Complexity Management in a Nutshell

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The Product Diversity Nightmare

It's been a while since Henry Ford's days of "any color, as long it is black"-approach to product diversity: Today's automobiles have possible assembly combinations, which easily exceed the number of cars that ever will be built. One of the current forerunners is BMW's 7 Series with about 10^{17} technical assembly combinations, closely followed by other brands. Looking into individual modules, diversity well beyond the market requirements is found everywhere: 144 different types of carpet modules for one single car model, 130 different types of interior lamps, 4800 different front seats, etc.

Over the last few years, product diversity has become a growing concern in other industries as well: 400 different types of packages for the same medicine, 800 different types of leathers to cover all models of a shoe manufacturer, not even to mention the many different types of bank accounts and insurance contracts available from the same provider.

Usually, every product variant is started with a good intention – to grow sales and maximize profits for the company in order to overcome current problems such as price competition in the existing markets, stagnating or even decreasing sales or in order to deal with overcapacities in the production processes. To deal with the situation, a company decides to introduce new products, most often some niche products nobody has been offering so far, hoping that the niche would protect the profit margins for a while (Figure 1).

What is often underestimated however are the effects of the added products on internal (endogenous) complexity: Development, engineering, purchasing, production planning and logistics, production, sales, marketing – all these departments have to deal with the new products, add new variants, develop, produce, or communicate them, just contributing to a cost increase due to complexity. Due to difficulties of attributing these additional costs clearly to the new products or variants, rather general price increases will normally follow to cover for the additional costs. Needless to say that these general increases will further hurt the competitiveness of the original products, leading just into another spin of the vicious.

To successfully avoid this vicious complexity cycle, companies must understand the effects of every new product variant on their entire system and implement effective and efficient complexity management processes and tools.

The Effects of Product Complexity

Every new product variant, unless a replacement only, is likely to create some additional sales. In fact, as explained

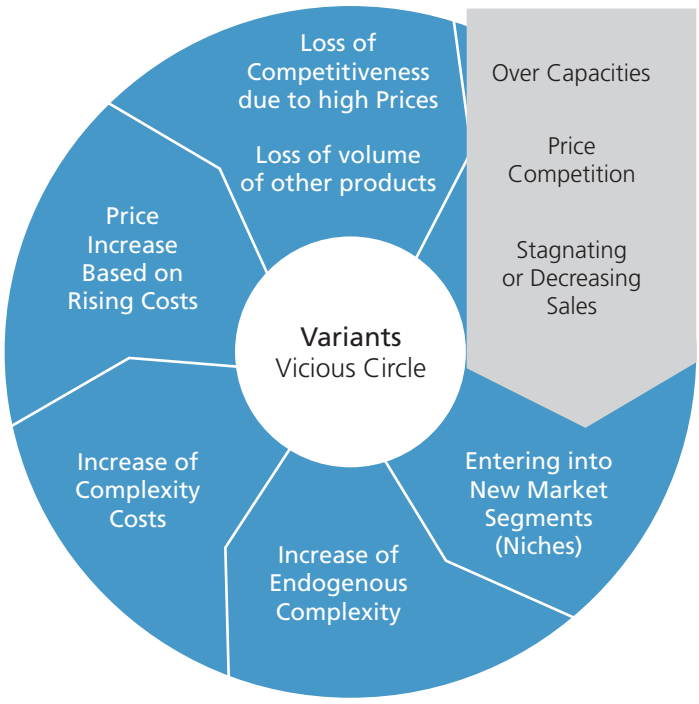


Figure 1: The Vicious Diversity Cycle

above, in most cases it is already the idea to increase sales that leads to the creation of new product variants.

Curve A in Figure 2 shows how Product Variants and Sales Volume are correlated. The actual shape of the curve is different depending on the type of business a company is in. An extreme mass manufacturer will have a very steep curve because the majority of sales are accomplished with a narrow range of products. An extreme niche manufacturer on the other hand will have a flat curve, indicating that sales volumes can only be increased with new product variants. As a result of increased competition, the curve tends to become less steep; thus companies are adding product variants in order to outpace their competitors. Many companies have a curve as shown in the figure with about 20 % of product variants providing about 80 % of the sales volume.

Besides the positive effect of increased sales, increasing product complexity also has a number of negative effects, summarized in Figure 2 by the Complexity Cost curve B. The reasons for growing complexity costs are manifold. On the sales side it becomes more expensive to explain the customer the differences between individual products and to consult the customer in choosing the right product. More training for the sales force is required, more money must be spent for brochures and product flyers. On a technical level, there are more products that must be developed, requiring more parts that must be designed or evaluated, more suppliers that have to become part of the game, etc. Finally, there are higher costs involved with production itself because more different products have to be planned and processed through manufacturing and the distribution channel.

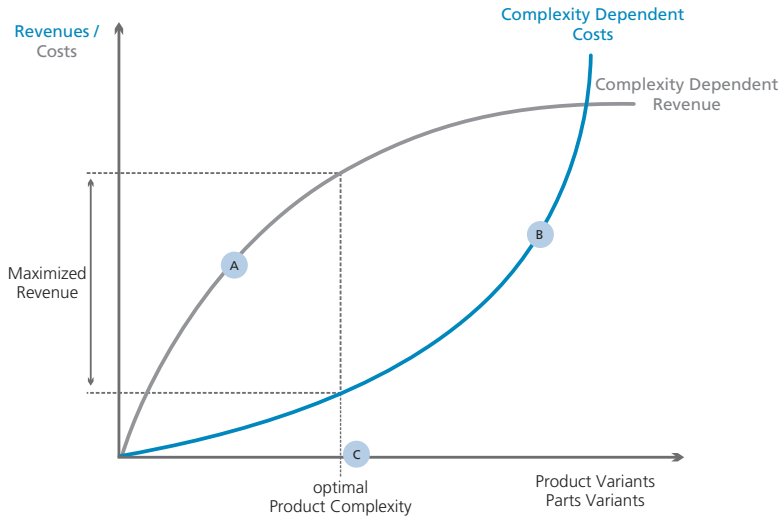


Figure 2: Complexity dependent revenues and costs

Once a certain complexity is reached, the sum of all these costs is more than likely to outweigh the additional revenues of an increased sales volume, the company is in a situation where every new variant still will slightly increase the sales volume, but will decrease overall profit at the same time.

Obviously, the optimal point to be is where the difference between complexity dependent revenues and costs is maximized (Point C in Figure 2). That's the Point of Operation where the total profit for the company is maximized.

Maximizing Total Profit

Looking into the graphs of Figure 1, there are four different possibilities to maximize total profit. Each approach thereby requires its distinct set of methods and procedures:

- Repositioning the 'Point of Operation': Change the level of product complexity to an optimized working point (usually: reduce complexity)
- Change the shape of the revenue curve in order to generate more sales with fewer variants
- Shift the complexity cost curve to the right (horizontal shift) to make sure the external complexity can be provided at lower levels of internal complexity
- Shift the complexity cost curve downwards (vertical shift) by reducing the costs of handling the internal complexity.

Repositioning the 'Point of Operation': Adjusting the External Diversity

The majority of companies have a product diversity that is to the right side of the point of maximized profit shown in Figure 2. Performing a classical ABC analysis often reveals that less than 20 % of the products are contributing 80 % or more of the total sales volume and quite often there is also a significant number of products accounting only for a fraction of a percent of total sales.

Analyzing product sales and eliminating these 'micro-volume' products is already a good starting point, however, it does not always provide the intended improvements. Maybe it is not possible to eliminate the products from the system because of long-term contracts or the necessity to provide spare parts. Possibly, sales may claim that

eliminating a certain product would reduce complimentary sales of a high-volume product, or Management (and stock market analysts) may not like the idea of reducing sales altogether, etc.

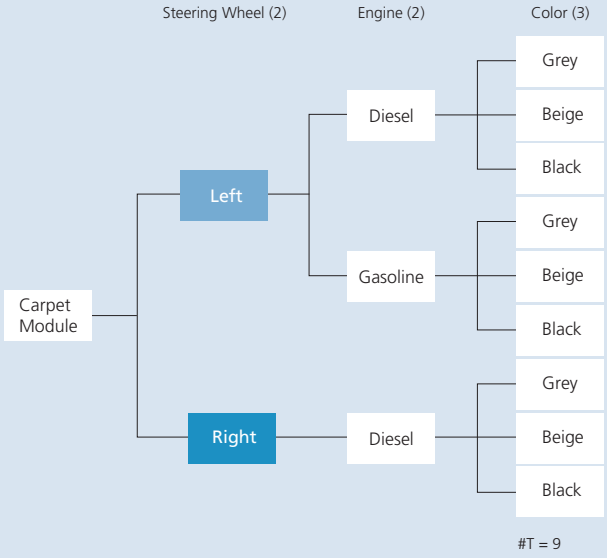
Changing the Shape of the Revenue Curve

Eliminating existing low volume variants is no problem if it is possible to further shift sales towards the already well selling variants. In terms of the complexity-dependent revenue curve (B) in Figure 2, this means a curve that raises steeper and ends sooner. Methods to reshape the revenue curve are primarily marketing and product management related. The primary focus is on better matching customer requirement clusters with product feature packages. A closer match will increase the number of potential buyers for a certain product package, thereby reducing the total amount of variants needed to satisfy a given number of buyers.

An often-unrecognized opportunity in this area is available for parts manufacturers supplying a relatively low number of parts to only a few large customers as typically found in the automotive industries. Here, the supplier is usually involved in the product development cycle of the customer, in many cases nowadays the supplier is even in charge of the development. Consequently, the supplier has a realistic opportunity to influence the buyer's requirements. In this situation it may become possible to sell the same parts to several OEM's or at least make sure that the variant sold to buyer B is very close to the variant sold to buyer A.

Example: Volkswagen Golf

The carpet module of the 5th Generation Volkswagen Golf was planned to have 144 variants including colors. From a market point of view only 9 variants were really needed to satisfy customer requirements as shown in this Feature Tree:



All other variants were technically induced. Even though planning was almost completed, it was still possibly to reduce the diversity to 18 variants. As a result, the logistics concept for this module could be simplified, resulting in annual cost savings of several million dollars.

Horizontally Shifting the Complexity Cost Curve

A horizontal shift of the complexity cost curve means to reduce the internal technical diversity of parts while maintaining the diversity available on the market. This can be achieved through a distinct set of methods, namely parts standardization, parts integration, and postponement of individual steps within the assembly sequence.

Parts standardization means using a part everywhere instead in selected variants only, thereby greatly reducing the number of variants. An example is notebook computers that nowadays always are equipped with a built-in network card, even though the customer may not need it. It is simply cheaper to have the required network chip standardized in every new computer.

Parts integration means the combination of two different parts with individual functionality into a single part with combined functionality, thereby again greatly decreasing the total number of variants. A good example for parts integration is what is seen regularly in consumer electronics: There used to be cell phones, digital cameras, and PDA's. After integration, we see a cell phone with built-in camera. Best of all, it can be used as PDA as well. Of course the new device is significantly less expensive than the total price of the three previous devices, primarily because of reduced complexity as a result of the integration.

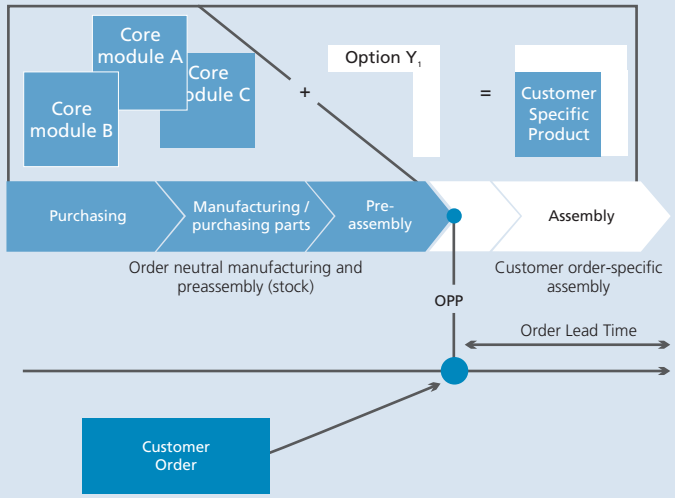
Postponement can be distinguished in Product Postponement and Interface Postponement. Product postponement stands for changes in the assembly sequence

Keywords Explained: Modular Architecture and Platform Concepts

Modularization means structuring of a product in order to reduce dependencies between individual elements (modules) of the product and to reduce interface diversity between them.

Platform Concepts aim at unifying certain components, interfaces, and product functions in order to make parts and modules reusable in several product families.

The cost cutting benefits of both of these methods comes from post-poning the order penetration point within the overall order processing procedure. This allows for using mass manufacturing principles along bigger parts of the logistics and manufacturing processes and only dealing with the specifics of the individual customer order very late in the process.



that allow mounting of variant driving parts only as late in the sequence as possible. Interface postponement means the same principle, but this time certain steps are even postponed from one assembly location to another in order to reduce the number of product variants that have to be handled by logistics between two locations. The perfect example for product postponement is paint distribution: By adding color concentrate only at the point of sale, the manufacturer keeps the diversity of the voluminous product down to one variant (white) and provides the entire diversity of several hundred colors through a simple mixing process.

These basic methods can be leveraged in higher level concepts like modular product architectures, platform concepts, and mass customization concepts. All these concepts use the above methods as building blocks and share the common goal of shifting the complexity cost curve to the right, enabling a company to provide a certain product diversity on the market with fewer parts and modules.

Vertically Shifting the Complexity Cost Curve

A vertical shift of the complexity cost curve means to reduce the resource consumption for the provision of a given level of parts and product diversity, primarily through improvements in all processes along the entire product life cycle. There are numerous methods of concepts and approaches available: Continuous Improvement, Quality Management Systems, Six Sigma, Business Reengineering etc. only to name a few. If applied well, all these concepts should allow for an annual reduction of costs involved with producing a certain amount of unavoidable diversity.

Complexity Management and Product Life Cycle

Interesting enough, most companies, when becoming aware of the diversity problem, try to master complexity by cutting costs and increasing efficiency as described in the paragraph above. While there is nothing wrong with doing this, it is only 'curing symptoms instead of killing the virus' and therefore the achievable cost reduction potential is very limited as shown in Figure 3.

Therefore, in order to successfully manage product diversity, methods of Complexity Management should form an integral part of the entire product life cycle.

This should start with a careful definition of what's needed on the market in order to be successful, thereby identifying and avoiding every product variant without significant contribution to the total sales amount of the company. Variant targets should be established in that phase, providing benchmarks for the diversity along the entire product life cycle.

During the realization phase (product development and engineering), goal-oriented application of parts standardization, integration and postponement, possibly within the context of higher-level concepts such as modularization or mass customization, should be used to provide the required external diversity with as few internal

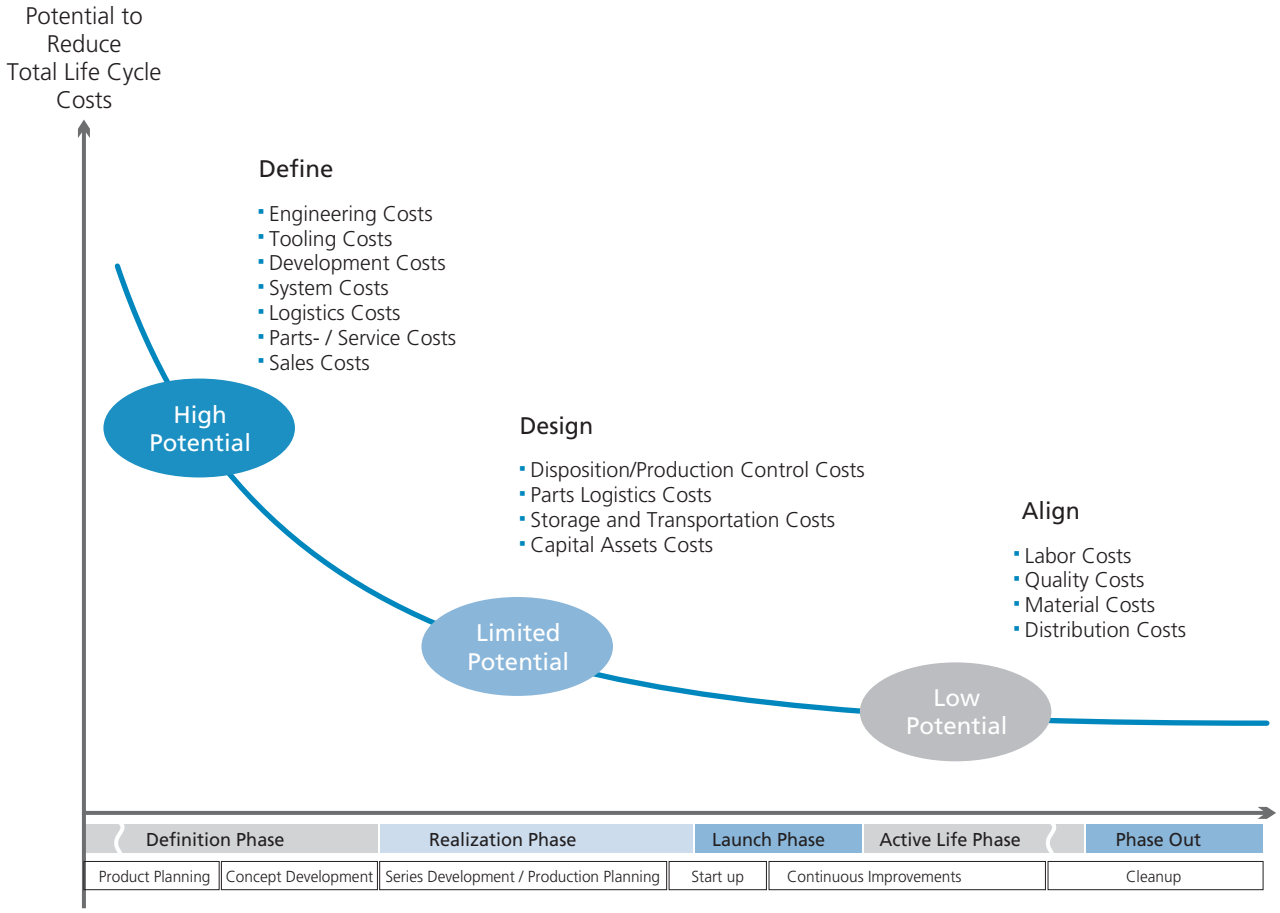


Figure 3: Complexity Management and Product Life Cycle

technical variants as possible. Again, every part and module variant that can be avoided or eliminated allows to reduce the production and logistics costs during the active life phase of the product.

Conclusions

Product complexity is an issue that an increasing number of companies have to address in order to survive. As many examples show, most of the complexity in current product structures is not really needed in order to satisfy customer requirements, they are rather the result of a lack of a compelling strategy regarding product diversity. Consequently, the possibilities to increase total profit are significant. However, to exploit them, it is not sufficient to just attack complexity at the 'tail end', the production and logistics departments, where diversity is experienced in its highest intensity. Rather than that, a company should pursue a more holistic approach, making complexity management a priority along the entire product life cycle, using some of the methods outlined in this article.

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