



















## Appendix 1 Notation

Table 1. Notations used in the mathematical model

<b>Sets and Indices</b>			
$I$	Set of commercial storage centers $i \in I$	$S$	Set of scenarios
$J$	Set of distribution centers $j \in J$	$R$	Set of transportation modes from storage centers to distribution centers $r \in R$
$K$	Set of demand points $k \in K$	$M$	Set of transportation modes from distribution centers to demand centers $m \in M$
<b>Parameters</b>			
$C_j$	Capacity of distribution center $j$	$Zar_m$	Capacity of transportation mode $m$ from distribution centers to demand centers
$Cap_i$	Capacity of storage site $i$	$NI$	Maximum number of open storage centers
$a_j^s$	Probability of lost capacity of distribution center $j$ under scenario $s$	$NJ$	Maximum number of required distribution centers
$b_i^s$	Probability of lost capacity of storage center $j$ under scenario $s$	$P^s$	Probability of scenario $s$ occurring
$d_k^s$	Demand of node $k$ under scenario $s$	$LP_{ij}^r$	Travel time for vehicle $r$ between nodes $i$ and $j$
$Kap_r$	Capacity of transportation mode $r$ from storage centers to distribution centers	$L_{jk}^m$	Travel time for vehicle $m$ between nodes $j$ and $k$
<b>Variables</b>			
$U_i$	Binary variable. Equals to 1 if storage center $i$ is open and zero otherwise.		
$Y_j$	Binary variable. Equals to 1 if distribution center $j$ is open and zero otherwise.		
$Xs_{jk}^{ms}$	Quantity of assigned commodity from distribution center $j$ to demand center $k$ with transportation mode $m$ under scenario $s$		
$NV_{ij}^{rs}$	Quantity of assigned commodity from storage center $i$ to distribution center $j$ with transportation mode $r$ under scenario $s$		