Strategic Implications and Business Case for Warehouse Automation

Professor Raj Veeramani & Professor Ananth Krishnamurthy
Tugce Martagan (PhD student) & Vivek Dubey (PhD student)
Center for Retailing Excellence
University of Wisconsin-Madison

www.retailingexcellence.wisc.edu
January 24, 2012
University of Wisconsin’s Center for Retailing Excellence Corporate Partners

To accelerate innovation and to collectively explore the future vision of retailing.
Three key questions

1. Why is there growing interest in warehouse/DC automation?
   – Should your company care?

2. How can you systematically evaluate the business impact of automation?
   – Understanding benefits and broader implications

3. How do you determine what is strategically “best” for your company?
   – Alignment with business strategy
Agenda

Industry drivers & trends

Analysis framework

Business case & strategic implications
Industry Drivers & Trends

- Workforce
- Business Complexity
- Customer
- Technology
Industry Drivers & Trends

- Aging DC workforce
- Labor turnover
- Difficulty in attracting replacement
- Labor costs are significant and continuing to rise

*Business Complexity*
*Customer*
*Technology*

Aging DC workforce, Labor turnover, Difficulty in attracting replacement, Labor costs are significant and continuing to rise.
Increasing product variety and SKU proliferation

The end of cheap oil

Sustainability / Carbon footprint

Food safety and traceability

Industry Drivers & Trends

Workforce

Business Complexity

Customer

Technology
Product availability / Service level expectations are growing

Smart phones and mobile devices are transforming customer behavior

Aging customer demographic
Industry Drivers & Trends

- Workforce
- Business Complexity
- Customer
- Technology

- Information visibility is enabling real-time demand-driven supply chain
- Warehouse/DC automation systems
Implications from Supply Chain perspective

• Will your current distribution network and operations strategy serve you well in the future?
  – Or will it prove to be your *Achilles heel*?

• Can warehouse/DC automation be a source of competitive advantage?
BUSINESS CHALLENGES

- DC labor shortage and high labor costs
- More SKUs, more complex DC operations
- Reduce out-of-stock at stores
- Reduce carbon footprint and energy costs
- Increasing transportation costs

Can DC automation help address these challenges?
DC automation is not new
– But it has evolved considerably in recent years
Evolution of Automated Systems

1970s
- Automatic carton selection system
- Order selection system for individual items
- Cart systems (train) / AGV
- Conveyorized / Pick to belt systems

1980s
- Various forms of AS/RS systems

1990s
- Automated systems across all categories including Dry Grocery, the Dairy/Deli refrigerated cooler, the Produce rooms, the Fresh Meat room and the Freezer.

2000s
<table>
<thead>
<tr>
<th>Material handling automation vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beumer</td>
</tr>
<tr>
<td>Daifuku</td>
</tr>
<tr>
<td>Dematic</td>
</tr>
<tr>
<td>Fives Group</td>
</tr>
<tr>
<td>Flexlink</td>
</tr>
<tr>
<td>Intelligrated</td>
</tr>
<tr>
<td>Interlake Mecalux</td>
</tr>
<tr>
<td>Kardex Remstar</td>
</tr>
<tr>
<td>Knapp Logistik</td>
</tr>
<tr>
<td>Legris Industries</td>
</tr>
<tr>
<td>Murata Machinery</td>
</tr>
<tr>
<td>Schaefer Holding Intl.</td>
</tr>
<tr>
<td>Swisslog</td>
</tr>
<tr>
<td>Vanderlande</td>
</tr>
<tr>
<td>Viastore Systems</td>
</tr>
<tr>
<td>Witron</td>
</tr>
<tr>
<td>Wynright</td>
</tr>
</tbody>
</table>

... and many more
Example installations of warehouse automation in N. America

- Associated Food Stores
- C&S Wholesale
- Fareway Stores
- H.E.B.
- Kroger
- Publix Super Markets
- Sobey’s (Canada)
- Stop and Shop
- SuperValu
- Target
- Walmart
- Wegman’s Food Markets

... and many more installations in Europe
Assessing the potential business impact of DC automation is not trivial

— Requires a systematic and comprehensive analysis framework
Agenda

Industry drivers & trends

Analysis framework

Business case & strategic implications
How Much Automation is Necessary?

Many choices and degrees of automation exist

<table>
<thead>
<tr>
<th>Technology Choices</th>
<th>Manual</th>
<th>Fully-Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Movers, Sale items</td>
<td>Mini-Load</td>
<td>AS/RS</td>
</tr>
<tr>
<td>Regular SKUs</td>
<td>Hi-Bay Warehouse</td>
<td></td>
</tr>
<tr>
<td>Slow movers</td>
<td>Depalletizer</td>
<td></td>
</tr>
<tr>
<td>Piece packs</td>
<td>Gantry Systems</td>
<td>Shuttle</td>
</tr>
<tr>
<td>Frozen</td>
<td>Conveyor Systems</td>
<td></td>
</tr>
<tr>
<td>Pharmacy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulky, “Uglies”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Framework for Justifying Automation

Modeling Framework to Build the Case for Automation

<table>
<thead>
<tr>
<th>Store Labor Costs</th>
<th>Store Damage Costs</th>
<th>Out of Stock Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>One time Investment and Re-allocation Costs</td>
<td>DC Damage Costs</td>
<td>Labor Costs</td>
</tr>
<tr>
<td>Inventory Costs</td>
<td>Cross Docking Costs</td>
<td>Delivery Frequency, Fleet and Truck Utilization</td>
</tr>
<tr>
<td>Outbound Transportation Cost</td>
<td>Inbound Transportation Cost</td>
<td>Impact of Fuel Prices</td>
</tr>
</tbody>
</table>

- **Store Level**
- **Distribution Center Level**
- **Supply Chain Level**
Impact on Outbound Transportation

• Increased transportation costs?
• Less cross docking?
• Lower routing efficiencies?
• Lower truck utilizations?
• Impact on delivery frequencies?
Impact on Inbound Transportation

- Reduced transportation costs?
- Increased truck utilizations?
- Less cross docking?
- Increased backhaul costs?
- Impact on delivery frequencies?
Models for Inbound Transportation

- Transportation Cost Per Mile
- Delivery Frequency from all Suppliers
- Distance from Suppliers to DCs
- Inbound Transportation Routes
- Total Outbound Costs
- Truck Utilization
- Total Distance Traveled
- Deliveries per Year
- Routing Efficiency

Location of the Suppliers, DCs

Inbound Transportation Cost
Effect on Truck Utilization: Round-ups

- Week 1 North DC
  - Demand
  - Round-up

- Week 1 South DC
  - Demand
  - Round-up

- Week 2 North DC

- Week 2 South DC

- Week 1 Central DC
  - Demand
  - Round-up

- Week 2 Central DC
  - Demand
  - Round-up
Models for Cross Docking Costs

- SKUs and Pallets per being Cross Docked
- Cross Docking Cost per Pallet
- Transportation Costs per Mile
- Location of the DCs
- Labor Costs of Cross Docking
- Transportation Costs of Cross Docking
- Labor Requirements
What is the Impact of Fuel Price?

- Inbound Transportation
- Outbound Transportation
- Backhauls
- Cross docking costs
- Routing Efficiencies
# Framework for Justifying Automation

## Modeling Framework to Build the Case for Automation

<table>
<thead>
<tr>
<th>Store Level</th>
<th>Distribution Center Level</th>
<th>Supply Chain Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Labor Costs</td>
<td>Store Damage Costs</td>
<td>Out of Stock Costs</td>
</tr>
<tr>
<td>One time Investment and Re-allocation Costs</td>
<td>DC Damage Costs</td>
<td>Labor Costs</td>
</tr>
<tr>
<td>Inventory Costs</td>
<td>Cross Docking Costs</td>
<td>Delivery Frequency, Fleet and Truck Utilization</td>
</tr>
<tr>
<td>Outbound Transportation Cost</td>
<td>Inbound Transportation Cost</td>
<td>Impact of Fuel Prices</td>
</tr>
</tbody>
</table>
Impact on Inventory: Consolidate at Existing Locations

- Less safety stock, round up inventory, out of stock
- Lower supply chain risk
- Transportation costs (higher or lower?)
- Increased cross docking
Impact on Inventory: Partially Consolidate at Existing Locations

- Slightly less safety stock, round up inventory, out of stock
- Reduced supply chain risk
- Transportation costs (higher or lower?)
- Increased cross docking
Ideal Inventory: 
Order only to Meet the Demands

<table>
<thead>
<tr>
<th>Time</th>
<th>Inventory Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Order Quantity</td>
<td>Safety Stock</td>
</tr>
</tbody>
</table>

Inventory Needed for Demands
Actual Inventory: Orders Inflated due to Various Constraints

Retailers often order sooner and more than needed
Impact on Inventory: Consolidate at Central Location

- Less safety stock, round up inventory, out of stock
- Higher supply chain risk
- Transportation costs (higher or lower?)
- Reduced cross docking
Duplication of Inventory at Each Location

Inventory Due to Round Up

Inventory for Demands

Safety Stock

Inventory Due to Round Up

Inventory for Demands

Safety Stock
Savings in Inventory due to Consolidation

- Inventory Due to Round Up
- Inventory for Demands
- Safety Stock

- Dry
- Frozen
- Produce

- HBC
- Pharmacy
- GM

- Inventory Due to Round Up
- Inventory for Demands
- Safety Stock

- Inventory Due to Round Up
- Inventory for Demands
- Safety Stock
Models for Inventory Costs

- Minimum Order Quantities, Supplier Constraints
- Delivery Frequency for each Suppliers
- SKU Demands at Each Stores
- Stock outs, Service Levels
- Inventory needed for Demands
- Safety Stocks
- Extra Inventory due to Supplier Constraints
- Stock out Reduction

SKU Demands at Each Stores

Inventory Cost
Framework for Justifying Automation

<table>
<thead>
<tr>
<th>Store Labor Costs</th>
<th>Store Damage Costs</th>
<th>Out of Stock Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>One time Investment and Re-allocation Costs</td>
<td>DC Damage Costs</td>
<td>Labor Costs</td>
</tr>
<tr>
<td>Inventory Costs</td>
<td>Cross Docking Costs</td>
<td>Delivery Frequency, Fleet and Truck Utilization</td>
</tr>
<tr>
<td>Outbound Transportation Cost</td>
<td>Inbound Transportation Cost</td>
<td>Impact of Fuel Prices</td>
</tr>
</tbody>
</table>

Modeling Framework to Build the Case for Automation

- Store Level
- Distribution Center Level
- Supply Chain Level
Impact of Automation on Labor Costs

- Automation could significantly reduce labor needs at the DC

- Fewer but more skilled labor needed at the DC
Models for Labor Costs

- **Picking and Replenishment:** pallets per day, SKUs
- **Maintenance, Supervision, Verification:** Staffing per shift, dock door
- **Receiving and Shipping:** Trucks per day, pallets per truck, SKUs
- **Labor cost per hour, Fringe and benefits**
- **Labor cost per case**
- **Staffing level in each category**
- **Staffing per shift**
- **Total Labor Costs**
Framework for Justifying Automation

Modeling Framework to Build the Case for Automation

- Store Labor Costs
- Store Damage Costs
- Out of Stock Costs

- One time Investment and Re-allocation Costs
- DC Damage Costs
- Labor Costs

- Inventory Costs
- Cross Docking Costs
- Delivery Frequency, Fleet and Truck Utilization

- Outbound Transportation Cost
- Inbound Transportation Cost
- Impact of Fuel Prices

- Store Level
- Distribution Center Level
- Supply Chain Level
Put away at Store: Conventional Pallet

Backroom

Unloading

Staging

Breakdown

Stocking

Facing
Zoomed View: Flow Diagram for Eight Observed Pallets

Significant back and forth travel to put away items in each aisle
Impact of Automation on Store Operations

• **Store Operations due to Manual Operations at DC**
  – Significant labor and time involved in pallet breakdown
  – Inefficiencies in material handling
    • Re-piling and re-arranging cases in order to transport them to the aisles
    • Excessive number of trips between staging area and the aisles
    • Reduced employee efficiency and productivity
  – Damage and out of stock
    • Increased chance of damage due to inefficient pallet design (heavy cases placed on the top of fragile ones)

• **Store Friendly Pallets Due to Automation at DC**
  – Significant reduction in labor and time
  – Improved material handling efficiencies
  – Less damage and out of stock at stores
Put away at Store: Store Friendly Pallet
Models for Store Operations

- SKU profile and Demands for SKUs
- Store Layout
- Deliveries per week
- Labor Costs and Staffing Level

Store Friendly Pallets

- Pallets per delivery
- Labor Savings
- Fewer Touches
- Reduced Stock outs
- Reduced Damage

Material Handling Costs
Framework for Justifying Automation

Modeling Framework to Build the Case for Automation

<table>
<thead>
<tr>
<th>Store Level</th>
<th>Distribution Center Level</th>
<th>Supply Chain Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Labor Costs</td>
<td>Store Damage Costs</td>
<td>Out of Stock Costs</td>
</tr>
<tr>
<td>One time Investment Costs</td>
<td>One time Re-allocation Costs</td>
<td>Labor Costs</td>
</tr>
<tr>
<td>Inventory Costs</td>
<td>Cross Docking Costs</td>
<td>Delivery Frequency, Fleet and Truck Utilization</td>
</tr>
<tr>
<td>Outbound Transportation Cost</td>
<td>Inbound Transportation Cost</td>
<td>Impact of Fuel Prices</td>
</tr>
</tbody>
</table>
Agenda

Industry drivers & trends

Analysis framework

Business case & strategic implications
Key Take-Away #1

• DC automation will impact not just your DC operations, but also your upstream (supplier) and downstream (stores).
  – DC automation should therefore be viewed in the context of a comprehensive supply chain integration/optimization initiative
    • Is the current distribution network optimized?
    • Is the SKU allocation to DCs optimal?

Decision to automate DC operations **must be** well-aligned with overall business strategy
Key-Takeaway #2

Marketing
Goal: Increase sales

Supply Chain Mgt.
Goal: Reduce costs

Instead both should focus on the common goal of fulfilling the customer value proposition
• Large product variety, high quality, low price, guaranteed product availability, superior service

DC Automation can be a key enabler for this
Key-Takeaway #3

Outbound Transportation

Cross Docking

Inbound Transportation

Delivery Frequency, Fleet Utilization

A comprehensive analysis framework is needed

Costs

Benefits

One time Re-allocation Costs

One time Investment Costs

Higher truck utilization

Stock-out reduction

Damage reduction

Inventory savings

Labor Savings - DC and Stores
Key Take-Away #4

- Automation systems are unforgiving!
- Product suppliers/manufacturers and distributors/retailers need to be partners
  - **Packaging**: Cases need to be sturdy enough for automated handling
  - **Data synchronization**: Data provided by supplier regarding dimensions and weight of product need to be accurate for every SKU.

When it comes to automation, small things can make a big difference
The Bottom Line

**BUSINESS CHALLENGES**

- DC labor shortage and high labor costs
- More SKUs, more complex DC operations
- Reduce out-of-stock at stores
- Reduce carbon footprint and energy costs
- Increasing transportation costs

---

**Workforce**

**Business Complexity**

**Customer**

**Technology**

Yes!!
The Bottom Line

Impact of Automation

- Automated DCs require considerably less people to operate
- Can efficiently handle fast-moving (pallet loads) and slow-moving SKUs (layers), requiring less inventory
- Provides higher storage density
- Can pick, pack and ship product more quickly and accurately, and less damage
- Higher throughput through DC enables more store order fulfillment
- Demand visibility allows for efficient staging of orders and timely fulfillment
- Higher truck cube utilization is possible
- Pallets delivered in right sequence to loading docks – Minimizes loading time.
- C-footprint reduction due to less forklifts, lighting in storage areas, HVAC, etc.

Business Challenges

- DC labor shortage and high labor costs
- More SKUs, more complex DC operations
- Reduce out-of-stock at stores
- Reduce carbon footprint and energy costs
- Increasing transportation costs

Workforce

Business Complexity

Customer

Technology
For additional information, please contact

Dr. Raj Veeramani
raj@engr.wisc.edu
608-262-0861

Dr. Ananth Krishnamurthy
ananth@engr.wisc.edu
608-890-2236