3.1 Sets

$c = \{1, 2, \ldots, C\}$	Set of carcass suppliers
$p = \{1, 2, \ldots, P\}$	Set of packing facilities
$s = \{1, 2, \ldots, S\}$	Set of cold storage facilities
$m = \{1, 2, \ldots, M\}$	Set of retailers
$\omega = c \cup p \cup s \cup m$	Set of all nodes
$vc = \{1, 2, \ldots, VC\}$	Set of vehicle types at 1st echelon
$vp = \{1, 2, \ldots, VP\}$	Set of vehicle types at 2nd echelon
$vs = \{1, 2, \ldots, VS\}$	Set of vehicle types at 3rd echelon
$vm = \{1, 2, \ldots, VM\}$	Set of vehicle types at 4th echelon
$t = \{1, 2, \ldots, T\}$	Set of periods

3.2 Parameters

de_{kt}	The demand for node k for red meat in period t ($k \in m$)
ho_{jt}	Inventory holding cost for node j in period t ($j \in p \cup s \cup m$)
vpc_{it}	Variable production cost at packing facility type i for produce red meat in period t ($i \in p$)
fpc_i	Fixed production cost at packing facility type i for produce red meat ($i \in p$)
sc_{it}	Supply cost at carcass supplier type i for supply carcass in period t ($i \in c$)
afc_j	Annual fixed cost for opening cold storage facility type j ($j \in s$)
$disa_{ij}$	The distance among nodes i and j ($i, j \in p \cup s$)
$disb_{jk}$	The distance among nodes j and k ($j, k \in s \cup m$)
$disc_{ik}$	The distance among nodes i and k ($i, k \in p \cup m$)
$disd_{ij}$	The distance among nodes i and j ($i, j \in c \cup p$)
$caps_j$	Holding capacity of cold storage facility type j for holding red meat ($j \in s$)
$capf_i$	Holding capacity of packing facility type i for holding red meat ($i \in p$)
$capr_k$	Holding capacity of retailer type k for holding red meat ($k \in m$)
thf_{it}	Maximum production capacity at packing facility type i in period t ($i \in p$)
thc_{it}	Maximum supply capacity at carcass supplier type i in period t ($i \in c$)
cva_{vp}	The storage capacity of vehicle type vp
cvb_{vs}	The storage capacity of vehicle type vs
cvc_{vc}	The storage capacity of vehicle type vc
cvd_{vm}	The storage capacity of vehicle type vm
vta_{vp}	Variable transport cost for vehicle type vp per unit distance
vtb_{vs}	Variable transport cost for vehicle type vs per unit distance
vtc_{vc}	Variable transport cost for vehicle type vc per unit distance
vtd_{vm}	Variable transport cost for vehicle type vm per unit distance
fta_{vp}	Fixed transport cost for vehicle type vp per trip
ftb_{vs}	Fixed transport cost for vehicle type vs per trip
ftc_{vc}	Fixed transport cost for vehicle type vc per trip
ftd_{vm}	Fixed transport cost for vehicle type vm per trip
nva_{vpt}	The number of vehicle type vp existing in period t
nvb_{vst}	The number of vehicle type vs existing in period t
nvc_{vct}	The number of vehicle type vc existing in period t
nvd_{vmt}	The number of vehicle type vm existing in period t
tn	The number of all available nodes
β	A coefficient converting the meat to carcass unit
I_{i0}	Initial inventory level of red meat in node i ($i \in p \cup m$)

3.3 Decision variables

ZS_j	1, if cold storage facility type j opened, 0, else ($j \in s$)
UA_{vpt}	1, if vehicle type vp is used in period t, 0, else
UB_{vst}	1, if vehicle type vs is used in period t, 0, else
UC_{vct}	1, if vehicle type vc is used in period t, 0, else
UD_{vmt}	1, if vehicle type vm is used in period t, 0, else
OP_{it}	1, if packing facility type i produces in period t, 0, else ($i \in p$)
XA_{ijvpt}	1, if arc (i,j) is visited by vehicle type vp in period t, 0, else ($i, j \in p \cup s$)
XB_{ikvct}	1, if arc (i,k) is visited by vehicle type vc in period t, 0, else ($i, k \in c \cup p$)
YA_{jkvst}	1, if arc (j,k) is visited by vehicle type vs in period t, 0, else ()
YB_{ikvmt}	1, if arc (i,k) is visited by vehicle type vm in period t, 0, else ($i, k \in p \cup m$)
XP_{it}	The quantity of red meat that facility type i produced in period t ($i \in p$)
QA_{ijvpt}	The quantity of red meat transferred among node i and j by the vehicle type vp in period t ($i, j \in p \cup s$)
QB_{ikvct}	The quantity of red meat transferred among node i and k by the vehicle type vc in period t ($i, k \in c \cup p$)
GA_{jkvst}	The quantity of red meat transferred among node j and k by the vehicle type vs in period t ($j, k \in s \cup m$)
GB_{ikvmt}	The quantity of red meat transferred among node i and k by the vehicle type vm in period t ($i, k \in p \cup m$)
I_{jt}	The inventory level at node j for red meat in period t ($j \in p \cup s \cup m$)
EA_{jt}	An auxiliary variable used for sub-tour elimination for cold storage facility type j in period t ($j \in s$)
EB_{kt}	An auxiliary variable used for sub-tour elimination for retailer type k at 3rd echelon in period t ($k \in m$)
EC_{it}	An auxiliary variable used for sub-tour elimination for packing facility type i in period t ($i \in p$)
ED_{kt}	An auxiliary variable used for sub-tour elimination for retailer type k at 4th echelon in period t ($k \in m$)