	P1	(None)	Maximum External Receipts		100	100					
				Production Receipts								
	L2	P1	(None)	Maximum External Receipts		100	100					
				Production Receipts								
		P2	(None)	Maximum External Receipts		100						
				Production Receipts								
	L3	(None)	R5	Capacity Supply		1.000	300	100	100	1.000	1.000	
		P1	(None)	Maximum External Receipts								
				Production Receipts								
		P2	(None)	Maximum External Receipts								
				Production Receipts								
		P3	(None)	Maximum External Receipts								
				Production Receipts			100	100				
		P4	(None)	Maximum External Receipts								
				Production Receipts								
	L4	P3	(None)	Maximum External Receipts								
				Production Receipts								
	L5	P3	(None)	Maximum External Receipts								
				Production Receipts								
		P4	(None)	Maximum External Receipts								
				Production Receipts								
C1	(None)	P3	(None)	Customer Demand					300			
				Late Delivery Max Periods		1	1	1	1	1	1	1
	L4	P3	(None)	Customer Receipts								
C2	(None)	P3	(None)	Customer Demand						300		
				Late Delivery Max Periods		1	1	1	1	1	1	1
		P4	(None)	Customer Demand								
				Late Delivery Max Periods		0	0	0	0	0	0	0
	L4	P3	(None)	Customer Receipts						100	100	
C3	(None)	P4	(None)	Customer Demand					300			
				Late Delivery Max Periods		0	0	0	0	0	0	0
	L5	P4	(None)	Customer Receipts								

Following are the constraints/issues because of which not all demands were fulfilled.

- Resource capacity
- Missing production input
- Lead time

Explanation Results view:

Issue	Period	Product ID	Customer ID	Loca	Reason	Period	Product ID	Cust	Location ID	Ship-	Sourc	Resource ID
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P3	C1		Maximum external receipt of 100.000000 too low. Raise at least by 800.000000.	19.01.2020	P1		L1			
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P3	C1		Resource Capacity of 300.000000 too low. Increase resource capacity at least by 200.000000.	20.01.2020			L3			R5
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 200.000000, Explained amount: 100.000000)	23.01.2020	P3	C2		Maximum external receipt of 100.000000 too low. Raise at least by 800.000000.	19.01.2020	P1		L1			
Customer demand can't be fully satisfied (Requested amount: 300.000000, Fulfilled amount: 0.000000, Explained amount: 300.000000)	22.01.2020	P4	C3		Sourcing cannot be done in time for missing supply of 300.000000 due to planning horizon.		P4		L5			

P3@C1 on 22.01.2020 was not fulfilled completely because of two reasons:

- Insufficient external receipts – only 100 external receipts of product P1 on 01/19/2020 whereas total customer demand is 900
- Low resource capacity – Only 300 resource capacity on 1/20/2020 whereas total customer demand is 600. 100 out of 600 can be fulfilled from available capacity on 1/21/2020 with allowed late fulfillment. So additional 200 capacity is missing.

P3@C2 on 23.01.2020 was fulfilled partially because of insufficient external receipts.

P4@C3 on 22.01.2020 was not fulfilled at all because of lead time issues.

6 Runtime and Complexity

Impact of Model Size and Complexity on Optimizer Runtime:

Several factors have a significant influence on optimizer runtime

- Overall model size
    - Typically measured in number of variables and constraints (properties of the mathematical model)
    - From a supply chain perspective, model size is determined by number of location products, demands, periods, production sources, transportation lanes etc.
- Model complexity
    - Model complexity is mainly driven by two factors
        - Number and type of constraints
        - Number and type of discrete (binary/integer) variables
    - Increase/decrease number of discrete variables typically has a very high impact on performance
    - Adding/removing constraints has a high impact if they result in bottlenecks or conflict with other constraints
- Numerical properties of the model
    - Numerical difficulties can lead to significant performance degradation

Estimating/Determining Runtime for an Optimizer Scenario:

- Based on sizing data, only a very rough runtime estimate for an optimizer scenario is possible
    - Too many "soft" factors can have a significant impact on runtime

- How constrained is the model (e.g. with respect to capacity or material availability)
- Different values for (minimum) lot sizes may lead to significant runtime differences
- Number of levels of the supply chain (production and distribution)
- Use of fair share logic
- Numerical properties

- Volume testing with realistic data is required for proper performance / runtime analysis
  - With full data volume and realistic transactional data
- Defining a maximum runtime window is usually better than trying to estimate "ideal" runtime
  - Runtime for optimizer jobs is constrained by planning schedule and other jobs
  - Runtimes of more than 12 hours currently not supported by IBP
  - Different parameterizations (e.g. use of product decomposition) can lead to significantly different runtimes

7 How to reduce the complexity

Reducing Problem Complexity and Size:

- Main drivers to reduce problem complexity and size are
  - Planning horizon
  - Discretization horizon
  - Time aggregation
  - Discrete lot sizes (minimum lot size, rounding lot size)

Reducing Problem Complexity and Size – Planning Horizon:

- Influence of the planning horizon
  - Each decision for e.g. production, transport, inventory holding, etc. must be performed per planning period passed to the optimizer
    - Each decision induces at least one variable per period (e.g. result for production with source S)

    - Most features induce at least one constraint per period (e.g. capacity supply of resource R)
- At least size of the model is influenced quadratic by number of periods
    - Model size itself directly influences numerical operations (matrix transformation) per iteration
- Reduce planning horizon as much as possible to receive a smaller problem

Reducing Problem Complexity and Size – Discretization Horizon:

- Discrete decisions are caused by
    - Minimum lot size
    - Rounding lot size
    - Fixed cost of sourcing decisions

Discrete decisions lead to a mixed integer linear problem and not a pure linear problem, which is much harder to solve

To decrease complexity, try to avoid discrete decisions, or restrict them (at least for the optimizer) to a small number of periods (default is discrete for the entire planning horizon unless changed in optimizer profile)

Reducing Problem Complexity and Size – Time Aggregation:

In case a large planning horizon is needed with a fine granularity in the beginning, e.g. one-year planning and planning on daily level, number of periods would lead to a very huge model

Using time aggregation profile there is the option to change planning granularity from fine to coarse, e.g. starting with daily planning level for 3 months, using weekly level for the next 3 month and having only monthly level for the last 6 months of planning.

- Would result in approx. 110 effective periods in the optimizer although planning 365 days
- Constraints for the entire year are considered (at least roughly aggregated on monthly level)

Caveat:

- Some features are switched off starting aggregation of periods:

  - Discrete decisions, sub periods of supply, quota arrangements, aggregated constraints…etc.
- Some features are modified to fit to the changed periodicity:
  - Lead time, maximum values

Reducing Problem Complexity and Size – Lot Sizes:

As minimum and rounding lot size induce discrete decisions, we highly recommend to avoid them

If they are a must have feature,

- Restrict them via discretization horizon to only the first x periods, later planning most likely gets changed anyhow and has other uncertainties
- Restrict them only to the main location products of interest and not apply them to every source
- If for any reason there is a must to have them for several consecutive levels in the supply chain, try to get them aligned, i.e. to integer multiples between them (ideally factor 1)

8 How to deal with Numerical Problems

Resolve/reduce potential root causes for numerical problems:

- Avoid large differences between highest and lowest costs
  - Typically, a range or 6 – 8 orders of magnitude between highest and lowest cost should not be exceeded
  - Pseudo-hard costs (e.g. for violation of adjusted values) can increase the cost range
- Avoid very large and very small values for constraints and coefficients
  - Can be achieved by suitable choice of units of measure (UoM)
- Avoid input data with many decimals
  - E.g. demands, adjusted values, BOM coefficients

Improve performance with suitable parameterization:

- Numerical focus and numerical scaling parameters in optimizer profile
- Numerical pre-optimization

Refer to SAP note # 2922352 to understand more about numerical issues in Supply or Deployment optimization.

Refer to blog Expert settings for IBP supply optimization for additional information on expert settings.