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How Competition, Customization, and Niche Markets Have Affected SKU Proliferation and Management

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HOW COMPETITION, CUSTOMIZATION, AND NICHE MARKETS HAVE AFFECTED SKU PROLIFERATION AND
MANAGEMENT

By

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of the Requirements for
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1. Introduction

When Ford originally found success it was with the Model T automobile. One of the driving forces behind the success and fame of the Model T was that Henry Ford learned to produce the vehicles quickly and cheaply. The Model T was offered with few options, and Ford is famously paraphrased saying that customers could choose any color, so long as that color was black. However, progress and competition have changed the business world. Differentiation has become a major competitive advantage. The end result is that many companies and businesses have found a competitive advantage by offering a wide variety of products. While Henry Ford may have only had to keep up with a limited number of parts for his relatively standard Model T, the Ford Motor Company now sells sixteen different models of consumer vehicles. This has not only happened to the Ford Motor Company. Growth in the number of stock keeping units (SKUs) is present across most consumer goods. What has caused this explosion in SKUs, how have companies adapted warehouses and the supply chain for the growing inventory diversity, and how will businesses cope with inventory in the future as SKUs continue to grow?

2. Causes and Justification of SKU Expansion

SKU proliferation has certainly made the supply chain a much more complex operation. But before diving in to the complexity and variety of potential solutions for high level of SKUs, it is important to understand what has caused SKUs to grow. SKUs are mostly growing in an attempt to reach more niche markets to expand sales, penetrate a market, or to maintain a presence in a market.

The beverage industry is particularly affected by SKU proliferation. This allows it to serve as a good example to study the effects of growing SKUs. To investigate this market Joseph Springs was contacted for a phone interview. Springs is the Director of Product Supply Planning at Coca-Cola Bottling Company Consolidated, a Coca-Cola franchise that services the Southeast. He helped explain the reasoning for both Coca-Cola Bottling Company Consolidated and its parent company's SKU proliferation. His explanation for the vast number of SKUs in today's market can serve as evidence to the necessity of a large diversity of products. In the interview, Springs discussed that SKU proliferation could be for reaching new customers and markets, appealing to ever more niche markets by increasing user customization, and how retailers are sometimes the customer that wants variation in products. Springs also mentioned that sometimes SKU proliferation is for other purposes such as brand expansion, breaking into and remaining relevant in highly competitive markets, and obtaining auxiliary benefits such as consumer research (Springs, Joseph).

2.1 Reaching New Markets

2.1.1 Introduction

The first and most obvious goal of adding products is to reach new customers. There are only two ways to increase sales. You can either increase how much each customer buys, or find new customers. By introducing more products, a company is able to reach customers that may not have otherwise bought product. For example, Sprite appeals to a different market than Coca-Cola Classic. Some of the Sprite customers would have never bought any product from Coca-Cola had Coca-Cola Classic been the only option available to them. By having a Sprite as an additional product, the Coca-Cola Company is able to increase its sales and therefore increase its profits (Springs, Joseph).

This may be an oversimplified example, but it demonstrates the core idea behind introducing new products. There are many more factors at play, but the base idea holds true. As new products are introduced that target untapped markets, sales and profits should also increase. As time passes, more and more markets become competitive. While the lemon-lime carbonated beverage market may have lacked real competitors when Sprite entered, it is now highly contested. As a result, these major markets are harder to enter. That is not to say that all of the beverage markets are saturated. It also means that reaching customers through wholly new products is the only reason for the existence of multiple SKUs. SKUs exist for reasons starting at introducing new products to target more niches, to introducing existing products in new packaging, even to large retailers wanting special products or packaging. Some SKUs exist for reasons not even directly driven by the consumer such as marketing strategies involving consuming shelf

space, remaining relevant in a market to sell complimentary goods, and market research.

2.1.2 New Products to Target New Consumers

One of the major consumer trends in recent years has been that customers want more and more personalized goods. Niche markets are getting smaller and more diverse. In response to this, companies pursue those markets. Springs points out that Coca-Cola experiences this in the cola flavored soda market, which has become more and more divided. Some customers want not just cola flavored soda, but cherry cola soda. So, Cherry Coca-Cola is created to capitalize on that market and bring in sales. As these markets grew and became competitive companies again adapted. Now the Coca-Cola Company produces Cherry Coca-Cola Zero for the consumer who wants a cherry cola flavored beverage, but is also health conscious and wants to avoid calories. It is easy to see how this continued until the present day situation where Coca-Cola Bottling Company Consolidated carries around 700 unique SKUs (Springs, Joseph).

All of this diversification has led to the SKU proliferation we see today. One great example of Coca-Cola catering to user customization is the Freestyle machine. This new take on the traditional soda fountain allows consumers to mix a multitude of flavors with their beverage. Springs mentioned that “some customers want Coke Cherry Vanilla, not just Cherry Coke,” and that is the strength of the Freestyle machine. Customers can make their drink to their own niche desire. This results in a more valuable experience for the consumer. As Springs confirms “The landscape of the

customers has changed, people like more individualized consumer goods than in the past.” This presents a great opportunity for Coca-Cola. By continuing to target niche markets and personalizing goods for the consumer, the company is able to target new markets that could potentially continue to bring in more sales (Springs, Joseph).

The beverage industry is one of the better examples of SKU proliferation. As a result, there are several different forces driving its SKU proliferation. Coca-Cola is in a predicament that explains why their SKUs are expanding so rapidly. Coca-Cola is named after their bestselling product, a cola-flavored soda. Unfortunately for soda companies, recent health trends and unfavorable press have led to soda sales falling for a while, and are continuing to do so. Oddly, Coca-Cola’s sales and profits have stayed up. The company, instead of pushing soda sales, has moved on to markets that are more of blue ocean opportunities. Springs notes that many of the products added are “a lot of things not in the sparkling category that are in more of the health and nutrition category.” He goes on to explain the logic behind this shift;

“Core soft drink sales are actually down. Year after year soft drink sales are actually declining. So, if you were in our shoes and you see a declining market for soft drinks, and you don’t expand your portfolio to diversify into different markets you are expecting that you are declining. If we want to expand to maintain our profitability, we have to go out and go after new markets that we didn’t play in before” (Springs, Joseph).

To avoid this decline, Coca-Cola has branched out into products such as Dasani, Smart Water, Core Power, and Zico. Bringing in these new products has enabled Coca-Cola to maintain their profit margins while soda sales continue to fall (Springs, Joseph).

2.1.3 Product Diversity in Consumer Goods

Springs was quick to point out that while this trend towards customization and consumer individualization is certainly observable in the beverage industry, it is true for any consumer good. He used the example of consumer electronics to demonstrate this. What may initially seem like a standardized product is still highly varied and personalized. If you walk into a store to buy a computer, you are well aware of the tasks that you need that device to perform, if not the exact specifications you want. With Windows based computers there are tons of options to fit every need. Even Apple, who does not have a wide diversity of products has a number of colors and sizes per model for the consumer to pick from. Springs observes that “there are so many offerings that they can’t get you at Best Buy that you’re not going to walk away with that new Apple, but you’re going to spec it out to fit you.” Consumers will go to another store, or – with increasing probability – buy the product online if they cannot find it in store. Driving home the point, customers can actually order a customized computer online. This is particularly true with Windows based computers. Some of the providers of these computers even allow consumers can go to the company’s website and specify exactly which combination of parts (such as which processor, hard drive, RAM, etc.) it wants on a computer and what color or designs will be on that computer. While Springs used the example of consumer electronics he included that “it’s no different than any other consumer good. The market itself has demanded more individualization of product. Therefore, in order to be relevant in that space you have to have more offerings” (Springs, Joseph).

2.1.4 Existing Products in New Packaging

Coca-Cola has not abandoned their namesake however. They have continued to expand in the soda markets too. However, to hit profitable niches, the company has to keep in mind that health trends are the reason for declining soda sales. As a result, Coca-Cola has been introducing more health focused products such as Coke Zero and smaller portion sizes of their traditional drinks. These products have helped Coca-Cola remain relevant and profitable in their home market segment. The small containers are particularly interesting. They contain identical product to the traditional cans, but their sales trends are opposite that of the general soda trend. The smaller size appeals to the health conscious consumer surprisingly well. As a result of these trends, Coca-Cola's SKU count continues to grow at extraordinary rates (Springs, Joseph).

2.1.4 Retailer Driven SKU Diversity

While all demand is ultimately driven by the consumer, some SKU proliferation is driven by intermediary customers. Consolidated retailers actually drive some of the unique SKUs that Coca-Cola produces. This only occurs with large retailers such as Wal-Mart and Target. However, while they may not represent a large percentage of Coca-Colas customers, they do represent a vastly disproportionate quantity of their sales (Springs, Joseph).

It may seem curious that these companies would want specialized products. However, these retailers are constantly looking for ways to pull in more revenue and

profit from their customers. They have found that certain packaging and products is one way to do this. In fact, many of these retailers want specialized products that only they sell. So Wal-Mart may carry a special packaging or promotion that only that retailer is allowed to run. These exclusive promotional products are shown to bring in more money for Wal-Mart. This puts pressure on suppliers such as Coca-Cola. Wal-Mart is not willing to pay for this special service. As a result, Coca-Cola's supply chain has to handle these additional SKUs without additional compensation. With these accounts being so large it still makes sense for Coca-Cola to supply these unique SKUs. As a result, the supply chain must cope. Failing to do so would hurt the company's profit. The supply chain should enable a business, not constrain it. Therefore, creative solutions are needed to accommodate the rise in SKUs (Springs, Joseph).

2.2 Product Diversity for Alternative Purposes

2.2.2 Brand Expansion with Monster Energy Drink

While many products are introduced to pursue niche markets in order to drive up sales and profit, this is not always the case. Sometimes a wide variety of products are introduced with no concern given to current demand. For Coca-Cola, Monster, Dasani, and the Freestyle machine demonstrate different reasons for which products may be introduced that are not directly related to demand.

Monster Energy Drink has been a resounding success for Coca-Cola due to its high profit margins. After recently joining with the company, Coca-Cola has benefitted from the relatively uncompetitive and lucrative market of energy drinks. It likely caused

a few headaches for the supply chain however. Monster produces over 50 varieties of its energy drink. Springs added that Coca-Cola Bottling Company Consolidated carries 42 of those varieties. Surprisingly, the large variety of Monster has minimal sales cannibalization. Every variety is profitable. However, this still does not justify carrying 42 varieties of a beverage in a relatively undiversified market. Monster sales are still largely driven by a core few flavors. Springs refers to convenience stores saying, “If you go and look at a monster door, it’s like half a door of just green monster” (Springs, Joseph). The rest of the varieties of Monster serve more purpose than just offering more choice to the consumer. The more a product is seen, the more shelf space it has, the more likely a consumer is to buy it. When a store wants to stock some of the myriad of Monster varieties, it has to allocate some shelf space for each variety. Springs explains this strategy “If you continue to fill up that cold vault with more flavors of Monster, eventually nobody sees Rockstar” and replied further that it is indeed “a physical pushing them out of that cooler set” (Springs, Joseph).

2.2.2 Breaking into New Markets with Dasani and Mello Yello

Unlike Monster, not all Dasani products are profitable. Cases of Dasani water are actually loss leaders. The margins per case are too slim, and the cases lose profitability by sitting on the shelf. This is not necessarily by mistake. The product does serve a purpose. “We are losing profitability to be relevant in that space... There is value in being in a line up” explains Springs. The reason cases of Dasani sit on the shelves of Wal-Mart is to ensure that brand recognition continues throughout the rest of Dasani’s line such as flavored water, Dasani drops, and the sale of individual bottles. If

Coca-Cola does not provide cases of water, they are at risk of losing a foothold in the water market (Springs, Joseph).

Springs brings up another interesting case of maintaining relevance. He reveals that “in convenience retail the number one selling beverage in most convenience retail accounts is actually 20-ounce Mountain Dew.” This was and is a large problem for Coca-Cola, as Mountain Dew is produced by rival beverage company, Pepsi. To combat this Coca-Cola introduced Mello Yello. Mello Yello actually came into the market rather successfully. Springs comments that this was definitely intentional. He brings up that while profit is typically the goal when bringing out a new product, market share can also be the objective. Market share indicates future and sustainable growth. Putting money into promotion can temporarily boost sales, but the real sign of a healthy product is if it genuinely increases market share. This results in brand extension, which is similar to the Monster example. If consumers only see Coca-Cola products because the Pepsi products have been pushed to the bottom of the fridge or even to another fridge, that will ultimately result in better profits for Coca-Cola (Springs, Joseph).

2.2.3 Individualization, Auxiliary Benefits, and Market Research with the Freestyle Machine

The Freestyle machine brings yet another benefit from diversification. The Freestyle initially seems to have questionable purpose. While it pleases customers to have more choice in their beverage, the machines are more expensive than the typical soda fountain and typically create larger queues. Some may argue that the machines

are resulting in more customers buying beverages at the restaurants that have them, and those sales are making it back to Coca-Cola. Another argument is that the machines bring in more customers and that this justifies the restaurants purchasing them. This is a valid point, as the machines have been on the market for a few years, they still continue to bring in more customers to restaurants. If customers are willing to drive to a restaurant just for the machine, that brings a competitive edge and more profit to that business. As a result, it is currently a good business case to have one of these machines, but eventually the effect will wear off (Springs, Joseph).

Because effect is destined to wear off as the market reaches saturation, this cannot be the entire purpose of the machine. The true purpose of the machine does fall back to consumer individualization. Whenever a customer fills their drink at a Freestyle machine it is silently recording data. “The long term benefit of Freestyle machines is consumer insight” comments Springs. By understanding what consumers blend for themselves, Coca-Cola can better understand the market. Once the company has a better grasp of the market, it can produce to what the market desires. The Freestyle machine is, in a sense, a giant consumer focus group. However, this has a double effect on the supply chain. Ingredients in the machines themselves raise SKU counts, and then the research they provide leads to Coca-Cola producing new products for retail, again adding more SKUs (Springs, Joseph).

One final benefit of the Freestyle machines is the opportunity to cross sell. When a representative enters a restaurant to restock the Freestyle machine, it is also an opportunity to sell that business cups and lids. Because cups and lids are highly profitable, this is a great opportunity. Because the Freestyle offers more to the end

consumers, restaurants will prefer them. Ultimately, this leads to more opportunities for Coca-Cola to sell cups and lids, which results in more profit. This is true of most stocking operations Coca-Cola conducts. Anytime a representative is at a location is an excellent time to cross sell products (Springs, Joseph).

While loading the machines up with new syrups may be fairly easy, they create challenges in Coca-Cola's supply chain. Coca-Cola's supply chain is designed for moving heavy cases, primarily in pallet quantities. While easy to switch out, Freestyle machine cartridges are not similar to a case of soda cans, and thus do not conform to Coca-Cola's existing supply chain. Many other SKUs being introduced also bring challenges to Coca-Cola's supply chain. Dasani Drops are a product that can be squeezed into water to add flavor. They ship in small boxes roughly the size of two or three bricks. Products such as these force the supply chain to innovate and look for solutions to ensure consistent service to retailers and internal customers (Springs, Joseph).

2.3 Supply Chains Role in Business

The supply chain exists to enable businesses to deliver product to its customers. If the supply chain were to prevent a company from selling a new product because it is unable to handle the new volume or unique challenges presented by that product, it will have failed. Being able to handle difficult products and situations efficiently is what differentiates supply chains.

“That’s a huge part of our role as the supply chain. Innovation is hard. Innovation is difficult. My distribution network is built for delivering the products we sold yesterday. So, it is our responsibility as supply chain leaders to build the distribution network that enables our marketing team and our company to distribute the items of tomorrow” (Springs, Joseph).

Springs explained the role of the supply chain well. Supply chain leaders must look at what is happening around them, look at what is possible on the horizon, and combine the two to make sure that they are continuing to build a supply chain capable of distributing the items of tomorrow.

3. Modern Solutions for High SKU Counts

Obviously, times have changed since the early days of manufacturing. Ford now makes more than just a Model T, and their cars come in colors other than just black. Many soft drink distributors now keep over 500 SKUs (Cernivec, Stephanie). Some businesses have developed creative strategies and tactics to manage and distribute their inventory.

As mentioned in Jessica Jacobsen’s *Warehouses Cope with Growing Pains*, “consumers, even though they’re challenged money-wise, they don’t want to give up their demands for their niche products.” Jacobsen goes on to quote Lonnie Watkins who posits “I don’t think the SKU proliferation game is going to slow down anytime soon” (Jacobsen, Jessica). These two statements draw attention to the problems faced by many working in production and warehousing, and show that it is something that is

not going away. Businesses must evolve and develop solutions to handle this great diversity of product. Jacobsen point out some of the difficulties that come with large amounts of SKUs. Often customers downstream cannot handle full pallets of such products due to expiration dates, cost of product, and their own storage constraints. Many of these customers need mixed-SKU pallets (Jacobsen, Jessica). Having to break down pallets is a time-consuming process, and extra touches are costly in warehousing. This forces businesses to find new solutions if they want to maintain profit margins.

3.1 Infrastructure Solutions for High SKU Warehouses

3.1.1 Automated Storage/Retrieval Systems

One opportunity for cost reduction lies in the infrastructure within the warehouse. A solution that is particularly well suited for the mixed-product pallets is to install automated picking systems. These are often referred to as AS/RS systems, which is short for automated storage/retrieval systems. Jeff Stingle, vice president of Vertique (a company that sells warehouse solutions) is quoted saying that “Some companies have grown 50 to 75 percent in their SKUs in the last year” and that this “makes it more difficult and increases errors, and therefore starts to push the need even more for automation in the case picking end of the business.” Stingle was speaking particularly on the beverage industry at the time in an article titled “Better Warehouse Inventory Management.” He went on to comment that not all warehouses need full automation,

but that installing any portion or style of AS/RS systems helps reduce the error in high-SKU scenarios (Strzelecki, Molly).

The benefits from this are fairly obvious. If extra touches are expensive, errors are even more so. Having to rework a misconfigured pallet takes drastically more time. The pallet will need to be broken back down, and then the correct product must be added and the pallet reconfigured. The incorrectly included product must be returned to the correct place in the warehouse, all taking time and effort which eventually translates to profit loss. This is only when the error is discovered before the pallet leaves the warehouse. In the instance an outbound pallet is misconfigured and shipped out, there are even more costs. The receiver of the pallet will not receive needed inventory, and as supply chains become more and more lean, this causes more problems. Lost sales from stock outs or production line shut downs could be charged back to suppliers. At the least, the product would either need to be shipped back to the original warehouse and the order corrected (incurring extra shipping costs) or the product could be considered a loss. Thus, it is clear why Stingle was quick to point out the potential error reduction his company's solutions could provide.

3.1.2 Storage Racking Systems

Adding more SKUs does not only complicate picking though, product needs to be stored in an organized fashion, and picked pallets are not all the same. As more SKUs are introduced into a warehouse, floor space becomes an issue. If a beverage distributor only has one SKU, the warehouse can be filled as high as the product can be

stacked. However, as SKUs are added this becomes more of a problem. Low volume SKUs may not be plentiful enough to create tall stacks, and as a result will consume more floor space. Thus, warehouses must find a way to create more space, but expanding the warehouse may not be an option. This seems rather contradictory, and presents a problem.

However, as with mixed-SKU pallets, it presents an opportunity. In Strzelecki's article *Better Warehouse Inventory Management*, Doug Hayden of Twinlode comments on his company's solution. Using special storage racks, product can be stacked much higher in a warehouse. High volume product can be stacked higher as the rack provides strength and stability to go higher. Low volume product essentially gained a second "floor", and two SKUs can be kept in the same square footage, but one above the other. Since both products are accessible, this alleviates some of the problems of consuming large amounts of square footage with small amounts of volume. Hayden comments that "It doubles the capacity in the same cube" (Strzelecki, Molly).

3.1.3 Additional Benefits

In Strzelecki's article, there seemed to be a few common themes echoed by every provider of these solutions. First, they echoed the secondary benefits of their systems. While the intentions of the systems are to help with rapid and accurate picking across a large number of SKUs, their systems offer other benefits and are versatile enough to scale up into huge warehouses or down into smaller warehouses. One of Westfalia's systems involves racks with cranes on the ends. This system eliminates the

need for a forklift to go up and down aisles, and instead a dedicated crane for each aisle handles pallets. While this covers the basic requirements of allowing denser storage of product by utilizing racks and increases pick rate and accuracy, it has some other added benefits. Having dedicated cranes in a secured environment increases safety by taking out the risks associated with forklifts. Vertique's Stingle later points out that "as labor [costs] continues to go up, insurance continues to go up and [the cost of] maintaining your employees has gone up." Increasing safety and reducing labor helps with these costs. Westfalia's Juergen Conrad is also quick to mention that their system reduces the amount of shrink wrap and other packaging needed for pallets. He also mentions that his system increases cleanliness in the warehouse, as reducing the number of forklifts in a facility lowers the amount of dirt tracked in and byproducts created by burning fuel in the forklifts. Lastly, Conrad notes that he considers his systems modularity to be one of the most important features. He notes that "particularly our system, can be built for smaller footprints. We can go multiple deep with the technology of having two cranes in the aisle. The whole construction of our system can be in a small, condensed and efficient warehouse" (Strzelecki, Molly). By having such an adaptable system, it can be applied in dense warehouse situations, or adapted to a large variety of warehouses. As Strzelecki pointed out "But it's not just the big players who are rethinking how they store their products. While smaller players may not be handling 600 SKUs, they are still handling more products than ever, and efficient and well-managed storage systems are key to their success as well" (Strzelecki, Molly). It is clear to see why Conrad would be proud of the Westfalia AS/RS system's ability to adapt to its situation and serve a wider customer base.

While these systems are highly scalable and would certainly help in most warehousing situations, the companies that produce them may oversell the practicality of instituting the system in smaller applications. Twinlode's Doug Hayden is quoted in Strzelecki's article commenting that "Steel prices are always a concern," but seems to not be concerned himself as "If anything, it's something that our clients are having to plan for and deal with the increase in steel cost and availability of steel, because there is still a need for them to add pallet racking or add storage methods to accommodate the trends that are happening" (Strzelecki, Molly). These systems are not cheap, and may not be a solution for all business or situations. Their price can even be an issue for large companies. Hopefully as time progresses these machines will be produced more efficiently and be cheaper to purchase and install. For now, while they simplify warehouse operations in the long run they also introduce complexity, especially during implementation.

3.2 Gander Mountain Case

Large and complex solutions may not be the solution for every business or situation. As the saying goes, sometimes it is better to work smarter than harder. Gander Mountain is a sporting goods retailer that focuses on activities such as camping, hunting, and fishing. Before it came up with an innovative warehouse management solution, product was stored in pallets, shelves, and even totes on the ground. Employees would have to climb on ladders to reach product on higher shelves or product stored overhead. Even when they found the correct pallet or tote, employees would still have to dig through them to find the right product. This problem arose from a

lack of right-sized storage locations and rapidly expanding SKUs. Because there was a lack of proper storage, multiple products were consolidated into single bins. The current systems in place were not scalable to fix the problem, and Gander Mountain did not want to have product in multiple warehouse locations (Bond, Josh).

Gander Mountain considered turning to an AS/RS system. However, the systems are expensive and Gander Mountain did not want to take on the added costs of the systems. Further, Gander Mountain looked at the total cost of ownership for such systems including the costs associated with the needed warehouse management systems and further complications with automation and conveyance, and ruled out an AS/RS system. Instead they turned to a less expensive solution. They added new fabric storage cells from a company called SpeedCell. By dividing up the previously incorrectly sized bins, Gander Mountain was able to increase the number of bins while increasing the utility of the storage area at the same time. After a short testing period, Gander Mountain introduced 219 new storage location per bay for a total of 4380 new locations per aisle. This added over 17,000 locations for the warehouse while not consuming any more space and avoiding the costs and complications associated with an AS/RS system. Most importantly however, is that the system works. It has increased storage capacity by 86% per bay, reduced travel time for pickers, and had an overall increase in picking and storage efficiency of 25% (Bond, Josh).

The Gander Mountain case demonstrates a few key points on the management of growing SKU proliferation. The first is that more expensive solutions may not always be the best. Gander Mountain avoided the AS/RS solutions and used a more situation-appropriate solution. The bin division is essentially the same idea as

putting dividers in a fishing tackle box. It is almost obvious that it is quicker to find the lure that you need if you organize your lures into compartments as opposed to having them randomly strewn throughout the box. While it may increase complexity due to having many more bins, the increase in locational precision outweighs the increase in complexity. It is easy to jump to the solution with the most “wow factor.” However, Gander Mountain did not particularly need all the complications that came with such a system. By subdividing its storage locations, it tackled all the problems it was having and saw great improvements in warehouse operations. The second key point that this case demonstrates is that solutions are not a one-fits-all situation. The subdivision of bins worked great for Gander Mountain. However, if a Coca-Cola franchise created bins for its product it may not work. Cases of beverages wouldn’t fit into compartments so well, it is easier just to grab cases from a pallet or pallets from a stack of pallets. Cases of beverages also have different handling characteristics. As such, an AS/RS system may be fitting for such a warehouse, while adding in fabric bin dividers may not be. While inspiration may be drawn from what has worked for others, it is important moving forward to remember that these decisions need to be well analyzed and thought through before they are implemented.

3.3 Under Armour Case

Another strategy being used to combat increasing SKU proliferation is evidenced in a 2009 case with Under Armour. The company has seen consistently large growth in the past years, and is intent on maintaining that growth. One such way it has been maintaining its growth is by expanding into new markets. However, all this growth

comes with opportunities and challenges. Under Armour's director of distribution systems, Eric Olsson, quickly points to market expansion and thus increasing SKU proliferation as one of the biggest challenges stating "From our perspective the biggest one is SKU growth. It has just been enormous" (Cole, Michael). From 2007 to 2009 Under Armour saw its SKU count more than quadruple from a maximum of 4500 individual SKUs to over 20,000. Under Armour has two main warehouses to store this product, both in Baltimore and both just over 300,000 square feet (Cole, Michael).

Further constraints come when looking at the distribution of the plethora of SKUs. 90% of Under Armour's sales came from only 5100 SKUs one month, while the remaining 10% came from 19,500 different items (Cole, Michael). The 5100 SKUs are made up of items such as compression shirts and underwear, products Under Armour has produced for a long time. These products are also easier to move in large quantities and make Olsson's job easier. The remainder of products, the 80% that makes up only 10% of sales, are comprised of seasonal items (such as snow jackets) and more niche or varied items (such as scent controlling clothing for hunting). Olsson points out that the e-commerce side of Under Armour is fond of the tail products, and keeps the pressure on for those goods to be properly serviced. While wholesale to retailers tends to be easier with a smaller set of SKUs (Cole, Michael).

It is easy to see where these varied means of distribution and wide array of products would tempt Olsson to discourage the SKU expansion. However, Olsson comments that he does not "want to constrain the business and [tell the company] 'don't come up with new SKUs' only because it's a challenge on the distribution side" (Cole, Michael). Thus, distribution and warehousing had to come up with a solution to handle

the growth. When touring other businesses to see what solutions they had come up with, Under Armour ran into a common problem. Companies were making large capital investments, but part of their decision process for these projects included the changes lasting for ten years. Olsson commented that “[At Under Armour,] we're lucky if we'll see a year and a half” (Cole, Michael).

As a result, Under Armour was in a position where they needed to find a solution that was either effective enough to meet its required return on investment in at most a year and a half, or a solution flexible enough that it could evolve alongside Under Armour's growth. Under Armour ultimately mentions the use of five tools in this case. A warehouse management system and slotting optimization tool which Under Armour used in conjunction with a pick-to-light system, RF pick system, and a rack system. Without using all of these tools Under Armour would either have unacceptably high costs, or high rates of error and unfulfilled orders (Cole, Michael).

First, they turned to Manhattan Associates, a software and consulting firm. Under Armour implemented Manhattan Associates' warehouse management system and slotting optimization tool. The slotting optimization tool was key for Under Armour to stay on top of its expanding SKUs. The system takes data on the physical characteristics of each product to determine every possible location for it in the warehouse, and any other constraints based on these characteristics. It then looks at the recent demand for items to determine the best possible layout for the warehouse. This solution fits several of Under Armour's more unique challenges. It allows for SKUs heavily affected by seasonality to be more or less easily picked depending on whether or not that item is in season, by moving that product to a more accessible bin when it is

in high demand. Further, the system is fully scalable to Under Armour's ever expanding SKU base, as all the slotting tool need is for the new items to be entered into the system (Cole, Michael).

This is not to say that Under Armour did not use any more physical changes. Under Armour would introduce several changes, and the slotting tool would then move products to different areas to best utilize the capacity of these solutions. Once Under Armour was able to identify the fast moving SKUs, it set up a pick-to-light system to ensure that the warehouse could fulfill demand for those SKUs. A pick-to-light system ensures that pickers grab the correct products. If a picker begins to pick the incorrect item, a light will notify the picker. By reducing error, pickers will be able to more accurately compile orders, which leads to less rework, which ultimately leads to a decrease in the amount of time needed for each order. For the SKUs that were not moving as quickly as the fastest SKUs Under Armour implemented a radio frequency, or RF, system to assist with picking. Finally, Under Armour used a reserve rack to help manage the slowest moving SKUs. The slotting optimization allows Under Armour to decide which SKUs belong in each system, and even moves SKUs from one category to another depending on seasonality or trends. After the tool places an item under a particular solution (such as pick-to-light), the tool can even analyze where the item should be within the area designated for that solution. For instance, for the slowest moving SKUs, the tool will try to group products together that will likely be picked together so that the picker will have a shorter trip between SKUs. All of this technology has allowed Under Armour to sustain its growth while also keeping its warehouse under control. Olsson seems happy with the solutions stating that "We're spending our money

wisely. Slotting optimization is enabling us to take advantage of the tools at our disposal first--before we have to invest more capital into the building” (Cole, Michael).

Under Armour’s case demonstrates that moving forward one solution may not be enough. As SKUs continue to multiply, many tools will have to be used in conjunction for warehouses to continue meeting demand.

3.4 RFID Case

A final case study involves the implementation of an RFID system in an anonymized distribution center. When the system was instituted, certain lean practices were also introduced. The study looked at how much time could be saved by these processes, especially when combined. The study took the total number of hours the warehouse was in operation to measure improvement. Before any changes were made, total operation time in the warehouse was 1301.4 hours. After the lean processes were brought in the same tasks took only 269.1 hours. A savings of 79%. When the RFID system was added, the tasks only took 171.9 hours for a total saving of 87%. It is notable that the reduction in the time it took to store and ship product were decreased by 95.6% and 99.8% respectively (Chen, James).

The case demonstrates the effectiveness of technology. Percentages can be misleading. After the lean improvements were made the RFID system was added. The RFID only jumped total savings by 8%. However, the process took 269.1 hours before adding the RFID system and 171.9 after. This is a savings of nearly 64%. Looking at

the numbers this way it is much more obvious that the RFID system resulted in a reduction in time required for these processes (Chen, James).

Yet, there are other lessons to be learned in this case. The Under Armour case demonstrated the necessity to use multiple solutions to optimize a warehouse, and this is again apparent here. This case also demonstrates the importance of looking to process improvements before bringing in expensive equipment. By using lean practices, the warehouse was able to save over 1000 hours of total operational time. Most of these practices require considerably less investment. Lastly, while not discussed by Chen, the implementation of RFID brings another advantage that will be realized a bit more in the future. RFID enables managers to monitor movements within the warehouse much more closely. When looking for future improvements or dealing with issues that may arise, this information will be key. Much like the research gains of the Coca-Cola Freestyle machines, The RFID system will allow these managers to have historic data and recognize trends to prevent problems from arising and find any potential areas for improvement with their facilities.

4. The Future of Warehousing and Inventory Management

The current state of warehouse management is quite impressive, and new technologies and solutions continue to show impressive improvement possibilities. However, SKUs will continue to rise and with them bring more potential problems and

opportunities. Technology will also continue to progress, and warehouse managers should be actively looking for creative and innovative solutions for their operations. Progress will continue to march onward and those who do not try to stay ahead will quickly fall behind.

An article by Gwynne Richards concludes by stating that the most dangerous sentence in the English language is “It’s always been done that way.” This kind of thinking can certainly prove fatal, especially in today’s rapidly advancing world. If companies and warehouses want to stay on top, or simply not get left behind, they will have to continually search for new and better ways to do things. Disruptive technologies are likely to play a huge part in the evolution of the warehouse. Just as the rise of the computer changed the way warehouses function today, a new technology could revolutionize warehouses again. Warehouse managers will need to look to technologies such as automated vehicles and drones, smarter software, optically guided picking systems, and even 3D printing along with not as new ideas such as RFID and more automation.

As mentioned before, not all changes coming to warehouse will be brand new technology that shock and awe. Not all warehouses have fancy or elaborate equipment such as automated picking, RFID, or voice activated picking. As some of the big players will move forward into cutting edge technology, most will be taking advantage of the older technologies depreciation curve and natural cost reductions that come as the producers of these solutions find cheaper ways to build and implement them. Even the higher budget firms will look to use some of the older technologies that have not reached their full potential.

4.1 Utilizing Existing Tools to Create a Data Driven Supply Chain with Cisco

In an article about Cisco's vision of the future of warehouses Bob Trebilcock asserts that "the tools of Cisco's trade, such as sensors, RFID, RF, data collection technologies, and supply chain software are already on the shelf." He claims that the real advantage moving forward is "the integration of these tools to create new and innovative processes" (Trebilcock, Bob). Thus not all the technologies in the warehouse of the future may be unthinkable new gadgets, rather many of the innovations will be from applying the tools we already have in smarter ways that more effectively utilize their full potential. Jack Allen is the senior director of logistics and manufacturing solutions for Cisco, and was quoted in Trebilcock's article saying that "If you think about it the touchscreens and the user interface in the first iPhone weren't new either. The secret sauce was in how Apple put it all together" (Trebilcock, Bob).

4.1.2 Information as the Driver of Efficiency, not Automation Alone

Many of the technologies that may lead to revolutionizing warehouses already exist. However, they are not being utilized to achieve the revolutionary potential they could possess yet. To reach that potential, they must be either paired with data, used to acquire data in new ways, or both. Cisco's vision of warehouses in the future has outlined many of the possibilities for some of these technologies. Trebilcock

remembers a statement made to him that stressed the importance of data. “Forget all the cool automation on the show floor.’ He viewed that as a commodity. What he wanted was intelligent software that could give him more real-time information about more aspects of his operations than he was getting now” (Trebilcock, Bob). Cisco seems to agree. Allen of Cisco remarks “I walk through a lot of warehouses where people are enamored with the mechanical technology, but in our view, it’s not about mechanical automation: It’s about software” (Trebilcock, Bob). Cisco envisions a world, beyond just the warehouse, where every element is communicating and constantly collecting data. This data can then be used to optimize the warehouse and make decisions (Trebilcock, Bob).

Cisco does not see the data as something that will only be used to make large scale decisions or in improvement projects. Instead, Cisco envisages this new information being actively used by the warehouse itself to make decisions on a daily basis. Cisco’s idea of an automated warehouse is not merely one where the picking is done by machines. Automation for them means that the decisions of what to pick, where to send it, and how is all decided without human input (Trebilcock, Bob).

The Internet of Things refers to the trend where devices are becoming “smart” and are increasingly becoming connected to each other and the internet. Cisco believes that they will be able to incorporate this trend into their warehouses. By using pre-existing tools such as RFID, Cisco can record and feed data to software. That software can then make decisions. The software would use more than just the data from its own network. By looking out to the internet, the software would be able to spot trends or possible disruptions. Allen references the tsunami in Japan as an instance

where such technology could have been especially useful. People were going through spreadsheets trying to figure out which parts came from affected suppliers, and eventually realized that they had some instances where all the suppliers for a product were unable to fulfill Cisco's needs. If this were to happen again in the warehouse of the future, the system would be able to notice the tsunami in the news, check to see if suppliers were affected, find new suppliers, place orders, organize transportation, and expedite if necessary. All of this would be done faster than any team of people would ever be able to (Trebilcock, Bob).

For this to be possible, data is key. The system would need data on everything, and thus systems like RFID would be needed. The system needs to know about transportation, warehousing trends, historical demand, and much more. Thus, innovation will be the use of existing technology, and not the technology itself. Allen expresses Cisco's view on it by saying, "That's why we believe the future will be as much about the movement of data as it is about the physical movement of goods. In the big picture, that's where we want to go" (Trebilcock, Bob).

4.1.3 Lufthansa and the Automated Warehouse

This is not all totally conceptual. Cisco points to Lufthansa who has already adopted a similar system. While it may not be quite as advanced as the warehouse of the future that Cisco envisages, it still utilizes many of the features Cisco discusses. Namely, the company has a system that automates order fulfillment. When an aircraft needs repair, Lufthansa has an in-house facility that stores most of the parts that could

be needed to fix a plane. Over 30,000 parts are stored in an AS/RS system. The system receives orders electronically. From there it checks to see if the warehouse has all of the needed parts to fulfill the order. It then checks to see how soon the part is needed and checks for the least expensive transportation option that gets the order there on time. The system also continually monitors the shipment so that it is aware of any occurrence that would delay the order. This process used to take over two days. Now, with the automated system, Lufthansa can get a part to anywhere in Europe within twelve hours (Trebilcock, Bob).

4.1.4 Vision of the Future Warehouse

Trebilcock ends his article by quoting Allen one last time. Allen states that “I believe we’re at a major cusp of another wave of disruption, another wave of productivity in the warehouse. In a connected world, we’re going to be much more intelligent about how we do things and use things” (Trebilcock, Bob). Allen’s claim seems valid. As big data continues to grow and the Internet of Things becomes more and more prominent, warehouses should evolve as Allen predicts. Information is already the key in many efficiency improvements in warehouses. In the earlier Under Armour example, the software examined data on how products moved through the warehouse. From there it was able to optimally arrange products, and determine which SKUs would be best fit for each storage option. As Allen would be quick to point out, this is not about physical tools, but rather information. He is not alone in his vision either. In his article “Step Into the Future of Logistics” Ian Roper asserts that “the much-hyped Internet of Things is becoming a reality, one in which robots – from domestic

freezers through intelligent warehouse racking to containers, trucks and production machines and all the associated systems – are in constant communication.” He also states;

The Internet of Things will also see an even greater deployment of tracking and tracing technologies throughout the supply chain. A much more fine-grained visibility of the supply chain becomes possible, not just that the goods have left the Chinese factory, but also that they are in a specific container on a specific ship at a specific point in the Malacca Straits or in a particular van at Leicester Forest East services; not only location, but also condition – a full history of temperature, humidity, magnetic fields, acceleration – that is, the shock of being dropped – or whatever condition is deemed important (Roper, Ian).

Roper’s opinions seem perfectly in line with Allen’s. The information gathered by the internet-enabled devices will feed data to the main system, which will in turn send instructions back to the connected gadgets.

4.2 Evolution of Warehouses Functionally and Physically

4.2.1 Introduction

All of the changes discussed so far have been internal to the warehouse. These changes involved adding automation, rearranging the warehouse, and introducing new software packages. This is not looking at the full picture. To accurately forecast what the warehouse of the future may look like, it is imperative to realize that warehouses may not look or function as warehouses today do. In Gwynne Richards’ and Ian

Roper's articles, both argue that the physical layout and structure of warehouses will change in the future.

4.2.2 Warehouses as Hubs Feeding Local Distributors

In "Warehouses of the Near Future" Richards' points out that forty to fifty years ago, no one could have predicted the rise of computers and the internet, or the effect they would have on warehouses and the world. On this logic that things can change drastically, Richards' continues by stating that the warehouses of today with large inventories may become dinosaurs of an outdated system. These warehouses will be replaced by structures that more closely resemble transit sheds. Companies will be at the point that their inventories are so well managed that the high rate of cross-docking and transshipments will increase demand for such structures while decreasing the need for warehouses (Richards, Gwynne). Thus, the warehouse of today may become rare and centralized while existing warehouses are converted to suit a much leaner supply chain.

Indeed, Richards supports the conclusion that warehouses will be more centralized and more adapted to a highly lean supply chain. Richards claims "The current trend seems to be towards greater centralisation of warehousing" (Richards, Gwynne). This will allow for peak efficiency when large stock quantities are needed. However, as product moves closer to the customer, warehouses will become local operations that are much smaller (Richards, Gwynne). Thus, warehouses will grow in

opposite directions, some becoming larger and fewer while others shrink, move closer to the customer, and become more frequent. These will complement each other. The large consolidated warehouses can efficiently handle mass quantities of goods with large amounts of automation. An economies of scale will make this cheaper on a per item cost. Because the automation is present, pallets could be assembled that contain just the products that retailers need, eliminating the need for picking at the downstream, smaller warehouses. As a result, the smaller warehouses would not need the space, equipment, or manpower necessary to break full pallet quantities down to the quantities retailers need. As products become more niche and more SKUs added, stores will be less capable of handling full pallet quantities of product. This would combine the advantages of economies of scale in large warehouses and the short windows allowed by more localized warehouses.

4.2.3 Changes in Size and Layout of Warehouses

The large centralized warehouses will see some changes in physical form also. She predicts that the warehouses will also feature low-roofed areas for cross-docking and mezzanines to handle the greater level of SKUs and for operations such as low-volume picking. These changes are expectable with the current needs in warehouses. Structures such as mezzanines help with diverse SKUs much in the same way racking systems do. The mezzanine provides a second floor for more product and for operations such as repackaging. These large warehouses will be nearly fully autonomous, and with machines such as cranes and AS/RS product can be stacked higher and still be effectively picked (Richards, Gwynne).

4.2.4 The Collaborative Warehouse

Richards also points to a trend predicted in an article by Capgemini. They see the future of warehousing and the supply chain as one of collaboration. Capgemini believes that companies will produce products, and then ship them in shared transportation and store that product in shared warehouses. Once the product arrives near its final destination, it will be cross-docked before going out to retail or direct customers (Richards, Gwynne). This theory works well with the consolidation of warehouses and the rise of small localized distribution centers that specialize in cross-docking. Sharing the large warehouses allows for economies of scale to be fully realized even by smaller companies. Whether these facilities are run by a collaboration between stakeholders or a third-party, efficiency improvements would be realized. This would allow for a leaner supply chain and lower costs for every entity involved. Richards points out that this would ensure maximum utilization of truck loads and warehouse space (Richards, Gwynne). Third-party services have been helping businesses for years in a variety of settings and industries. It makes sense that the advantages of third-parties would carry over to warehouses. Companies may run into issues if they shared a warehouse outright. If one company grew at a faster pace or one went into bankruptcy, this could cause some major problems for the partnership. As a result, third-parties will be able to move in and run these warehouses. These companies could offer the space, equipment, and labor as a service. This would allow many more companies to use these warehouses, making better use of the available resources. Further, as these third-parties expanded, economies of scale could kick in, and they

could become highly proficient at running these warehouses. Whether third-parties will be needed for the collaborative warehouse to happen or companies will come together on their own remains a question.

4.3 3D Printing and Its Potential to Disrupt the Supply Chain

4.3.1 The Rise of 3D Printers

A technology has the potential to upset the whole warehousing industry is 3D printing. The method by which 3D printers work varies, but typically they work by having a nozzle add material on a plate in layers. As more material layers build on top of existing material layers, a three dimensional product is formed. While it may not revolutionize warehousing overnight and is still years away from being a common household appliance, 3D printers have a huge potential to totally revolutionize the way we see production, warehousing, and delivery of products. In a report by Transport Intelligence quoted by Richards, the company notes that these printers are “very good at producing products (even with moving parts) which previously would have required the assembly of multiple components” (Richards, Gwynne). This could have large implications. These machines are rapidly increasing in capability while decreasing in price. With this technology “people will be able to print a required item at home providing they have the scanned image or the blueprints of the product itself” (Richards, Gwynne). Even if customers are not printing out entire goods, the ability to print parts for repair and replacement will have huge implications on the supply chain. Instead of holding replacement parts close to the end user in case of failure, the customer would

just be able to print the part out themselves. Much of this stock is currently redundant, but necessary to keep up required service levels in the event of a failure. The ability to print parts will revolutionize the repair industry, and will undoubtedly revolutionize the supply chain around this industry. Whether it eliminates almost all need for it, or reinvents the repair supply chain with the need for printing raw materials, it will have major implications on the supply chain (Richards, Gwynne).

4.3.2 Jay Leno's In-Home 3D Printing

In home 3D printing is already occurring. While most consumer 3D printers are not quite to the capabilities needed for the revolution suggested by Richards, they are improving. The capabilities and potential uses for such appliances are also being explored by those who can afford the expensive industrial printers. One such example is reported by the Wall Street Journal. Known car enthusiast Jay Leno uses a 3D printer and scanner to maintain his vast fleet of collector automobiles. Since many of these vehicles are long out of production, some more than a century old, parts can be difficult and expensive to come by. To get around this problem, Leno turned to 3D printing. Leno explains to the Wall Street Journal reporter that;

"We took the worn piece and copied it with a scanner that can measure about 50,000 points per second. That created a digital file or image of the part, which we can modify in the computer if there are imperfections or defects in the part being scanned. Then you feed that data into the 3-D printer, and, presto, you have a mold that will allow you to cast a brand new part."

As a result, Leno can repair any vehicle he can acquire. His shop is even building a 1906 vehicle nearly from the ground up with parts made in-house. While most would not be able to justify the cost of such an operation, it does make some sense for Leno. The cars he repairs are often already worth hundreds of thousands of dollars, and the parts to repair them are either unobtainable or so expensive that it is actually economical to produce the part himself (Koten, John). While this may only be a viable option for the extremely wealthy currently, it is easy to see the possibilities and advantages of such technology as it improves and becomes cheaper. Leno has nearly totally cut out his need for parts suppliers. If this occurrence were more widespread, it would have significant impacts on the supply chain.

4.3.3 Advantage of 3D Printing in Manufacturing with Koenigsegg

While the technology may not have made it into the hand of the average person yet, it is certainly being used in industry. Another automotive example involves the work of Koenigsegg, a Swedish exotic car manufacturer. Koenigsegg's production numbers are extraordinarily low, producing around fifteen to twenty cars annually. Comparatively, Ferrari and Lamborghini are large scale producers. Yet, this does not stop Koenigsegg's innovation.

In a video by /DRIVE Christian von Koenigsegg, the eponymous owner of the company, describes how he has been able to successfully utilize 3D printing. He outlines how some of the pieces his company prints are superior because they were printed. Their flagship vehicle, the One:1, has an exhaust tip that is the largest piece of

titanium ever printed, which gives the car substantial weight savings over using aluminum. The company also utilizes special turbochargers that cannot be casted or milled, and were only feasibly created with the assistance of a 3D printer. However, the real implications come when he discusses the economics of 3D printing. With it, he is able to prototype parts in plastic. This drops the company's design window for a mirror down to a week, and entire seats down to a couple of weeks (*3D Printing: Titanium, Carbon Fiber, & The One:1 - /INSIDE KOENIGSEGG*). This allows the company to more quickly meet customer needs and more easily customize a product to the customer's desires. It is easy to see how this could move to more mass produced products in the future. As customers come to expect products tailored to their preferences, 3D printing will be able to fulfill their desires.

Koenigsegg highlights the feasibility of smaller manufacturers producing highly specialized goods by pointing out the inverse economies of scale that work in printings favor. Mr. Koenigsegg explains that;

“At the low volume that we are at it is very expensive to make the tooling and only making ten, fifteen, twenty pieces per year out of them. So we can actually use that as an argument to pay a lot for 3D printed metal parts, as we save tooling costs, we save tooling time, and we can make otherwise impossible shapes that are more efficient and lighter than our competitors can do even if they are at a production volume of maybe 100 cars. They can't motivate the 3d printing cost” (*3D Printing: Titanium, Carbon Fiber, & The One:1 - /INSIDE KOENIGSEGG*).

This could lead to huge implications in the supply chain as it becomes feasible or even economical to produce highly specialized products. If companies begin offering high levels of customization, then warehouses may have to deal with the influx of exponentially more SKUs as each core product sees more and more variations.

3D printing will not have these extreme implications on the supply chain in the near future. However, they will likely begin to slowly show their advantages and appear more in areas where they prove most useful. As the technology advances and costs continue to fall however, they have potential to massively change the supply chain as it exists today. They also represent the importance of looking to the future. 3D printers will be a great opportunity for those who position themselves to take advantage of them, and a major problem for those who are not preparing for future trends.

5. Conclusion

SKU proliferation is the result of businesses accomplishing their key goal: generating profit. Sometimes this may occur from targeting niche markets and thereby acquiring new customers. Other times it may be more focused on acquiring market share to increase profits in the future. No matter why SKUs are evolving, it is the supply chains job to efficiently service that product. As the supply chain should never impede the progress and profitability of a business, it is therefore its obligation to find solutions for the growing SKU count in today's businesses. As Joseph Springs put so well;

“That’s a huge part of our role as the supply chain. Innovation is hard. Innovation is difficult. My distribution network is built for delivering the products we sold yesterday. So, it is our responsibility as supply chain leaders to build the distribution network that enables our marketing team and our company to distribute the items of tomorrow.”

In order to effectively build the distribution network that can efficiently distribute the items of tomorrow, supply chain leaders need to look around them and to the future. Whether it be finding a more clever and cost effective solution as Gander Mountain did or implementing hybrid solutions to maintain flexibility and efficiency as Under Armour did, supply chain leader will need to utilize tools more creatively to further enable their supply chains. This will not only involve looking at what others are currently doing, but looking to the future. Being aware of how disruptive technologies such as the Internet of Things and 3D printing could be capitalized on will keep these same technologies from becoming threats. Information is becoming the new driver of supply chain efficiency improvements, and the same should be true of supply chain managers. By knowing how their own supply chains work and what tools are around them and on the horizon, supply chain managers will best be able to increase the capabilities of their distribution networks and provide the best service to their business and its consumers.

Works Cited

- "3D Printing: Titanium, Carbon Fiber, & The One:1 - /INSIDE KOENIGSEGG." YouTube. /DRIVE, 15 Apr. 2014. Web. 29 Mar. 2016.
- Bond, Josh. "High-Density Storage System Keeps Pace With SKU Growth." *Modern Materials Handling* 70.6 (2015): 45. Business Source Complete. Web. 22 Mar. 2016.
- Cernivec, Stephanie. "Accommodating SKU Growth." *Beverage Industry* 105.1 (2014): 36-37. Business Source Complete. Web. 18 Apr. 2016.
- Chen, James C., et al. "Warehouse management with lean and RFID application: a case study." *The International Journal of Advanced Manufacturing Technology* 69.1-4 (2013): 531-542.
- Cole, Michael D. "Under Armour protects its distribution house: the sports apparel and accessories juggernaut continues its dynamic growth and SKU productivity at a sizzling pace. To keep up, its Baltimore distribution operations rely on state-of-the-art WMS and slotting optimization technologies that offer maximum warehouse efficiencies--helping the performance apparel pioneer stay at the top of its game." *Apparel* Aug. 2009: 18+. Biography in Context. Web. 16 Feb. 2016.
- Jacobsen, Jessica. "Warehouses Cope With Growing Pains." *Beverage Industry* 103.2 (2012): 56-58. Business Source Complete. Web. 22 Mar. 2016.
- Koten, John. "Who Says Jay Leno Isn't Cutting Edge?" *WSJ. Wall Street Journal*, 10 June 2013. Web. 29 Mar. 2016.
- Richards, Gwynne. "Warehouses Of The Near Future." *Logistics & Transport Focus* 16.10 (2014): 40-45. Business Source Complete. Web. 24 Mar. 2016.

Roper, Ian. "Step Into The Future Of Logistics." *Operations Management (1755-1501)* 41.1 (2015): 37-39. Business Source Complete. Web. 26 Mar. 2016.

Springs, Joseph. Telephone interview. 25 Mar. 2016

Strzelecki, Molly V. "Better Warehouse Inventory Management." *Beverage Industry* 99.2 (2008): 54-55. Business Source Complete. Web. 22 Mar. 2016.

Trebilcock, Bob. "Cisco's Warehouse Of The Future." *Logistics Management* 54.9 (2015): 56-60. Business Source Complete. Web. 24 Mar. 2016.