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Project Case Study

OUTLINE

Company ABC is seeking cost-effective solutions to meet current and possible demand from our distributors. Currently, the presented options are to increase capacity for our long-standing plants in Kansas City and Santiago, which both currently have a capacity of 60,000 units, or opening a new plant (or plants) in the recommended cities of Auckland, Birmingham, Frankfurt, Mumbai, and Singapore. Our team has worked diligently to compare the costs and efficiency of both options.

METHODOLOGY

We used prescriptive analytics for this problem, because we are attempting to determine the best course of action in a situation with many influential factors, such as our supply, cost to ship, demand, and potential one-time fixed costs. All of these factors can be considered and compared using prescriptive analytics and save hours of manual calculations with the use of AMPL coding.

ANALYSIS

ABC Co. is currently spending a best-case $210,570 on shipping to only a portion of our distributor's needs from plants that were built before current safety guidelines.

We calculated the current output by creating the following:

Parameters	Definition
S	= {KC, SA}
D	= {T, SH, MC, M, L, CA, AT}
C_{ij}	= Transportation cost between Plant i and DC j, $i \in I$, $j \in J$
Demand	= Demand at DC j, $j \in J$
Supply	= Supply capacity at the Plant i, $i \in I$
Variables	**Definition**
x_{ij}	Amount of product shipped from plant i to DC j
Formulas	**Definition**

Min: $\sum_i \sum_j C_{ij} * x_{ij}$	Minimize the cost of shipping from each plant to the distributors
s.t. $\sum_{j \in J} x_{ij} = S_i \ \forall i \in I$	The sum of the number of units at both locations is the supply
$\sum_{i \in I} x_{ij} <= D_j \ \forall j \in J$	The sum of the number of units demanded by each distributor is the demand
$x >= 0$	There can be no values less than 0

The table below shows the cost of shipping from our plants to our distributors, along with the capacity (or supply) of each plant and the demand of each distributor.

Distribution Center

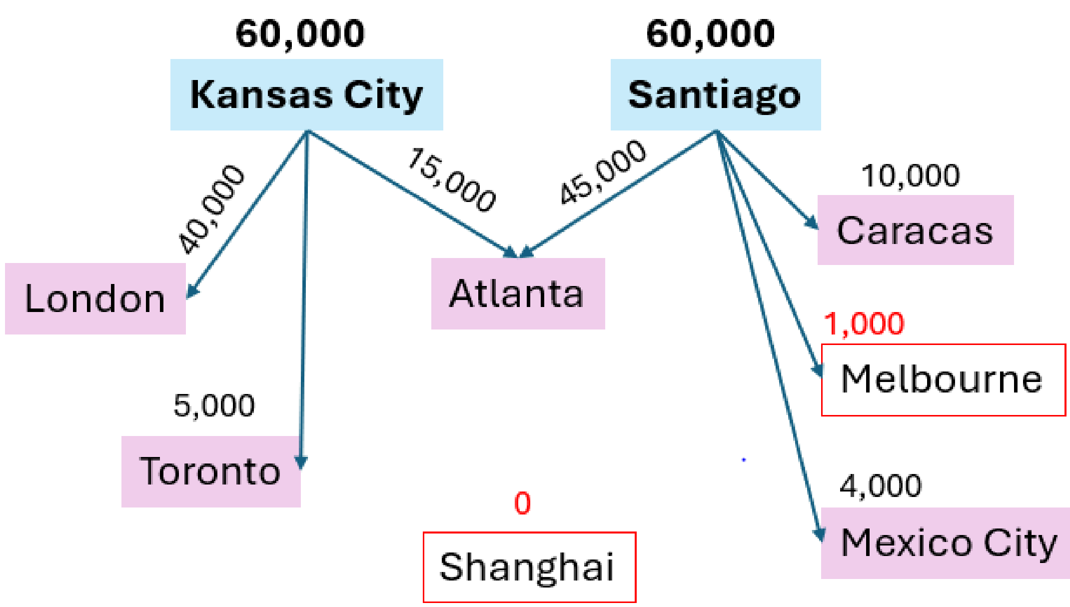
	Toronto	Shanghai	Mexico City	Melbourne	London	Caracas	Atlanta	Capacity
Kansas City	$1.79	$2.13	$1.76	$2.34	$1.86	$1.90	$1.82	60000
Santiago	$2.13	$2.03	$1.58	$1.80	$2.14	$1.26	$1.76	60000
Demand	5000	50000	4000	6000	40000	10000	60000	

With these numbers used in our cost matrix, we discovered that our current distribution is as follows:

```
Z = 210570

x :=
KC AT   15000
KC CA       0
KC L    40000
KC M        0
KC MC       0
KC SH       0
KC T     5000
SA AT   45000
SA CA   10000
SA L        0
SA M     1000
SA MC    4000
SA SH       0
SA T        0
;
```

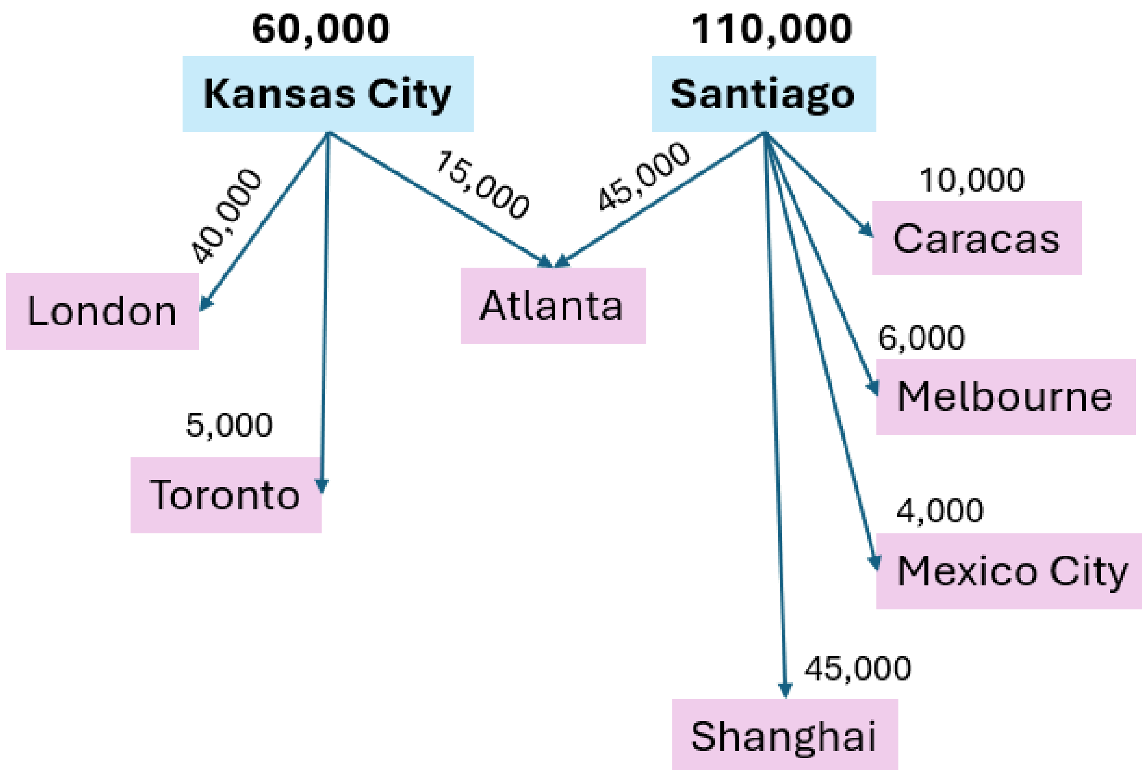
With a minimum cost of $210,570, we see that our manufacturing plant in Kansas City can reach Atlanta, London, and Toronto, while the Santiago plant reaches Atlanta, Caracas, Melbourne, and Mexico City. Neither can serve our distribution center in Shanghai (which has a demand of 50,000) and our distributor in Melbourne is only receiving a fraction of their demand (1,000 instead of 6,000). This leaves 55,000 units left unfulfilled.



Q2: Due to these limitations, we have reviewed the numbers provided to us from the Office of Planning and Efficiency (OPE), which would increase the capacity of Kansas City by 50,000 units (for a total of 110,000) or Santiago (also for a total of 110,000), with the one time associated cost of $2,590,000 and $2,061,000, respectively.

Parameters	Definition
S	= {KC, SA}
D	= {T, SH, MC, M, L, CA, AT}
C*ij*	= Transportation cost between Plant *i* and DC *j*, $i \in I, j \in J$
Demand	= Demand at DC *j*, $j \in J$
Supply	= Supply capacity at the Plant *i*, $i \in I$
FC	=Fixed cost at Plant *i*, $i \in I$
Variables	**Definition**
xij	Amount of product shipped from plant *i* to DC *j*
yi	=1 if plant i is operational, 0 otherwise
Formulas	**Definition**
Min: $\sum_{i \in S} yi{*}FCi + \sum_{i \in S}\sum_{j \in J} Cij{*}xij$	Minimize the cost of shipping from each plant to the distributors with one time fixed cost
s.t. $\sum_{j \in J} xij = 60000+50000{*}yi$	The sum of the number of units at both locations is the supply
$\sum_{i \in I} xij <= Dj \; \forall j \in J$	The sum of the number of units demanded by each distributor is the demand
$yKC+ySA >= 1$	Expanding one plant or the other
$x >= 0$	There can be no values less than 0

Our office found that the optimal increase would be with the Santiago plant, with a total associated cost of $2,371,920.



Q3: The second option suggested by OPE, was the creation of one or more plants. The cities chosen for analysis are Auckland, Birmingham, Frankfurt , Mumbai, and Singapore. Each location has new shipping costs associated with it and we are expected to maintain the Kansas City and Santiago plants at their current operational level. To simplify, we have only included the missing shipments (45,000 for Shanghai and 5,000 for Melbourne) with our hypothetical plants.

Parameters	Definition
S	= {AUC, BIR, FRA, MUM, SIN}
D	= {SH, M}
C*ij*	= Transportation cost between Plant *i* and DC *j*, $i \in I$, $j \in J$
Demand	= Demand at DC *j*, $j \in J$
Supply	= Supply capacity at the Plant *i*, $i \in I$

FC	=Fixed cost at Plant i, $i \in I$
Variables	**Definition**
xij	Amount of product shipped from plant i to DC j
yi	=1 if plant i is operational, 0 otherwise
Formulas	**Definition**
Min: $\sum i \in S\ yi*FCi + \sum i \in S \sum j \in J\ Cij*xij$	Minimize the cost of shipping from each plant to the distributors with one time fixed cost
s.t. $\sum j \in J\ xij = Si\ \forall i \in I$	The sum of the number of units at both locations is the supply
$\sum i \in I$ xij <= D$j\ \forall j \in J$	The sum of the number of units demanded by each distributor is the demand
$yAUC+yBIR+yFRA+yMUM+ySIN$>= 1	Building one or more new plant(s)
x>= 0	There can be no values less than 0

Our office has determined that covering the unfulfilled distribution will cost a minimum of $3,003,370, with new plants required in three new locations: Auckland, Mumbai, and Singapore. This would be a much more expensive option and our office recommends that this option not be chosen unless demand at our distributors is also expected to greatly increase in the next quarter.

```
Z = 3003370

x :=
AUC M      6000
AUC SH     9000
BIR M         0
BIR SH        0
FRA M         0
FRA SH        0
MUM M         0
MUM SH    25000
SIN M         0
SIN SH    16000
;

y [*] :=
AUC  1
BIR  0
FRA  0
MUM  1
SIN  1
```

Q4: Furthermore, our office has investigated the potential numbers if the Shanghai distribution center were to increase or decrease their demand. The table below demonstrates the cost for each option with each dummy demand: 20,000, 70,000, and 90,000 units supplied by either increasing capacity in our existing plants or building new plants.

	Shanghai Demand Estimates		
	20,000 units	70,000 units	90,000 units
Capacity Increase	$2,320,270	$5,014,170	$5,055,970
New Plant(s)	$1,905,390	$4,128,530	$5,123,130

Notably, at the 90,000 unit mark for Shanghai, even if all new locations were opened and running, they would fall 1,000 units short of meeting total demand of distributors and cost the highest price. For capacity expansion of our current facilities in Kansas City and Santiago, both plants would need to increase their capacity in order to meet a demand of 90,000 units from Shanghai. This is both less expensive than opening five new plants, and manages to meet the potential demand.

CONCLUSION

In conclusion, it is the recommendation from our office that ABC Company modify our existing plants in Santiago to meet demand. If we were to build new plants, that would save ABC revenue in the short term, but ignore the long term needs of our distributors, all of which will surely grow.

APPENDIX

Attached.