Diploma Thesis

Automotive trends from global platforms to industry toolkits and their impact on global suppliers like MAGNA

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Statutory Declaration

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Abstract

In highly competitive industries like the automotive industry, companies are constantly striving for new strategies to reduce costs and thus gain competitive advantages. After the successful use of automotive platforms to reduce costs for vehicle development and production, a shift towards increasingly modular approaches has taken place in recent years. One of these highly modular strategies is the so called modular toolkit, which offers OEMs not only the opportunity to benefit from synergies across multiple vehicle segments and even brands, but also increases flexibility in production substantially.

A fairly new approach that aims to benefit from further synergies across independent OEMs is the industry-toolkit. Industry-toolkits are modular toolkits shared across different OEMs in order to achieve production volumes that would otherwise not be possible.

Especially for large global suppliers like Magna it is of high importance to analyze and fully understand the implications of such trends for their business.

This piece of work analyzes the advantages and disadvantages of industry-toolkits and their implications for automotive suppliers and OEMs. Subsequently, potential industry-toolkit initiators and partners are identified. Furthermore, conclusions are drawn on which modules are potentially suitable for industry-toolkits and what preconditions are necessary to maximize the economic benefit of such an approach.

Kurzfassung

In von hohem Konkurrenzdruck geprägten Geschäftsfeldern wie der Automobilindustrie, stehen Wettbewerber unter ständigem Druck neue Strategien zur Kostenreduktion zu entwickeln, um einen Wettbewerbsvorteil gegenüber anderen Mitbewerbern zu erzielen. Mit Hilfe von automobilen Plattformen war es möglich die Entwicklungs- und Produktionskosten für Fahrzeuge drastisch zu senken. In den letzten Jahren erlang vor allem das Thema Modularität in Zusammenhang mit Plattformen immer größere Bedeutung. Modulare Baukästen stellen momentan den Stand der Technik bezüglich Modularität dar. Sie ermöglichen Herstellern nicht nur Synergien zwischen verschiedenen Fahrzeugklassen und –marken zu nutzen, sondern erhöhen auch gleichzeitig die Flexibilität in der Produktion erheblich.

Ein neuer Ansatz, der darauf abzielt von zusätzlichen Synergien zwischen unabhängigen Automobilherstellern zu profitieren, wird als Industrie-Baukasten bezeichnet. Industrie-Baukästen sind, vereinfacht ausgedrückt, modulare Baukästen, die von mehreren Herstellern gleichzeitig genutzt werden um somit höhere Produktionsvolumen zu erreichen.

Vor allem für große globale Automobilzulieferer wie Magna ist es wichtig, solche Trends zu analysieren und deren Auswirkungen auf ihr Geschäftsfeld zu verstehen.

In dieser Arbeit werden sowohl die Vor- und Nachteile von Industrie-Baukästen, als auch deren Konsequenzen für Automobilzulieferer und -hersteller aufgezeigt. Daraus abgeleitet, wird auf potentielle Initiatoren und Teilnehmer solcher Industrie-Baukästen geschlossen. Weiters werden potentiell geeignete Module für Industrie-Baukästen, sowie die notwendigen Voraussetzungen zur Maximierung des wirtschaftlichen Nutzens identifiziert.

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1 Introduction

In the last few years the automotive market has been undergoing some major changes that strongly affect the structure of the whole industry.
Due to globalization new major players emerged in low-cost countries like China or India. This leads to very strong pricing competitions on a global market and forces established OEMs to minimize their production costs while producing on a global scale in order to stay competitive.
Secondly, customer requirements have changed over the recent years. Nowadays customers have very specific ideas of how their car should look like and which functions it should have. This leads to a highly segmented automotive market, which can only be served successfully through a broad product portfolio and addressing region specific niche markets. However, such a strategy increases the complexity of the production process and consequently also the costs.
These problems, among others, lead to new approaches in vehicle development and production. One of these approaches are modular toolkits and industry toolkits, which are the main focus in this piece of work.

1.1 Initial Situation

A well-established approach to overcome the before mentioned dilemma is the use of product platforms, which enables OEMs to provide a high variety of models while reducing complexity and costs of production. Along the way, development costs and development time are reduced as well. This platform approach in the automotive industry has been further enhanced through extensive use of modularity. One of these highly modular strategies is the so called modular toolkit, which offers OEMs not only the opportunity to benefit from synergies across multiple vehicle segments and even brands, but also increases flexibility in production substantially.
A fairly new approach that aims to benefit from further synergies across independent OEMs is the industry-toolkit. Industry-toolkits are modular

toolkits shared across different OEMs in order to achieve production volumes that would otherwise not be possible.
For Magna, as a global automotive supplier, it is necessary to keep an eye on these developments in order to be able to react accordingly and keep a competitive advantage to other suppliers.

1.2 Introduction to Magna International

Magna is one of the largest and most diversified global automotive suppliers with more than 123.000 employees. The company consists of 314 manufacturing operations and 89 product development, engineering and sales centers in 29 Countries as of Q2 2013. In the year 2012 Magna achieved total sales of US $30.8 Billion and a net income of US $1.433 Million. The total assets in 2012 add up to US $17.1 Billion.[1]

Figure 1.1 shows Magna's global presence. The red numbers represent Manufacturing and assembly sites, the blue numbers engineering, product development and sales sites. The grey numbers provide information about the amount of employees in each region.

[1] cf.: Magna Intranet (2013), access date 20.09.2013

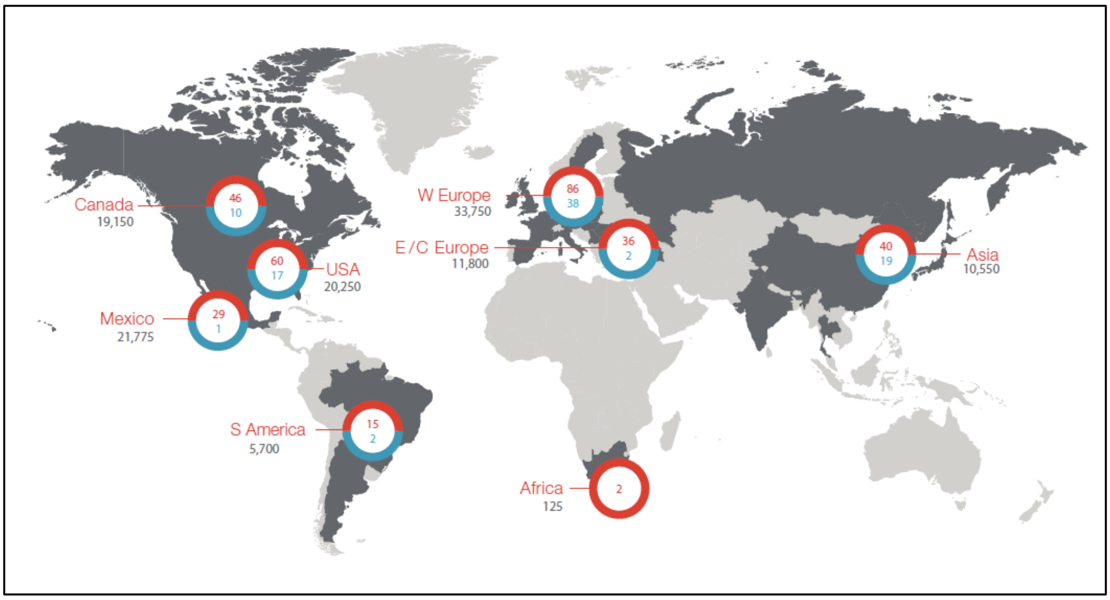

Figure 1.1: Magna's global presence[2]

The company's history dates back to 1957 when Frank Stronach, after emigrating from Austria to Canada, founded a tool die company called Multimatic Investments Limited, which subsequently expanded into the production of automotive components. In 1969, Multimatic Investments Limited merged with the Magna Electronics Corporation Limited, and subsequently became Magna International Inc. Through continuous expansion of the product portfolio, as well as strategic acquisition of competitors, Magna quickly developed into the leading global automotive supplier that it is nowadays.[3]

Today Magna provides design, development and manufacturing services of automotive systems, assemblies, modules and components as well as engineering and assembly of complete vehicles. These products are sold primarily to original equipment manufacturers (OEMs) all over the world.[4]
The company's capabilities include the design, engineering, testing and manufacture of automotive interiors, seating, closures, body & chassis, vision systems, electronics, exteriors, powertrain, fuel & battery systems, roof

[2] cf.: Magna Intranet (2013), access date 20.09.2013

[3] cf.: Magna (2013), http://www.magna.com, access date 20.09.2013

[4] ibd.

systems as well as complete vehicle engineering and contract manufacturing. Magna is structured in the following divisions:[5]

- Magna seating
- Magna Exteriors & Interiors
- Magna Mirrors & Magna Closures
- Cosma International
- Magna Powertrain & Magna Electronics

With its commitment to build better quality products at a better price Magna continues to strengthen its position as one of the leading global automotive suppliers.

1.3 Definitions

Literature provides us with various different definitions of product platforms. To prevent confusion, it is therefore necessary to define a common vocabulary for this piece of work.

There can be found various broad general definitions for the term *product platform:*

- McGrath refers to product platforms as ”a collection of the common elements, especially the underlying core technology, implemented across a range of products”.[6]
- Meyer and Lehnerd describe a product platform as “a set of components, modules, or parts from which a stream of products can be efficiently developed and launched”.[7]

[5] cf. Magna Intranet (2013), access date 20.09.2013

[6] McGrath, M.E. (1995), p. 39

[7] Meyer, M.H.;Lehnerd, A.P. (1997), p. xii

- Robertson and Ulrich define a product platform as “the collection of assets [i.e. components, processes, knowledge, people and relationships] that are shared by a set of products”.[8]

In this piece of work the term *platform* will mostly be used in an automotive context. In a basic definition, an automobile platform would, from a technical point of view, consist of the underbody and chassis. The underbody is made of the front floor, underfloor, engine compartment and the frame (reinforcement of the underbody). To this narrow technical definition there could be added, depending on the OEM, several other systems like engine, transmission, steering system, fuel tank, exhaust system or even unseen parts of the cockpit.[9]
In this classic approach, the rest of the car, the so called *hat*, would provide the necessary differentiation and individuality to every model built on the platform.
Figure 1.2 shows an example for an automobile platform.

Figure 1.2: KIA's FCEV platform for fuel cell and electric vehicles[10]

[8] Robertson, D. et al. (1998), p.20

[9] cf.: Muffato, M. (1999), p.147

[10] cf.: www.kia-world.net (2013), access date 10.10.2013

An advancement of this classic platform approach is to combine it with the idea of modularity. Developing modular systems that can be used on several platforms gives OEMs the possibility to create partial synergies over different vehicle segments. The interchangeability of different variants of these modules also increases flexibility, with little increase to complexity in the product portfolio.

The next step was towards a highly modular and therefore more flexible approach. The “platform” is replaced by a set of modules of which several variants exist. These modules can then be assembled in any desired combination and serve as basis for the development of several platforms. This gain in flexibility allows OEMs to benefit from synergies not only over models of one vehicle segment, but multiple segments within the whole product portfolio. This piece of work will refer to that kind of vehicle architecture as a *modular toolkit.*
Figure 1.3 illustrates the basic difference between a classic platform strategy and a modular toolkit approach.

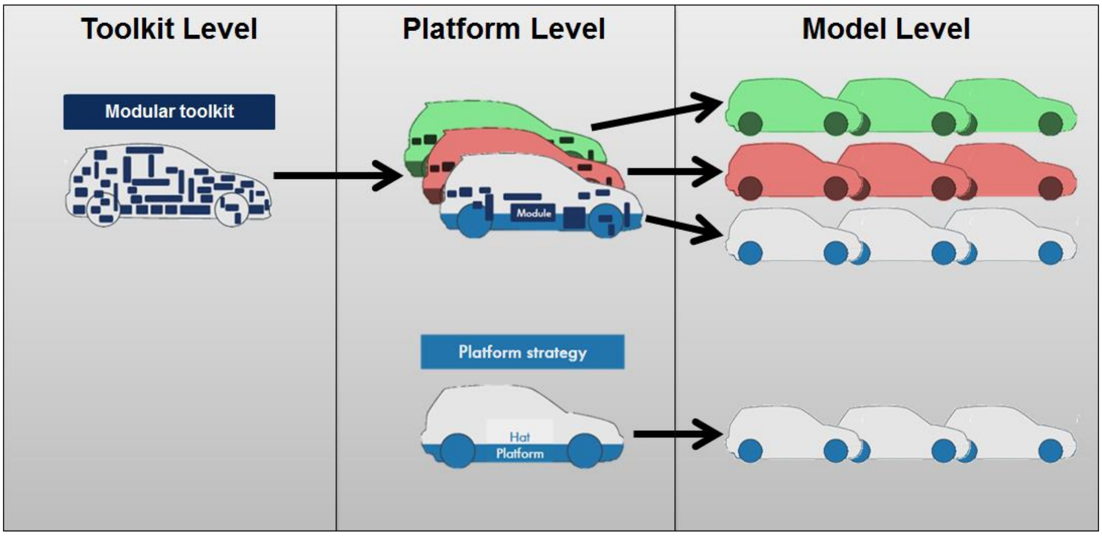

Figure 1.3: Comparison toolkit and platform strategies

One of the examples, that represent the concept of a modular toolkit best at the moment, is Volkswagen’s MQB platform (*Modularer Querbaukasten* or *Modular Transversal Toolkit*), which can be seen in Figure 1.4. One of the big advantages of a high degree of modularity in platforms is the substantial increase in variability.

Figure 1.4: Volkswagen's MQB platform[11]

The Volkswagen group uses its MQB modular toolkit as part of its multi-brand strategy. It serves as a platform for small and medium size vehicles with front-wheel drive from multiple brands like Volkswagen, Audi, Skoda and Seat. This approach enables the Volkswagen group to not only profit from synergies between various vehicle classes, but also from synergies between different brands.

Taking the modular toolkit strategy across multiple brands one step further, would lead to a toolkit shared across multiple independent OEMs. We will refer to this strategy as an *industry toolkit*.
An industry toolkit might be of special interest for OEMs that do not have the possibility to share between group internal brands, like Volkswagen does, but who also want to profit from possible synergies. However, it could also be an option for large OEMs like Volkswagen to reach further cost reduction for their vehicles.
Figure 1.5 shows the evolution of the modular toolkit expanded to the industry toolkit.

[11] cf.: www.volkswagenag.com (2013), acess date 10.10.2013

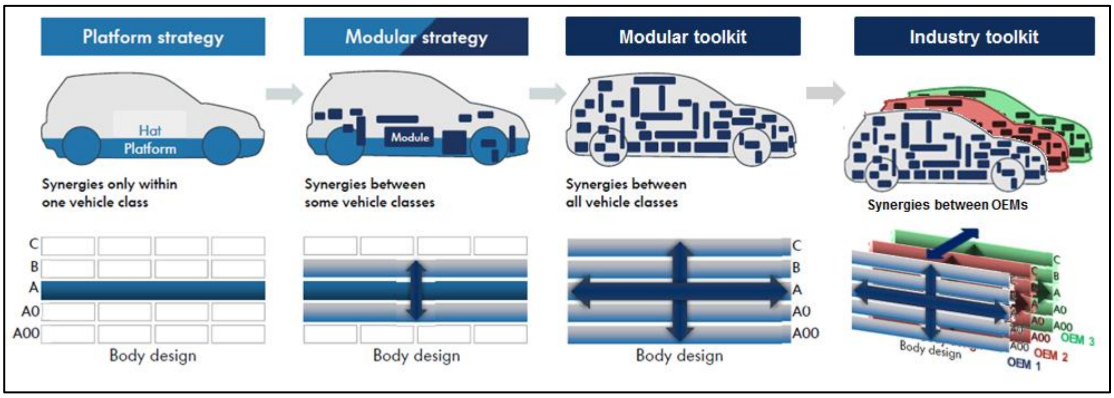

Figure 1.5: The evolution from the platform strategy to the Industry toolkit[12]

Chapter 2.3 will provide a more detailed view on Platforms and modularity in the automotive industry.

1.4 Objectives

This diploma thesis aims to provide an overview and analysis of past and future developments of product platforms, modular toolkits and especially industry toolkits in the automotive industry.
Furthermore, advantages and disadvantages of industry toolkit strategies are explored. The trade-offs and compromises, that OEMs and suppliers involved in such a strategy have to consider, are investigated. This concludes in the identification of the drivers and potential initiators of industry toolkits. Furthermore, potential industry-toolkit partners are analyzed and identified.
For global suppliers like Magna it is essential to know which modules and components are potentially suitable for an industry toolkit. Therefore, the two main influencing factors, differentiating potential and economic feasibility, are investigated. Additionally, a tool to support strategic decisions in Magna’s core product groups is provided.

[12] Own illustration based on www.volkswagenag.com (2013), access date 10.10.2013

1.5 Approach

In order to get an understanding of what the developments concerning platforms and toolkits over the last years were, as well as for getting an idea of which future developments are expected, the first part of this work consists in an analysis and interpretation of the IHS Light Vehicle Production Forecast.
Following this, several interviews with Magna employees with different fields of experience are conducted. This should help to get a practical view on the automotive supplier business and commonality between OEMs. Furthermore, an interview with an academic expert on inter-OEM commonality is conducted for gathering information on industry-toolkit strategies.
The information gathered in these first two steps is used as a basis for a SWOT-analysis of an industry-toolkit strategy. This SWOT-analysis then serves as the foundation for statements on potential industry-toolkit initiators and partners.
To identify suitable modules for industry toolkits, in a first step, the modules are analyzed on their influence on vehicle differentiation. This is done in accordance with several Magna employees with several years of experience in their fields.
In a subsequent step, the economic influence factors in production and development of modules are identified and separately analyzed in a qualitative way. This results in an idea of the necessary cost structure for module suitability for industry-toolkits.
Figure 1.6 illustrates the approach used in this piece of work.

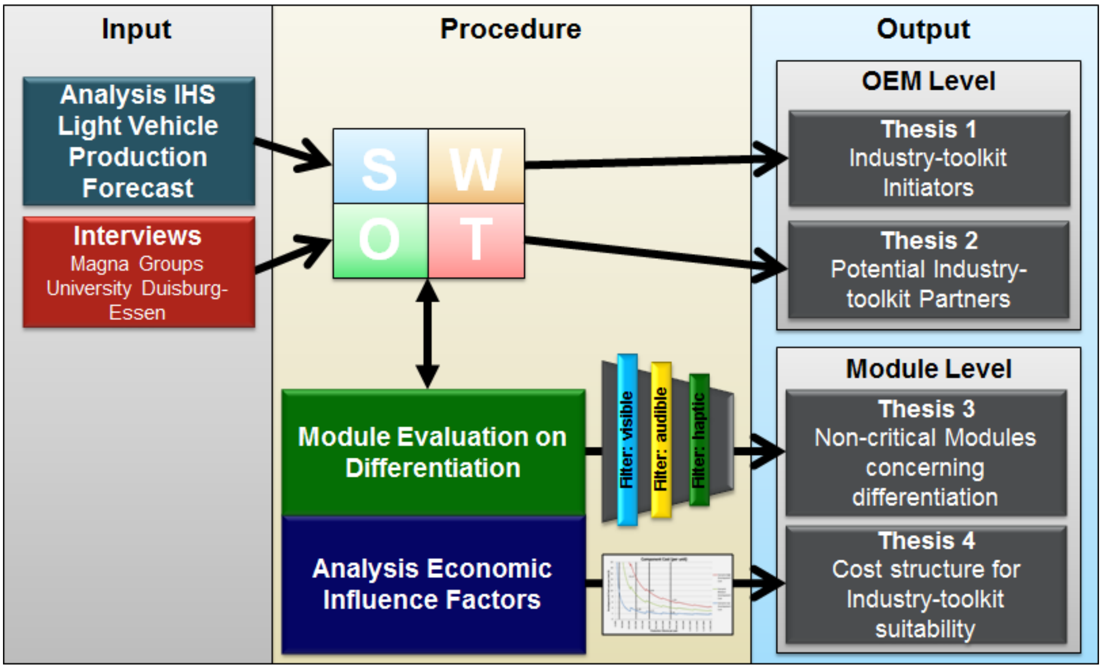

Figure 1.6: Approach

2 Innovation and Modularization in Manufacturing

This chapter will provide an overview on literature on several topics connected to industry-toolkits.
The area of this piece of work could be classified as somewhere between production innovation and production management. Consequently, the first part of this chapter gives a short introduction to innovation management.
The second part consists of an overview on the evolution and principles of manufacturing systems. A special focus lies on mass customization, as this is the predominant manufacturing system in the automotive industry today.
The last section of this chapter will deal with product platforms, their evolution towards modular toolkits and their impact on the automotive industry.

2.1 Innovation Management for Modularization

Being a very broad concept, the term innovation itself can be understood in various ways. A big part of literature agrees that, from an economic perspective, "Innovation is concerned with the commercial and practical application of ideas and inventions". This means that innovation not only includes converting ideas into new products or processes, but also the economic exploitation of these.[13]
One of the best definitions of innovation is the following:

"Innovation is the management of all the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new (or improved) product or manufacturing process or equipment."[14]

There are several different types of innovation that can be identified. Trott differentiates between the following types of innovation:[15]

[13] cf.: Trott, P. (2005), p.15

[14] Trott, P. (2005), p.15

[15] Trott, P. (2005), p.17

- Product innovation
- Process innovation
- Organizational innovation
- Management innovation
- Production innovation
- Commercial/marketing innovation
- Service innovation

As the concept of Industry toolkits would not so much concern an innovation of the manufacturing process itself but more the approach to production, this piece of work should be located mainly in the field of production innovation. Production innovation is concerned with the development of a new production system with the objective to improve production in terms of quality, speed or efficiency. Examples for this would be Quality circles, Just-in-time manufacturing systems, a new production planning software or a new inspection system.[16]

2.1.1 Drivers for Innovation

Innovations can give companies big advantages over their competitors in the market. This does not only count for new products, but also potential savings in cost or time or an increase in quality or efficiency. These aims should be a goal of each CEO and therefore lead to innovations. But it is not only internal forces that drive innovation, but also the market itself pushes companies towards innovations. Cooper identified the following four major external drivers for Innovation:[17]

[16] cf.: Trott, P. (2005), p.17

[17] cf.: Cooper, R.G. (2001), p.8

- **Technological progress**

The rapidly growing amount of knowledge and new technology available to us make it possible to find solutions to problems that we were not able to solve before. New technology and knowledge will always drive innovations and lead to new products, processes, etc.

- **Changing customer demands**

Markets can be very dynamic, especially in industries like, for example, the computer or automotive industry. Market needs and customer preferences are constantly changing. Customers are looking for products with the newest technology or significant reductions in price. In order to fulfill these needs and to keep up with the markets dynamic, innovations are inevitably necessary for a company to survive.

- **Shortening product life cycles**

As a result of the already mentioned technological progress combined with the changing customer demands, life cycles of products are constantly shortening. Depending on the industry, a new product can be superseded by competitive products within only a few months. Therefore, companies have to be able to keep up with the development of new products in order to stay competitive.

- **Increased global competition**

Through the rise of globalization there has been a development from local markets towards big international markets. This development sped up the pace of innovation in two ways. Firstly, it is now possible for the companies to reach bigger markets with their innovations. This means the benefits of the competitive advantage would also increase. Secondly the competition in what used to be local markets is intensified through foreign competitors. Therefore, the importance of innovation increases further.

2.1.2 The Innovation Process

The innovation process itself is characterized by high complexity, uncertainty and risk. In order to be able to succeed with innovations, it is therefore essential to have a clearly structured view on the whole process. Despite of all the complexity, uncertainty and risk, innovation is a systematic process with defined phases and should also be managed that way. [18]

An important characteristic of successful innovations is that the innovation process is not a linear process. There exist several feedback-loops between the different phases of the process, which might cause a mix up between those phases.[19]

Literature provides several different phase-models describing the innovation process. One of the most famous phase-models of innovation processes is the model developed by Thom in 1980.

This model roughly splits up the innovation process into three main phases. These main phases are then divided into more detailed steps:[20]

- Phase 1: Idea generation
    - Definition of the search field
    - Idea selection
    - Idea proposal

- Phase 2: Idea acceptance
    - Idea evaluation
    - Preparation of innovation plan
    - Decision for one implementation plan

- Phase 3: Ideas implementation
    - Realization of the new idea
    - Sale of the new idea to target customers
    - Check on acceptance

[18] cf.: Gelbmann, U. (2003), p. 6

[19] ibd.

[20] cf.: Thom, N. (1980), pp. 53

This piece of work can be classified as a part of phase 2, idea acceptance, or more accurately as part of an idea evaluation.

Additionally, this model also considers environmental influences on the innovation process.
Thom identifies the following components of environmental influences:[21]

- Economic component
- Technologic component
- Political component
- Socio-cultural component
- Physical component

Changes in these components can have impact on corporate planning and consequently on the innovation process itself.

Figure 2.1 illustrates the basic structure of this model.

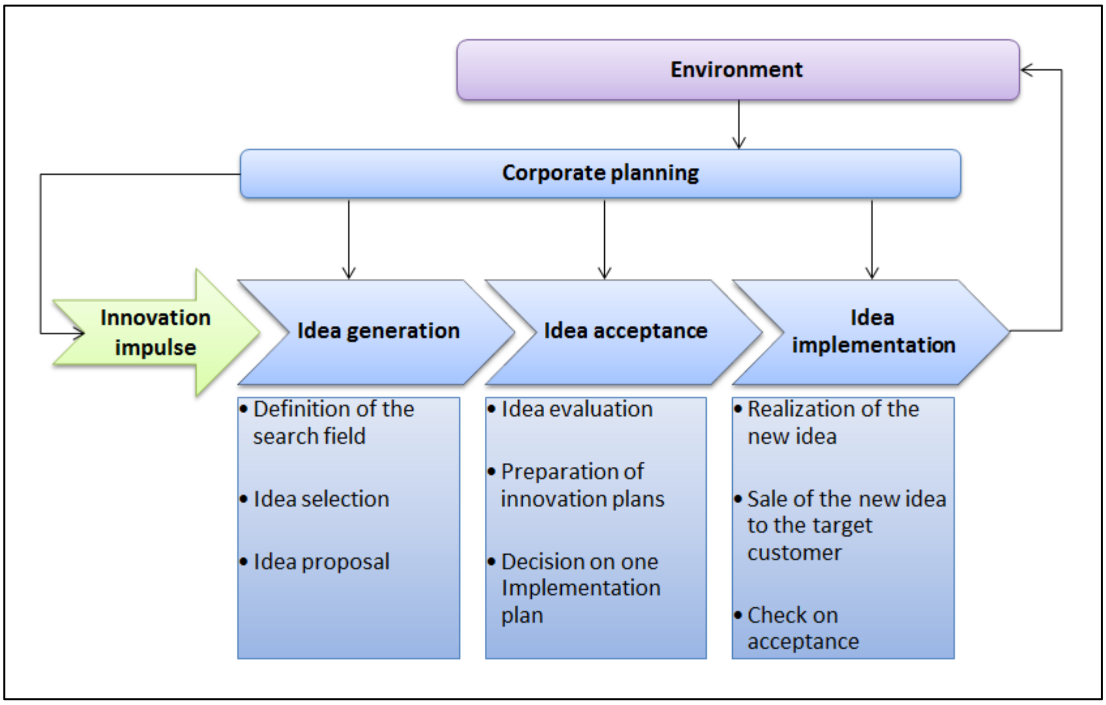

Figure 2.1: The Innovation process by Thom[22]

[21] cf.: Thom, N. (1980), pp. 144

[22] Own illustration based on Thom, N. (1980), pp. 53

Another important element in this model is the Innovation impulse. This element can be found in most innovation-process models. There are several different sources that can trigger innovations. The most common of these sources are by far ideas coming from customers. In his studies, A.D. Little concludes that about 80% of ideas in innovative companies come from customers.[23] However, other studies result in smaller numbers. Another large part of innovations can be triggered through company-internal ideas, competitors, fairs, conferences, suppliers or external research institutes.

In general there can be identified two types of innovation impulses:

- If an unsatisfied market demand is discovered and this results in an innovative idea, this is called **Market pull**. In this case society as a whole or single individuals drive innovation within the company.

- The second type of innovation impulse is referred to as **Technology push**. In this case innovations are triggered through new technical knowledge. Usually only a small part of all innovations is caused by a technology push, but in many cases these innovations are more radical than those based on a market pull.

Figure 2.2 illustrates the mechanisms of Technology push and Market pull.

[23] cf.: Little, A.D. (1988), p. 21

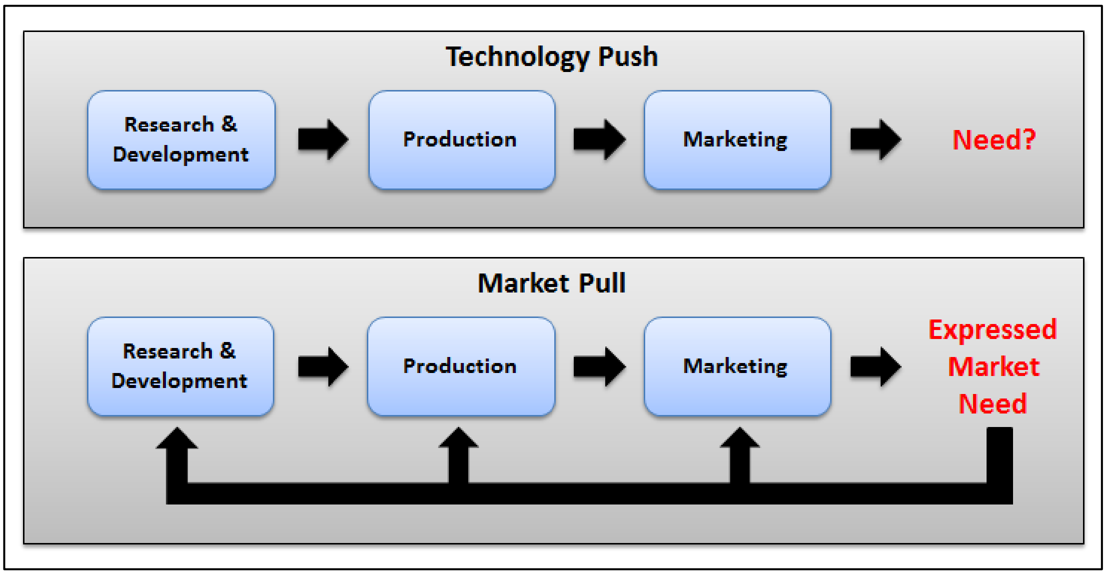

Figure 2.2: Technology push and Market pull[24]

The case of industry toolkits should be classified as a market pull. End customers want to choose from a high variety of car models and at the same time pay less money for a car. This market demand, among others, forces automotive manufacturers and their suppliers to consider new approaches in product development and production.

2.2 Manufacturing Systems and their Principles

As this diploma thesis deals with a partially new strategy to develop and manufacture automobiles, this chapter will give a short overview on the different types of production systems and the most important principles they follow. Successively, due to the close relation to the topic of platforms and toolkits, the manufacturing system of mass customization and modular product architectures are discussed in detail.

There exist several different kinds of manufacturing systems that have been evolving since the industrial revolution in the late 18th and early 19th century, from single unit production towards mass customization. This evolution was

[24] Own illustration based on Martin, M.J.C. (1994), p. 44

triggered and supported by the invention of new technologies, as well as revolutions concerning the management of the production process. Many principles originating from early forms of production systems are still valid today and can also be found in modern manufacturing systems.

2.2.1 Single Unit Production

The first and most basic manufacturing system was the so called single unit production, which already existed before the industrial revolution. Here each product is unique and manufactured for a specific customer. Typical characteristics of this manufacturing system are a high degree of flexibility and a low output.
Single unit production still exists today in form of shop production for products customized for a very specific application where only a low number of units are necessary, or the uniqueness of the product is emphasized. Due to the low volumes, the products are usually very costly.

2.2.2 Mass Production

Products, that do not have to be tailored to a very specific application or where uniqueness is not essential, can be produced in a much more efficient way. Productivity can be increased significantly if the same products are manufactured several times. This makes it possible to produce the goods at lower prices compared to single unit production, thus enlarging the group of potential customers.
The first approaches to serial production can be found in America in the early 19th century. Therefore, this production system is also known as “The American System of Manufacturing”.[25]

[25] cf.: Pine, B.J. (1994), p.36

Pine identifies the following Principles of “the American system of Manufacturing”:[26]

- Interchangeable parts
- Use of specialized machines
- Trust in suppliers
- Focus on production processes
- Division of labor
- Skills of American workmen
- Flexibility
- Continuous technological improvement

One of the most important of these principles is the first one: *Interchangeable parts.* This principle led to a considerable simplification of the manufacturing process and reduction of the amount of work. At the same time, it simplified repairing and maintenance of products.[27]
Focus on the production processes is another principle that is of great importance, even today. It basically aims at optimizing the production process through breaking it down into single work steps which greatly increases the system’s efficiency.[28]
As a consequence of this principle, *Division of labor* was introduced. It basically increases efficiency and productivity through assigning only one single work step to each workman. [29]

Through the application of these principles in their manufacturing systems it was possible for the American industry to advance to the predominant one in the world by the end of the 19th century.

[26] Pine, B.J. (1994), p. 37

[27] cf.: Pine, B.J. (1994), p. 37

[28] cf.: Pine, B.J. (1994), p. 39

[29] ibd.

2.2.3 Advanced Mass Production

With the beginning of the 20th century, a new production system started to develop. Based on the "American system of mass production", the new system adopted some of its principles but also introduced additional ones, causing further increase in efficiency and reduction of costs. One of the most famous pioneers in this field is Henry Ford, who implemented this production system in its purest form.[30]

The following principles, including the adopted ones from the American system, can be found in advanced mass production systems:[31]

- Adopted from the American system:
    - Interchangeable Parts
    - Use of specialized Machines
    - Focus on production processes
    - Division of labor

- Additional principles:
    - Flow principle
    - Focus on low production costs and prices
    - Economies of scale
    - Product standardization
    - Increased specialization (of machines and workers)
    - Focus on profitability
    - Hierarchical Organization with professional Managers
    - Vertical integration

One of the most important principles to emerge with the advanced mass production system is the *Flow principle.* It increases productivity through the elimination of time-consuming activities like the search for material or tools. The work "comes to the workmen" and not the other way around. It was the birth of the conveyor belt production line.[32]

[30] cf.: Pine, B.J. (1994), p. 42

[31] Pine, B.J. (1994), p. 42

[32]cf.: Pine, B.J. (1994), p. 43

The focus on low costs and prices is important in order to produce products "for the masses". This principle is closely related to *Economies of scale,* which is still of great importance today and describes the relation between the quantity of production and costs. The more items are manufactured, the lower are the costs per unit. This holds especially true for specialized machines that are expensive and can only be operated economically at high quantities. In other words: The fixed expenses are distributed over more products, thus reducing the costs per piece.[33]

As we will later see, this principle of *Economies of scale* is one of the most important for us, due to its close relation to the industry-toolkit approach.

Additional advantages of larger quantities are the easier separation of work and increased learning effects.

In many industries this system of mass production can still be found and the before mentioned principles still have a fundamental value.

2.2.4 The Mass Customization System of Manufacturing

In the second half of the 20th century, mass production systems started to fail in several industries. This happened due to sever changes in the competitive landscape of these industries. Diversity and customization started to replace standardized products. This led to once homogenous markets splitting up into heterogeneous markets, which also brought with it a reduction of product life- and development cycles.[34]

The Automotive industry serves as a good example for this development. In the early- to mid-20th century cars became increasingly standardized and differentiated themselves mostly through their price. Then, as the market matured, the rate of innovations started to increase. This concerned product features as well as manufacturing processes. Especially Japanese process improvements, like Just-in-time-Production or Total-quality-Management, started to change the industry fundamentally. Suddenly not only the amount of different products and processes started to increase, but also the fulfillment of individual customer desires got more and more important.

[33] cf.: Pine, B.J. (1994), p. 44

[34] cf.: Pine, B.J. (1994), pp. 65

Nowadays it is possible to choose from thousands of different variants of a car. The challenge is to manufacture flexible enough to provide the desired variety and responsiveness to customer wishes, while keeping delivery times at an acceptable level.[35]

Once again, some principles from the advanced system of mass production were adapted for the system of mass customization and joined by several additional ones:[36]

- Adopted from the advanced system of mass production:
    - Interchangeable Parts
    - Focus on production processes
    - Division of labor
    - Flow principle
    - Focus on low production costs and prices
    - Economies of scale
    - Focus on profitability

- Additional principles:
    - Use of flexible production facilities
    - Sourcing and focus on core processes
    - Team oriented organization
    - Modular product architectures

A mass customization system needs to be more flexible than a mass production system, in order to be able to produce the whole variety of products. One essential difference is therefore the *use of flexible production facilities* instead of highly specialized machines that are designed for the manufacturing of only one specific product.
Outsourcing the manufacturing of parts and modules to suppliers is another principle that is essential to mass customization. It allows *focusing on the core processes* that create the most value for the end customer.
The principle of *team-oriented organization* refers to a softening of the hierarchical structures in mass production. Teams of workers organize the

[35] cf.: Pine, B.J. (1994), pp. 66

[36] cf.: Pine, B.J. (1994), pp. 35

work content and overall work plan. Additionally, workers need to be educated better in order to be able to handle the highly automated production facilities and product changes.

Another main principle of mass customization is *modular product architectures*. They support the creation of a high number of product varieties while still achieving economies of scale. This topic will be discussed in more detail later in this chapter.

Figure 2.3 summarizes the manufacturing systems of mass production, advanced mass production and mass customization with the principles each of them follows.

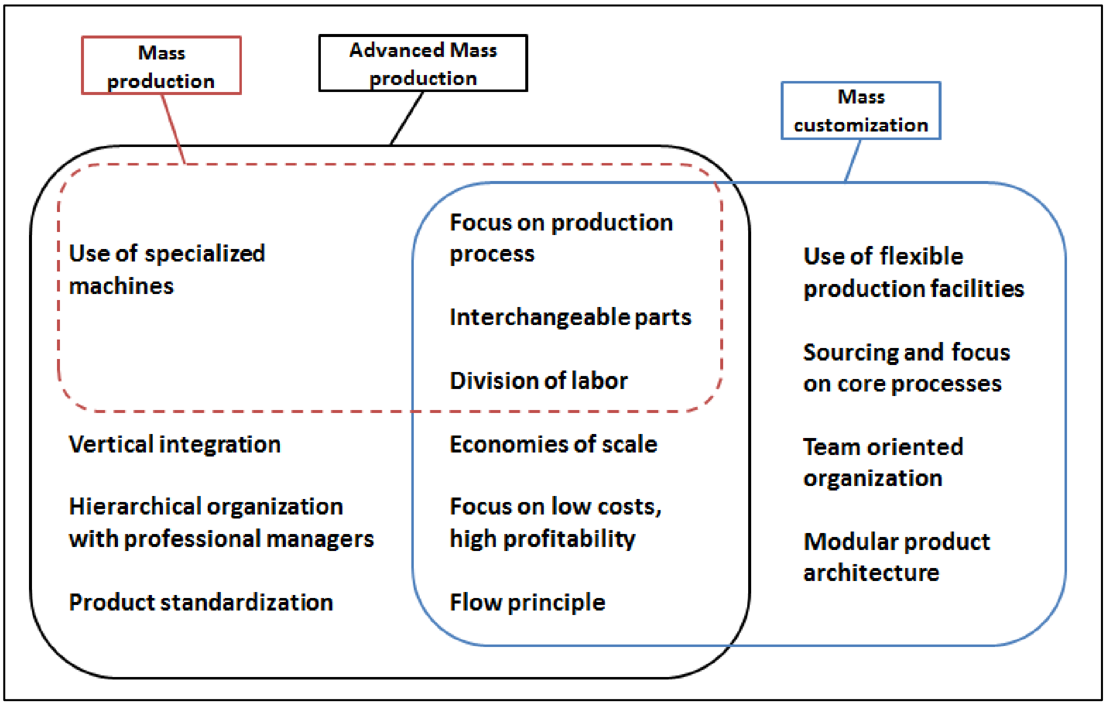

Figure 2.3: Principles of manufacturing systems[37]

[37] cf.: Pine, B.J. (1994), pp. 35

2.3 Product Platforms, Modular Toolkits and their Application in the Automotive Industry

Since the end of the 20th century, mass customization has become the predominant production system in many industries, the automotive industry being among them. Car manufacturers realized that it was not enough to simply offer a vehicle, but that customers wanted status symbols with individual character. Therefore, OEMs were forced to offer a considerable variety of models, in order to fulfill customer needs. This, on the other hand, increased the complexity of the production and development processes. Consequently, it was necessary for car manufacturers to reconsider their product development methodology, to stay capable of offering their products at affordable prices with a high quality.

Strategies that support the concept of mass customization are among others parts standardization, component commonality, common platforms and modular product architectures.[38] Automotive manufacturers have been making use of these strategies for years and are still continuing to improve them towards more efficiency.

This chapter will examine the fundamentals of product platforms and the evolution of product design strategies in the automotive industry. Additionally, it will give an overview of modularity in the automotive industry, as this topic is closely related to that of platforms and toolkits.

2.3.1 Fundamentals on Product Platforms

It is a well-recognized fact that product development plays an important role for the success of a company.[39] The use of product platforms can greatly improve the efficiency of the product development as well as the production process. This is especially true for companies aiming at mass customization, where it is essential to create a continuous stream of successful products

[38] cf.: Shamsuzzoha, A. et al. (2010), p. 362

[39] cf.: Robert, E.B. (1991), p. 4

over an extended period of time, while ensuring the attractiveness of these products to the target market niches[40].
As mentioned before, Meyer and Lehnerd define a product platform as "a set of components, modules, or parts from which a stream of products can be efficiently developed and launched".[41] A well-designed product platform can therefore be seen as the technical basis for any company's approach towards mass customization.

Robertson and Ulrich point out that the successful application of product platforms can bring multiple benefits with them. The sharing of components and production processes across product platforms helps companies to efficiently develop differentiated products, increase the flexibility and responsiveness of their manufacturing processes and gives them a competitive advantage over competitors that develop only one product at a time.[42] Additional advantages are reduced development time and system complexity, reduced development and production costs and improved ability to upgrade existing products.[43] Better learning effects across projects should also be considered.[44]

Product Architecture and Modularity

In order to understand the concept of product platforms, it is necessary to discuss the topics of product architectures and modularity, which are closely related to platforms.

The term "product architecture" is understood as the structure by which the different functions of a product are allocated to its physical components. The decision on how this architecture should look like is a very crucial one and can be a key driver of the performance of the manufacturing firm. It will greatly influence ease of product change, the division between internal and

[40] cf.: Tseng, M.M. et al. (2001), p. 4
[41] Meyer, M.H. et al. (1997), p. 7
[42] cf.: Robertson, D. et al. (1998), p. 20
[43] cf.: Simpson, T.W. et al. (2005), p. 3
[44] cf.: Muffatto, M. (1999), p. 145

external development resources, the ability to achieve certain types of technical product performance and the way development is managed and organized.[45]

Ulrich defines the term product architecture more precisely as:[46]

1. The arrangement of functional elements
2. The mapping from functional elements to physical components
3. The specification of the interfaces among interacting physical components.

Theoretically, there are two basic kinds of architectures. The first type is a modular architecture where one component fulfills exactly one function. Figure 2.4 shows a modular architecture with the example of a trailer. Here we have a clear structure of component-function relations. This also means that, if a certain function has to be changed, this can be achieved with low efforts by redesigning the corresponding component.

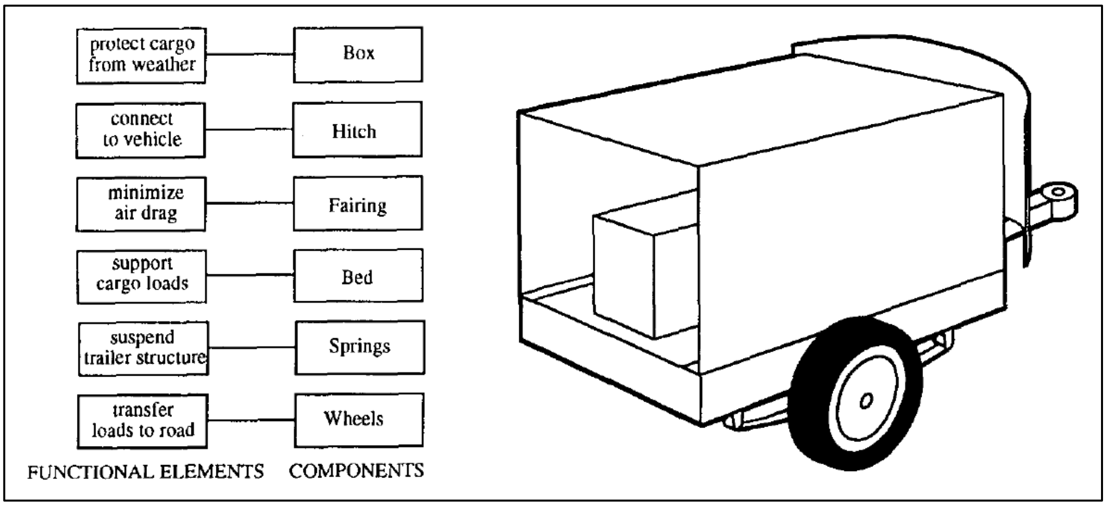

Figure 2.4: A modular trailer architecture[47]

In modular architectures, the design of interfaces is of special importance. An interface is the physical connection between two components. In a well-

[45] cf.: Ulrich, K. (1995), p. 419

[46] Ulrich, K. (1995), p. 420

[47] Ulrich, K. (1995), p. 421

designed modular architecture, interfaces are decoupled. This means that the exchange or modification of one component does not influence the surrounding components.[48]

The second type of product architectures is the integral architecture. In this case one function can be fulfilled by multiple components, or the other way around, one component can fulfill multiple functions. Figure 2.5 shows an example of an integral trailer architecture. Here, the relations between the components and their functions are much more complex compared to a modular architecture. If a function in an integral architecture needs to be modified, this can require a lot of effort due to the various interconnections between the different components.

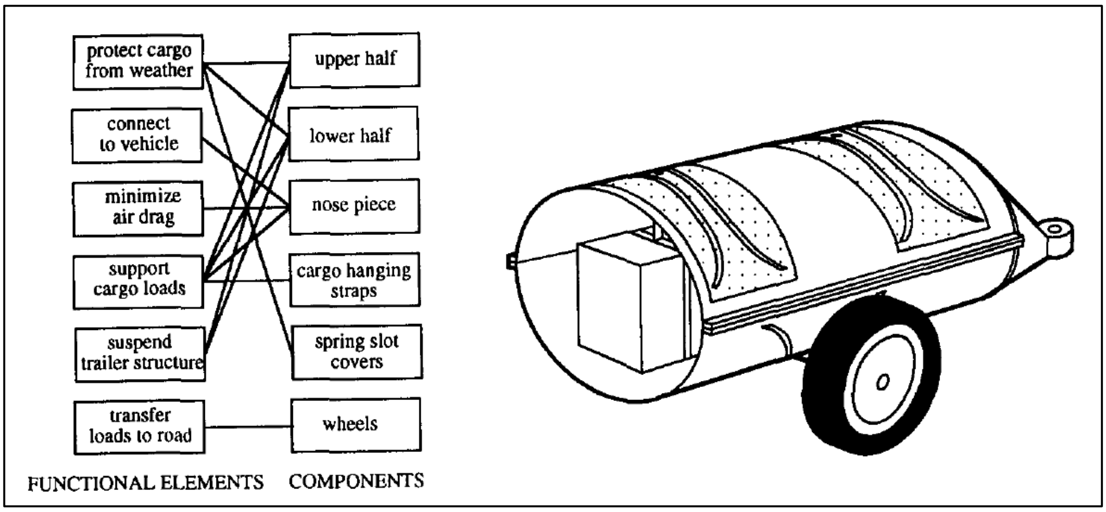

Figure 2.5: An integral trailer architecture[49]

In practice, a product architecture will hardly ever be purely modular or integral, but a combination of both. This piece of work will mainly focus on modular product architectures, as this is the dominant design in automotive development.

There is no unique definition of modules and modularity in literature. Muffatto describes modules as large groups of components that are physically coherent as sub-assemblies with usually standardized interface designs.

[48] cf.: Ulrich, K. (1995), p. 423

[49] Ulrich, K. (1995), p. 422

They can either be shared across different products or be specific to just one model.[50]

The definition of modularity depends very much on the context of the industry. It can be described as the use of common units to create product variants with the aim to identify independent, standardized, or interchangeable units to satisfy a variety of functions.[51] Modularity can also be seen as a very general concept that describes the “degree to which a system’s components can be separated and recombined and refers both to the tightness of the coupling between components and the degree to which the rules of the system architecture enable (or prohibit) the mixing and matching of components.”[52]

In comparison to integral architectures, modularity has several advantages. A high amount of modularity brings with it a high flexibility in production. As mentioned before, it is possible to exchange components with newer or upgraded versions without any effects on other modules. This facilitates the creation of new variants of a product and, at the same time, reduces development times for these new variants significantly. Simultaneously, modular product architectures also simplify the sharing of components in different products. This standardization can lead to products of higher quality at lower overall costs.[53]

However, there are also some drawbacks that a modularization strategy brings with it. First of all, it is not a simple task to define independent modules. This is especially true for complex products like for example automobiles. Here a clever interface design is of crucial importance. Due to the complexity of modular platform design for such complicated products, it is a costly and time consuming process.[54] In a successful platform design, however, the long term advantages will outweigh these short term drawbacks.

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[50] cf.: Muffatto, M. (1999), p. 146

[51] cf.: Huang C.C. et al. (1998), p. 66

[52] Schilling, M.A. (2000), p. 312

[53] cf.: Pine, B.J. (1994), p. 113

[54] cf.: Muffatto, M. (1999), p. 146

Interface and Component standardization

A modular platform can help to substantially increase the amount of component standardization. Component standardization refers to the use of the same component in multiple products and is closely linked to product variety. In general it can be said that standardization of components reduces costs due to economies of scale and can help to increase the performance of the component due to learning and faster accumulation of experience in production. It also helps to reduce complexity in, for example, inventory management, production or quality control. It is possible to differentiate between two types of component standardization. The first type is internal standardization where standardization occurs within products of a single company. External standardization, on the other hand, goes across multiple firms and typically happens through a supplier.[55]

There are two prerequisites in order to make component standardization possible. Firstly the component should implement commonly useful functions. This is greatly supported by a highly modular product architecture where, as mentioned before, each component fulfills one specific function. This function can then be carried over to other products through the use of the very same component. Secondly, the interface to the component has to be identical across several products in order to physically fit into other applications. Due to the decoupled interfaces in modular architectures, an interface standard can be adopted and the same component can be used in different settings of surrounding components. [56]

Methods of variety generation

Product variety can be defined as the diversity of products that a production system provides to the marketplace.[57] Pine argues, based on empirical evidence, that product variety has become one of the most important elements of manufacturing competitiveness and that this importance will

[55] cf.: Ulrich, K. (1995), pp. 431-432

[56] cf.: Ulrich, K. (1995), p. 431

[57] cf.: Ulrich, K. (1995), p. 428

even continue to increase.[58] Increasing product variety is also mentioned to be one of the goals of lean production, which proved to be a very effective approach in automotive manufacturing.[59] It is therefore essential for any automotive manufacturer to offer a high variety of different models to address niche markets and stay competitive. The big challenge here is to create this variety in an economically feasible way. This is facilitated through modular product architecture and a high degree of flexibility in the manufacturing systems.

Starting from the basis of an effective modular product architecture with different variants of the according modules, several variants of the product can be generated through combinations of these modules.

There are three basic variety generation mechanisms:[60]

- **Attaching:**

Figure 2.6 shows how a new product variant (Variant 2) is created through attaching an additional module to a base product (Variant 1). The attachable module can carry out additional functions and must have appropriate interfaces to the base product.
An example for this kind of variety generation would be the equipping of a vehicle with an additional infotainment module.

[58] cf.: Pine, B.J. (1994), pp. 147

[59] cf.: Womack, J.P. (2007), p. 12

[60] cf.: Du, X. et al. (2000), p. 438

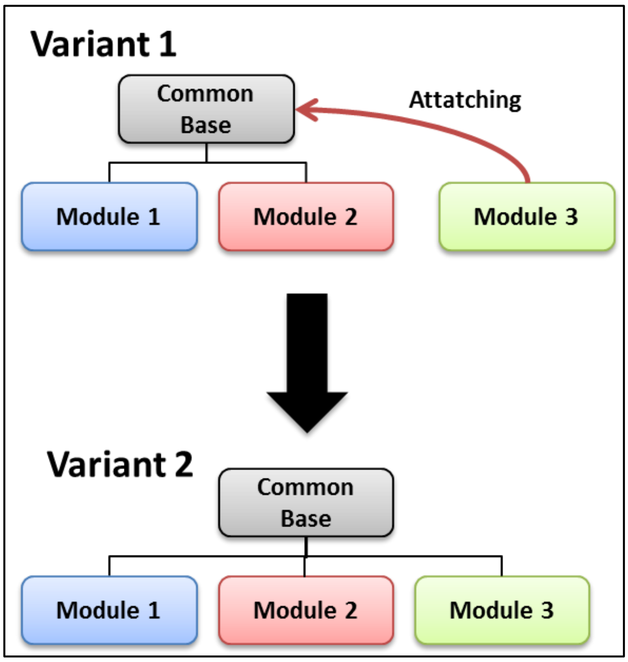

Figure 2.6: Variety generation through attaching[61]

- **Swapping:**

Figure 2.7 shows variety generation through swapping. This method is usually applied when variety in terms of different performance requirements is necessary. In the case shown in Figure 2.7, Module 2 and Module 3 fulfill the same function, but at different performance levels. Module 2 is substituted by Module 3, thus creating a new variant of the product with a new level of performance. Substitutable modules typically have the same interfaces.

An example for this kind of variety generation would be the upgrading of a car through a more powerful engine.

[61] Own illustration based on Du, X. et al. (2000), p. 439

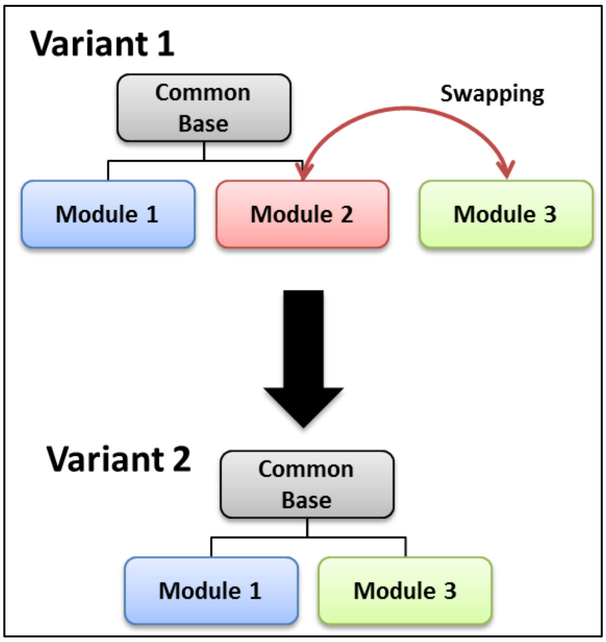

Figure 2.7: Variety generation through swapping[62]

- **Scaling:**

In Figure 2.8 the mechanism of variety generation through scaling can be seen. Here certain parameters of a product or module can be changed within certain limits without substitution of the element.
A good example for this is Volkswagen's MQB platform where amongst others the length, width, height or wheelbase of the car are variable (as can be seen in Figure 1.4)

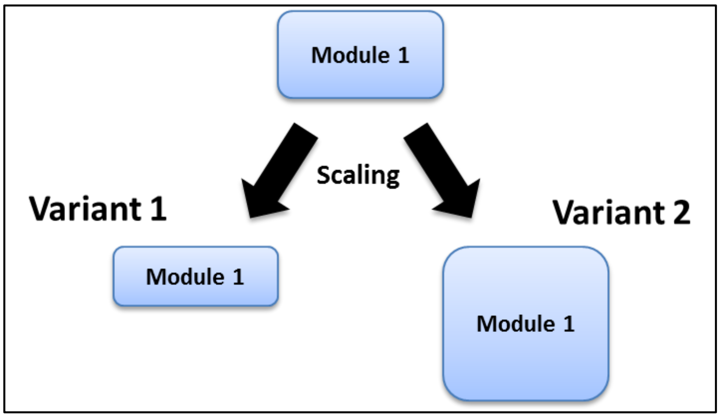

Figure 2.8: Variety generation through scaling[63]

[62] Own illustration based on Du, X. et al. (2000), p. 439

Product family evolution

Meyer and Lehnerd define a product family as “a set of individual products that share common technology and address a related set of market applications.”[64] This means that, based on one product platform, different products are derived through the methods of variety creation that were shown before. These individual products should, in the best case, be identifiable as a member of the product family by their physical appearance. Features and user interfaces are similar to those from other products of the same family.[65]

Figure 2.9 illustrates a general framework for the evolution of one single product family. Starting from the initial development of the original platform it also shows successive major enhancements to the core product and process technology of the platform. For each generation various products are derived.[66]

[63] ibd.

[64] Meyer, M.H. et al. (1997), p. 35

[65] cf.: Meyer, M.H. et al. (1997), p. 35

[66] cf.: Meyer, M.H. et al. (1997), pp. 36

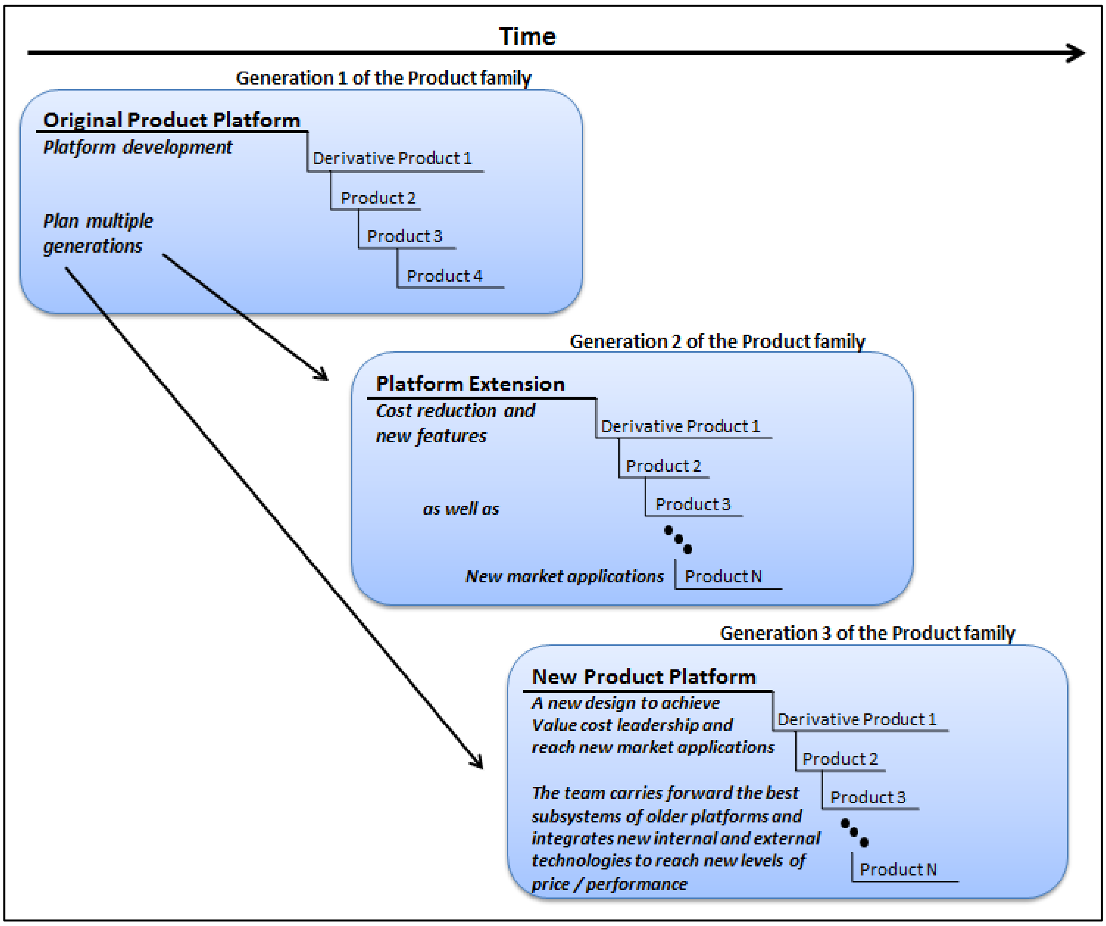

Figure 2.9: Product family evolution[67]

This process of continuous renewal of the platform architectures is essential to address future market needs and thus sustain the company's success. A highly modular platform facilitates the extension of the current platform by replacing modules or subsystems through improved ones. In the case of a platform renewal, some subsystems and interfaces may be carried over to the next generation, but are joined by entirely new subsystems and interfaces.[68]

[67] Own illustration based on Meyer, M.H. et al. (1997), p. 36

[68] cf.: Meyer, M.H. et al. (1997), pp. 42

Organizational implications of modular Platforms

The introduction of modular platforms in a company does not only influence the structure of the product itself, but can also have some impact on organizational issues.
First of all, highly modular designs allow companies to divide their development and production organization into specialized departments with a narrow focus. This is due to the decoupled nature of the components, which fulfill precisely specified functions. Therefore, they can be developed independently and simultaneously. This also supports the involvement of the supplier network in development and production. The resulting specialization and focus on a particular functional element can lead to the development of deep expertise.[69]
The application of modular platforms can also help to significantly reduce the complexity in the product development process. Von Hippel argues that problem decomposition in development can greatly increase the process efficiency.[70] Clark provides evidence that automotive OEMs with a high degree of outsourcing the detailed development of components to suppliers often profit from reduced lead-times and man-hours in their development process.[71]
A potential problem in the modular organization of a company lies in the organizational barriers that come with it and thus prevent architectural innovation. This problem may arise as a side effect to the previously mentioned focus and specialization.[72]

2.3.2 Platforms and Toolkits in the Automotive Industry

The concept of platforms has been applied for a long time in the automotive industry and is nowadays a standard that most OEMs implement in varying forms. The implementation of platforms changed the automotive industry

[69] cf.: Ulrich, K. (1995), p. 435

[70] cf.: Von Hippel, E. (1990), p. 18

[71] cf.: Clark, K.B. (1989), p. 1261

[72] cf.: Ulrich, K. (1995), p. 437

substantially in multiple aspects and still keeps doing so, as the evolution of platform strategies has not yet come to an end.
In order to understand where the automotive industry stands right now and where it is going, it is important to look at how automotive platforms evolved up to now.

The evolution of automotive platforms

Already at the beginning of the 20th century, the first platforms appeared in the automotive industry. Once again, it was Henry Ford that had the role of a pioneer when he introduced the first platform approach in automotive development and production. It consisted of a frame carrying the powertrain. On this platform, which was already able to drive, different upper bodies were mounted, thus creating convertibles, limousines or even light trucks.[73]
The basic understanding of an automotive platform has not changed very much over the years. Figure 2.10 shows the main components of a typical automotive platform. Still, there is no uniform understanding of which components are part of a platform and most OEMs have their own interpretation. Consequently, the scope of automotive platforms varies in each case.

[73] cf.: Wallentowitz, H. et al. (2009), p. 142

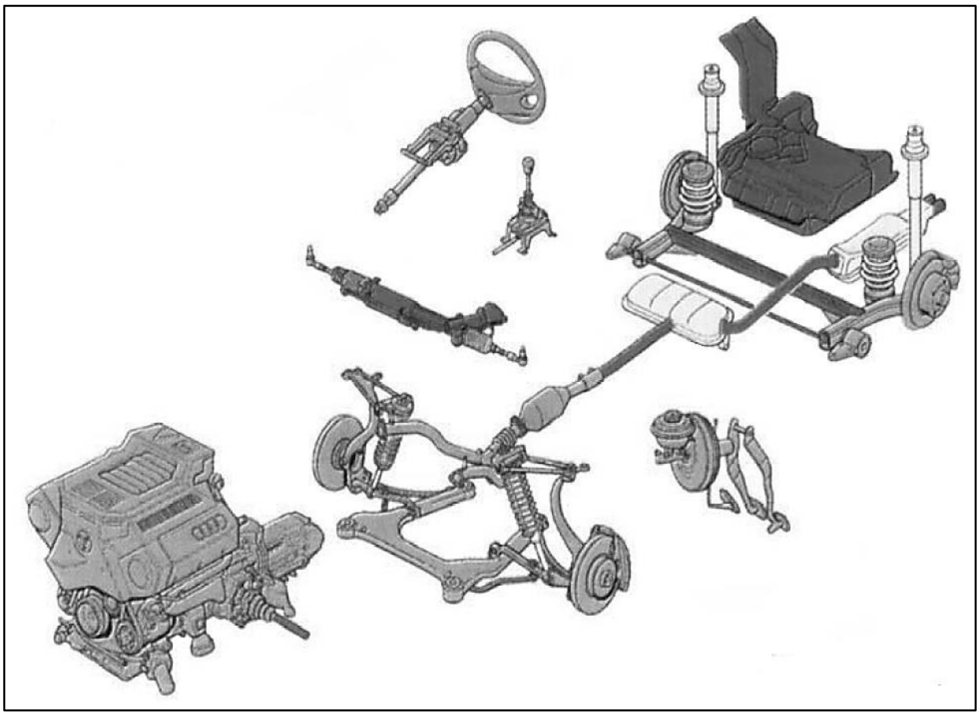

Figure 2.10: Components of an automotive platform[74]

In the early 1990s the manufacturing system of mass customization was introduced by a growing numbers of companies, striving to combine the benefits if mass production and product variety.[75] It was not before long that mass customization also came to play an important role in the automotive industry. Consequently, the concept of modular vehicle architectures, being closely related to mass manufacturing, was first introduced to the industry in the mid to late 1990s.[76]

Modularity in the computer industry was a very promising success, especially for companies like IBM, who were able to achieve dramatic reductions in lead time for designing and manufacturing their products.[77] Dell, among other examples in the computer industry, demonstrated the successful exploitation of further benefits of modularity, which were of high interest to the automotive industry. Through the highly modular architecture in their computers, it was possible to decouple the design and manufacturing of the various modules and outsource this task to their suppliers. These relatively interchangeable

[74] Wallentowitz, H. et al. (2009), p. 143

[75] cf.: Ro, Y.K. et al. (2007), p. 172

[76] cf.: Camuffo, A. (2001), p. 4

[77] cf.: Sako, M. et al. (1999), p. 1

modules could then be mixed and matched and consequently brought together in the manufacturing plant for final assembly. Being aware of the potential of these benefits, OEMs were motivated to change their, up until then mostly integral architectures, towards more modularity.[78]
Today, the modularization of different subassemblies is state of the art. Those modules can be roughly defined as an aggregation of components that are then mounted to the vehicle at final assembly. The developments go in a direction where some of these modules have an increasing amount of supporting functions. Typical examples of automotive modules are, among many others, doors, engine hood, cockpit, wheels, frontend, rear carriage, seats, powertrain or the roof.[79]
This development also enabled OEMs to follow a so called platform strategy. This means an improvement of cost effectiveness of vehicle components through the use of the same modules in multiple vehicle models or types. Obviously this is only possible for parts that are not directly perceived through the customer, in order to ensure differentiation between the models. This strategy helped OEMs to reduce costs of logistics and manufacturing and at the same time improve quality.[80]

With a growing amount of modularity in the automotive industry, there also came with it substantial changes in the OEM–Supplier relations. OEMs started to outsource the development and production of the modules to their suppliers, while at the same time focusing on the assembly of these modules. This would not have been possible with the highly integral product architecture used before. Suppliers were able to produce the modules at lower costs and a high degree of modularity made it now possible to take advantage of that.[81]
Much in line with the principles of mass customization, the use of modules brought with it several other advantages. There was not only a reduction in costs and lead time, but also a substantial increase in quality and flexibility. The newly acquired ability to customize product lines in mass quantities resulted in an increase in the number of niche vehicles with innovative and

[78] cf.: Ro, Y.K. et al. (2007), p. 173

[79] cf.: Wallentowitz, H. et al. (2001), p. 38

[80] cf.: Wallentowitz, H. et al. (2001), pp. 38

[81] cf.: Ro, Y.K. et al. (2007), p. 173

trendy designs. Accelerated innovation cycles gave OEMs an advantage over competitors that still used integral architectures and enabled them to react faster to changes in customer demand. Especially in highly competitive industries like the automotive industry, a strategic advantage in product development can have crucial effects on the performance of a company.[82]

After the first steps towards modular vehicle architectures were made, OEMs kept improving and refining their modular platform concepts for several reasons. For one thing, the pace of technological developments kept speeding up while at the same time the competitive environment got increasingly tougher. With an advanced approach towards modularity, OEMs were able to handle this development. [83]
Secondly, the automotive market got increasingly fragmented. This fragmentation quickly became one of the biggest challenges for the automotive industry. Volkswagen, for example, increased its number of customer segments from nine in 1987 to thirty in 2000.[84] Figure 2.11 shows the growing number of perceived vehicle segments by the end-customer. The dimensions of this perceived segmentation are driving pleasure, prestige, usefulness and versatility as well as price. [85]

[82] cf.: Ro, Y.K. et al. (2007), pp. 173

[83] cf.: Gottschalk, B. (2007), p. 241

[84] cf.: Miltenburg, P.R. (2003), p. 19

[85] cf.: Gottschalk, B. (2007), p. 241

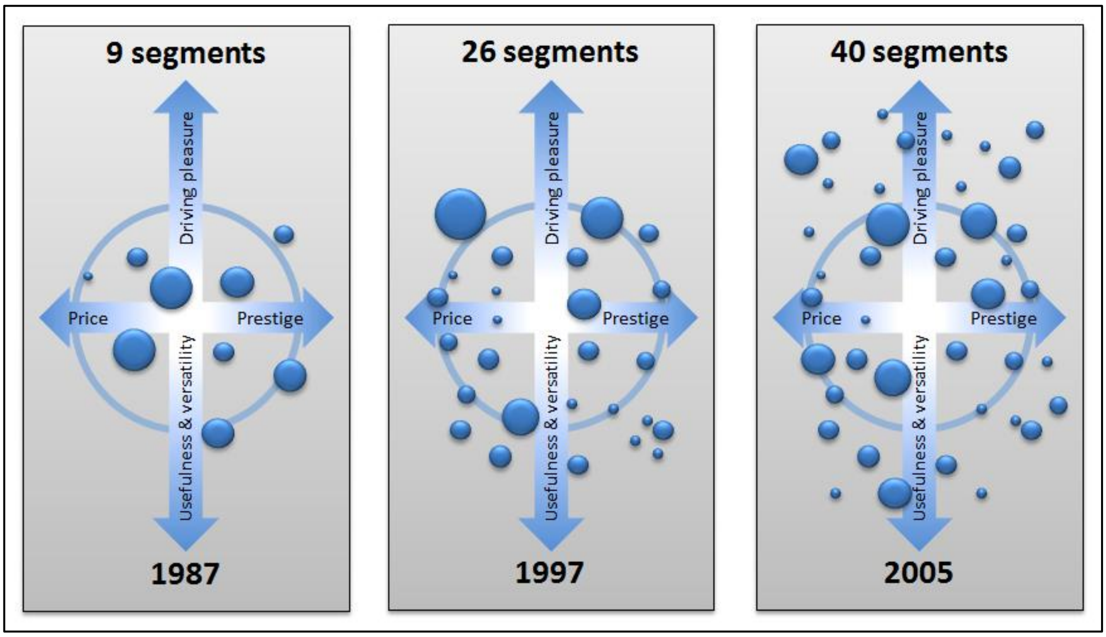

Figure 2.11: The development of the market fragmentation[86]

For the automobile manufacturer this development means, that he has to offer every customer exactly the car that fits best to his or her individual requirements. Consequently, the number of models and model families on offer kept growing, while at the same time the number of units per model decreased. Another development supporting this effect is the rising degree of competitive pressure, resulting in a declining number of manufacturers. Thus, the remaining manufacturers have to offer a higher number of models while producing fewer units per model (see Figure 2.12).

[86] Own illustration based on Gottschalk, B. (2007), p. 242

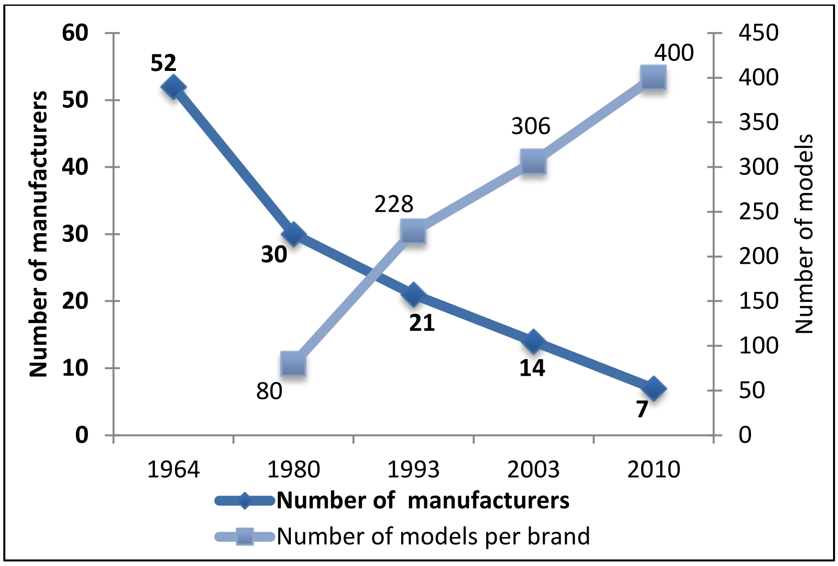

Figure 2.12: Development of number of manufacturers vs. number of models on offer[87]

This increasing amount of models also brought with it an effect known as the "complexity trap". The necessary amount of components increases with the number of different products and with it costs and complexity of logistics and the assembly. Modular vehicle architectures, the use of modules in multiple models to reduce variety of parts and modular sourcing can help to reduce the complexity for the OEM.

As a result of these developments, OEMs were forced to design their platforms in a way so that they could support an increasingly high number of different models. This lead to the highly modular and flexible automotive platforms we know today, that we previously defined as modular toolkits. Figure 1.5 summarizes this historical evolution of platforms in the automotive industry.

Modular Toolkits at the example of Volkswagen

Volkswagen, as one of the leading automotive OEMs concerning modular strategies, even managed to design toolkits that are used as technical bases

[87] Own illustration based on Gottschalk, B. (2007), p. 242

for not only different segments, but also vehicles across the group's various brands.

Figure 2.13 shows the modular toolkit strategy of the VW group. All toolkits span over several segments and brands, but the centerpiece and biggest toolkit is the MQB or "Modular transverse toolkit". The MQB is intended to be the basis for over 40 different models from the brands Volkswagen, Audi, Seat and Skoda. Popular examples for models based on this toolkit are among others the VW Golf, VW Passat, Audi A3, Audi TT, Skoda Octavia or Seat Leon.[88]

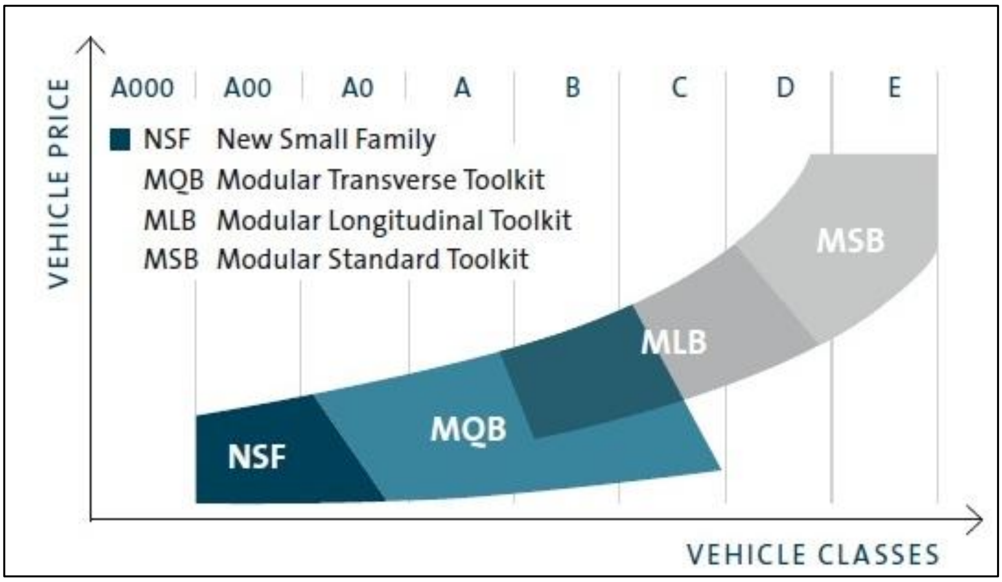

Figure 2.13: Modular toolkits in the Volkswagen group[89]

What distinguishes a modular toolkit form a conventional platform is, as the name already says, the high amount of modularity. Wallentowitz differentiates modular toolkits form other modular systems through the ability to integrate modules with different functions. These modules can then in turn be mounted to other building blocks.[90]

Throughout the evolution of platforms towards modular toolkits, the platform as well as parts of the hat got replaced by modules. This increasing amount of modularization offers the necessary flexibility to create synergies over

[88] cf.: www.volkswagenag.com (2013), access date 11.11.2013

[89] www.volkswagenag.com (2013), access date 11.11.2013

[90] cf.: Wallentowitz, H. et al. (2009), p. 143

several vehicle classes. Figure 2.14 illustrates the increased amount of modules compared to platform- and hat-components in a modular toolkit.

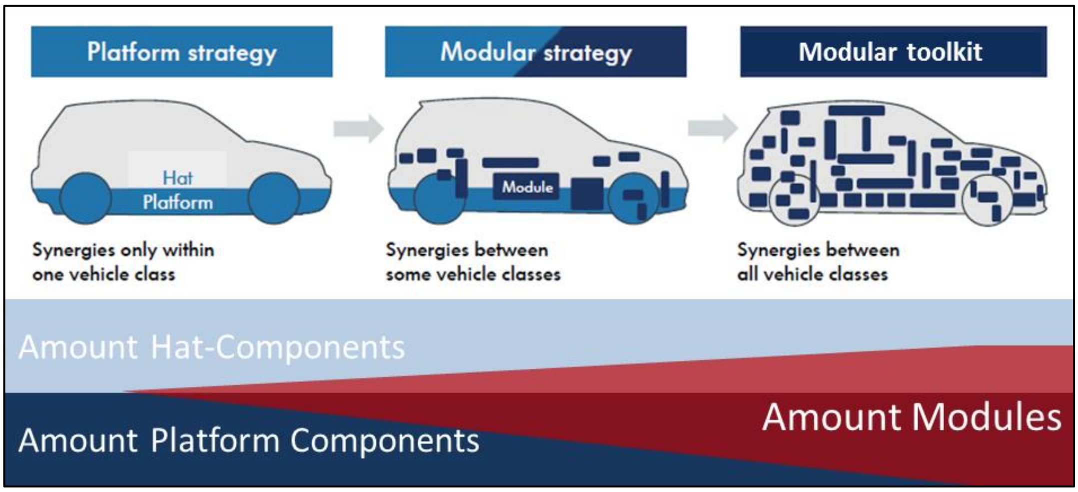

Figure 2.14: The growing amount of modules[91]

Modular toolkits offer, in comparison to conventional platform approaches, several advantages. Through the use of modules across multiple segments, or in the case of VW even over multiple brands, it is possible to achieve high quantities of common parts, while offering a high variety of different models. These increased volumes of the shared modules enable OEMs to reduce production costs at the same time offer a better quality. The high amount of common parts also helps to further reduce complexity in production and development. [92] Volkswagen, for example, was able to reduce the group's engine and gearbox variants by approximately 90 percent through the introduction of a modular engine toolkit.[93] Furthermore, it is possible to achieve a reduction in delivery time. [94] New derivates can also be derived at reduced costs and in shorter time through the combination of the different variants of modules. Consequently, this results in a reduction of the "time to market" of new Vehicles. This means that the OEM is able to react faster and with more flexibility to changes in customer requirements and model-

[91] Own illustration based on www.volkswagenag.com (2013), access date 10.10.2013

[92] cf.: Wallentowitz, H. et al. (2009), p. 143

[93] cf.: http://www.volkswagenag.com (2013), accesss date 12.11.2013

[94] cf.: Wallentowitz, H. et al. (2009), p. 143

lifecycles can be better adjusted to the market.[95] Furthermore, when producing with modular toolkits, a standardization of production processes is possible, which helps to further increase flexibility and reduce costs.[96] Last but not least a successfully designed modular toolkit can facilitate the introduction of luxury-class technology in high volume models through a significant reduction in price.[97]

Every additional model derived from a modular toolkit increases cost-reduction effects while, at the same time, the development risk is reduced for each model.[98]

The big challenge with modular toolkits, on the other hand, is to ensure sufficient differentiation between the different models, segments and especially brands. This means, that all parts of the car that the end-customer perceives should be individualized, while non-perceivable components or systems should be standardized. This is necessary in order to prevent cannibalization between the different product lines.[99]

Figure 2.15 shows four different vehicles, each form a different brand within the Volkswagen group. Although all are based on the MQB, the exterior designs are distinct and trying to underline the individual identity of each brand.

[95] cf.: Wallentowitz, H. et al. (2009), p. 144

[96] cf.: Winterkorn, M. (2009), p. 22

[97] cf.: http://www.volkswagenag.com (2013), accesss date 12.11.2013

[98] cf.: Winterkorn, M. (2009), p. 22

[99] cf.: Wallentowitz, H. et al. (2009), p. 145

Figure 2.15: Differentiation between brands of the MQB[100]

The introduction of modular concepts does not only have consequences for the OEM, but also for its suppliers. For example, they facilitate the outsourcing of larger development tasks to the suppliers. Consequently, OEMs, as well as suppliers, can focus on their core capabilities. Wallentowitz et al. define further advantages and disadvantages of modular sourcing for OEMs and suppliers, as can be seen in Table 2-1.

[100] http://www.volkswagenag.com (2013), accesss date 14.11.2013

	OEMs	Suppliers
Advantages	• Reduced **Investments** • Reduced **Quality control** at goods received and outgoing goods • Increased know-how at supplier enables increase of **module variations** • **Complexity decrease** in assembly • Lower **"transaction-costs"** (lower coordination costs through learning effects • Reduction of **assembly- and delivery-times** • Reduced **Inventory**	• Additional **value creation** • Long term supply-relationships with high **planning reliability** • Build-up of know how through independent **development of modules**
Disadvantages	• Giving away of **know-how**	• **Capacity utilization risk** may increase • Close relationship may lead to **dependencies**

Table 2-1: Advantages and Disadvantages of Modular Sourcing[101]

Volkswagen may be the leading car manufacturer in terms of modular platform strategies, especially concerning its modular toolkit approach, but many OEMs are heading towards similar but slightly different strategies. Figure 2.16 shows the status of the most important OEMs concerning their modularity strategy.

[101] cf.: Wallentowitz, H. et al. (2009), p. 150

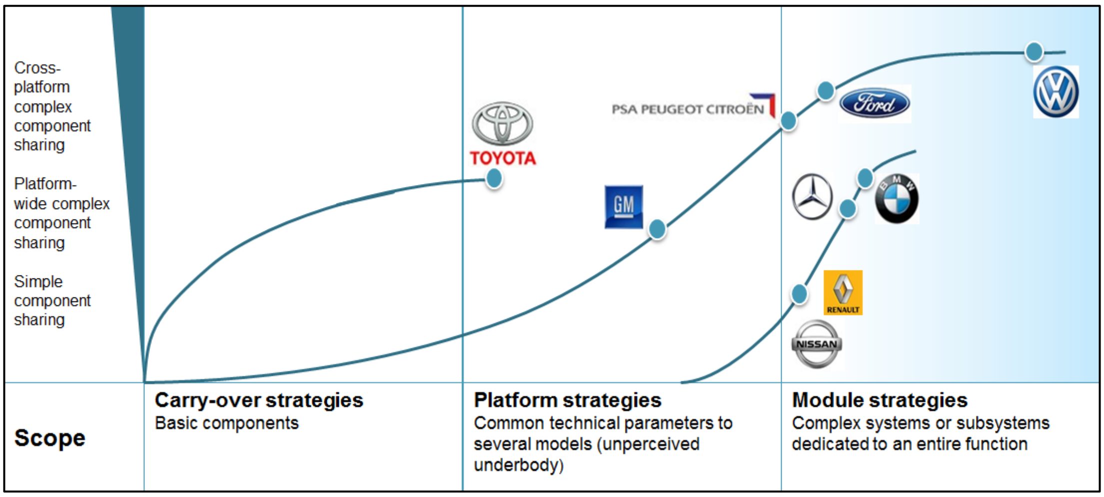

Figure 2.16: Modularity status OEMs[102]

If this trend of increasing modularity and sharing of modules across brands continues, it might lead to modular toolkits shared across independent OEMs. We previously defined this approach as an Industry toolkit which is illustrated in Figure 1.5.

An Industry toolkit strategy brings with it several advantages and disadvantages for both, OEMs and Suppliers, which will be discussed more closely in the chapters 4 and 5.

Although there have been a few occurrences of cooperations between OEMs, for example to develop engines or even whole vehicles, it has not yet become common practice develop and share modular toolkits. The cooperation that comes closest to that of an industry toolkit is the one between BMW and Mercedes. These two OEMs formed a purchasing alliance for modules like window lifters, seat structures, entry systems, lighting system components, heat exchangers, actuators and ventilation systems.[103]

So far, there is also hardly any scientific literature to be found, that deals with the topic of industry toolkits.

[102] Own illustration based on Roland Berger (2011) Magna Market Study

[103] cf.: www.auto-motor-und-sport.de (2008), access date 27.02.2014

3 Forecast for Light Vehicle Production

In order to understand the developments in the automotive industry over the last few years and to get an idea of future trends, this chapter provides an analysis and interpretation of the IHS Light Vehicle Production Forecast. All the data used in this chapter comes out of this IHS database. The database spans more than 50 countries, 600 plants and 2300 vehicle models and is used by the top-20 automotive OEMs as well as more than 90 of the top 100 automotive suppliers. Magna uses this database for its long-term strategic planning as well. The database is updated monthly and provides a 12 year horizon backed by 10 years of historical data.[104]

3.1 Restrictions and Definitions

The data used in this analysis is based on the forecast of June 2013 and was not updated during the research in order to ensure consistency. It covers the years 2000 to 2025. Furthermore, we only consider vehicles with a gross vehicle weight below 3,5 tons, as this is the relevant segment for this study.

As the scope of this work is limited, it is not possible to fully analyze the developments in the whole automotive industry. Consequently, some further restrictions have to be made. For the investigation of more detailed developments we therefore choose the following representative automotive groups that serve as examples:

- **Volkswagen** as the biggest European car manufacturer and innovation leader concerning modular strategy

- **Ford** representing North-American OEMs with an international orientation

[104] cf.: www.ihs.com (2013), access date 01.11.2013

- **BMW** as an example for a premium car manufacturer with only a small production volume

- **Toyota** representing Asian car manufacturers and being the biggest car manufacturer in 2013

Furthermore, the developments are observed in five-year steps from the year 2000 to 2025 as this gives an insight with enough detail while keeping the scope of the work within reasonable limits.

To get a better insight into the developments, it is necessary to differentiate between regional and global platforms. Therefore, we introduce the following definitions in accordance with the platform definitions at Magna:

- **GLOBAL Platforms:**

  Platform-derivatives are produced in more than one region (prime region) and in at least one further region production is at least 5 % of the production volume of the prime region.

- **REGIONAL Platforms:**

  Platform-derivatives are produced in only one region or in more than one region, but production in further regions is at maximum 5 % of the production volume of the prime region.

In addition to this definition, global platforms were divided in platforms with production volumes bigger and smaller than one Million units per year for an even better understanding of the development of global platforms.
It also has to be mentioned that the IHS Light Vehicle Production Forecast does not differentiate between platforms and toolkits and that therefore the data includes both.

Although the Data form the IHS Light Vehicle Production Forecast is considered to be a reliable source for strategic decisions among a majority of the top OEMs and suppliers, there still exists some uncertainty due to the simple fact that it is a forecast. The data, especially data for the far future, might therefore be inaccurate due to possible unforeseeable developments.

3.2 Analysis

The analysis of the IHS Light Vehicle Production Forecast Database covers several different topics and developments that are observed in 5 year steps. Depending on the development investigated, the analysis considers either the whole automotive industry or the previously mentioned representative examples.
In this analysis the following topics are looked into:

- Covering the **whole industry:**
  - The total production per year depending on regions (IHS considers 7 different regions)
  - The total production per year depending on segments (A to F)
  - The percentage of shared platforms

- Using **examples:**
  - Production volumes per year and number of platforms used
  - Average number of units per platform
  - Average number of brands per platform
  - Number of models produced
  - Average number of models per platform
  - Average number of units per model (and platform)
  - Average number of segments per platform

Investigating these developments gives a good overview on current trends in the automotive business and where the industry is going. The numbers and figures are interpreted with a special focus on platforms, which gives an insight on the growing importance of platforms strategies in automotive production.

3.2.1 Total Production in Regions

To get a first understanding of how the automotive industry has changed over the last years and where this development will lead, we first take a look at the production in different regions. The IHS Light Vehicle Production Forecast considers seven different regions of interest to the automotive industry:

- Europe
- Greater China
- Japan / Korea
- Middle East / Africa
- North America
- South America
- South Asia

Figure 3.1 shows the situation in the year 2000. The production in every region is split up in regional platforms and global platforms with volumes lower and higher than one Million units per year. Regional platforms are represented in green, global platforms with volumes smaller than one million units per year in blue and global platforms with higher volumes in red.

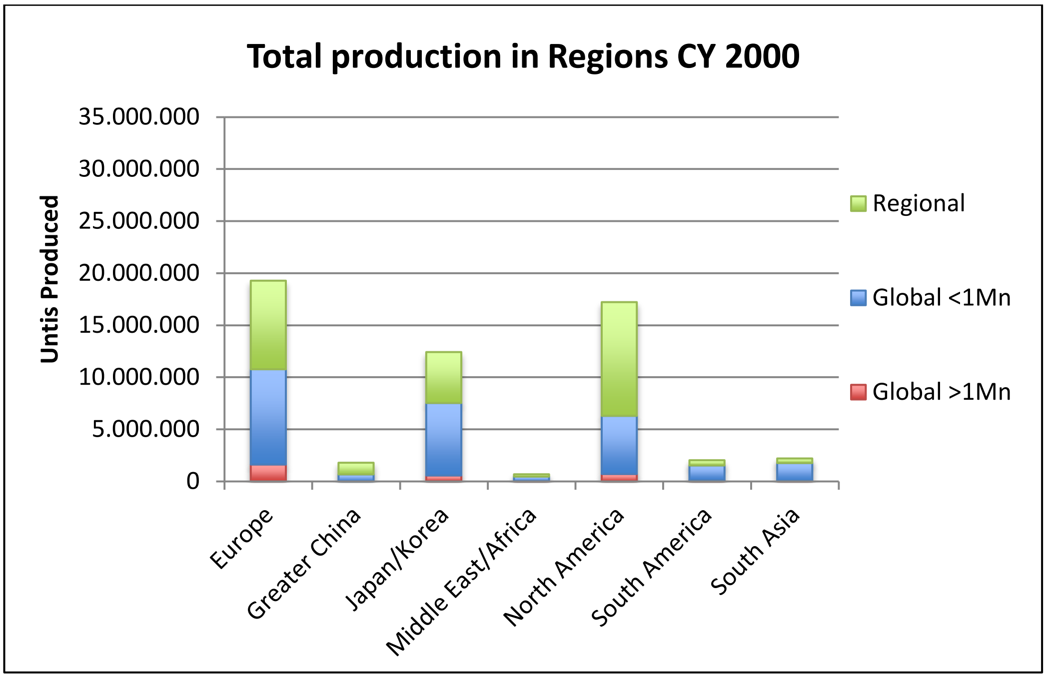

Figure 3.1: Total production in regions in the year 2000

It can clearly be seen that in 2000 the three dominant production regions, as in the decades before, were still Europe, Japan / Korea and North America. Almost 90% of the global production was done in these regions. Additionally, it can be observed that only 5% of the global automotive production was based on global platforms with volumes higher than one Million units per year, whereas almost half of the production was based on regional platforms. Especially in North America a strong regional market for mainly Pickup-Trucks, SUVs and MPVs existed.

Figure 3.2 illustrates the situation in 2025 according to the IHS Database for Light Vehicle Production. For more detailed information on the development of production in different regions see Figure 1 to Figure 6 in the Appendix.

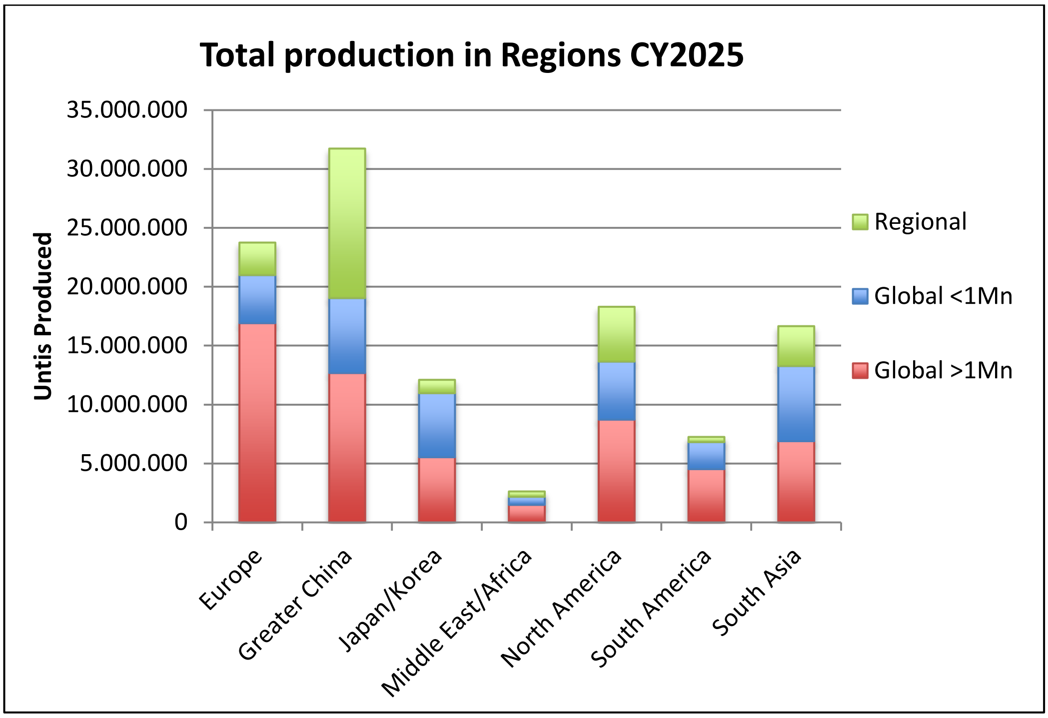

Figure 3.2: Total production in regions in the year 2025

Comparing the charts from 2000 up to 2025 several developments and trends can be identified.

There has been a continuous growth of the global automotive market with little interruptions (e.g. economic crisis 2008). While traditional markets like Europe, North America or Japan/Korea stay strong but grow only slowly, a significant level of growth can be observed in emerging markets like China, South Asia or South America. Consequently, OEMs will increasingly develop platforms that are able to fulfill the requirements of these markets. Especially China is a region of interest as this market has the highest growth rate of all and evolved to be the region with the highest production volumes by 2013. This development will continue and by 2025 approximately 28% of the world's light vehicle production will be situated in China.

As a result of the strong growth of emerging markets, the automotive industry moves more and more towards globalization. For automotive suppliers it will therefore be necessary to be able to manufacture in all regions. Suppliers that are not present in the emerging markets, where the major part of the growth happens, will face a competitive disadvantage in the long term.

Another very important development that can be observed is the trend towards production on global platforms. Especially large global platforms with annual volumes bigger than one million units are the basis for a growing

percentage of the overall global production. While in 2000 only 5% of all production was realized on large global platforms, it will be more than 50% by 2025.
Production on regional platforms decreases in most regions. Here, once again, China plays a special role. In China the regional market has been growing significantly in recent years and will continue to stay strong.
Although a trend towards global platforms can be observed, regional platforms will continue to play an important role in the automotive industry. For one thing, norms and legal requirements can differ significantly from country to country. For example, Vehicles have to fulfill different crash standards in the US than in the European Union. Secondly, consumer behavior varies greatly between different markets. While in North America larger vehicles like Pickup-Trucks or SUVs are dominant, emerging markets are mainly dominated by small cars. Toolkit strategies might serve as an opportunity for many OEMs to produce on large global platforms, while keeping the ability and flexibility to serve regional markets.

3.2.2 Production Volumes per Year and Number of Platforms

To get a better understanding of platform strategies, the developments of production volumes and the number of platforms at our four examples VW, Ford, BMW and Toyota are examined.
As Figure 3.3 shows, there is a trend towards large global platforms. At the same time, the number of regional platforms and global platforms with smaller volumes are reduced. This can be seen in Figure 7 to Figure 10 in the Appendix.

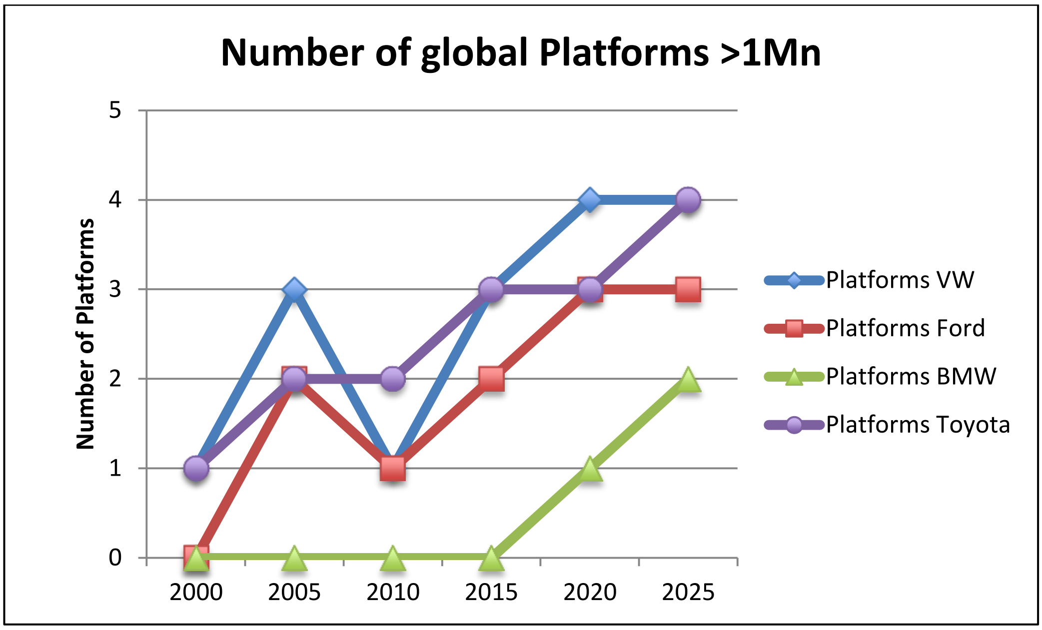

Figure 3.3: Number of global platforms >1Mn

The growing amount of global platforms with annual production volumes bigger than one million units will be the basis for a major part of the production. All of our examples follow a strategy where a big part of the production is consolidated on only a few large global platforms, also often referred to as "core platforms". This brings with it the advantage of scale effects, but also means for other OEMs that by 2020 it will be necessary to achieve the highest possible volume on global platforms to stay competitive. Especially smaller OEMs will need to restructure their production in order to keep up with large competitors. Figure 9 shows the aggressive platform strategy that BMW follows. BMW aims to produce over 94% of their vehicles on only 2 global platforms, while the remaining 6% are regional or small volume models.

Figure 3.4 compares the production volumes on large global platforms of the four examples. It can clearly be seen that the volumes on these platforms are increasing in every case. BMW acts as a follower concerning large global platforms. This is mainly caused by their lower overall production volume. As we will see later BMW is still in a process of developing a market through starting a "model initiative".

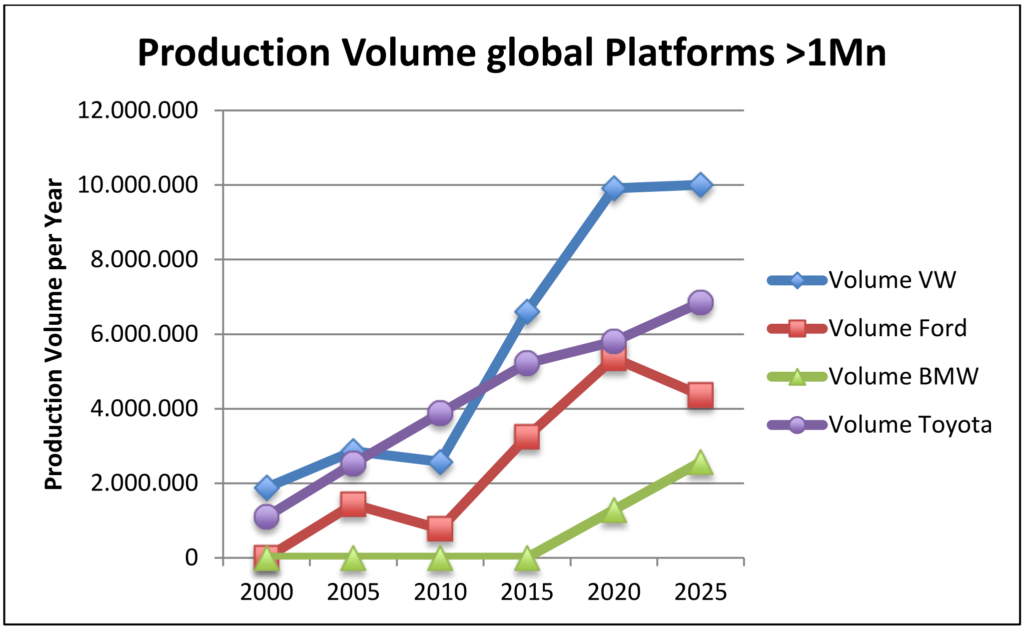

Figure 3.4: Production volumes on global platforms >1Mn

Ford, on the other hand, already produces considerable volumes but has to reorganize its production. In Figure 8 it can be seen that, what used to be mainly regional and small volume global production, is also aiming towards consolidation on a few large global platforms.

For suppliers, this development towards a major part of the production volume being based on only a few large platforms will lead to an increased competition on a global market due to fewer awards. Especially smaller regional suppliers might come under pressure due to these developments. On the other hand, the consequently higher volumes on each platform offer the opportunity of receiving higher sales per award.

3.2.3 Units per Platform

The before mentioned consolidation of a major part of the production on a few large global platforms, leads to a significant increase in the average number of vehicles produced on these platforms. At the major OEMs this will lead to the emergence of a few “mega platforms” with a high degree of flexibility. Examples for that would be Volkswagen’s MQB with over five million units in 2025, CMF2 by Renault and Nissan with almost five million units in 2025, or Toyota's NGA-C with 3,5 million units in 2025.

Figure 3.5 shows that OEMs, especially those that did not implement their platform strategy as consequent as others, will start doing so in the near future in order to stay competitive on the market. In this case Ford and BMW would be examples for this.

For OEMs that already achieved high volumes on their platforms, like Volkswagen or Toyota, no further increase can be identified. The reason for this might be a limit where further increase in volume will not provide additional economic benefits.

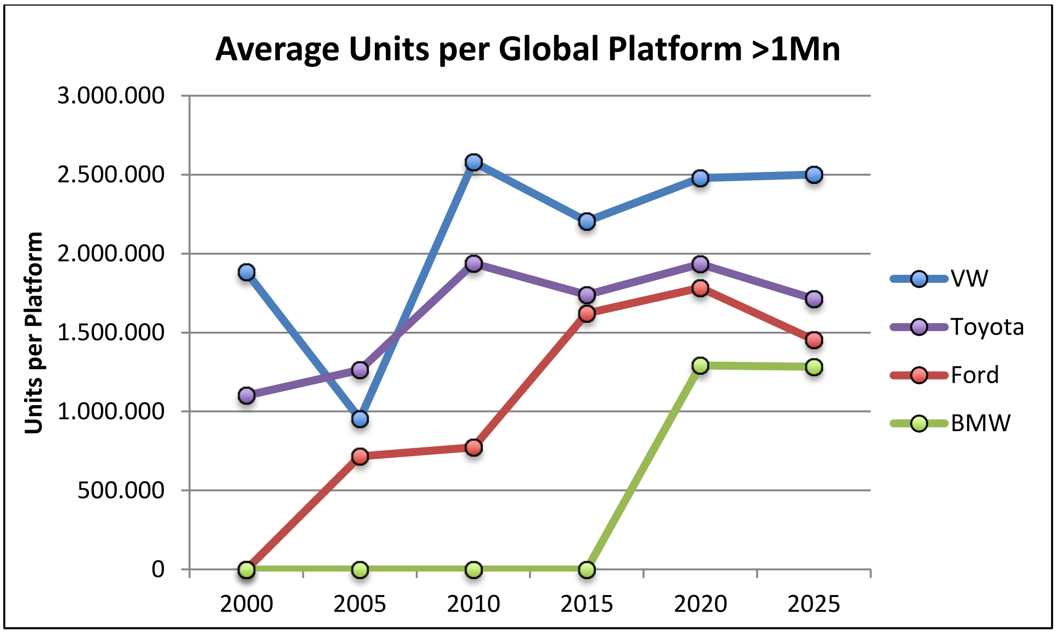

Figure 3.5: Average units per global platform >1Mn

Figure 11 to Figure 14 in the Appendix show that for regional and smaller global platforms the average number of units produced on these platforms remains mostly on the same level. This means that growth primarily happens on large global platforms.

3.2.4 Brands per Platform

Most of the bigger OEMs, that also have multiple brands in their portfolio, have been using their global platforms across these brands. This gave them the possibility to profit from synergies between the brands. Table 3-1 gives an overview on the brands owned by Volkswagen, Ford, BMW and Toyota.

Volkswagen	Ford	BMW	Toyota
Audi	Ford	BMW	Daihatsu
Bentley	Lincoln	Mini	Dario
Bugatti	Mercury	Rolls-Royce	Hino
Lamborghini		Zhinuo	Lexus
Porsche			Ranz
SEAT			Scion
Skoda			Toyota
Volkswagen			

Table 3-1: The brands owned by VW, Ford, BMW and Toyota

Obviously Volkswagen and Toyota clearly profit from the advantage of owning a higher number of brands, whereas Ford and BMW own a significantly lower number of brands. As can be seen in Figure 3.6, the average number of brands per global platform is higher for groups owning more brands. The Volkswagen group, with its eight passenger car brands, is here clearly the most successful concerning the use of synergies over multiple brands. Only through its aggressive platform-consolidation strategy BMW manages to keep up with OEMs like Volkswagen or Toyota. See Table 1 in the Appendix for information on the platforms supporting most brands in 2025. Volkswagen and Toyota are clearly the leading OEMs in terms of intra-brand platform sharing with four to five brands on their biggest platforms.

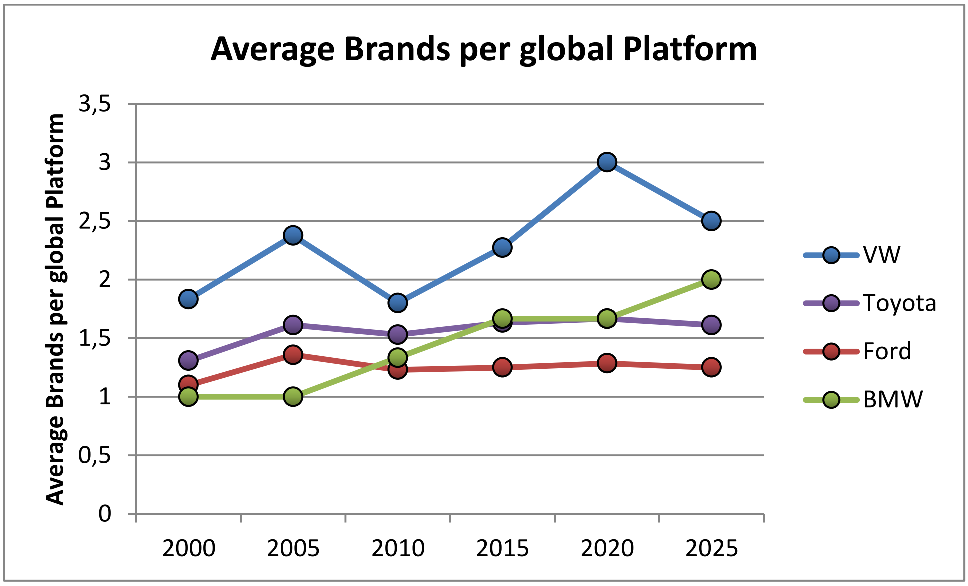

Figure 3.6: Average number of brands per global platform

Figure 3.7 shows the percentage of platforms that support more than one brand for the four examples. All OEMs aim to increase the number of platforms supporting multiple brands to 40-60% by 2025. Especially for OEMs with smaller volumes, like BMW, it will be of great importance to leverage the effect of platforms over multiple brands.

See Figure 15 to Figure 18 in the Appendix for more detailed information.

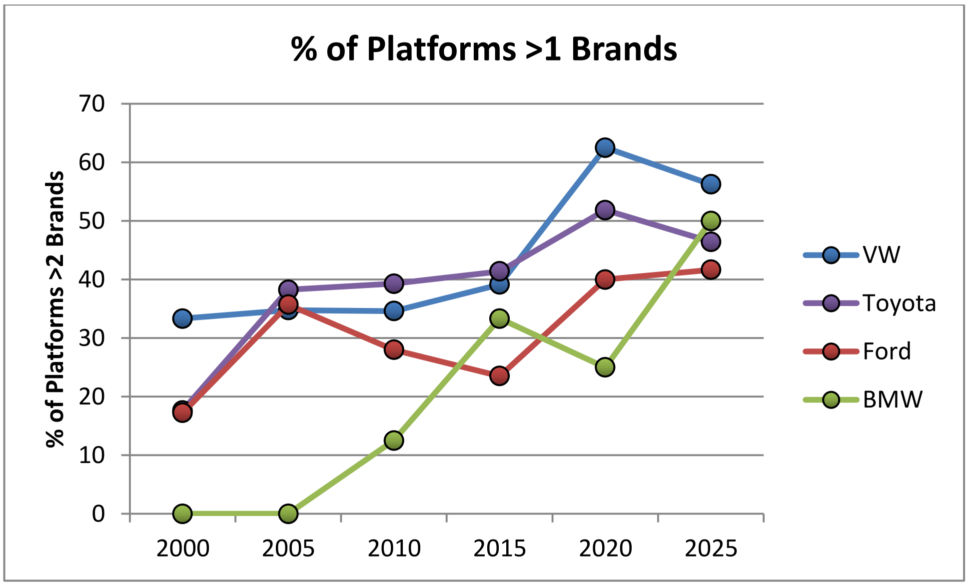

Figure 3.7: Percentage of platforms supporting more than one brand

Due to the intensifying competition on the market, it might be necessary for small OEMs, with only a few or even just one brand, to cooperate with other OEMs in order to stay competitive. This would support the use of industry toolkits.
Although scale effects can be a big advantage, the problem of brand differentiation has to be considered. Using one platform over multiple brands can reduce differentiation between the models and consequently damage the brand image. Therefore, limits have to be set to which parts of a car can be used as “common components”. This topic and possible consequences are discussed more thoroughly in chapter 6.

3.2.5 Number of Models

As previously mentioned, customer expectations are getting more and more specific, which leads to the development of a high number of niche-markets. For OEMs this means that they are required to offer a high variety of different models in order to serve this highly segmented market. To keep production volumes on an acceptable level none the less, it will be of crucial importance to develop and design platforms that can support several models.
See Table 2 in the Appendix for information on the platforms supporting the highest variety of different models. The biggest platform of this kind will be the CMF2 which is a cooperation between various OEMs, among them Daimler, General Motors and Renault/Nissan. Volkswagen’s MQB will be the biggest platform in terms of model variety owned by only one OEM. The MQB is designed to support more than 40 different models.

As can be observed in Figure 19 to Figure 22 in the Appendix, there is a tendency towards a reduction of regional models, while the number of models produced on global platforms increases. Different strategies can be identified between our exemplary OEMs. Toyota has been offering, with around one hundred different models, a high variety for a long time. The main goal here was to restructure the production towards more global models and a reduction of regional models. Volkswagen and BMW have been expanding their product portfolio and will still continue to do so with a majority of the production on global platforms. Especially BMW is in the process of an aggressive "model initiative". While in the year 2000, BMW offered only 7 different models, by 2020 the number of different models will grow to 40. Ford, on the other hand, is a special case. They traditionally used to offer a high amount of regional models, especially for the North-American market. Here we can observe a strong reduction of the regional models, while maintaining approximately the number of global models on offer. This leads to an overall reduction of the product portfolio.

Figure 3.8 shows that there is a tendency towards increasing the amount of models on global platforms. Especially Volkswagen and BMW are strongly increasing the number of different models on global platforms, while maintaining the amount of these platforms. This leads to an average of around 10 models per global platform. Ford and Toyota, on the other hand, do not follow such an offensive strategy and aim at an average of around 4 models per global platform.
For more detailed information see Figure 23 to Figure 26 in the Appendix.

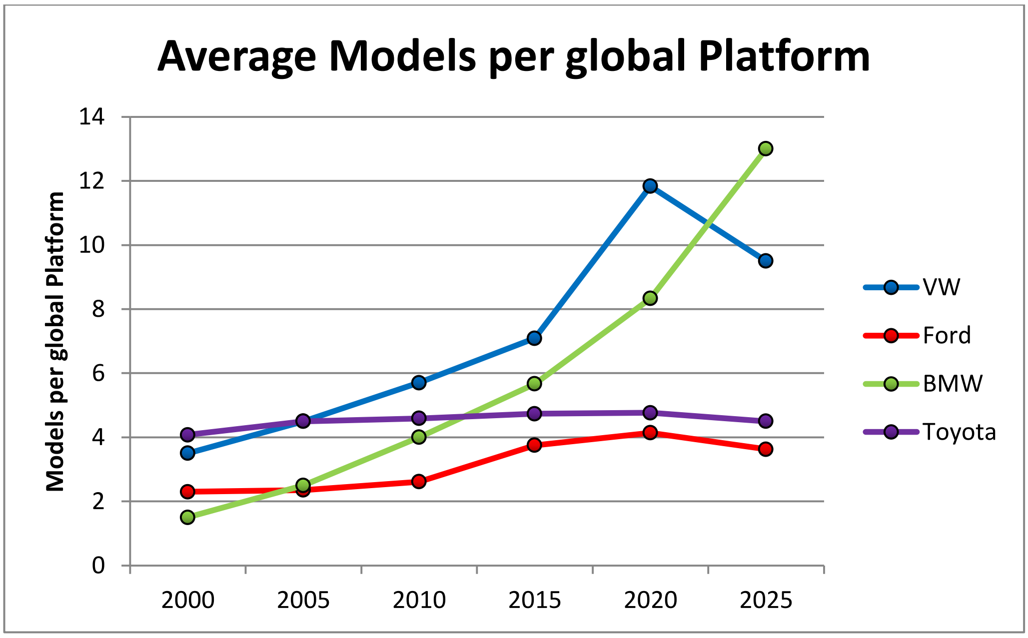

Figure 3.8: Average models per global platform

Figure 3.9 shows similar developments for regional platforms, although the average number of models supported is significantly lower than for global platforms. Concerning this development, Toyota is a special case. Toyota's average number of models on regional platforms stays at a low level of

around two due to their drastic reduction of regional models. This development can be seen in Figure 30 in the Appendix.
For more detailed information see Figure 27 to Figure 30 in the Appendix.

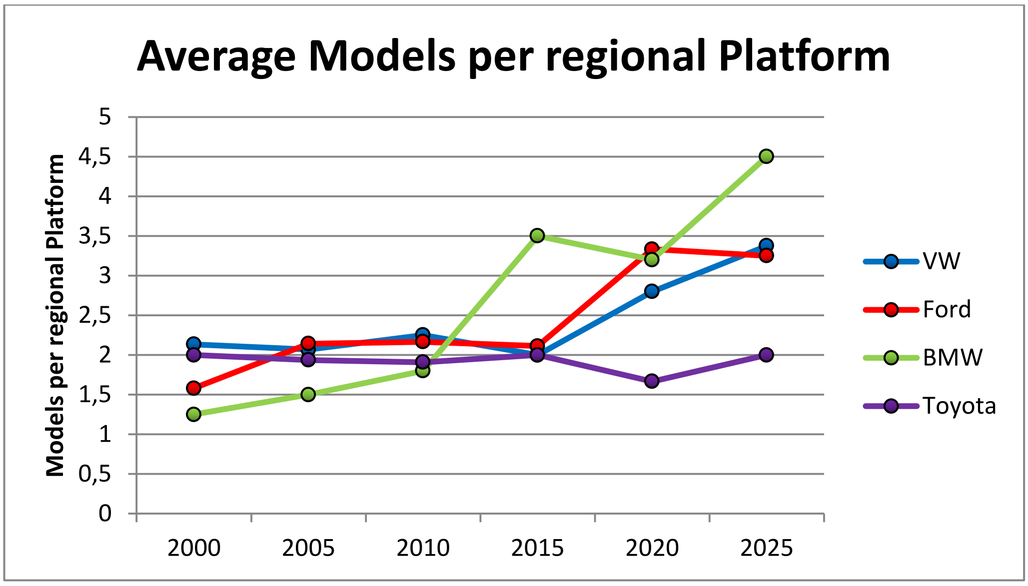

Figure 3.9: Average models per regional platform

In general, it can be said that volume segment models will primarily be produced on global platforms. This means a high number of models are derived from only a few large global platforms. Regional models, on the other hand, are derived from smaller platforms and will fill region specific market niches.
Furthermore, it is important to note that for any OEM it will be necessary to introduce platforms that can support multiple models. Especially models with low volumes can only be produced at competitive prices if large enough volumes are achieved on the platform level. Smaller OEMs, like for example BMW, will have the need to consolidate their production on only a few platforms to reach big enough volumes. In some cases cooperations with other OEMs might be a promising option.
However, when thinking of the problem of brand differentiation, it would be more favorable to derive several models of the same brand from one platform than sharing a platform over multiple brands. This would prevent the models of different bands from being perceived as too similar by end customer. None the less, multiple-brand-strategies can be an advantage in terms of reaching necessary volumes or further cost reduction.

3.2.6 Units per Model

The increasing number of niche markets and the therefore necessary variety of models is a big challenge for many OEMs. This segmentation of the market leads to lower sales figures for each model.

Figure 3.10 shows the development of the average units per model produced. This chart also differentiates between the same models produced on different platforms. The average volume per model for the whole industry is not rising significantly, although the market is growing much faster. This is due to the increasing number of models. Especially for smaller OEMs it will be challenging to keep a certain level of volume when increasing the number of models on offer. For example, BMW, as we have seen before, is starting a "model initiative" but this leads to lower volumes per model on average. Ford on the other hand is decreasing its product variety and can raise the average volume per model. It will therefore be necessary for OEMs with growing product portfolios to use platforms over several models to achieve scale effects.

This consolidation of multiple models on one platform can also bring problems with it. The growing amount of commonality increases the risk of product recalls in case of severe quality issues.

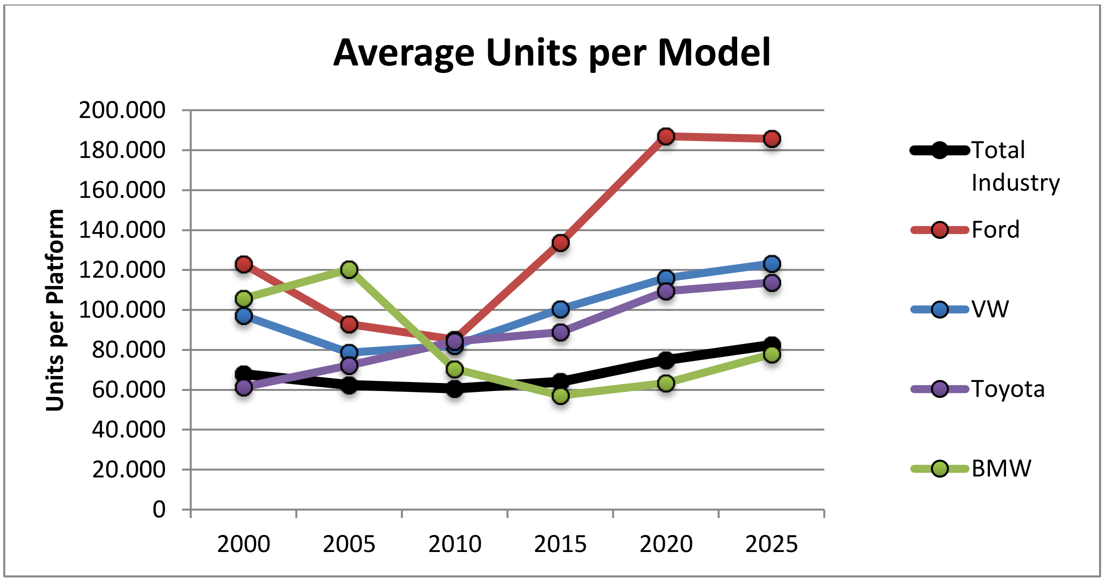

Figure 3.10: Average units per model

Figure 3.11 provides an overview on the annual volumes for the best-selling models of our examples for comparison.

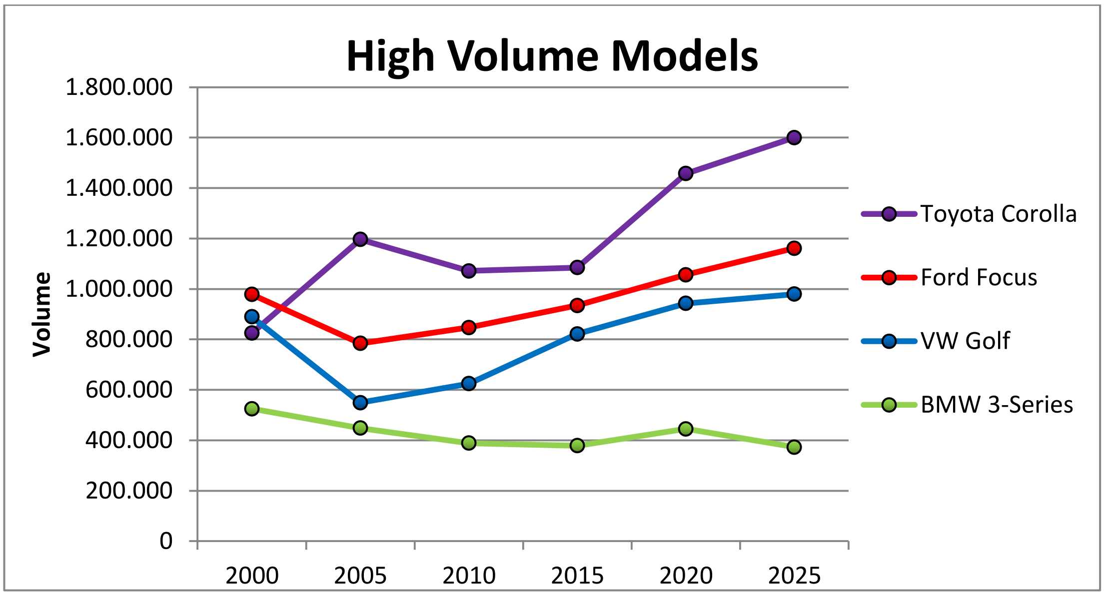

Figure 3.11: Volumes per year for best-selling models

Figure 31 to Figure 34 in the Appendix show that models on global platforms usually have higher production volumes than those on regional platforms. Although the production volumes on large global platforms are high and rising, the average volumes per model stay at a low level. This is due to the growing numbers of models on these platforms.

Another important point is that, for platforms designed for multiple models, scale effects can be achieved. However, the development, tooling and manufacturing costs for non-platform components are still high. These can be reduced through a high degree modularization and toolkits.

3.2.7 Total Production in Segments

The IHS Light Vehicle Production Forecast considers six different automotive segments (A to F). An analysis of the overall production volumes of the whole industry in each of these segments showed where the focus of large global platforms lies.

Figure 3.12 and Figure 3.13 show the overall production in each segment in the year 2000 and 2025. See Figure 35 to Figure 40 in the Appendix for detailed information on the developments between the years 2000 and 2025.

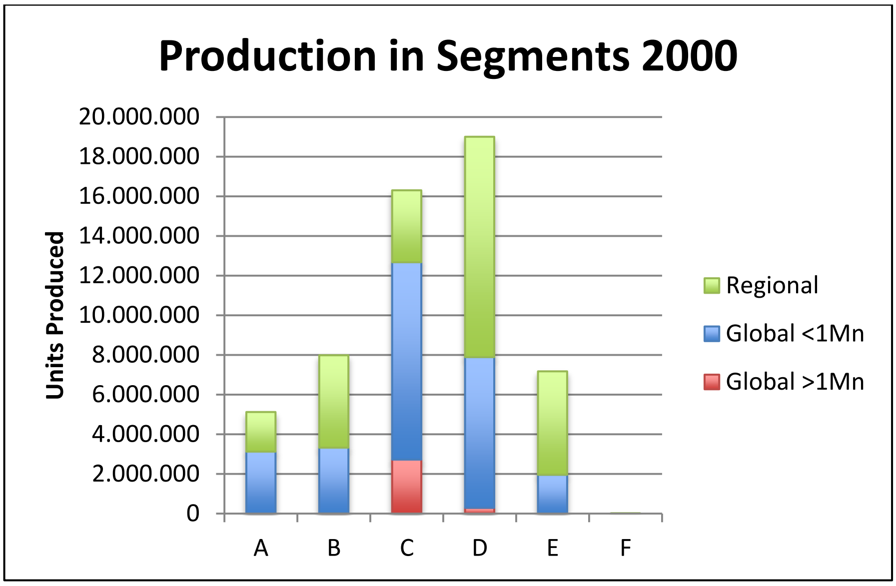

Figure 3.12: Overall production in segments 2000

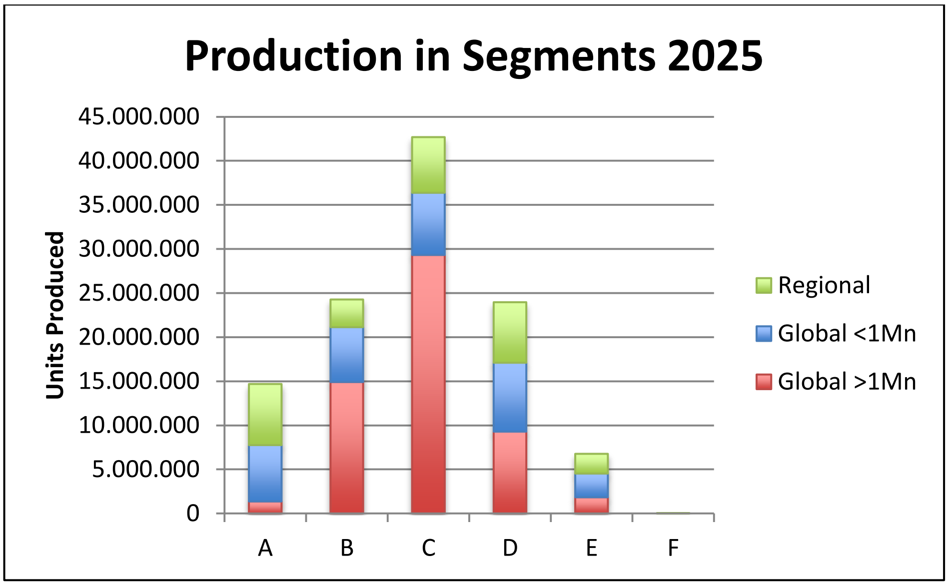

Figure 3.13: Overall production in segments 2025

While in 2000 the segment with the highest volume was segment D, there was a development towards smaller cars, which resulted in segment C growing to be the largest segment by 2005.

In contrast to the segments A, B and C, where a major growth has taken place and will continue to do so, there was only little or no growth in higher segments.
In 2000, the amount of vehicles produced on large global platforms with volumes bigger than one million units per year covered only a minor part of the overall production. Since then, the amount of these vehicles has been growing constantly and will continue to do so. Especially in the segments B, C and D a major part of the production is expected to be based on these large global platforms. This is in accordance with the previously made statement that large global platforms have their focus mainly on volume models, which are to be found mostly in these segments.
Starting from 2020 an expansion towards the segments A and E will take place. However, the production in these segments will still be dominated by regional and smaller global platforms.

3.2.8 Segments per Platform

To achieve large volumes in order to profit from scale effects it will be important for most OEMs to develop platforms that are flexible enough to support more than just one segment.
As Figure 3.14 and Figure 3.15 show, most OEMs have already been leveraging platforms over multiple segments and in some cases a slight increase on the average number of segments per platform can be identified.

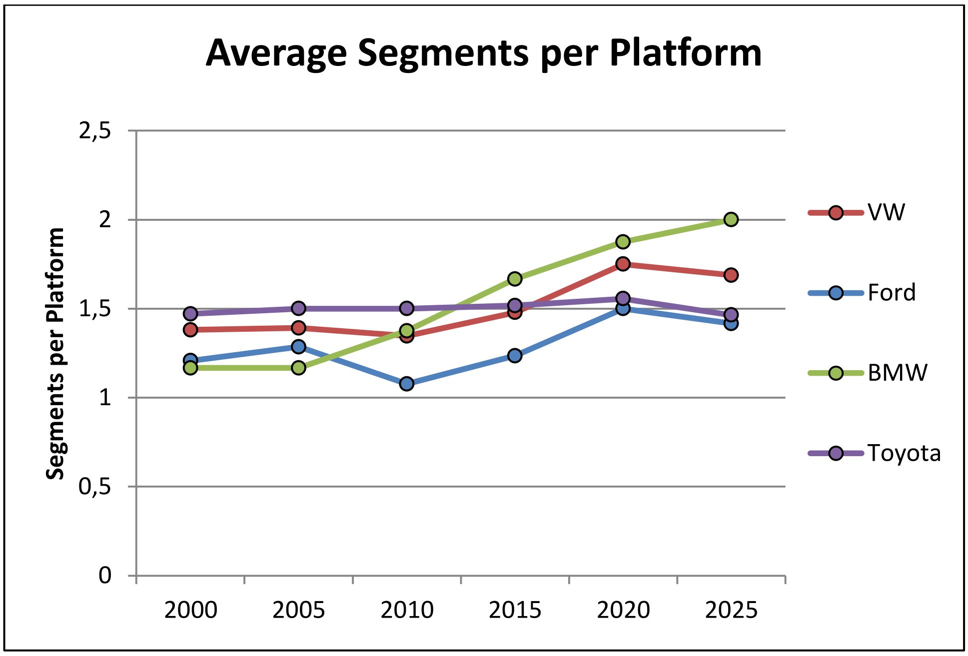

Figure 3.14: Average segments per platform

It can also be seen that the average number of segments per platform is slightly higher for global platforms. This means that global platforms, especially those with production volumes higher than one million units per year, usually span over multiple segments. See Figure 41 to Figure 44 in the appendix for more detailed information on the developments at each of the exemplary OEMs.

The biggest platforms to be found are flexible enough to support up to 4 segments. One example for that would be Toyota's NGA-C that is the basis for vehicles of the segments B, C, D and E.

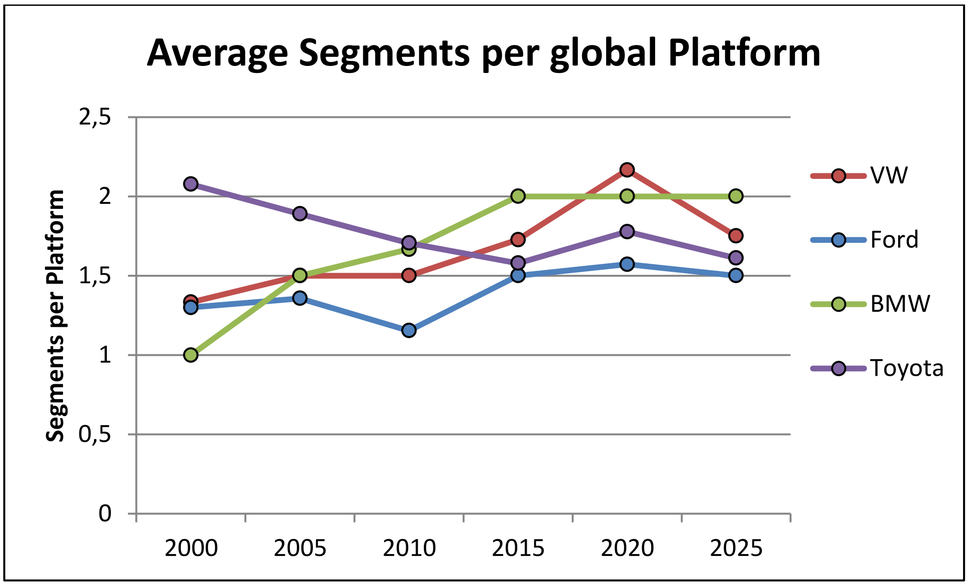

Figure 3.15: Average segments per global platform

Figure 3.16 shows the percentage of platforms that support more than one segment for each OEM. Especially for small OEMs like BMW it will be important to have platforms that support multiple segments in order to be able to benefit from scale effects. For bigger OEM with larger volumes this might not be as important, because they already reach high volumes within each separate segment. None the less an additional increase in volume could lead to additional benefits.

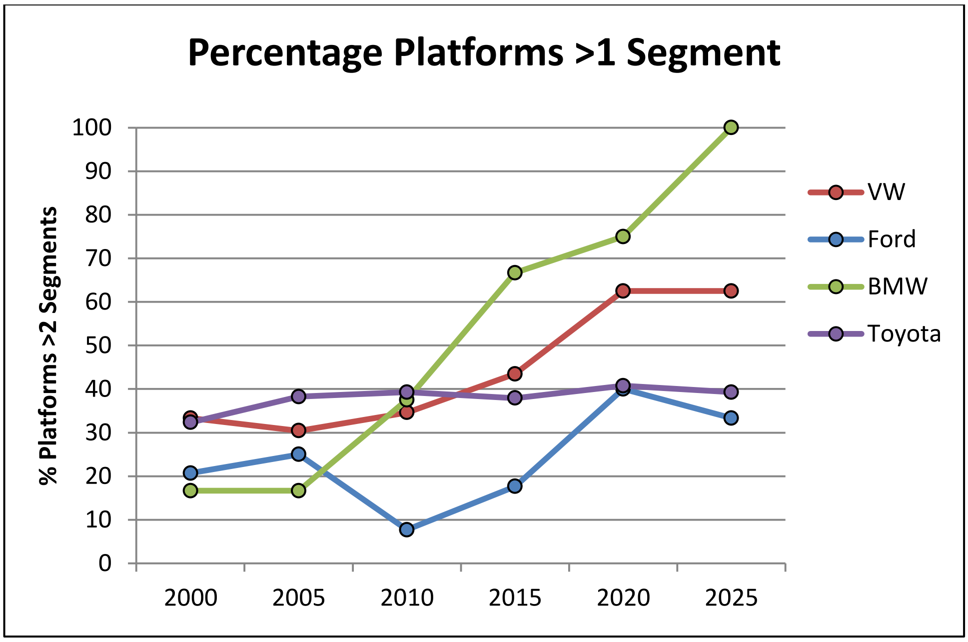

Figure 3.16: Percentage of platforms that support more than one segment

3.2.9 Shared Platforms

Due to the fact that modularity and the synergies that can be achieved are limited to a certain point, partnerships between different OEMs are important. To get an idea of how much sharing of platforms between independent OEMs already exists and where it is going, the percentage of shared platforms within the whole industry is investigated.

Figure 3.17 and Figure 45 in the appendix show that in the years 2000 to 2008 the percentage of shared platforms has been increasing. Starting from 2008, there has been a decline which is predicted to converge towards approximately 18%. This development can be interpreted as a sign for a limitation to shared platform strategies. This, on the other hand, could encourage the use of industry toolkits or sharing of certain modules between independent OEMs.

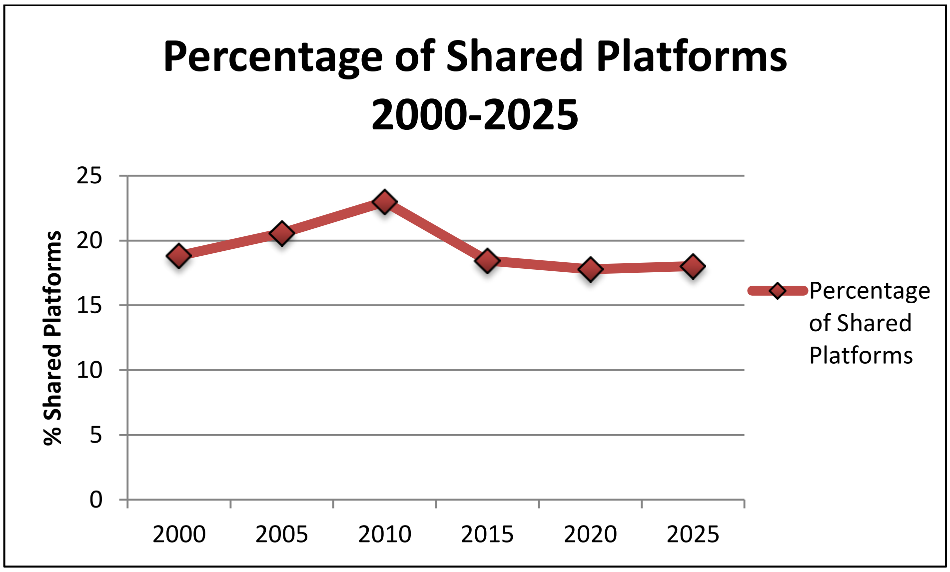

Figure 3.17: Percentage of shared platforms

See Table 3 in the appendix for examples for already existing shared platforms between different automotive groups. Interesting examples for intra-group collaboration are Renault and Nissan who develop platforms together or PSA Peugeot Citroen who work together with Toyota, General Motors or Fiat.

3.3 Summary of Data Collection

For a better overview on the results of the IHS Light Vehicle Production analysis a short summary of the most important conclusions is given on the following pages:

- As a result of an increasingly global market it will be necessary for suppliers to be able to manufacture in all regions and markets. A special focus lies on China as this will be the region with the highest production volume in the future.
- Regional markets, especially China with the biggest regional market, will continue to play an important role due to differing legal requirements and varying consumer behavior.
- A major part of the production volume will be produced on only a few large global platforms. This will bring the advantage of scale effects but also leads to increased competition for suppliers on a global market due to fewer awards with higher volumes. Especially smaller regional suppliers might come under pressure.
- OEMs will be facing a pricing competition and therefore need the necessary volume on their platforms to stay competitive. Especially smaller OEMs need to consolidate their production on a few core platforms to keep up with high-volume competitors.
- In order to reach the required scale effects OEMs will have to use platforms over several brands. This brings up the problem of brand differentiation and also sets limits to which parts of a car can be used as “common parts”.
- OEMs that own only a few numbers of brands might be forced to share platforms and toolkits with competitors in order to achieve the necessary volume for staying competitive.
- As customers’ expectations are getting more and more specific the market will develop a high number of niche-segments. Therefore, OEMs are required to offer a high variety of models in order to serve these niches. To keep the production volumes on a high level none

the less, platforms and toolkits will have to support several models. (e.g. MQB designed to support over 40 models)

- The volume segment models will be produced on global platforms, whereas regional models will fill region specific market niches.
- In order to prevent the problem of brand differentiation, it would be more attractive for OEMs to leverage platforms effects over several models of one brand before using platforms over multiple brands. However, it might be necessary to follow a multiple-brand strategy in order to reach the necessary production volumes or achieve further cost reduction.
- While the production volume on large global platforms is high and rising, the volume per model on these platforms stays at a low level. This is due to the growing number of models on global platforms. As a consequence there will be scale effect for the platforms, but still high development, tooling and manufacturing costs for the upper body. These could be reduced through the use of toolkits and modules.
- Consolidation of multiple models on one platform can also bring problems with it. The growing amount of commonality increases the risk of product recalls in case of severe quality issues.
- Large global platforms focus on B/C/D segments. Starting from 2020 expansion to A and E segments.
- There will be no significant rise in platform sharing between independent OEMs. One possible reason might be the problem of brand differentiation. In that case it would be more feasible to introduce industry toolkits with non-critical components concerning differentiation.

4 Expert Interviews about Industry-Toolkits

In order to gather some basic information on Industry toolkits and their potential, several interviews were conducted.

The first part of this chapter summarizes multiple interviews with Magna employees from the different groups. Here the aim was to gather information from experienced people in the automotive supplier industry and get an insight on what is going on in the business form a practical point of view.

The second part consists of an interview with an employee of the “Institute of Automotive Engineering and Management” at the University Duisburg-Essen. Part of the research focus of this institute deals with modularity in the automotive industry and the effects and consequences of platform sharing. This interview should give an insight on the research status concerning industry toolkits.

Due to requests by some interview-partners these interviews will stay anonymous.

4.1 Interviews with Magna Group Employees

To get information on the situation concerning component commonality, platform sharing and industry toolkits form a practical point of view, several interviews were conducted. Each of the interview partners is part of one of the five Magna core groups: Magna seating, Magna Exteriors & Interiors, Magna Mirrors & Magna Closures, Cosma International, Magna Powertrain & Magna Electronics. All of them had several years of experience in the automotive supplier business, are considered to be experts in their specific fields and possess profound knowledge of what is going on, on both the supplier and the OEMs side. The interviews were mainly conducted via telephone, due to the fact that most interview partners live in America. Whenever possible the interviews were conducted as face-to-face discussions.

4.1.1 Main Topics during Interviews

In these interviews, the questions asked dealt primarily with the following topics:

- The present situation concerning the sharing of components, modules or systems between independent OEMs
- The kind of components, modules or systems that are shared
- Future collaborations concerning part commonality that are to be expected
- The kind of components, modules and systems that are used as a differentiating element, where OEMs put great emphasis on differentiation
- How these differentiating elements differ between OEMs

Additionally, information on production cost, time, quantity and other data was collected. Due to the confidential nature of this information the data cannot be presented here.
The following pages will provide a short summary of the most important information gathered.

4.1.2 Summary

In this section the most important and relevant information and insights gathered during the interviews are summarized. There are several points that seem to apply for all business divisions, while some are very specific to a certain group.

A statement which was made quite often is that there are **hardly any cases of component sharing between independent OEMs** known. Several interview partners mentioned that years ago there was a lot of component sharing going on, but nowadays this sharing got less. If it happens it mostly takes place “unintentionally” **on a supplier base.** This means that Suppliers develop certain systems or modules and sell them to different OEMs. Many

OEMs have very specific ideas and requirements which certain systems or modules have to fulfill. Consequently, some re-engineering or application-engineering is necessary. Nonetheless, most systems will still contain some similar parts.

For **certain systems, suppliers already have modular toolkits**, variants of which are then sold to different OEMs. These are usually low volume business-cases. Magna, for example, has already developed all-wheel drive, roof-system, battery system toolkits which can then be assembles according to the customers' requirements and wishes for functionality.

In most cases OEMs want to have cost advantages resulting from the suppliers' modular toolkits. They are usually not interested in which competitor also takes part in the toolkit as long as their specific requirements are fulfilled. From an OEM point of view these modular toolkits act as a pool for risk- but also opportunity-sharing.

The situation is different **for engine development.** There have been several well-known **development-cooperations** like for example BMW and PSA for gasoline engines, BMW and Toyota for diesel engines or the Renault-Nissan alliance. The reason for this increased amount of cooperations in engine development lies in the fact that there does not exist a big supplier market in this area. OEMs mostly develop engines themselves and are looking for knowledge pooling or increase in volumes.

Cooperations in general are nowadays going **more towards R&D and development** and not so much towards manufacturing.

If there is intra-OEM sharing, it mostly happens **on a very basic level** where there is not much individuality in design possible or necessary. The shared parts are not visible to the customer, nor are they perceived in any other way. An example that was mentioned was rails in the seating structure.

Most sharing that is happening nowadays, is sharing **within one platform or** at least within the same **OEM**. Front seat structures, for example, are often identical even across different platforms. This is common practice for pretty much all OEMs.

Many **second-tier-supplier products** like for example airbags, sensors or displays are shared components. They are bought by first-tier suppliers and are then sold to multiple OEMs.

The increasing amount of **electronics** in cars has been identified as a **potential driver for commonality** by multiple interview partners. Especially components like LCD- or LED-displays or sensors have a high potential to be shared.

A problem, on the other hand, with sharing electronic components is that there are **no common standards and interfaces** used by the OEMs. Therefore, most of the electronic components cannot yet be shared. If, however, there was a common standard it would be a field with high potential for commonality with the ability to achieve differentiation through software.
For electronics it might even be possible to **share components with other industries**. Good examples for that would be image-processors for cars, cameras or phones.

The main differentiating element in most cases is obviously the **design**. Other possibilities for differentiation are **quality and functions**. However, this difference in quality and function, especially within the same segment, does not work as a differentiator on a long term. Most OEMs use similar materials and shapes. If a successful technology is developed and introduced, competitors never take long to introduce similar technologies. This effect is intensified by the shortening of the development cycles in the automotive industry.

An Industry toolkit-strategy can be suitable for OEMs that want to **increase their market share without** an increase in **development costs**. Whenever there are low volumes for a component or module there is a trend towards collaborations. The suitability of such a module for an industry toolkit is mainly predetermined by the marketing-strategy of each OEM and where they want to differentiate themselves.

One interview partner mentioned that, from his point of view, one of the biggest problems with component sharing is that it would make the suppliers unhappy. At the moment different prices can be charged for similar

components, depending on the OEM and the required specifications. The use of industry toolkits might lead to bigger volumes but a **decrease in the achievable price**. Additionally, there will be a loss of income for the supplier as engineering activities can be charged only once instead of multiple times.
Differing legislation or marketing requirements in different regions of the world have also been mentioned to be a big challenge for sharing systems and components. If one part has to be changed, that can make it necessary to reengineer the surrounding components. In this case a high modularity would help to solve this problem.

Another interesting point made by one of the interview partners is that in some cases the production tools are owned by the OEMs. This is, for example, the case for some stamped components at Magna Cosma. It is thus not possible to use these tools to produce for other clients.

The interview partners were also asked which components or modules in the product portfolio of their department had, in their opinion, the highest potential for possible future sharing:

- **Magna Cosma:** Cradles and lower control arms
- **Magna Mirrors & Closures:** components inside of door mirrors, electronics (displays), inside mirror modules and inside mirror electronics (screens, compass, etc.)
- **Magna Seating:** Recliners, fore-aft adjuster rails, lumbar mechanisms, active headrest mechanisms, electronics, seating structure
- **Magna Interiors & Exteriors:** mostly second tier components like Sensors, Airbags, electronics
- **Magna Powertrain & Electronics:** Electronics like e.g. processors could be used even by other industries, Internet in the car, electric motors, sensors, Hydraulics

4.2 Interview with the Institute of Automotive Engineering & Management

The second part of the interviews was conducted with the aim to gather information on industry toolkits from a theoretical point of view and to get an insight on the research status on this topic. The “Institute of Automotive Engineering and Management” at the University of Duisburg-Essen deals with modular toolkits and platforms used over multiple OEMs as part of their research area. The head of the Institute, Prof. Dr. Heike Proff, writes in her book “Dynamisches Automobilmanagement” about the effects of commonality in design with insufficient differentiation. The interview has been conducted with M. Sc. Dominik Kilian, who is working at the institute as a research associate and concerns himself with the topic of industry toolkits as part of his dissertation.

4.2.1 Main Topics of the Interview

The following main topics were discussed in the curse of the interview:

- Existing examples for industry toolkits
- Challenges and Problems connected to industry-toolkits
- Potential field of application for industry toolkits
- Differentiation in the automotive industry

The Interview was conducted per telephone.

4.2.2 Summary

In the following section the most important information gathered in the interview with M. Sc. Dominik Kilian is shortly summarized. Mr. Kilian points out several potential difficulties in the application of industry toolkits as well as some general prerequisites and the most suitable fields of use for industry toolkits.

Challenges and Problems with the application of Industry toolkits:

- When independent OEMs start a collaboration using the same modular toolkit for development and production, it is essential to clarify **who** of the participants **is the lead-developer**. If it is not clearly defined who of the partners is the one to make crucial decisions and has the main responsibility in the development of the toolkit, there might be difficulties with differing solutions for the same problem. This in turn would lead to complications and reduction of the efficiency in development and production.

- Another important issue, closely related to that of the lead-developer, is the question of the **responsibility for quality issues**. If this is not clearly defined it might lead to problems concerning liabilities. Furthermore, it is necessary to define a common standard for testing and quality control, but also for manufacturing processes. This standardization is necessary in order to be able to benefit from scale effects and provide a certain level of quality for the customer.

- Another big issue in connection with modular toolkits used across several brands is **Cannibalization** between brands. This means that the use of common components or modules causes similarities between the models of different brands which are perceived through the customer. This will result in increased customer flows between the participating brands and consequently to disadvantages for some participants, while others profit from additional customers. This phenomenon is to some degree **accepted** in the industry, as long as it happens **within one group** (e.g. customers change from VW to Skoda but stay within the VW-Group). The whole issue gets far **more problematic** if OEMs from different groups share one toolkit**,** or in other words, **in the case of industry toolkits.**

- A general issue for each automotive OEM that is also closely related to the topic of industry toolkits is the **conflict between standardization and differentiation**. Logistics and production, on the one hand, try to maximize standardization and minimize complexity in order to reduce costs. Marketing, on the other hand, wants to achieve as much differentiation as possible, not to prevent the before mentioned cannibalization effects, but also to achieve certain brand-specific characteristics which are necessary to establish a certain price premium over competitors.

- Another important topic pointed out in the interview concerns components that are already manufactured by suppliers. The development of standardized modules for multiple OEMs is problematic because they would have to agree to a **compromise and restrictions in engineering and design**. A high degree of modularity in their vehicle architectures would be necessary and all participating OEMs have to agree on the use of the same interfaces. The problems connected to standardized modules are not only of physical, but also of temporal nature. A **temporal coordination of development steps** of the products is necessary and results in big restrictions for the participating OEMs as there often are big differences in the duration of the development cycles between different OEMs.

During the Interview Mr. Kilian also pointed out several general remarks on differentiation, industry toolkits and their application, which are summarized on the following pages:

Toolkit-strategies are in general **more suitable for OEMs in the volume-segment**. Nonetheless, it could also be of interest for **Premium-OEMs** under certain circumstances. In that case it is essential to **maintain obvious differentiations to other OEMs in order to preserve exclusivity and characteristics** of the brand. The necessary preconditions for the use of industry toolkits are discussed in detail in chapter 6.

In the case of collaborations between brands that cover different segments, it is necessary to pay special attention to quality standards. Common parts should always **comply with the quality standards of superior brand**. This is necessary in order to prevent damage to the brand-image of the superior brand. Consequently, it is important for suppliers to provide high-quality products that fulfill the standards of all participants.

Differentiation is primarily accomplished through **design.** Especially the car body and the interior play an important role for differentiation. There is also the possibility to delay differentiation to a l**ater point in time in the value-creation-chain.** This strategy is closely related to the principles of mass customization which have been discussed above. An example for delayed differentiation would be individualization through applying decals on the exterior of the car or adding seams on the seating trim. Differentiation is possible even in the **after-sales and service area.** This could for example consist of special offers for maintenance and inspection.

Differentiation issues are considered especially important when it comes to **electro-mobility** where vehicles **differ even less in characteristics**. Here differentiation is mainly possible through **design and additional services** like driver-assistance systems.

The **brand itself gets less important as a differentiator**. A car is not the status-symbol that it used to be anymore. What gets more and more important is individual mobility and technical specifications. Nonetheless, buying decisions are still very emotionally influenced.

5 SWOT-Analysis of Industry Toolkit Strategies

This chapter contains a SWOT-Analysis of industry-toolkit strategies. The aim of this analysis is to get a compact overview on the strengths, weaknesses, opportunities and threats that the application of an industry-toolkit brings with it. The implications of the use of industry-toolkits are explored from two perspectives, both the supplier side and the OEM point of view. This differentiation will help to identify who has the bigger advantage or disadvantage using industry-toolkits and who will consequently act as the main initiator for its application.

5.1 OEM Perspective

From an OEM perspective, industry-toolkit strategies offer a multitude of strengths and opportunities, but also several weaknesses and threats. On the following pages the implications of using industry-toolkits for OEMs and their possible consequences are discussed in detail.

Strengths

One of the most obvious strengths of an industry-toolkit strategy for an OEM is the economies of scale that can be achieved. As mentioned in chapter 2.2.4, economies of scale are one of the most important principles of mass customization. Through the increase of the production volume by sharing the modules, the costs per piece can be reduced. This offers the OEMs the possibility to increase their revenues or sell their vehicles at a lower price. As the automotive business is very cost driven, this advantage can be identified as one of the main drivers for industry-toolkit strategies.
Another important point is that, through the collaboration of multiple OEMs, the development costs for the shared modules can be divided between the participants. This leads to a further reduction of costs. It is important to note that the overall development costs for a shared module will be higher than for

a module developed for only one OEM. This is due to the increased requirements and the necessity for flexibility of the interfaces, which enables sharing. However, the development costs per OEM will decrease significantly.
An industry-toolkit strategy also offers the possibility of sharing investments other than those for development. A good example for that would be sharing the costs for the production line. It can also be seen as a way to reduce the risks for the OEMs. In case a project is not successful, the reduced investments per OEM are an advantage.
For OEMs taking part in an industry toolkit, there is also a business case improvement for niche- and low-volume models. As mentioned before, the number of produced units of the shared modules increases through the application of industry-toolkits. This can make the production of certain niche-models a more attractive opportunity than before.
But industry-toolkits do not only offer benefits for low-volume vehicles. They can also make functionality options with low take-rates more affordable. For optional equipment, which customers order at rare intervals, higher volumes and consequently significant cost reductions can be achieved.
Another quite interesting effect that increased production volume brings with it is a reduction in cost sensitivity. This means that, at higher production volumes, a fluctuation in volume has less effect on the costs. This topic is discussed in more detail in chapter 6.2 and illustrated in Figure 6.7.
Industry-toolkit strategies also affect the quality of the products. Firstly, the combining of expertise from the participating OEMs can help to improve the quality of the product. Secondly, the increased production volumes lead to learning effects, which result in improved product quality.[105]

Weaknesses

An industry-toolkit strategy brings with it not only advantages, but also has several weaknesses that might prevent OEMs from following such an approach.
One of the most obvious weaknesses of industry toolkits is that OEMs have to accept certain restrictions concerning engineering and design freedom. In

[105] cf.: Kneip, J.G. (1965), pp. 398

collaborations with other OEMs, compromises have to be found, so that the shared components fulfill the requirements of all participants. Furthermore, interfaces have to be flexible enough to support individual components of all partners.

An additional disadvantage of industry-toolkit strategies is the complication of the change management process for the toolkit. All the changes over the lifecycle have to be coordinated and approved by all partners. It might be the case that some participants have differing opinions and so decisions can take a long time, or no compromises can be found at all. It is therefore necessary to define beforehand, who of the participants has the last word in engineering, design and management issues. This poses a big problem, as not many OEMs are willing to give away such decisions to other car manufacturers.

Another fundamental weakness of industry-toolkits is the coordination of the different timelines of the participating industry-toolkit partners. Each OEM follows its own specific strategy concerning the time interval between the development of new derivates or even new model-generations. These development steps have to be coordinated and timed between the industry-toolkit partners. For the OEMs, this implies that they have to come to a compromise and might be forced to change their strategy concerning development cycles.

Opportunities

The application of Industry toolkits also offers some opportunities for the participating OEMs.

Firstly, there is the possibility for OEMs to increase their market share through entering new markets or segments that did not seem profitable without industry-toolkit cooperations. The achievable cost reductions offer the chance to attract new customer segments in the low-cost region.

Secondly, there is the possibility for the OEM to profit from its industry-toolkit partner. Especially in cases where the participants have different areas of expertise this can be a diver for industry-toolkits.

Furthermore, industry toolkits offer the opportunity to introduce premium-class technology in lower vehicle classes. This is possible through the cost reductions that can be achieved with higher volumes. At the same time, the costs for the premium vehicles are reduced.

Threats

One of the biggest threats of industry-toolkit strategies is the problem of reduced differentiation. Using the same modules or components in different models leads to similarities between them. It is therefore essential to carefully choose which part of a car should be included in the industry-toolkit and which should remain individual. This issue is especially critical for toolkits shared between independent OEMs, as it might lead to cannibalization or unwanted customer flows between the participants.

Resulting from the problem of reduced differentiation, there is also the threat of a possible loss of reputation. If customers perceive two models from different brands as essentially the same, this will have negative effects on the higher-valued brand's image. Therefore, an industry-toolkit strategy is especially critical for premium brands that put their price-premium at risk. This risk can be reduced if the industry-toolkit partners are perceived as of more or less equal value by the end-customer.

From a quality perspective, the increased production volumes also bring with it a big risk. If there are quality problems, a much bigger volume is impacted. This can, in a worst case scenario, lead to extended recalls across several models and even bands. In order to prevent this from happening, a well-functioning quality-control is a requirement for industry toolkits.

As mentioned above, industry-toolkit partners have to accept restrictions in engineering and design freedom. The necessary compromises to ensure flexibility, might lead to designs that may not represent the perfect technical solution (e.g. oversized components). It is therefore important for OEMs invest additional resources in design and engineering for clever solutions that combine both, flexibility and technical optimization.

5.2 Supplier Perspective

The application of industry-toolkits not only affects the OEMs involved, it also has several consequences for the supplier business. These consequences are explored on the following pages.

Strengths

Most of the benefits of the scale effects resulting from industry-toolkit application will be on the OEM side. However, the reduced parts price, that supplier can offer through industry-toolkits, can hardly be achieved through conventional approaches. Therefore, suppliers with the capability to offer industry-toolkit solutions will have a competitive advantage.
Another main advantage for the supplier is the reduction of the number of variants in production. Instead of producing different variants of one module for each OEM, the production is consolidated and the same module is sold to multiple OEMs.
Closely related to this topic is the standardization of manufacturing and testing processes, which is necessary for a successful industry-toolkit strategy. This standardization reduces the complexity of the processes and enables the supplier to be even more cost effective.

Weaknesses

An obvious weakness of an industry-toolkit strategy for the supplier is the increased requirements for the modules from the OEM side. All interfaces have to be highly flexible and multiple expectations from all participants have to be fulfilled. This requires increased development efforts and implies that developing industry-toolkits will be more cost and time intensive than the development of modular toolkits.
The before mentioned coordination of timelines will also be a problem for the suppliers involved. The development steps have to be coordinated and timed between the participants, which is a big managerial challenge for the supplier.

The high volumes that can be reached with industry toolkits also affect quality control at the suppliers. Due to the fact that quality issues impact much bigger volumes, it becomes essential to ensure a high-level quality control. Only then can the risk of quality problems be kept at an acceptable level.

Opportunities

The biggest opportunities for suppliers, which industry-toolkits bring with them, are potentially bigger awards. Through sharing certain modules over multiple OEMs, the produced units per module are consequently higher than with conventional awards. This means that higher revenues per award can be expected.

Furthermore, the higher volumes achieved through industry toolkits facilitate the introduction of new technologies from the supplier side. A new technology introduced via an industry toolkit has a much higher market-entry volume and consequently higher chances of being successful.

Additionally, the standardization of manufacturing and testing processes also offers suppliers the opportunity to improve the efficiency of their quality control.

Threats

From a supplier perspective, there exist several serious threats that have to be considered.

The consolidation of awards from multiple smaller ones to one large award brings with it several risks. Firstly, if industry toolkits become common practice, there will consequently be fewer awards, which lead to an intensified competition between the suppliers.

Secondly, reduced revenue for the same volumes can be expected. This is due to the fact that at the moment development costs can be charged for each separate project. If these projects are then consolidated, the revenues for the development and engineering will decrease.

A third quite crucial point is that the risk in case of quality problems is, as pointed out before, increasing with the size of the awards. In the case of industry-toolkits, a certain component or module will be integrated not only

into a higher number of vehicles, but also various brands of different groups. Consequently, the damage would be far worse than with quality problems at conventional projects. This risk is additionally increased by the high number of new parts that would have to be developed for any new industry-toolkit.
In case of timing problems there are also higher volumes affected. If, for example, the deadline for the start of production (SOP) cannot be met, this could cause severe costs for the supplier. Additionally, there is a higher risk of reputation loss for suppliers as multiple customers are affected in one project.

5.3 Overview

For a compact overview on the strengths, weaknesses, opportunities and threats of an industry-toolkit strategy, the above mentioned statements are summarized in Figure 5.1. The points written in bold text primarily apply to OEMs, while the points written in normal text affect mainly the supplier business.
It can be seen that, from an OEM perspective, there are quite a high number of advantages an industry-toolkit strategy can bring with it. Nonetheless, there are also several disadvantages and risks that have to be considered.
Form a supplier perspective there are approximately as many advantages as disadvantages. This means that, in order to profit from the advantages, the suppliers have to accept these trade-offs and try to minimize the risks involved. It is therefore quite likely that industry-toolkit strategies will mainly be driven from the OEM side and not so much initiated by the supplier business.

S

OEM

- **Reduced part price (Economies of Scale)**
- **Sharing of development costs**
- **Investment sharing**
- **Business case improvement for niche-models**
- **Affordable small-volume Business cases**
- **Decreased cost-sensitivity on volume fluctuations (through additional volume)**
- **Quality improvement (combining of different OEM expertise)**
- **Quality improvement through high volume processes**
- **Affordable low-volume functionality options with low take-rates in higher volume vehicles**

Supplier

- Reduction of number of variants in production
- Better competitive position through cost reductions
- Cost reduction through standardization

W

OEM

- **Restrictions in Design/ Engineering Freedom**
- **Change management over life-cycle**
- **Coordination of different Timelines**

Supplier

- Increased requirements due to multiple expectations from OEM side
- Increase of development costs and time due to multiple requirements (flexibility of interfaces)
- Improved Quality-control necessary
- Coordination of different Timelines

O

OEM

- **Entering new markets/customers (increase of market share) through reduced costs**
- **Profiting from ITK partner (Knowledge)**
- **Introduction of premium-class technology in lower vehicle classes through price reductions**

Supplier

- Bigger awards → higher revenues per award
- Facilitation of market entry with new technologies (higher entry volume)
- Improved quality control through standardization of manufacturing and testing processes

T

OEM

- **Reduced Differentiation**
- **Reputation loss through insufficient differentiation**
- **In case of Quality problems bigger volume impacted**
- **Decreased optimization due to compromises**

Supplier

- Reduced revenue for same volume (Only one large order instead of multiple smaller ones)
- Increased Competition
- Higher risk in case of quality and timing problems (SOP)

Figure 5.1: SWOT-Analysis Industry toolkit

6 Criteria for Component Suitability

In order to determine which parts of a vehicle have the potential to be shared across different OEMs, it is necessary to define the criteria for industry-toolkit suitability in a first step. In this chapter, these criteria are identified and subsequently analyzed on their influence.

Essentially, there exist the following two categories of prerequisites that have to be fulfilled, so that a certain module or component of a car has the potential to be shared across different brands or even groups:

- Brand differentiation
- Economic benefits

For one thing, it is essential that the necessary differentiation between models from different OEMs is ensured. The main principle of an industry-toolkit is using the same modules across vehicles from different OEMs. One of the major drawbacks of this strategy is that, with an increasing amount of commonality, the differences between the vehicles decrease. Consequently, it gets harder for the customer to differentiate between the different brands, or in other words, the brand loses its specific characteristics. It therefore makes sense to only use modules as part of an industry-toolkit which have no or little influence on differentiation.

When differentiation is ensured, economic factors come into play. As seen in chapter 5, several disadvantages and risks are connected with an industry-toolkit strategy. It is therefore essential that the economic benefits outweigh these disadvantages and risks involved.

On the following pages these two categories of criteria are discussed and analyzed in more detail.

6.1 Brand Differentiation

The topic of differentiation, especially concerning strategies that involve common or shared parts, is a very important one in the automotive industry. Each automotive brand aims at developing a certain brand image with very specific characteristics concerning design, quality or driving experience. If not approached in the right way, the use of common parts across products of one company or even across products of competitors leads to a situation where these products get increasingly similar concerning their characteristics as well as achievable prices. This results in many cases in a customer-shift from superior brands towards brands of lower value. That was, for example, the case with Volkswagen and Skoda in the late 1990s.[106]

Figure 6.1 illustrates the Volkswagen case and shows the customer flows in the years 1997 and 1999 between the group's brands. As a result of increasing communization and decreasing differentiation between the brands, customers switched towards lower positioned brands like Seat and Skoda. This cannibalization within one group can be accepted to a certain degree, but is far more problematic if it happens between competitors which would be the case with an undifferentiated use of industry-toolkits.

[106] cf.: Proff, H. et al. (2012), pp. 129

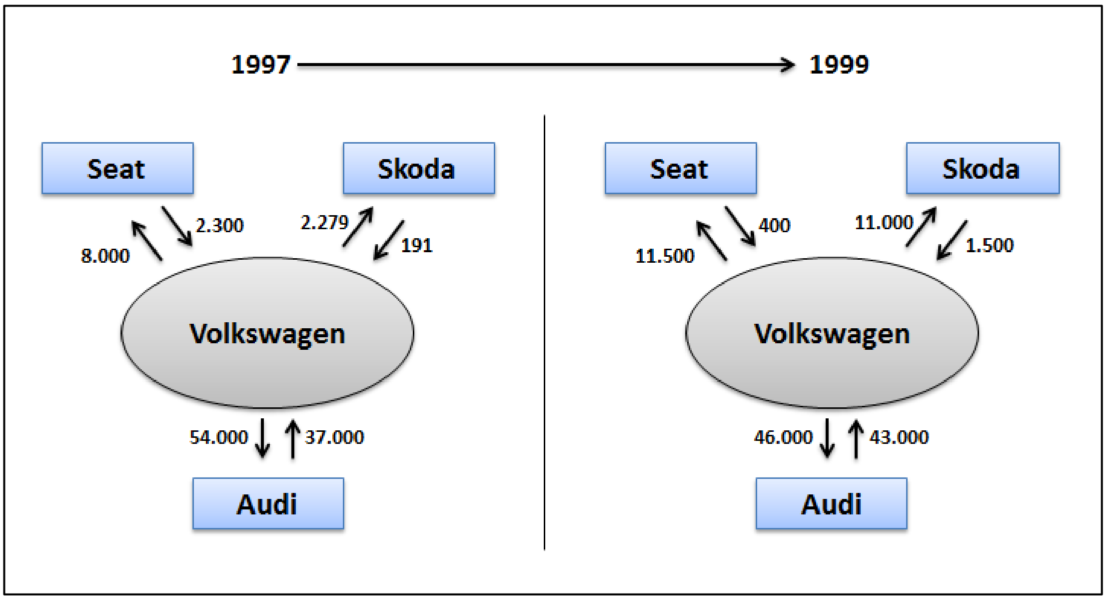

Figure 6.1: Cannibalization within the Volkswagen group[107]

It is therefore essential, especially for premium brands, to ensure differentiation from other brands in order to prevent the loss of market share and maintain their price-premium.[108]

6.1.1 Basics on Product-Differentiation

The amount of differentiation between products based on the same platform or toolkit can be influenced by two factors. Firstly the amount of parts shared. There always exists a trade-off between commonality and differentiation. If all parts in two different products were the same, it would not be possible for the customer to see any differences between them. If no parts were shared the distinctiveness of the products could be arbitrarily high. Depending on the product architecture of the platform or toolkit, this trade-off can take different forms.[109]

Figure 6.2 illustrates this trade-off and shows examples for different product architectures and amounts of commonality. The preferable architecture of these examples would be Architecture 3, as this one allows a high amount of

[107] Own illustration based on Wallentowitz, H. (2008), p. 82

[108] cf.: Proff, H. et al. (2012), pp. 139

[109] cf.: Robertson, D. et al. (1998), p. 22

commonality without substantial loss of distinctiveness. Consequently, any OEM has to decide accordingly to its strategy if a high amount of commonality and the related cost reductions, or the distinctiveness of its products is of more value.

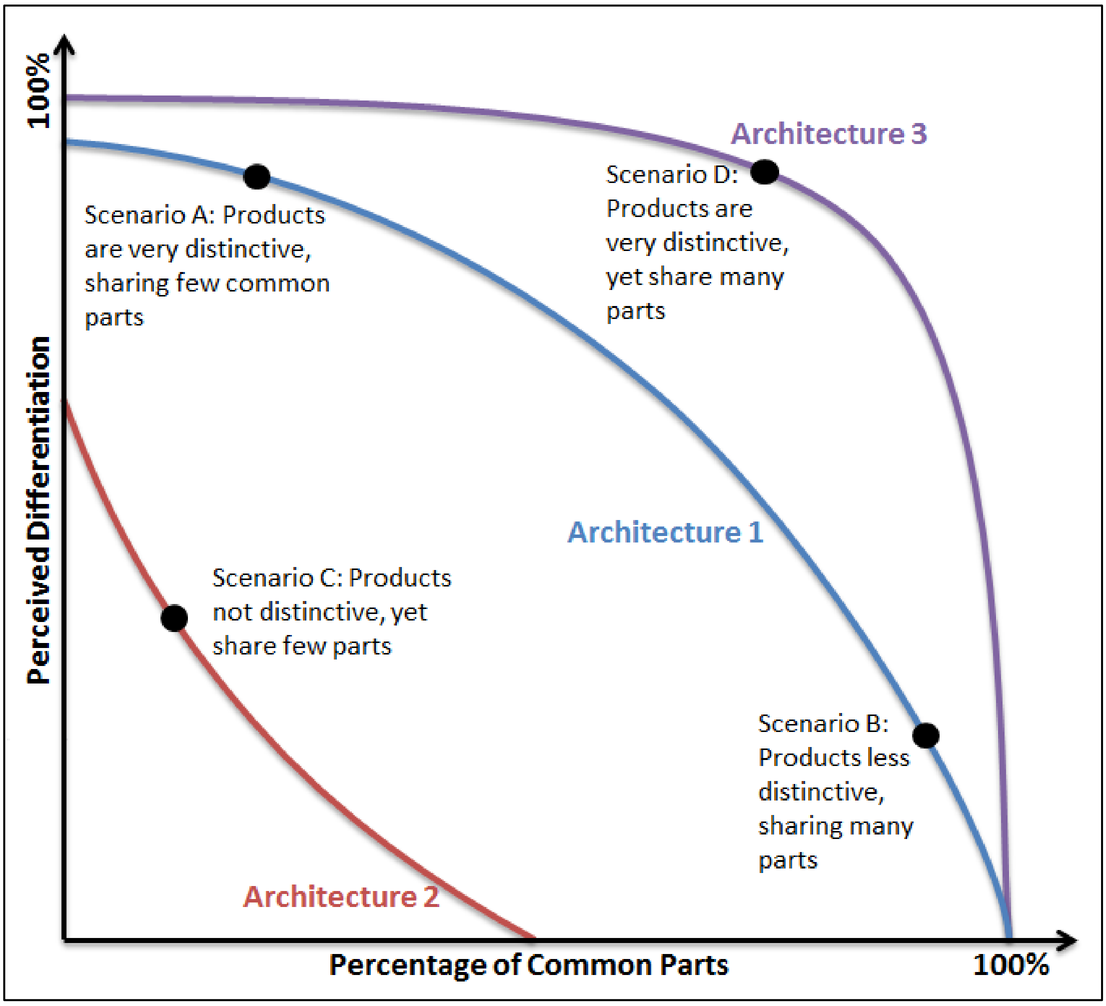

Figure 6.2: Trade-off between commonality and differentiation[110]

Secondly, it is of great importance which modules are part of the platform or toolkit. One of the basic rules of platform-strategies is to standardize components and systems in non-visible areas, while differentiating in areas that can be perceived optically or physically by the end-customer.[111] In other words, it is necessary to ensure sufficient differentiation potential of a

[110] Own illustration based on Robertson, D. et al. (1998), p. 22

[111] cf.: Wallentowitz, H. et al. (2001), p. 39

platform or toolkit, especially when it serves as the base for vehicles of different OEMs.

The fact that product differentiation is of special importance in the case of industry toolkits makes it a complex, yet necessary task, to identify those modules that have the potential to be shared without significant loss of differentiation. It also has to be considered that all brands, especially premium brands, have different core attributes that are strongly connected with the brand image. These specific characteristics also have great influence on the sharing potential of the modules related to them. Therefore, some modules that would generally have big sharing potential, will not work for some OEMs as they define the characteristics of the brand.

To illustrate this, we take the case of BMW. Figure 6.3 shows the relevance of different car modules according to the BMW brand. Already by taking a look at the brand's slogan "Sheer Driving Pleasure" it is obvious that for BMW it would damage the brand's competitive advantage if modules like the motor, the steering or parts of the chassis were shared with competitors.

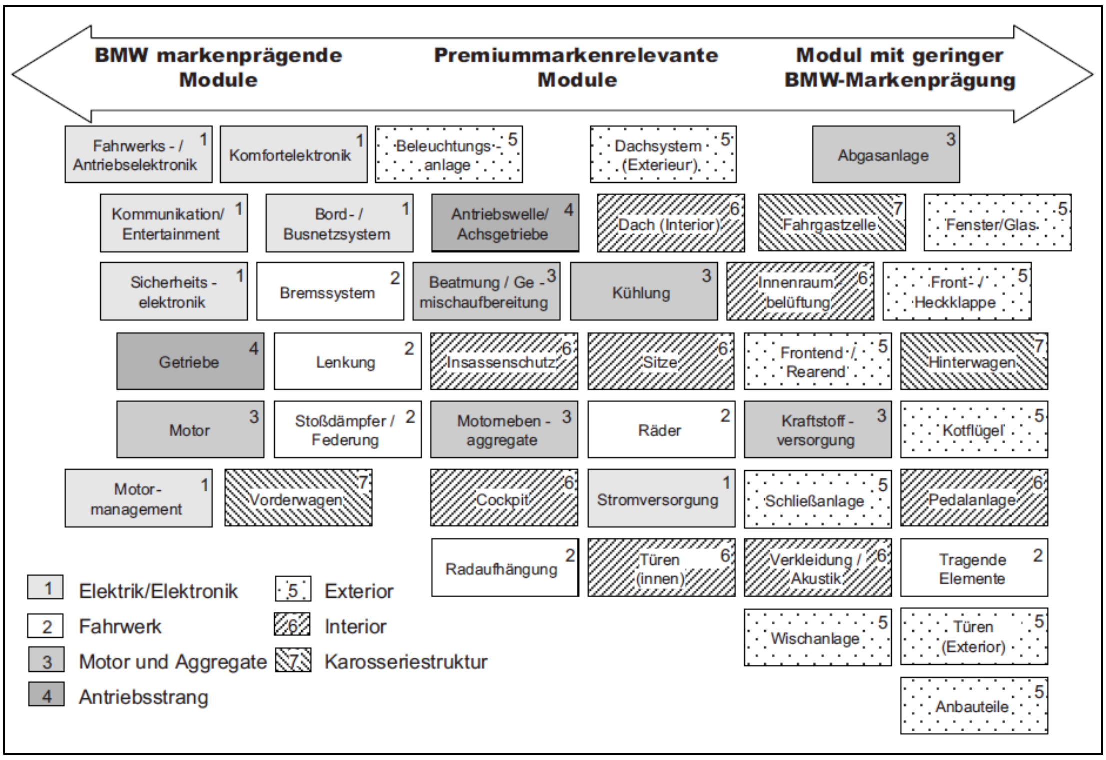

Figure 6.3: Module-relevance for BMW brand image[112]

[112] Wallentowitz, H. (2008), p. 80

With these restrictions in mind, it is possible to identify the criteria to evaluate automotive modules according to their influence on differentiation and their potential suitability for industry-toolkits.

6.1.2 Differentiation Criteria

As indicated before, it is necessary to differentiate at those modules that can, in any form, be perceived by the end-customer. Human perception is essentially based on the five senses:

- Optic
- Acoustic
- Haptic
- Olfactory and
- Gustatory

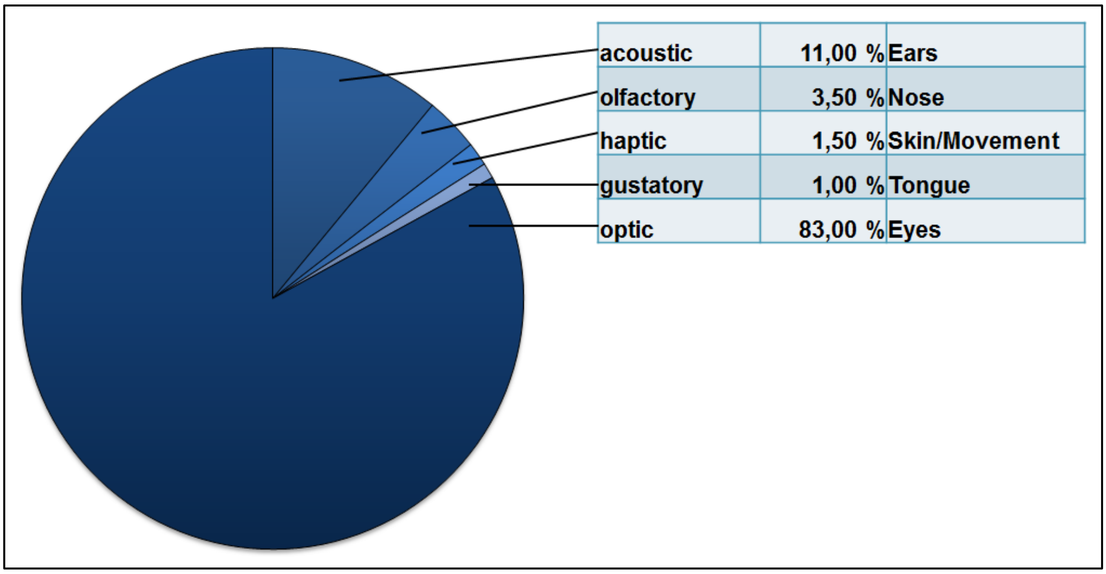

Figure 6.4: Distribution of sensory perception[113]

Figure 6.4 shows the percentage share of sensory perception of each sense. Optic perception is by far the most influential one with approximately 80%

[113] Own illustration based on Kilian, K. et al. (2005), p. 12

followed by acoustic perception with 11%. Together these two senses account for 94% of our sensory perception. However, due to sensory overload we experience nowadays, especially concerning acoustic and optic perception, the other senses should not be left out of consideration to communicate differentiation to the end-customer.[114]

Table 6-1 shows the relations between product attributes and the five modes of sensory perception. Once again it is easy to see that visual and auditive perception play an important role in perceiving a majority of product attributes. Haptic perception, however, also plays a crucial role, as almost all of the mentioned product attributes can be perceived, either directly or indirectly, that way.

Sensory organ	Eyes	Ears	Nose	Skin	Mouth
Modality	visual	auditive	olfactory	haptic	gustatory
Material	●	○	○	●	○
Form	●			○	
Color/Light	●			○	
Smell/Gas	○		●	○	●
Aroma			●		●
Sound/Tone	○	●		○	
Movement	●	○		○	
Temperature	○	○		●	
Space	●	○		●	
Force				●	
Legend: ● = always applies, ○ = applies partially / indirect					

Table 6-1: Relations between product attributes and perception[115]

Olfactory and gustatory perception, on the other hand, play an insignificant role concerning differentiation and automotive industry toolkits. For one thing, gustatory perception does not have any significance in the automotive industry at all. Concerning olfactory perception, there are several approaches

[114] cf.: Kilian, K. et al. (2005), p. 12

[115] Own illustration based on Kilian, K. et al. (2005), p. 12

towards including this mode of perception, as scents can serve as an indicator of quality in the vehicle interior. It does, however, not apply to the case of industry toolkits, as scents are not necessarily linked to certain modules and can be modified at a later point in the value chain through the use of aromas.

This leaves us with three crucial modes of sensory perception concerning differentiation in the automotive industry, listed according to their significance:

1. Optic perception
2. Acoustic perception
3. Haptic perception

6.2 Economic Criteria

The next step, after identifying the influential factors on differentiation, is to examine the industry-toolkit strategy from a cost perspective. Due to the several drawbacks of an industry-toolkit strategy mentioned in chapter 5, such an approach will only make sense for OEMs if a significant reduction of costs can be expected.
In order to evaluate the suitability of certain modules for industry-toolkits from an economic perspective, it is necessary to identify the influential factors on the cost-saving potential.
The influential factors on the cost function can be structured the following way:

- **Fixed Costs:**
    - Development & Validation Costs
    - Initial Investments

- **Incremental Costs:**
    - Tool costs
    - Assembly line extension costs

- **Variable Costs:**
    - Procurement Costs
    - Labor Costs

- **Additional Factors:**
    - Tool capacities
    - Assembly line capacities

Figure 6.5 illustrates how these factors influence the total costs depending on the production volume. While the sum of all variable costs is rising constantly with the production volume, tool costs and assembly line extension costs cause steps in the cost function whenever capacities are reached. Fixed costs, on the other hand, include all investments that have to be made before the production starts.

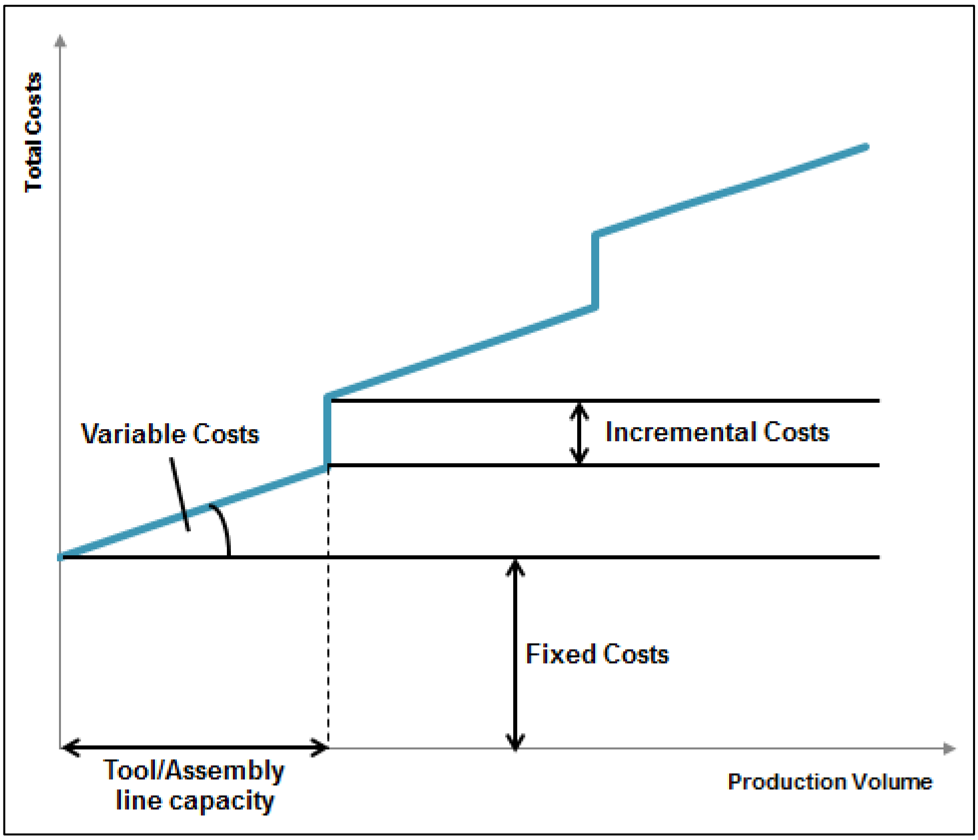

Figure 6.5: Influencing factors on cost-function

One of the main goals of industry toolkits is to reduce the costs per unit through scale effects. Therefore, it is necessary to investigate how each of

these influence factors affects the costs per unit depending on the production volume and thus, their influence on the cost saving potential.
In order to do that, an approach similar to that of a sensitivity analysis is used. In a first step, each of the above mentioned influence factors are varied separately. Subsequently, the effects of these variations on the cost per unit function are examined. These examinations are then used to draw conclusions on how the cost structure of a module should look like to increase economic benefits of industry toolkits.
The example used for this investigation is a cradle for premium C-segment-cars and are backed by data from the IHS database and Magna internal data on production. The calculations are based on a 7-year horizon.

6.2.1 Fixed costs

Figure 6.6 shows the influence of the fixed costs on the costs per units as a function of the production volumes per year. For a better demonstration of this influence, this diagram only considers development (representative for fixed costs) and tool costs (representative for incremental costs). Variable costs would only increase the costs per unit, independent of the production volume. The black lines in the pictures show exemplary production volumes of some vehicle models for better orientation.

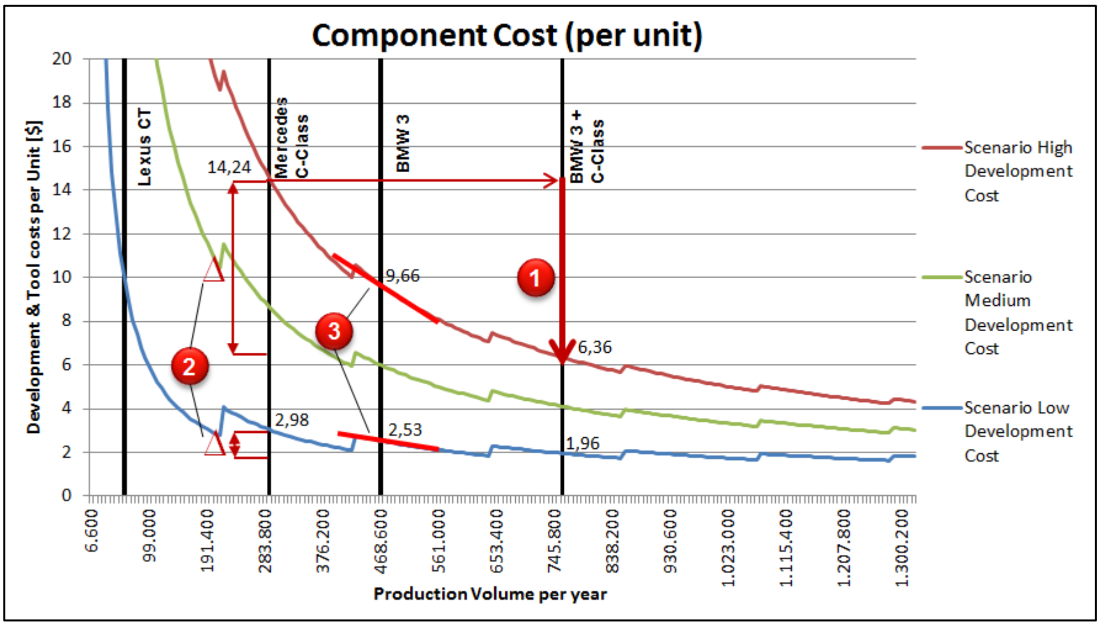

Figure 6.6: Influence fixed costs

The first and most obvious observation in this example are the economy of scale effects. Higher production volumes lead to lower costs per unit. (see 1) As fixed costs are non-recurring investments and independent of the production volume, these costs can be shared perfectly between industry-toolkit partners. The higher the production volume, the lower is the proportion of fixed costs in the costs per unit.

Resulting from this, a high ratio of fixed costs in the overall cost structure leads to an increased cost reduction potential with increasing volumes (see 2). In other words, the ratio of fixed costs should be high to increase economic benefits from industry-toolkits.

This can be observed very well at our fictional example in Figure 6.6, combining the volumes of the Mercedes C-class and the BMW 3. In the high development cost scenario, the costs per unit for Mercedes are 14,24$, for BMW 9,66$ and for the industry-toolkit 6,36$. This means that Mercedes could achieve a cost reduction of approximately 55% and BMW could achieve a cost reduction of 34%. In the low development cost scenario, the possible cost reductions would only be 34% for Mercedes and 23% for BMW.

Additionally, a high amount of fixed costs increase the cost-gradient, especially at lower volumes (see 3). This results in an increased costs sensitivity in case of production volume fluctuations, which is a highly unwanted effect in production. As Figure 6.7 shows, to reduce this costs sensitivity, higher production volumes would be favorable.

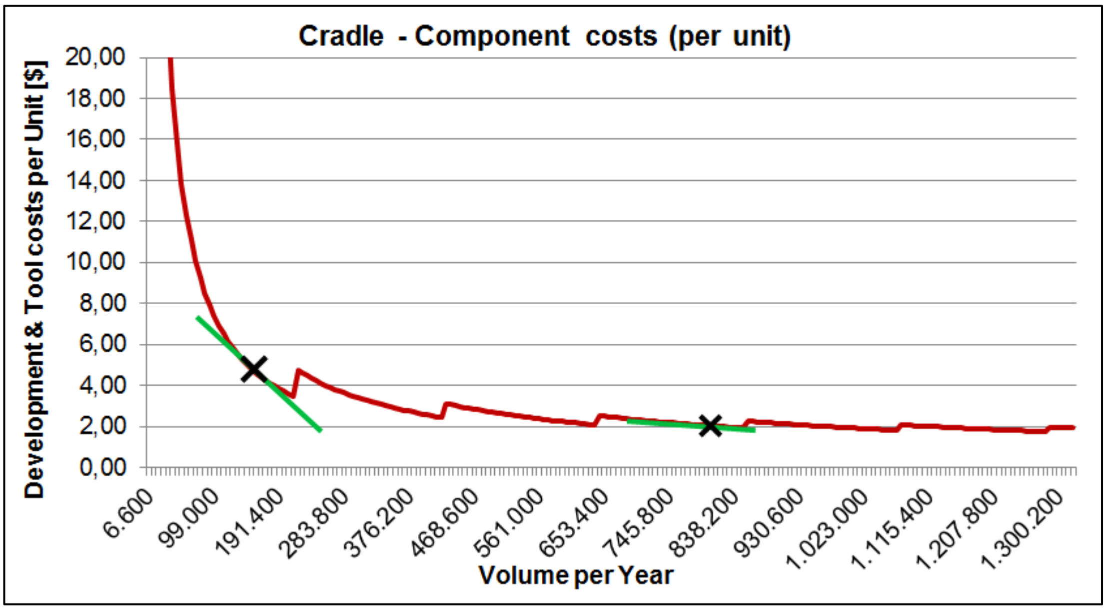

Figure 6.7: Decreasing cost-sensitivity with production volume

The costs per unit (C) consist of the fixed costs (Fc) per unit, the incremental costs (Ic) per unit and the variable costs per unit (Vc). N represents the production volume:

$$C = \frac{Fc}{N} + \frac{\sum Ic}{N} + Vc$$

The first derivative of this function results in the function for the cost gradient or cost sensitivity:

$$\frac{dC}{dN} = -\frac{Fc}{N^2} - \frac{\sum Ic}{N^2}$$

The quadratic influence of the production volume leads to smaller negative cost gradients with increasing volume. Although the term including the incremental costs is not decreasing steadily due to the stepped function, it decreases with each capacity interval.

This means that through increasing the production volume, for example through the application of industry-toolkits, the risk of high cost-sensitivity can be reduced. Double volumes can thus lead to risk reductions of up to 50% at the same percentage fluctuation. The potential of this risk reduction depends mainly on the ratio of fixed to incremental costs. In the preferable case, the fixed costs would be the dominant cost type.

Summing up, a high ratio of fixed costs in the overall cost structure favor the use of industry-toolkits.

6.2.2 Tool Costs

Tool costs are incremental costs, which means that whenever the capacities of the tools are reached, an additional tool is necessary. This causes a step in the cost function. The higher the tool costs, the bigger the steps will be.
As Figure 6.8 shows, these steps can lead to situations where an increase in capacity provides hardly any cost reduction or even a cost increase. Especially with high tool costs and at high volumes these situations are more likely to occur. It is then of far greater importance to increase capacity utilization instead of the production volume. (see 1)

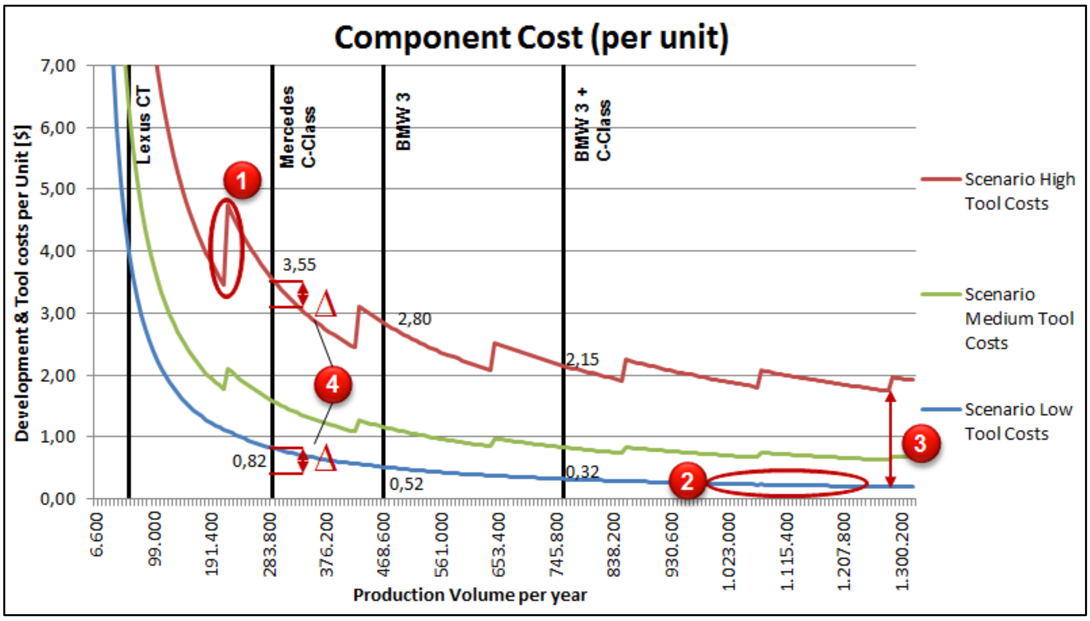

Figure 6.8: Influence tool costs

Secondly, if the tool costs are relatively low in comparison to the development costs, the function will be much smoother. (see 2) This, in turn, increases the probability of a cost reduction through increasing production volumes. Consequently, additional volumes through industry-toolkits will necessarily reduce costs in this case.
The third observation to be made here is that, especially at high volumes, tooling is one of the major cost drivers for overall component costs. (see 3) This happens because at higher production volumes the fixed costs per unit sink. Consequently, incremental and variable costs become the major cost drivers.
Low tool costs also lead to lower overall costs. This means that the relative cost reductions through scale effects are much higher. (see 4) For example, a cost reduction of 0,5$ from initial costs of 4$ would be a cost reduction of 12,5%. If the initial costs were only 2$, this would lead to cost reductions of 25%.
A low ratio of tool costs in the overall cost structure is therefore more favorable for industry-toolkits and increases its economic benefits.

Figure 46 in the appendix shows some exemplary vehicle parts with different proportions of development and tool costs. Comparing these different cost-functions, it becomes obvious that each of these scenarios require differentiated strategies. The case of high development costs and low tool costs on the left side offers a smoother cost function. This allows more or less continuous cost reductions with increasing volume. Here the focus should lie on maximizing the production volume and industry-toolkits represent a suitable approach for that.
The case of low development costs and high tool costs on the right side results in high incremental steps in the cost functions. Here it is more important to ensure capacity utilization than increasing production volumes.
In a worst-case scenario an increase in volume could even result in a cost increase.

6.2.3 Tool capacities

For tools there are two different kinds of capacities that are of interest in this work:

- The tool capacity per year
- The overall capacity per tool

The capacity per year describes the maximum amount of units that can be produced with one tool per year. In other words, it defines how many tools need to be used simultaneously.
Secondly, there is the overall capacity per tool. It describes how many units can be produced over the lifetime of a tool and determines the overall number of tools necessary for a whole project (the examples are calculated on a 7-year basis).
As investigations will show, both types of tooling capacities have very similar effects on the cost function.

Figure 6.9 shows the influence of the tool capacity per year on the costs per unit. The diagram, once again, only considers development and tool costs for a better demonstration of how the variation of tool capacities affects the cost function.

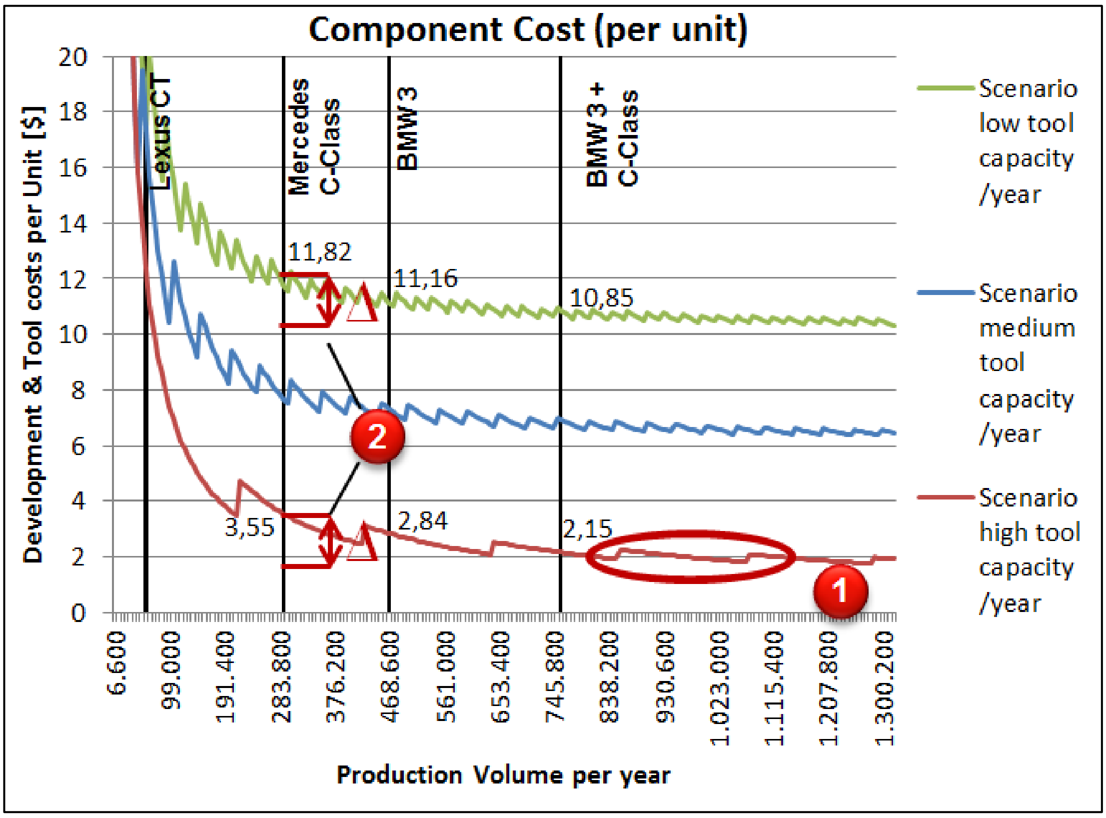

Figure 6.9: Influence tool capacity/year

Firstly, higher tool capacities per year cause a smoother cost function and an increase in volume flexibility (see 1). This facilitates the achievement of cost reductions, even at higher volumes.

Secondly, low tool capacities per year increase the overall costs per piece, as more tools are necessary. This leads to a reduction of the relative saving potential. (see 2) This effect is very similar to the one already described in the section Tool Costs.

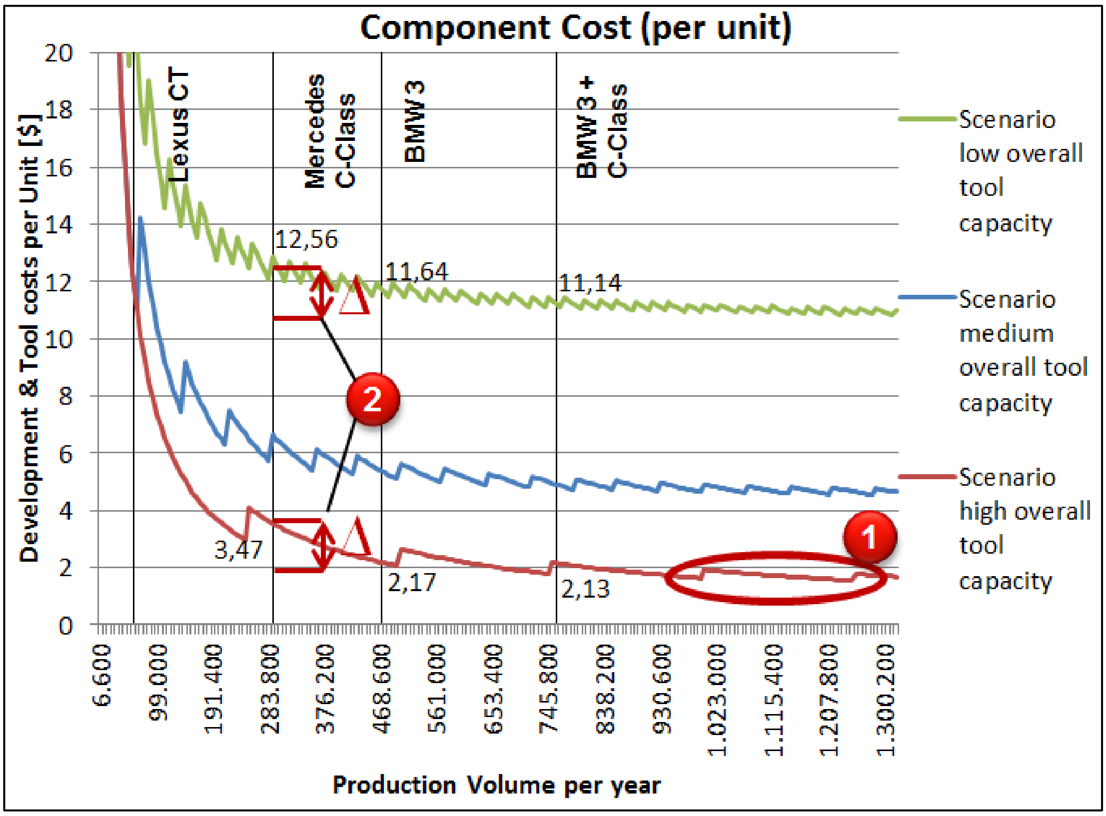

Figure 6.10: Influence overall tool capacity

Concerning the influence of overall tool capacities, the effects are very similar to those of the capacities per year. As can be seen in Figure 6.10, higher overall tool capacities lead to smoother cost functions (see 1) and increased relative savings potential (see 2).

6.2.4 Assembly Line Costs & Capacities

Concerning the influence of assembly line costs and capacities, very similar effects to those of tool costs and capacities can be observed.

The following calculations consider development costs (representing fixed costs), tool costs and assembly line costs (representing incremental costs). Again, variable costs are not considered here for a better demonstration of the effects on the cost function.

Figure 6.11 shows the effects of varying assembly line costs. Similar to what has been observed with tool costs, high assembly line extension costs cause big steps in the cost function (see 1). It is important to note that the costs for the first assembly line can be considered as fixed costs and therefore be shared between the industry-toolkit partners. All extensions to this initial line have to be considered as incremental costs and should therefore be as low as possible. In other words, a cost situation with high costs for initial investments, but cheap extensions for the assembly line favor the application of industry-toolkits.

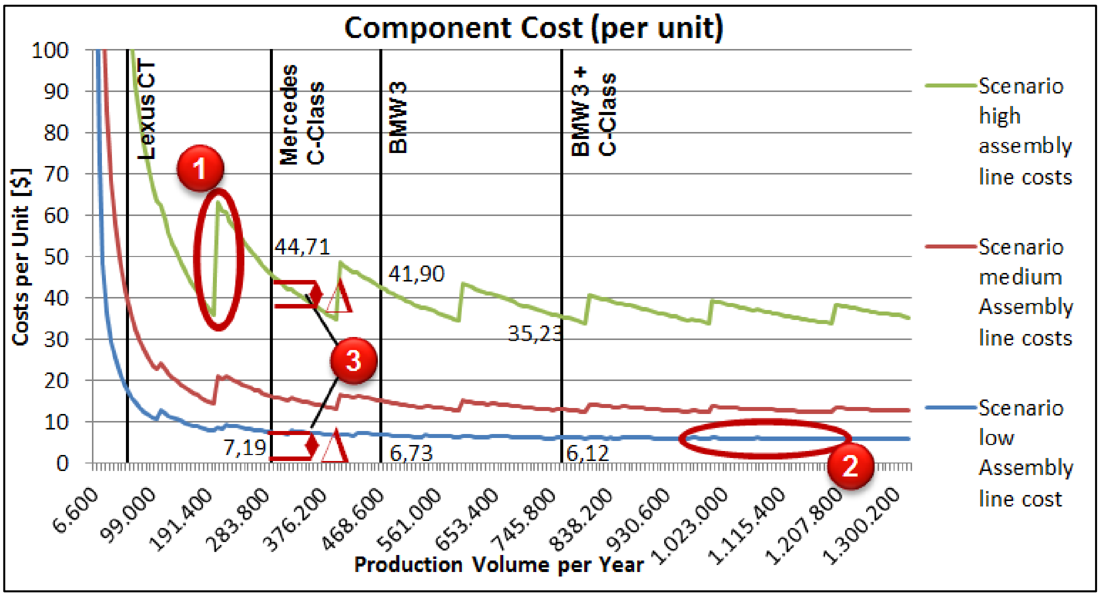

Figure 6.11: Influence assembly line cost

Low assembly line extension costs result in a smoother cost function which facilitates the achievement of cost reductions, even at higher production volumes (see 2). Additionally, cost sensitivity is reduced.
With lower assembly line costs, the overall costs per unit also sink. Consequently, lower assembly line costs increase the relative saving potential as already explained before (see 3).

Figure 6.12 illustrates the effects of assembly line capacities. Higher assembly line capacities cause smoother cost functions with less frequent incremental steps (see 1). This facilitates the achievement of cost reductions through additional production volume. Additionally, the cost gradient is reduced, and with it cost sensitivity.

Secondly, the higher the capacity, the lower the overall costs. This increases, as we have seen before, the relative saving potential (see 2).

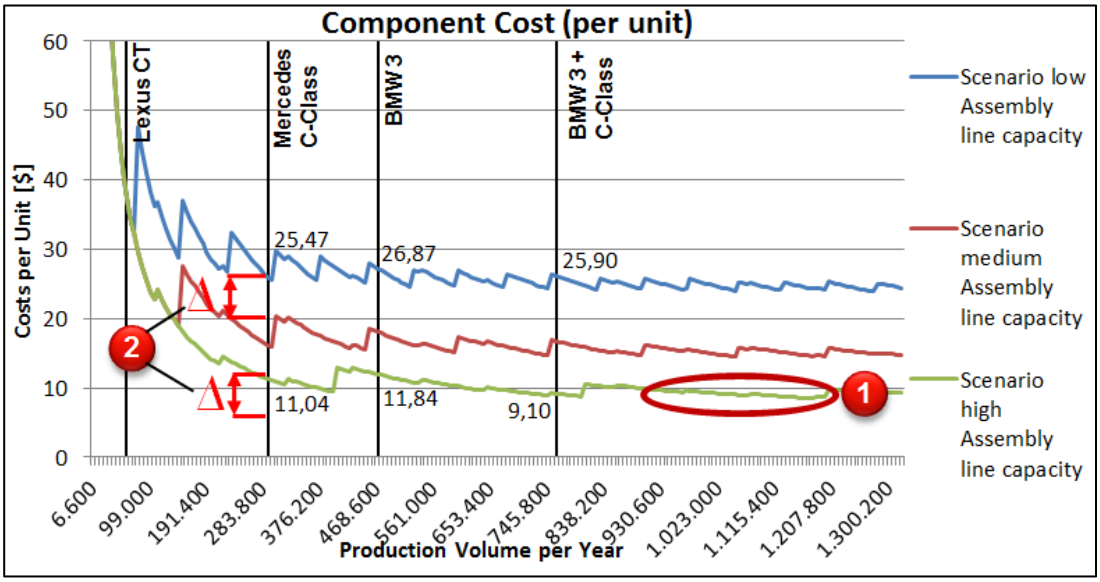

Figure 6.12: Influence assembly line capacity

Summing up, industry-toolkits require high capacity assembly lines with affordable extensions to be cost-effective.
It is important to note that costs for assembly lines are usually a multiple of what tooling costs are. Therefore, the influence of assembly line costs and capacities is far greater than that of tooling, although the effects are very similar. Figure 6.11 and Figure 6.12 consider both assembly line and tool cost. However, the effects of tooling can hardly be perceived in comparison to those of assembly lines. Modules with a suitable cost structure from an assembly line perspective should therefore be prioritized.

6.2.5 Variable Costs

The main part of the variable costs consists of procurement costs and labor costs.

As the labor costs per unit can hardly be influenced by the production volume, they only have a minor significance for industry-toolkits. However, as we have seen before, low overall costs per unit increase the relative savings potential. Consequently, a low ratio of labor costs in the cost structure is favorable. This can, for example, be achieved through a high degree of automation.

Concerning procurement costs, a differentiation has to be made between procurement for raw materials and for components from tier-2 suppliers. In order to understand how the production volume influences the costs for procurement, interviews were conducted with Magna employees from the procurement department, as well as with sales personal from suppliers.

The price for raw materials, like for example sheet metal, can vary significantly as a result from market developments, capacity utilization and from strategic reasons at the supplier. Under the right circumstances price reductions through higher volumes can be achieved. Big customers like Magna usually have consolidated procurement for raw materials. This means that scale effects are already used to a large part.
The cost situation for a tier-2 component supplier is very similar to the one at tier-1 suppliers shown in the previous diagrams. It is highly dependent on capacity utilization and the saving potential is reduced at higher production volumes. These cost effects can then drip down the supply chain.
All in all, management for these factors is required. Under the right conditions, however, there is potential for additional savings.

Summing up, variable costs are those costs that cannot be shared between the industry-toolkit partners. Therefore, they should be reduced to a minimum in order to favor the application of industry-toolkits.

7 Results

This chapter will sum up the most important conclusions reached within this piece of work. There are four essential statements that can be made answering the following questions:

- Who will be the main initiator of industry-toolkit strategies?
- Who are the potential participants in an industry-toolkit?
- Which modules, from a differentiation perspective, are suitable for industry-toolkits?
- What should the cost structure for the production of an industry-toolkit module look like to maximize economic benefits?

Furthermore, an excel-tool for the evaluation of modules on their suitability for industry toolkits has been developed. This tool follows the approach used for this work and should serve as a support for strategic decisions.

7.1 Potential Initiators for Industry Toolkits

Taking a look at chapter 5 and especially Figure 5.1, it becomes obvious that most advantages are on the OEM side. Despite several disadvantages an industry-toolkit strategy brings with it, there are still significant advantages concerning cost reduction, quality improvements and strategic issues. Each OEM will have to balance the trade-offs for industry-toolkits individually. If the cost-pressure, however, gets too big, there will be several OEM considering the option of an industry-toolkit.
For suppliers, on the other hand, the trade-offs that have to be accepted with industry-toolkits are much higher. Figure 7.1 illustrates one major problem resulting from industry-toolkits that suppliers have to face. With the application of industry-toolkits, multiple OEMs are consolidated into one large customer. Firstly, this puts suppliers in a situation with increased competition with each other. Secondly, OEMs achieve a bargaining advantage over the suppliers through their increased volume.

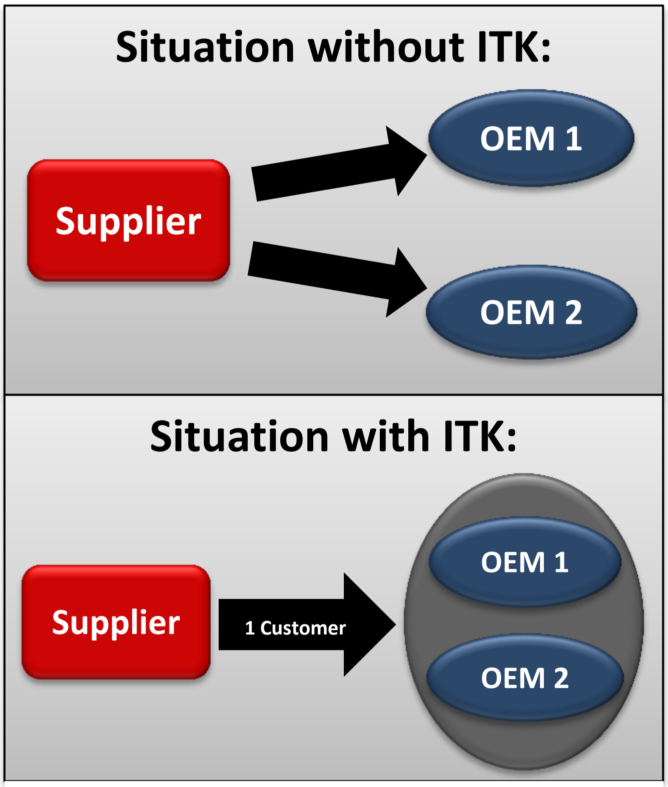

Figure 7.1: Trade-offs for suppliers

To sum up, industry-toolkits bring more advantages on the OEM-side while requiring big trade-offs for suppliers. This speaks in favor of the thesis that industry-toolkits will be initiated from the OEM side.

7.2 Potential Industry Toolkit Partners

Before being able of making a statement on the potential of different OEMs for participating in an industry-toolkit, the OEMs need to be structured in different groups. For our purposes it is most suitable to divide the OEMs up into the three following groups:

- High-Volume OEMs (e.g. Volkswagen, Toyota, Ford, GM,…)
- Low Volume OEMs without premium standards (e.g. Mitsubishi, Mazda,…)
- Premium OEMs (e.g. BMW, Daimler, Volvo,…)

Figure 7.2 shows the three OEM-groups. It also includes representative examples and the main advantages and disadvantages of an industry-toolkit partnership for each of these groups.

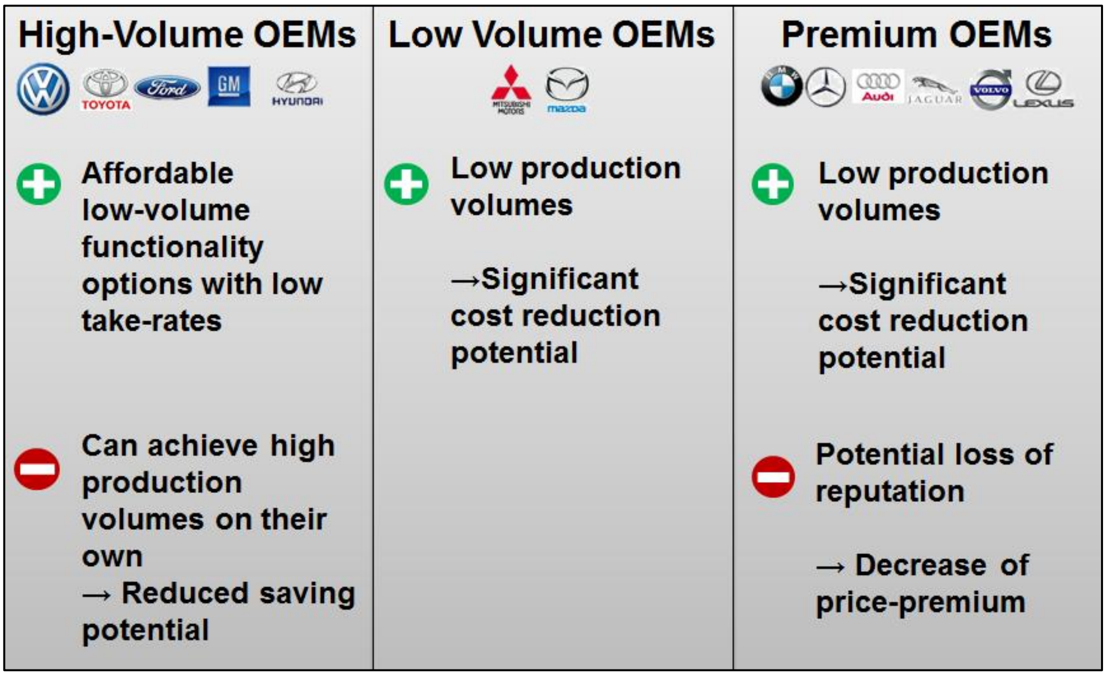

Figure 7.2: OEM potential for industry-toolkits

As can be seen, industry-toolkits offer a great opportunity for cost reduction for low-volume OEMs. An industry-toolkit partnership would enable them to reach scale effects that would never be possible on their own.
Premium OEMs have similarly low volumes and would also profit from industry-toolkits from a cost perspective. For them, however, it has to be a key requirement to maintain differentiation and their brand characteristics. Premium OEMs without clear differentiation from competitors will inevitably experience a decrease in their price premium and consequently weaken their competitiveness. This means that premium OEMs can potentially profit from industry-toolkits, but only under the precondition that the toolkit only includes modules that are non-critical to differentiation and fit to their brand characteristics. This topic is discussed more closely in chapter 6.1 and the following chapter.

High-volume OEMs, on the other hand, are able to reach large production volumes on their own with conventional modular toolkits. An additional increase in production volume will therefore bring with it only minor cost reductions. This can be observed in the diagrams provided in chapter 6.2. For them, however, there might be a possibility to profit from industry-toolkits that include modules for low-volume functionality options with low take-rates. For these modules similar preconditions as for low-volume OEMs would apply, which means that there is a significant potential for cost reduction.

Furthermore, it can be stated that future industry-toolkit partnerships will most likely be formed by OEMs that address the same customer segment, either premium or volume. This will reduce potential risk of damage to the brand image and help premium brands maintaining their price-premium over the volume segment.

7.3 Potential Modules for Industry Toolkits

After identifying the criteria for the suitability of automotive models for industry-toolkits in the previous chapter, the next step is to identify which of the modules fulfill these requirements.
For a full list of all considered modules see Table 4 in the appendix. This list was taken from a study previously done by “Roland Berger Strategy Consultants” for Magna. The original list was expanded by several additional modules in accordance with employees from each of the Magna groups.

In chapter 6.1.2 we identified three senses (optic, acoustic and haptic) to be the essential elements in perceiving difference between automotive models. Starting from this basis the list of modules was filtered according to their influence on differentiation. Figure 7.3 illustrates this process. In a first step all modules that are visually perceived by the end customer and contribute to differentiation in this way are filtered out. The necessary evaluation of each module was conducted in accordance with several, Magna-internal experts in their specific field. This process was subsequently performed for acoustic and haptic perception.

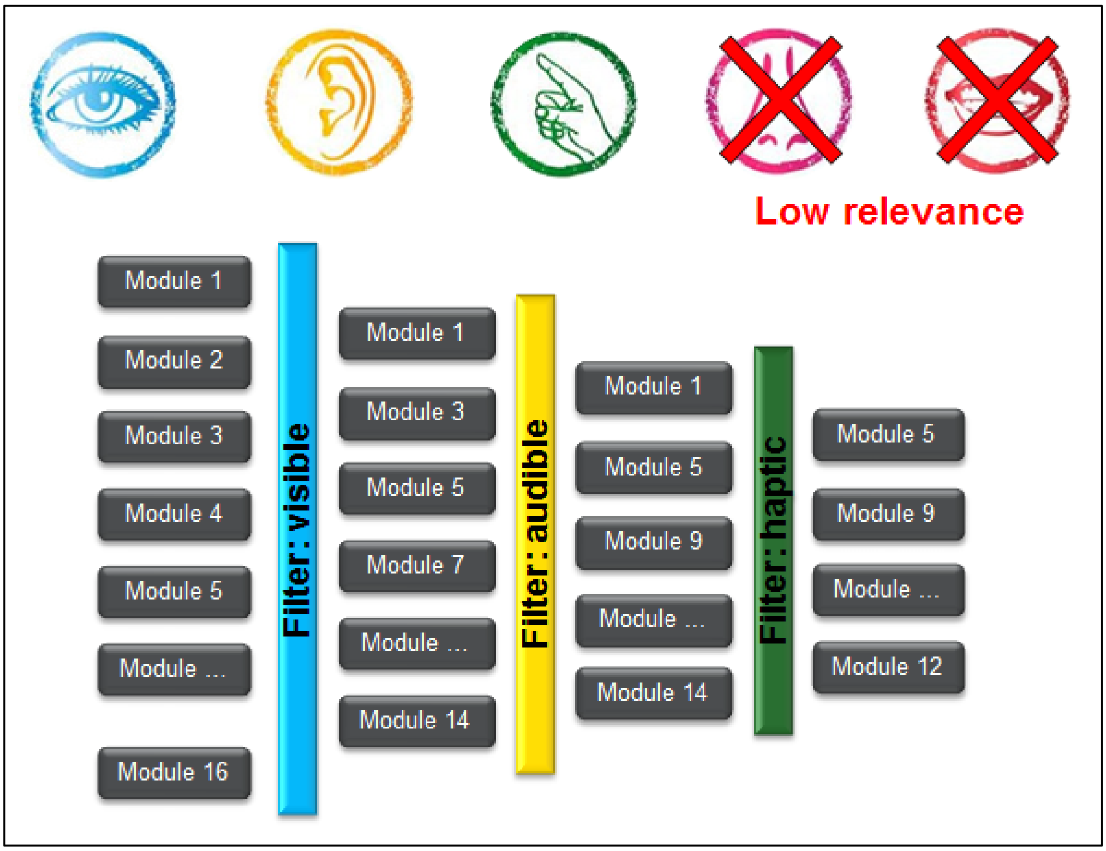

Figure 7.3: The process of filtering modules

The result of this filtering process is a list of modules which are non-critical to differentiation and therefore potentially suitable for industry-toolkits. This list of modules is independent of the OEMs participating and their specific relevance of modules according to their band image (see chapter 6.1.1)
Figure 7.4 shows the results of this filtration process. Additionally, it has to be mentioned that modules which are not included in the product portfolio of Magna, as well as typical standard components, have been filtered from the list.
The result is a list of modules in the Magna portfolio that are non-critical to differentiation and therefore have the potential to be shared as part of an industry toolkit across different OEMs.

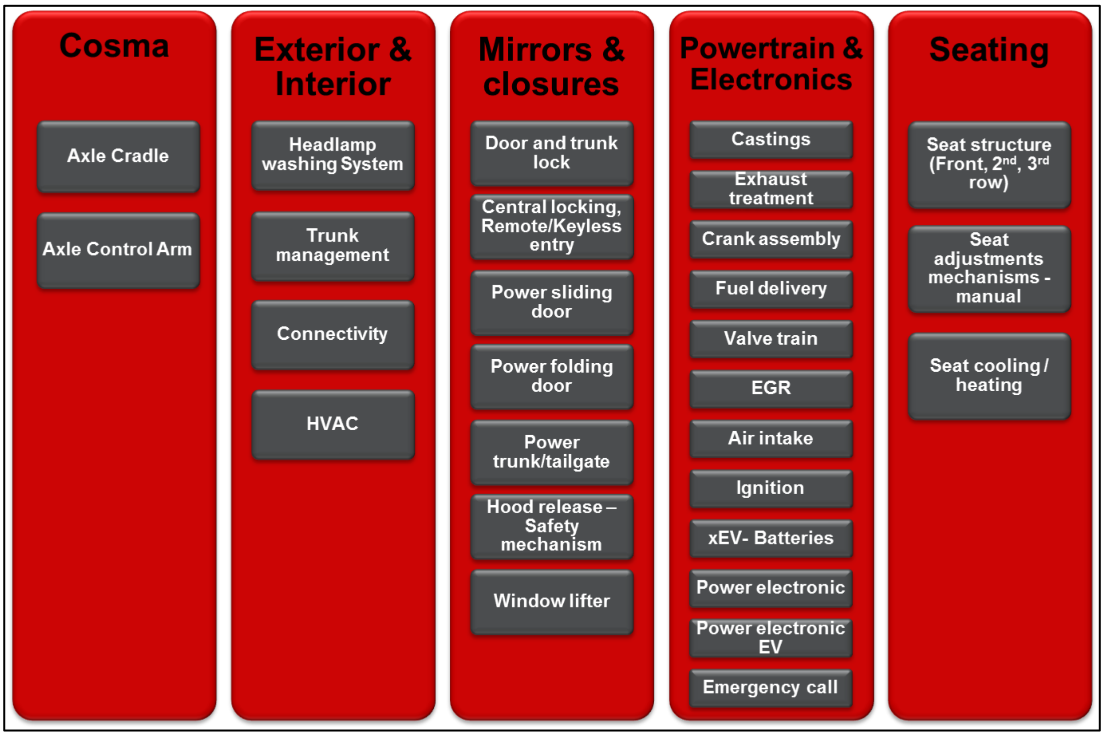

Figure 7.4: Non-critical modules concerning differentiation

7.4 Cost Structure for Industry-Toolkit Suitability

After examining the cost-structure and capacity properties that support the application of industry-toolkits in chapter 6.2, this chapter will sum up the most important findings on that topic.

Fixed costs form the fraction of the overall cost-structure which can fully be shared between the industry-toolkit participants. Therefore, it is the fixed costs, like for example development costs or initial investments, that hold a substantial potential for cost reduction. For a module to be economically feasible for an industry-toolkit, the share of fixed costs in the overall cost structure should consequently be as high as possible.
Incremental costs, like tool costs or costs for assembly line extensions, should accordingly represent only a minor part of the overall costs. This leads to smoother cost functions that allow increased flexibility of production volume while increasing the relative saving potential through lowering overall

costs. Due to the fact that assembly line costs are usually substantially higher than tooling costs, their effects are more influential than those of tooling.
The share of variable costs like material or labor costs should also be low to favor the application of industry-toolkits. The lower they are, the higher the relative saving potential is. To achieve low labor costs, a high degree of automation is necessary. Procurement costs for raw material and tier-2 supplier components also hold significant cost saving potential through scale effects under the right circumstances. This, however, varies largely from case to case and therefore calls for a management strategy for these factors.
Tool capacities, as well as assembly line capacities, should be as high as possible to favor industry-toolkit application. Higher capacities lower overall costs and therefore increase the relative saving potential. Furthermore, higher capacities lead to smoother cost functions and therefore offer increased volume flexibility.
Table 7-1 summarizes the findings concerning economic influence factors.

Favor Industry-Toolkit if high:	Disfavor Industry-Toolkit if high:
• Fixed Costs • Assembly line capacities • Tool Capacities	• Assembly line extension costs • Tool costs • Labor Costs • Procurement Costs

Table 7-1: Summary economic influence factors

7.5 Evaluation Tool

This chapter will give a short overview on the functions of the Excel-tool for module evaluation. The developed tool should support future strategic decisions that have to be made concerning module evaluation for industry-toolkits. Figure 7.5 shows a screenshot of the tool.

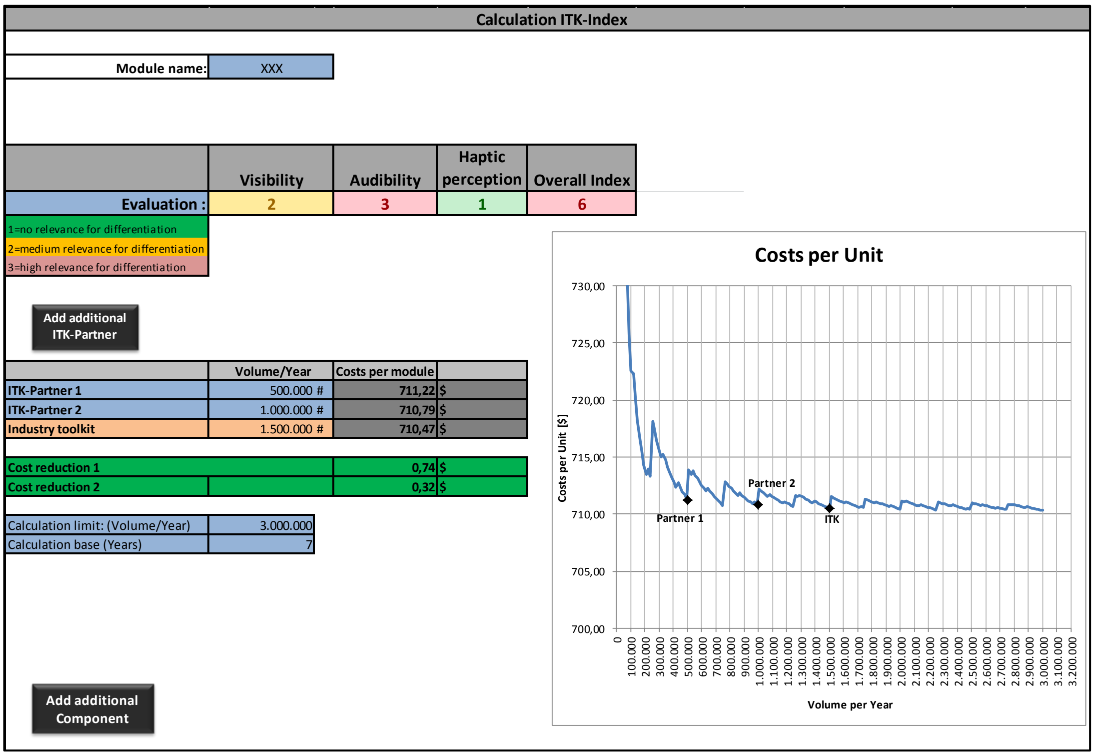

Figure 7.5: Screenshot evaluation tool

The evaluation basically follows the approach developed in this piece of work and happens on two levels.

On the first level the module is evaluated concerning its relevance for differentiation. Using the filter-model introduced in chapter 7.3, the module is evaluated concerning its visual, audible and haptic perceptibility. This results in an overall differentiation index which indicates the modules relevance for differentiation.

On the second level, the module is evaluated concerning its economic suitability for an industry toolkit. Through entering various data on costs and production in an input-mask, the potential cost reduction for two specific industry-toolkit partners is calculated. Furthermore, the basic properties for the calculation, like for example the life span of the project, can be easily adjusted.

The following input-data has to be provided:

- **Calculation data:**
    - Annual production volumes of the industry-toolkit partners
    - Calculation limit (Up to which annual production volume should the diagram be calculated?)
    - The intended life-span of the project in years

- **On a module level:**
    - Fixed costs (Development, Testing Costs,…)
    - Assembly/Production line costs
    - Assembly/Production line capacity
    - Procurement costs
    - Labor costs

- **On a component level:**
    - Quantity of each component in the module
    - Tool costs
    - Tool capacities

The results of the calculation are also visually presented in a diagram, showing the costs per unit varying over the annual production volume. This diagram is created automatically.

For a demonstration of the output of the tool, a fictional example is used. The module consists of four different components with differing input data. The industry toolkit is used by two partners. One of them has an annual production volume of 500.000 units, the other one has an annual production volume of 1.000.000 units.
Figure 7.6 shows the diagram created using the data of the example. It can clearly be seen how the cost function varies over the annual production volume and where each of the industry-toolkit partners, as well as the industry-toolkit (ITK) are positioned. This helps to decide whether an additional partner would be beneficial in order to reach higher capacity utilization or further cost reduction through additional volume.

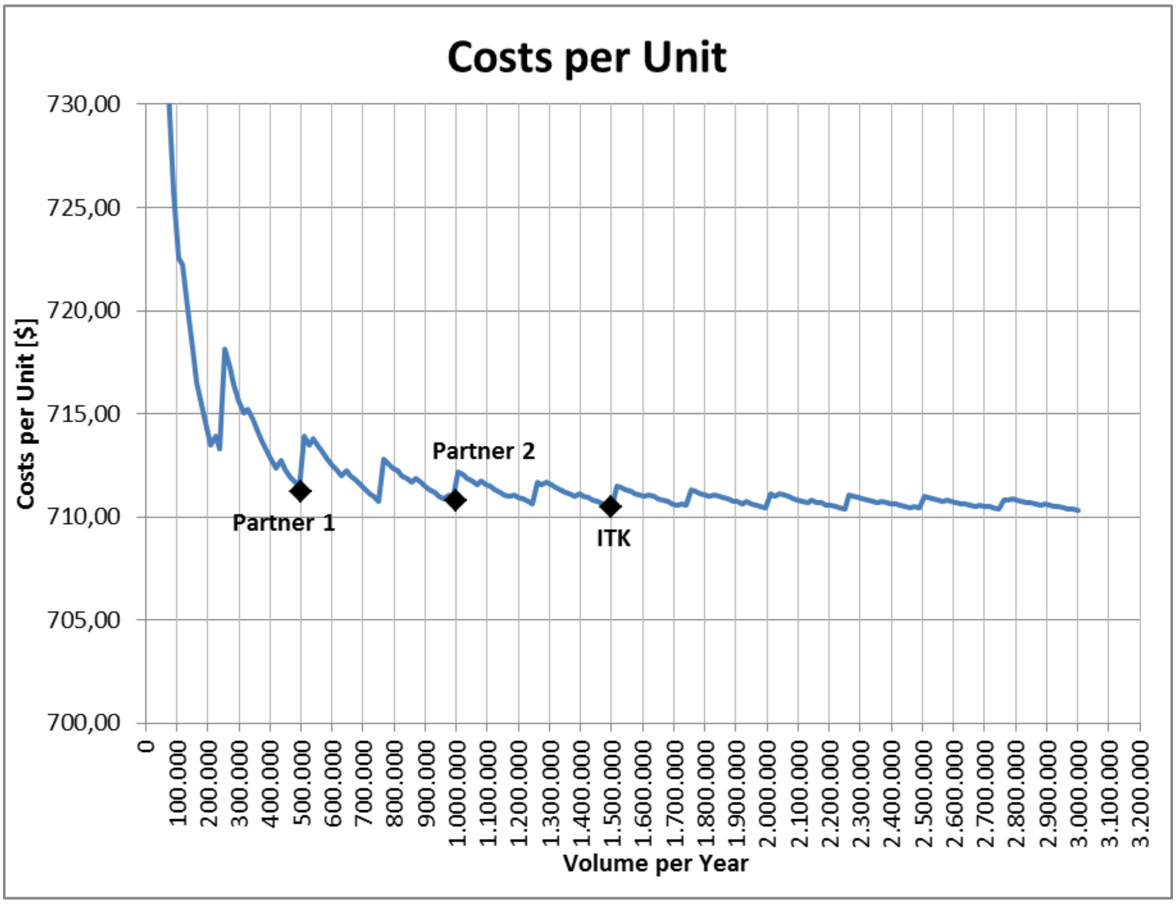

Figure 7.6: Costs per unit diagram for example

Figure 7.7 shows the calculated results for the example. For ITK-Partner 1 the costs per module are 711,22$, for ITK-Partner 2 the costs per module are 710,79$. The costs per unit in case of an industry-toolkit cooperation could be reduced to 710,47$. This means that Partner 1 could achieve cost reductions of 0,74$ and Partner 2 could reduce the costs per unit by 0,32$.

	Volume/Year	Costs per module	
ITK-Partner 1	500.000 #	711,22	$
ITK-Partner 2	1.000.000 #	710,79	$
Industry toolkit	1.500.000 #	710,47	$
Cost reduction Partner 1		0,74	$
Cost reduction Partner 2		0,32	$

Figure 7.7: Results for excel-tool example

It needs to be decided individually for each case if the achievable cost reduction is sufficient to justify such an industry-toolkit. It might be necessary to adjust certain factors in production or get an additional partner.

The tool should help to illustrate module suitability for industry-toolkits for future decisions on this topic at Magna. Although it is not possible to provide a clear yes or no answer for any given module due to the complexity of the topic and the high number of influence factors, this tool can help to support strategic decisions in relation to industry-toolkits nonetheless.

8 Conclusion

The topic of industry-toolkits is a highly complex one due to the high number of influence factors on both, an economic and strategic level. The SWOT-analysis provided in chapter 5 shows the multitude of advantages and disadvantages an industry-toolkit strategy can bring with it, for both the OEM and supplier side. It is important to understand that the decision, whether to head for an industry-toolkit approach, cannot be made solely from an economic point of view, but also requires considerations like the influence on brand differentiation.

In the course of this work, it has been shown that the advantages industry toolkits bring with them are mainly on the OEM side, while suppliers need to accept a number of trade-offs. This led to the conclusion that the development of industry-toolkits will most likely be driven from the OEM side. For suppliers like Magna, on the other hand, it would hardly make sense to push for an industry-toolkit approach. However, if industry-toolkits are demanded from the OEM side, suppliers should be prepared to offer suitable solutions in order to stay competitive.

Furthermore, the conclusion has been reached that an industry-toolkit approach is most attractive for low-volume OEMs due to the cost reduction potential. For premium OEMs, this potential for cost reduction also exists, but it will be necessary to focus on maintaining differentiation and brand characteristics. High-volume OEMs, on the other hand can reach large volumes on their own by introducing modular toolkits. For them, industry toolkits will only make sense for special equipment with low take rates. Here cost reductions can still be achieved through an increase of the production volume. For suppliers like Magna, this information is of high value in terms of how to approach customers. OEMs from each segment have different requirements which require differentiated strategies from the supplier side.

The second part of this work deals with industry-toolkits on a module level. The most important modules in a car have been evaluated according to their relevance for differentiation. This resulted in a list of modules that only have insignificant influence on differentiation (presented in chapter 7.3) and therefore have a high potential to be shared in an industry-toolkit. For Magna, this provides an idea of the areas that are most likely to be part of future industry-toolkits.

In a last step, the preconditions for economic suitability of modules for industry-toolkits have been identified. Through using examples based on data from production, it has been possible to show how the overall cost structure of a module should look like to achieve economic benefits from industry-toolkits. This information enables the Magna-groups to evaluate modules in their product portfolio on potential economic suitability for industry-toolkits. To support this, an excel evaluation-tool has been developed that can be used to support future strategic decisions concerning industry-toolkits.

For further research it might be of interest to evaluate the, from a differentiation perspective, suitable modules on their economic suitability for industry-toolkits. This was not possible due to a lack of the necessary data.
The characteristics and differentiation focus of each brand differs greatly. Therefore, an analysis of module suitability from an OEM-specific point of view can be a topic for further research.
Last but not least, the topic of hardware commonality and differentiation through software, which is of increasing importance in the automotive business, offers a wide field for additional research. Among others, the questions of how much differentiation through software is possible, in which areas software can be used as a differentiator or how much commonality in software is possible still call for answers.

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List of Abbreviations

CEO – Chief Executive Officer
ITK – Industry Toolkit
Mn – Million
MPV – Multi Purpose Vehicle
MQB – Modularer Querbaukasten
OEM – Original Equipment Manufacutrer
SOP – Start of Production
SUV – Sport Utility Vehicle
US – United States
VW – Volkswagen

Appendix

The IHS Light Vehicle Production Forecast – Detailed Data

- **Total Production in Regions**

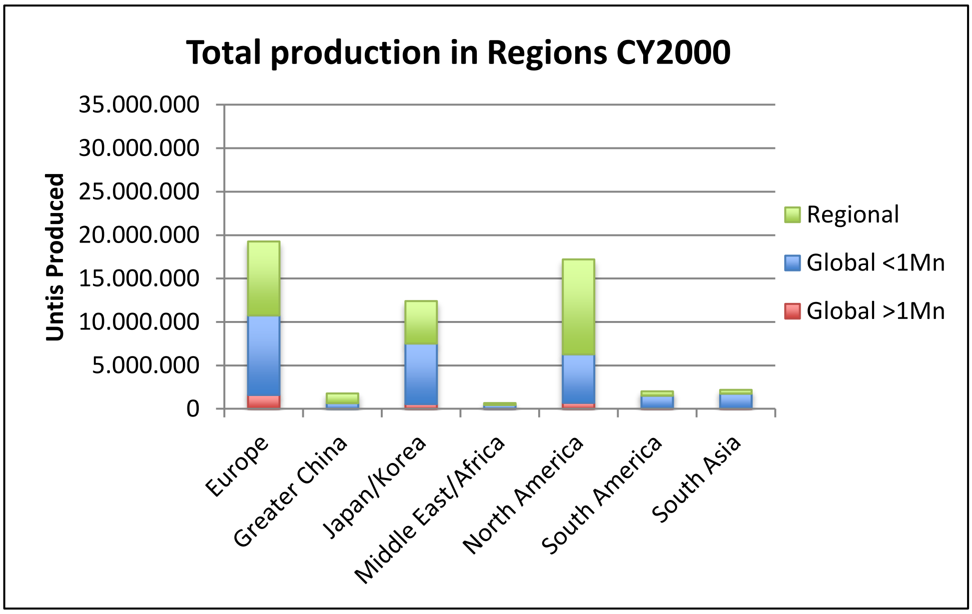

Figure 1: Total Production in Regions in the year 2000

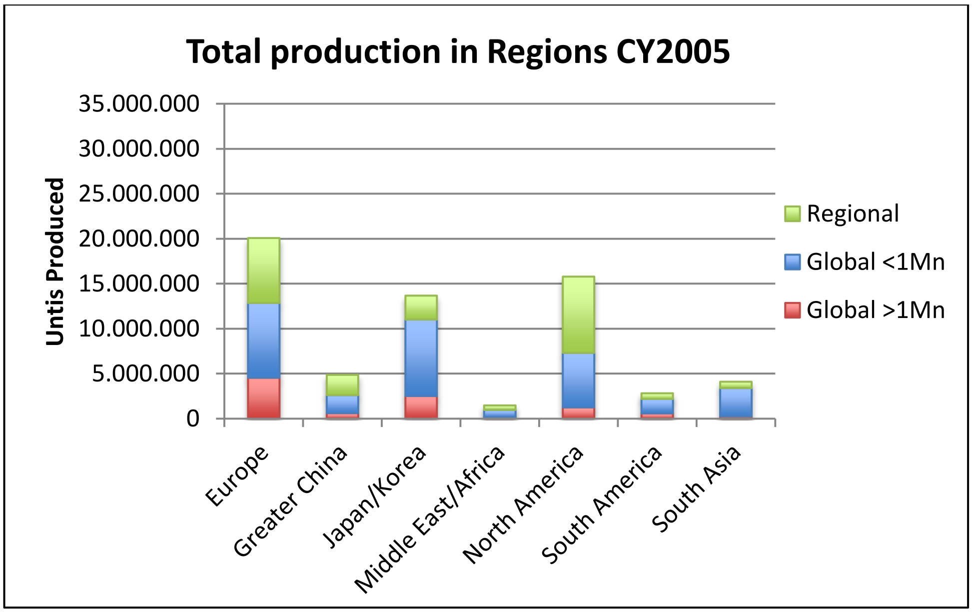

Figure 2: Total Production in Regions in the year 2005

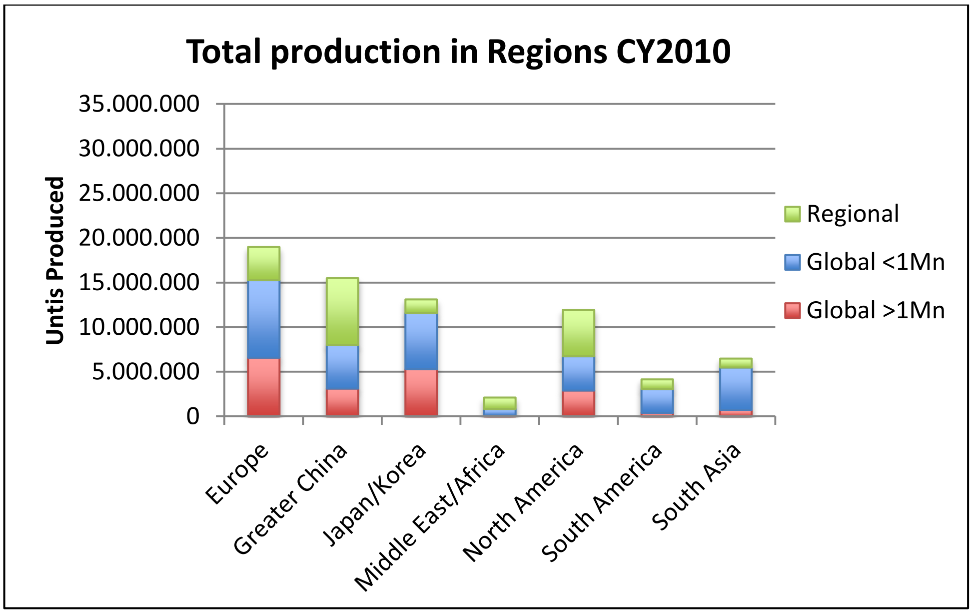

Figure 3: Total Production in Regions in the year 2010

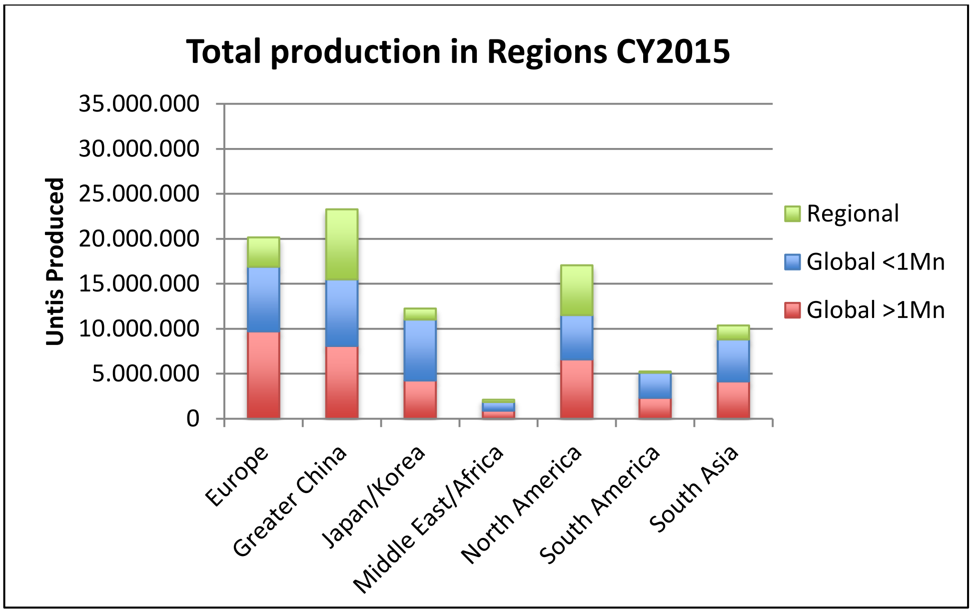

Figure 4: Total Production in Regions in the year 2015

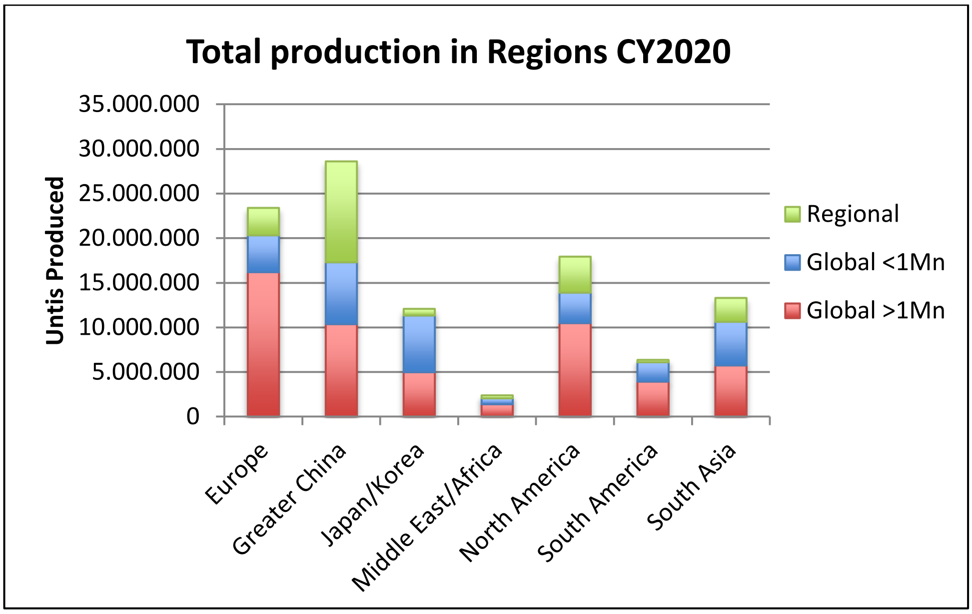

Figure 5: Total Production in Regions in the year 2020

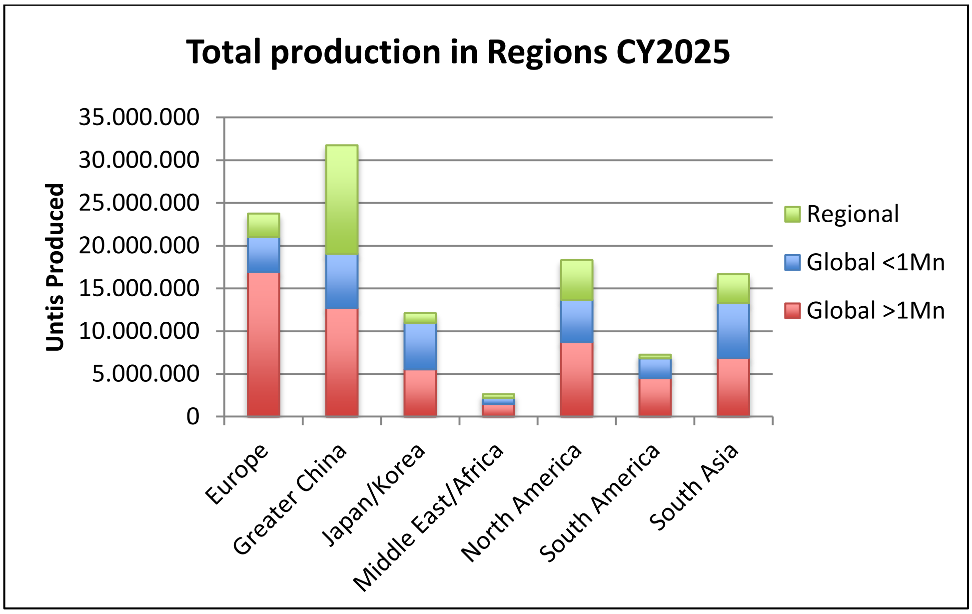

Figure 6: Total Production in Regions in the year 2025

- **Production Volumes per Year and Number of Platforms**

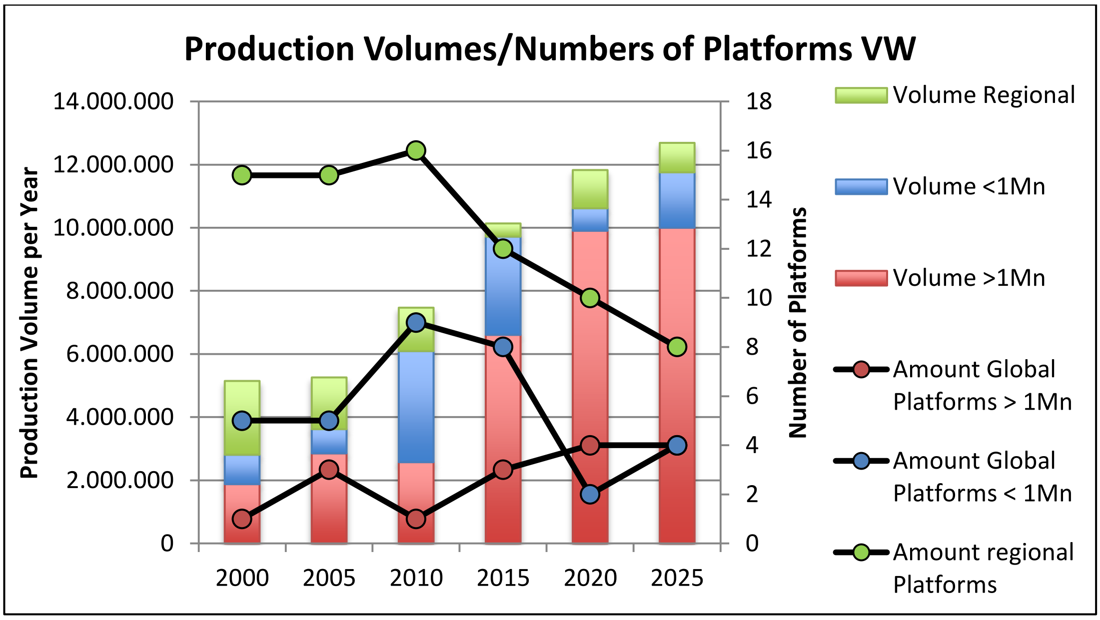

Figure 7: Production Volumes per Year and Number of Platforms VW

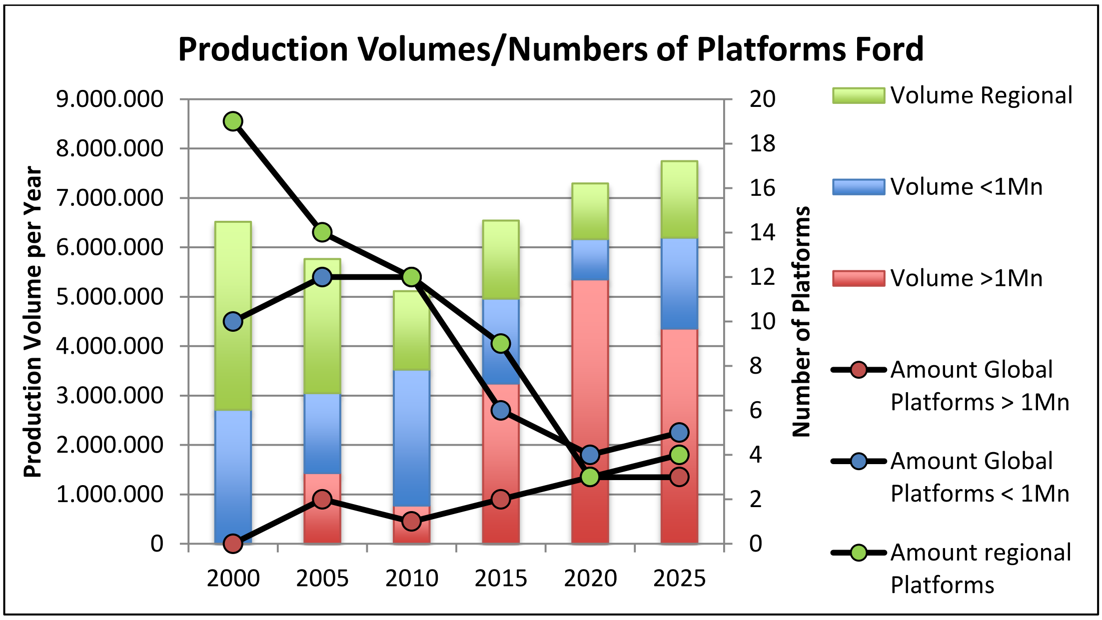

Figure 8: Production Volumes per Year and Number of Platforms Ford

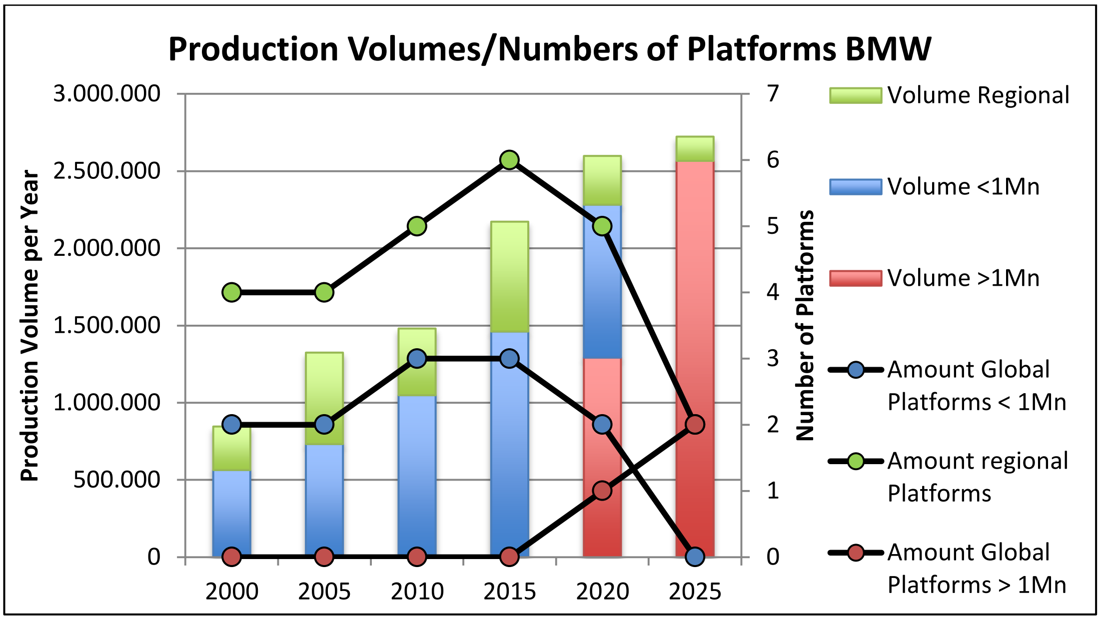

Figure 9: Production Volumes per Year and Number of Platforms BMW

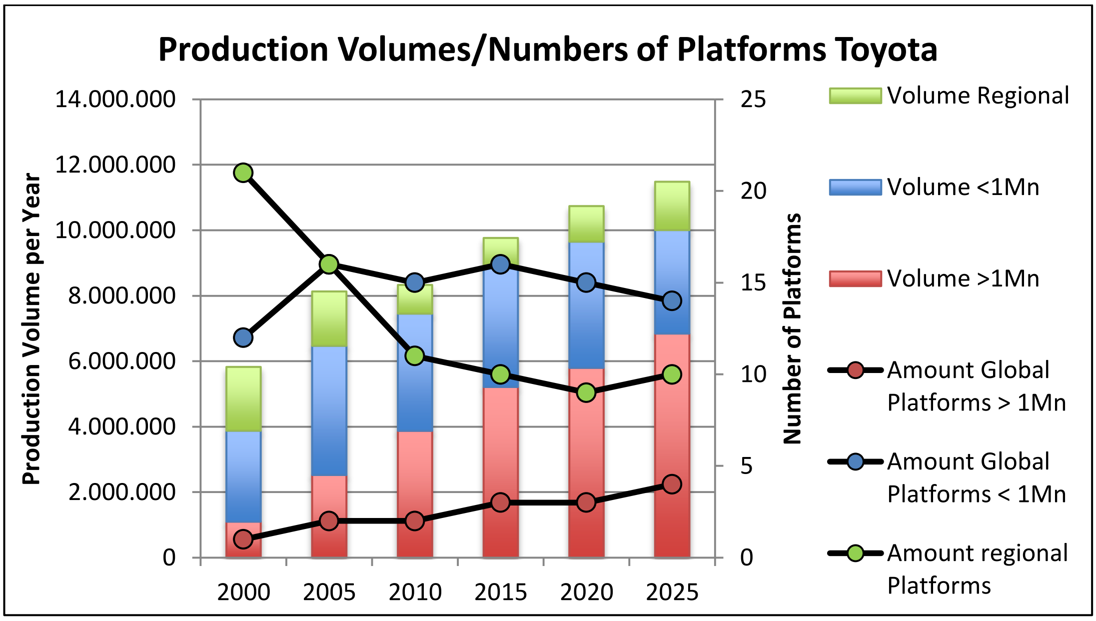

Figure 10: Production Volumes per Year and Number of Platforms Toyota

- **Units per Platform**

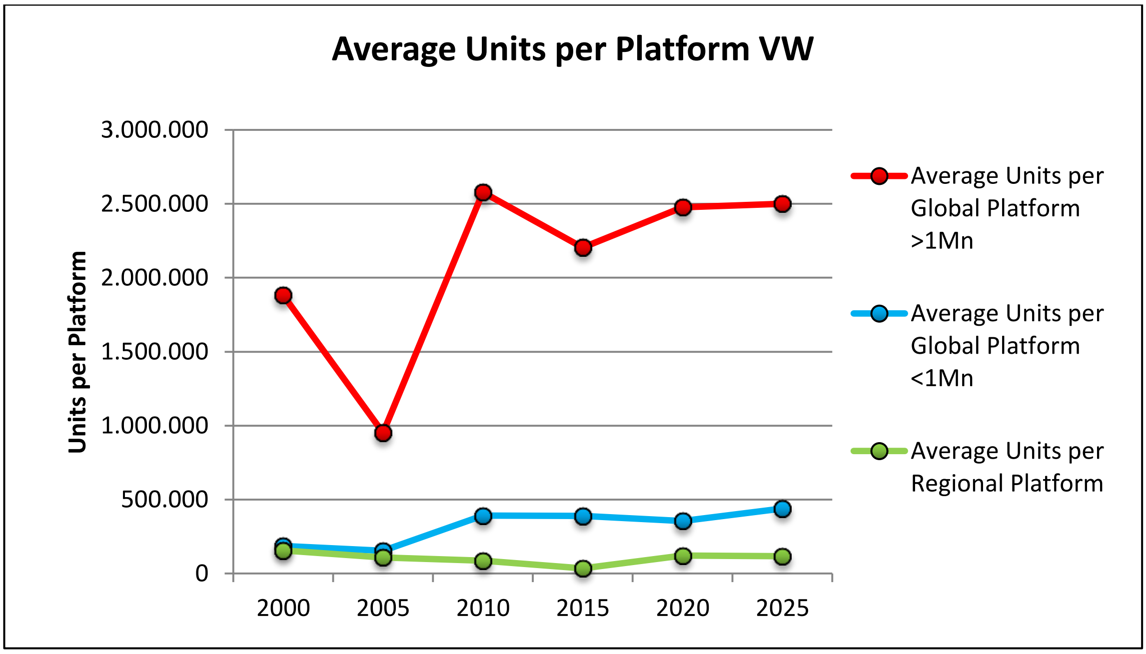

Figure 11: Average Units per Platform VW

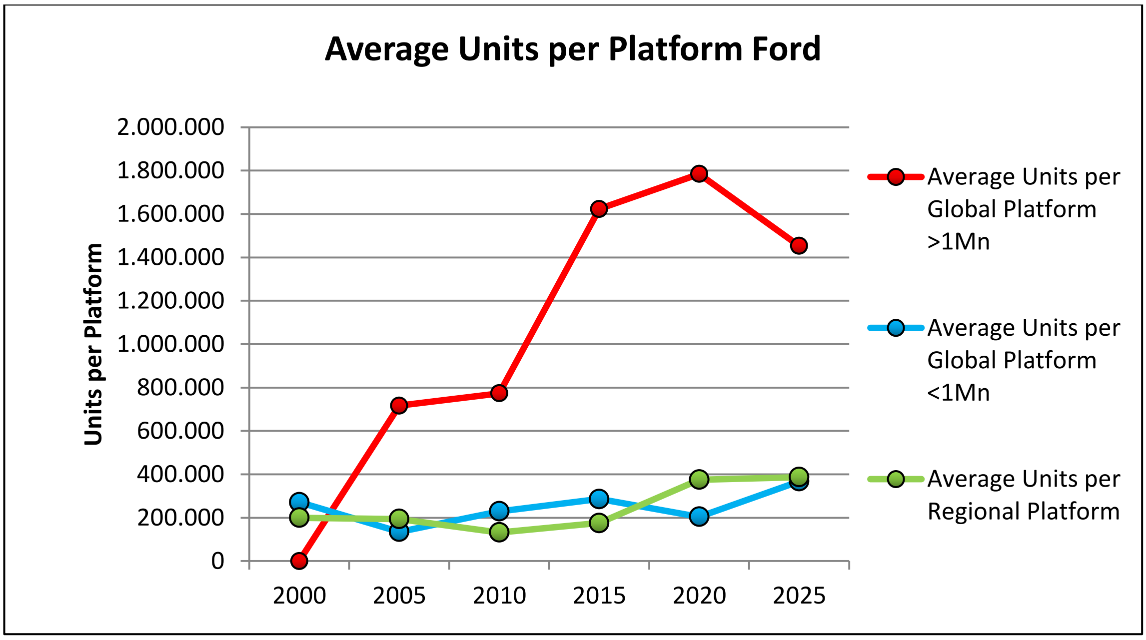

Figure 12: Average Units per Platform Ford

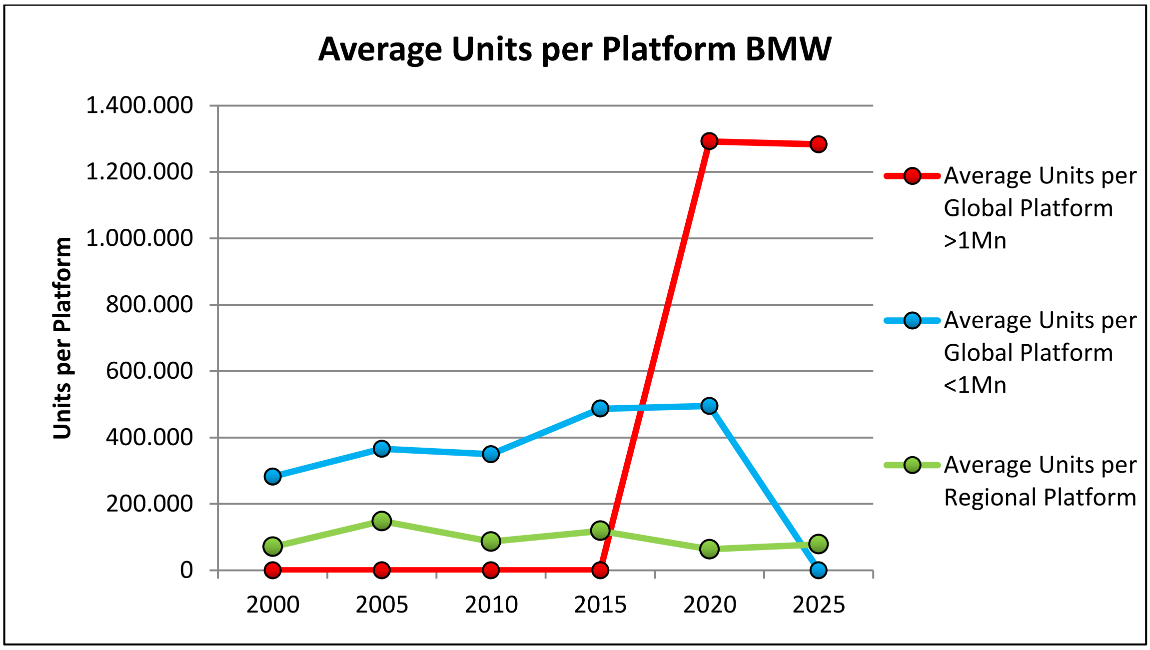

Figure 13: Average Units per Platform BMW

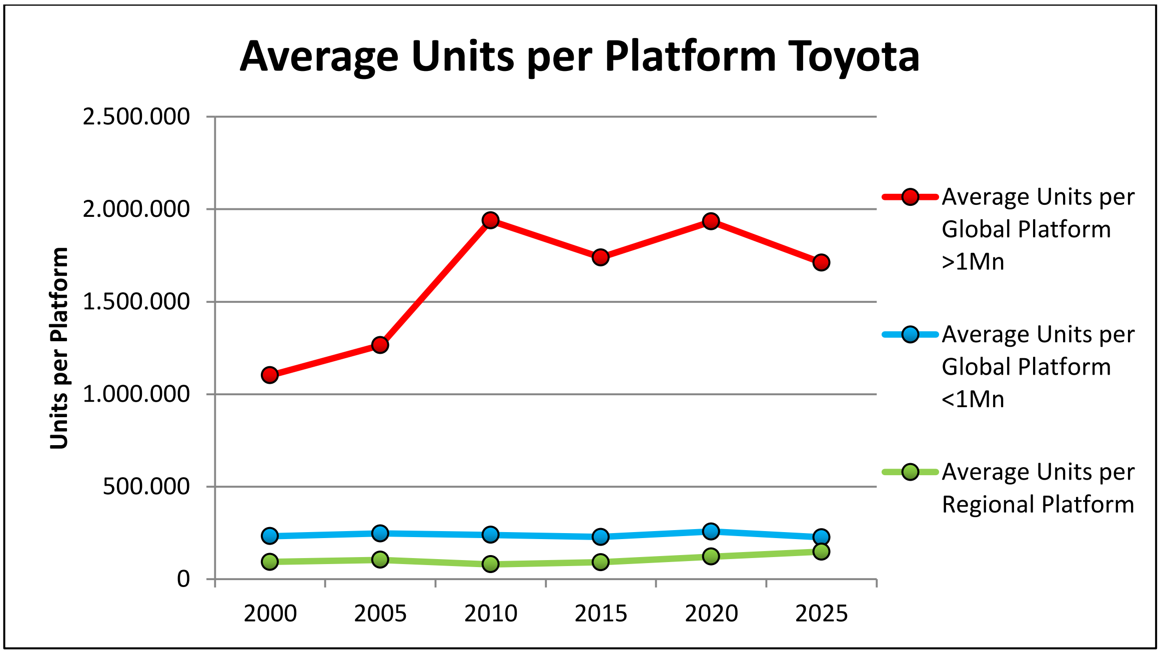

Figure 14: Average Units per Platform Toyota

- **Brands per Platform**

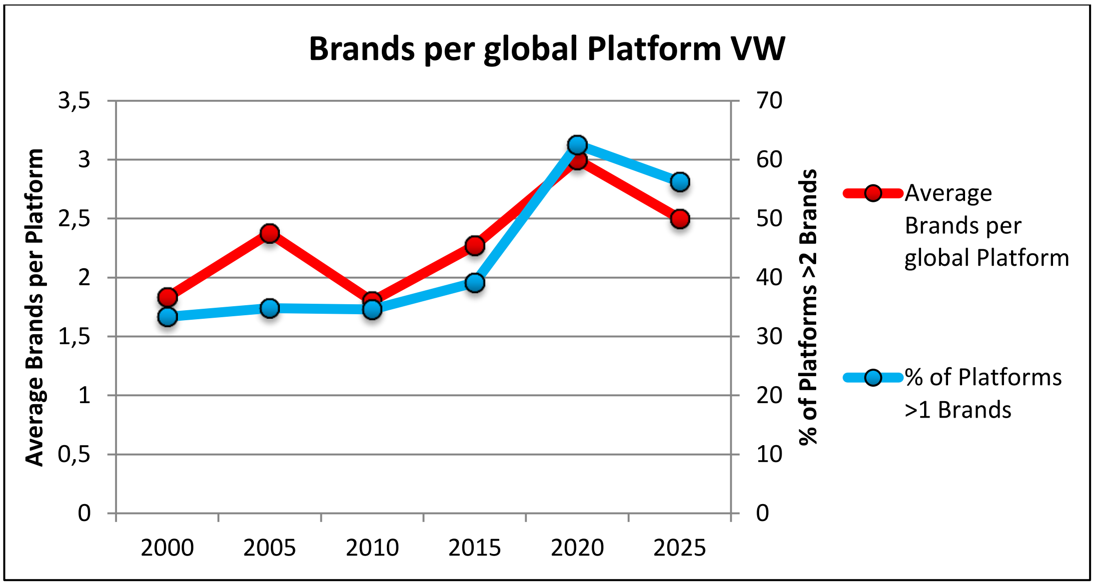

Figure 15: Brands per global Platform VW

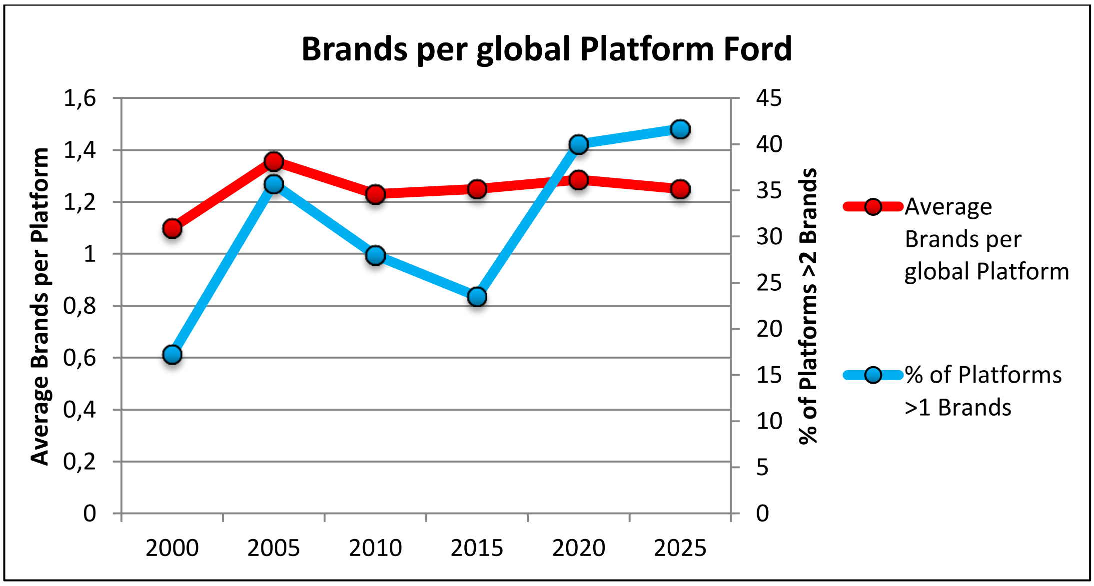

Figure 16: Brands per global Platform Ford

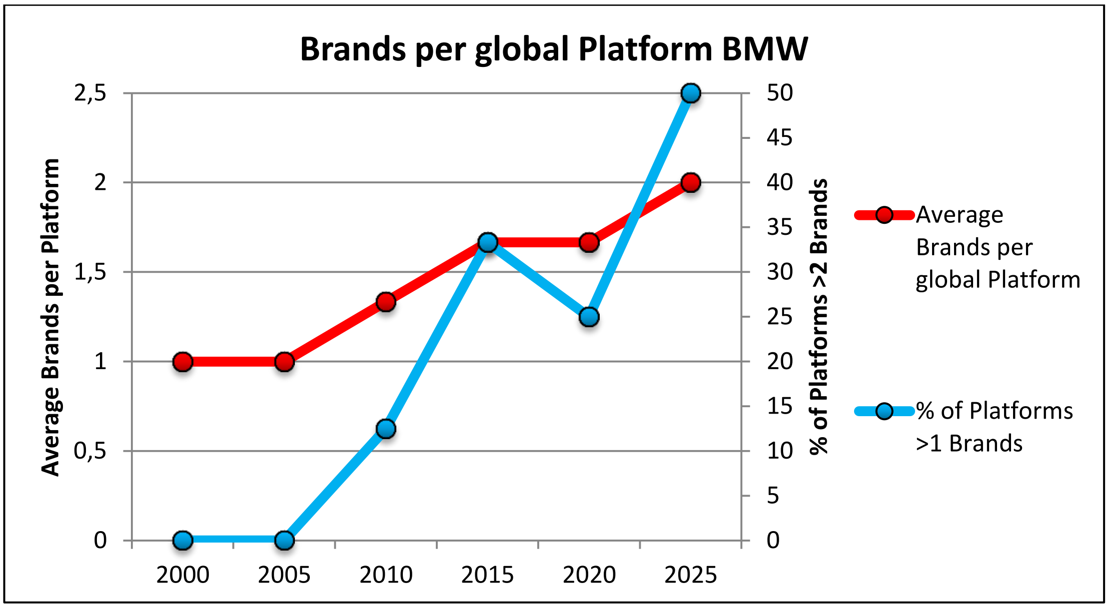

Figure 17: Brands per global Platform BMW

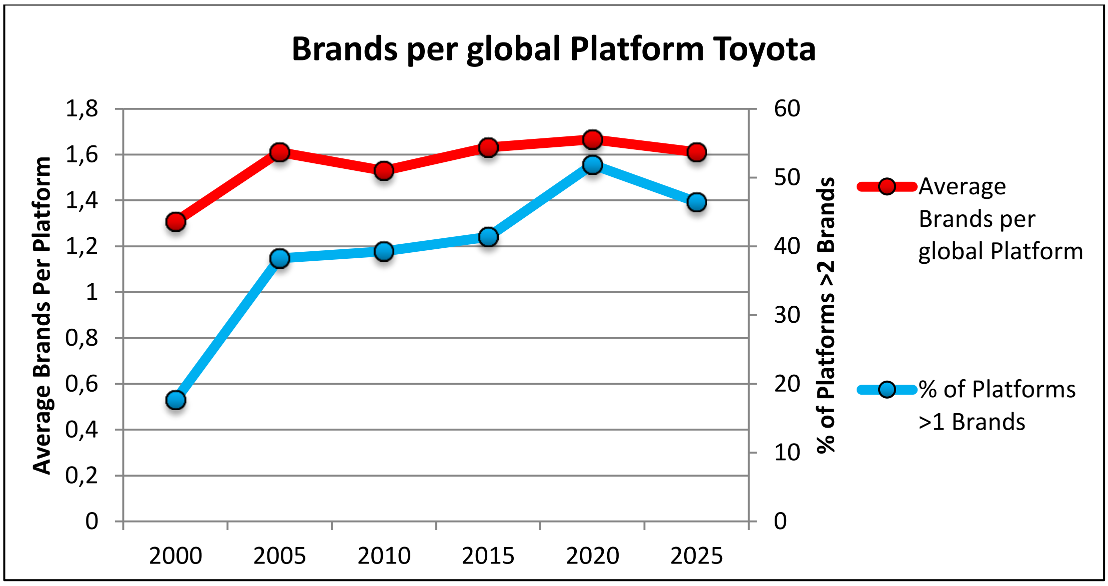

Figure 18: Brands per global Platform Toyota

Volkswagen			Ford	BMW	Toyota
MQB A/B; MQB A0	**MLB D(2)**	**MSB**	**C2; CD4, CD5**	**LU**	**NGA-C**
Audi	Audi	Bentley	Ford	BMW	Lexus
SEAT	Bentley	Bugatti	Lincoln	Mini	Ranz
Skoda	Lamborghini	Lamborghini		Zhinuo	Scion
Volkswagen	Porsche	Porsche			Toyota
	Volkswagen				

Table 1: Platforms supporting most brands in 2025

- **Number of Models**

Owners:	Ashok Leyland, AvtoVAZ, Daimler, Dongfeng, General Motors, Renault/Nissan	Volkswagen	Toyota
Platform:	**CMF2 40 Models**	**MQB A/B 35 Models**	**NGA-C 20 Models**
Models:	March	A3	Allion
	AD Van	Alhambra	Auris
	Almera	Altea	Avensis
	B-Hatch	Bora	B-CUV
	B-MPV	Caddy Van	C-CUV
	B-Sedan	CC	Corolla
	B-SUV	C-CUV	C-Sedan
	Captur	C-MPV	CT
	C-CUV	C-MPV(A)	EZ
	C-Hatch	Cross Blue	NAV1
	City Express	C-SUV	Premio
	Clio	C-SUV(A Plus)	Prius
	C-Sedan	Golf	Prius Alpha
	Cube	Golf Plus	RAV4
	D50	Gran Lavida	Rumion
	Dokker	Jetta	SAI
	Dokker Van	Jetta SportWagen	tC
	EV	Leon	Voxy
	Evalia	New Beetle	Wish
	Juke	New Beetle Convertible	xB
	Lafesta	Octavia	
	Leaf	Passat	
	Lodgy	Passat CC	
	Logan	Praktik	
	Logan MCV	Q3	
	Micra	Q4	
	Note	Roomster	
	NP200	Sagitar	
	NV200	Scirocco	
	Pulsar	Sharan	
	Pulse	Superb	
	R50	Tiguan	
	Sandero	Touran	
	Scala	TT	
	Stile	Yeti	
	Succe		
	Sunny		
	Tiida		
	Tondar		
	Zoe		

Table 2: Platforms supporting most models in 2025

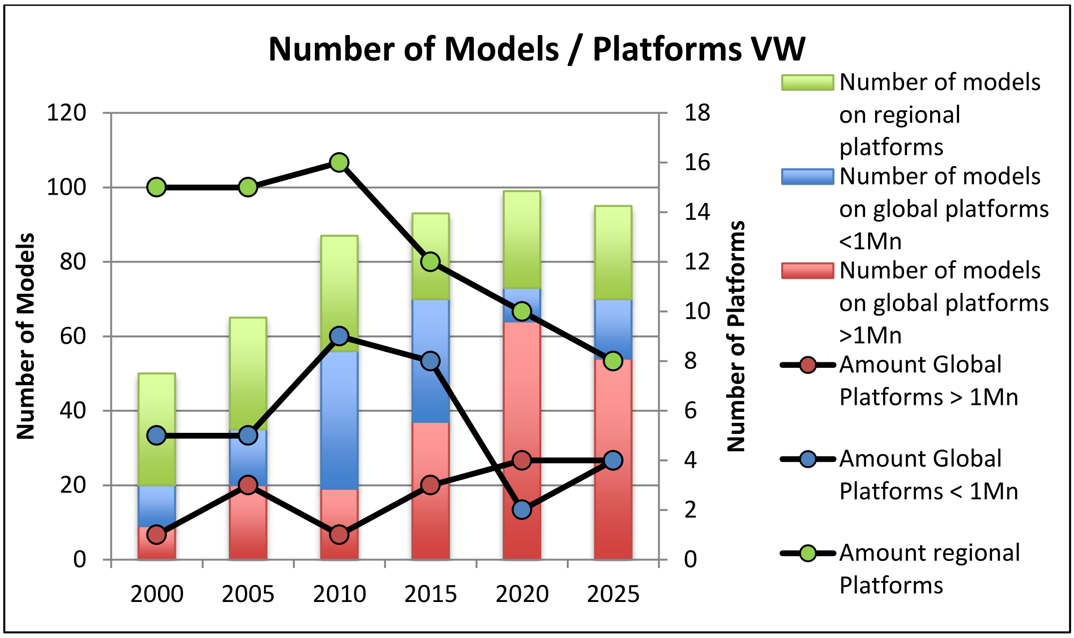

Figure 19: Number of Models and Platforms VW

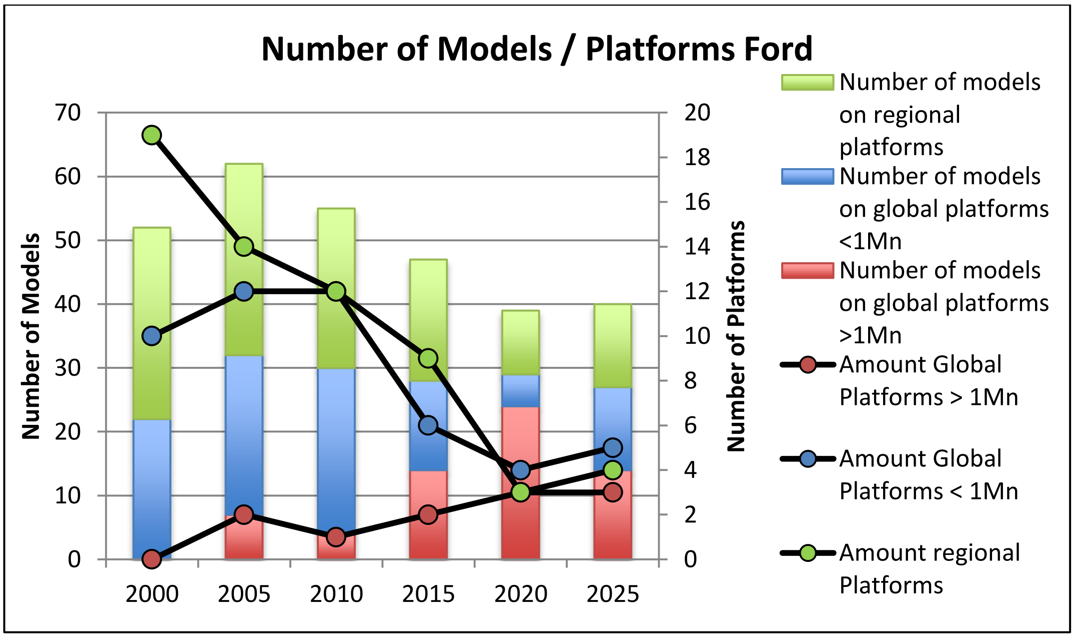

Figure 20: Number of Models and Platforms Ford

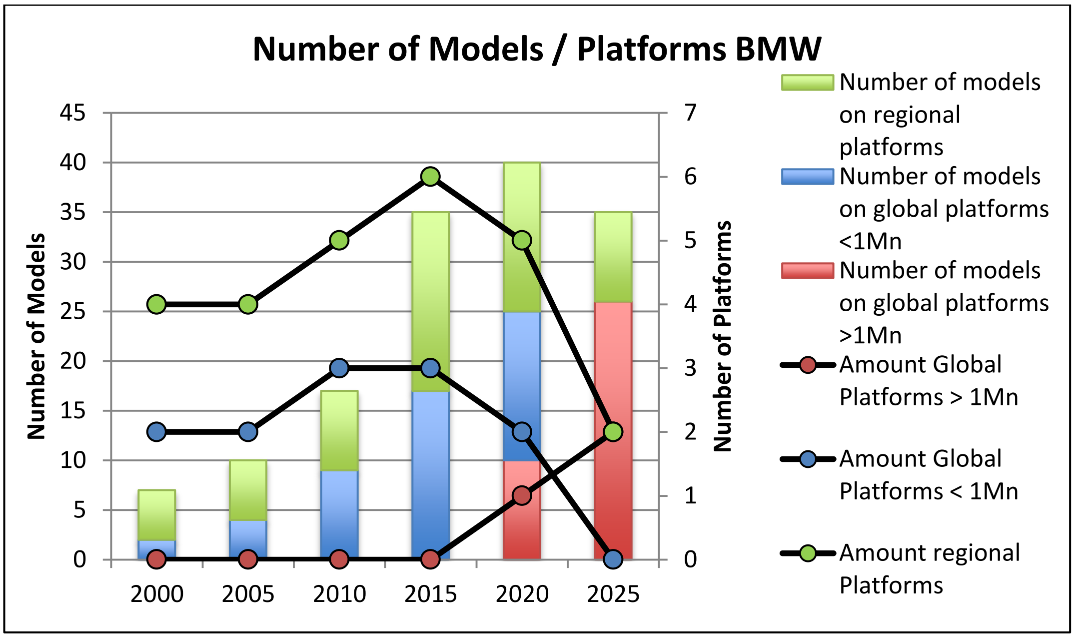

Figure 21: Number of Models and Platforms BMW

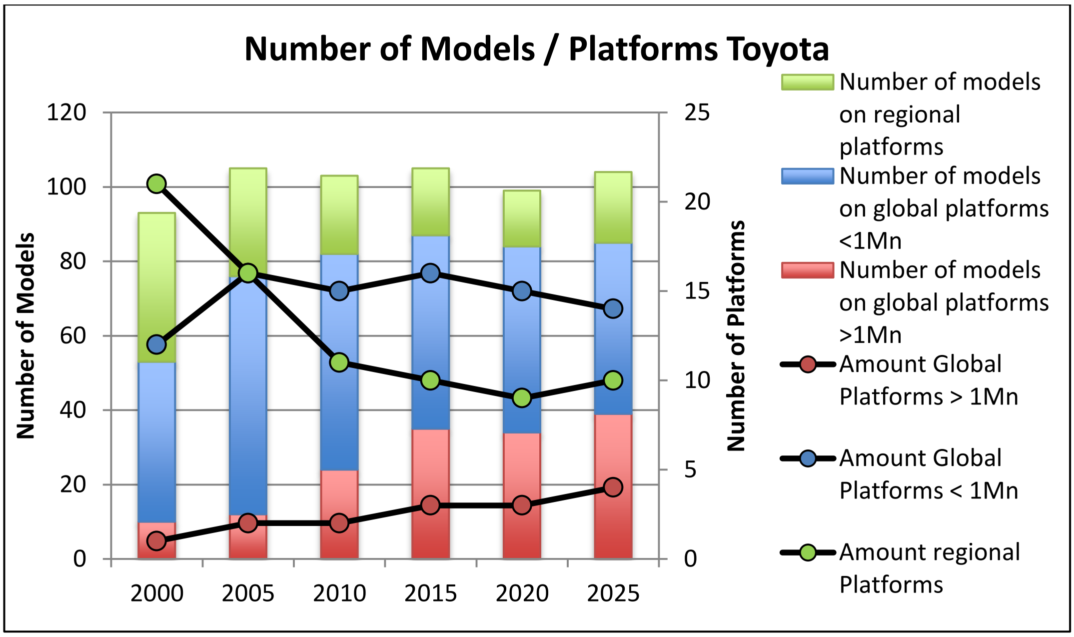

Figure 22: Number of Models and Platforms Toyota

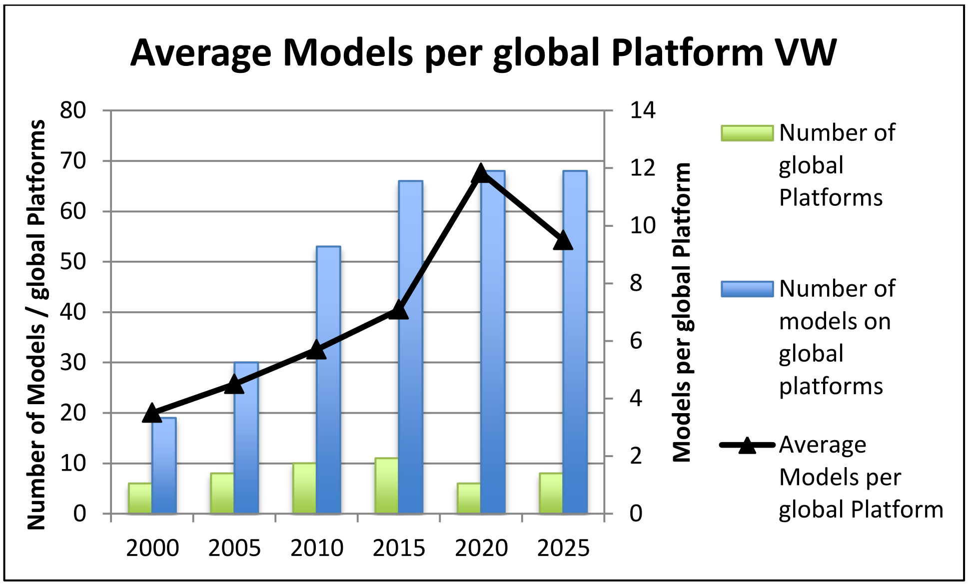

Figure 23: Average Models per global Platform VW

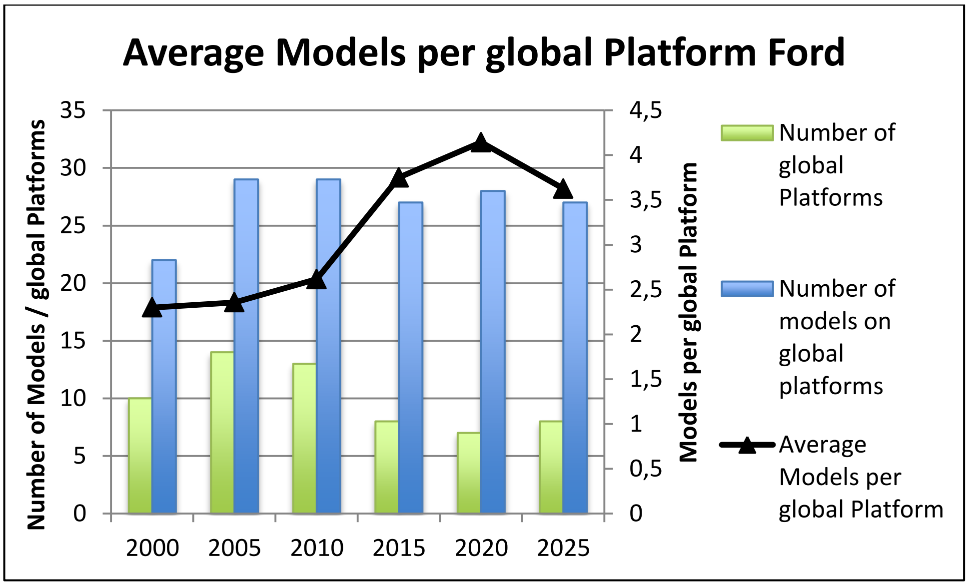

Figure 24: Average Models per global Platform Ford

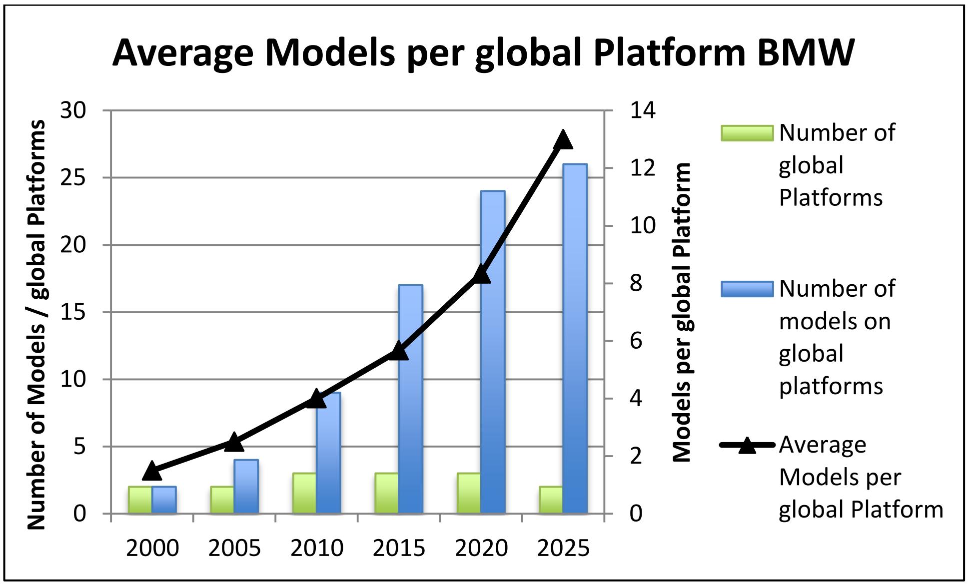

Figure 25: Average Models per global Platform BMW

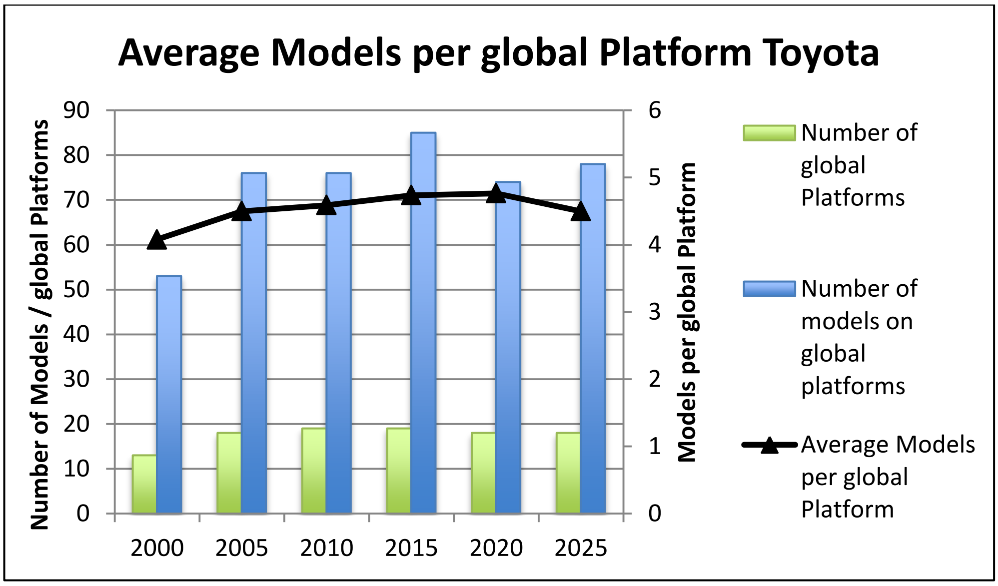

Figure 26: Average Models per global Platform Toyota

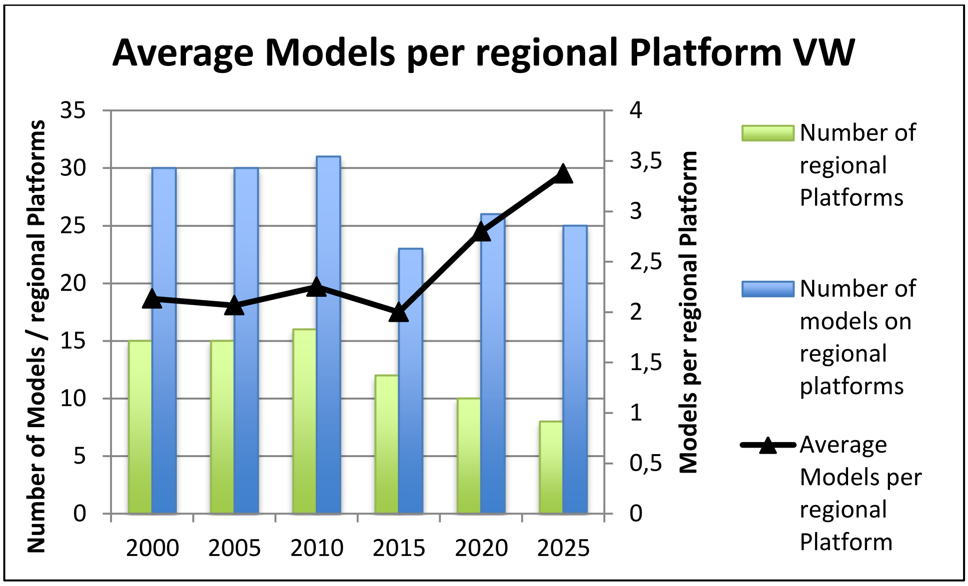

Figure 27: Average Models per regional Platform VW

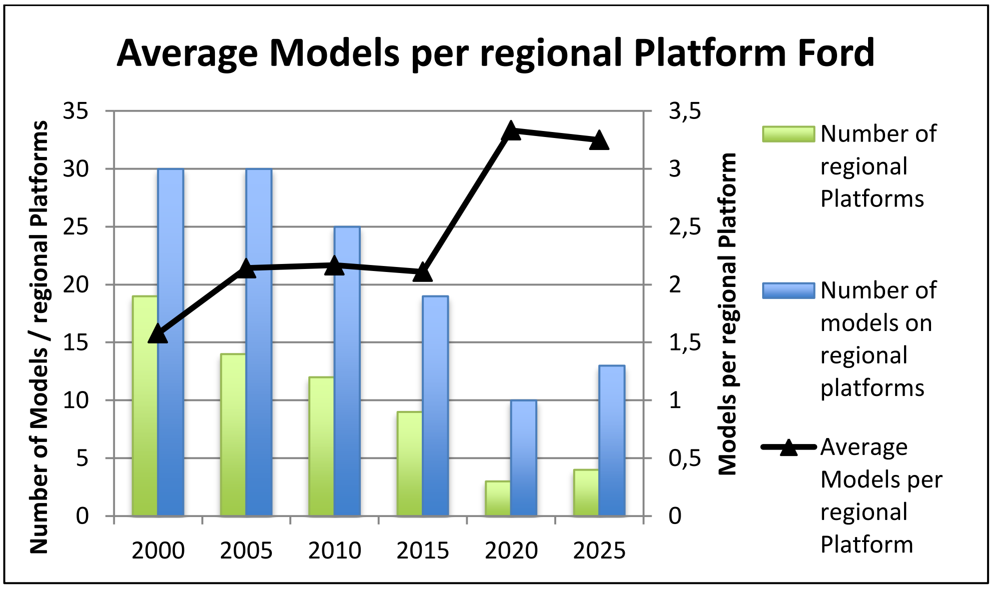

Figure 28: Average Models per regional Platform Ford

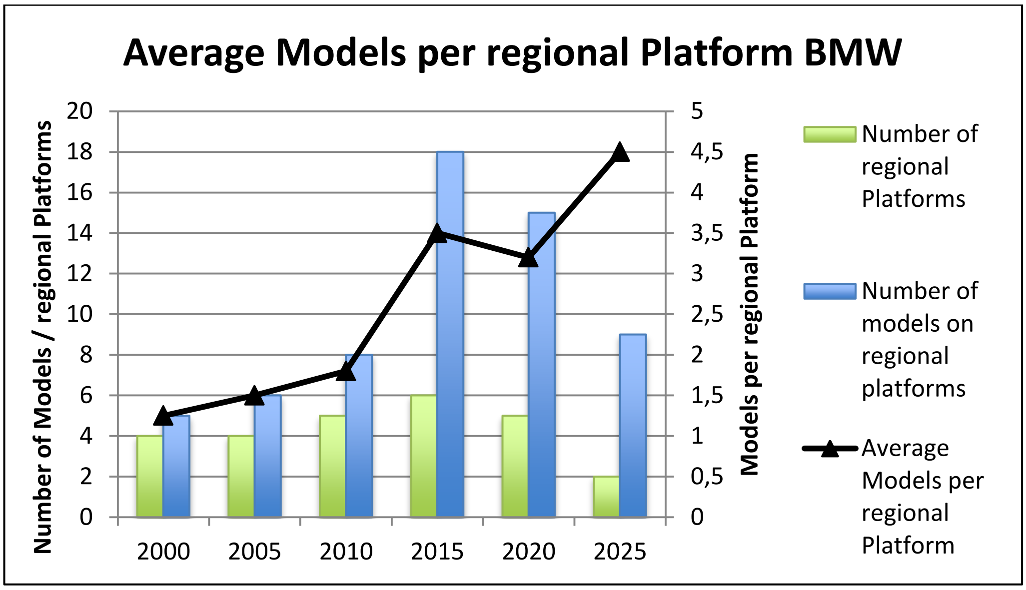

Figure 29: Average Models per regional Platform BMW

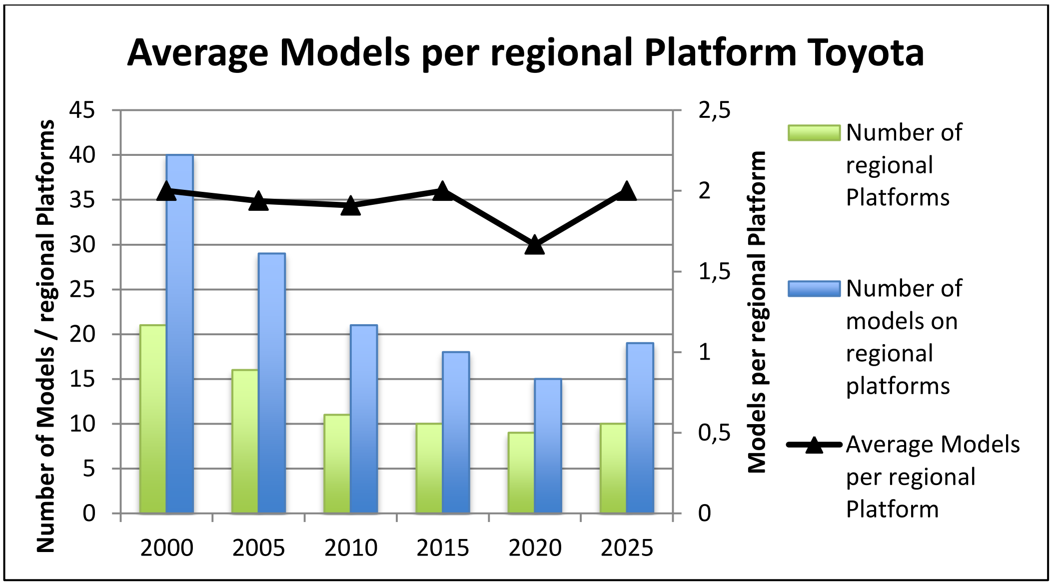

Figure 30: Average Models per regional Platform Toyota

- **Units per Model**

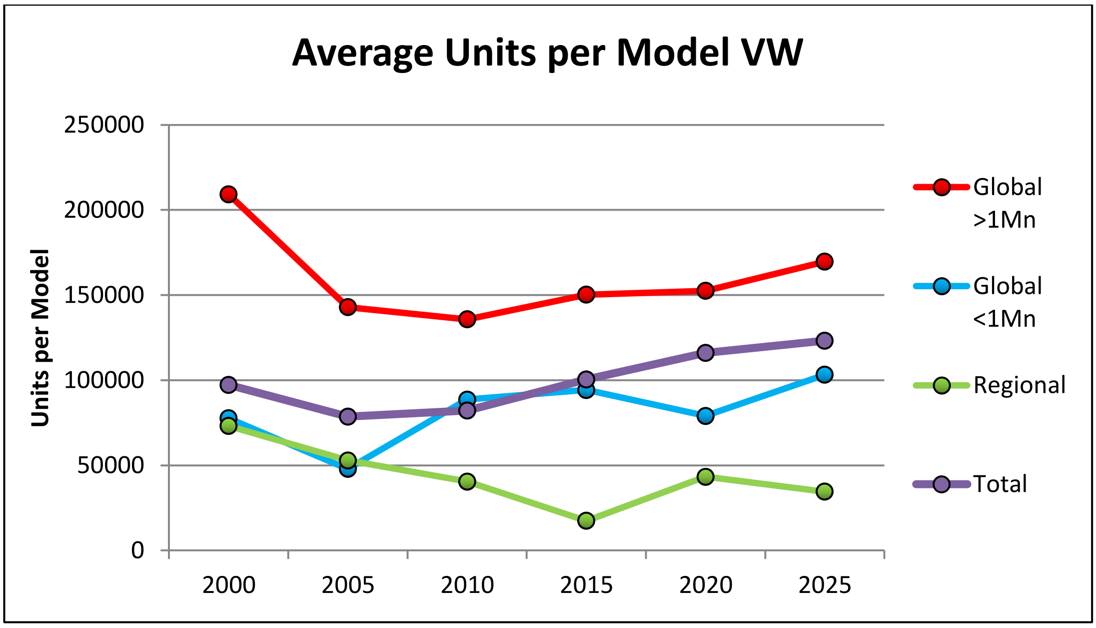

Figure 31: Average Units per Model VW

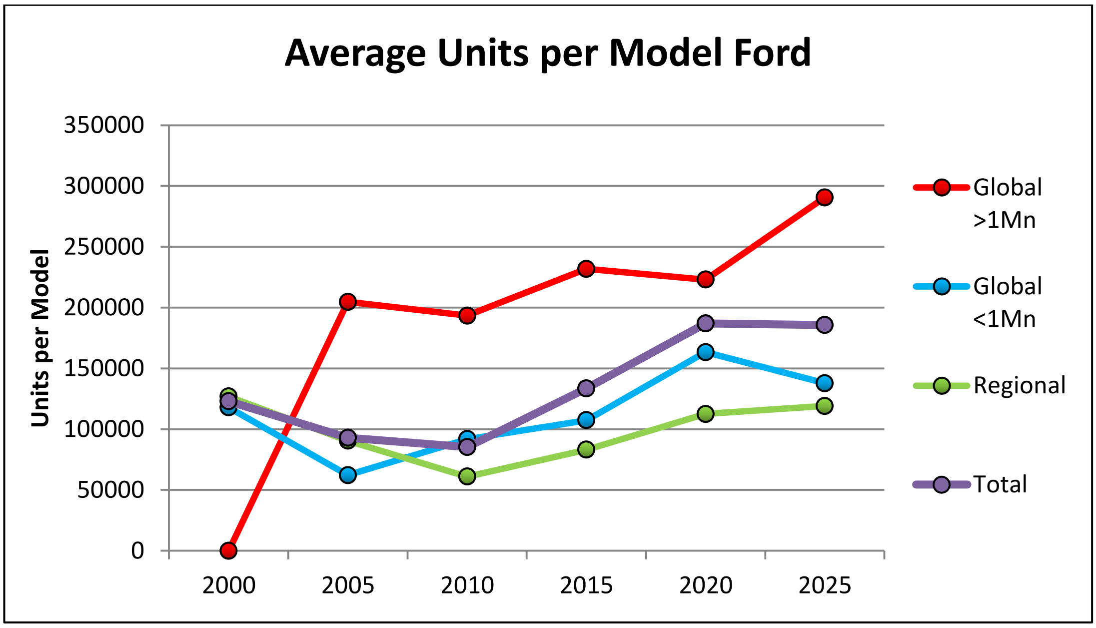

Figure 32: Average Units per Model Ford

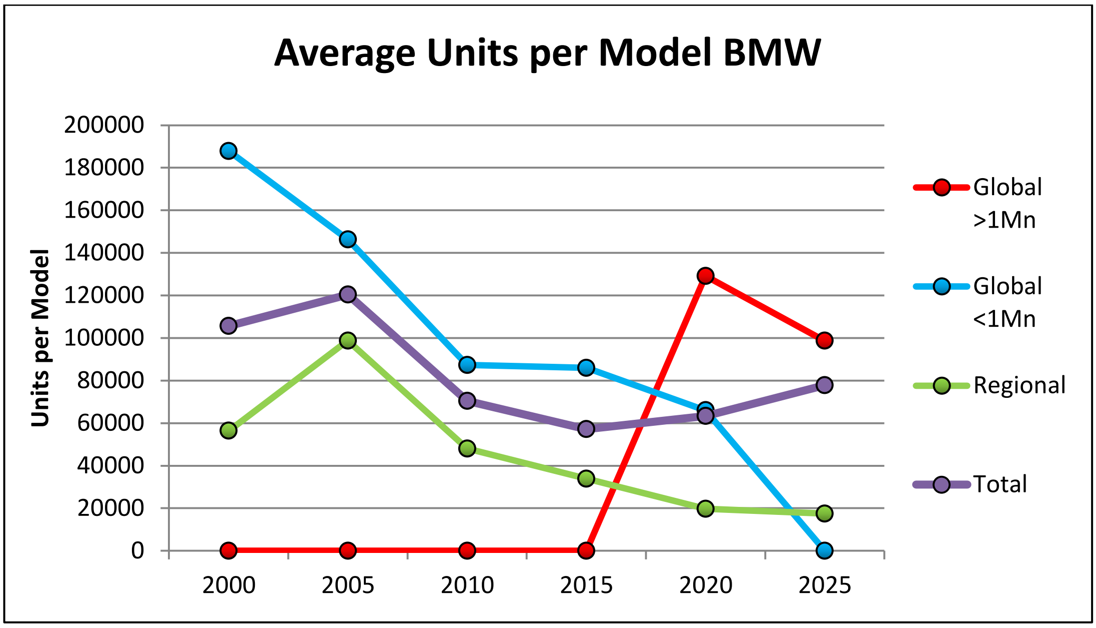

Figure 33: Average Units per Model BMW

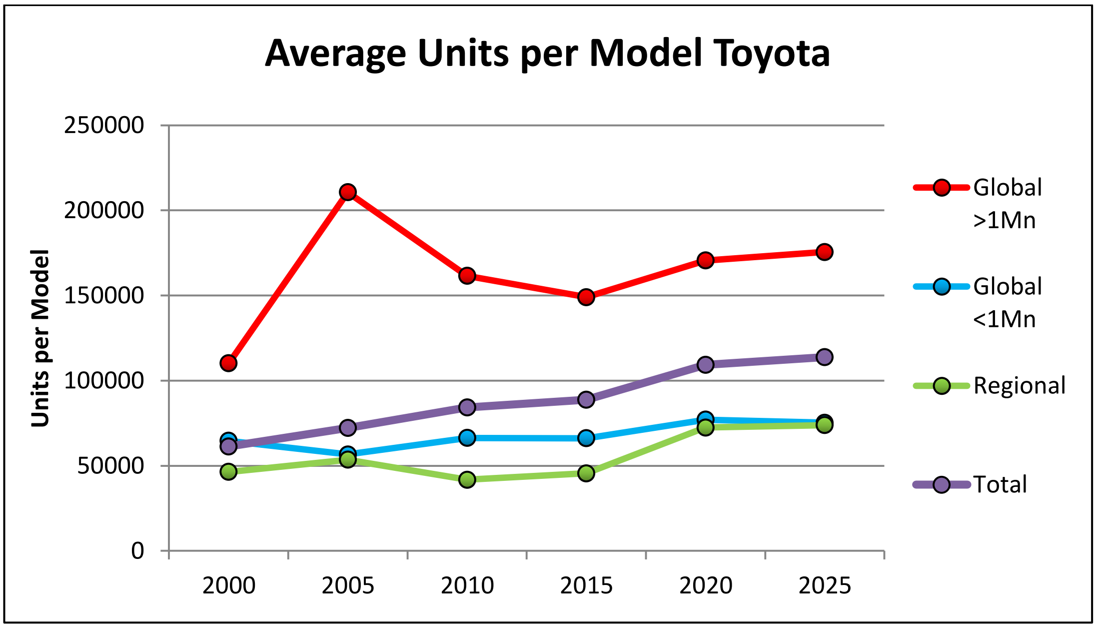

Figure 34: Average Units per Model Toyota

- **Total Production in Segments**

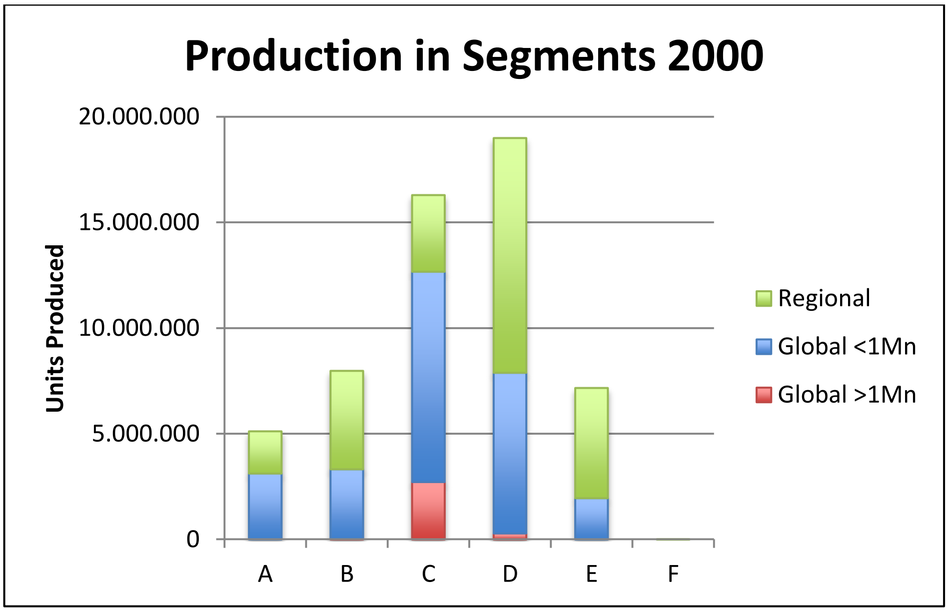

Figure 35: Overall production in Segments 2000

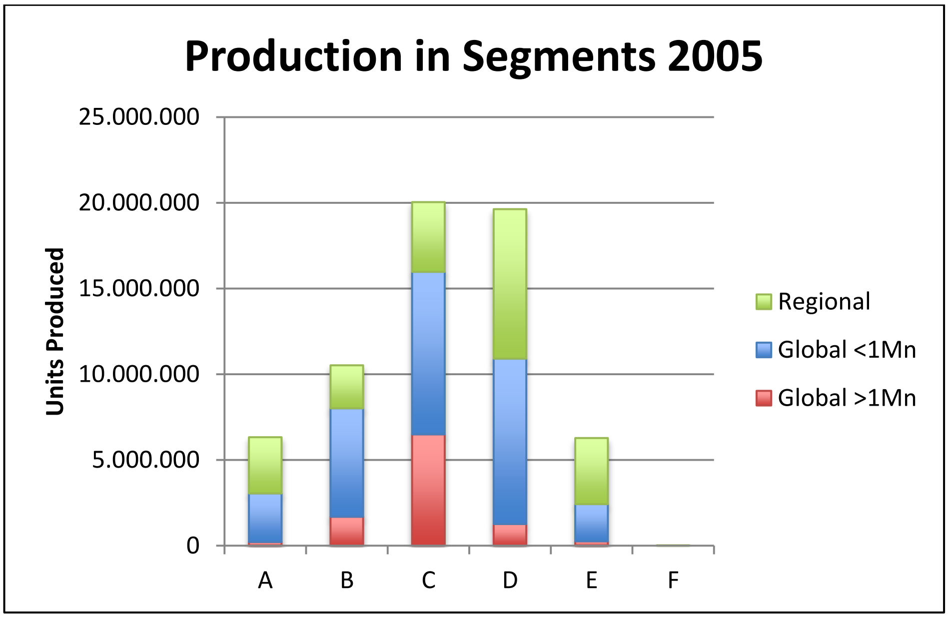

Figure 36: Overall production in Segments 2005

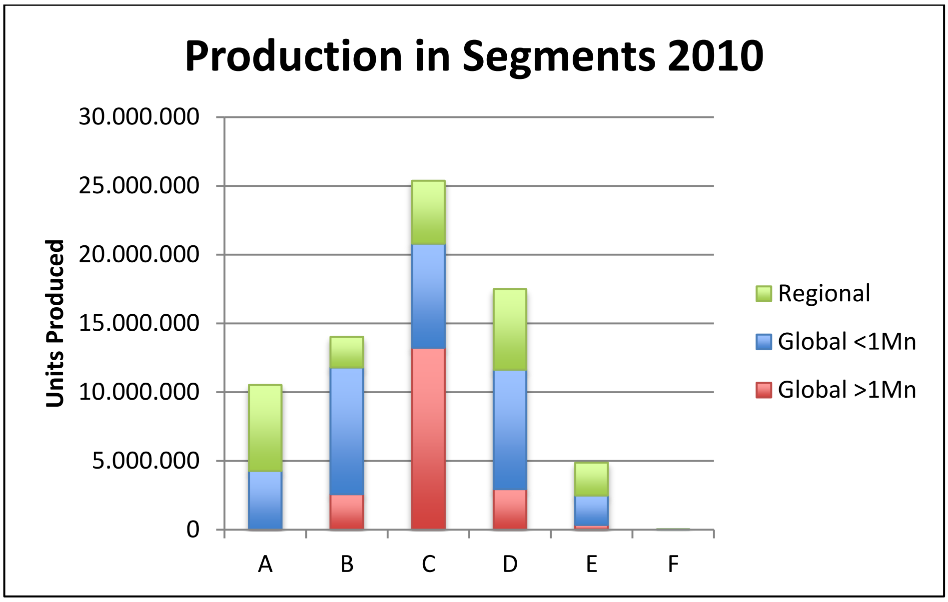

Figure 37: Overall production in Segments 2010

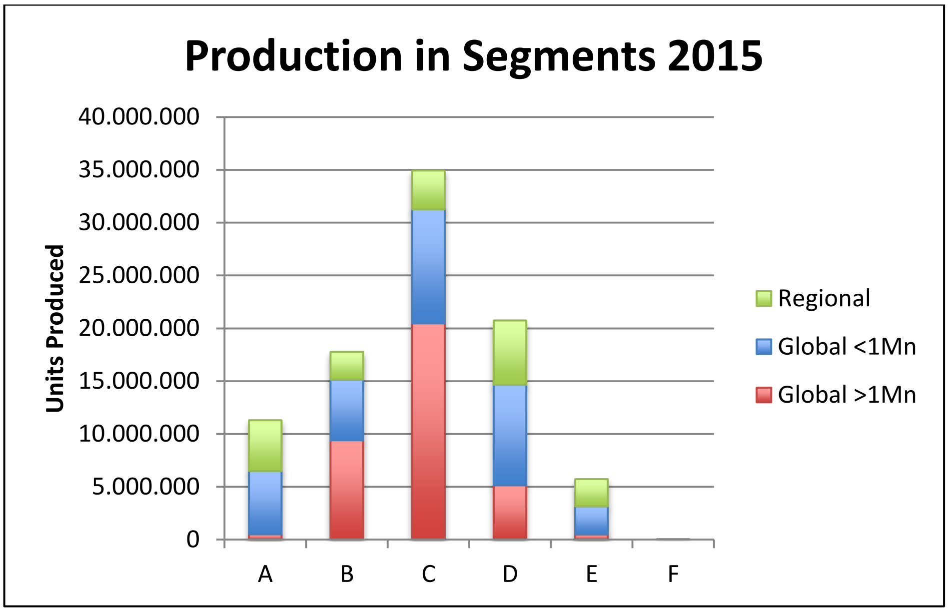

Figure 38: Overall production in Segments 2015

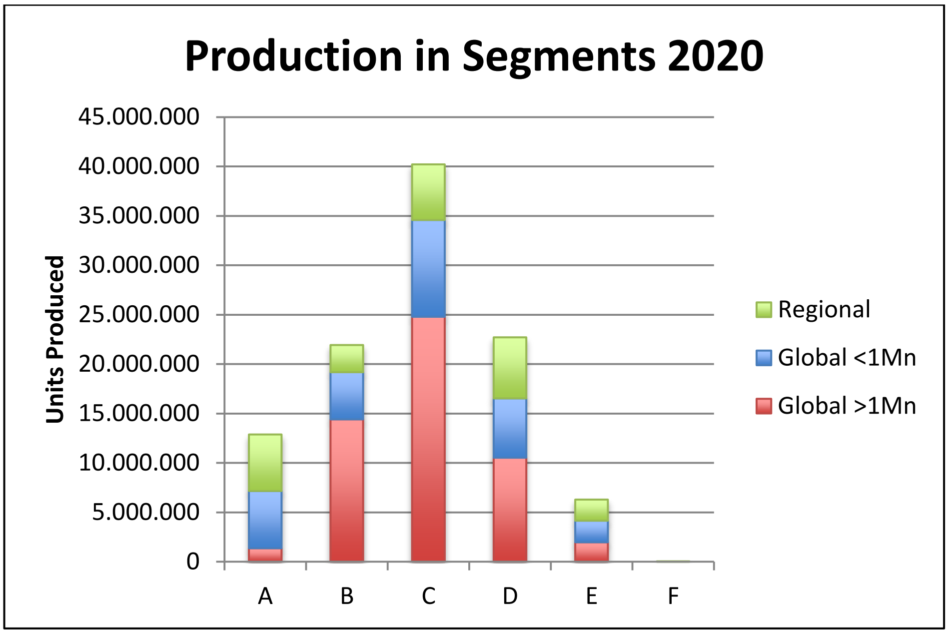

Figure 39: Overall production in Segments 2020

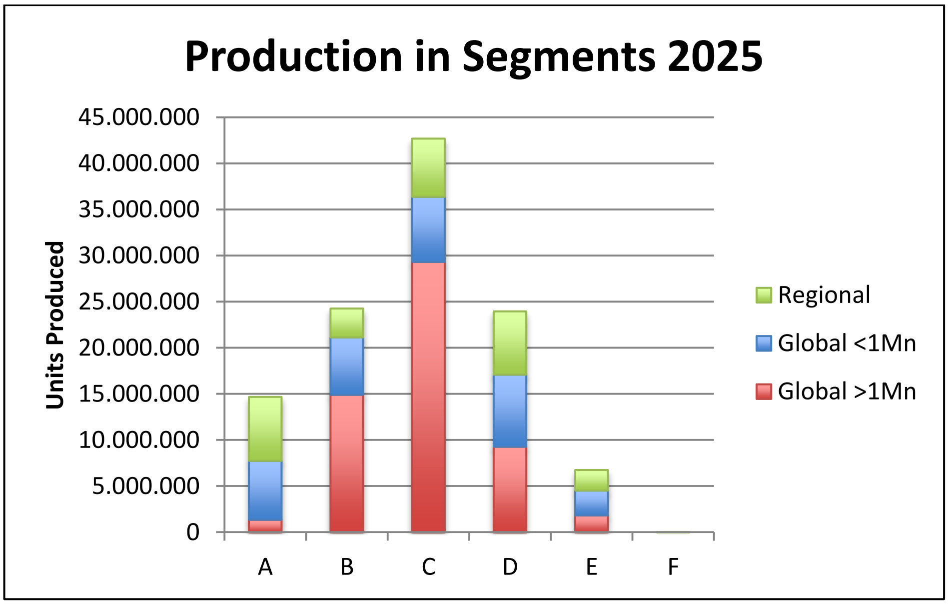

Figure 40: Overall production in Segments 2025

- **Segments per Platform**

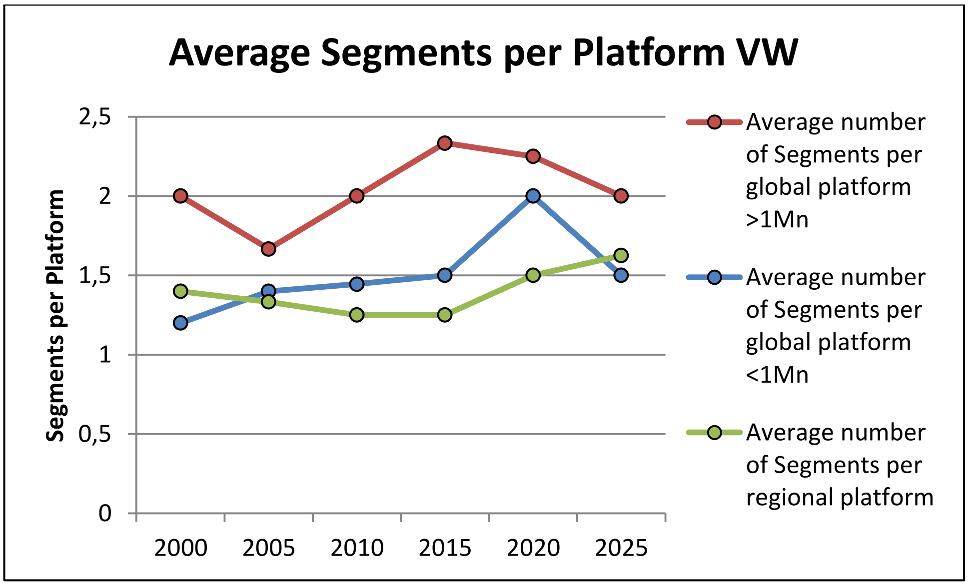

Figure 41: Average Segments per Platform VW

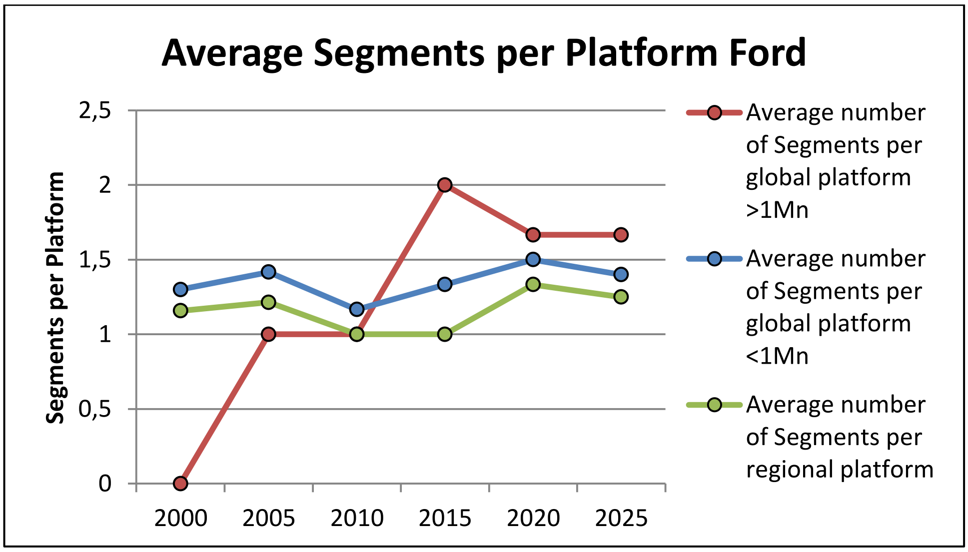

Figure 42: Average Segments per Platform Ford

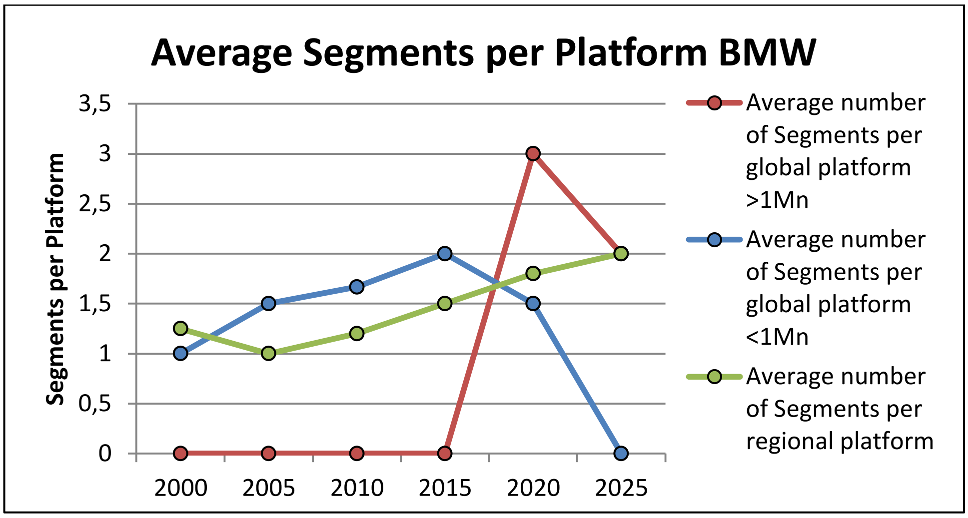

Figure 43: Average Segments per Platform BMW

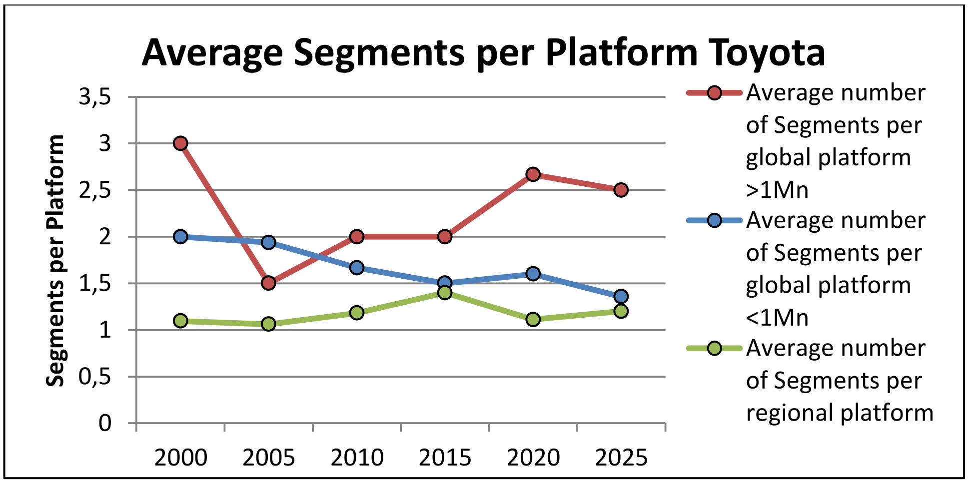

Figure 44: Average Segments per Platform Toyota

- **Shared Platforms**

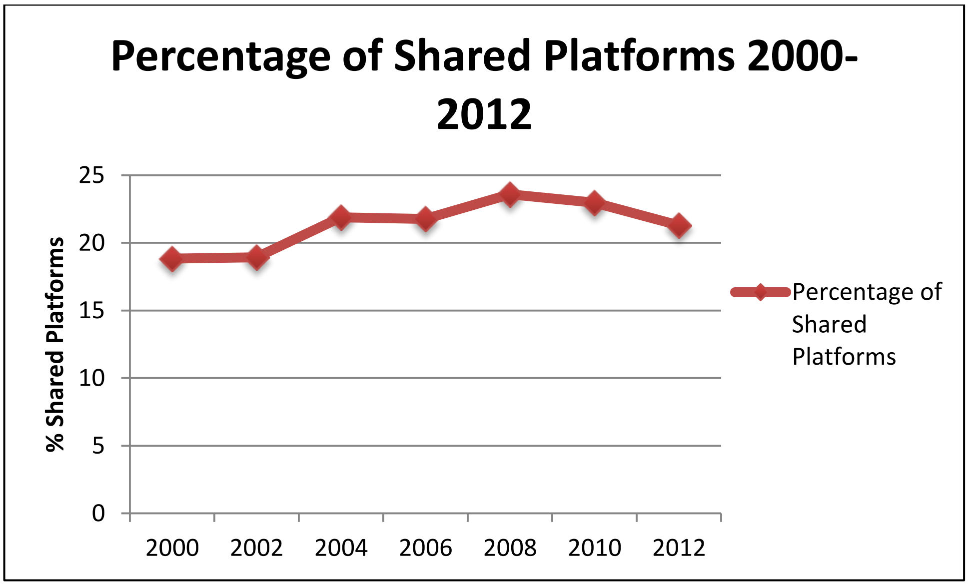

Figure 45: Percentage of shared Platforms 2000-2012

Platform:	BE91	B-0	B-VX62	B2	C	C1	CD1-3	CD-EU	D3/D4	EDISON	EMP1	CMF2
	Ford	PSA	Ford	Ford	Daimler	Changan	FAW	Ford	Ford	Daimler	General Motors	Ashok Leyland
	Ford	Citroen	Ford	Ford	Mercedes-Benz	Changhe	FAW	Ford	Ford	Smart	Opel	Ashok Leyland
	Bantam	C1	Galaxy	Ecosport	Citan	Ideal	Besturn B70	Galaxy	Explorer	Forfour	Corsa	Stile
	Courier	Peugeot	Volkswagen	Fiesta	Dongfeng	Ford	Ford	Mondeo	Flex	Fortwo	Meriva	AvtoVAZ
	Festiva	107	SEAT	Fiesta Van	Dongfeng	Ford	Ford	S-Max	Taurus	Renault/Nissan	Iran Khodro	Lada
	Fiesta	108	Alhambra	Figo	C-Sedan	Escort	Edge	Geely	Taurus X	Renault	Iran Khodro	B-Hatch
	Fiesta Van	Toyota	Volkswagen	Fusion	C-SUV	Focus	Fusion	Volvo	Lincoln	Twingo	Runna	C-Sedan
	Ikon	Toyota	Sharan	StreetKa	Yumsun	Focus C-Max	Mondeo	S60	MKS		PSA	Daimler
	Ka	Aygo		Mazda	Hawtai	i-Max	Lincoln	S80	MKT		Citroen	Mercedes-Benz
	Puma			Mazda	Hawtai	Kuga	MKX	V60	Mercury		B-CUV (EM)	B-Hatch
	Mazda			Demio	C-CUV	Geely	MKZ	V70	Sable		C3	Dongfeng
	Mazda			Verisa	Jianghuai	Volvo	Mercury	XC60	Geely		C3 Picasso	Dongfeng
	121			Volkswagen	Jianghuai	C30	Milan	XC70	Volvo		C-Cactus	Succe
				Volkswagen	Binyue	C70	Mazda	Tata	C70		C-Elysee	General Motors
				Santana	Hechang	S40	Mazda	Land Rover	S60		DS3	Chevrolet
				Santana 2/3000	Renault/Nissan	V50	Atenza	Freelander	S70		Peugeot	City Express
					Nissan	Mazda	CX-7	Range Rover Evoque	S70/V70		2008	Renault/Nissan
					Dualis	Mazda	CX-9		S80		208	Dacia
					Lafesta	Axela	D-CUV		V70		301	Dokker
					Qashqai	Biante	MPV				Hoggar	Dokker Van
					Rogue	Premacy	Tata					Lodgy
					Serena		Jaguar					Logan
					Sunny		X-Type					Logan MCV
					Tiida							Sandero
					X-Trail							Datsun
					Renault							B-Hatch
					Fluence							B-MPV
					Kangoo							Infiniti
					Kangoo LCV							EV
					Koleos							Nissan
					Megane							March
					Scenic							AD Van
					Samsung							Almera
					QM5							B-SUV
					SM3							C-Hatch
					Venucia							Cube
					C-SUV							Evalia
												Juke
												Lafesta
	EMP2	J97	ROLLS ROYCE	S2	TC/TY	TYPE 169	TYPE 199	U/V	YD	YN		Leaf
	General Motors	Ford	BMW	Hyundai	Ford	Fiat	Fiat	Fiat	General Motors	Fiat		Micra
	Opel	Ford	Rolls-Royce	Kia	Ford	Fiat	Alfa Romeo	Fiat	Chevrolet	Fiat		Note
	Zafira Tourer	Everest	Arnage/Silver Seraph	Towner Truck	Pronto	500	MiTo	Scudo	Cruze	Sedici		NP200
	Iran Khodro	Ranger	Volkswagen	Towner Van	General Motors	Panda	Fiat	Ulysse	Opel	General Motors		NV200
	Iran Khodro	Mazda	Bentley	Perodua	Chevrolet	Panda Van	Doblo	Lancia	Agila	Opel		Pulsar
	Samand	Mazda	Arnage	Perodua	Super Carry	Lancia	Fiorino	Phedra	Suzuki	Agila		Sunny
	PSA	B-Series	Azure	Rusa	Daewoo	Ypsilon	Idea	Zeta	Suzuki	Mazda		Tiida
	Citroen	Fighter	Brooklands	PSA	Damas	Ford	Linea	PSA	Swift	Mazda		Renault
	Berlingo		Continental	Citroen	Mitsubishi	Ford	Palio	Citroen	Wagon R	VX-1		Captur
	C4		Mulsanne	Saxo	Mitsubishi	Ka	Punto	C8		Suzuki		Clio
	C4 L			Saxo Van	Colt T120		Punto Van	Evasion		Maruti-Suzuki		Dokker
	C4 Picasso			Peugeot	Maven		Scudo	Jumpy		Ertiga		Lodgy
	C5			106	Suzuki		Siena	Peugeot		Ritz		Logan
	D-CUV			Toyota	Maruti-Suzuki		Strada	806		Sub-Compact SUV		Pulse
	DS4			Daihatsu	Eeco		Ram	807		Swift		Sandero
	DS4 SUV			Hijet	Omni		C-Van	Expert		Swift Dzire		Scala
	DS5				Versa		General Motors			SX4		Tondar
	Pallas				Suzuki		Chevrolet			SX4 SUV		Zoe
	Shijia				APV		Corsa Utility			Suzuki		Venucia
	Peugeot				Carry Pickup		Opel			C-CUV		B-Hatch
	3008				Carry Truck		Adam			C-Sedan		B-Sedan
	308				Every		Combo			Ertiga		C-CUV
	401				Ravi		Corsa			Solio		C-Hatch
	5008						Corsa Utility			Splash		D50
	508						Corsa Van			Swift		R50
	Partner						PSA			SX4		
	RCZ						Citroen			SX4 Sporty		
							Nemo			SX4 SUV		
							Peugeot					
							Bipper					

Table 3: Examples for shared Platforms

Mirrors & Closures	Cosma	Exterior & Interior	Seating	Powertrain & Electronics
Wing mirror	Tires and Wheels	Headlamps	Front seats trim & Foam, including styling and contours	Transmission
Inside mirror	Steering column	Bumper	Front seat structure	Base Engine
Door handles	Parking brakes	Windshield	Front seat belts and airbags	Castings
Sun roof - Standard	Steering rack	Windshield washing / wiping systems	Seat Plastic shields, handles	Exhaust treatment
Door and trunk lock	Brake booster	Side windows	Seat adjustment mechanisms - electrical	Crank assembly
Remote entry	Tire pressure monitoring	Rear window	Seat adjustment mechanisms - manual	Drivetrain
Keyless entry	Struts	Plastic exterior parts	Seat cooling / heating	Injection
Sun roof - Panorama	Emergency / Repair kit	Rear lamps	2nd Row seat trim & Foam	Auxiliaries
Central locking	Stabilizer	Rocker panels	2nd Row seat structure	Charging system
Convertible roof top - Hard top (RHT)	Brake systems	CMHSL	2nd Row seat belts	Exhaust
Convertible roof top - Soft top	Wheel brake	Rain sensor	2nd row seat mechanisms	Fuel delivery
Power sliding door	Night vision systems	Automated light systems	3rd row seats trim & foam	E-machine
Power folding door	Brake actuators	Fog light	3rd row seat structure	Valve train
Power trunk/tailgate	Springs	Rear window washing / wiping system	3rd row seat belts	EGR
Active grill	Rear wheel steering	Headlamp washing system	3rd row seat mechanisms	Air intake
	Body in white	Front end module		Control
	Hood	Rear end module		Ignition/Glow system
	Doors	Lift gate		xEV - Batteries
	Trunk lid	Roof module		Battery (12V)
	Gaskets / Sealants	Other		Power electronic
	Wheel hub	HVAC		E-machine EV
	Axle control arms	Airbags		Power electronic EV
	Axle cradle	Cockpit		Parking systems
	Hinges	Wiring		Active Cruise Control
	Roof system	Trim		Lane departure waring
		Carpet / Acoustics		Emergency call
		Window lifter		Blind spot detection
		Audio		Drowsiness
		Instrumentation		Rear view camera
		Navigation		Top - surround view
		Vehicle security		
		Trunk management		
		Connectivity		
		Infotainment		
		HMI		
		Door trim panel		
		Headliner		
		Center Console		
		Package Tray		

Table 4: Module list

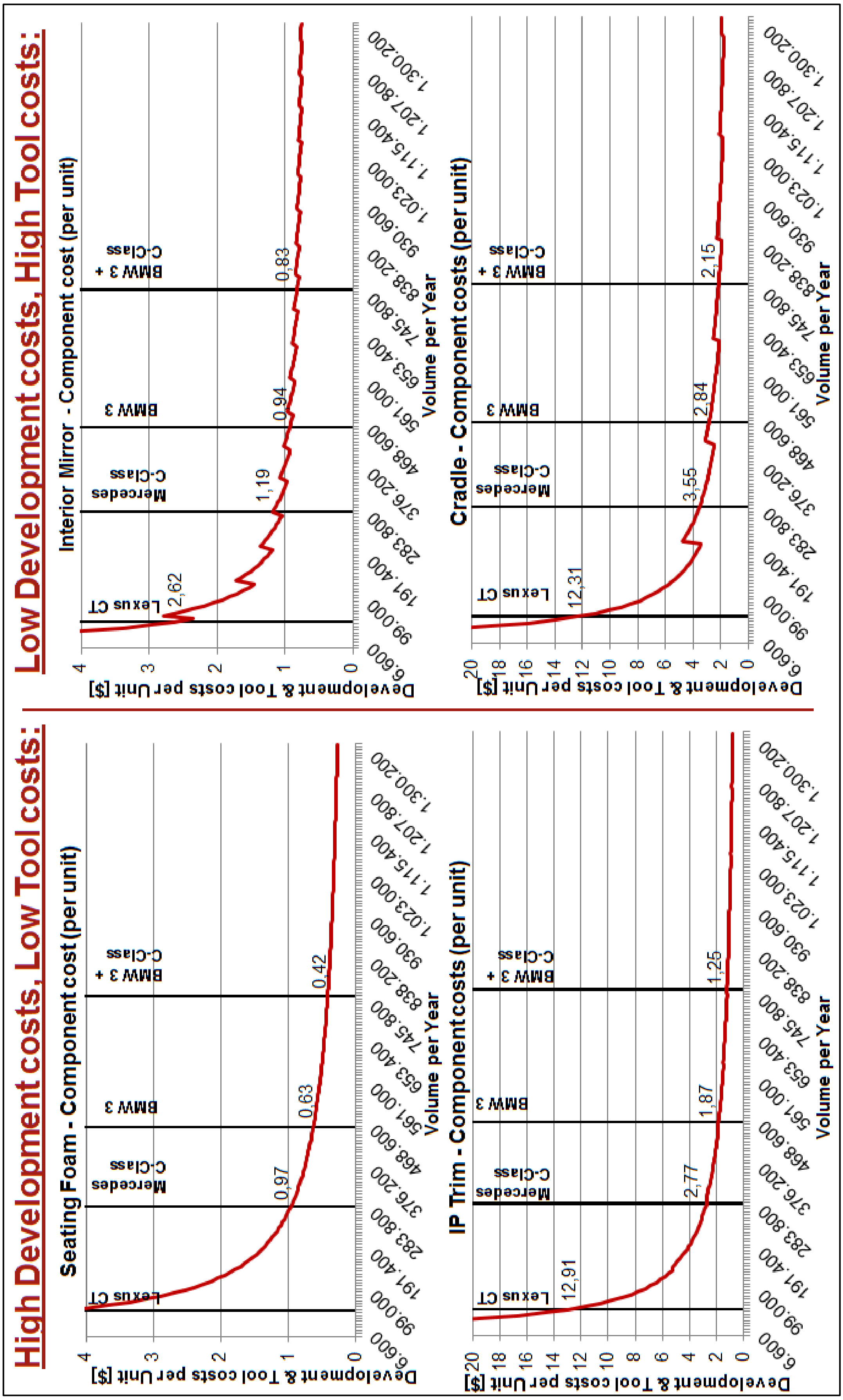

Figure 46: Comparison Tool & Development Costs