Multi-retailer stochastic inventory control with service level constraints and routing decisions

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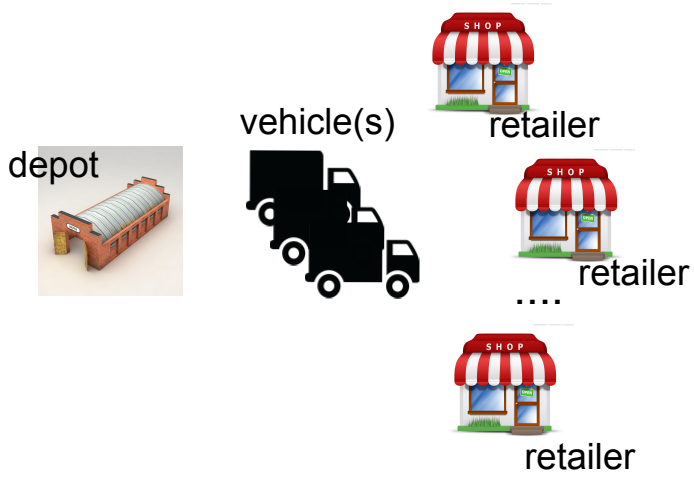
Problem definition

- discrete finite time horizon
- multiple retailers
- single production facility
  - infinite production capacity
- one (or more) vehicle(s)
  - infinite loading capacity
- single product item
  - non-stationary stochastic demand
- back orders if stock out
- negative orders not allowed
- zero delivery lead times



- fixed transportation cost b/w any *nodes*
- fixed ordering cost
- unit ordering cost
- unit holding cost
- service level constraint

Problem definition (cont'd)

- Objective
  - To minimise the expected total costs incurred - these include
    - vehicle routing costs
    - replenishment costs
    - inventory costs
- Main *Ingredients*
  - a vehicle routing component, i.e. essentially
    - a Travelling Salesman Problem (if 1 vehicle)
    - a Clover Leaf Problem (if more than 1vehicle)
  - a Stochastic Lot Sizing component - at each retailer
- Inventory Control Policies
  - *ref.* J.H. Bookbinder and J.Y. Tan, *Management Science*, 34, 1096-1108, 1988
    - Static Uncertainty (SU)
    - Dynamic Uncertainty
    - Static-Dynamic Uncertainty (RS)

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    - **Static-Dynamic Uncertainty (RS)**

Literature

Deterministic

Authors	Year	Demand		Routing			Lot-sizing		Technique
		Static	Dynamic	TSP	VRP	IRP	EOQ	WW	
Anily & Federgruen	1990,1994	✓			✓		✓		
???	???		✓	✓				✓	
???	???		✓		✓			✓	
???	???		✓			✓		✓	

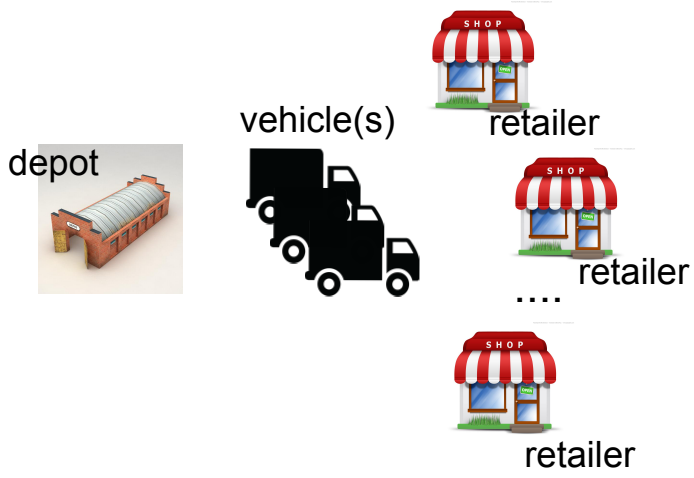
Stochastic

Authors	Year	Demand		Routing			Lot-sizing			Technique
		Stationary	Non stationary	TSP	VRP	IRP	SU	SDU	DU	
Adelman	2004	✓				✓			✓	MILP
Yu et al.	2012		✓			✓	✓			MDP

Notation

Numerical study

- network notation
  - depot: node 1
  - retailers: nodes 2,. . . ,6
- planning horizon
  - 12 periods
- demand
  - normally distributed
  - $\sigma/\mu = 0.2$
- initial stock
  - zero everywhere
- service level
  - $\alpha = 0.95$
- other parameters
  - $v = 0$
  - $h = 1$

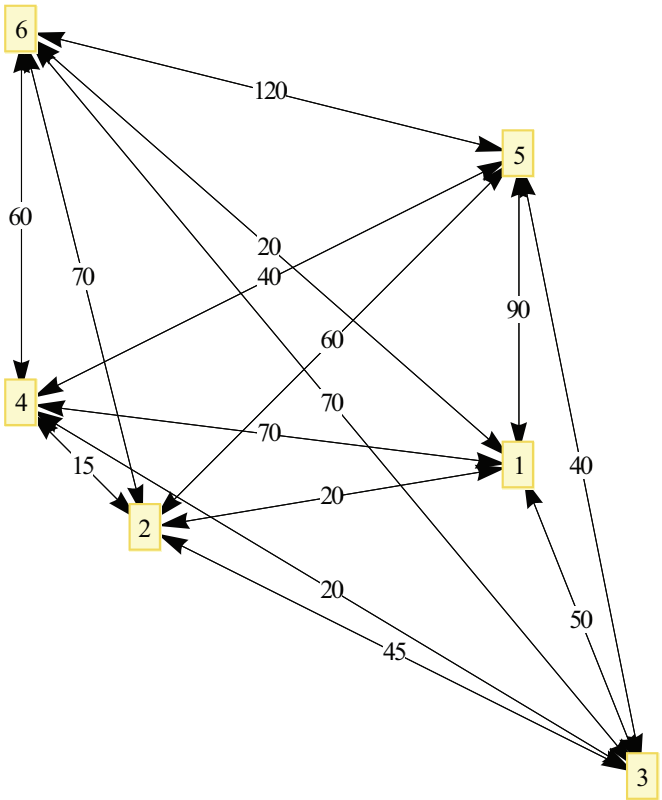


Problem data - mean values of demand (μ)

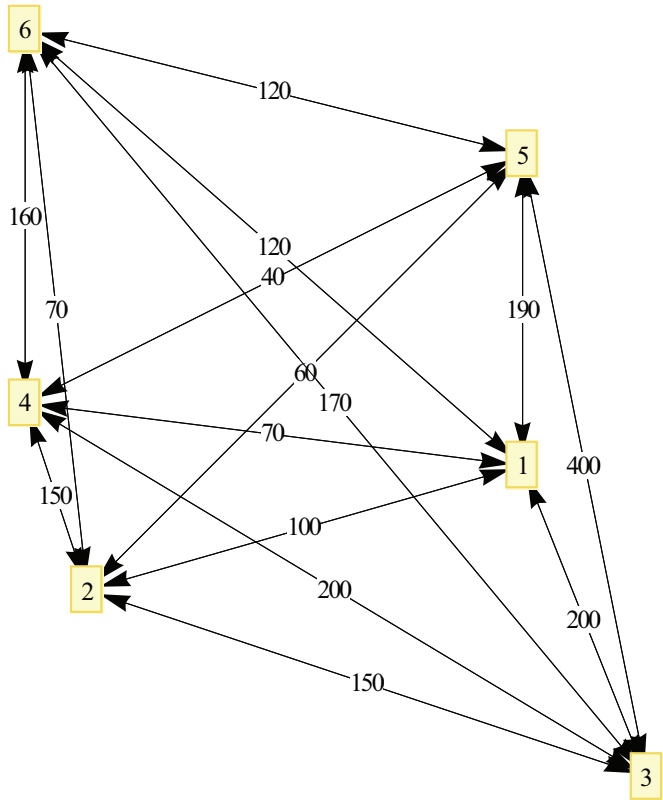
	Period											
Retailer	1	2	3	4	5	6	7	8	9	10	11	12
2	80	10	20	90	80	15	85	30	80	10	20	90
3	100	10	20	90	80	15	15	30	100	10	20	90
4	80	100	20	120	80	135	65	30	100	10	20	190
5	80	10	20	90	230	15	65	30	100	10	20	90
6	80	10	20	90	80	15	85	30	100	10	20	190

Problem data - fixed transportation costs

Intance 1



Instance 2



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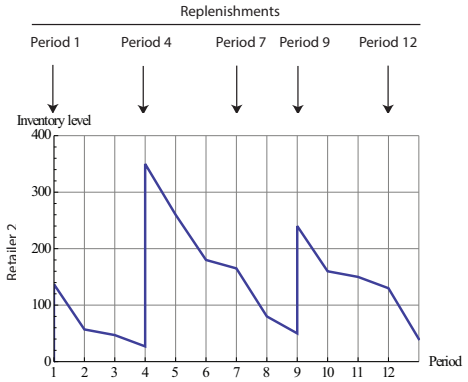

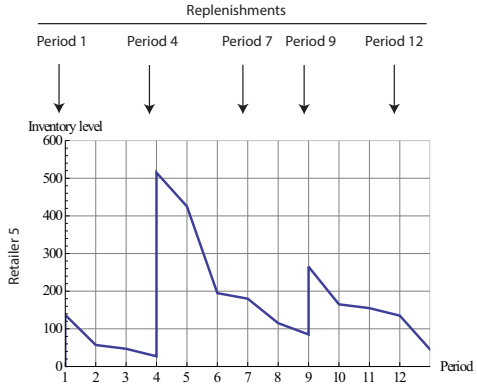

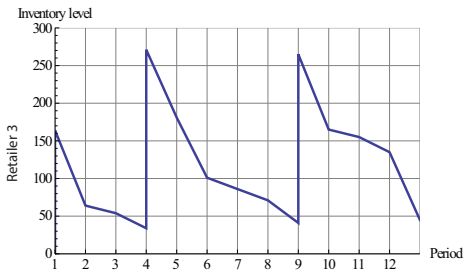

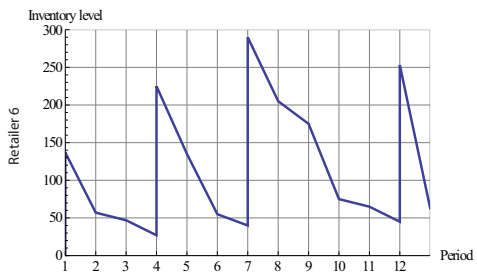

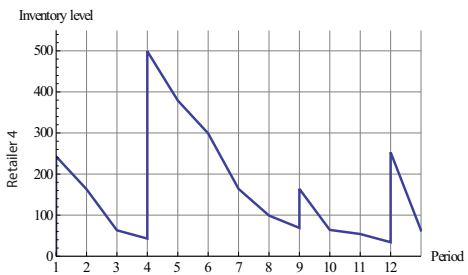

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Solution time: 20s (R)
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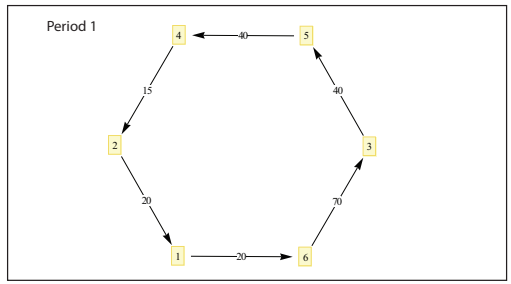

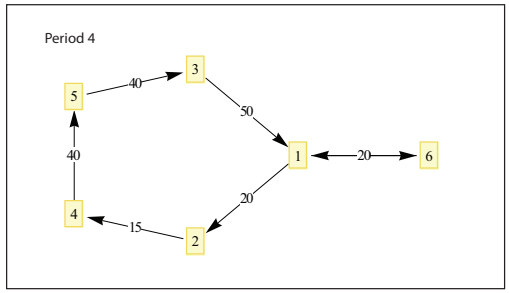

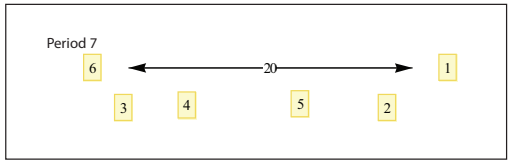

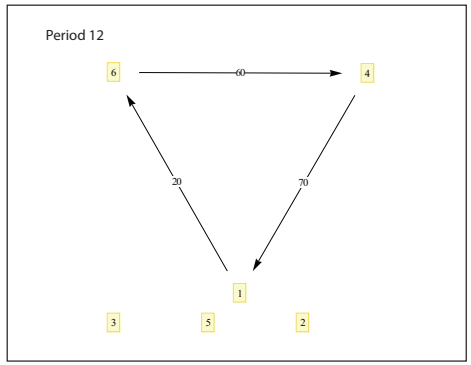

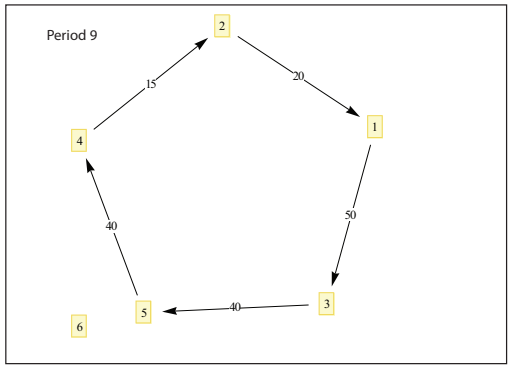

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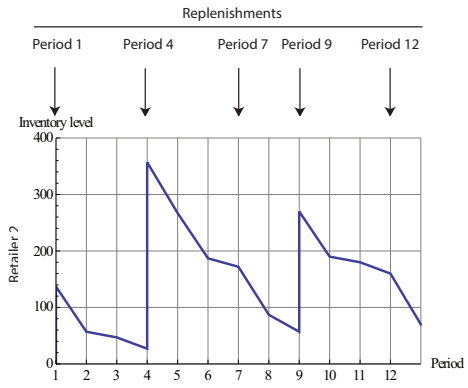
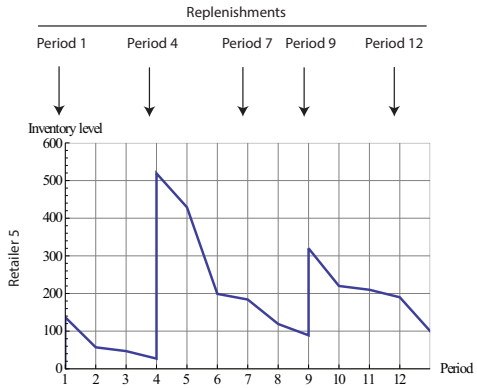
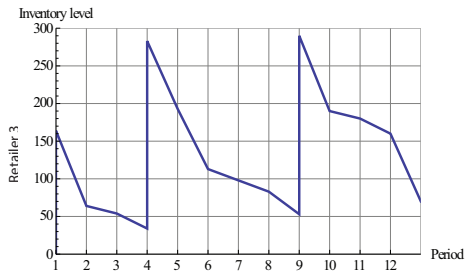
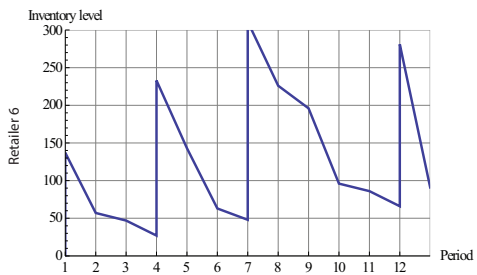
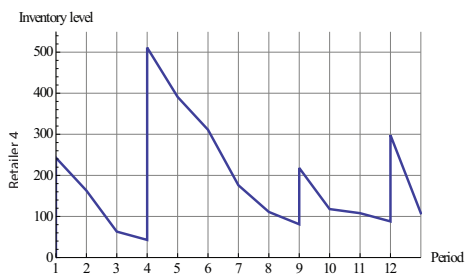




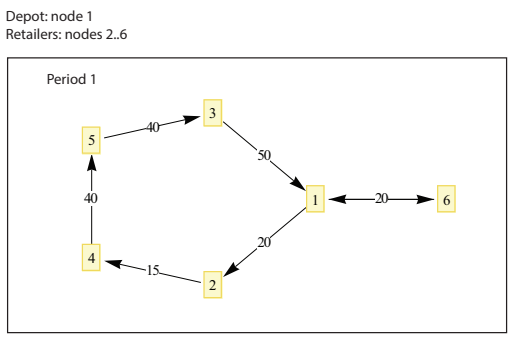


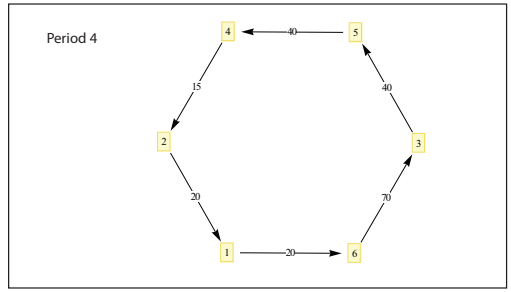


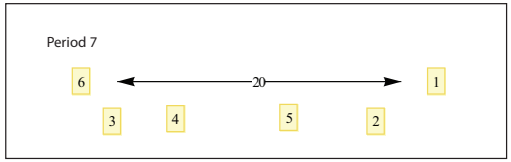


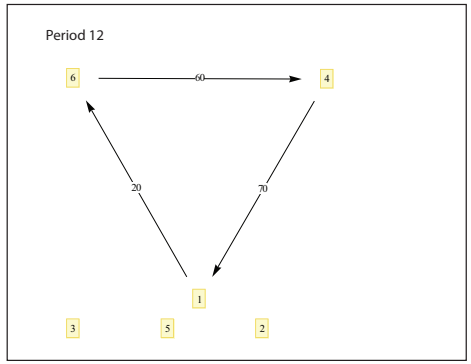
E[TRC]: 16836

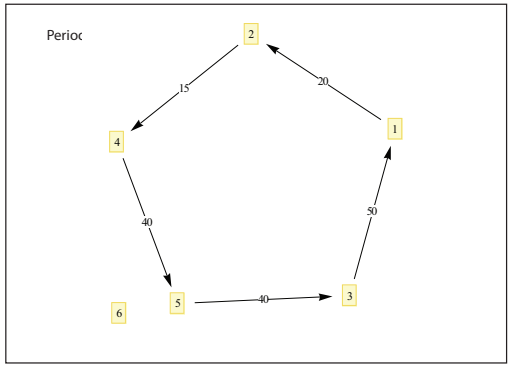
Solution time: 10.78s



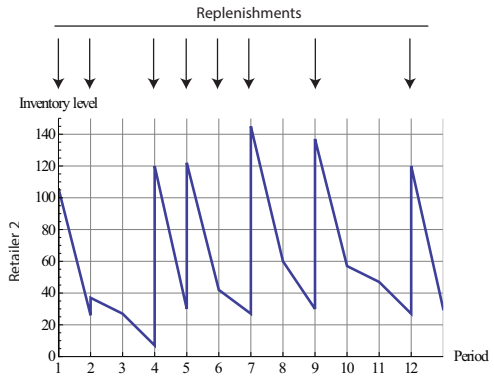


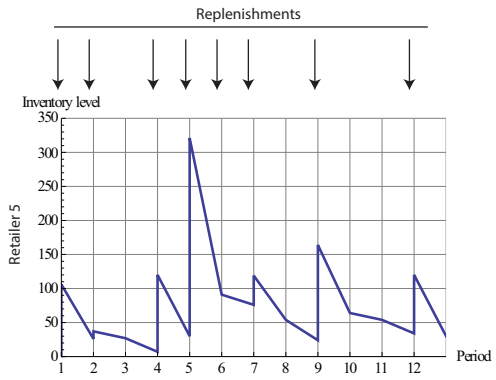


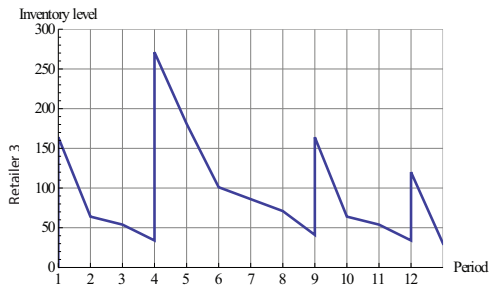


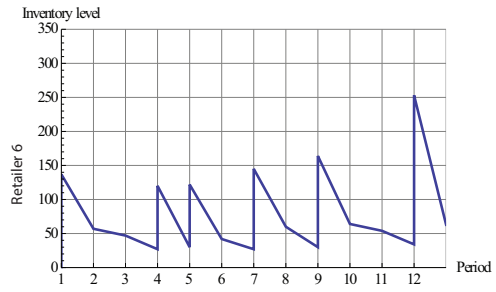


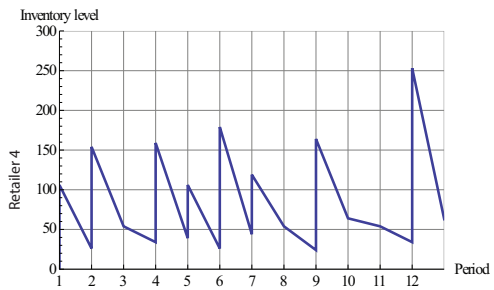
RS: Instance 2

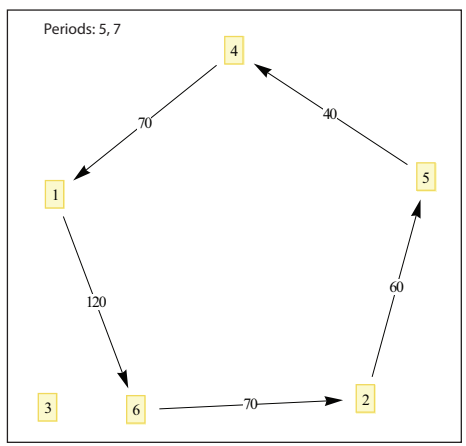


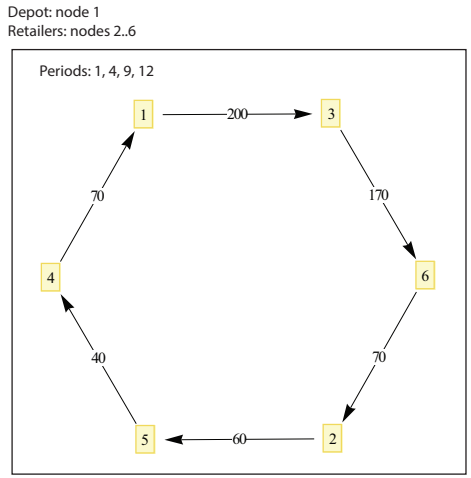


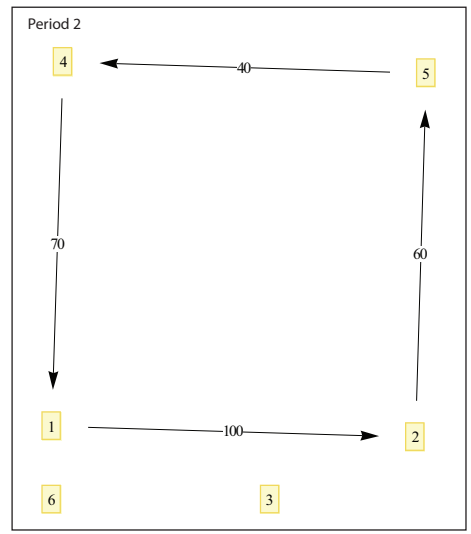


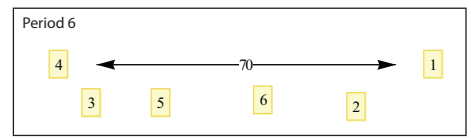








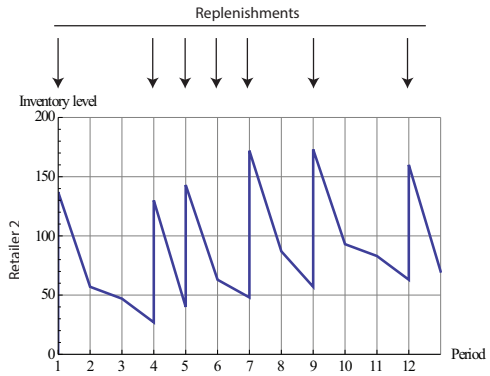


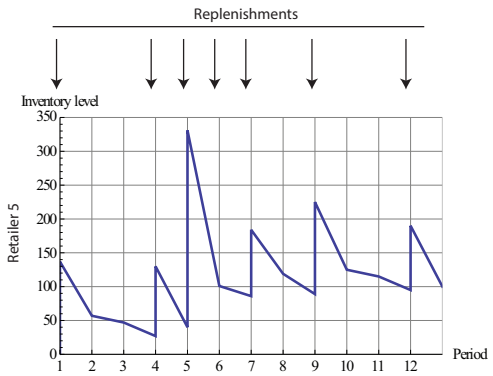


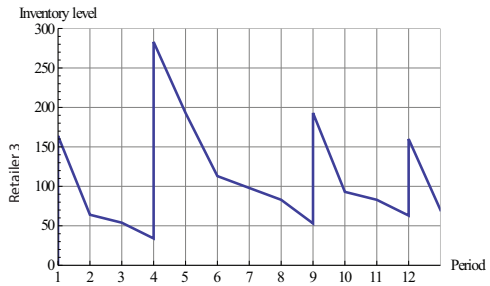
E[TRC]: 6362

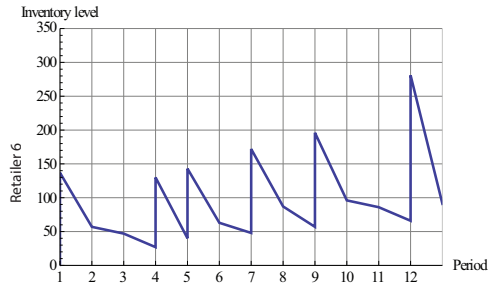
Solution time: 2293s (R)
850s

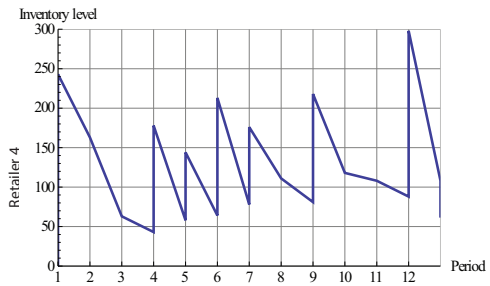
SU: Instance 2

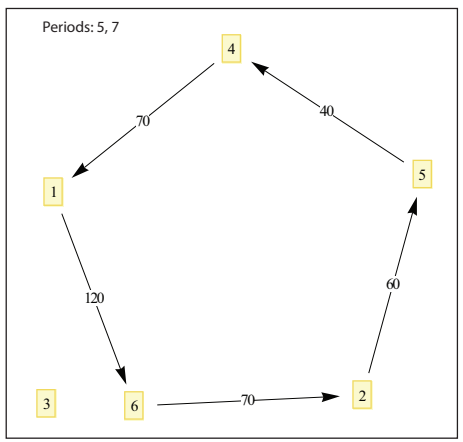


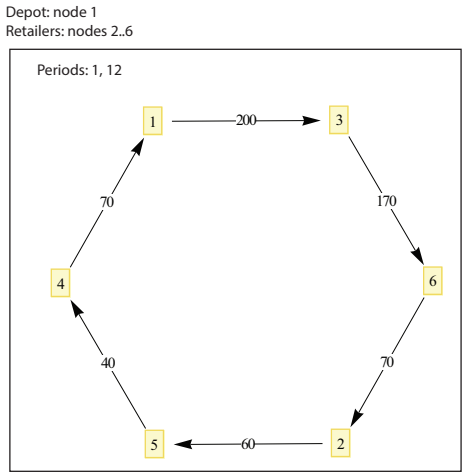


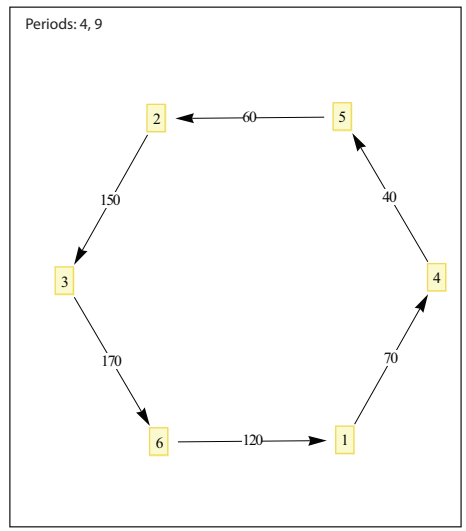


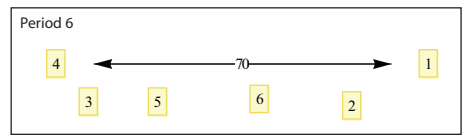












E[TRC]: 7885

Solution time: 62.59s

Ongoing Work

- Experimental campaign being completed
- So far - RS up to 30% better than SU
- Delivery lead times being incorporated