Achieving and Sustaining an Optimal Product Portfolio in the Healthcare Industry through SKU Rationalization, Complexity Costing, and Dashboards

By

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Abstract

After years of new product launches, and entry into emerging markets, Company X, a healthcare company, has seen its product portfolio proliferate and bring costly complexity into its operations. Today, Company X seeks to achieve and sustain an optimal product offering that meets their customers' needs. Through a six-month research effort, we develop a process for stock-keeping-unit (SKU) rationalization to reduce SKU complexity while maintaining sales volumes. We, also, implement operational models to compute complexity costs associated with SKU complexity and employ SKU portfolio dashboards to monitor SKU development and govern SKU creation.

This thesis discusses a process for applying these tools to any healthcare company. Through two case studies, we apply the rationalization process on one pilot brand and develop a dashboard to improve product portfolio management. We expect that the SKU rationalization process will release 38% of avoidable costs associated with the pilot brand. These case studies also provide insight into how to correctly diagnose the cost reduction opportunity associated with SKU complexity, as well as methods for a step-change improvement in lead-times and cost-reduction. Lastly, removal of complexity provides flexibility to capture other business opportunities.

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1 Introduction

1.1 Overview of Company X

Company X is a healthcare company that develops and manufactures healthcare products for markets across the world. To bring these products to the market, the company employs over thousands of associates across the world, of which some are responsible for the manufacturing and supply chain footprint. These employees make up the operations organization - a division that ensures all products are manufactured, packaged, and delivered around the world. Through this global network, the operations organization delivers approximately thousands of finished products in multiple different languages to over one hundred countries across the world.

1.2 Problem Statement

As Company X continues to launch and retire products, meet new market requirements, and keep up with customer needs, the operations organization must adapt to the changing environment while balancing quality, cost, and customer service level. Due to these aforementioned market effects and other internal drivers, Company X has seen its product portfolio proliferate and bring costly complexity into its operations. Cost reduction and increased productivity have become key strategies for the company in order to meet profitability targets and to release capacity for new products.

With thousands of finished product SKUs, Company X has identified SKU proliferation as a key driver of cost and complexity. The operations organization is responsible for the SKU portfolio and for implementing complexity reduction processes that will avoid SKU proliferation at launch stage and remove current SKUs that no longer positively contribute to the company's overall profitability. After exhausting the benefit of pruning low-margin SKUs, Company X seeks to determine the root cause of SKU proliferation and to further remove SKU complexity through SKU Rationalization and a governance measure for SKU creation.

Company X has had difficulties building a traditional business case for the benefit of SKU rationalization. Further, Company X fears that further complexity reduction efforts will impact sales volumes, which will already be affected other market effects. In order to be successful, Company X intends to apply a simple method for bringing transparency to complexity costs in order to incentivize their sales organization to help reduce cost and complexity.

1.3 Hypothesis

We propose that it is possible to quantify the complexity costs associated with offering a high variety of products in a healthcare company through modeling. Further, we propose it is possible to sustain an optimal product offering by bringing transparency of complexity costs to the organization.

1.4 Thesis Outline

In the following chapter, we review past research regarding the effects of product variety on operations and in the areas of complexity reduction.

In Chapter 3, we perform a study of the organization by applying a 3-lenses analysis and by evaluating Company X's costing system. This chapter also discusses how Company X's costing system and the organization's strategic, political, and cultural design will impact the implementation of SKU rationalization and the sustainment of SKU portfolio management.

In Chapter 4, we define our approach for SKU rationalization and discuss in detail each step of the rationalization process. We conclude this chapter with a sustainment step that describes the use of dashboards for portfolio management. In Chapter 5, we discuss a case study where we rationalize a brand of Company X. Further, we discuss general implications for each approach and why there is benefit for Company X and other industries.

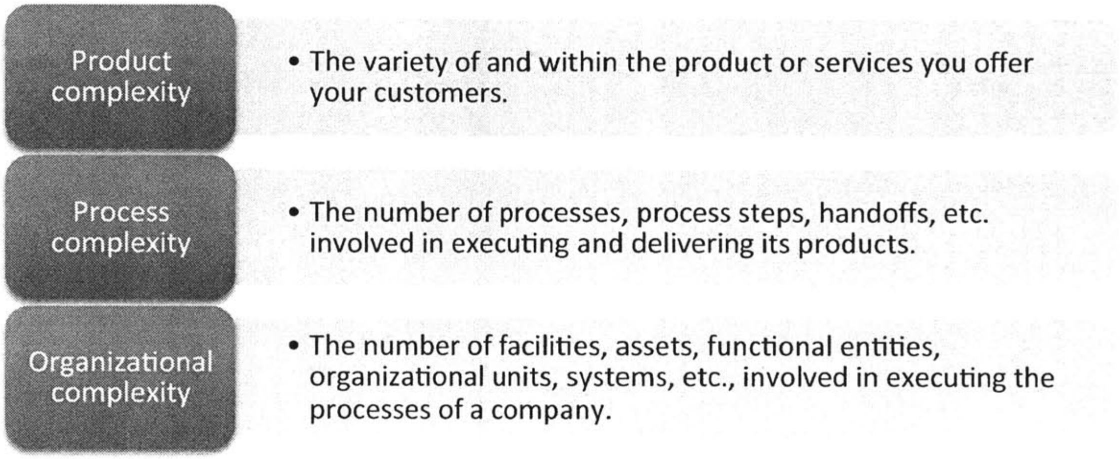
In Chapter 6, we discuss another case study where we use dashboards to monitor and manage the SKU portfolio of Company X. First, we define a SKU portfolio dashboard that allows for the monitoring of the company's SKU portfolio. Then, we use this dashboard to identify the root cause of SKU proliferation and recommend methods to govern the creation of SKUs. Chapter 6 concludes with the general implications of this case study for other firms.

In Chapter 7, we conclude with a summary of our findings and further recommendations. This chapter includes detailed next steps for SKU rationalization and for general complexity reduction at Company X unconstrained from the scope of SKU portfolio management.

2 Literature Review

Perumal defines three types of complexity that firms face as product complexity, process complexity, and organizational complexity, as shown in Figure 1.

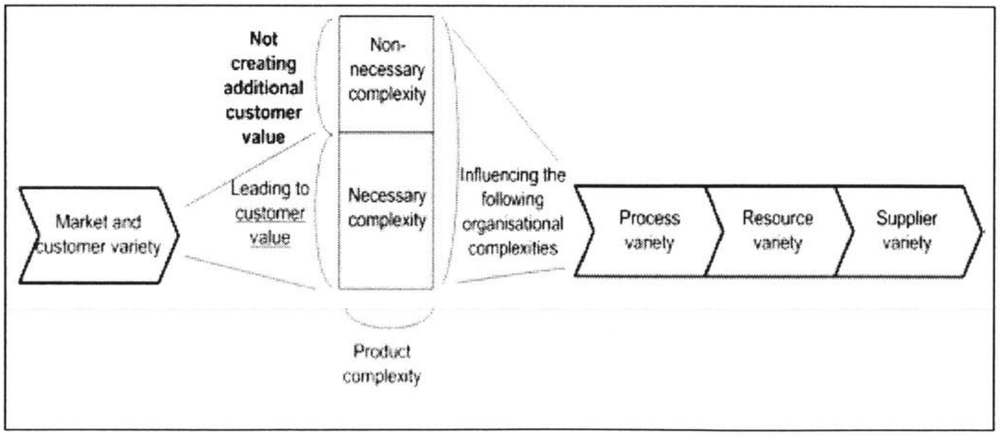
Figure 1. Perumal's three types of complexity [1]



Perumal continues by noting, "the three types of complexity are interwoven and interdependent". For example, in order to remove complexity, one must understand how product complexity impacts your process complexity and organizational complexity.

But, of course, not all complexity is bad. In *Crossing the Chasm*, Moore highlights this point. He notes that bad complexity in product variety is "differentiation that does not drive customer preference" [2]. Pasche visualizes the ideas of both Perumal and Moore in Figure 2.

Figure 2. Pasche's necessary and non-necessary product complexity [17]

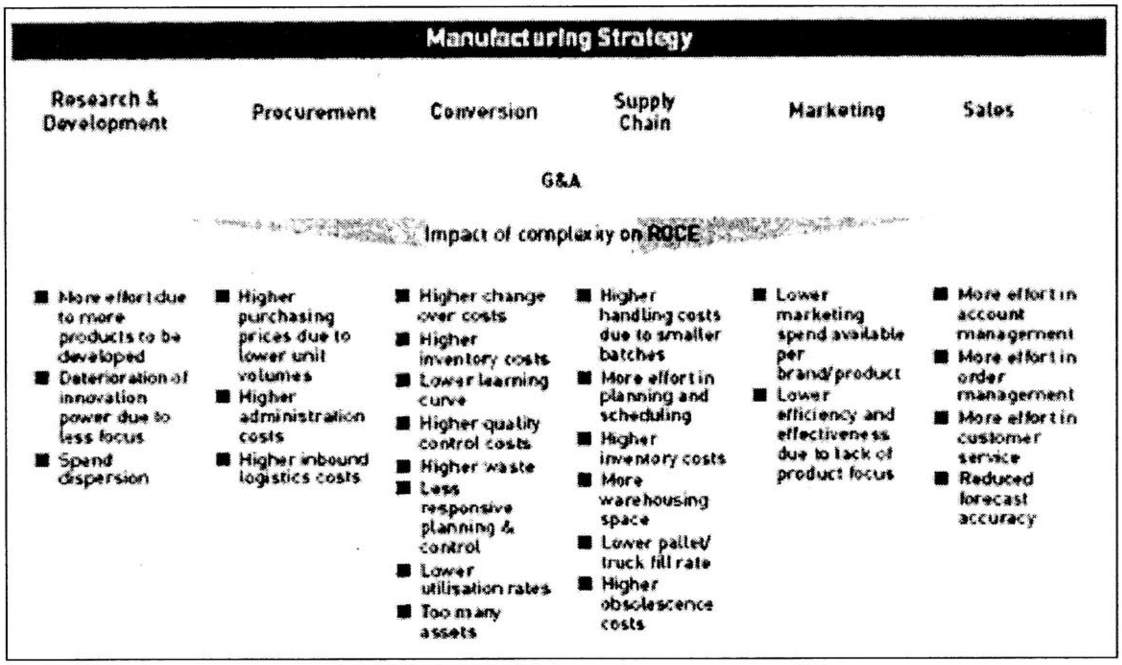


We will extend upon these ideas by reviewing how product complexity affects process and organizational complexity and how commonly used costing systems can hide costs associated with this complexity.

2.1 Effects of Product Complexity

In a whitepaper by Arthur D. Little, the effects of product complexity across the value chain were identified as shown in Figure 3. This study estimates that the greatest impact on return on capital employed (ROCE) is within the conversion and supply chain functions.

Figure 3. Arthur D. Little findings on the effects of complexity across the value chain [3]

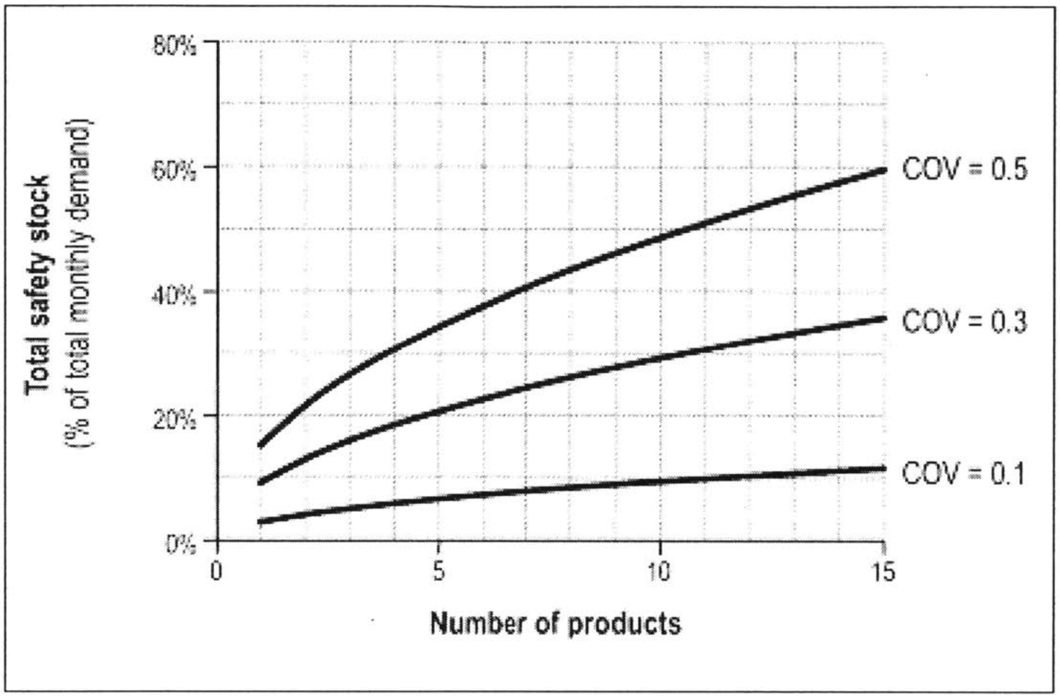


Research & Development	Procurement	Conversion	Supply Chain	Marketing	Sales
■ More effort due to more products to be developed ■ Deterioration of innovation power due to less focus ■ Spend dispersion	■ Higher purchasing prices due to lower unit volumes ■ Higher administration costs ■ Higher inbound logistics costs	■ Higher change over costs ■ Higher inventory costs ■ Lower learning curve ■ Higher quality control costs ■ Higher waste ■ Less responsive planning & control ■ Lower utilisation rates ■ Too many assets	■ Higher handling costs due to smaller batches ■ More effort in planning and scheduling ■ Higher inventory costs ■ More warehousing space ■ Lower pallet/ truck fill rate ■ Higher obsolescence costs	■ Lower marketing spend available per brand/product ■ Lower efficiency and effectiveness due to lack of product focus	■ More effort in account management ■ More effort in order management ■ More effort in customer service ■ Reduced forecast accuracy

Many of these effects are intuitive with reference to a rise in product complexity. For example, consider a packaging line in which each finished product has different packaging material. For each packaging order processed, the packaging line would need to undergo a setup, which will increase overall change over costs and reduce utilization rates and production capacity. As capacity is eroded, more fixed cost assets need to be purchased to handle the same volumes. Also, consider that the number of orders received for each product is proportional to the administrative and coordinative costs to process those orders.

Another key effect of product complexity is its impact on forecast accuracy. As product variety is increased, demand is segmented and the benefit of demand pooling is reduced. As forecast error increases, the inventory required to maintain a minimum customer service level increases. Perumal demonstrates how both the number of products and variation in demand impact overall safety stock in Figure 4.

Figure 4. Perumal's depiction of total safety stock as a function of product variety for different levels of demand variation



The interactions of product complexity on process complexity and organizational complexity are quite clear. As product variety increases, we see process complexity increase through the breakdown of inflexible processes and the erosion of capacity. Organizational complexity increases as fixed assets are acquired and the cost of administration and holding inventory rises. Low utilization, fixed assets depreciation costs, and large inventories combine to add hidden complexity costs to the organization. In the next chapter, we will discuss how these costs hide in the costing system of Company X

3 Costing System Analysis

In this chapter, we bring context to this research. Specifically, we discuss the costing system of Company X. This analysis will include an inspection of the costing system, as well as the implications it has for the SKU rationalization and SKU portfolio management projects.

Another factor relevant to consider is the company's costing system and the transparency of cost across the organization. Standard-costing systems can hide the costs associated with variety. Many companies spread the cost of setup times, machine downtimes, warehousing & distribution, and overhead across their finished products based on sales volumes. We will quickly review these areas with reference to Company X and the company's vulnerability to hidden complexity costs.

With regard to setup times and down times, Company X has a budget process that includes planned setup and down times at the SKU level. Although, it is not clear that production variances are allocated back to the SKU level once computed. If Company X does not allocate the variances at the SKU level, the effect of SKUs with erratic order frequencies and the impact of production planning on setup times will be hidden.

In the area of warehousing, distribution, and material handling, Company X segments costs in two different ways. Handling costs during the manufacturing or packaging process are allocated by weight. This is more accurate than by sales volumes but does not consider the number of orders processed for a given product, which is essentially a setup-time that should be accounted for. Warehousing and distribution costs of the finished product are then allocated at the brand level or charged to the country organization distributing the product. This is another example of costs that can accumulate with variety but are hidden by the costing system.

Overhead costs brought from SKU complexity can also be hidden by Company X's costing system. These costs are spread across the finished product SKUs based on direct costs and equipment costs. This allocation method hides the complexity of low volume SKUs that eat up capacity and warehouse space.

Company X could benefit from some of the latest costing methods but a transformation of this type is outside the scope of this research. We focus on the impact on cash flows and capacity from SKU rationalization and SKU portfolio management.

Along with the hidden complexity costs associated with Company X's costing system, the organization also compartmentalizes cost data from certain stakeholders. Company X's policy restricts cost data from being shared outside of headquarters. This, of course, has significant implications for SKU rationalization and SKU portfolio management. In order to align marketing and sales stakeholders, a top-down order from upper management must be used or Company X's cost transparency policy must be changed. For this research, both methods were taken to communicate the benefit of complexity reduction. In 2012, Company X has plans to measure sales management based on both volumes and profitability but at this time the metric is only planned at the brand level. Further, the complexity reduction project is now championed by a sales and finance leader in a key market region.

4 SKU Optimization Process for Healthcare Companies

In this chapter, we devise a data-driven process to optimize a brand's variety offered to the market through SKU rationalization and SKU portfolio dashboards. This SKU process includes:

- A method to identify brands and SKUs for rationalization
- A collection of models to compute the operational and cash flow benefit of rationalization
- A dashboard to monitor and sustain the optimum SKU portfolio.

This chapter begins with a description of the SKU Rationalization process along with key metrics and requirements. Following this description, we dive deep into the implementation steps for SKU rationalization, as well as, details on how to compute the benefits of rationalization. Then, we discuss how dashboards help manage each brand's variety. We conclude with a summary of the benefits of this approach.

4.1 Overview

The SKU optimization process aims to achieve the following objectives:

- Identify SKUs within a brand and/or country that when rationalized will reduce cost and complexity without impacting sales volumes
- Identify the SKU or SKUs within a brand's offering that should not be rationalized due to customer and regulatory requirements
- Compute the quantitative benefit (aka the removed complexity cost) from reducing variety within a brand offering
- Use dashboards to support governance measures and ensure sustainability of optimized brand variety
- Communicate the value and impact of complexity reduction to stakeholders

Each objective was measured through a series of metrics and tools to assess the progress of our research and complexity reduction overall.

4.2 Metrics

In order to measure success, we define the complexity cost as the impact that rationalization of a brand has on cash flows, labor hours, machine hours, forecast accuracy, inventory, number of SKUs per healthcare product, and sales per SKU. We detail each of these metrics below.

4.2.1 Cash flows

Cash flows are defined as "the movement of money into or out of a business, project, or financial product" [4]. The effect on cash flows is more appropriate than the impact on accounting costs because each SKU has different percentages of avoidable and unavoidable costs. This is mostly attributed to different material costs and manufacturing channels. A global assumption on avoidable costs per SKU does not capture the true effect of rationalization.

4.2.2 Labor hours

A reduction in labor hours is related to cash flows. This metric is communicable and intuitive to stakeholders. For example, if enough labor hours could be reduced to remove the 3rd shift at a packaging plant then there is substantial benefit to direct and indirect costs.

4.2.3 Machine hours

Machine hours are the number of hours in which a machine such as a packaging line is used for setup, packaging, or maintenance. This metric can be appropriate for strategic reasons. Specifically, a company might like to keep capacity utilized at a certain percentage or release capacity for launch products.

4.2.4 Forecast accuracy

Forecast accuracy is a very important metric in the healthcare industry due to the high service level requirements and the reputational cost of stock outs. It is also a significant metric because variety directly affects forecast accuracy.

4.2.5 Inventory

Lower inventories will reduce write-offs and holding costs, which will reduce overall COGS making this an important metric to communicate.

4.2.6 Number of SKUs per product per country

Upper management expects the number of SKUs to be reduced through the complexity reduction initiative. Although this metric is not a direct cost benefit, it communicates an intuitive reduction in complexity and coordination, as well as a signal of progress that is necessary for stakeholder alignment. The lowest SKU complexity possible within the scope of this research is one SKU per product per country.

4.2.7 Sales per SKU

The metric, sales per SKU, is computed by dividing the total sales volume of a brand by the number of SKUs offered for that brand. This is another metric that is appropriate for communicating to sales teams and signals possible cannibalization of sales. Also, as the number of SKUs offered in a brand is reduced, this metric demonstrates a greater contribution from the remaining SKUs offered to the market.

4.3 Requirements

The SKU optimization process has some key requirements that are necessary for stakeholder alignment and implementation success. Details of these requirements are discussed below.

4.3.1 Reproducibility

The process needs to be easily understood and reproducible in order to make the maximum impact. If the process is reproduced across the brands where there is opportunity, a step-change reduction in cost and complexity is possible.

4.3.2 Zero Sales Impact

The rationalization process must consider the impact on sales that reducing variety will have. If there is a possible impact on sales, rationalization should not be performed.

4.3.3 COGS Improvement

Selection of brands and SKUs for rationalization must consider the impact on COGS. For example, a brand that has COGS lower than the average COGS of the brand portfolio weighted by volume may not be a candidate for rationalization.

4.3.4 Communicable Benefit

Since this process affects the whole organization, the impact of rationalization and associated metrics need to be communicable and intuitive. This benefit is realized in the metrics discussed above. Stakeholder alignment is key to the success of this process and sustainment of its results.

4.4 Implementation Process

The SKU optimization process is a six-step process from brand and SKU identification to monitoring and sustainment. These six steps include:

1) Brand selection – This step involves selecting candidate brands based on each brand's margin, number of SKUs per product, and the brand's position in its product lifecycle. Cross-functional

stakeholders must evaluate and approve selected brands to ensure alignment with the overall company strategy.

2) SKU selection – Within a brand, we segment the SKUs based on market requirements, sales channel, and product. For each, we identify the most common packaging based on sales volume. Finally, we identify candidate SKUs for rationalization within each segment based on volume, demand variation, and margin.
3) Sales impact analysis – In this analysis, we categorize the probability of a significant sales impact for a given SKU if it is rationalized. Each category is based on sales volume and the current finished product offering in a country.
4) Costing system analysis -- Before computing complexity cost, we investigate the cost areas that will be affected by SKU rationalization. Further, we identify which of these costs are actually avoidable costs.
5) Complexity cost computation – We apply models of production and forecasting to simulate a rationalization scenario for the brand. The outputs of the models include the effect on cash flows, capacity, inventory, and forecast accuracy. These outputs can be used for the business case to rationalize the selected SKUs.
6) Monitoring and sustainment – In order to sustain the optimum brand variety, the SKU complexity of the brand must be transparent to the organization. We recommend a SKU portfolio dashboard that brings transparency to the creation and removal of SKUs, as well as the metrics described above. If the brand deviates outside the boundaries of an optimal variety, it should be again be considered for SKU rationalization. This dashboard can also be used as governance measure for the creation of SKUs.

We design these steps to formulate a data-driven process for SKU optimization at a healthcare company.

4.4.1 Brand Selection

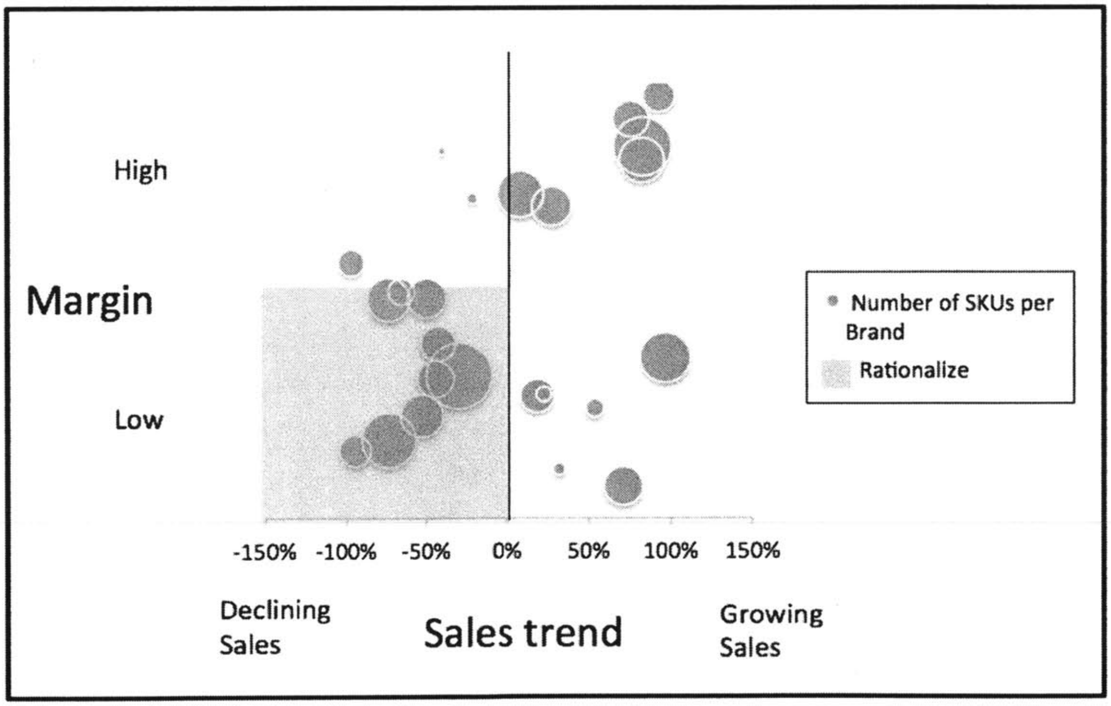
As mentioned, brands are selected based on margin, number of SKUs, and the brand's position in its product lifecycle. With regard to margin, if a company seeks to improve the overall profitability of its brand portfolio, intuitively brands that are below the average margin of the portfolio might be candidates for rationalization. Of course, these brands with relatively lower margin need to present an opportunity for SKU rationalization. Only if the brand has a large number of SKUs based on the number of products offered and the number of markets served is the brand actually a candidate for rationalization.

Brands can also be selected for qualitative reasons. These qualitative reasons are based on the current point in the brand's lifecycle. Each stage of the product lifecycle presents opportunities to perform SKU rationalization:

- Launch – Shortly after a brand is launched, rationalization can be performed. One or two years after launch, organizations can review sales volumes of a brand's variety and rationalize the low value SKUs in the market. Further, the brand launch team can avoid unnecessary complexity reduction by launching a lean variety for new products, in which finished product variety is limited.
- In-Market – Another opportunity to rationalize occurs when a brand's production needs to be transferred from one manufacturing site to another site. The cost and risk of transfers can be minimized through rationalization.
- End of Lifecycle – A reduction in a brand's sales volumes and market effects such as competitor entry present opportunities to rationalize and maximize the profit contributed by the brand. Rationalization of old brands depends on the company's strategy for the brand. If the brand is strategic, rationalization may not make sense. On the other hand, if the brand is not strategic but the company provides the brand for market access, rationalization allows the company to optimize the contribution of the brand.

For brand selection, we recommend a cross-section of margin, lifecycle status, and the number of SKUs per brand. Figure 5 demonstrates an example of this cross-section.

Figure 5. Example comparison of margin vs. sales trend over 3 years vs. SKU complexity of brand portfolio



In the figure above, we identify a brand as a candidate for rationalization if that brand has a high number of SKUs, declining sales over the last three years, and a low margin relative to the company's portfolio margin. This method presents a way to perform a data-driven decision for brand selection using high-level information. Alternatively, brands can also be selected for qualitative or strategic reasons. Some possible rational for qualitative selection include the following:

- Brands impacted by footprint consolidation
- Brands that are no longer core to the business
- Brands affected by external forces such as competition.

With brand selection complete, the next step of SKU selection should begin.

4.4.2 SKU Selection

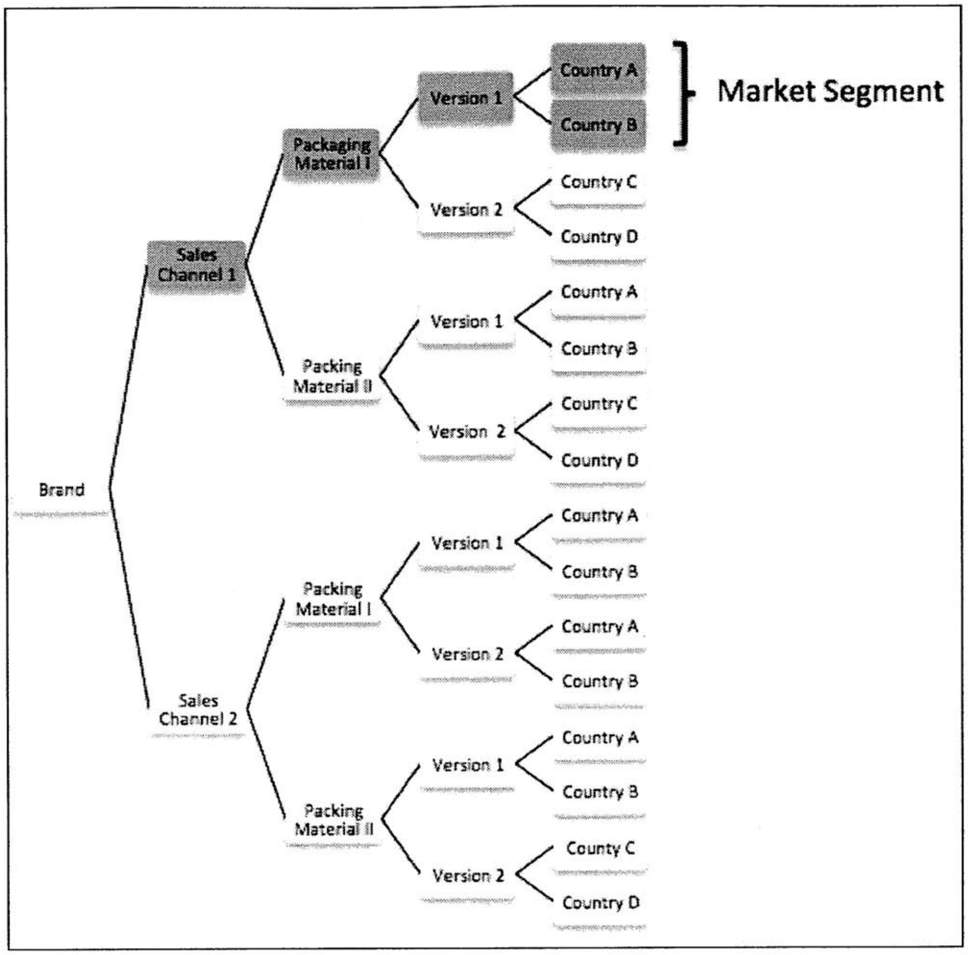
Given a brand, we select SKUs for rationalization based on sales volume and demand variation within a market segment, as well as opportunities for packaging harmonization. A market segment is defined by market region, sales channel, and product. Each market segment characteristic is defined below:

- Packaging material requirement – Some markets require a specific packaging material for safety purposes. This requirement diminishes packaging standardization.
- Sales channel – Healthcare products can be packaged differently depending on the sales channel. These channels can include businesses, consumers, or others. Depending on the product, healthcare companies might need to support many of these channels, which increases necessary SKU complexity.
- Product version – Many brands have several different product versions. Each version has two dimensions, which we will not explain for confidentiality purposes.

4.4.3 Identify Market Segments

The first step in SKU selection is to identify the market segments within a brand based on sales channel, packaging material requirements, and product versions. Market segments depend on requirements served by the firm and could include more dimensions than these three. Figure 6 below highlights one sales channel within the SKU complexity tree of a brand that has two sales channels, two packaging requirements, and two product versions.

Figure 6. SKU complexity tree with a highlighted market segment

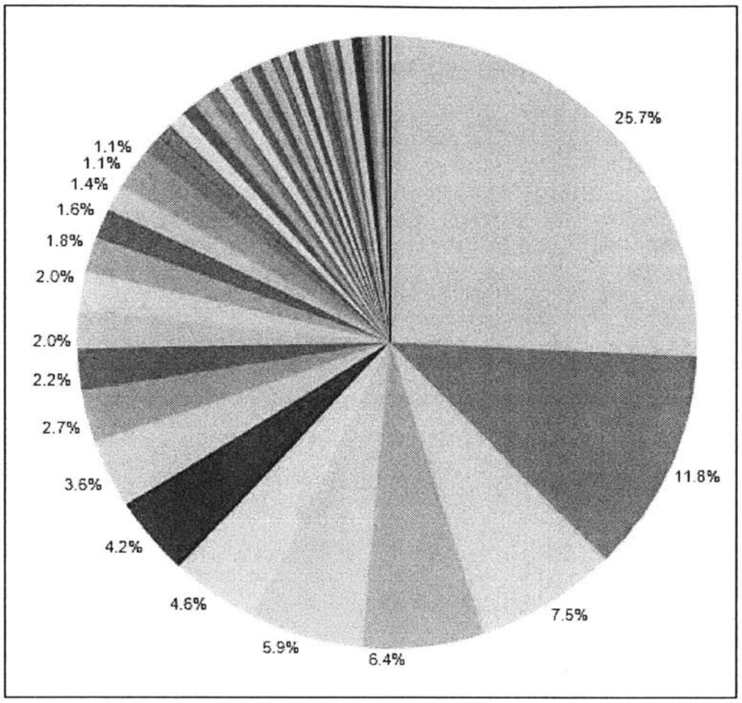


In the figure above, the example brand has eight different market segments. Each market segment has different constraints for rationalization since the sales channel, packaging material requirement, and versions all impact the requirements of the product's packaging. Next, we identify the priority markets and the most common packaging.

4.4.4 Identify Priority Markets

In order to identify the priority markets, we apply the Pareto principle [5] to determine which markets account for 80% or more of the sales volume. Markets with high sales volumes can justify SKU complexity if the demand variation is low. This will be discussed further later in this chapter. In Figure 7, the pareto principle is demonstrated using sales volumes per market.

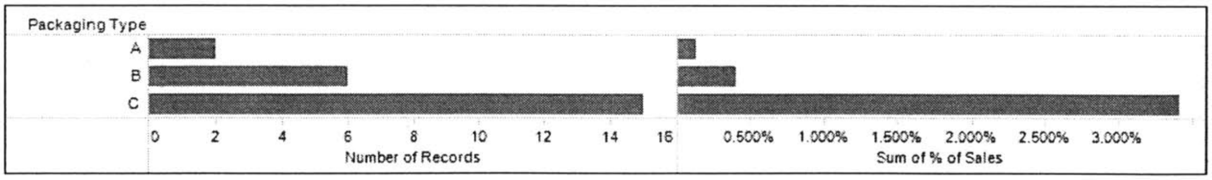
Figure 7. Priority markets identified by pareto principle ***(Each color represents a different market)***



4.4.5 Identify Common Packaging

Next, we identify the most common packaging within a market segment. Our research finds that brands usually have one packaging type that accounts for a majority of sales volumes within a market segment. In these cases, the other packaging types have small volumes unless there is a market requirement for a certain type. This relationship is depicted for one market segment below in Figure 8.

Figure 8. Packaging type vs. market segment sales volume of total brand sales



This view is useful to identify how an variety can be harmonized. In this example, there is an opportunity to rationalize SKUs with packaging type A and B.

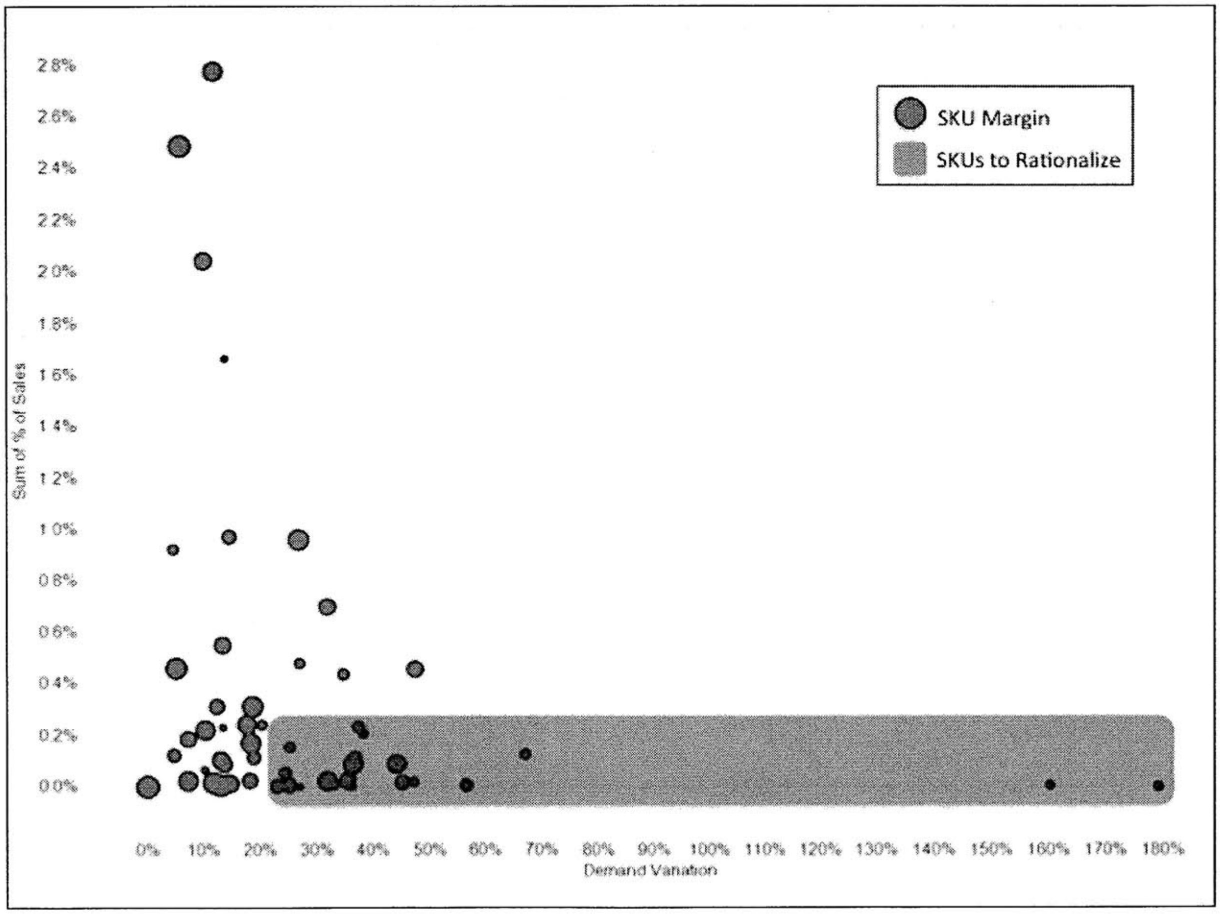
4.4.6 Identify SKUs for Rationalization

With market segments, priority markets, and the most common packaging identified, we have the understanding necessary to correctly determine the opportunity for rationalization. To identify the SKUs within each market segment, we look at the sales volume and demand variation of each SKU. As discussed in Chapter 2, SKUs with low volumes and high demand variation bring cost and complexity into an organization. These SKUs are selected for rationalization with two constraints:

- Priority markets - SKUs that serve priority markets can be exceptions to this selection process.
- Most common packaging – SKUs that account for the majority of sales volumes within a market can be exceptions to this selection process.

Leveraging sales data, we develop the following figure to identify the candidate SKUs.

Figure 9. Example of SKU selection based on sales volume and demand variation



In the figure above, we highlight SKUs with high demand variation and a low percentage of the sales volumes as candidates for rationalization.

4.4.7 Sales Impact Analysis

We design this process in order to target SKUs that are redundant and/or cannibalizing sales. Although a sales cannibalization analysis is outside of the scope of this research, we recommend such an analysis if feasible. Instead, we perform a qualitative analysis of the candidate SKUs to assess the risk of a significant sales impact. The SKU selection process targets low volume SKUs so these candidate SKUs will inherently have a low impact on sales. Further, the SKU selection process appropriately selects within market segments. Therefore, we select candidates from a group of SKUs serving the same market and likely meeting the same requirements. Sales transfer is more likely if sales are moved between SKUs that meet similar requirements. As shown in Table 1, we recommend clustering candidates as low, medium, or high risk of sales impact according to certain characteristics, assuming selection within a market segment. Clustering candidates SKUs is important when pursuing management approval. For example, management will allow approve rationalization of low and medium risk SKUs but not high risk.

Table 1. Risk assessment of sales impact

Risk	Sales Channel	Packaging Type	Volume
Low	Free goods / General Market	Redundant / Unique	< 1% of sales
Medium	General Market	Unique	1-2% of sales
High	Priority Customer / Market Requirements	Unique	> 2% of sales

The complexity reduction team should aggressively pursue rationalization of free goods, redundant, and/or low volume offerings. Medium-risk SKUs require strong alignment with the marketing and sales teams of the respective market to confirm feasibility. These SKUs have a unique pack size or packaging and 1-2% of sales. And finally, high-risk SKUs account for large sale volumes or might meet a specific market requirements. We recommend that the organization strongly consider the context of their customers and markets when assessing the risk of sales impact.

4.4.8 Costing System Analysis

As discussed in Chapter 2, complexity costs refer to costs that are difficult to quantify using common organizational costing systems. Although costing systems will not itemize the complexity costs, we perform a thorough analysis to achieve an understanding of where costs will be reduced due to SKU rationalization. Some of these cost reductions are intuitive such as the reduction in labor costs due to less setup times on a packaging line. Other cost reductions are second order effects such as avoidance in capital investment to increase capacity or reduced costs to transfer production between manufacturing sites. We focus this analysis on costs that are directly affected by SKU rationalization.

To begin, we work with company stakeholders who know the cost accounting system from the plant to the global aggregated costs in order to understand each major itemized cost in their costing system. If the brand is sourced from multiple locations or value chains, the cost allocation differences must be understood between each channel.

With an understanding of these costs, we generate a table of the itemized costs and how these costs are affected by SKU rationalization and whether the costs are avoidable and should be quantified. An example is shown in Table 2.

Table 2. Example of an organization's itemized costs

Cost Item	Includes	Effect of SKU Rationalization	Avoidable	Quantify?
Raw Material Costs	• Non-packaging Raw Materials • Packaging Materials	Possible volume discounts from packaging harmonization	Partial	No. Now-packaging raw materials accounts for majority of cost but are unaffected.
Direct Labor	• Setup time • Processing time • Maintenance	Removal of setup times	Partial	Yes. Setup times can be greater than processing and maintenance times.
Fixed Assets	• Utilization • Depreciation • Leasing	Frees capacity hours from less setup times	No, unless removal of high number of SKUs causes divestment of fixed asset	Yes. Quantify freed capacity to avoid capital investment. No direct cash flow effect.
General Overhead	• Management • Support	Less coordination	No	No
Utilities	• Electricity • Heating/Cooling	Possible reduced labor shifts	Partial	No. Small percentage of total cost.
Warehousing & Distribution	Shipping and handling	Reduced order processing	Yes	Associated labor is avoidable and separate from direct

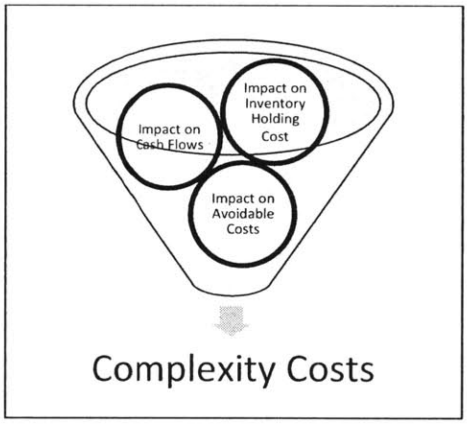
				labor

This step is important because it allows the complexity reduction team to understand where the value of SKU rationalization is coming from and to focus on cost areas to quantify. In the next section, we will quantify the affected cost areas.

4.4.9 Complexity Costs Calculation

With SKUs selected for rationalization and an understanding of cost allocations within the organization, we compute the complexity cost associated with the current brand variety. We define complexity cost as the sum of the impact that increased SKU variety has on cash flows, inventory, and avoidable costs. This relationship is demonstrated in Figure 10 below.

Figure 10. Definition of complexity costs



We discuss each complexity cost element and its calculation in detail below. In brief, we compute the impact on cash flows by modeling the current and future state of setup times and labor hours on production lines. Next, we calculate the impact on inventory holding costs by modeling the current and future state of cycle stock and safety stock inventory levels.

4.4.9.1 Production Model Formulation

The purpose of the production models is to quantify the reduction in labor hours, the impact on utilization, and the effect on replenishment time that SKU rationalization has on operations. We create two models to capture the impact on operations – a descriptive model and a queuing model. The descriptive model uses historical data and highlights the reduction in setup time if SKU rationalization is performed. The queuing model captures the effect on utilization and replenishment time from SKU rationalization.

4.4.9.1.1 Descriptive Model with Economic Order Quantity

The descriptive model is a scenario analysis that quantifies how much non-value added time could be reduced if a lean variety was offered for a given brand. We focus on the packaging process in this model for the following reasons:

- Production quantities of healthcare product raw materials are computed by pooling demand of each SKU and therefore are not strongly impacted by SKU variety.
- Rationalization of healthcare versions are outside of the scope of SKU rationalization
- The scope of SKU rationalization focuses on finished product SKUs and driving efficiencies in the packaging process step

Further, we focus on cash flows in order to compute a quantifiable benefit that is separate from a debate regarding accounting costs. This allows us to capture a benefit that is easily communicable to external stakeholders. In this section, we discuss the inputs, outputs, calculations, and assumptions associated with this model.

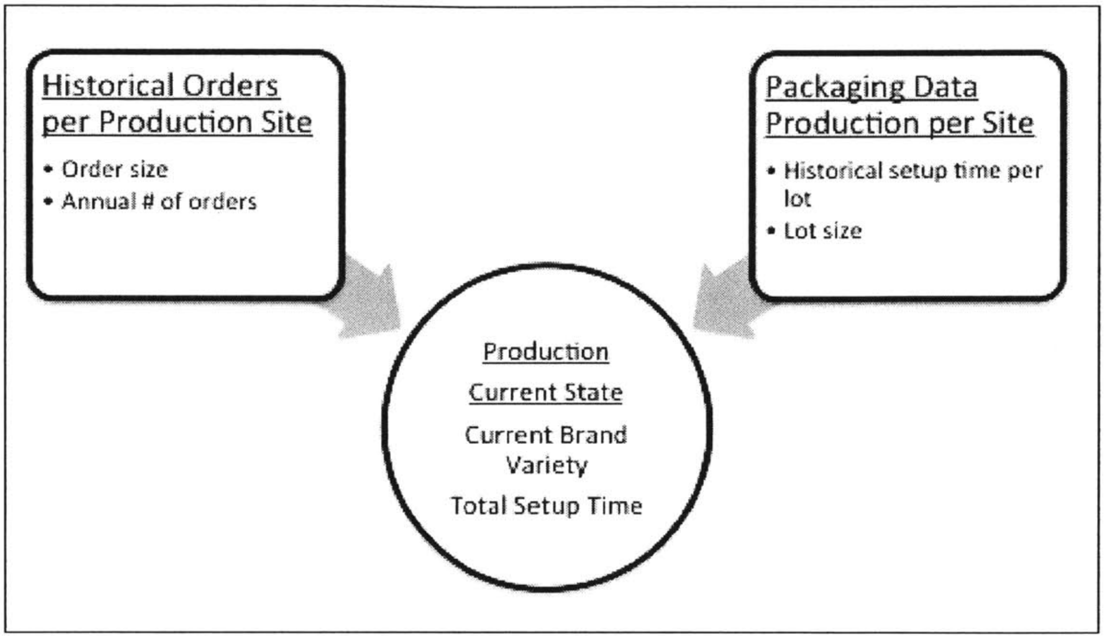
4.4.9.1.2 Inputs and Assumptions

In order to determine the current state of total setup time for the brand, the model requires the following historical information for each SKU:

- Annual number of orders
- Order quantity per order
- Production lot size
- Setup time per lot

These inputs are further described in Figure 11 below.

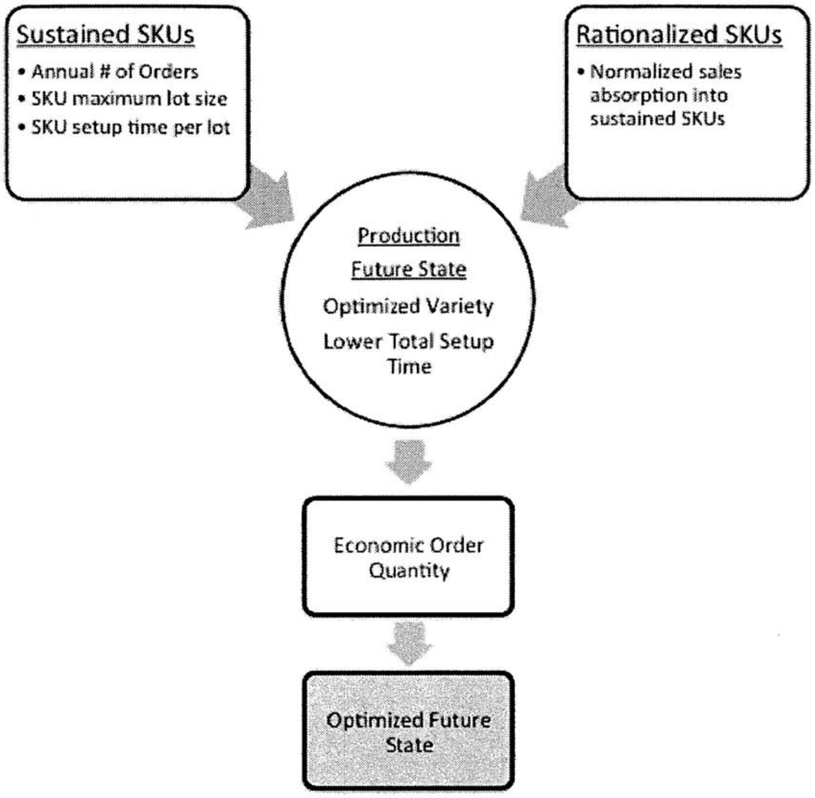
Figure 11. Current state of production model



To compute the future state of total setup time, the model requires the new lean product offering and its associated volumes. The remaining SKUs that are not rationalized make up the lean offering. The sales volumes of the lean product variety are the sum of current volumes of sustained SKUs and the volumes of rationalized SKUs that are transferred to sustained SKUs, assuming zero sales impact.

Initially, we assume in the future state that the number of orders per year of each SKU stays constant. We then relax these constraints and include the benefits of computing the economic order quantity for each sustained SKU. The process behind capturing the future state is depicted in Figure 12 below.

Figure 12. Future state of production model



4.4.9.1.3 Outputs

The outputs of this model match up with many of the metrics described earlier in this chapter. These metrics include the following:

- Cash flows
- Labor hours

For each metric, we compare the current and future state to determine the benefit of the future state.

4.4.9.1.4 Model Formulation

The computation for this model is trivial which makes the process reproducible and the benefit easily communicable. Both characteristics are requirements of the model. Further, the model has two computations, which include:

- Total annual setup time

- Economic order quantity

4.4.9.1.4.1 *Total Setup Time*

To compute the total setup time annually for a given brand, we employ the parameters detailed in Table 3.

Table 3. Parameters of total setup time equation

Parameter	Description	Units
l_i	Lot size of SKU *i*	Packaging Units
s_i	Setup time per lot of SKU *i*	Hours
$q_{i,j}$	Order quantity of order *j* of SKU *i*	Packaging Units

Using these parameters, total setup time is computed as follows:

Equation 1. Total setup time for n SKUs of a brand

$$\sum_{i=1}^{n}\sum_{j=1}^{m}\frac{q_{i,j}}{l_i}s_j$$

This equation is used to compute the total setup time of both the current variety and the future lean offering. The reduction in setup hours is equal to reduction in labor hours required to meet demand. The effect on cash flows is simply computed by multiplying the number of heads per shift by the number of setup hours reduced.

4.4.9.1.4.2 *Economic Order Quantity*

For each sustained SKU, we recommend applying the economic order quantity (EOQ) model to determine the optimal lot size to produce that minimizes setup costs and holding costs. The parameters for the EOQ model are detailed in Table 4.

Table 4. Parameters of economic order quantity model

Parameter	Description	Units
A	Cost of setup	\$/order
D	Annual demand	items
r	Holding cost	\$/\$/year
v	Unit cost	\$/item

Using these parameters, the economic order quantity is computed as follows:

Equation 2. Economic order quantity [8]

$$EOQ = \sqrt{\frac{2AD}{vr}}$$

4.4.9.1.5 Summary

With this model, we determine the complexity cost associated with the cost of setup time for the current offering sold to the market in comparison to the setup time cost of a lean offering. By quantifying labor hours, this model meets the requirement that the benefit of SKU rationalization can be easily be communicated to stakeholders. Further, this model maps SKU complexity to operational complexity. Although the model only captures the effects on labor hours, this output could provide the impetus for fixed cost reduction such as capital investment avoidance, a work shift reduction, or footprint consolidation.

4.4.9.2 Queuing Model [6]

The queuing model allows us to analyze the impact of SKU complexity on capacity, utilization and replenishment time. For the queuing model, we use the simple M/M/1 system. In the case of packaging, we did not assume that any available packaging line could service an order. Instead, we analyze each packaging line and its associated demand using the M/M/1 system to determine the overall impact on utilization and replenishment time. With a M/M/1 system, both the arrival process and service process are memory-less and there is one server or packaging line in the system.

SKU complexity impacts both the arrival process and service process by increasing the number of orders and the utilization time. With constant demand, an increase in orders leads to an increase in arrival rates and a reduction of service time due to setups. To understand the impact of SKU complexity, we compare the queuing system with the current product variety to the queuing system with a lean offering.

4.4.9.2.1 Inputs and Assumptions

The queuing model requires information regarding the arrival process, the service process, and the available processing time. Regarding the arrival process, we assume a Poisson process. The input of the arrival process is the annual orders per year processed by the packaging line and the available hours for receipt of orders. The available hours are the number of hours in a year that the packaging line is operating and ready to setup for or to process an order.

The input of the service process is the number of orders received annually, the number of units produced annually, the total setup time to produce the aforementioned volume, and the service rate of the packaging line. Packaging lines rates can be in terms of units per minute.

4.4.9.2.2 Outputs

The queuing model provides the following expected values of the performance of the system [6]:

- Total runtime – the theoretical total time that the packaging line is producing units per year
- Total setup time – the theoretical total time that the packaging line is being setup to produce per year
- Utilization – the percentage of time that the packaging line is in use for processing over the course of the year
- Expected waiting time – the expected number of hours an order will need to wait before being processed
- Expected queue length – the expected number of orders waiting to be packaged
- Expected system time – the expected time for an order to be processed
- Expected number in system – the expected number of orders in the system (i.e. orders are either in the queue or being processed by the server)

4.4.9.2.3 Model Formulation

The queuing model is a standard M/M/1 system and applies the following equations as defined by the model to approximate the outputs mentioned above.

Equation 3. Expected # of orders in system [6]

$$L = \frac{\rho}{(1-\rho)}$$

Equation 4. Expected system time of an order [6]

$$W = \frac{\rho}{\lambda(1-\rho)}$$

Equation 5. Expected length of the queue [6]

$$Q = \frac{\rho^2}{(1-\rho)}$$

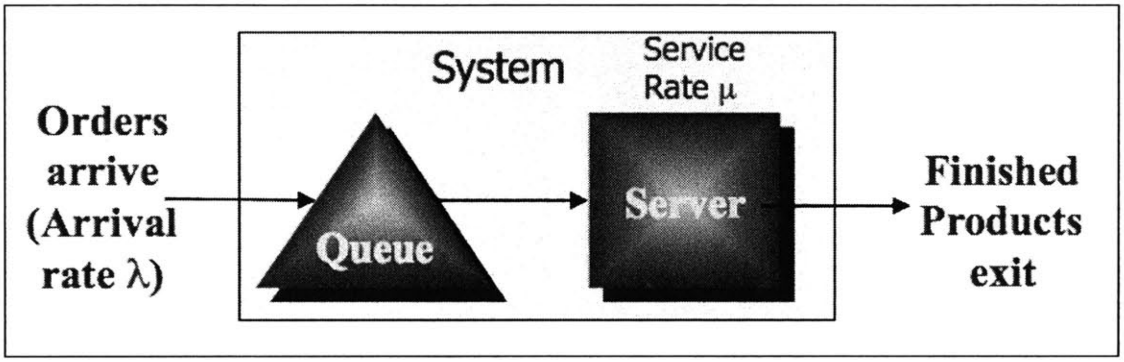
Equation 6. Expected queuing time of an order [6]

$$D = \frac{\rho^2}{\lambda(1-\rho)}$$

Parameter	Description	Units
ρ	Capacity utilization	Percent
λ	Arrival rate of orders	Orders per hour

A depiction of the M/M/1 queing model is shown in Figure 13 below.

Figure 13. M/M/1 queuing model [6]



4.4.9.2.4 Summary

The queuing model captures the effects of SKU complexity on replenishment lead-time and cycle stock. A change in SKU complexity impacts both setup time and the arrival rate in the queuing system. If the SKU complexity is reduced, we observe a decrease in replenishment lead-time. Lower lead-times contribute to improved forecast accuracy and decreased cycle and safety stock.

For computation of the associated complexity cost element, we use the difference between the expected system time of the current and of the future state. This lead-time reduction is used to quantify a savings in both cycle stock and safety stock.

4.4.9.3 Forecast Accuracy Model

We formulate a forecasting model to quantify the improvements in forecast accuracy that are possible through the demand pooling that occurs with the implementation of SKU rationalization. By improving forecast accuracy, the company can reduce safety stock and write-offs, and therefore, complexity costs. We measure forecast accuracy as the Mean Absolute Deviation (MAD) divided by average sales and use the standard calculation for safety stock. In this section, we discuss our assumptions, the inputs and outputs of the model, the model's formulation, and the benefits of this analysis.

4.4.9.3.1 Input & Assumptions

In order to compute the MAD/Mean ratio, we collect at least one year of historical forecasting data for the brand selected for SKU rationalization. This data includes the forecast for demand over the lead-time period and the actual demand over the lead-time. The forecast accuracy for the current brand variety can be computed with this data.

For the future state, the candidate SKUs for rationalization and the SKUs that will absorb the sales of these rationalized SKUs are required. By combining demand, we leverage the benefits of risk pooling in reducing forecast error. The two inputs of the future state model are the sum of forecasted demand and the sum actual demand for each collection of pooled SKUs.

4.4.9.3.2 Outputs

The output of the model is the improvement in forecast accuracy in terms of percentage points. The output is provided in improvement by affected SKUs but can easily be computed for other contexts including the following:

- Improvement by brand
- Improvement by market packaging requirements
- Improvement by sales channel
- Improvement by country
- Improvement by product version

4.4.9.3.3 Model Formulation

Both the current state formulation and future state formulation use the MAD/Mean ratio. The MAD or mean absolute deviation is the absolute average difference between the forecasted demand and actual demand [7]. The Mean is the average demand over the measurement period. We recommend the use of at least one year of measurement. The formulation for the MAD/Mean ratio is as shown in Equation 7.

Equation 7. Formulation of MAD/Mean ratio [7]

$$\frac{\frac{\sum_{i=1}^{n}|f_i - a_i|}{n}}{\frac{\sum_{j=1}^{n} a_j}{n}}$$

where,

- n - the number of periods of measurement (i.e. weeks, months, years)
- f_i – the forecasted demand for period i
- a_i – the actual demand for period i

In the future state, the variables represent pooled forecasted demand and pooled actual demand. In other words, the sales volumes are transferred from a rationalized SKU to a sustained SKU as shown in Table 5.

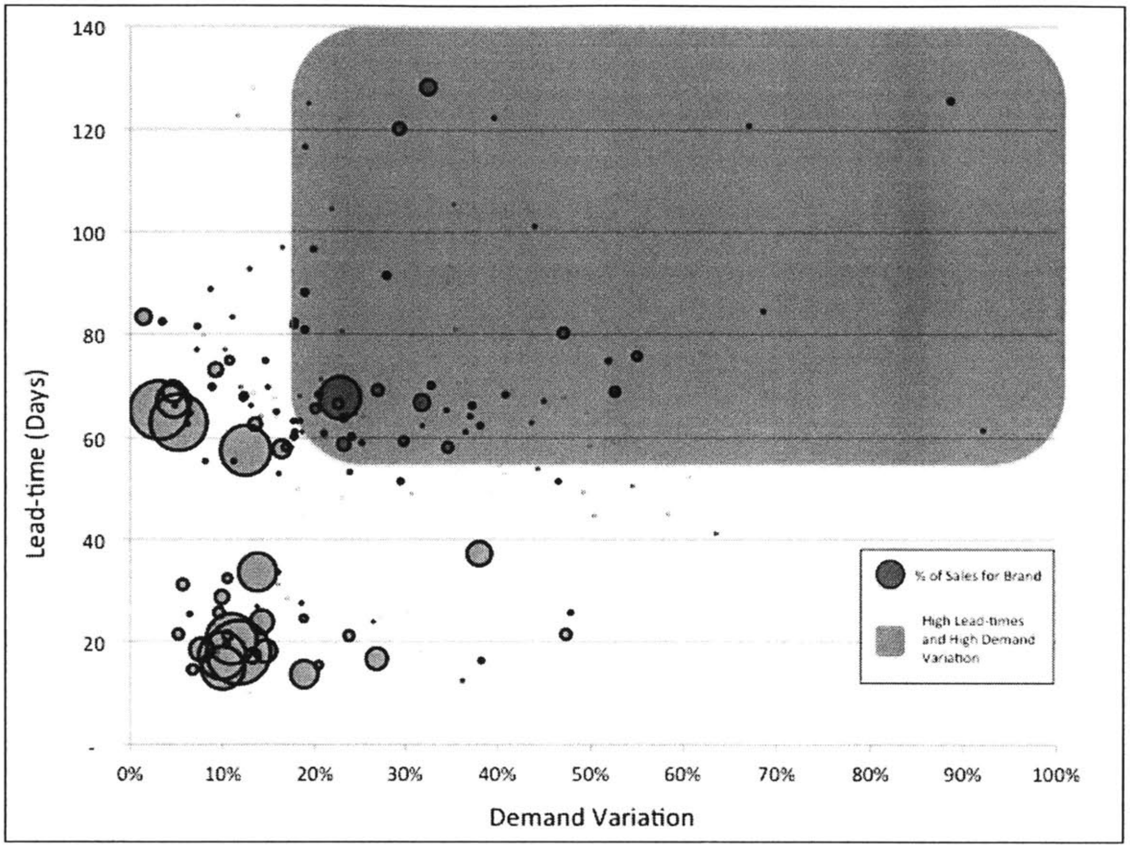
Table 5. Representation of demand transfer from rationalized SKU to sustained SKU

SKU Number	Current Demand	Future Demand	SKU Future Status
1	X	0	Rationalized
2	Y	X_normalized + Y	Sustained

The improvement in forecast accuracy is simply computed as the difference between the current and future state forecast error. Improved forecast accuracy will reduce write-offs, lost sales, and safety stock, all of which are complexity costs driven by SKU complexity.

Safety stock is further reduced due to a correlation that we find between high demand variation and long lead-times [18]. This can be investigated by simply comparing demand variation versus lead-time as shown in Figure 14. In this figure, we see that low volume SKUs (shown by small bubbles) exist to the top right of the graph. This shows that the SKUs in the red region will have a larger effect on safety stock reduction if replaced by SKUs in the non-red regions.

Figure 14. Demand variation vs. lead-time vs. % of brand sales per SKU



For rationalized SKUs that are replaced with SKUs that have shorter lead-times, we can compute a multiplicative reduction effect due to the reduction in lead-time and the reduction in forecast error. We compute the complexity costs associated with safety stock by computing the difference in safety stock levels between the current and future state. This delta is a reduction in holding cost for the brand. We compute safety stock levels using the safety stock equation and historical lead-times as shown in Equation 8.

Equation 8. Safety stock equation for a SKU [9]

$$safety\ stock = ss = z\sigma_{LTD}\sqrt{LT}$$

where,

- z – safety factor for the appropriate service level
- σ_{LTD} - standard deviation of forecast over lead-time
- LT - order lead-time of a given SKU

We then compute the associated complexity cost as shown in Equation 9.

Equation 9. Safety Stock Complexity Cost per SKU

$$complexity\ cost_{ss} = vr(ss_{current} - ss_{future})$$

where,

- v – value per unit of safety stock in $
- r – holding cost in $/$/year
- ss_i – number of units of safety stock in period i

4.4.9.3.4 Summary

The forecasting model quantifies how SKU complexity contributes to rising inventory and forecast error. As the number of SKUs increase for a given brand within a sales channel, demand is segmented and forecast error increases. Forecast error has a major impact within the healthcare industry where there are lives in need of these healthcare products. Further, this error is directly proportional to safety stock levels. We also find that high demand variation correlates with longer lead-times. By rationalizing high variation SKUs, SKUs with long lead-times are also removed. This highlights another complexity costs brought by a stronger increase of safety stock due the multiplication of forecast error and the square root of lead-time. As inventory increases, write-offs and working capital increase which further grow complexity costs.

4.4.10 Monitoring and Sustainment

In support of our research, we develop dashboard views of the SKU portfolio to facilitate both the rationalization process, monitor the impact on sales, and to govern SKU creation. In this section, we describe the different views of the dashboard and how these views will benefit the organization.

4.4.10.1 Dashboard Views

Dashboards can be implemented using a variety of IT tools. We recommend using simple-to-use visualization software that can connect real-time to the databases of your organization. Leveraging the IT databases that exist to generate the views that will bring transparency and communicate well to stakeholders allows you to frame the argument for rationalization, as well as identify the opportunity. For this research, we implement dashboards using *Tableau Software*. Our dashboards highlight the metrics outlined earlier in this chapter and help identify opportunities for optimizing the SKU portfolio.

Through a dashboard, we are able to quickly bring transparency to key decision criteria for SKU rationalization and to identify good and bad complexity. The views we generate allows us to perform the following:

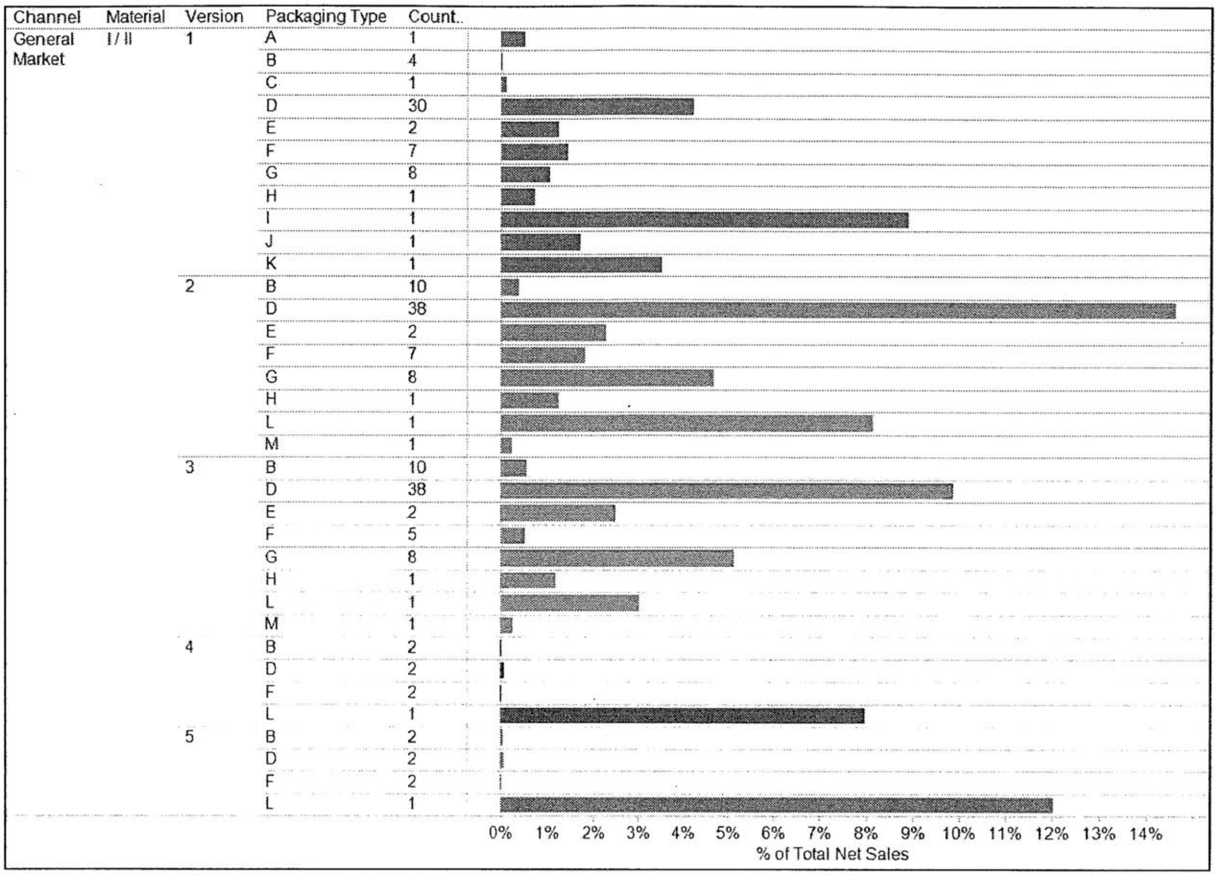
- Identify the emergent most commonly-used packaging for each brand, product version and/or market
- Compare volumes across product versions
- Identify priority markets by brand
- Identify candidate SKUs for rationalization based on SKU complexity, volumes, and priority markets
- Monitor SKU creation trends versus sales trends
- Monitor progress of complexity reduction projects

For each capability, we discuss the derived benefit of this transparency.

4.4.10.1.1 Packaging Commonality

One approach to SKU rationalization is to harmonize the variety through common packaging. Due to aspects of the healthcare industry, we find that one packaging type accounts for a majority of the SKU offerings and of a brand's sales volumes. This begs the question of why should the organization support the other packaging types. In Figure 15, we present a view of the packaging offerings within five market segments.

Figure 15. Packaging types for each market segment



Channel	Material	Version	Packaging Type	Count
General Market	I / II	1	A	1
			B	4
			C	1
			D	30
			E	2
			F	7
			G	8
			H	1
			I	1
			J	1
			K	1
		2	B	10
			D	38
			E	2
			F	7
			G	8
			H	1
			L	1
			M	1
		3	B	10
			D	38
			E	2
			F	5
			G	8
			H	1
			L	1
			M	1
		4	B	2
			D	2
			F	2
			L	1
		5	B	2
			D	2
			F	2
			L	1

Table 6. Explanation of fields in packaging types dashboard

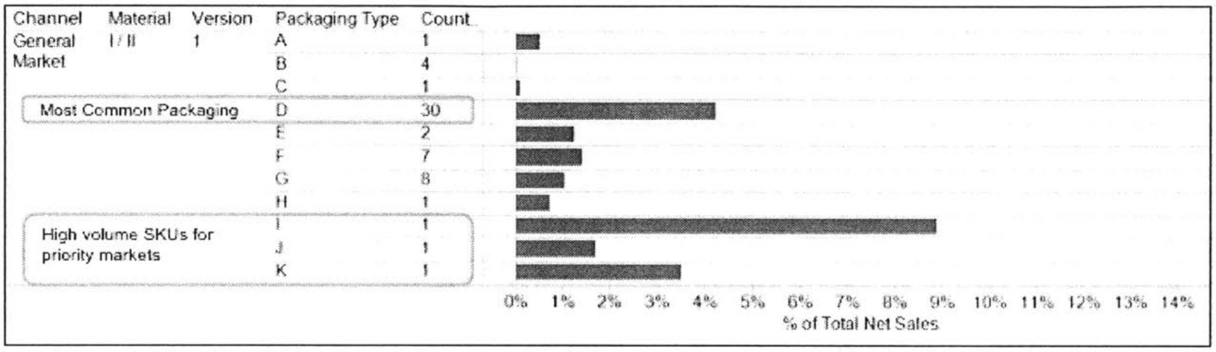
Field	Description
Channel	Sales channel (i.e. general market, business, free goods)
Material	Packaging material to meet market requirements
Version	Product version
Packaging Type	Type of packaging configuration
Count	Number of SKUs of packaging format in market segment
% of total net sales	Percentage of global sales for that brand

For each brand, we can see the following information for this market segment:

- The most common packaging type for each brand
- The most common packaging type for each product version
- Number of SKUs per packaging type
- Sales volumes per packaging type

By zooming in on one product version, we infer more relevant information as shown in Figure 16.

Figure 16. Most common packaging and priority market SKUs



Channel	Material	Version	Packaging Type	Count
General Market	I / II	1	A	1
			B	4
			C	1
			D	30
			E	2
			F	7
			G	8
			H	1
			I	1
			J	1
			K	1

In the figure above, we see that the packaging type D is the most commonly used packaging with 30 SKUs for this market segment. This presents an opportunity to question the other finished product offerings. This view also highlights high volume SKUs that meet the requirements of high priority markets.

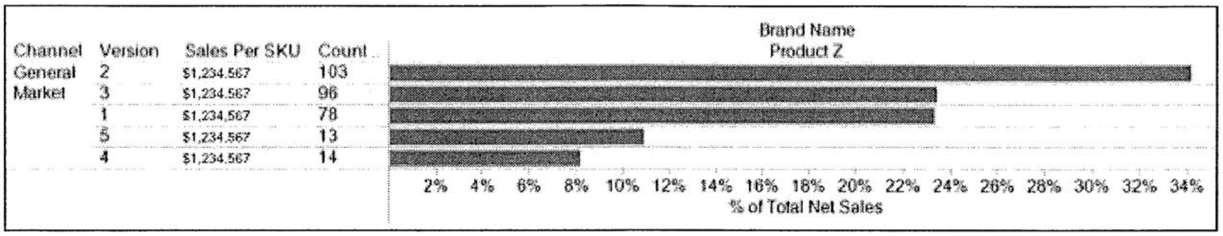
To summarize, this view brings forth an opportunity to standardize the variety across a market segment, a product version, or the whole brand. Further, the dashboard highlights the SKUs that are the biggest topline contributors. We recommend using these views to question market segments that deviate from the common SKU and to serve as a basis to deny proliferation of non-standard or uncommon packaging types in low volume markets.

4.4.10.1.2 Metric Transparency

Another view we develop brings forth the metrics for monitoring SKU complexity - specifically sales per SKU, numbers of SKUs per product version, and sales per product version. We find these metrics to be significant for a few reasons. The metric, sales per SKU, measures how optimum the SKU variety is for the brand. Higher sales per SKU are a signal that a low number of SKUs is able to contribute high sales volumes. This metric is also valuable in communicating to marketing and sales stakeholders.

We also track metrics with regard to each product version. This view highlights low contributing product versions, as well as the product versions that have high SKU complexity, as shown in Figure 17.

Figure 17. Volumes per product version for one brand



Channel	Version	Sales Per SKU	Count
General Market	2	$1,234,567	103
	3	$1,234,567	96
	1	$1,234,567	78
	5	$1,234,567	13
	4	$1,234,567	14

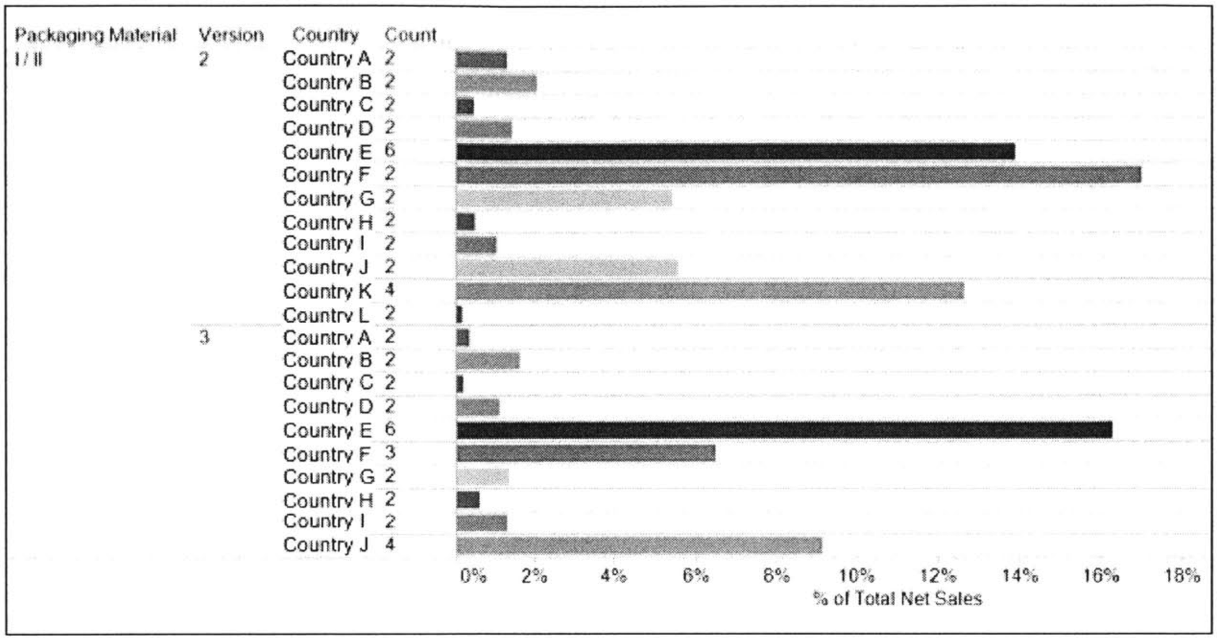
Table 7. Explanation of fields in product version dashboard

Field	Description
Channel	Sales channel (i.e. general market, business, free goods)
Version	Product version
Count	Number of SKUs matching selected field criteria
Sales per SKU	Total sales contributed by SKUs matching above field criteria
% of total net sales	Percentage of global sales for that brand

4.4.10.1.3 SKU Identification for Rationalization

Our next dashboard identifies opportunities for SKU rationalization. This dashboard leverages the process outlined in this chapter. The lowest possible complexity for a brand's variety is one SKU per market segment per country. In other words, one type of packaging for each brand, packaging material, product version, and country combination is the lowest SKU complexity offering. This dashboard brings forth all countries that market more than one SKU per market segment and delineates between priority markets and low volume markets. Figure 18 is a screenshot of the dashboard for one packaging material with product versions and countries selected.

Figure 18. SKU complexity per market segment



In this figure, priority markets are highlighted in green and low volume markets are highlighted in red. The darker red or green represent an extreme in low or high sales volumes, respectively. The ranges for low and high volumes are adjustable by the user. With this view, the user can quickly identify opportunities to release SKU complexity. More information is inferred by investigating one product version at a time. Figure 19 highlights the countries where SKU rationalization opportunities exist.

Figure 19. SKU rationalization opportunities in one segment

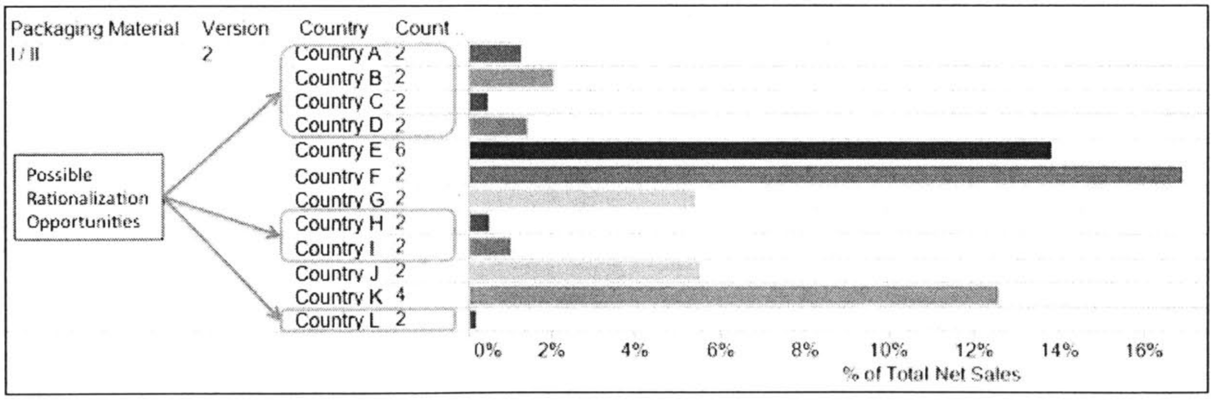


Table 8. Explanation of fields in SKU rationalization dashboard

Field	Description

Packaging Material	Packaging material to meet market requirements
Version	Product version
Country	Country where this product version is sold
Count	Number of SKUs in country matching selected field criteria
% of total net sales	Percentage of global sales for that brand (green – priority market / red – low volume market)

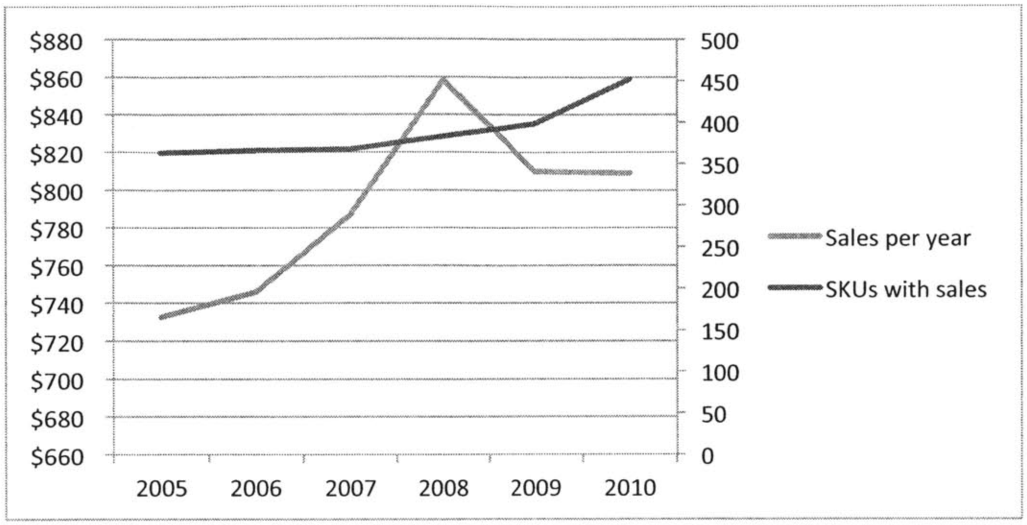
Again with this dashboard, the user can target opportunities quickly and save time from building worksheets and filtering data to determine the appropriate scope for SKU rationalization. This dashboard has the appropriate filters visible and user-defined so both good and bad SKU complexity can be identified.

4.4.10.1.4SKU Trends vs. Sales Trends

We generate a view to monitor SKU complexity at the brand level, as well. As discussed, we recommend selection of brands based on the company's strategy and sales trends. In support of brand selection, we create a dashboard that monitors the sales trends versus the SKU trends.

We identify an opportunity for rationalization when sales for a brand begin to decrease while SKUs for the brand continue to rise. It is possible that the increase in SKUs is used to counter the downturn in sales but in either case, this presents an opportunity to optimize the variety. Figure 20 below exhibits a continual rise in SKUs despite a substantial change in the product's lifecycle.

Figure 20. Example of SKU trend versus sales trend for a brand

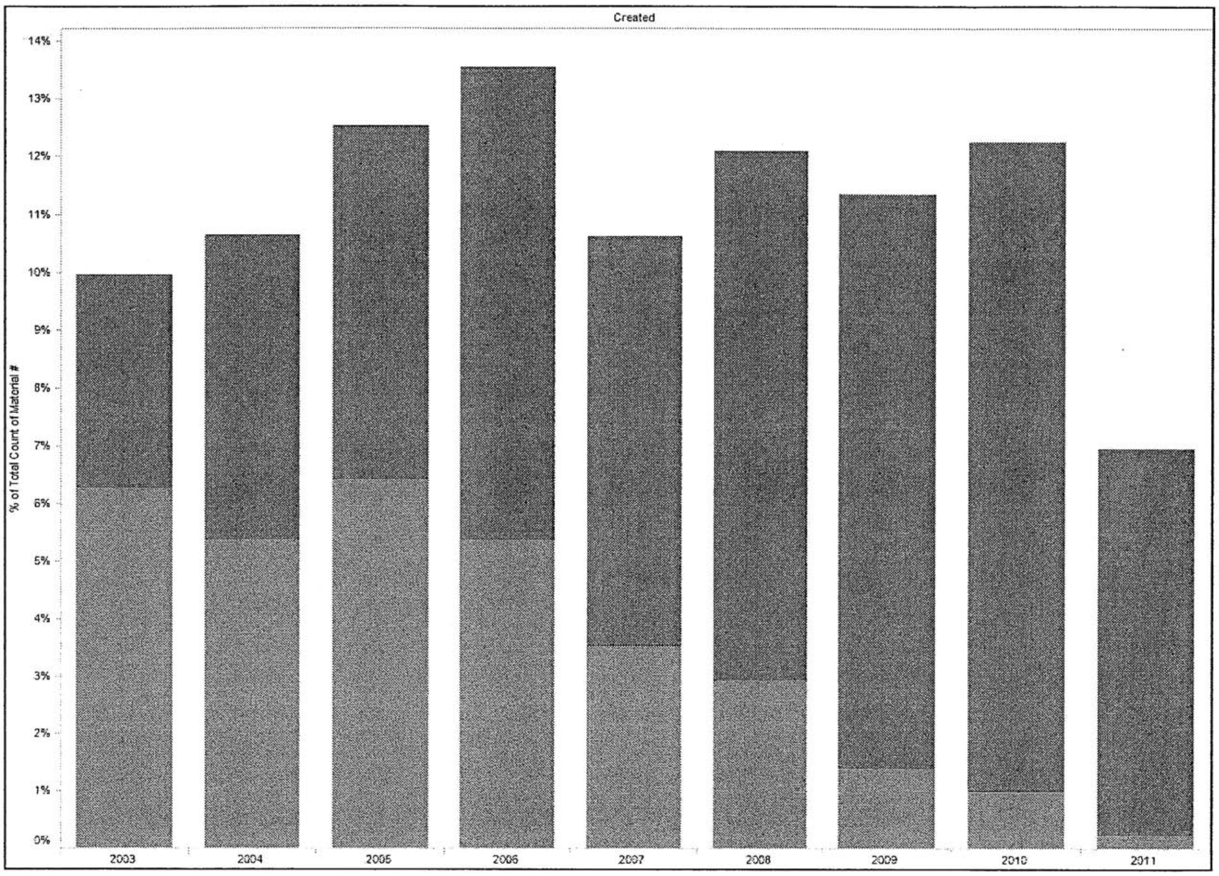


When a brand drops in sales, the organization should revisit the brand's variety and ensure that it is appropriate for the lifecycle of the product and other externalities. This dashboard view presents a way to alert a complexity reduction team that action should happen on this brand.

4.4.10.1.5 Monitoring SKU Creation and Removal

Many complexity reduction initiatives work off a static view of the SKU complexity in their organization. Our research finds that bringing transparency to both the status of the SKU portfolio, as well as the historical trends of the portfolio, help frame the problem for the organization. In large organizations where SKU proliferation is a problem, SKU creation and removal can happen daily. Thus, having visibility into the dynamics of the SKU portfolio allows a firm to monitor their progress and identify the sources of proliferation. In Figure 21, we demonstrate an annual view of SKU creation and removal.

Figure 21. Annual timeline of SKU creation and removal



This dashboard shows the following:

- The number of SKUs created in each year
- The number of SKUs that were created in a given year that have been removed or divested

For example, if 100 SKUs were created in 2004, we can see about 50% of those 100 SKUs have been removed or divested as of today. This is a high level view but it can demonstrate how well an organization is managing SKU creation (blue) and SKU removal (orange).

4.4.10.2 Summary

The SKU Rationalization process outlined above provides methods to identify brands and SKUs that add cost and complexity to the organization, to compute the cost associated with unnecessary SKU variety, and to monitor an organization's SKU portfolio for the purpose of governing SKU creation and effective portfolio management.

In our research, we find that brands that are not strategic and have declining sales should be targeted for SKU rationalization. Within each brand, we recommend that SKUs with low volumes and high demand variation be targeted for rationalization. These SKUs increase ordering costs and inventory while reducing forecast accuracy and effective utilization. Further, rationalizing these SKUs provides an opportunity to standardize packaging. Common packaging standards lower setup times on the packaging line and increases volume discounts on packaging materials. SKUs that are exception to this selection process are those that serve priority customers whom account for the large majority of the brand's sales volumes.

In order to compute the benefit of SKU rationalization, the complexity reduction team must understand the costing system of the organization. By understanding the costing system, the team can communicate where the organization will see value in SKU rationalization. Although costing systems are unable to account for complexity costs, the team should have a thorough understanding of how costs are accounted in order to align with the finance function.

With knowledge of the costing system, we generate models of the production system through a descriptive model and a queuing model. Further, we model the impact on forecast accuracy and inventory. By modeling how SKU rationalization affects operations, we compute the impact on costs. These models are simple, intuitive, and reproducible so that multiple stakeholders can understand and trust in the output of the models.

After implementation of SKU rationalization on a brand and throughout the lifecycle of each brand, we recommend monitoring the SKU portfolio through a dashboard. The dashboard allows the user to monitor metrics (such as SKUs per product version), identify opportunities for rationalization, capture sales and SKU trends, and identify priority and low volume markets. A dashboard provides a reference to align with stakeholders, frame the SKU proliferation problem, and saves time in filtering good and bad SKU complexity.

5 Case Study – SKU Rationalization on a Company X Brand

In this chapter, we discuss a case study regarding a Company X brand where we apply the SKU rationalization process to identify candidate SKUs and calculate the benefit of rationalization on this brand. We describe the purpose of performing SKU rationalization on this brand, as well as our approach and findings.

5.1 Background

The purpose of performing SKU rationalization at Company X is twofold. First, Company X would like to optimize the profitability of each brand's variety in order to reduce overall COGS in the organization. Second, Company X will be launching multiple brands. These changes will cause a major shift in the operational footprint and capacity allocations of the company. By performing rationalization, Company X can:

- Update the variety offered with older brands
- Release capacity needed for new brands
- Reduce the cost of transferring production between manufacturing sites

Further, Company X requires a method to compute the quantitative benefit of SKU rationalization. Complexity costing has been discussed at Company X for many years. For this phase of complexity reduction, Company X seeks a complexity-costing model that quantifies the benefit of SKU rationalization if sales volumes are unaffected.

5.2 Objectives

With the support of Company X's operations team, we set the following objectives for SKU rationalization:

- Reduce cost – Company X seeks to reduce cost through improved productivity and reduced complexity
- Do not impact sales – Company X wishes for SKU reduction without impacting sales
- Meet customer requirements – The optimal variety after performing rationalization must meet all customer and market requirements.
- Quantify complexity costs – Company X wants the capability to quantify the cost benefit from reducing SKUs and transferring sales to the remaining SKUs offered to the market.

- Improve forecast accuracy – Company X seeks to reduce lost sales, back orders, and write-offs through improved forecasting.

5.3 Approach

To meet these objectives, we align them with the implementation steps discussed in the previous chapter. Table 9 below shows the relationships between the SKU rationalization process and Company X's objectives.

Table 9. Alignment with Company X's objectives

Implementation Step	Objective Met	Comments
• Brand selection	• Reduce costs	• Reduced cost of transferring production between manufacturing sites
• SKU selection • Sales impact analysis	• Maintain sales volumes • Meet customer requirements • Improve forecast accuracy	• Low volume SKUs with high demand variation are identified. • Priority markets with unique requirements are exceptions.
• Costing system analysis • Complexity cost computation	• Quantify complexity cost	• Operations research modeling to derive benefit

5.3.1 Brand Selection

Since Company X has consolidated its footprint, production of brands has shifted throughout its network. The cost of transfers is extremely expensive. To reduce that cost, we focus on a brand undergoing a transfer. Nominally, we recommend a data-driven brand selection, but in this case, selection of this brand aligned with Company X's strategy.

5.3.2 SKU Selection

For SKU selection within this brand, we focus on packaging standardization, exceptions for priority markets, and high-variation, low-volume SKUs. Regarding package standardization, we find that one packaging type accounts for a majority of finished product SKUs. Table 10 shows a view of the different packaging offered for the brand across many countries.

Table 10. Example packaging variety for a Company X brand

Brand Z	Country 1	Country 2	Country 3	Country 4	Country 5	Country 6	Country 7	Country 8	Country 9	Country 10	Grand Total
General Market											
Packaging Type 1											
Material A											
3X				2							**2**
Packaging Type 2											
Material B											
1X							4				**4**
Packaging Type 3											
Material A											
1X	1										**1**
2X	4	4	4		2	2		8	8	1	**33**
3X								8			**8**
5X			4		4	2		8			**18**
Grand Total	**5**	**4**	**8**	**2**	**6**	**4**	**4**	**24**	**8**	**1**	**66**

In the figure, we see that the 2-count Type 3 Packaging with Material A is the most common packaging with almost 50% of the SKUs for this brand. These finished products are highlighted in green. The numbers represent how many different SKUs are offered in each country. Through stakeholder alignment meetings, we identify an opportunity to standardize this brand with a 2-count Type 3A packaging with exception for certain priority countries. These are countries with high volumes and unique regulatory environments.

All other countries could be subject to this standardization. By standardizing the packaging, Company X can achieve volume discounts on packaging materials and reduce setup times on the packaging lines. For example, instead of adjusting the packaging machine for a packaging type and count, the line workers only need to change the packaging for the appropriate country. Also, by switching sales from multiple SKUs per country to one SKU per country, the countries can order larger quantities allowing the packaging lines to achieve greater utilization. Most orders are an order of magnitude below the optimum order size so a major reduction in non-value-added setup time could be achieved.

High-variation, low-volume SKUs were also identified. These SKUs would also be tackled by standardization and pooling demand from several SKUs into one standard SKU. As previously mentioned, pooling demand within a market segment will increase sales per SKU and reduce forecast error. This process identified 17% of the brand's SKUs for rationalization.

5.3.3 Sales Impact Analysis

With SKUs identified, we assess the risk of sales impact and come to the following findings:

- Free goods should be standardized across the brand as they have no sales impact and are very low volume
- Business healthcare products need to be sustained as is because they serve priority markets
- Redundant packaging should be rationalized. Redundant packs are two or more SKUs with the same packaging characteristics that are served to the same market segment.
- Unique SKUs that are low volume, high variation, and are not the standard pack should be rationalized.
- Unique SKUs that are medium volume should be challenged but only rationalized per direction of the marketing and sales organization
- High volume SKUs and priority markets are left alone.

5.3.4 Costing System Analysis

We begin our costing system analysis by building an understanding of the cost elements. First, we determine the percentage of each cost element for the brand on average. Next, we conduct interviews and review the controller's manual to understand what each cost element includes, how the cost is allocated, and the manufacturing and supply chain channels that produce the brand. Then, finally we generate assumptions regarding the effect that SKU rationalization will have on each cost element.

By looking at cost percentages, we understand the major sources of cost for the brand. Then, we target the large cost contributors that are affected by SKU rationalization. Table 11 highlights the major costs for this brand. These percentages are blinded for confidentiality.

Table 11. Brand cost percentages (top cost drivers highlighted)

Global Cost Type	COGS Item	%
Total Material Costs	3rd Party Material	A%
	Intercompany Material	B%
	Delivery Costs	C%
	Direct Labor	D%

Total Process Costs	Building Cost	E%
	Overhead	F%
	Material Handling	G%
	Quality Assurance	H%
	Equipment Costs	I%

With the constraint of maintaining sales volumes, many major cost items are unaffected. Although there is savings in material costs due to packaging harmonization, the majority of material costs are accountable to other raw materials. Processing costs and labor costs will still account for maintaining sales volumes as well, but there is an effect from reducing setup times. In fact, our interviews with line workers and plant managers noted the large opportunity in reducing setup times. Utilization of packaging lines is nominally low across the company due to many long setups. We decide to focus on the impact that SKU complexity has on the labor setup time and labor associated with order processing such as material handling costs. Unavoidable costs such as general factory overhead and equipment costs are ignored. Table 12 shows our complete analysis of avoidable costs through SKU rationalization.

Table 12. Costs affected by SKU rationalization (Avoidable costs highlighted)

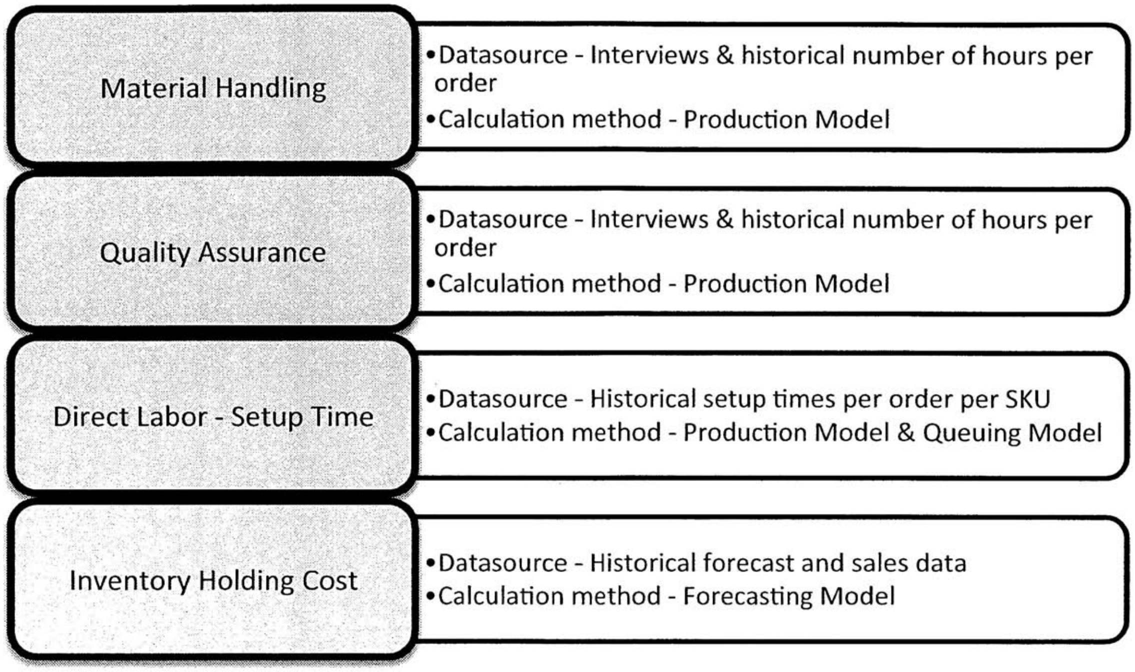
COGS Item	Includes	Allocation	Avoidable	Reason
3rd Party Material	Raw materials	Per unit	No	Sales volume maintained
Intercompany Material	Intercompany products	Per unit	No	Sales volume maintained
Delivery Costs	Shipping costs of raw and packaging materials	Order	No	Sales volume maintained
Direct Labor	Labor hours	Per hour	Partial – labor hours per setup	Reduced setup time
Building Cost	Depreciation, Maintenance, Leasing,	Planned processing time by product (setup/run/downtime	No	Overhead

	IT	)		
Overhead	Management, support, administration, IT	Processing costs	No	Overhead
Material Handling	Warehousing and Internal Transport / QA of raw and packaging material / Purchasing	Material Costs according to BOM and production plan	Partial – labor hours per order	Reduced packing material costs (volume discounts). Reduced labor for material fetching by reduced orders. Includes labor costs and consumables
Quality Assurance	QA of finished products	Per batch and standard testing time	Partial – labor hours per order	Less finished products to QA
Equipment Cost	Depreciation, Maintenance, Leasing, IT	Planned processing time by product (setup/run/downtime)	No	Overhead

5.3.5 Complexity Cost Computation

Through our costing system analysis, we identify three COGS elements in Company X's costing system that are affected by SKU rationalization. We also identify inventory-holding costs and write-offs as complexity costs that are not direct COGS items but need to be quantified. In order to compute the complexity cost, we apply the production model and inventory model. Further, we gather cost data from SAP systems, a database software solution, and through interviews with manufacturing site personnel. Each complexity cost is quantified as shown in Figure 22.

Figure 22. Complexity cost calculation method



5.3.5.1 Data Collection

We begin by collecting data from manufacturing sites through interviews and SAP systems. For material handling and quality assurance labor, we gather activity-based cost data per order processed. For each order processed, the packaging site must fetch the materials, prepare documentation, record process data, and perform quality assurance measures. Each activity has an associated number of labor hours and full-time employees (FTEs). Table 13 shows the results of our interviews with regard to material handling and quality assurance per order. These results are blinded for confidentiality.

Table 13. Example of activity-based costs per order from survey of manufacturing site

Activity	Hours	FTE	Total hours	Comment
Printed packaging material	1	4	4	Personnel cost (Purchasing and Quality Control)
Testing	1	3	3	Personnel cost
Storage	2	2	4	Personnel cost
Create & update record	2	2	4	Personnel cost
Prepare documentation	2	1	2	Personnel cost

Material handling	2	1	2	Personnel cost
Total Activity Hours			**19**	**Labor hours per order for handling and QA**

Setup times per order, unlike the activities above, vary widely depending on the SKU, its associated lot size, and the order size. For this cost item, we obtain SAP data for historical order information and nominal lot sizes. Similarly, for the effects on inventory holding cost, we download historical forecasting and sales data from Company X's SAP systems.

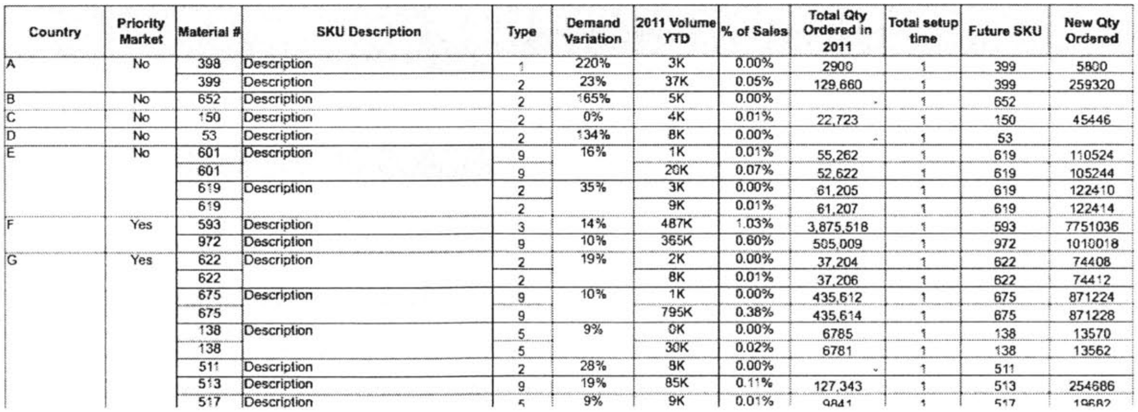
5.3.5.2 Production Model - Descriptive

For our descriptive model, we calculate the non-value added setup-time due to SKU variety. As previously mentioned, we target finished product SKUs in the pilot brand that deviate from the most common packaging format with the exception of priority markets. We generate the model using the following data:

- Historical orders for one year – The historical order database contains every order processed by Company X packaging plants. Each order data item contains the SKU ordered, the order date, and the order quantity.
- Historical setup time for each SKU – This database comes from manufacturing sites and contains the nominal lot size per SKU and the setup time per lot.

With these databases, we compute a current state of setup labor time as shown in Figure 23.

Figure 23. Example current state of setup times for one market segment



Country	Priority Market	Material #	SKU Description	Type	Demand Variation	2011 Volume YTD	% of Sales	Total Qty Ordered in 2011	Total setup time	Future SKU	New Qty Ordered
A	No	398	Description	1	220%	3K	0.00%	2900	1	399	5800
		399	Description	2	23%	37K	0.05%	129,660	1	399	259320
B	No	652	Description	2	165%	5K	0.00%	-	1	652	
C	No	150	Description	2	0%	4K	0.01%	22,723	1	150	45446
D	No	53	Description	2	134%	8K	0.00%	-	1	53	
E	No	601	Description	9	16%	1K	0.01%	55,262	1	619	110524
		601		9		20K	0.07%	52,622	1	619	105244
		619	Description	2	35%	3K	0.00%	61,205	1	619	122410
		619		2		9K	0.01%	61,207	1	619	122414
F	Yes	593	Description	3	14%	487K	1.03%	3,875,518	1	593	7751036
		972	Description	9	10%	365K	0.60%	505,009	1	972	1010018
G	Yes	622	Description	2	19%	2K	0.00%	37,204	1	622	74408
		622		2		8K	0.01%	37,206	1	622	74412
		675	Description	9	10%	1K	0.00%	435,612	1	675	871224
		675		9		795K	0.38%	435,614	1	675	871228
		138	Description	5	9%	0K	0.00%	6785	1	138	13570
		138		5		30K	0.02%	6781	1	138	13562
		511	Description	2	28%	8K	0.00%	-	1	511	
		513	Description	9	19%	85K	0.11%	127,343	1	513	254686
		517	Description	5	9%	9K	0.01%	9841	1	517	19682

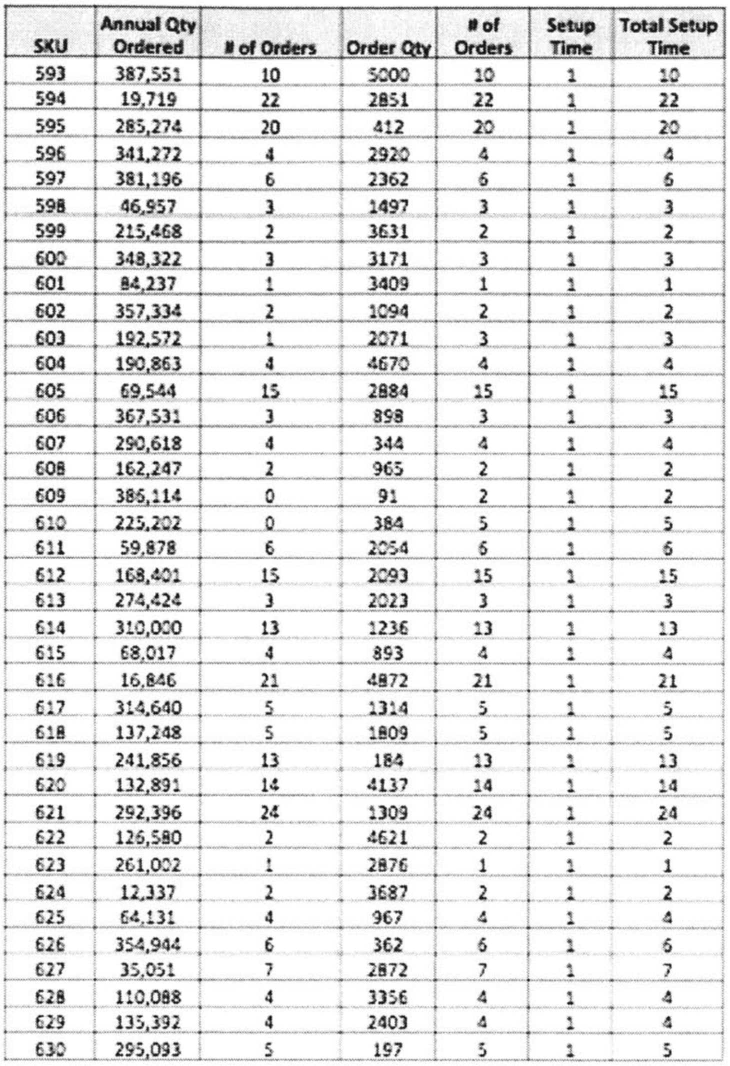
Table 14. Explanation of fields in current state of setup times spreadsheet

Fields	Data Source	Description
Country	Database	Country that SKU is sold
Priority market	Computed based on % of brand sales	Boolean whether country is a priority market
Material # and Description	Database	Finished product SKU unique ID and description. Red are candidates for rationalization. Yellow are exceptions due to market priority.
Type	Database	Packaging type
Demand variation	Computed based on historical forecasts	Historical forecast error of SKU
Volume	Database	Units ordered
% of sales	Computed based on % of brand sales	Percentage of total brand sales
Total setup time	Computed based on historical orders and manufacturing data	Total setup time to process orders
Future SKU	• Selected based by user based on demand variation and packaging standardization	SKU that will absorb sales from a rationalized SKU
New quantity ordered	• For rationalized SKUs, this is zero. • For sustained SKUs, the new quantity is the current quantity plus the absorbed normalized quantity from rationalization SKUs	Future state volume per SKU

As shown in Figure 23, SKUs highlighted in red are candidates for rationalization. Sales of rationalized SKUs are reallocated to the standard packaging type offered in that market. The SKUs highlighted in yellow represent finished products that deviate from the standard packaging but exist in priority markets.

We use the new quantity ordered per SKU to develop the future state model. The future model simply aggregates the future order quantities for sustained SKUs and assumes the same number of orders per sustained SKU. The new order quantity allows larger lot sizes while combining of orders reduces both ordering time and setup time. Figure 24 shows the future state model.

Figure 24. Example future state of setup times



SKU	Annual Qty Ordered	# of Orders	Order Qty	# of Orders	Setup Time	Total Setup Time
593	387,551	10	5000	10	1	10
594	19,719	22	2851	22	1	22
595	285,274	20	412	20	1	20
596	341,272	4	2920	4	1	4
597	381,196	6	2362	6	1	6
598	46,957	3	1497	3	1	3
599	215,468	2	3631	2	1	2
600	348,322	3	3171	3	1	3
601	84,237	1	3409	1	1	1
602	357,334	2	1094	2	1	2
603	192,572	1	2071	3	1	3
604	190,863	4	4670	4	1	4
605	69,544	15	2884	15	1	15
606	367,531	3	898	3	1	3
607	290,618	4	344	4	1	4
608	162,247	2	965	2	1	2
609	386,114	0	91	2	1	2
610	225,202	0	384	5	1	5
611	59,878	6	2054	6	1	6
612	168,401	15	2093	15	1	15
613	274,424	3	2023	3	1	3
614	310,000	13	1236	13	1	13
615	68,017	4	893	4	1	4
616	16,846	21	4872	21	1	21
617	314,640	5	1314	5	1	5
618	137,248	5	1809	5	1	5
619	241,856	13	184	13	1	13
620	132,891	14	4137	14	1	14
621	292,396	24	1309	24	1	24
622	126,580	2	4621	2	1	2
623	261,002	1	2876	1	1	1
624	12,337	2	3687	2	1	2
625	64,131	4	967	4	1	4
626	354,944	6	362	6	1	6
627	35,051	7	2872	7	1	7
628	110,088	4	3356	4	1	4
629	135,392	4	2403	4	1	4
630	295,093	5	197	5	1	5

Table 15. Explanation of fields in future state of setup times spreadsheet

Fields	Data Source	Description
SKU	Current State Model – Future SKU list	Unique identifier of SKU
Annual quantity ordered	Current State Model – New quantity ordered	Annual units ordered per SKU
# of orders	Database	Historical number of orders for this SKU per year
Order quantity	MIN(Quantity ordered ÷ # of orders, Max lot size)	# of units per order

Setup time	Database	Historical setup time per lot
Total setup time	# of orders X setup time	Annual setup time attributed to relevant SKU

Both the current state model and future state model generate the total setup time for the brand in its respective scenario. We compute the non-value added time that the current SKU complexity brings to Company X as follows in Equation 10.

Equation 10. Non-value added time due to SKU complexity

$$(s_{current} - s_{future}) + h_{order}(o_{current} - o_{future})$$

where,

- $s_{current}$ – current state total setup time for brand
- s_{future} - future state total setup time for brand
- h_{order} – labor hours per order processed
- $o_{current}$ – current numbers of orders processed for brand
- o_{future} – future numbers of orders for brand

Using activity-based costing data surveyed for order processing labor time and SAP data for setup labor time, we quantify a 38% reduction in non-value added labor time by rationalizing 17% of SKUs. This reduction signifies a step change in labor time that could reduce the number of shifts needed annually on the packaging line. The full results are shown in Table 16.

Table 16. Results of SKU rationalization on non-value added time

% SKU Reduction	**17%**
% Setup Time Reduction	**44%**
% Order Time Reduction	**37%**
% Non-Value Added Time Reduction	**38%**

5.3.5.3 Queuing Model

Using the same data sources and the results of our production model, we investigate the impact on queuing time. The reduction in setup-time decreases the waiting time for an order to be processed through the system and therefore reduces lead-times. We apply the M/M/1 queuing model to quantify the expected waiting time for an order, expected queue length of orders, expected system time of an order, and expected number of orders in the system.

Table 17 shows the comparison of the current and future states of the pilot brand's main packaging line.

Table 17. Comparison of queuing times

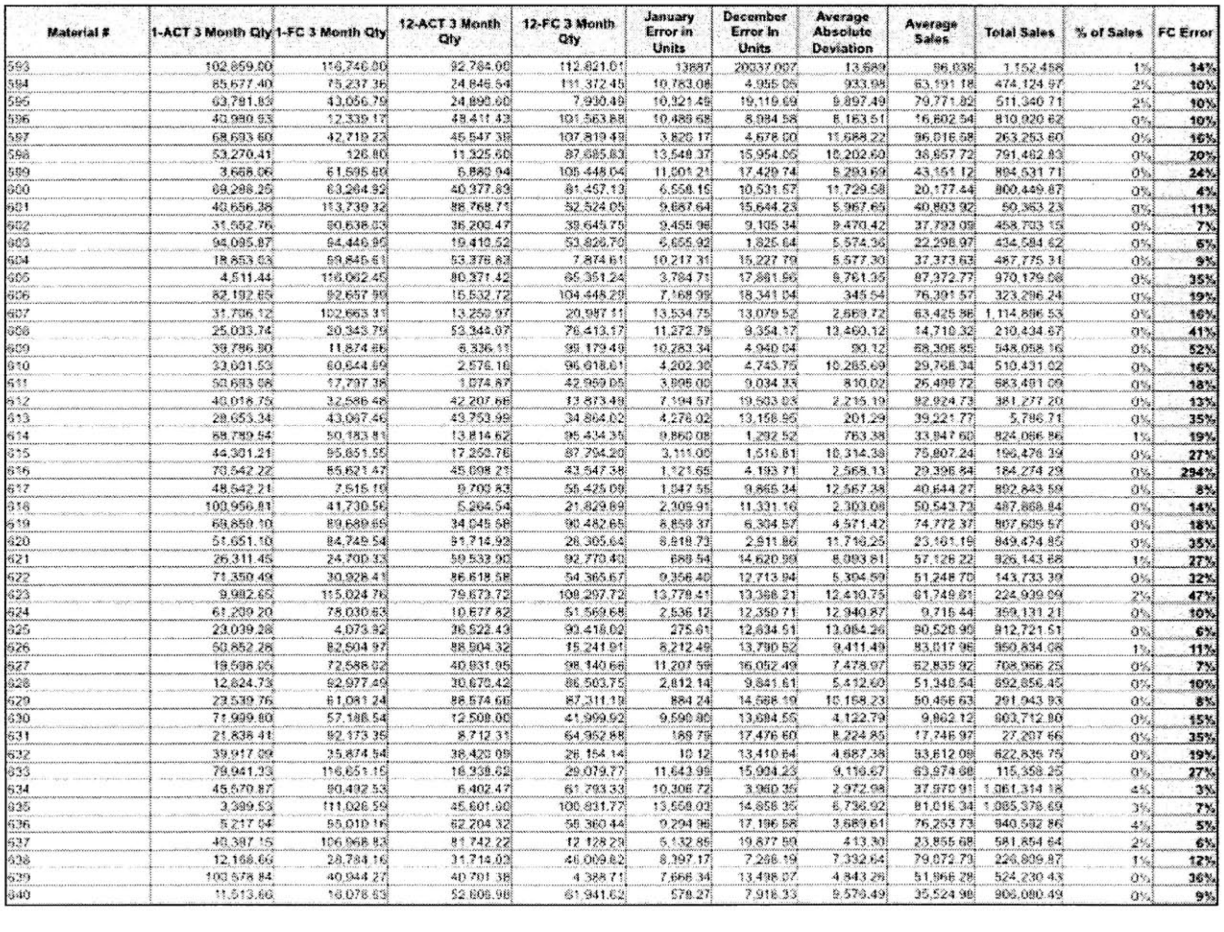
Current State				**Future State**		
Workload	1583	orders/year		Workload	1372	orders/year
Available Labor	6000	hours/year		Available Labor	6000	hours/year
Lambda	**0.2638**	**orders/hour**		**Lambda**	**0.2287**	**orders/hour**
Runtime required	904	hours/year		Runtime required	904	hours/year
Setup time required	2285	hours/year		Setup time required	2091	hours/year
Total time required	**3189**	**hours/year**		**Total time required**	**2995**	**hours/year**
Mu	**0.496**	**orders/hour**		**Mu**	**0.458**	**orders/hour**
Utilization	**53%**			**Utilization**	**50%**	
Expected waiting time	**2.29**	**hours**		**Expected waiting time**	**2.18**	**hours**
Expected queue length	**0.60**	**orders**		**Expected queue length**	**0.50**	**orders**
Expected system time	**4.30**	**hours**		**Expected system time**	**4.36**	**hours**
Expected number in system	**1.13**	**orders**		**Expected number in system**	**1.00**	**orders**

Company X's production planning allocates one package line to multiple brands including the pilot brand of our research. Since our pilot brand only accounts for 24% of the total line utilization, we find the impact on queuing times quite small. The effective reduction in setup time on this line is only 8.5% because the other brands have not been rationalized. Due to the low impact on this line, the effect on lead-time is negligible. Since the pilot brand shares a packaging line with brands that are not candidates for rationalization, the benefits of rationalization can only impact a portion of the orders that affect the packaging line.

5.3.5.4 Forecast Model

Leveraging forecasting and sales data, we compute the current forecast error of each SKU in the brand's offering and the future forecast error if the rationalized brand was offered to the market. First, we develop the forecast error calculations per SKU of the pilot brand. We apply the MAD/Mean ratio to a year of historical sales and forecast data to determine the forecast accuracy of each SKU. Figure 25 shows our current state forecast model.

Figure 25. Current state forecast model



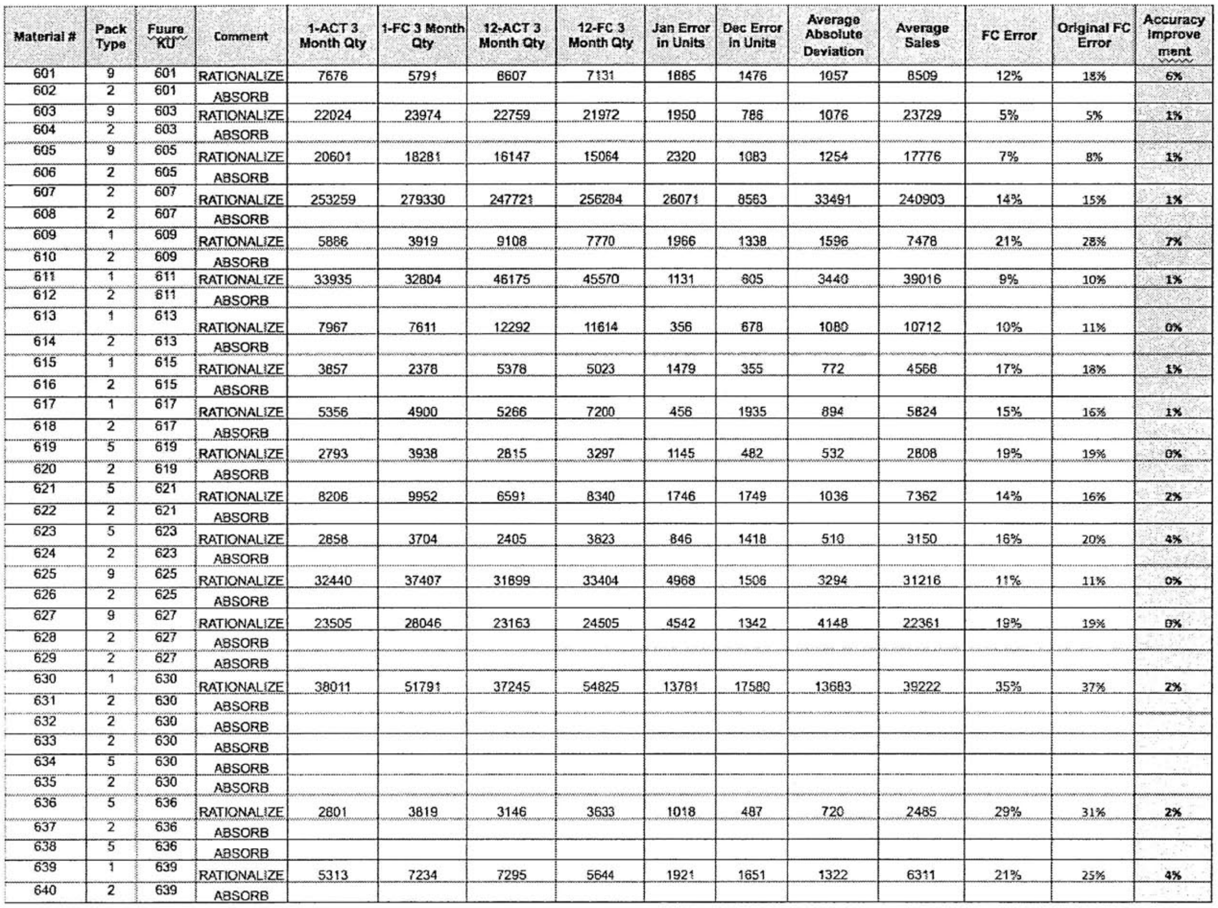
Material #	1-ACT 3 Month Qty	1-FC 3 Month Qty	12-ACT 3 Month Qty	12-FC 3 Month Qty	January Error in Units	December Error In Units	Average Absolute Deviation	Average Sales	Total Sales	% of Sales	FC Error
593	102,859.00	116,746.00	92,784.00	112,821.01	13887	20037.007	13,689	96,038	1,152,458	1%	**14%**
594	85,677.40	75,237.36	24,846.54	111,372.45	10,783.08	4,955.05	933.98	63,191.18	474,124.97	2%	**10%**
595	63,791.83	43,056.79	24,898.60	7,930.49	10,321.49	19,119.69	9,897.49	79,771.82	511,340.71	2%	**10%**
596	40,980.63	12,339.17	48,411.43	101,563.88	10,488.68	8,984.58	8,163.51	16,602.54	810,920.62	0%	**10%**
597	68,693.60	42,719.23	45,547.38	107,819.49	3,826.17	4,678.00	11,688.22	96,016.58	263,253.60	0%	**16%**
598	53,270.41	126.80	11,325.60	87,685.83	13,548.37	15,954.05	10,202.60	38,857.72	791,482.83	0%	**20%**
599	3,668.06	61,595.69	5,880.94	105,448.04	11,501.21	17,429.74	5,293.69	43,151.12	894,531.71	0%	**24%**
600	69,298.25	63,264.92	40,377.83	81,457.13	6,558.15	10,531.57	11,729.58	20,177.44	800,449.87	0%	**4%**
601	40,656.38	113,739.32	88,768.71	52,524.05	9,687.64	15,644.23	5,967.65	40,803.92	50,363.23	0%	**11%**
602	31,552.76	80,638.03	36,209.47	39,645.75	9,455.98	9,105.34	9,470.42	37,793.09	458,703.15	0%	**7%**
603	94,095.87	94,446.95	19,410.52	53,826.70	6,655.92	1,825.64	5,574.36	22,298.97	434,584.62	0%	**6%**
604	18,853.03	89,845.61	53,376.83	7,874.61	10,217.31	15,227.79	5,577.30	37,373.63	487,775.31	0%	**9%**
605	4,511.44	116,062.45	80,371.42	65,351.24	3,784.71	17,881.96	8,761.35	87,372.77	970,179.08	0%	**35%**
606	82,192.65	92,657.99	15,532.72	104,448.29	7,168.98	18,341.04	345.54	76,391.57	323,296.24	0%	**19%**
607	31,706.12	102,663.31	13,259.97	20,987.11	13,534.75	13,079.52	2,669.72	63,425.86	1,114,886.53	0%	**16%**
608	25,033.74	20,343.79	53,344.07	76,413.17	11,272.79	9,354.17	13,460.12	14,710.32	210,434.67	0%	**41%**
609	38,786.90	11,874.86	6,336.11	99,179.49	10,283.34	4,940.04	90.12	68,306.85	548,058.16	0%	**52%**
610	33,601.53	60,644.89	2,576.18	96,618.01	4,202.30	4,743.75	10,285.69	29,768.34	510,431.02	0%	**16%**
611	50,693.58	17,797.38	1,074.87	42,959.05	3,895.00	9,034.33	810.02	26,499.72	883,491.09	0%	**18%**
612	40,018.75	32,586.48	42,207.66	13,873.49	7,194.57	19,503.03	2,215.19	92,924.73	381,277.20	0%	**13%**
613	28,653.34	43,067.46	43,753.99	34,864.02	4,276.02	13,158.95	201.29	39,221.77	5,786.71	0%	**35%**
614	68,789.54	50,183.81	13,814.62	95,434.35	9,860.08	1,292.52	763.38	33,947.60	824,066.86	1%	**19%**
615	44,301.21	95,851.55	17,259.76	87,794.20	3,111.00	1,516.81	10,314.38	75,807.24	196,476.39	0%	**27%**
616	70,542.22	85,621.47	45,098.21	43,547.38	1,121.65	4,193.71	2,568.13	29,396.84	184,274.29	0%	**294%**
617	48,542.21	7,515.19	9,700.83	55,425.09	1,547.55	9,865.34	12,567.38	40,644.27	892,843.59	0%	**8%**
618	100,956.81	41,730.56	5,264.54	21,829.89	2,309.91	11,331.16	2,303.08	50,543.73	487,868.84	0%	**14%**
619	68,859.10	89,689.65	34,045.58	90,482.65	8,859.37	6,304.57	4,571.42	74,772.37	807,609.57	0%	**18%**
620	51,651.10	84,749.54	91,714.92	28,305.64	8,918.73	2,911.86	11,716.25	23,161.19	849,474.85	0%	**35%**
621	26,311.45	24,700.33	59,533.90	92,770.40	688.54	14,620.98	8,093.81	57,126.22	926,143.68	1%	**27%**
622	71,350.49	30,928.41	86,618.58	54,365.67	9,356.40	12,713.94	5,304.59	51,248.70	143,733.39	0%	**32%**
623	9,982.65	115,024.76	79,673.72	108,297.72	13,779.41	13,368.21	12,410.75	81,749.61	224,939.09	2%	**47%**
624	61,209.20	78,030.63	10,677.82	51,569.68	2,536.12	12,350.71	12,940.87	9,715.44	359,131.21	0%	**10%**
625	23,039.28	4,073.92	36,522.43	90,418.02	275.61	12,634.51	13,084.26	90,520.90	912,721.51	0%	**6%**
626	50,852.28	82,504.97	88,904.32	15,241.91	8,212.49	13,790.52	9,411.49	83,017.96	950,834.08	1%	**11%**
627	19,598.05	72,588.02	40,931.05	98,140.66	11,207.59	16,052.49	7,478.97	62,835.92	708,956.25	0%	**7%**
628	12,824.73	92,977.49	30,670.42	86,503.75	2,812.14	9,841.61	5,412.60	51,340.54	892,856.45	0%	**10%**
629	23,539.76	61,081.24	88,574.66	87,311.19	884.24	14,568.19	10,158.23	50,456.63	291,943.93	0%	**8%**
630	71,999.80	57,188.54	12,509.00	41,999.92	9,590.80	13,684.55	4,122.79	9,862.12	903,712.80	0%	**15%**
631	21,838.41	92,173.35	8,712.31	64,952.88	189.79	17,476.60	8,224.85	17,746.97	27,207.66	0%	**35%**
632	39,917.09	35,874.54	38,420.09	26,154.14	10.12	13,410.64	4,687.38	53,612.08	622,836.75	0%	**19%**
633	79,941.33	116,651.15	18,338.62	29,079.77	11,643.99	15,904.23	9,116.67	63,974.68	115,358.25	0%	**27%**
634	45,570.87	90,492.53	6,402.47	61,793.33	10,306.72	3,960.35	2,972.98	37,970.91	1,061,314.18	4%	**3%**
635	3,389.53	111,026.59	45,601.00	100,831.77	13,558.03	14,858.35	6,736.92	81,016.34	1,085,378.69	3%	**7%**
636	5,217.04	95,010.16	62,204.32	58,360.44	9,294.98	17,196.58	3,689.61	76,253.73	940,582.86	4%	**5%**
637	40,387.15	106,968.83	81,742.22	12,128.28	5,132.85	19,877.50	413.30	23,855.68	581,854.64	2%	**6%**
638	12,168.66	28,784.16	31,714.03	46,009.82	8,397.17	7,268.19	7,332.64	79,072.73	226,809.87	1%	**12%**
639	100,578.84	40,944.27	40,701.38	4,388.71	7,666.34	13,498.07	4,843.28	51,966.28	524,230.43	0%	**36%**
640	11,513.60	16,078.63	52,608.98	61,941.62	578.27	7,918.33	9,576.49	35,524.98	906,080.49	0%	**9%**

Table 18. Explanation of fields in current state of forecast model spreadsheet

Fields	Data Source	Description
Material #	Database	Unique identifier of SKU
Actual 3-Month Quantity Sold	Database (only January and December shown)	Actual lead-time demand in units
Forecast 3-Month Quantity	Database (only January and December shown)	Forecasted lead-time demand in units
Forecast Error in Units	Difference between forecast and actual (only January and December shown)	Error in units
Average Absolute Deviation	Calculated	Mean absolute deviation
Average sales	Calculated	Mean sales per month
Total sales	Calculated	Cumulative sales per year
% of sales	Calculated	% of total brand sales
FC Error	Calculated	MAD/Mean ratio

We apply the same computation to the future state product variety, except in this case, we pool demand within market segments for selected SKUs. Pooled SKUs are those selected for rationalization and sales absorption. We compute the forecast accuracy improvement of the pooled demand as shown in Figure 26.

Figure 26. Future state forecast model



Material #	Pack Type	Fuure KU	Comment	1-ACT 3 Month Qty	1-FC 3 Month Qty	12-ACT 3 Month Qty	12-FC 3 Month Qty	Jan Error in Units	Dec Error in Units	Average Absolute Deviation	Average Sales	FC Error	Original FC Error	Accuracy Improve ment
601	9	601	RATIONALIZE	7676	5791	8607	7131	1885	1476	1057	8509	12%	18%	6%
602	2	601	ABSORB											
603	9	603	RATIONALIZE	22024	23974	22759	21972	1950	786	1076	23729	5%	5%	1%
604	2	603	ABSORB											
605	9	605	RATIONALIZE	20601	18281	16147	15064	2320	1083	1254	17776	7%	8%	1%
606	2	605	ABSORB											
607	2	607	RATIONALIZE	253259	279330	247721	256284	26071	8563	33491	240903	14%	15%	1%
608	2	607	ABSORB											
609	1	609	RATIONALIZE	5886	3919	9108	7770	1966	1338	1596	7478	21%	28%	7%
610	2	609	ABSORB											
611	1	611	RATIONALIZE	33935	32804	46175	45570	1131	605	3440	39016	9%	10%	1%
612	2	611	ABSORB											
613	1	613	RATIONALIZE	7967	7611	12292	11614	356	678	1080	10712	10%	11%	0%
614	2	613	ABSORB											
615	1	615	RATIONALIZE	3857	2378	5378	5023	1479	355	772	4568	17%	18%	1%
616	2	615	ABSORB											
617	1	617	RATIONALIZE	5356	4900	5266	7200	456	1935	894	5824	15%	16%	1%
618	2	617	ABSORB											
619	5	619	RATIONALIZE	2793	3938	2815	3297	1145	482	532	2808	19%	19%	0%
620	2	619	ABSORB											
621	5	621	RATIONALIZE	8206	9952	6591	8340	1746	1749	1036	7362	14%	16%	2%
622	2	621	ABSORB											
623	5	623	RATIONALIZE	2858	3704	2405	3823	846	1418	510	3150	16%	20%	4%
624	2	623	ABSORB											
625	9	625	RATIONALIZE	32440	37407	31899	33404	4968	1506	3294	31216	11%	11%	0%
626	2	625	ABSORB											
627	9	627	RATIONALIZE	23505	28046	23163	24505	4542	1342	4148	22361	19%	19%	0%
628	2	627	ABSORB											
629	2	627	ABSORB											
630	1	630	RATIONALIZE	38011	51791	37245	54825	13781	17580	13683	39222	35%	37%	2%
631	2	630	ABSORB											
632	2	630	ABSORB											
633	2	630	ABSORB											
634	5	630	ABSORB											
635	2	630	ABSORB											
636	5	636	RATIONALIZE	2801	3819	3146	3633	1018	487	720	2485	29%	31%	2%
637	2	636	ABSORB											
638	5	636	ABSORB											
639	1	639	RATIONALIZE	5313	7234	7295	5644	1921	1651	1322	6311	21%	25%	4%
640	2	639	ABSORB											

Table 19. Explanation of fields in future state of forecast model spreadsheet

Fields	Data Source	Description
Material #	Database	Unique identifier of SKU
Packaging Type	Database	Packaging type
Future SKU	SKU selection process	SKU that will absorb sales of rationalized SKU
Actual 3-Month Quantity Sold	Database (only January and December shown)	Actual lead-time demand in units of normalized volume of rationalized SKU plus volume of sustained SKU
Forecast 3-Month Quantity	Database (only January and December shown)	Forecasted lead-time demand in units of normalized volume of rationalized SKU plus volume of sustained SKU

Forecast Error in Units	Difference between forecast and actual (only January and December shown)	Error in units
Average Absolute Deviation	Calculated	Mean absolute deviation
Average sales	Calculated	Mean sales per month
FC Error	Calculated	MAD/Mean ratio
Original FC Error	Current state forecast model	MAD/Mean ratio
Accuracy Improvement	Difference between current and future state forecast error	Improvement in percentage points

The lean product variety reduces the forecast error by up to 6 percentage points in some market segments. Since SKUs within each market segments likely serve the same customer and requirements, we find the demand correlation to be high in some market segments, as well. High correlation reduces the benefits that risk pooling has on forecast accuracy.

Safety stock has a greater improvement due to overall reduction in lead-times of the SKUs. Some rationalized SKUs are replaced with SKUs that have lead-times that are 40% lower than the lead-time of the rationalized SKU. As mentioned in the model definition, this leads to a multiplicative reduction effect on the safety stock of respective SKUs. On average the lead-time reduction for rationalized SKUs is 10%, which leads to a holding cost reduction of approximately 11% for SKUs affected by the multiplicative effect in the safety stock equation.

5.4 Recommendations

SKU rationalization at Company X identifies a large opportunity to reduce labor time associated with setups and order processing. Lead-time and forecast accuracy are not greatly impacted by this flavor of SKU rationalization but overall safety stock is reduced by the multiplicative reduction effect from the forecast error improvement and the reduction of SKUs with long lead-times.

We recommend that Company X apply SKU rationalization to leverage the full opportunity of setup time reduction and to reduce the quality risk associated with line stoppages. Our research focuses SKU selection within a brand in order to target the value chain complexity that produces the brand. We recommend that Company X now target all brands sharing the same value chain. For example, by targeting all the brands on the same packaging line as the brand of our research, we would see a large impact on queuing and thus shorter cycle-times and lead-times. Assuming the same reduction in setup-time and order-time is applicable to the other brands on the packaging line, we estimate a 45% reduction in waiting time and 20% reduction in system time. Further, 32% of capacity can be released for other brands. The results of these calculations are shown in Table 20.

Table 20. Impact on queuing through SKU rationalization of other brands

Current State				**Future State**		
Workload	1583	orders/year		Workload	997	orders/year
Available Labor	6000	hours/year		Available Labor	6000	hours/year
Lambda	**0.2638**	**orders/hour**		**Lambda**	**0.1662**	**orders/hour**
Runtime required	904	hours/year		Runtime required	904	hours/year
Setup time required	2285	hours/year		Setup time required	1280	hours/year
Total time required	**3189**	**hours/year**		**Total time required**	**2183**	**hours/year**
Mu	**0.496**	**orders/hour**		**Mu**	**0.457**	**orders/hour**
Utilization	**53%**			**Utilization**	**36%**	
Expected waiting time	**2.29**	**hours**		**Expected waiting time**	**1.25**	**hours**
Expected queue length	**0.60**	**orders**		**Expected queue length**	**0.21**	**orders**
Expected system time	**4.30**	**hours**		**Expected system time**	**3.44**	**hours**
Expected number in system	**1.13**	**orders**		**Expected number in system**	**0.57**	**orders**
Effective Setup Time Reduction on Packaging Line			**44.0%**			
Waiting time reduction			**45%**			
System time reduction			**20%**			
Capacity hour			**32%**			

reduction				

Company X could also improve the queuing time of the full manufacturing process instead of only the packaging process step. Currently, the lead-time is very long and should be optimized to minimize system time. We recommend optimizing the allocation of products to work centers based on volume, order frequency, and variation. We find that both high volume and low volume SKUs are allocated to the same lines. This is a possible area for improvement.

With regard to forecast accuracy, we find that applying SKU rationalization in this context will only have a small impact. Although demand is segmented within each market segment, that demand is highly correlated producing limited benefits from risk pooling. Our research does find that low volume SKUs are major contributors to demand variation and longer lead times. Since both of these factors lead to larger safety stocks, SKU rationalization leads to lower overall safety stocks. Company X should periodically review its SKU portfolio for low sales volumes SKUs and ensure governance measures are in place to prevent creation of these SKUs.

Lastly, we recommend an in-depth analysis of the benefit of the universal and regional SKUs. These SKUs were created to reduce complexity but appear to have brought complexity. We find the following issues with these SKUs:

- SKUs historically have high demand variation
- Countries independently order these SKUs causing an increase in order and setup costs
- Changes in in one market triggers a new SKU that other markets might not comply too

6 Case Study – Company X SKU Portfolio Dashboard

In this chapter, we discuss the creation of a SKU portfolio dashboard at Company X. Company X seeks to monitor the company's SKU portfolio, understand the source of SKU proliferation, and institute appropriate governance measures to effectively manage SKU creation. Along with SKU pruning, brand divestments, and SKU rationalization, the company seeks to bring transparency to the input of SKUs into its portfolio. Our research at Company X generated multiple dashboard views to support the aforementioned objectives.

6.1 SKU Portfolio Monitoring

For Company X, we generate a monitoring dashboard that monitors portfolio management progress through transparency of creation rates versus removal rates, as well as, provides transparency to the creation and removal of SKUs by brand, by market, and by brand-market. The capability to monitor SKU creation allows Company X to understand how many SKUs are created monthly or annually, to know which brands and countries are contributing to SKU proliferation, and to monitor implementation of complexity reduction initiatives. Figure 27 shows the monitoring dashboard.

Figure 27. SKU portfolio monitoring dashboard

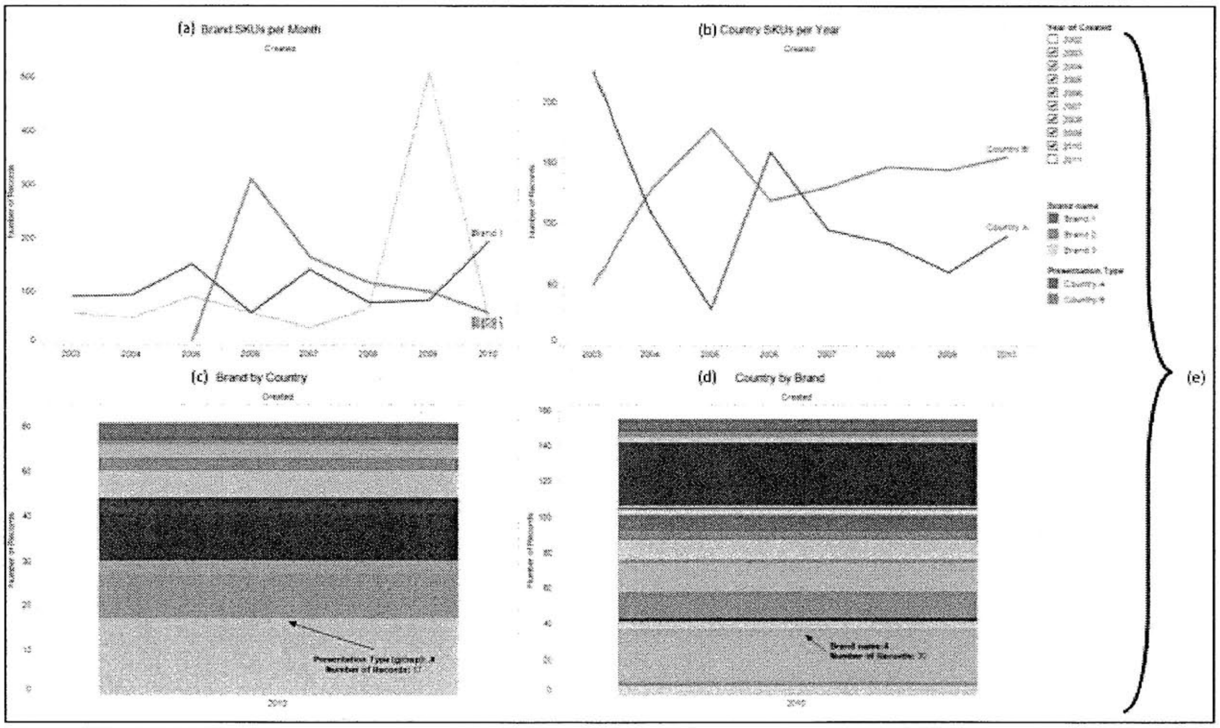


Table 21. Explanation of sections in SKU portfolio monitoring dashboard

Section	Description
Brand SKUs by Year (a)	Provides the number of SKUs per year created for user-selected brands
Country SKUs by Year (b)	Provides the number of SKUs created for user-selected country markets per year
Brand by Country (c)	Provides the numbers of SKUs per brand created within a user-selected country in a year
Country by Brand (d)	Provides the number of SKUS per country created for a user-selected brand in a year
Filters (e)	Provides user controls to define the brands, years, and countries shown in each section

The dashboard provides framing to the SKU proliferation problem and helps target opportunity or problem areas. Along with data such as creation date, Company X's SAP system contains an explicit or implicit reason for creation for the majority of SKUs. Leveraging this data, we use the dashboard to investigate further into SKU creation. Specifically, we investigate SKU creation in 2010 and find the following:

- 38% of SKUs were created in support of brand launches
- 23% of SKUs were created for data management purposes such as SAP integration or for lifecycle changes such as transfers or divestments (new SKUs are created for tracking purposes and the former SKUs are removed). These SKUs are thus called "one-for-one" or transactional SKUs.
- The remaining SKUs are extensions to existing brands

These results bring forth interesting conclusions. First, almost one quarter of the SKUs created are for data management purposes and therefore do not impact manufacturing complexity. Further investigation reveals that only 15% of the SKUs created in 2010 have sales or inventory recorded in the SAP system, meaning the operational complexity behind the SKU proliferation in 2010 is actually quite low. In 2009, only 41% of SKUs created had sales or inventory recorded in SAP. Interviews with stakeholders pointed out that SKUs are created to build infrastructure for the launch of the brand and may or may not be used.

The SKU portfolio dashboard ensures that complexity reduction initiatives like SKU rationalization appropriately identify the opportunity to reduce complexity. Simply reducing SKUs does not actually reduce cost and complexity. Only removal of SKUs that affect operational complexity will make an impact.

6.2 SKU Governance Dashboard

To meet the objective of a governance process for SKU creation, we develop a SKU governance dashboard that supports both decision-making when approving the creation of a SKU and when selecting SKUs for rationalization. Figure 28 shows the governance dashboard.

Figure 28. SKU governance dashboard

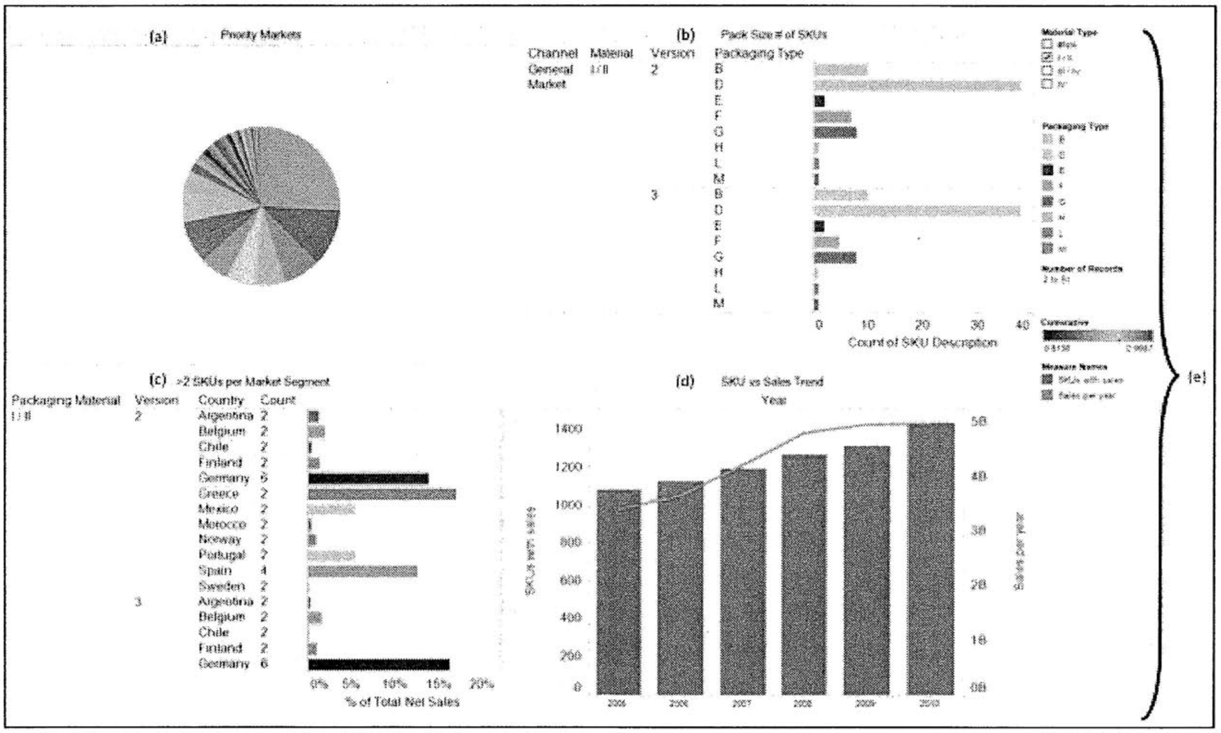


Table 22. Explanation of sections in SKU governance dashboard

Section	Description
Priority Markets (a)	Provides a view of the markets that account for a majority of the sales volumes for a brand
Most Common Packaging per Product version (b)	Provides a comparison of the different packaging per product version and how many markets use each type of packaging
SKU Complexity per Market	Highlights low priority markets with more than one SKU per

Segment (c)	product version
Sales Trend vs. SKU trend (d)	Provides a comparison of the sales trend versus the creation of SKUs trend for a brand
Filters (e)	Provides user controls to define the brands, product versions, and market segments shown in each section

The governance dashboard is a powerful tool for decision-making. With visibility into the priority markets and most common packaging for a brand, supply chain representatives have quick access to data that can be used to argue against the creation of a SKU. The priority markets section lets the user know which markets have volumes to warrant some SKU complexity. The common packaging section promotes packaging standardization while the SKU complexity section highlights sales cannibalization within low volume markets. Lastly, the trends section can bring visibility to declining volumes versus rising SKUs. By leveraging this transparency, the user can make data-driven decisions while governing SKU creation and removal.

6.3 Recommendations

The SKU portfolio dashboards provide transparency to Company X's strong dataset so that management can effectively select SKUs for rationalization and govern the SKU portfolio. We recommend that Company X fully implement this dashboard with a real-time connection to the SAP systems. Company X should also continue to explore other opportunities to bring transparency of cost and complexity to the organization. Further, we recommend that the dashboard be integrated into the processes of supply chain managers.

We propose that this dashboard, if connected to SAP systems in real-time and integrated into standard processes, will bring the following benefits:

- Provide data to manage the SKU portfolio effectively and quickly
- Save time gathering data from the SAP systems
- Frame the problem of SKU proliferation for stakeholders
- Remove waste in SKU database management and related coordination time
- Bring visibility to which SKUs actually contribute to cost and complexity

7 Conclusions and Next Steps

Through our research, we developed a process to rationalize finished product SKUs and a dashboard to effectively manage a SKU portfolio within a healthcare company. By applying the SKU rationalization process, we were able to map SKU complexity to operational complexity. This operational complexity could then be used to compute complexity costs.

To compute complexity costs, we analyze the organization's costing system for avoidable costs and employ a descriptive production model, a queuing model, and a forecasting model. The descriptive production model captures the historical complexity cost associated with order processing and setup times. Since the scope of our research focused on rationalization of finished product SKUs holding sales volumes constant, costs associated with runtimes are unaffected. We find that the benefit of reduction in labor time due to less order processing and setup times is substantial and warrants application of the SKU rationalization process across all brands at the appropriate point in each brand's lifecycle.

The queuing model computes the affect on lead-time and utilization of a given packaging line. At Company X, multiple brands that include both high volume and low volume lot sizes are packaged on the same line. Since our pilot brand accounted for a minority of its packaging line's utilization, we saw little impact on the lead-time of order processing and utilization. We find that if SKU rationalization was applied to other brands on the same packaging line, assuming similar results from rationalization, that 20% of cycle-time could be reduced and 32% of capacity hours could be released for new products. The queuing model provided insight into the impact of SKU rationalization if used more broadly. By applying the rationalization process to all brands on a given packaging line, we see a step-change in efficiencies and cost.

The forecasting model computes the benefits of demand pooling. We find that SKU rationalization in this context did not greatly improve forecast accuracy but did help reduce safety stock inventories. Although there is a small improvement in forecast accuracy, SKUs rationalized with long lead-times reduce safety stock to a greater degree due to the multiplicative reduction in both forecast error and lead-time. The low forecast error improvement relates to the SKU selection step of the rationalization process and the SKU complexity of the pilot brand. We find that SKUs within a market segment are highly correlated since the SKUs serve the same market requirements. High correlation decreases the probability of sales loss but diminishes the benefits of demand pooling. Further, the pilot brand was selected because it was undergoing a transfer to another manufacturing plant. A brand with higher SKU complexity within low priority market segments would have been a better choice from a forecast improvement standpoint. Our pilot brand only had two or three SKUs per low priority market segment. Less SKUs to pool also diminishes the benefits of demand pooling.

Application of these three models to our SKU rationalization case study provided beneficial insight into where the cost benefit of rationalization is and where it is not. The case study was also the impetus to produce SKU portfolio dashboards in order to simplify data analysis.

Our second case study investigates the benefits of a SKU portfolio dashboard to verify, understand, and frame the SKU proliferation problem, to monitor progress of complexity reduction initiatives, and to govern SKU creation. At Company X, we find the monitoring dashboard beneficial in identifying the sources of proliferation. In particular, we were able to identify which SKU complexity actually contributes to cost and operational complexity. In 2009 and 2010, only 30% of the SKUs created in SAP had actually been produced and/or sold.

The governance dashboard provides the visualization necessary to identify and communicate where there is opportunity to rationalize SKUs and to decide whether to approve the creation of a new SKU. Previously, supply chain representatives at Company X did not have the data to reject the creation of SKUs. With the governance dashboard, users can quickly obtain a holistic view of a brand's variety and make a data-driven decision whether to approve or deny SKU creation.

These two case studies demonstrate the benefit of applying operational models to validate the benefits of SKU rationalization, as well as the benefit of using dashboards to effectively govern a finished product SKU portfolio. We conclude that the SKU rationalization process should be applied to all brands per the brand selection process outlined in this research and the company's strategy for each brand. Further, we find the SKU portfolio dashboards to be immensely useful during our research and feel that the dashboards could provide the infrastructure for a well-managed SKU portfolio at Company X

7.1 Next Steps for Company X

With consideration of the conclusions outlined above, we develop the following recommendations for Company X:

- *Continue development and implementation of the SKU portfolio dashboard* – The dashboard at this time leverages downloads from the SAP system. These dashboards should be connected to SAP in real-time and be available on the intranet to bring ultimate transparency to organization. This step will help align stakeholders, promote packaging standardization, and increase efficiencies of complexity reduction efforts. We recommend the dashboards as the impetus for a systemic fix against SKU proliferation
- *Integrate governance measures into best practices of supply chain representatives* – We recommend that the steps for SKU governance that are identified in this research be integrated

into the processes of supply chain representatives. Through process integration, Company X can maximize the use of the data transparency provided in the SKU portfolio dashboards

- *Scope SKU rationalization projects based on packaging line production allocations* – To maximize the benefit of SKU rationalization, apply the process to all brands that share the same packaging line. Given that the brands meet the requirements of the brand selection step, Company X will be able to see a step change in cost reduction by focusing SKU reduction on releasing complexity from production lines
- *Investigate optimization techniques in production planning and capacity allocation of manufacturing process* – From interviews, we find that production planning is performed to minimize setup time. We recommend that Company X seek to optimize the allocation of brand production within its manufacturing process in order to minimize queuing time. Finding efficiencies by balancing variation, variety, and volume across the manufacturing process will reduce lead-times and have a positive effect throughout operations
- *Optimize brand variety menus* – Today, each brand has a menu of possible packaging configurations provided to all country markets. This menu is an impetus for SKU proliferation as it allows any country to order many types of packaging. We recommend that low priority markets are allowed a lean variety menu that has minimal variety while high priority markets are provided unique menus for their market that are confidential. Further, free goods should only be offered in one packaging variety across the brand. These packs do not benefit from high margins and should be rationalized if more than one packaging configuration exists per brand.
- *Investigate the benefit of universal and regional packs* – We find that universal packs add cost and complexity. Although these packs drive standardization, country sales organizations order them separately so orders are not pooled. Further, demand variation for this packaging is generally very high, and SKUs proliferate as market requirements change. Our research recommends that the ordering process be improved to bring out the benefit of package standardization.
- *Challenge minimum order quantity (MOQ)* – The minimum order quantity is calculated based on cost volumes per SKU. SKUs are grouped into three categories based on cost volumes. Each category is ordered at a certain frequency over the course of the year. The MOQ should be calculated with a holistic view of minimum setup time, product version max lot size, and frequency of market changes. The MOQ is suboptimal and causes operational inefficiencies.

Company X's operations team demonstrates a passion for continuous improvement and has proven to be effective at serving the market profitability. We believe the implementation of these recommendations will help Company X lead in operational excellence across the healthcare industry.

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