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Using Omnichannel Sales Data Analytics to Decide Between Store and Distribution Center Fulfillment Options

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USING OMNI-CHANNEL SALES DATA ANALYTICS TO DECIDE BETWEEN STORE AND DISTRIBUTION CENTER FULFILLMENT OPTIONS

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OMNI-CHANNEL RETAILING

Single Channel

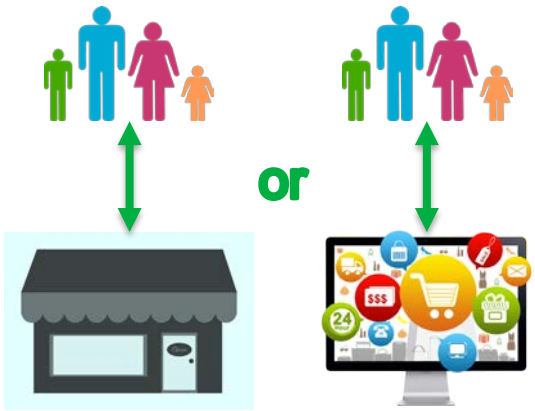
- Brick-and-mortar stores (offline) or Web stores (online)
- Buy from store or ship from fulfillment center

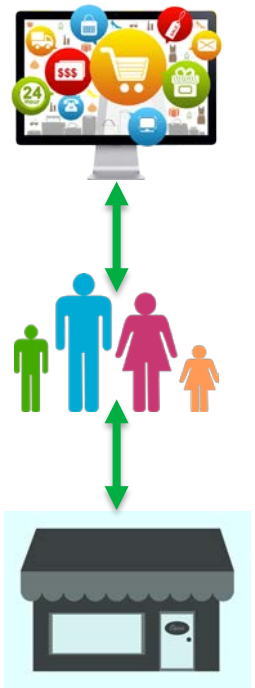
Multi-Channel

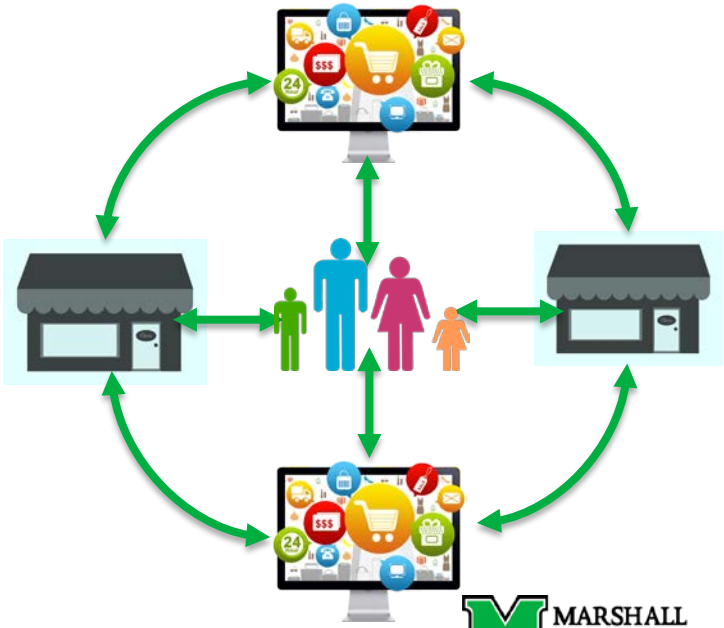
- Digital revolution
- Both offline and online
- Interactive but separate channels
- Buy from store or ship from fulfillment center

Omni-Channel

- Integrated channels providing seamless retailing experiences
- Centralized management
- Buy from store or ship from fulfillment center
- Buy online fulfill from store







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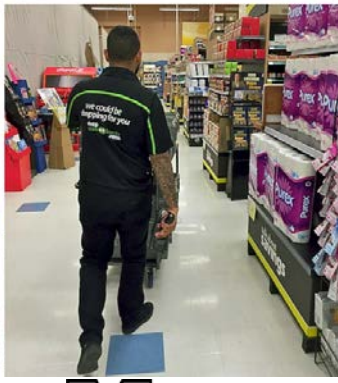
E-FULFILMENT AND DISTRIBUTION

Melacini, Perotti, Rasini and Tappia (2018) provided a comprehensive review on E-retailing and logistics system in Omni-channel retailing. In detail, these papers or research could be grouped into three categories.

- **Distribution network design**
  - Internet Fulfillment Center
  - Central warehouse + stores
- **Inventory and capacity management**
  - Inventory Assortment and cost
  - Inventory pooling and sharing
  - Replenishment Policies
- **Delivery planning and execution**
  - Last mile delivery
  - Buy online fulfill by store (BOFS)
    - Click and Collect
    - Click and Drive



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INSIDE ECOMMERCE GROWTH – WALMART

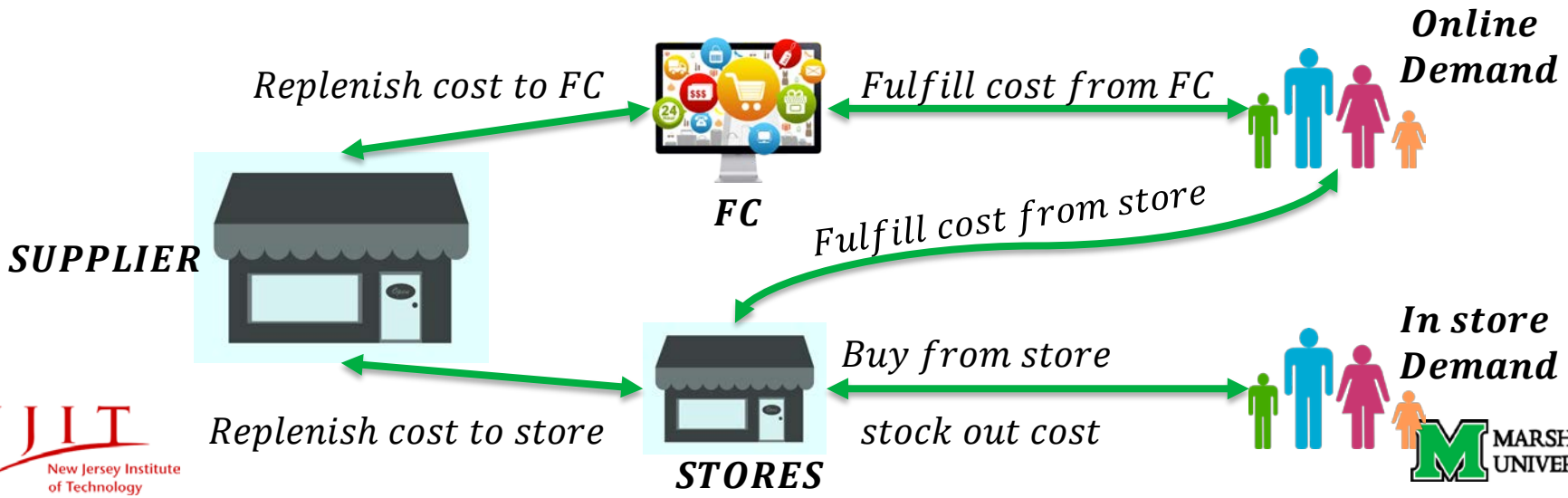
- Walmart operates nearly 4,800 U.S. stores, including 3,600 supercenter stores, with more than 700 automated pickup towers for online order pickup and more than 1,800 locations with grocery curbside pickup.

- Walmart's next-generation e-commerce fulfillment network is based on Omni-channel retailing, involving 12 large-scale e-commerce fulfillment centers, Walmart distribution centers, e-commerce facilities, stores and transportation fleet.

Fulfillment objective: to provide seamless shopping experience and fast delivery to customer

THE OMNI-CHANNEL RETAIL FULFILLMENT PROCESS

- The Omni-channel operational challenges: 1) in-store inventory is shared across channels; 2) Online orders picking up or fulfilling from store is convenient to local customer but has high replenishment and holding cost in-store; 3) Delivery speed affects customers' channel preference.
- The Omni-channel retail fulfillment process includes online and offline channels, considering stochastic channel demand, central controlled and allocated replenishment, inventory availability, and the probability of cross-channel fulfillment.



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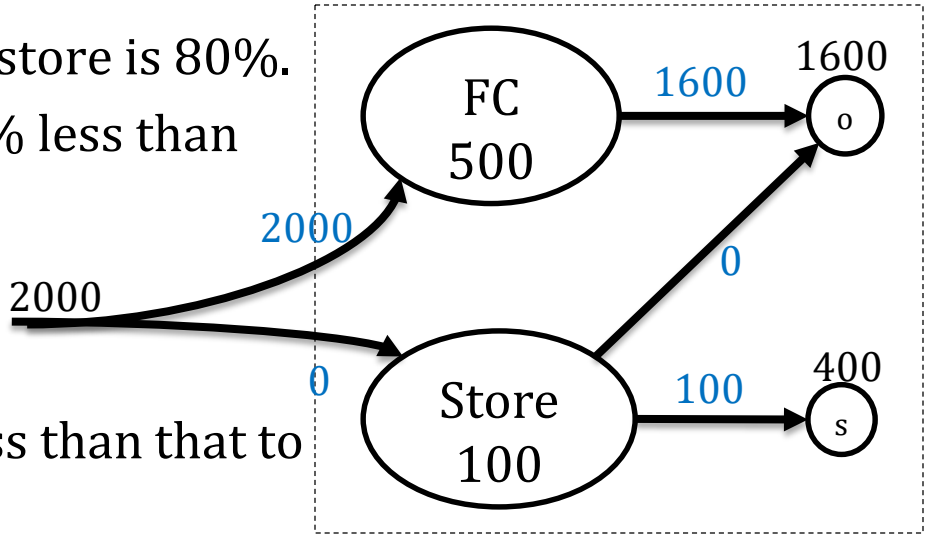
SYSTEM OBJECTIVE FOR COST MINIMIZATION

- Omni-channel retail fulfillment process *objective is to maximize customer shopping experience with fast delivery, low total cost and stock-out risk*. System design objective is using stores as shared inventory for fast fulfillment, while the operational objective is to identify the replenishment allocation and fulfillment across channels for minimizing total order fulfillment cost and stock-out risk.
- System identifies the subset of online orders fulfilled by stores and replenishment policies to both channels. Replenishment allocation and fulfillment choice are constrained by the inventory state and channel demand.

- ***Economic Solution:***
- *No stock-out risk, in-time fulfillment, inventory keeps balance for both channel*
- ***Non-economic Solution:***
- *BOFS fulfill majority of online demand, Store stock out, fulfillment center overstock*

FULFILLMENT DECISION – AN EXAMPLE

- Consider a fulfillment center with one store in the same region, replenished by a bulk of 2000 units products.
- Given the demand prediction is 2000 units.
- The ratio customer prefer online to store is 80%.
- Unit replenishment cost to FC is 10% less than that to store.



- Stock-out cost is 0.
- Unit fulfillment cost to FC is 10% less than that to store.
- Unit holding cost in FC is 20% less than that in store.
- Current store inventory level is 100 units and that of FC is 500 units.

Replenishment decision: 2000 units to Fulfillment center and 0 to store;

Fulfillment decision: 1600 online demand by fulfillment center, 0 from store.

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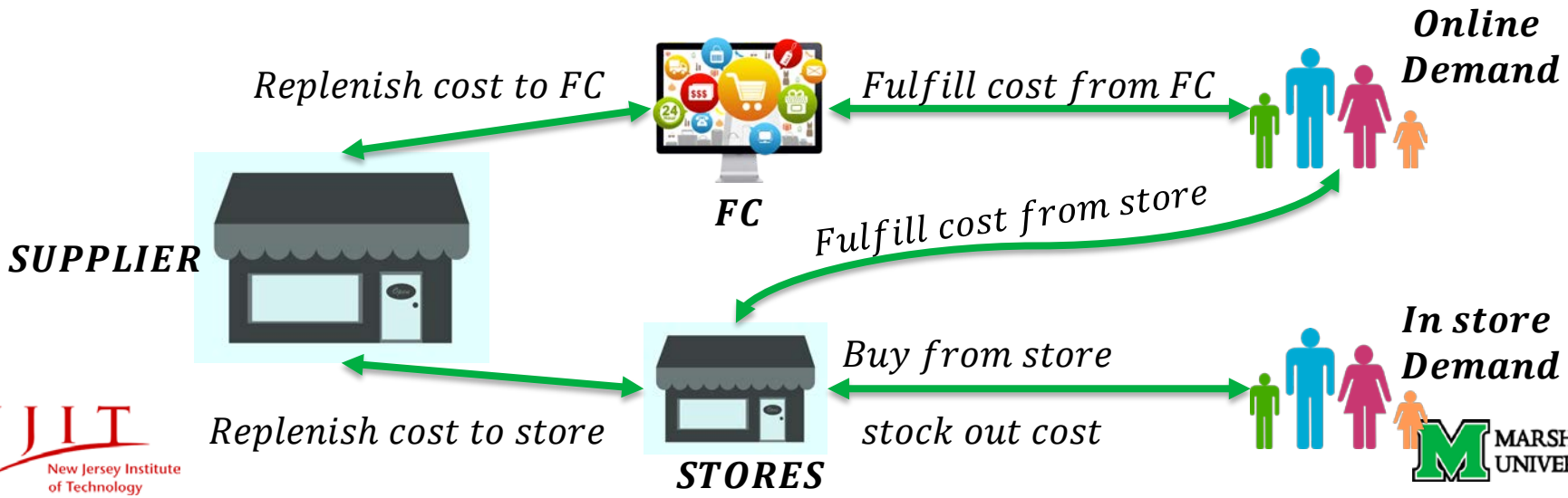
THE OMNI-CHANNEL RETAIL FULFILLMENT PERIODIC MODEL

Assumptions:

1. No price advantage in each channel.
2. No transshipment between two channels and stores.
3. Store and online retail demand are forecasted from periodically updated sales data within past **n** periods.
4. This model is solved period by period where the inventory level and demand forecasting are adjusted to the updated actual sales.
5. In a region, a fulfillment center shares multiple local stores' stock
6. Buy online fulfilled by store occurs via two approaches: when fulfillment center is out of stock to complete a single customer order; or when customer selects to ship from store and store has inventory to fulfill the order.



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MIP FORMULATION – PERIODIC SOLUTION

$$Min: Total\ Cost = \sum_i \left(C_{F,i} Q_{F,t,i} + X_{t,i,F} \alpha_{F,i} + H_{F,i} I_{t,i,F} \right) + \sum_s \left(C_{S,i} Q_{s,t,i} + X_{t,i,B,s} \alpha_{B,i} + H_{s,i} I_{t,i,s} + \right)$$

Where:

$Q_{m,t,i}$	Replenishment Allocation to Channel m
$X_{t,\,i,\,m}$	Channel Sales
m	F – Fulfilment center S – Store (stock out) B – Buy Online Fulfill from Store
$I_{t,\,m}$	Inventory in Channel m
$\delta_{m,t,\,i}$	Demand Prediction in Channel m
$\alpha_{m,\,i}$	Fulfillment cost for Channel m
$C_{m,\,i}$	Replenishment Promising cost to Channel m
$H_{m,\,i}$	Holding cost in Channel m
β_i	Stock out cost in store

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PERIODIC MODEL WITH PRODUCT INDEPENDENCE

1. Assume only one store in each region shares inventory with the local FC.
2. All products are independently processed for fulfillment.

A single-product periodic solved model is simplified as below:

$$Objective:$$

$$Min: Total\ Cost_t = C_F Q_{F,t} + C_S Q_{S,t} + \alpha_F X_{F,t} + \alpha_B X_{B,t} + \beta X_{S,t} + H_s I_{s,t} + H_F I_{F,t}$$

$$s.t.$$

$$Q_{B,t} = Q_{F,t} + Q_{S,t}$$

$$I_{S,t+1} \geq I_{S,t} + Q_{S,t} - X_{B,t}$$

$$I_{S,t+1} \geq 0$$

$$I_{F,t+1} = I_{F,t} + Q_{F,t} - X_{F,t}$$

$$X_{S,t} \geq \delta_{S,t} - I_{S,t+1}$$

$$X_{S,t} \geq 0$$

$$X_{B,t} + X_{F,t} = \delta_{O,t}$$

$$\delta_{S,t} = f_n(\delta_{S,t-1}, \delta_{S,t-2}, \delta_{S,t-3}, \dots, \delta_{S,t-n})$$

$$\delta_{O,t} = f_n\left(\delta_{S,t-1}, \delta_{S,t-2}, \delta_{S,t-3}, \dots, \delta_{S,t-n}\right)$$

$$All\ I, X\ and\ Q \geq 0$$

FAST SOLUTIONS

- Price Advantage oriented solution:
  - When either channel has a price advantage, customers are motivated to purchase or be fulfilled from that channel, the replenishment and fulfillment solution will has a bias on offline channel.
- Cost oriented solution:
  - When either channel has a large replenishment or fulfillment cost, system is tended to use the other channel for product sales, to the purpose of reducing the total cost fulfilling customers' orders.
- Stock out loss oriented solution:
  - When stock-out loss is relatively small or even 0, store prefers to fulfill online demand. Replenishment solution depends on the relationship among unit replenishment and fulfillment cost in stores and FC.

SUMMARY

- Omni-channel fulfillment has two channels and three approaches to fulfill both online customer orders and in-store visits.
- Buy Online Fulfilled by the stores takes advantage from stores and distribution centers of Omni-channel retailers competing with pure online retailers on fast fulfillment.
- With a predetermined replenishment to the region, decisions on assortment and order fulfillment approach for cost reduction, are generated periodically and learning from historical sales data.
- Instead of cost factor driven decision, the objective is enhanced by implementing a customer satisfaction vector with fulfillment time and product variety included.
- BOFS can be considered as online orders picked up in store, where order fulfillment decision would be biased on online customer preference.