Chapter 6
Supply Chain Integration

Dell Desktop PC Supply Chain: Case Study
Optimizing the Flexibility of the Desktop PC Supply Chain

Agenda
- L6 vs. L5 Value Comparison
- Root Causes Analysis
- Project Methodology & Next Steps
- Lessons Learned

Critical Components of a Desktop PC & Major Component Manufacturers

Problem Statement
Since July 2004, Dell and its contract manufacturers (CMs) have had to adapt an increasing % of L5 manufacturing:
1. Empty chassis are shipped by ocean (L5) to Dell US & Europe first. Motherboards are then air-freighted to Dell US & Europe.
2. Dell incurs motherboard expedite/air-freight cost and 3rd-party integration cost.
3. CMs incur cost for idle labor dedicated for MB-chassis integration.

L6 vs. L5
- L6: 5 Weeks, Dell Manufacturing, 2nd Party Integration (managed by Equipment Manufacturers)
- L5: 1 Week, Dell Manufacturing, L5 additional cost

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3. CMs incur cost for idle labor dedicated for MB-chassis integration.
L6 vs. L5: Value Comparison

<table>
<thead>
<tr>
<th>L6</th>
<th>L5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated offshore &amp; outside a Dell facility</td>
<td>Integrated inside a Dell facility</td>
</tr>
<tr>
<td>Integrated motherboard inside chassis shipped on water</td>
<td>Chassis shipped on water</td>
</tr>
<tr>
<td>Labor savings</td>
<td>Motherboards shipped by air</td>
</tr>
<tr>
<td>MB air-freighting costs are eliminated</td>
<td>Increased supply chain flexibility</td>
</tr>
<tr>
<td>Reduced motherboard packaging costs</td>
<td>Increased motherboard air-freighting costs</td>
</tr>
<tr>
<td>Reduced supply chain flexibility</td>
<td>3rd-party integration cost in US</td>
</tr>
<tr>
<td>More motherboards need to be re-worked in the event of an MB ECN</td>
<td>Separate logistical costs for chassis and motherboards</td>
</tr>
</tbody>
</table>

L6 is more cost-effective than L5.

L5 Driving Increasing Operational Cost

Costs of air-freighting MBs and 3PI integration have been increasing.

Root Causes Analysis

Majority of expedites are caused by chipset supply shortage.

Project Scope

<table>
<thead>
<tr>
<th>Is</th>
<th>Is Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktops</td>
<td>Laptops, servers, storages, peripherals</td>
</tr>
<tr>
<td>DAO (Dell America Operation)</td>
<td>Outside DAO</td>
</tr>
<tr>
<td>Constrained by chipset supply shortage</td>
<td>To improve chipset supply</td>
</tr>
<tr>
<td>Focused on factory operational improvement</td>
<td>To improve Dell’s demand-forecasting ability</td>
</tr>
<tr>
<td>Motherboard-chassis integration</td>
<td>Fans, power supply, SPAMS (Speakers, Printers, Advanced Port Replicators, Monitors, Scanners), or other components</td>
</tr>
</tbody>
</table>

Project Methodology

BPI project team established to evaluate the following 6 scenarios:

1. Keep as current: 3rd-Party Integrator (3PI) managed by Equipment Manufacturers
2. DAO Cellular Integration: Enable the Dell factory work cells to perform L5→L10 mfg work
3. Offline Integration: Keep the current L6→L10 mfg process unchanged; add a separate facility to handle MB-chassis integration work
   a. At SLC (Supplier Logistics Center)
   b. At a Dell-leased building
4. 3PI managed directly by Dell
5. L6 from Equipment Manufacturers’ Mexico plants
Factors to Considered

For each of the 6 scenarios, BPI project team assessed the following attributes:

1. Process smoothness & sustainability
2. Cost per box
3. Product quality
4. Capital investment
5. Material handling/cost-accounting
6. Logistics

Project Goal:
Identify the optimal scenario based on these input attributes.

Complexity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3A</th>
<th>Option 3B</th>
<th>Option 4</th>
<th>Option 5</th>
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<tr>
<td>World Wide</td>
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<td>Regional Proc</td>
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<td>5</td>
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<td>5</td>
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<td>10</td>
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<td>10</td>
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<tr>
<td>Support Quality</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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<tr>
<td>Supplier Quality</td>
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<td>1</td>
<td>1</td>
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<td>1</td>
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<tr>
<td>Cost Accounting</td>
<td>10</td>
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<td>1</td>
<td>1</td>
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<td>1</td>
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<td>Inventory</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>Logistics</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td><strong>Total</strong></td>
<td>57</td>
<td>60</td>
<td>60</td>
<td>55</td>
<td>57</td>
<td>56</td>
</tr>
</tbody>
</table>

Cost per Box:
- Option 1: $10.07
- Option 2: $7.00
- Option 3A: $7.90
- Option 3B: $7.54
- Option 4: $7.70
- Option 5: $7.61
- Revised Option 2: $7.00

Legend:
The "Cost per Box" data has been modified to respect Dell’s data confidentiality.

Option 2 vs. 4: Value Comparison

**Option 4: Dell-managed 3PI**
- Dell has direct control over the 3PI
- More clear definition of quality issues ownership
- Less manufacturing infrastructure change required, less impact on existing supply chain network
- Little additional capital expenditure investment, little lead time change
- Only an incremental change from the original manufacturing design

**Option 2: Integration at DAO Work Cells**
- Lower capital expenditure investment
- Less impact to business if chipset supply reverts to 100% L6
- Fit the Dell Direct model better
- Builder headcount is more difficult to scale
- Increased inbound & scheduling complexity
- More part numbers to manage
- Factory throughput rate is downgraded

Lessons Learned

1. Supply chain coordination requires involvement from all partners in the chain (customer, supplier, sub-tier suppliers).
2. A well-planned strategy complements strong operational execution ability from supply chain partners.
3. Change management requires 3 key ingredients:
   - Top-down leadership
   - Bottom-up engagement
   - Cross-functional coordination
4. Qualitative judgment is just as important as or more critical than quantitative analysis.
5. Working in a bi-lingual/bi-regional setting has its perks and challenges.

Discussion and Q&A
6.1 Introduction

- Effective SCM implies:
  - Efficient integration of suppliers, manufacturers, warehouses, and stores.
  - Coordinate activities across the supply chain
  - Improve performance: reduce cost, increase service level, reduce the bullwhip effect, better utilize resources, and effectively respond to changes in the marketplace.
  - Challenges can be met by integrating:
    - the front-end, customer demand,
    - the back-end, production and manufacturing portion of the supply chain.
  - Various supply chain integration strategies:
    - Push, pull, push–pull strategy.
    - Matching products and industries with supply chain strategies.
    - Demand-driven supply chain strategies.
    - The impact of the Internet on supply chain integration.

6.2 Push, Pull, Push-Pull Systems

- Push and Pull traditional categories of manufacturing operations
- More recent hybrid strategy of combining the two, Push-Pull systems

**Push-Based Supply Chains**

- Production and distribution decisions based on long-term forecasts.
- Manufacturer demand forecasts based on orders received from the retailer’s warehouses.
- Longer reaction time to changing marketplace:
  - Inability to meet changing demand patterns.
  - Obsolescence of supply chain inventory as demand for certain products disappears.
  - Variability of orders received much larger than the variability in customer demand due to the bullwhip effect.
  - Excessive inventories due to the need for large safety stocks.
  - Larger and more variable production batches
  - Unacceptable service levels
  - Product obsolescence

**Bullwhip Effect in Push-Based Supply Chains**

- Leads to inefficient resource utilization
- Planning and managing are much more difficult.
- Not clear how a manufacturer should determine production capacity? Transportation capacity?
- Peak demand?
- Average demand?
- Results:
  - Higher transportation costs
  - Higher inventory levels and/or higher manufacturing costs
  - More emergency production changeovers
Pull-Based Supply Chains
- Production and distribution demand driven
  - Coordinated with true customer demand rather than forecast demand
  - Firm does not hold any inventory and only responds to specific orders.
- Intuitively attractive:
  - Reduced lead times through the ability to better anticipate incoming orders from the retailers.
  - Reduced inventory since inventory levels increase with lead times
  - Less variability in the system
  - Decreased inventory at the manufacturer due to the reduction in variability.

Implementation of Pull-Based Systems
- Often difficult to implement
  - When lead times are long
  - Impractical to react to demand information.
- More difficult to take advantage of economies of scale

Advantages and disadvantages of push and pull supply chains:
- New supply chain strategy that takes the best of both.
- Push–pull supply chain strategy

Push-Pull Strategy
- Some stages of the supply chain operated in a push-based manner
  - Typically the initial stages
- Remaining stages employ a pull-based strategy.
- Interface between the push-based stages and the pull-based stages is the push–pull boundary.

General Strategy
- Make a part of the product to stock – generic product
- The point where differentiation has to be introduced is the push-pull boundary
- Based on extent of customization, the position of the boundary on the timeline is decided

Supply Chain Timeline

Identifying the Appropriate Supply Chain Strategy

FIGURE 6-8: Push-pull supply chains

FIGURE 6-9: Push-pull supply chains
Impact of Demand Uncertainty and Economies of Scale
- Demand Uncertainty:
  - Higher demand uncertainty leads to a preference for pull strategy.
  - Lower demand uncertainty leads to an interest in managing the supply chain based on a long-term forecast: push strategy.
- Economies of scale:
  - The higher the importance of economies of scale in reducing cost.
  - The greater the value of aggregating demand.
  - Economics of scale are not important.
  - Aggregation does not reduce cost.
  - A pull-based strategy makes more sense.

Implementing a Push–Pull Strategy
- Achieving the appropriate design depends on many factors:
  - product complexity
  - manufacturing lead times
  - supplier–manufacturer relationships.
- Many ways to implement a push–pull strategy
  - location of the push–pull boundary.
    - Dell locates the boundary at the assembly point
    - Furniture manufacturers locate the boundary at the production point

Impact of the Push-Pull Strategy
- Push portion
  - Low uncertainty
  - Service level not an issue
  - Focus on cost minimization.
  - Long lead times
  - Complex supply chain structures
  - Cost minimization achieved by:
    - better utilizing resources such as production and distribution capacities
    - minimizing inventory, transportation, and production costs.
  - Supply Chain Planning processes are applied.

Pull portion
  - High uncertainty
  - Simple supply chain structure
  - Short cycle time
  - Focus on service level.
  - Achieved by deploying a flexible and responsive supply chain.
  - Order-fulfillment processes are applied.

Characteristics of the Push and Pull Portions of the Supply Chain

<table>
<thead>
<tr>
<th>Portion</th>
<th>Push</th>
<th>Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Minimize cost</td>
<td>Maximize service level</td>
</tr>
<tr>
<td>Complexity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Focus</td>
<td>Resource allocation</td>
<td>Responsiveness</td>
</tr>
<tr>
<td>Lead time</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Processes</td>
<td>Supply chain planning</td>
<td>Order fulfillment</td>
</tr>
</tbody>
</table>

Interactions of the Two Portions
- Only at the push-pull boundary
- Typically through buffer inventory
- Different role for the inventory in each portion
  - In the push portion, buffer inventory is part of the output generated by the tactical planning process
  - In the pull system, it represents the input to the fulfillment process.
- Interface is forecast demand
  - Forecast based on historical data obtained from the pull portion
  - Used to drive the supply chain planning process and determine the buffer inventory.
6.3 The Impact of Lead Time

- Longer the lead time, more important it is to implement a push based strategy.
- Typically difficult to implement a pull strategy when lead times are so long that it is hard to react to demand information.

Impact of Lead Time

- **Box A**
  - Items with short lead time and high demand uncertainty
  - Pull strategy should be applied as much as possible.
- **Box B**
  - Items with long supply lead time and low demand uncertainty.
  - Appropriate supply chain strategy is push.
- **Box C**
  - Items with short supply lead time and highly predictable demand.
  - Continuous replenishment strategy
  - Suppliers receive POS data
  - They use these data to prepare shipments at previously agreed-upon intervals
  - A pull strategy at the production and distribution stages and push at the retail outlets.
- **Box D**
  - Items with long lead times are long and unpredictable demand
  - Inventory is critical in this type of environment
  - Requires positioning inventory strategically in the supply chain

Forecast Errors Are Always Present!

- High demand forecast error has a detrimental impact on supply chain performance
- Approaches to improve accuracy
  - Aggregate forecasts are more accurate,
  - Select the push–pull boundary so that demand is aggregated over one or more of the following dimensions:
  - Across products/geography/time
  - Use market analysis and demographic and economic trends to improve forecast accuracy (see Chapter 2 for details).
  - Determine the optimal assortment of products by store
  - Reduce the number of SKUs competing in the same market.
  - Incorporate collaborative planning and forecasting processes with your customers
  - Demand forecast by SKU by location has to be supported by the supply chain
  - Interaction of demand planning and tactical supply planning
  - Iterative process

6.4 Demand-Driven Strategies

- Requires integrating demand information into the supply chain planning process
- **Demand forecast:**
  - Use historical demand data to develop long-term estimates of expected demand
- **Demand shaping:**
  - Firm determines the impact of various marketing plans such as promotion, pricing discounts, rebates, new product introduction, and product withdrawal on demand forecasts.

6.5 The Impact of the Internet on Supply Chain Strategies

- Expectation that increasing use of the internet would solve a lot of the business problems
- Reality was very different
- Many of the problems in the internet-based businesses were related to logistics strategies
Successes and Failures

- Notable Failures
  - Furniture.com
  - Peapod.com
- Notable Successes
  - Amazon.com
- Hybrid of successes and failures
  - Cisco
    - $2.2B inventory write-off in 2001
    - Has been successful in leveraging the internet subsequently

Key Observations

- E-commerce is only part of e-business.
- Internet technology is the force behind the business change.
- Focus on the extended enterprise
  - Business-to-consumer (B2C)
    - "direct to customer."
    - Retail activities over the Internet, and includes products, insurance, banking, and so forth.
  - Business-to-business (B2B)
    - Conducted over the Internet predominantly between businesses.
    - Includes:
      - electronic sourcing (the so-called eSourcing)
      - reverse auctions
      - collaboration with suppliers and vendors to achieve common goals.

Grocery Industry

- Typical supermarket employs a push-based strategy
- Peapod was built on pure pull strategy with no inventory and no facilities.
- Significant service problems with high stockout rates
- Changed to a push–pull strategy by setting up a number of warehouses
- Warehouse covers a large geographical area
- Aggregated demand
- Other challenges:
  - Reducing transportation costs
  - Short response time
  - Low customer density
- Products have low demand uncertainty
- High economies of scale in transportation cost
- Push-based strategy is more appropriate.

Book Industry

- Initial model of Amazon.com a pure pull system with no warehouses and no stock.
  - Ingram Book Group supplied most of Amazon’s customer demand.
- As volume and demand increased:
  - Amazon.com’s service level was affected by Ingram Book’s distribution capacity
  - Using Ingram Book in the first few years allowed Amazon.com to avoid inventory costs but significantly reduced profit margins.
  - As demand increased distributor no longer required.
- Current Amazon.com:
  - Several warehouses around the country where most of the titles are stocked.
  - Inventory at the warehouses is managed using a push strategy
  - Demand satisfied based on individual requests, a pull strategy.
  - Slow moving low volume books and CDs are not stocked at Amazon distribution centers
  - Amazon orders those when demand arrives.

E-Business

- E-business: a collection of business models and processes motivated by Internet technology and focusing on improvement of extended enterprise performance.
- E-commerce: ability to perform major commerce transactions electronically.

General Retail Industry

- Late to respond to competition from virtual stores and to recognize the opportunities provided by the Internet.
- Brick-and-mortar companies are adding an Internet shopping component to their offering.
  - Already have the distribution and warehousing infrastructure
- Click-and-mortar firms
  - High-volume, fast-moving products stocked in stores
  - Low-volume, slow-moving products are stocked centrally
  - Push/Pull strategy
Traditional Fulfillment Versus e-Fulfillment

<table>
<thead>
<tr>
<th></th>
<th>Traditional fulfillment</th>
<th>E-Fulfillment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain strategy</td>
<td>Push</td>
<td>Push–pull</td>
</tr>
<tr>
<td>Shipment</td>
<td>Bulk</td>
<td>Parcel</td>
</tr>
<tr>
<td>Reverse logistics</td>
<td>Small part of the business</td>
<td>Important and highly complex</td>
</tr>
<tr>
<td>Delivery destination</td>
<td>Small number of stores</td>
<td>Large number of geographically dispersed customers</td>
</tr>
<tr>
<td>Lead times</td>
<td>Relatively long</td>
<td>Relatively short</td>
</tr>
</tbody>
</table>

Summary

- Implementation of push-pull strategies and demand-driven strategies have helped many companies to improve performance, reduce costs, increase service levels.
- Collapse of many Internet companies shows that e-business has great challenges.
- Companies need to:
  - Identify the appropriate supply chain strategy for individual products.
  - Base for no physical infrastructure or inventory is tenous
  - Push–pull strategy
    - Advocates holding inventory
    - although it pushes the inventory upstream in the supply chain.