Total Hockey Optimizes Omnichannel Facility Locations

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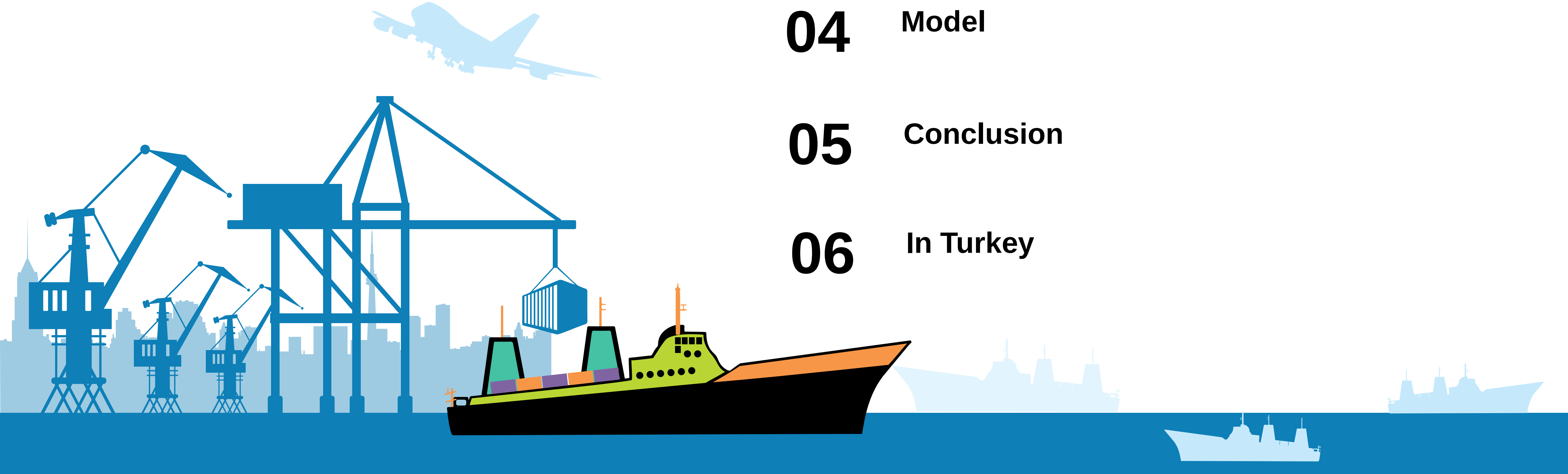
Content



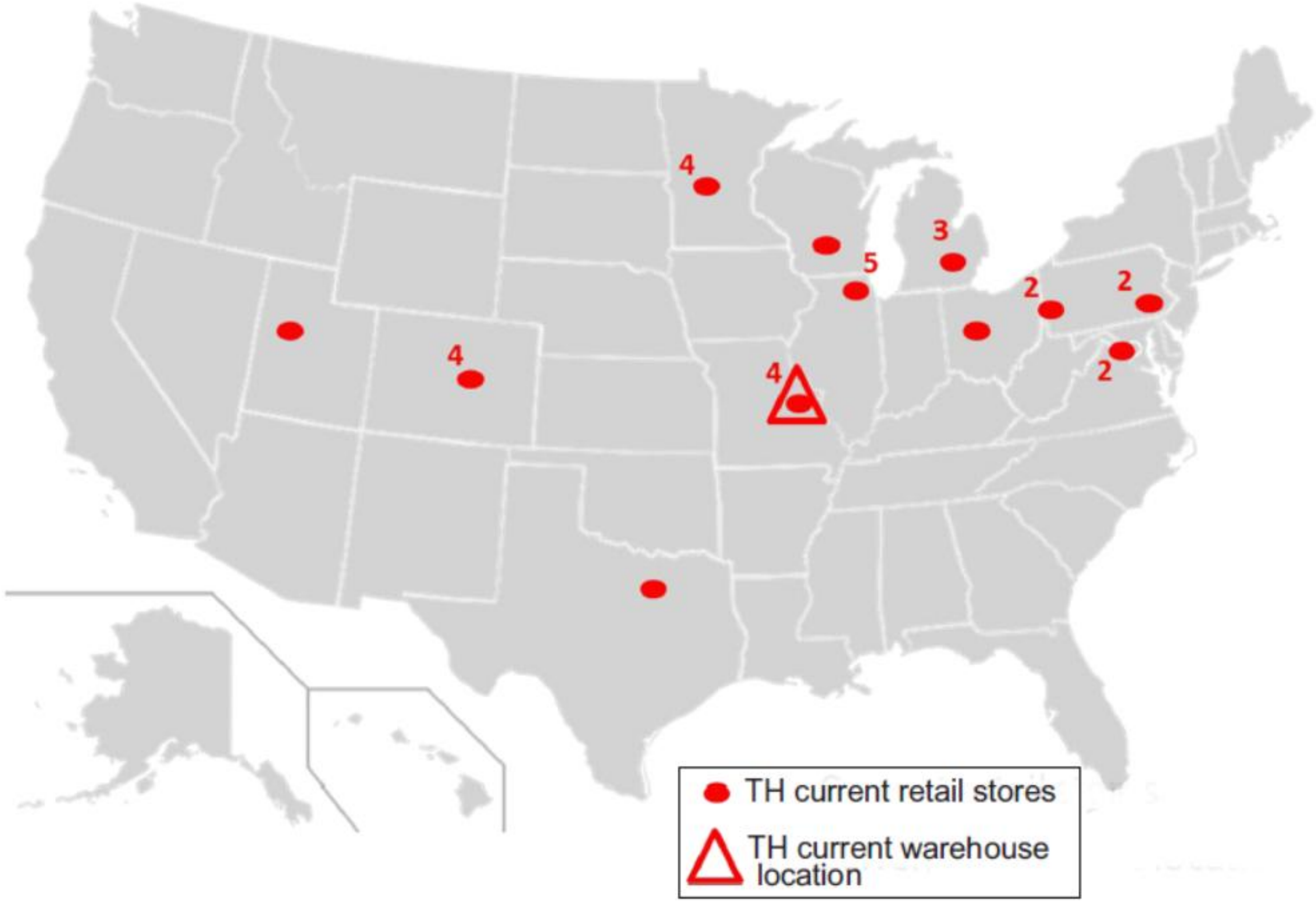
Introduction

TOTAL HOCKEY

- Total Hockey (TH) → a hockey equipment brick-and-mortar and e-commerce retailer that sought to locate omnichannel warehouses

- At the beginning of the study, TH operated 30 stores in 11 states, all served from a single warehouse in St. Louis

- TH expects to gain market share of e-commerce demand by positioning larger amounts of inventory close to the larger markets, which include the Northeast, Chicago, Minnesota and Detroit.



Note. The numbers indicate multiple stores in a city; for example, Chicago has five stores.

Problem Definition

→ One warehouse (St. Louis)

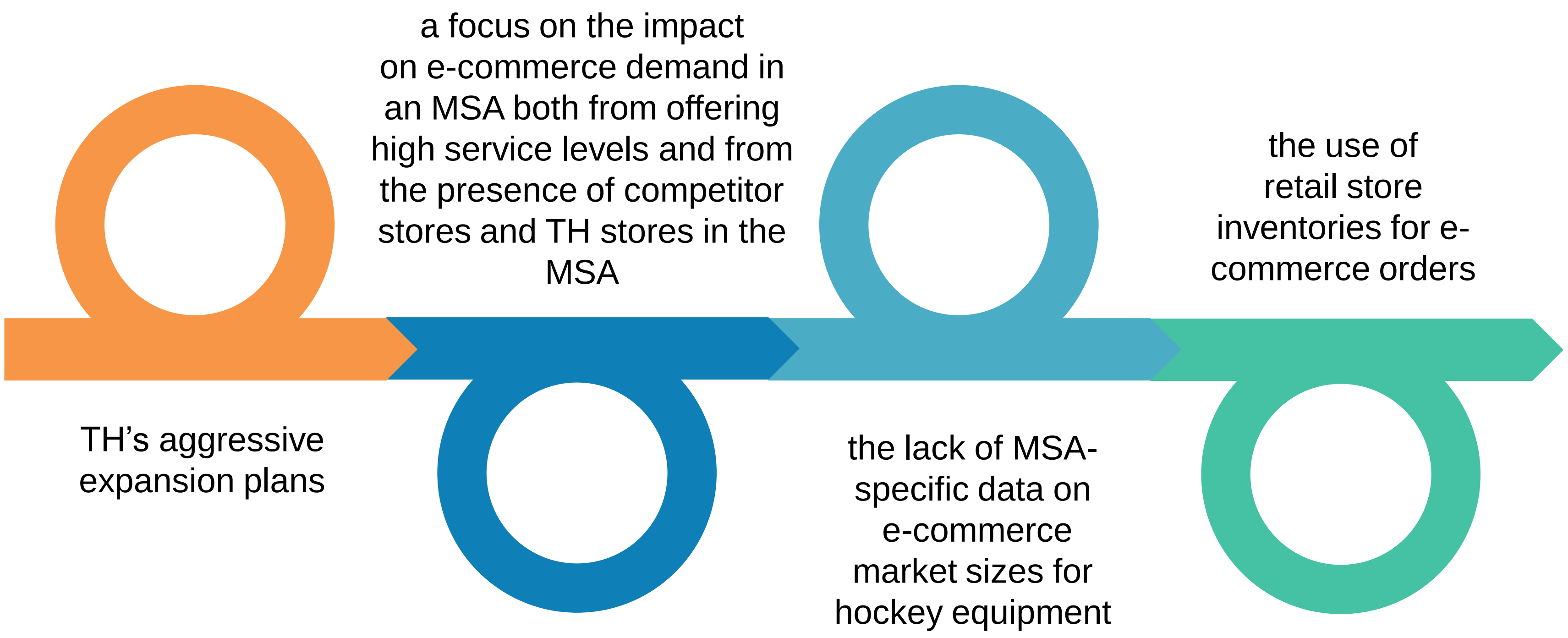
→Not enough retail stores

→Long delivery time

→Inefficient in e-commerce

→Low customer satisfaction

Important aspects of TH’s situation, which add complexity in the study



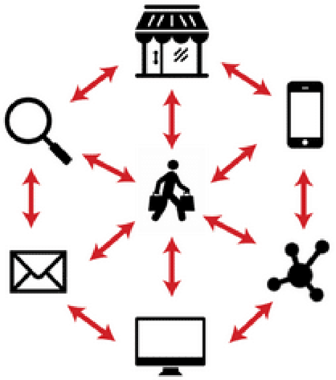
Objectives

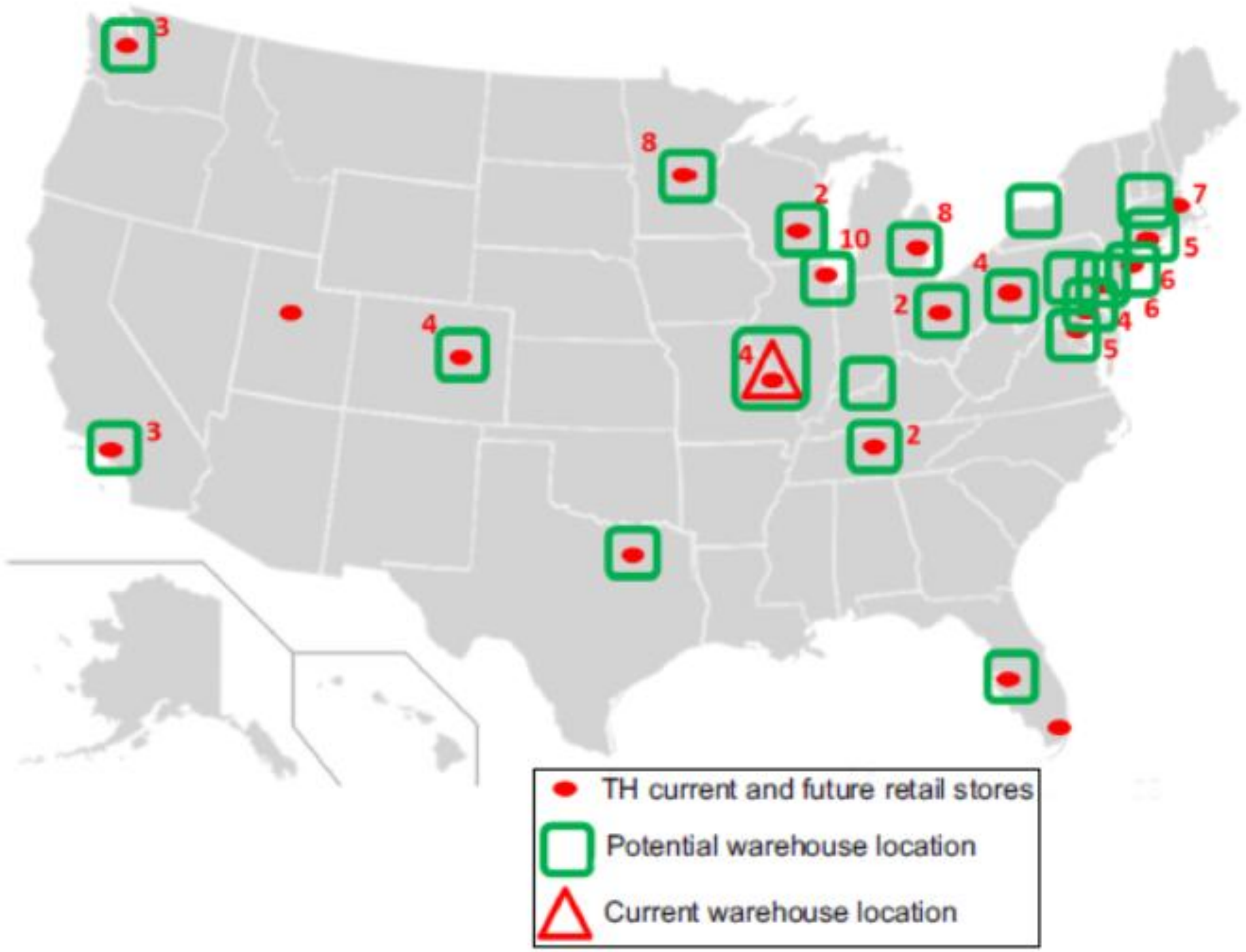
→**Maximize profit**
→**Redesign TH’s distribution system to serve 359 U.S. metropolitan statistical areas (MSAs) using an omnichannel warehouse location model**

01
Omnichannel Distribution Improvement

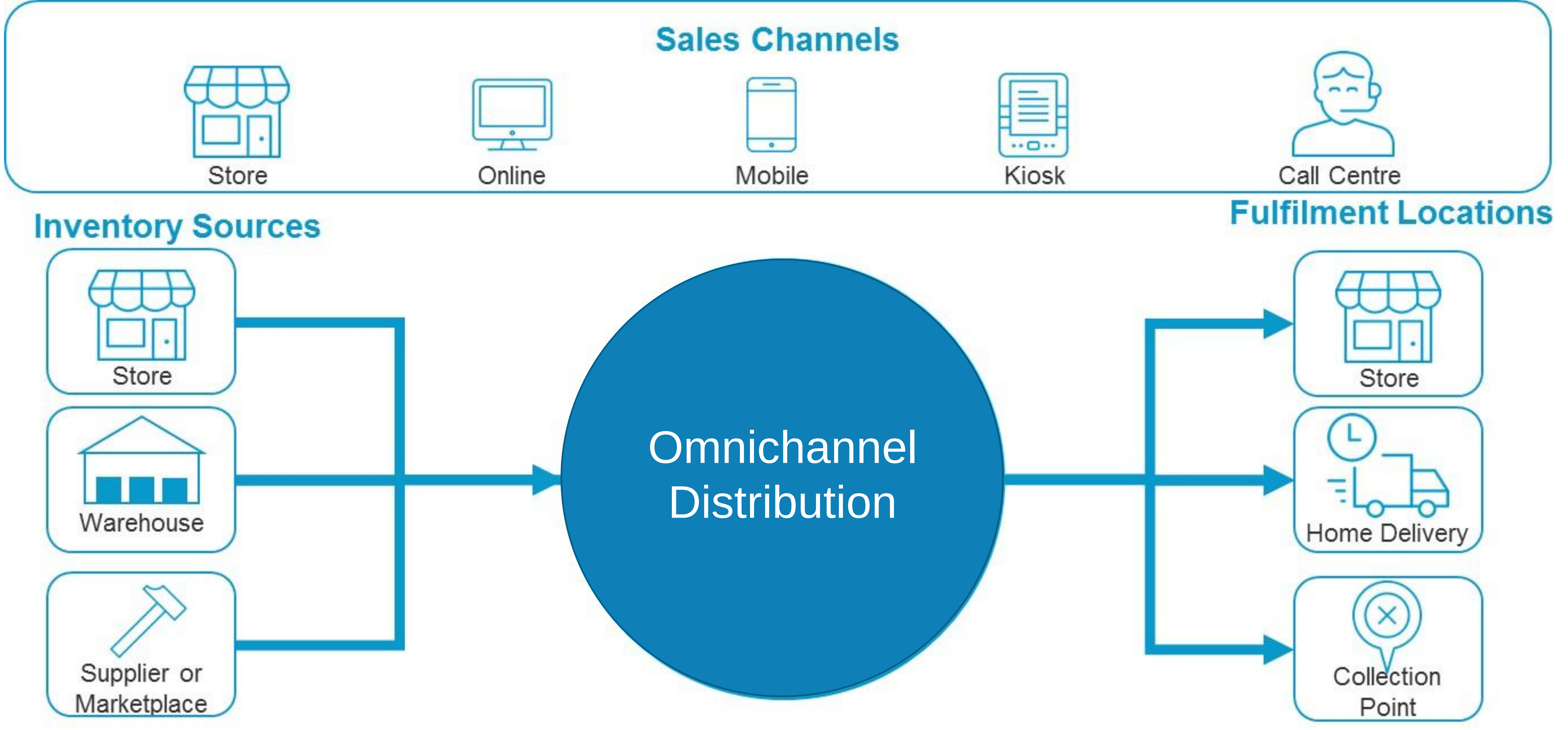
02
Decrease in Delivery Time

03
Increase in Customer Satisfaction





Note. The numbers indicate multiple stores in a city; for example, 10 stores are planned in Chicago.

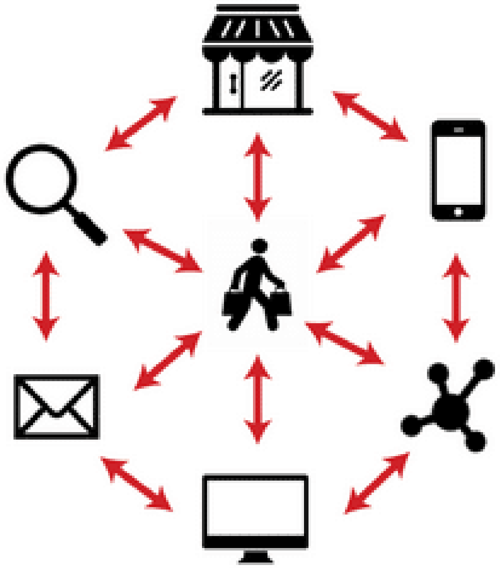

Sales Channels
Store
Online
Mobile
Kiosk
Call Centre
Inventory Sources
Fulfilment Locations
Store
Warehouse
Supplier or Marketplace
Omnichannel Distribution
Store
Home Delivery
Collection Point

Omnichannel Distribution

→One key concern in the omnichannel research literature is the channel selection decision of whether to fulfill e-commerce orders from dedicated e-commerce warehouses, the same warehouses that support retail stores, retail store inventories, or a combination of these sites.

→Results from a research show how the use of a dedicated e-commerce channel depends on the percentage of total demand that is e-commerce, the relative costs, the level of demand variation across customers, and the number of retail stores.

→The role of stores is evolving toward serving both in-store and online customers.



Market Share

→Key component of the study is the model for e-commerce market share that TH will capture in each MSA based on the market size, the service provided, and the presence of TH stores and competitor stores. Because this industry is dominated by privately held retailers that do not share data, we needed to estimate the e-commerce market size for each MSA. We accomplished this by combining industry-association data, census data, and internal data from TH sales.

600,000 hockey players

$600 million

20% e-commerce

891,000 e-commerce orders

Model

The formulation includes the following parameters:

p = gross profit per order for TH;
v = TH's hurdle rate;
γ_j^k = capacity in orders for a warehouse of size k at location j;
M_{ij} = e-commerce demand in orders per year from MSA i that will be captured if assigned to a facility at location j;
h_j^k = annual inventory holding costs for a warehouse of size k at location j;
a_j^k = annual operating costs for a warehouse of size k at location j;
f_j^k = one-time fixed costs to open a warehouse of size k at location j;
c_{ij} = parcel shipping cost for the average order ($ per order) to MSA i from a warehouse at location j;
d_{sj} = LTL shipping cost ($ per pallet) to MSA s from a warehouse at j;
b_s = number of pallets shipped to all TH stores in MSA s;
e_j^k = labor cost savings per TH store from having a warehouse of size k at location j; and
q_j = number of TH retail stores in proximity to a warehouse at location j.

$Y_{ij} = 1$ if MSA i is served by a facility at location j;
$X_j^k = 1$ if a facility of size k is open at location j, $k = \{1, 2, 3, 4, 5\}$;
$Z_{sj} = 1$ if stores in MSA s are served by a facility at location j;

$$O_i = 891{,}000 \cdot \frac{\text{no. of hockey players in MSA } i \times \text{median income of MSA } i}{\sum_i \text{no. of hockey players in MSA } i \times \text{median income of MSA } i}.$$

$$M_{ij} = O_i\left[\frac{1}{T_{ij} \times F} - \alpha_i \times L_i + \beta_i \times G_i\right].$$

$$A_{ij} = (p - c_{ij})M_{ij} \times \sum_{t=1}^{5} \frac{1}{(1+v)^t};$$

$$B_{jk} = [q_j e_j^k - (a_j^k + h_j^k)] \times \left[\sum_{t=1}^{5} \frac{1}{(1+v)^t}\right] - f_j^k;$$

$$C_{sj} = b_s d_{sj} \times \sum_{t=1}^{5} \frac{1}{(1+v)^t}.$$

→**Solver Premium Platform with the large-scale LP/IP solver.**

$$\max \sum_{i,j} A_{ij} Y_{ij} + \sum_{k,j} B_{jk} X_j^k - \sum_{s,j} C_{sj} Z_{sj} \tag{A.1}$$

$$\text{subject to } \sum_j Y_{ij} = 1, \quad \forall\, i; \tag{A.2}$$

$$Y_{ij} \le \sum_k X_j^k, \quad \forall\, i, j; \tag{A.3}$$

$$\sum_j Z_{sj} = 1, \quad \forall\, s; \tag{A.4}$$

$$Z_{sj} \le X_j^4 + X_j^5, \quad \forall\, s, j; \tag{A.5}$$

$$\sum_i M_{ij} Y_{ij} \le \sum_k \gamma_j^k X_j^k, \quad \forall\, j; \tag{A.6}$$

$$\sum_k X_j^k \le 1, \quad \forall\, j; \tag{A.7}$$

$$Y_{ij} \in \{0, 1\}, \quad \forall\, i, j; \tag{A.8}$$

$$X_j^k \in \{0, 1\}, \quad \forall\, j, k; \tag{A.9}$$

$$Z_{sj} \in \{0, 1\}. \quad \forall\, s, j. \tag{A.10}$$

Result of Sensitivity Analysis

F	Minneapolis	Chicago	Detroit	Philadelphia	No. of orders	Profit ($ millions) ($)	Average no. of delivery days
1.5	125,000	50,000	50,000	250,000	431,967	27.146	1.66
1.6	125,000	X	125,000	125,000	374,881	25.078	1.86
1.7	125,000	X	125,000	125,000	367,829	23.985	1.78
1.8	50,000	125,000	50,000	125,000	350,000	22.338	1.81
1.9	50,000	125,000	50,000	125,000	343,971	21.529	1.80
2.0	50,000	125,000	50,000	125,000	332,460	20.043	1.77
2.1	X	125,000	50,000	125,000	300,000	18.928	1.89
2.2	50,000	125,000	X	125,000	299,956	18.450	1.74
2.3	50,000	X	125,000	125,000	294,915	17.613	1.72
2.4	50,000	X	125,000	125,000	287,215	16.609	1.70
2.5	50,000	50,000	125,000	25,000	245,469	15.549	2.03
2.6	50,000	50,000	125,000	X	225,000	15.366	2.17
2.7	50,000	50,000	125,000	X	221,659	14.896	2.10
2.8	50,000	50,000	125,000	X	215,844	14.146	2.10
2.9	50,000	50,000	125,000	X	210,430	13.446	2.10
3.0	75,000	X	125,000	X	200,000	12.967	2.19
3.1	50,000	X	125,000	25,000	199,893	12.612	2.14
3.2	50,000	X	125,000	25,000	200,000	12.610	2.11
3.3	50,000	X	125,000	25,000	198,614	12.404	2.06
3.4	X	50,000	125,000	X	175,000	11.966	2.24
3.5	50,000	X	125,000	X	175,000	11.827	2.25
3.6	50,000	X	125,000	X	175,000	11.811	2.21
3.7	50,000	X	125,000	X	174,545	11.727	2.15
3.8	50,000	X	125,000	X	171,500	11.332	2.15
3.9	50,000	X	125,000	X	168,612	10.956	2.15
4.0	50,000	X	125,000	X	165,868	10.599	2.15

Note. X represents a location not selected by the model.

Table 3. Results for Orders, Locations, and Cost Components Vary Considerably with Changes in the Market Share Factor F

	$F = 2$	$F = 3$	$F = 4$
No. of orders	332,460	200,000	165,868
Locations	Min, Chi, Det, Phil	Min, Det	Min, Det
Five-year NPV inventory holding cost ($1,000) ($)	14,921	7,265	5,800
Five-year NPV e-commerce delivery cost ($1,000) ($)	11,798	7,439	6,196
Five-year NPV facility operating cost ($1,000) ($)	7,892	4,448	3,833
Five-year NPV store support delivery cost ($1,000) ($)	1,558	1,643	1,643
Warehouse opening cost ($1,000) ($)	349	228	199
Total cost ($1,000) ($)	36,518	21,024	17,671
Inventory holding cost per order ($)	0.409	0.346	0.328
E-commerce delivery cost per order ($)	0.323	0.354	0.351

Conclusion

Network design depends on the fulfillment strategy regarding the use of inventory from retail stores.

Although many e-commerce omnichannel strategies include shipping orders from the backrooms of individual stores at the beginning, if orders contain more than one item, the probability of having the right inventory in any one store can be very low. Where practical, bringing items from retail stores back to an omnichannel warehouse can be beneficial.

Optimal omnichannel warehouse locations depend on the level of e-commerce demand and on economies of scale in inventory and operating costs.

Sensitivity analysis with a comprehensive distribution-system design model can help clarify trade-offs and identify key parameters, especially in the face of uncertainty and in competitive environments where market capture and competitor responses are uncertain.

Suggestion

→If the delivery time is less than one day, they continue to use land transportation. If the delivery time takes more than one day, air shipping can be used to decrease the average delivery time and increase the profit.

→Lagrangian Relaxation Algorithm (Yu, 2015)

Example in Turkey

DeFacto

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Thank You