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Blood product inventory management using stochastic programming and Lagrangean decomposition

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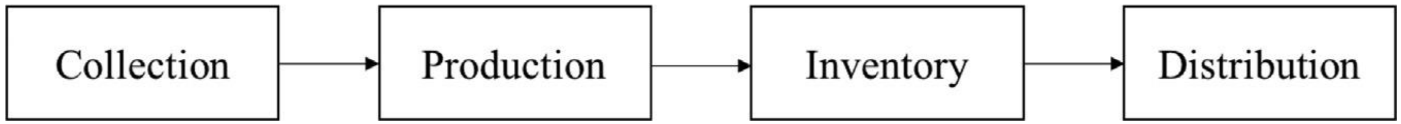
The blood supply chain (BCS)



Dillon et al. (2017)

- this study will focus on platelet inventory management
- platelets are used for example in cancer treatments and to prevent and treat bleeding
- different-aged platelets are used for different purposes

Challenges in managing the platelet SC

- short shelf life (3-5 days), high outdate rate
- processing and inventory management is expensive
- throwing products away is morally problematic
- a shortage may lead to loss of life
- **a bias**: satisfy demand but keep costs (outdate rate) low simultaneously

Modelling the inventory mathematically

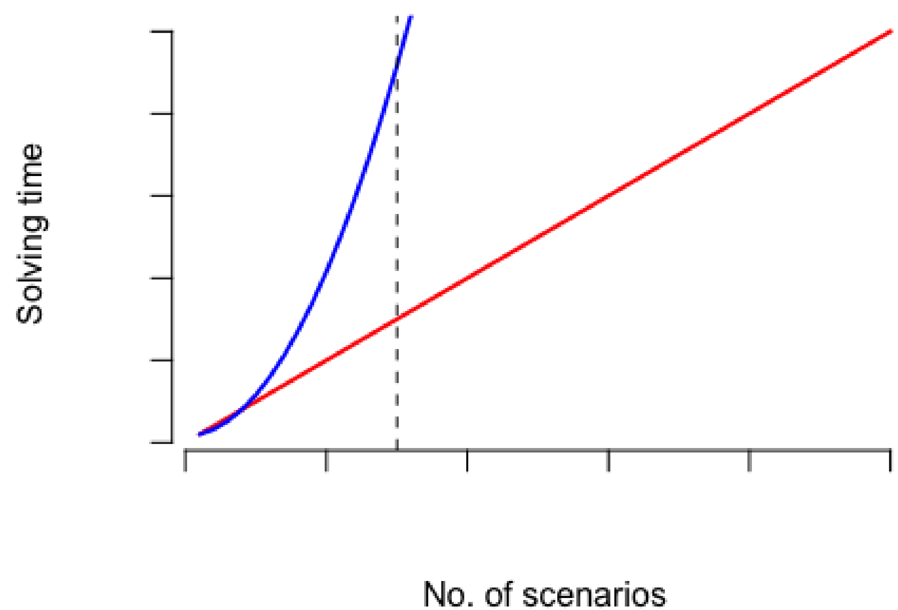
- 2SSP = two-stage stochastic programming
- uncertain, stochastic demand
  - often modelled as a Poisson process
  - many possible realizations (scenarios)
- two stages of decisions (decision variables)
  - ones before the realization of demand: target inventory level
  - ones afterwards: shortage, substitution, order amount

Modelling the inventory mathematically

- a Julia program for simulating the inventory is already available
- alternative policies for inventory management
  - when to order? how much to order?
- objective function: total expected costs
- constraints, for example
  - maximum allowed shortage rate
  - all items are either used or discarded

Challenges in optimizing the problem

- solving time grows very fast as the complexity increases
- could the problem be solved for each scenario separately?
  - the required time would only grow linearly
  - parallelization could be used
- this will be the main focus of the study



Lagrangean decomposition

- let first-stage variables *(x)* depend on scenarios

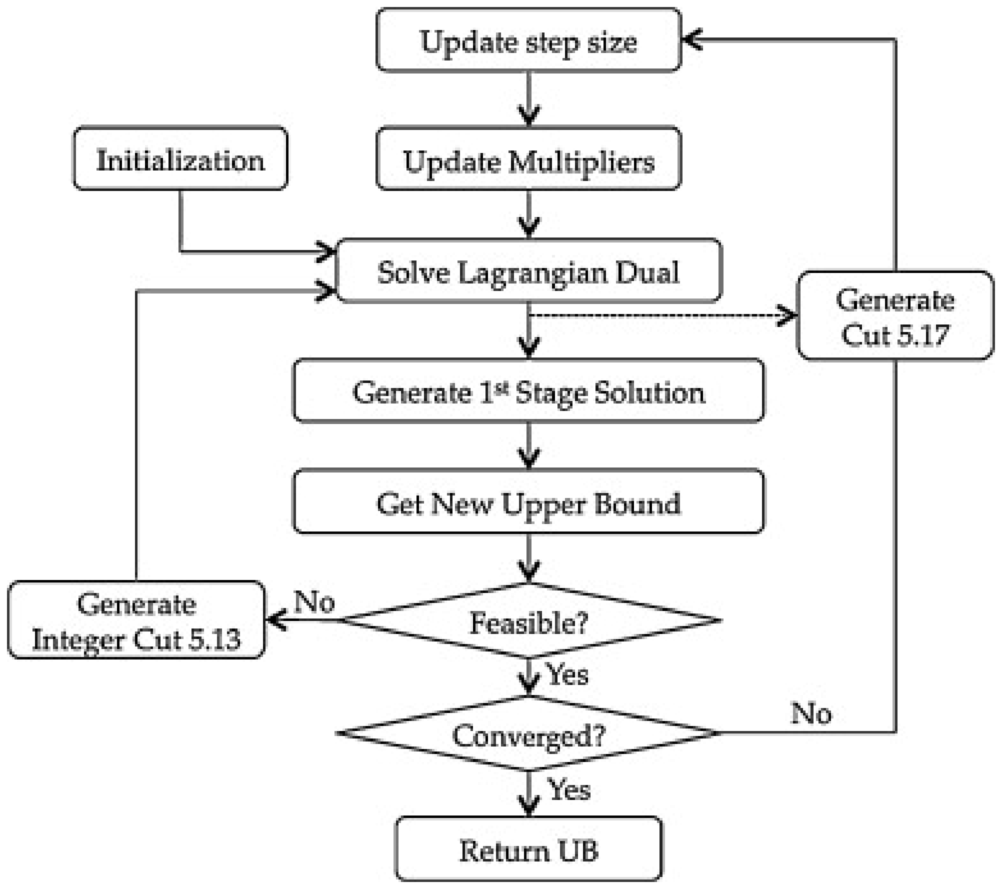
$$z = cx + \sum_{\xi} p^{\xi} q y^{\xi} \rightarrow z = \sum_{\xi} p^{\xi} (c x^{\xi} + q y^{\xi})$$

  - an extra constraint is needed: $x^i = x^j \; \forall \, i,j \in \Xi$
- transform the problem into maximization of the lower bound (Lagrangean dual):

$$max.\, D(\lambda) = max.\, \{min.\; z + \sum_{\xi=2}^{|\Xi|} \lambda^{\xi} (x^1 - x^{\xi})\}$$

- D(λ) can be separated into $|\Xi|$ independent subproblems

An algorithm for solving the Lagrangean dual problem (Oliveira et al., 2013)



Key dates

- presentation of the topic 14.06.2019
- the algorithm implemented by August 2019
- writing the thesis June-August 2019
- results and the thesis ready in September 2019

Literature and references

- Oliveira et al.: A lagrangean decomposition approach for oil supply chain investment planning under uncertainty with risk considerations (2012)
- Dillon et al.: A two-stage stochastic programming model for inventory management in the blood supply chain (2016)
- Civelek et al.: Blood platelet inventory management with protection levels (2015)