STOCHASTIC MULTICOMMODITY INVENTORY LOCATION PROBLEM

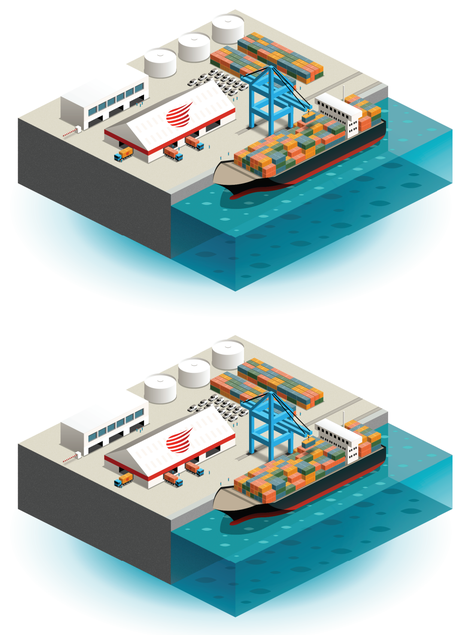
gustavojf88
gustavobittencourt
gbittencourt
email@gustavo.im

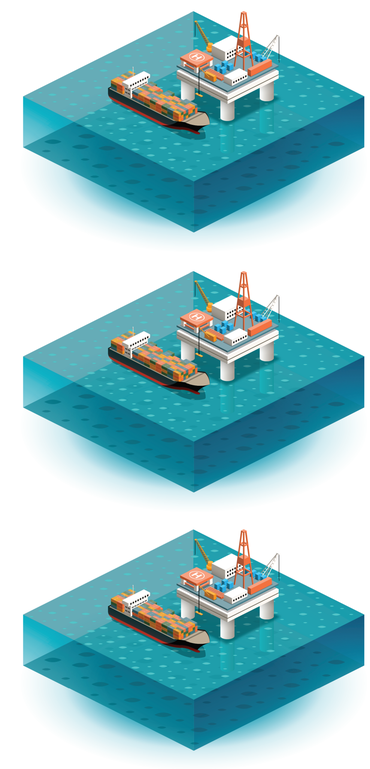
Gustavo Cunha de Bittencourt • Virgílio José Martins Ferreira Filho • Laura Silvia Bahiense da S. Leite

Production Engineering Program – Federal University of Rio de Janeiro – COPPE/UFRJ

The Problem

- Design a supply chain divided into three levels
- In this work: cargo transport model for offshore oil rigs
- Customers are the maritime units (MUs)
  - General Cargo
  - Diesel
  - Cements
  - Fluids
- Ports act as warehouses, receiving products from the accessible suppliers
  - Consolidate the cycle and safety stocks
- Mono or multi-purpose vessels
  - Routes should be drawn from one of the available ports





Current limitations

- Just one product
- Ignores supply policies and lead times
- Ignores setup times in the port

Formulation

Minimize
$$\sum_{j\in J} FJ_j w_j + \sum_{k\in K} FK_k z_k + \sum_{v\in V} FV_v q_v + \sum_{i\in I}\sum_{i'\in I}\sum_{v\in V} TB_{ii'} e_{ii'v} + \sum_{\xi\in\Omega} P(\xi)\left(\sum_{j\in J}\sum_{k\in K}\sum_{l\in L}\sum_{v\in V}\left(TA_{jk}+\frac{H_k}{2}\right)x^{\xi}_{jklv} + \sum_{l\in L} Ss^{\xi}_{l}\right) \quad (1)$$

Subject to
$$\sum_{j\in J}\sum_{k\in K}\sum_{v\in V} x^{\xi}_{jklv} = \sum_{k\in K} D^{\xi}_{l} y_{kl} - s^{\xi}_{l} \qquad \forall l\in L, \forall\xi\in\Omega \quad (2)$$
$$\sum_{k\in K} y_{kl} = 1 \qquad \forall l\in L \quad (3)$$
$$\sum_{k\in K}\sum_{l\in L}\sum_{v\in V} x^{\xi}_{jklv} \le CJ_j w_j \qquad \forall j\in J, \forall\xi\in\Omega \quad (4)$$
$$\sum_{j\in J}\sum_{l\in L}\sum_{v\in V} x^{\xi}_{jklv} \le CK_k z_k \qquad \forall k\in K, \forall\xi\in\Omega \quad (5)$$
$$\sum_{j\in J}\sum_{k\in K}\sum_{l\in L} x^{\xi}_{jklv} \le CV_v q_v \qquad \forall v\in V, \forall\xi\in\Omega \quad (6)$$
$$\sum_{k\in K}\sum_{i\in I} e_{kiv} \le 1 \qquad \forall v\in V \quad (7)$$
$$\sum_{i\in I}\sum_{v\in V} e_{ilv} = 1 \qquad \forall l\in L \quad (8)$$
$$u_{lv} - u_{l'v} + (|L|\cdot e_{ll'v}) \le |L| - 1 \qquad \forall l\in L, \forall l'\in L, \forall v\in V \quad (9)$$
$$\sum_{i'\in I} e_{ii'v} - \sum_{i'\in I} e_{i'iv} = 0 \qquad \forall i\in I, \forall v\in V \quad (10)$$
$$\sum_{i\in I} e_{kiv} + \sum_{i\in I} e_{ilv} - y_{kl} \le 1 \qquad \forall k\in K, \forall l\in L, \forall v\in V \quad (11)$$
$$x^{\xi}_{jklv}, s^{\xi}_{l}, u_{lv} \ge 0 \qquad \forall j\in J, \forall k\in K, \forall l\in L, \forall v\in V, \forall\xi\in\Omega \quad (12)$$
$$e_{ii'v} \ge 0 \qquad \forall i\in I, \forall i'\in I, \forall v\in V \quad (13)$$
$$w_j, z_k, q_v, y_{kl} \in \{0,1\} \qquad \forall j\in J, \forall k\in K, \forall v\in V \quad (14)$$

Nomenclature

Indices and sets

$j \in J$	Index and set of suppliers
$k \in K$	Index and set of warehouses
$l, l' \in L$	Indices and set of customers
$i, i' \in I$	Indices and set of second echelon locations ($I = K \cup L$)
$v \in V$	Index and set of vehicles
$\xi \in \Omega$	Index and set of scenarios

Parameters

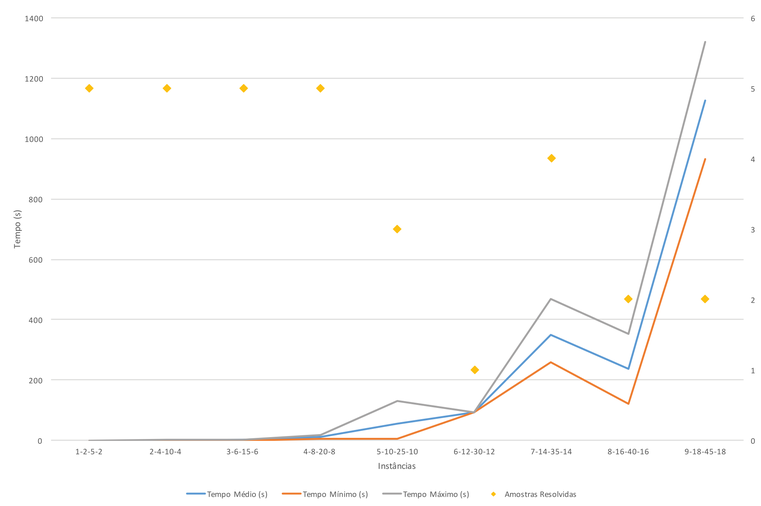
FJ_j	Fixed opening and operational cost of potential supplier j
FK_k	Fixed opening and operational cost of potential warehouse k
FV_v	Fixed leasing cost of vehicle v
TA_{jk}	First echelon transportation cost – from supplier j to warehouse k
$TB_{ii'}$	Second echelon transportation cost – between location i and location i'
H_k	Unit storage and handling cost in warehouse k
D^{ξ}_{l}	Demand of customer l in the scenario ξ
S	Unit shortage cost
CJ_j	Capacity of supplier j
CK_k	Capacity of warehouse k
CV_v	Cargo capacity of vehicle v
$P(\xi)$	Probability of occurrence of scenario ξ

Variables

w_j	Choice of suppliers: 1 if supplier j is used, 0 otherwise
z_k	Facilities opening: 1 if warehouse k is opened, 0 otherwise
q_v	Choice of vehicles: 1 if vehicle v is used, 0 otherwise
y_{kl}	Customers allocation: 1 if customer l is allocated to warehouse k, 0 otherwise
x^{ξ}_{jklv}	Number of items produced in supplier j and sent to warehouse k to meet the demand of customer l using vehicle v in scenario ξ
$e_{ii'v}$	Routes edges: 1 if location i precedes i' in the route of vehicle v, 0 otherwise
s^{ξ}_{l}	Number of missing items to customer l in scenario ξ
u_{lv}	Auxiliary variable of customer l to eliminate subtours of the route attended by vehicle v

Experiments and Results

Instance	Constraints	Variables	Binary	Nonzeros
1-2-5-2	87	149	113	507
2-4-10-4	501	1.205	834	4.741
3-6-15-6	1.543	4.477	2.751	18.247
4-8-20-8	3.513	11.753	6.452	48.489
5-10-25-10	6.711	25.301	12.525	104.851
6-12-30-12	11.437	47.869	21.558	198.637
7-14-35-14	17.991	82.685	34.139	343.071
8-16-40-16	26.673	133.457	50.856	553.297
9-18-45-18	37.783	204.373	72.297	846.379
10-20-50-20	-	-	-	-



Tools and Systems

python
PYOMO
GUROBI OPTIMIZATION

Next Steps

- Cover the limitations of the current model
- Decomposition and advanced solution methods
- Metaheuristics and hybrid methods (Matheuristics)
- Sampling and scenario generation
  - SAA
  - Moment matching
  - Random walks

COPPE UFRJ
LORDE