

# **RFID: Looking for Maximum Gain and Minimum Pain for Retailers and Their Suppliers**

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## **INTRODUCTION**

Radio Frequency Identification (RFID) is attractive within a supply chain, because its system of electronically tagging items, cases, or pallets can help deliver “the right product at the right place at the right time.” Major organizations like Wal-Mart, the U.S. Department of Defense, Target, and Best Buy have required large suppliers to apply RFID tags to cases and pallets in recent years to improve supply chain performance. According to U.K. research firm Frost & Sullivan, retailers spent \$400 million on RFID in 2004, a figure that may exceed \$4 billion by 2011.<sup>1</sup>

But RFID also presents a conundrum to retailers and their suppliers: despite the perceived benefits, the business case is not clear. In 2005, Spyglass Consulting Group found that many healthcare organizations were having difficulty justifying the investment in RFID because of cheaper existing solutions like barcode technology.<sup>2</sup> And McKinsey consultants suggest that “businesses should convert their excitement about the potential of RFID—as with any technology—into a solid business case.”<sup>3</sup>

This conundrum has resulted in many suppliers taking a wait-and-see attitude or implementing a partial deployment of RFID (often called a “slap-and-ship” process—slapping on RFID tags just before shipping to appease retailer mandates). Even retailers

have hesitated to implement RFID fully, despite the danger of diluting benefits by implementing partial RFID on top of existing bar-code technologies.

To shed light on this conundrum and to consider the merits of a business case for this technology, we first analyze the benefits of RFID in terms of process improvements that may result from tracking individual truckloads, pallets, cases, or even individual items across the supply chain up to the retail store. We use the supply-chain operations-reference (SCOR) model of processes<sup>4</sup> from the suppliers' plants to the retailer's stores and consider pallet-level, case-level, and item-level RFID implementation. Next, we consider the benefits of RFID at the item level in the retail store itself. Finally, we consider the IT-related costs and risks as they vary across the supply chain.

Our analysis indicates that benefits, costs, and risks vary across the supply chain and depend on the level of RFID implemented. At one end of the supply chain, a supplier implementing RFID at the pallet level in its plants or distribution centers will find low costs and risks but also low benefits. At the other end, the retailer implementing RFID at the individual item level in the retail store will find both high benefits but also high risks and costs. In between, **there are *high benefits and low costs and risks* corresponding to the use of RFID at the *case level* for backend processes of storage, handling, and moving to get a large variety of cases into retail stores.** The business case for RFID is clearest at this point.

## **RFID BASICS**

A basic RFID system comprises tags that hold unique tracking information about an item, as well as a tag reader. The RFID reader emits radio signals to activate the tag, read the data on it and, in some cases, write data as well. Compared to bar codes, read-only tags

can be “read” faster (< 100 milliseconds) and in a variety of visually challenging conditions such as dust, snow, and within packing material. The tag continually reports the item’s location, condition, and status to any reader connected to on-site information systems or to remote databases via the Internet.<sup>5</sup>

Just as bar code technology rests on UPC or the “Universal Product Code,” RFID rests on the “Electronic Product Code” (EPC). This code comprises an approach to data content, technical standards, coding standards, mark-up language, and software systems. The EPC standard assigns a unique product identification number to every manufactured item so that each item can be tracked in the supply chain all the way to the point of sale to a consumer and even beyond.

## **BENEFITS FOR THE SUPPLY CHAIN**

We first consider RFID in terms of its benefits within the supply chain up to the retail store but not including the operations inside the store itself. As we get nearer to the retail end of the supply chain, products become

- Increasingly differentiated and unique, resulting in more SKUs to manage;
- More likely to be packed and handled in smaller quantities (cases or units vs. pallets);
- and
- More valuable and thus more vulnerable to counterfeiting and shrinkage.

We expect benefits from RFID to increase as we move downstream in the supply chain (Figure 1). To study the benefits in detail, we use the Supply Chain Council’s SCOR classification of backend processes in the supply chain up to the retail store:

- *Plan*: Processes that balance aggregate demand and supply to develop a course of action that best meets sourcing, production, and delivery requirements

- *Source*: Processes that procure goods and services
- *Make*: Processes that transform product to a finished state
- *Deliver*: Processes such as order management, transportation management, and distribution management that provide finished goods and services to meet demand
- *Return*: Processes associated with product returns at any stage of the supply chain.

These processes are supported by “enable” processes, including data collection and supporting automation.

If a company is to invest in RFID, it must see meaningful improvements in at least some metrics related to these SCOR processes. These metrics include those related to time (processing, storage, or transit) and shrinkage (yield, spoilage, pilferage, or value reduction through discounts and returns).

Following is our detailed analysis of the impact of RFID on each of the SCOR process categories at different stages of a supply chain up to the retail store.

### ***Benefits for Planning***

From a planning perspective, the primary benefit that RFID offers relative to existing bar code technology is the elimination of some of the current hurdles in sharing data across supply chain partners. This sharing of data can help facilitate collaborative planning, forecasting, and replenishment (CPFR) in environments where it is difficult today. The benefits, however, are likely to be marginal relative to the existing barcode technology and will primarily accrue from a case-level implementation. Effective CPFR can benefit suppliers, manufacturers, carriers and retailers in a supply chain. The primary

hurdles, however, are not technology related, and RFID by itself is unlikely to have a significant enough impact to justify implementation.

### ***Benefits for Sourcing***

RFID is likely to improve the receiving and storage processes within the source category through increased efficiencies and improved visibility.

RFID is unlikely to provide significant value to the receiving process for most manufacturers who receive a limited variety in large quantities from their suppliers. For example, a cereal manufacturer is unlikely to derive significant benefit from deploying RFID because it sources a small variety of *direct* materials (like corn) in large quantities from its suppliers, which results in relatively simple receiving and storage. In contrast, manufacturers who receive a large variety of high-value parts from their suppliers will benefit from case-level and, in some cases, item-level RFID. For example, an auto company may find item-level RFID useful for receiving and tracking seats that must arrive at a car assembly plant in the sequence of production. Such a manufacturer can tie failures of finished goods to the individual components that went into the manufactured item, and thus tie the failures to the particular supplier's batch. These manufacturers can also track percent returns or manufacturing yield tied to components from a particular supplier.

Retailers are likely to benefit from RFID the most in terms of increased receiving efficiencies, because they typically source a large variety of products from many suppliers in case quantities. Moreover, shipments from a single supplier to a retailer often contain multiple products. Most large retailers source in case quantities or more. Thus, *case-level* RFID would significantly improve efficiencies relative to the use of bar codes

by automating the receiving process. However, *item-level* RFID is unlikely to have any impact on the receiving process for retailers or suppliers receiving in case quantities.

A carrier that cross-docks mixed pallets will benefit, as pallet- or case-level RFID tags improve the cross-docking process. Carriers also benefit indirectly as RFID speeds up the receiving process, thus freeing up trucks more quickly. However, the benefits for a carrier that delivers full truckloads direct from source to destination will be small.

Sourcing entails storage as well. RFID can improve inventory accuracy and help facilitate stock verification and stock rotation activities during storage. Consider the example of Synthesis, an Indian home furnishings manufacturer that supplies products to U.S. retailers. Synthesis carries out four stock checks a year, with an additional check by auditors. Stock checks take an average of two days and require significant manual labor. A case-level RFID system with accurate, real-time stock information eliminates the need for stock checks. In particular, during the peak Christmas season, case-level RFID tags can help reduce inventory by increasing visibility at the plant and the warehouse. The ratio of benefits to cost is likely to be highest for firms that have high product variety, have most of their inventory stored in cases, and use case-level RFID. For instance, Hewlett-Packard has used RFID to save 20 percent on stock control costs at some production facilities.<sup>6</sup>

Companies with inventory in transit could use case-level RFID to assign inventory to customers on-the-go. Intel hopes to assign in-transit inventory to customer orders using RFID,<sup>7</sup> and the technology has already allowed the company to cut inventories by over 80 percent by improving management of in-transit inventories.

The value of RFID is likely to be greater in the storage of maintenance, repairs, and operations (MRO) supplies that are expensive and have long supply lead times, especially if the cost of a shutdown is high. For example, Virgin Atlantic keeps spare part inventory and uses RFID to locate critical aircraft parts quickly and manage inventory better.<sup>8</sup>

Overall, case-level RFID can add significant value over existing systems in receiving and storage for large retailers who source a variety of products through many different suppliers. Metrics related to “Source” processes are listed in Table 1. Each metric is identified as requiring truck (T), pallet (P), case (C), or item (I) level RFID.

Supply chain step	Metric
Source	<ul style="list-style-type: none"> <li>- % returns tied to components from a particular supplier* (I)</li> <li>- % manufacturing yield tied to raw material supplies from a particular supplier* (I/C)</li> </ul>
Receiving	<ul style="list-style-type: none"> <li>- Dwell time of container/pallet/item in loading bay* (P/C)</li> <li>- Time to receive shipment (T)</li> </ul>
Storage	<ul style="list-style-type: none"> <li>- Average, maximum storage time across SKUs* (C/I)</li> <li>- Dwell time between receipt and transfer/use (to flag stock rotation problems if applicable)* (C/I)</li> <li>- Percentage of items by SKU with unacceptable level of storage time* (C/I)</li> </ul>
Storage of maintenance and repair items	<ul style="list-style-type: none"> <li>- Time for MRO item/batch in storage, average and maximum across items/batches* (I/C)</li> <li>- Accuracy of spare part inventory records in terms of quantity and location (I/C)</li> <li>- Repair kits available in full (I)</li> </ul>

\*New metric obtained from the use of RFID

(I/C/P/T): Item-level, Case-level, Pallet-level, or Truck-level

**Table 1: Existing and new metrics that reflect the benefits of RFID for sourcing**

## ***Benefits for Making***

During *make* processes, RFID is likely to add more value in manufacturing environments with complex flows, and less value where flows are simple.

Well-defined flows in a process industry, e.g., sugar, limit the value of RFID. In a make-to-order setting in a job shop, however, RFID tags linked to each job can help improve the ease and accuracy of data gathering. This provides the manufacturer with the ability to make scheduling adjustments based on the actual state of the job shop.

Item-level RFID can help improve the manufacturing of highly customized, high-value items. For instance, Vauxhall Motors uses RFID to increase accuracy in manufacturing customized “Astra” models by attaching an RFID tag to each vehicle containing assembly details. The system has increased quality and decreased labor costs associated with customization.<sup>9</sup>

In both examples above, RFID only provides marginal additional benefits over existing manufacturing execution systems that can accomplish the same objectives.

The gains from RFID can be significant in manufacturing environments such as pharmaceuticals, where tracking and the maintenance of compliance records is mandated. Wells Dairy, an ice cream supplier to Wal-Mart, has reduced the cost of maintaining quality control by tagging each two-bucket case of ice cream for quality control.<sup>10</sup>

If RFID is used to guard against counterfeits, unit-level implementation is required. For example, Pfizer wants to track Viagra all the way to the consumer.<sup>11</sup> Similarly, Parmigiano cheese is tracked to prevent counterfeits from getting into the supply chain.<sup>12</sup> Such implementations can only be justified if they result in a significant reduction in counterfeit sales.



As discussed earlier, RFID can help improve up-time for manufacturing resources at airlines and the steel industry by improving the visibility of MRO parts. This can be valuable when the industry is capacity constrained and the cost of lost production is high.

Table 2 illustrates metrics for *make* processes. The metrics are listed as requiring item (I), case(C) or batch (B) level tagging.

Process	Metric
Manufacturing	<ul style="list-style-type: none"> <li>- Production hours consumed by item/production batch (I/B)</li> <li>- Production cycle time (average, min, max) for item/SKU/batch* (I/B)</li> <li>- Manufacturing yield tied to raw material supplies or components from a particular supplier's batch (I/B)</li> </ul>
Maintenance	<ul style="list-style-type: none"> <li>- Repair cycle time for workstation</li> <li>- Time-to-fail for replaced part in workstation</li> </ul>

\*New metric obtained from the use of RFID

**Table 2: Existing and new metrics that reflect the benefits of RFID for “make” processes**

### ***Benefits for Delivering***

Within delivery processes, improved tracking with container-, pallet-, or case-level RFID can help reduce the mean as well as the variance of the move-store-move time between stages of a supply chain, especially for inter-modal shipments.

Firms like Wal-Mart that cross-dock supply from multiple suppliers into their distribution centers can improve the efficiency of this process with case- or pallet-level RFID. These benefits are reflected in the time and labor requirements for the cross docking operation.

RFID can also help track assets like crates, forklifts, and trucks that are used in delivery processes of the goods that may also be tracked. Asset-level RFID can be used to

match the asset to what is being moved and improve the scheduling of assets for loading and unloading. For example, Graniterock reduced the loading time for trucks at its quarries by half once each truck had an RFID tag.<sup>13</sup>

RFID can also reduce shrinkage during transportation and improve cash flows through quicker and more accurate reconciliation of deliveries. For instance, Cambium-Forstbetriebe, a German forest management company, expects to recoup an investment of \$600,000 in tagging individual logs within a year due to reduced shrinkage and improved payment reconciliation.<sup>14</sup>

When a supplier delivers to a retailer, a proof of delivery is necessary for completing the transfer of ownership of the products and for invoicing. Any discrepancy often requires significant manual effort to resolve. Case-level RFID can help automate the proof-of-delivery process, making it more efficient and accurate.

By using the same RFID tags through the supply chain, a manufacturer can link future failures of finished goods to suppliers and carriers. Specific metrics can be percent returns tied to particular suppliers, couriers, and DCs (Table 3). The metrics are listed as requiring asset(A), item (I), case(C) or pallet (P) level tagging.

Process	Metric
Deliver	<ul style="list-style-type: none"> <li>- Dwell time for each stage of deliver (move-store-move-etc.) by item; aggregated across items for average, min, max* (C/P)</li> <li>- Unrecoverable delivery assets (A)</li> <li>- Product shrinkage during delivery (C)</li> <li>- Total time per shipment before it is received (T)</li> <li>- Shipments damaged by carrier as noted at time of receipt (C)</li> <li>- Individual items damaged by carrier as noted by returns* (I)</li> <li>- Carrier performance: percentage of deliveries made on time in full</li> </ul>

\*New metric obtained from the use of RFID

**Table 3: Existing and new metrics that reflect the benefits of RFID for “deliver” processes**

## ***Benefits for Returns***

The handling of returned product in containers, pallets, or even cases may not be complex enough to benefit significantly from the use of RFID. Firms tend to have few reliable and accurate metrics related to returns, given the relative lack of sophistication of these processes even in otherwise savvy companies.<sup>15</sup> Item-level RFID offers the possibility of creating such metrics (Table 5).

Process	Metric
Returns from retailer to manufacturer	<ul style="list-style-type: none"> <li>- Time between return at retail store and receipt by manufacturer if applicable* (I)</li> <li>- Percentage of returns sent to manufacturer</li> <li>- Percentage returns associated with manufacturing / component defects</li> </ul>

\*New metric obtained from the use of RFID

**Table 4: Existing and new metrics that reflect the benefits of RFID for returns**

## ***Other Benefits***

Assessing performance of suppliers, carriers, personnel, plants, or other assets within a company is much easier and more accurate with RFID (though its value can be hard to measure). Related data is typically not captured today because of the high cost of collection. For example, Graniterock has deployed an RFID application to “run reports that determine everything from supply chain efficiency to customer satisfaction.”<sup>16</sup>

Similarly, enforcing supply chain policies is easier with RFID tags, an extreme example being tagging of high-risk patients or newborn babies in hospitals. However, quantifying improvements can be tricky. Where compliance is mandatory (e.g., pharmaceuticals), RFID savings is easier to quantify; where compliance is not mandatory (and is thus not tracked), benefits are more difficult to prove. RFID’s role as an enabler

will rarely make the case for an RFID implementation unless compliance is mandatory. Its role as an enabler, however, can be a useful add-on benefit.

## **BENEFITS AT THE RETAIL STORE**

Now we focus on processes inside a retail store and those that interact with customers to consider other potential benefits of RFID.

### ***Benefits to Retailers***

We first look at a case-level RFID implementation and the resulting improvement in in-store operations. For most large retailers, a fundamental issue is ensuring that store shelves are not short of a product while it is sitting in the back room. For a large retailer like Wal-Mart, which stocks case quantities on shelves, a case-level RFID implementation combined with existing bar code technology can be quite effective in ensuring that items are replenished from the back room before they run out. Item-level tagging will clearly be more effective, though case-level tagging will capture a large part of the benefits.

Item-level tagging in the store is expensive. But the cost of item-level tagging may be justified for high-value items such as DVDs and apparel, which are likely to be moved by customers, resulting in an “out of stock” shelf even though the product is in a different location. Apparel retailer Gap reported that an RFID trial improved in-store inventory accuracy from 85 percent to nearly 100 percent.<sup>17</sup> A test by grocer Tesco showed that on-shelf availability at stores improved by 50 percent with RFID, though it is somewhat unclear what fraction of the gains could actually be attributed to RFID.<sup>18</sup>

Item-level tagging in the store may also make it easier to track and prevent pilferage for high-value products. In addition, item-level RFID can also improve the speed and accuracy of the labor-intensive checkout process for both shoppers and checkout clerks. There are limits, however, because the technology is unlikely to check out an entire shopping cart of merchandise at one time, due to low read rates.<sup>19</sup>

RFID systems are effective at changing price for all or some units of an SKU. Thus, item-level RFID tags can facilitate price changes at retailers that vary product price based on age or expiration date.

RFID can also help streamline classification of the returned item, tagging whether it is defective (or not) and whether the item is to be discounted, discarded, or simply put back on the shelf. The U.S.-based retailer Sears uses RFID to update inventories based on returns from end-customers and to ensure appropriate placement in its warehouses.<sup>20</sup> The improved management of returns can contribute to—but is unlikely to—justifying item-level RFID on its own.

The metrics in Table 4 are listed as requiring item (I) or case(C) level tagging.

Process	Metric
Selling	<ul style="list-style-type: none"> <li>- Dwell time on shelf per item* (average/max by SKU) (I)</li> <li>- Percent availability on shelf* (I)</li> <li>- Percent time with back room availability and on shelf out of stock* (I/C)</li> <li>- Freshness level - time to expiration across items (I)</li> <li>- Time to checkout order (I)</li> <li>- Time to checkout item* (I)</li> <li>- Units sold by display type by SKU* (I/C)</li> <li>- Minimum, maximum, average selling price (discount level) aggregated by SKU</li> <li>- Shrinkage (theft and spoilage)</li> </ul>

Returns from end-customer to retailer	<ul style="list-style-type: none"> <li>- Number of returns per production batch for each SKU (I)</li> <li>- Percentage of returns put back on the shelf in retail store (I)</li> <li>- Discount level of returns (I)</li> <li>- Time per return transaction (I)</li> <li>- Time between return and re-sale if applicable* (I)</li> </ul>
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\*New metric obtained from the use of RFID

**Table 5: Existing and new metrics that reflect the benefits of RFID for retail**

***Benefits to Consumers***

Consumers are not affected by case level RFID but will be affected by item-level tags. Item-level tags may improve the handling of returns from end-customers because of large product variety and potentially a higher rate of return compared to any other part of the supply chain.<sup>21</sup> Because of consumer privacy concerns, however, both Tesco as well as CASPIAN are suggesting that RFID tags should be “killed” at the time of checkout. U.K.-based retailer Marks and Spencer’s is considering separating tags from clothing at the point of sale, with customers providing the tag if a product is returned.<sup>22</sup> Such an approach, however, adds little value to the customer compared to retaining a sales receipt.

RFID provides consumers with few benefits but many risks—most related to the perceived loss of privacy. Like “cookies” on the web and credit-card information, item-level RFID tags can be used to track, predict, and influence individual actions. Thus, many of the perceived risks and opportunities associated with cookies and credit-card information also apply to RFID tags.

More than any other technology, RFID has raised the scepter of business (or government) playing “Big Brother,”<sup>23</sup> resulting in a backlash from consumer advocacy groups. The issue has become increasingly sensitive in the light of the U.S. government’s collection of phone records of all consumers from three major phone companies and

search-data from companies such as Google. Concerns have also been raised by the U.S. General Accounting Office regarding the potential intrusiveness of RFID as it tracks and collects data.<sup>24</sup>

### ***Summary of Benefits in the Supply Chain***

Our analysis indicates that RFID is likely to provide the highest benefits in managing complex environments in the supply chain. Relative to existing technology, most of the additional benefits come from reduced supply chain costs related to receiving and storage, with some benefits in terms of planning, manufacturing and delivery. Most of these benefits are likely to accrue to large retailers and require RFID to track cases rather than individual items (Table 5).

<b>High level supply chain processes</b>	<b>How RFID can improve process for suppliers and retailers (as applicable)</b>	<b>Implementation Level Required to Extract Most of the Value</b>	<b>Benefit Relative to Existing Technology</b>	<b>Primary Beneficiary</b>
Planning	Improved forecasting	Case	Small	Manufacturer
Sourcing	Faster receiving; faster reconciliation of gap between receipts and invoice; accuracy of storage	Case	Large	Retailer
Make	Custom manufacturing but not applicable to consumer-packaged goods industry; useful for maintenance and repair	Item / Case	Small to medium	Manufacturer
Delivery	Better tracking of shipments; faster receipts; faster pick-and-pack in warehouse operations	Case	Small to medium	Supplier, Carrier, Retailer
Return	Better tracking of returns	Item	Small	Retailer
Enable	More automated, more accurate and faster capture of data, leading to faster processing and better tracking of supply-chain metrics	Item / Case	Small	Entire supply chain
In-store operations	Ensuring shelf availability of items in the back room and reducing shrinkage	Item / Case	Medium to large	Retailer

**Table 5: How RFID can improve the high-level supply chain processes.**

Based on our analysis, we make the following conclusions:

**Conclusion 1:** A case-level RFID implementation provides the highest marginal value in most supply chains.

**Conclusion 2:** Retailers are the primary beneficiaries from an RFID implementation in the supply chain (see Figure 2).

**Conclusion 3:** Suppliers and carriers can draw limited benefits from case-level RFID. Consumers do not benefit from case-level RFID. Item-level RFID comes with significant privacy concerns for consumers.

## **COSTS AND RISKS ASSOCIATED WITH RFID**

In 2005, the cost of an RFID tag was 15 to 20 cents, although in some instances the cost may be as low as 10 cents with large-volume commitments. A typical reader costs about \$1,000, but this cost continues to go down and may decline to about \$100 before 2010. The number of tags and readers required and, as a result, the cost of an RFID system, grows enormously as we move from pallet level to case level to item level (See Figure 3). Indeed, the cost of setting up item-level systems at retail stores is currently prohibitive (the cost of RFID readers covering all shelves of a store could cost more than the rest of the store!)<sup>25</sup>. Besides the cost, there are many risks related to an RFID implementation that we discuss next.

**Standards risks:** The lack of industry-wide RFID standards impacts adoption and interoperability. When information needs to be read, shared, and managed by multiple companies in a supply chain, the issue of different standards is serious. According to Deloitte, “Standards need to be established around Electronic Product Codes (EPC)... While these standards are coming closer to reality through the efforts of several well-



known oversight organizations, they remain an unresolved topic, with suppliers and customers, at present, being forced to choose one standard over another.”<sup>26</sup>

**Vendor risk:** As with any new technology, there is vendor-related risk with RFID, and companies should select their technology “partners” to ensure ongoing capabilities for the future. The Deloitte study anticipates that many small and mid-size RFID vendors will consolidate in the next few years or simply go out of business.<sup>27</sup>

**Change management:** User inability to manage change is an important risk when implementing RFID. For example, the lack of training among military service personnel on the use of RFID tags and other tracking tools adversely affected asset visibility and logistics in the 2003 war effort in Iraq.<sup>28</sup>

**IT operations risks:** Like any large IT system, RFID will incur high costs of maintenance, and support may be difficult to manage. A close parallel is ERP implementation, where several companies found the eventual costs to be higher and the benefits lower than envisioned. The use of RFID may be hampered by the lack of suitable technology at all locations. For example, a retailer may find that not all facilities have appropriate readers when it switches to second-generation RFID tags. Finally, the sharing of RFID data requires a level of IT that may not be available across the supply chain.

**Process risks:** The lack of adequate RFID-enabled backup facilities, business continuity planning, and the impact and integration of RFID-enabled processes with existing

business processes were identified as major risks in a study done by Gillette.<sup>29</sup> When RFID replaces an existing technology such as bar codes, firms often use both technologies in parallel for a period of time. This eases the transition but can have the unintended effect of reinforcing old but irrelevant business practices. It also requires the firm to run two different processes (one for RFID and the other for the current technology) at the same time to accomplish the task. This increases the risk of process failure.

**Technical risks:** There are several technical factors that may limit the effectiveness of tags and readers making the benefits much lower than anticipated. *Reader collision* occurs when multiple readers attempt to read the same tag at the same time. *Tag collision* occurs when one reader receives signals that have reflected back from multiple tags at the same time, confusing the reader because it cannot distinguish between the tags. Next-generation technology such as Gen 2 from EPC Global promises to decrease such collisions, especially at the case level.<sup>30</sup> *Signal interference and noise* arises when ambient warehouse conditions distort the electromagnetic signals sent by the tag and/or reader. A McKinsey report mentions field trials where single-tagged pallets were read with 78 percent accuracy and double-tagged with only 95 percent accuracy.<sup>31</sup> *Inconsistent data* occurs when readers at different points along the supply chain receive inconsistent information from the same tag. If readers and tags are not foolproof, there is a danger that junk data will generate junk performance measures and hence junk decisions.<sup>32</sup>

**Obsolescence risk:** RFID is a young technology that is likely to evolve in the future. Any investment in the technology may become obsolete if the next generation of RFID is significantly different. Many companies not seeing short-term benefits would prefer to wait for some resolution with regards to technology.

**IT security risks:** RFID tags should ideally be read only by the relevant supply chain partner(s). However, a third party, whether commercially or otherwise motivated, can get access by hacking the necessary password protection, as pointed out by John Hopkins and RSA.<sup>33</sup>

### ***Summary of Costs and Risks***

All the risks mentioned above compromise the benefits from RFID. With the rapid growth in the size and complexity of RFID systems as we move from pallet- to case- to item-level tags, the costs and risks associated with an implementation also grow exponentially (Figures 3 and 4). Item-level implementations in particular have a very high marginal cost and risk. Our main conclusion is the following:

**Conclusion 4:** Technology-related risks and related costs generally increase as we move from pallet- to case- to item-level RFID in the supply chain.

## **CONCLUSIONS**

So how does this analysis help illuminate a business case for RFID? The key idea is to find a “sweet spot” where the marginal costs and risks are contained but the marginal

benefits are large. Our analysis suggests that the retailer's (or distributor's) back-end supply chain processes—where a large variety of cases are received, stored, and handled—provide the maximum gains with the minimum pain (Figure 5). Upstream, suppliers will find lower benefits and lower risks and costs when applying RFID to pallets. Downstream within the retail store, marginal benefits from tagging individual items are not very high relative to the use of case tags in most cases, but the increase in costs and the risks are large. Item-level tagging in general will be justified only for high-value items such as jewelry or critical items such as important spare parts. Item-level tagging may also be justified in situations such as pharmaceuticals where tracking is mandatory.

Our analysis helps resolve the conundrum as to why companies are hesitant about RFID despite the promises of benefits. Our recommendation is that companies start where they get the most bang for their buck; i.e., at the case level in processes close to the retail end that receive, store, and handle a large variety of cases.

## Endnotes

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<sup>5</sup> See, for instance, Sodhi, M., 2004. "The Internet of things," *OR/MS Today*, February, also at [www.orms-today.com](http://www.orms-today.com)

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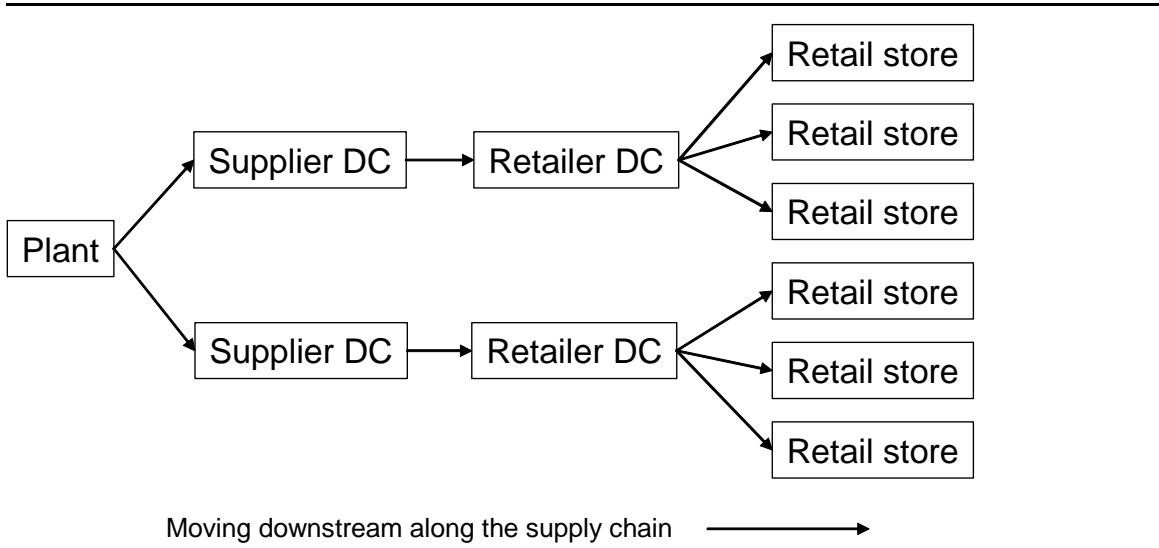
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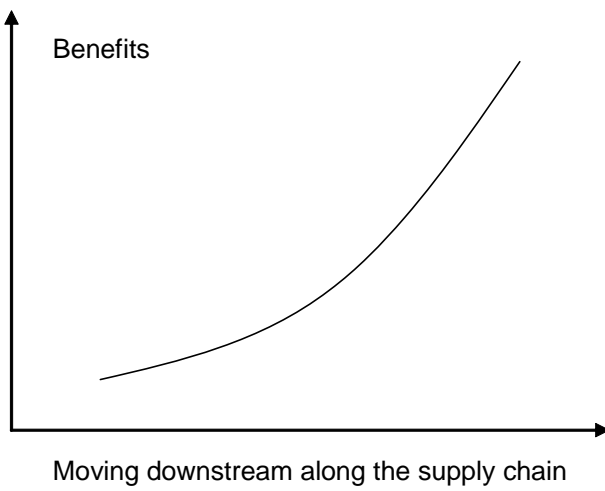
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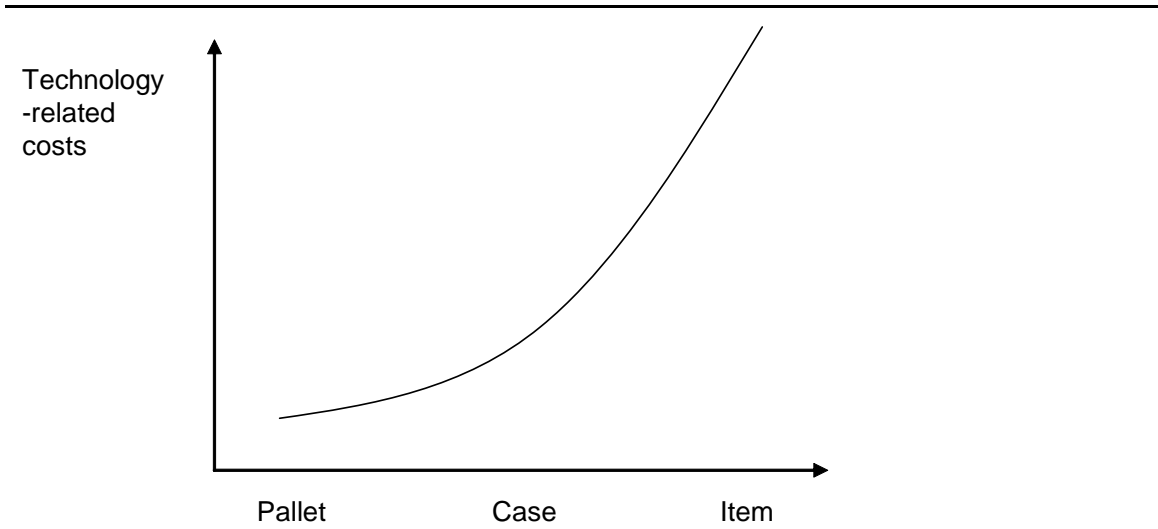
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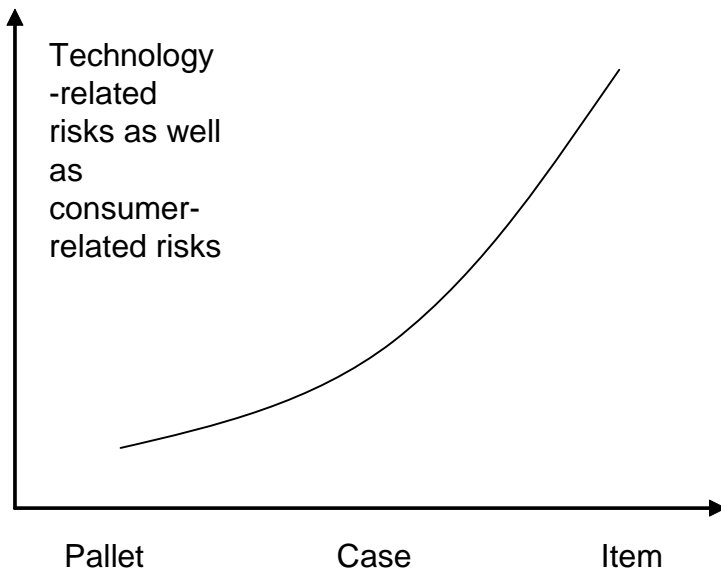
**Figure 1:** The retail supply chain (simplified)



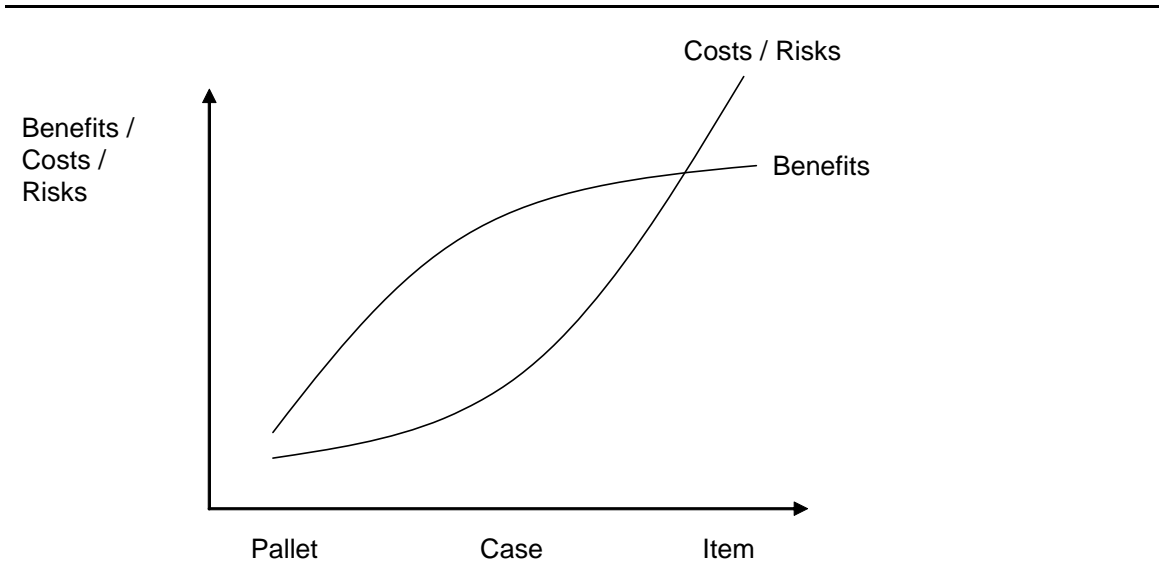
**Figure 2:** Benefits of RFID technology increase as we move downstream in the supply chain up to but not including the retail store



**Figure 3:** Technology-related costs increase as we move downstream in the supply chain with the retailer incurring most of the costs



**Figure 4:** Technology-related risks increase as we need to deploy more technology as we move downstream in the supply chain and deal with pallet-level, case-level, and item-level deployment. Consumer-related risks are highest with item-level RFID



**Figure 5:** Benefits taper off as we move downstream in the supply chain and go from pallet- to case- to item-level RFID deployment. At the same time, costs and risks mushroom at the retail store, with *net* benefits consequently being the highest at the case level.