

# **The Financial Management of Functions on Demand:**

## A Study on the Application of Functions on Demand as a Recent Business Model Innovation in the Automotive Industry

Zur Erlangung des akademischen Grades eines

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**Dissertation**

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**M. Sc. Sören Jaedeke**

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Erster Gutachter: Prof. Dr. Marc Wouters

Zweiter Gutachter: Prof. Dr. Martin Klarmann

Karlsruhe

23.03.2026



## Declaration of Originality

I hereby declare that this dissertation and the work described in it are my own work, that I have completely and specifically disclosed all assistance received, that I have specified everything quoted either literally or by content from other works, and that this paper complies with the regulations of good scientific practice of the Karlsruhe Institute of Technology (KIT).

*Karlsruhe, 23.03.2026*

A handwritten signature in black ink, consisting of a stylized 'S' followed by a horizontal line extending to the right.

Achievements are the building blocks that enable me  
to build my self-confidence to what it is today.

I continue to forge the iron as long as it glows.

For my beloved parents.

## Summary

The research topic of this dissertation is the management of the Functions on Demand (FoD) business model from a provider's point of view. The basic idea of FoD is to enable a customer to activate hardware or software features at a specific cost to be paid after a product has been purchased. Accordingly, FoD represent an after-sales business opportunity for firms, as they can provide additional income streams. Given that the successful implementation of FoD depends on several parameters that are difficult to assess beforehand (e.g., FoD take-rate), it exhibits a challenging undertaking with a severe level of uncertainty. The overall **research objective** of our dissertation is to generate knowledge about the business model innovation (BMI) of FoD. Next to the decision-making that original equipment manufacturers (OEMs) face when offering FoD, we aim to recognize further general challenges in this context.

We first conduct a **systematic literature review** to analyze the challenges, advantages, and potential risks of applying FoD. Our literature review supplements the existing but rather limited knowledge about FoD by providing an overview in addition to a classification of related business concepts. Additionally, we highlight marketing- and financial-related aspects that are relevant to OEMs. We also provide various recommendations for OEMs that make use of FoD.

Secondly, we conduct a **case study** within an automotive company to gain further application-related insights into the challenges faced by OEMs during the implementation process of FoD. In this context, we furthermore classify FoD as a form of BMI. By delivering three financial and six general BMI implementation challenges, we supplement our literature review, as most of the current research findings focus on the consumer perspective of FoD.

Thirdly, as part of a **methodological study**, we consider the decision-making process involved in determining whether an OEM should offer certain FoD in a dynamic business environment. For this purpose, we state a decision-support model that chooses between the alternatives of offering or not offering functions as FoD. Our study contributes to the literature by providing an initial mathematical model that is able to financially evaluate if FoD are profitable for OEMs. Our approach likewise includes an example and various extensions.

This dissertation was supervised by Prof. Dr. Marc Wouters from the chair of Management Accounting (IBU) at the Institute for Management at KIT. The language is English, and the author is aiming for the title of Dr. rer. pol.

## Kurzfassung

Das Forschungsthema dieser Dissertation ist das Management des Geschäftsmodells „Functions on Demand“ (FoD) aus Anbietersicht. Die Grundidee von FoD besteht darin, Kunden die Möglichkeit zu geben, Hardware- oder Softwarefunktionen zu einem bestimmten Preis zu aktivieren, der nach dem Kauf eines Produkts zu zahlen ist. Dementsprechend stellen FoD für Firmen eine After-Sales-Geschäftsmöglichkeit dar, da sie zusätzliche Einnahmequellen erschließen können. Da die erfolgreiche Umsetzung von FoD von mehreren Parametern abhängt, die im Voraus schwer einzuschätzen sind (z. B. die FoD-Buchungsquote), stellt diese eine Herausforderung mit einer hohen Unsicherheit dar. Das übergeordnete **Forschungsziel** unserer Dissertation ist es, Erkenntnisse über die Geschäftsmodellinnovation (BMI) von FoD zu gewinnen. Neben den Entscheidungen, denen Originalgerätehersteller (OEMs) bei der Bereitstellung von FoD gegenüberstehen, wollen wir weitere allgemeine Herausforderungen in diesem Zusammenhang erforschen.

Zunächst führen wir eine **systematische Literaturrecherche** durch, um die Herausforderungen, Vorteile und potenziellen Risiken der Anwendung von FoD zu analysieren. Unsere Literaturrecherche ergänzt das vorhandene, aber begrenzte Wissen über FoD, indem sie einen Überblick sowie eine Klassifizierung verwandter Geschäftskonzepte bietet. Darüber hinaus heben wir marketing- und finanzbezogene Aspekte hervor, die für OEMs relevant sind. Außerdem geben wir verschiedene Empfehlungen für OEMs, die FoD anwenden.

Zweitens führen wir eine **Fallstudie** in einem Automobilunternehmen durch, um weitere anwendungsbezogene Einblicke in die Herausforderungen zu gewinnen, denen OEMs während des Implementierungsprozesses von FoD gegenüberstehen. In diesem Umfeld klassifizieren wir FoD ebenfalls als eine Form von BMI. Indem wir drei finanzielle und sechs generelle Herausforderungen im Zusammenhang mit der Implementierung von BMI aufzeigen, ergänzen wir unsere Literaturrecherche, da sich die meisten bisherigen Forschungsarbeiten auf die Verbraucherperspektive von FoD konzentrieren.

Drittens betrachten wir in einer **methodologischen Studie** den Entscheidungsprozess, der bei der Frage eine Rolle spielt, ob ein OEM bestimmte FoD in einem dynamischen Geschäftsumfeld anbieten sollte. Zu diesem Zweck stellen wir ein Entscheidungshilfemodell vor, das berechnet, ob Funktionen als FoD angeboten werden sollten oder nicht. Unsere Studie leistet einen Beitrag zur Literatur, indem sie ein erstes mathematisches Modell liefert, mit dem sich finanziell bewerten lässt, ob FoD für OEMs rentabel sind. Unser Ansatz umfasst ebenfalls ein Beispiel sowie einige Erweiterungen.

Diese Dissertation wurde von Prof. Dr. Marc Wouters vom Lehrstuhl für Management Accounting (IBU) am Institut für Management des KIT betreut. Die Sprache ist Englisch, und der Autor strebt den Titel Dr. rer. pol. an.

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## List of Abbreviations

AB	Absolute bookings
AE	Access economy
BC	Business case/FoD billing costs
BM	Business model
BMI	Business model innovation
CIP	Continuous improvement product
CM	Contribution margin
CS	Calculation scheme
CY	Calendar year
DC	FoD development costs
DLC	Downloadable content
dr	Discount rate
ECU	Electronic control unit
ef	Expiry factor
EP	Expert partner
EPU	External product upgrade
FoD	Functions on Demand
HR	Headroom
hr	Headroom factor
IBU	Chair of Management Accounting
IoT	Internet of Things
IPU	Internal product upgrade
IR	Installation rate
KIT	Karlsruhe Institute of Technology
KPI	Key performance indicator
MA	Management accounting
MaaS	Mobility-as-a-Service
MC	Material costs
MP	Mobile payment
NPD	New product development
NPV	Net present value

ODCF	On-demand car feature
ODF	On-demand feature
ODS	On-demand services
OEM	Original equipment manufacturer
OPAC	On-demand product adjustment capability
OTA	Over-the-air
P	Price
PA	Product architecture
POS	Point of sale
PSS	Product-service systems
PPU	Pay-per-use
R	Sales region
RA	Research approach
rAB	Realistic absolute bookings
RO	Real option
RF	Revenue factor
rVV	Realistic vehicle volume
RY	Reference year
SaaS	Software-as-a-Service
SE	Sharing economy
sf	Sustainability factor
SVV	Special vehicle volume
SOP	Start of production
TC	Total costs
TR	Take-rate
TVV	Total vehicle volume
VV	Vehicle volume
VY	Vehicle year
V2V	Vehicle-to-vehicle
WC	FoD warranty costs
WTP	Willingness to pay
X	FoD price variation factor

## List of Definitions

Access-based services	“Grant customers the right to temporarily access a good but require them to share this particular good with other, unknown users” (Hazée et al. 2017).
Add-on features	“Functions that have to be consumed with a corresponding base product to provide utility” (Bertini, Ofek and Ariely, 2009).
Access economy	“A scalable socioeconomic system that employs technology-enabled platforms to provide users with temporary access to tangible and intangible resources that may be crowdsourced” (Eckhardt <i>et al.</i> , 2019).
Business model	“A business model describes the rationale of how an organization creates, delivers, and captures value” (Osterwalder and Pigneur, 2013).
Business model innovation	“A business model innovation promotes the innovation of the total business model of an organization to become client-driven. It identifies human involvements and interactions with customized products according to customer’s specific needs as the core activity of the new business model” (Steenkamp and Arnoldi-van Der Walt, 2004).
Continuous improvement products	“Products that are designed so that the firm can make post-purchase improvements over time to the products constituent assemblages without requiring the user to fully replace the product” (Ho-Dac <i>et al.</i> , 2020).
Connectivity	“Cars, that have telematics components for exchanging data with the ecosystem, whereby digital services are enabled, which generate added value for drivers and owners in terms of safety, navigation, information, comfort, and entertainment” (Bosler <i>et al.</i> , 2018).
Digital service	“An activity or benefit provided by one party to another through a digital transaction” (Williams, Chatterjee and Rossi, 2008).
External product upgrade	“An assured attribute is physically detached and sold separately from the original product” (Garbas <i>et al.</i> , 2022).
Functions on Demand	“Services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”.
Innovation	“The multi-stage process whereby organizations transform ideas into new/improved products, services or processes, to advance, compete, and differentiate themselves successfully in their marketplace” (Baregheh, Rowley and Sambrook, 2009).
Internet of Things	“Group of infrastructures interconnecting connected objects and allowing their management, data mining, and access to the data they generate” (Dorsemaine <i>et al.</i> , 2015).

Internal product upgrades	“Fee-based activation of originally built-in, but deliberately restricted, optional features” (Garbas <i>et al.</i> , 2022).
Modular upgradability	“A way to reduce a customer’s costs of keeping up with new technologies” (Ramachandran and Krishnan, 2008).
New product development	“Product development is the process by which an organization transforms market opportunities and technical possibilities into valuable information for commercial production” (Clark and Fujimoto, 1991).
On-demand features	“Services that allow customers to temporarily access certain features of a product for an additional fee after the initial purchase has been made” (Schaefers <i>et al.</i> , 2022).
On-demand service	“An ubiquitously available service, able to instantaneously supply the exact required amount of resources for the exact required duration, at the moment they are requested by the customer” (Van der Burg <i>et al.</i> , 2019).
On-demand product adjustment capabilities	“On-demand product adjustment capabilities allow customers to efficiently process their request for short-term changes of service quality to meet time-varying demands” (Jiang <i>et al.</i> , 2022).
OTA software updates	“Self-contained modules of software that are provided to the user for free to modify or extend a software after it has been rolled out and is already in use” (Fleischmann <i>et al.</i> , 2016).
Product architecture	“The product architecture summarizes the product structure as a physical structure and the functional structure as a functional description of a product and relates their elements to each other. The product architecture is the totality of the functional and physical descriptions of a product” (Krause and Gebhardt, 2018).
Product configuration	“Special design activities that take place after the design by capitalizing on design results, such as functional features, component specification, and relationships between functional features and component specifications” (Zhang, 2014).
Product-service system	“A product-service system is a system of products, services, networks of players and supporting infrastructure, that continuously strives to be competitive, satisfy customer needs, and has a lower environmental impact than traditional business models” (Goedkoop <i>et al.</i> , 1999).
Real option	“An investment decision that is defined by uncertainty, the provision of managerial discretion to exercise at the appropriate time and irreversibility” (Kogut and Kulatilaka, 2001).
SCOPUS	“The largest abstract and citation database of peer-reviewed literature” (Elsevier, 2017).
Servitization	“Transformation of a firm from taking a product- to taking a service-centric approach” (Raddats <i>et al.</i> , 2019).
Subscription model	“Arrangements involving a recurring fee for access to a specified product, content, or service” (Schuh <i>et al.</i> , 2020).

## Acknowledgment

The dissertation emerged out of an industrial cooperation between the Karlsruhe Institute of Technology (KIT), more precisely the chair of Management Accounting (IBU), and the AUDI AG, one of Germany's leading automotive manufacturers. It offers readers interested in the application of new business model innovations (BMIs) in the automotive environment several valuable insights, for example into the recent trend of "Functions on Demand" (FoD).

After completing my master's degree in collaboration with the IBU in November 2021, I received an offer to participate in this industry promotion. Despite the uncertainties caused by COVID-19 and my plans to take a break after completing my studies, discussions with the people in charge at the KIT and Audi AG convinced me to participate. The reason for my commitment was the concern of later regret if I had chosen a different career path, as well as the opportunity to test my abilities outside the comfort zone of university. Today, I can say that I have no doubts about my decision. However, success on this journey would not have been possible if a certain companionship had not granted me their unconditional support:

Primarily, I want to thank my supervisor and IBU chair holder Prof. Dr. Marc Wouters for the continuous exchange and guidance throughout my work. Your tireless motivation for authoring scientific papers has repeatedly inspired and encouraged me whenever I was unsure about the next steps. Your recommendations had a profound impact on the final design of my dissertation. Thank you for the influence you have had and continue to have on me.

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# 1 Introduction

This Chapter 1 serves as a brief impression of the research objective of our dissertation. The outline is also intended to provide a better understanding of the structure of the dissertation. Most parts of the dissertation are written in the first-person plural perspective due to the pleasant reading style. However, the dissertation was exclusively authored by Sören Jaedeke.

The research objective of our dissertation can be perceived as the creation of insights into the challenges of the Functions on Demand (FoD) business model innovation (BMI), next to the decision-making process that OEMs encounter when implementing FoD. Throughout this dissertation, we define FoD as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. Despite various advantages, major concerns for OEMs remain. This is because FoD involve a high degree of uncertainty due to the financial upfront investments and the preinstallation of functions, in combination with the unpredictable acceptance rate of features (Garbas *et al.*, 2022). Since the continuous development of technical novelties using diverse business models (BMs) and innovations is promising, solving the challenges for such concepts is of interest to scholars and OEMs. Most studies about FoD to date analyze the topic from the consumer perspective and primarily address their perceptions and reactions to this BMI (Wiegand and Imschloss, 2021; Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). As a result, there is a limited understanding of the challenges for OEMs involved in implementing BMIs such as FoD. Moreover, the product architecture (PA) decision-making process, whether it is financially advantageous for OEMs to offer functions as FoD or not, remains unclear.

To close this gap, we conduct three independent research studies. Starting, we provide a systematic literature review about the FoD concept, revealing several theoretical insights. Subsequently, in the scope of a case study, we gain perceptions of the associated challenges regarding the implementation of BMIs (e.g., FoD) for companies. Finally, conducting a methodological study, we present a financial decision-support model that illustrates how OEMs can decide whether or not they should offer certain features as FoD. For this purpose, we divide our dissertation into five overarching chapters, as furthermore shown in Figure 1.

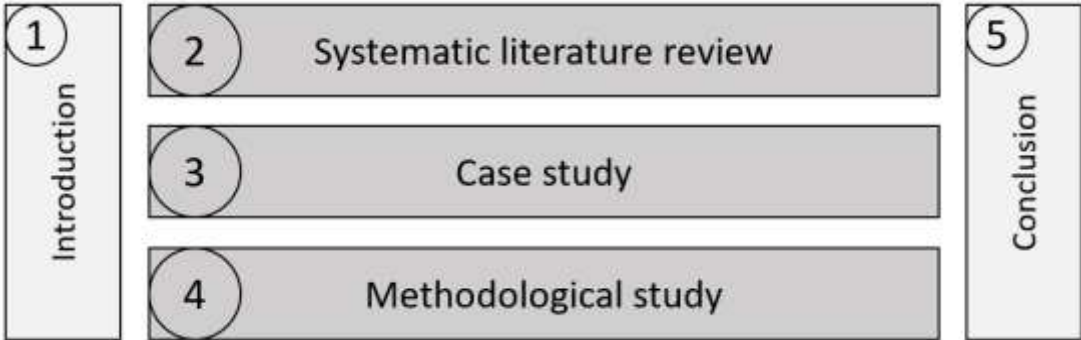


Figure 1. Overview of the five chapters comprising the dissertation

The systematic literature review of Chapter 2 delivers various insights about FoD. We provide a comprehensive overview of the current state of knowledge by identifying a set of 50 publications and industrial reports that deal with the application, issues, and benefits of FoD. First, we formulate a revised definition of FoD that classifies the BMI in connection with the access economy (AE), on-demand services (ODS), and connectivity. We then divide the literature into four clusters: FoD-related BMs, customer perceptions and responses to FoD, payment processes and offering structure for FoD, and implications for OEMs applying FoD. Regarding the first cluster, next to general FoD insights, we compare FoD to related concepts such as add-on features and modular upgradable products. By these means, our systematic literature review successfully contributes to expanding the previously limited FoD knowledge (Wiegand and Imschloss, 2021; Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022).

The qualitative case study of Chapter 3, which was conducted in cooperation with an automotive company, sheds light on the financial implementation challenges of FoD and BMIs. We worked almost full-time in the accounting department of the firm for three years. This set-up enabled access to a wide range of sensitive information. In addition, daily exchanges with colleagues who operated with BMIs such as FoD provided us with valuable comprehensions. Applying a case study, we aim to understand how the literature can learn from the industry and the other way around. By making use of discussion-style interviews, a research diary, and additional data sources (e.g., e-mails, PowerPoint presentations, and Excel files), we can provide a thorough picture of the financial challenges associated with implementing BMIs. We identify three financial challenges next to six more general challenges in implementing BMIs and successfully illustrate how OEMs can counteract these. We also discuss FoD as BMI and provide further insights in this regard. Because there was little empirical evidence available about the difficulties of applying BMIs prior to our study (Chesbrough, 2010; Frankenberger *et al.*, 2013; Spieth, Schneckenberg and Ricart, 2014), we expand the present knowledge.

Chapter 4 provides a financial decision-support model for FoD. Because most research studies concentrate on the customer reactions to FoD, we develop a model that allows OEMs to assess whether offering features as FoD is economically viable. Facing our model, we make use of several previously published PA decision-support models, exemplary by Wouters *et al.* (2011), and of available theoretical and practical FoD insights. Moreover, our model was also inspired by the case study at the same automotive company. The final model analyzes a FoD scenario and an alternative configuration scenario in which features can only be installed in advance. Using a range of mathematical assumptions and variables within our heuristics, the two net present values (NPVs) are compared in order to find the more promising alternative and state a recommendation for action. After delivering a numerical example, we also modify our basic model by incorporating additional input variables and extensions to examine more closely which influences from which set-up are more promising. The final choice depends on the more economically sufficient alternative. All things considered, we close our dissertation with the conclusion and a summary of our overarching contributions in Chapter 5.

## **2 A Systematic Literature Review on Functions on Demand**

### **Abstract**

Significant changes in recent years, such as connectivity, digitalization, and electrification, are leading to various new industrial concepts among original equipment manufacturers (OEMs). For example, Functions on Demand (FoD) display a service innovation that grants customers temporary or permanent access to hardware and software features for a fee. FoD can provide a device with functions, which can be of safety, convenience, or performance origin, and deliver various customization possibilities. Firms apply such business model (BM) to generate recurring revenues next to the traditional one-time sales and to achieve a higher degree of standardization in the production, resulting in lower costs. Despite the implementation of FoD by various OEMs, scientific insights remain rare. Accordingly, our systematic literature review investigates the available FoD knowledge, as we analyze research findings and use cases from white papers and consulting firms. We then classify the insights into four categories. First, on-demand services in connection with the aspect of upgrading certain devices across industries are examined. In this manner, we also point out related BMs to FoD. Next, we review customer perceptions and responses to FoD by evaluating the influences on consumer behavior. Following, financial insights for OEMs that offer FoD, such as payment processes and offering structure, are being observed. We conclude the review with implications for OEMs using FoD.

### **Keywords**

Functions on Demand, Literature review, On-demand services, Product upgradability, Business model innovation

## 2.1 Introduction

It is not to be denied that fast-paced technological enhancements have a major influence on industrial original equipment manufacturers (OEMs). For example, due to the ongoing launch of new product models and the availability of many configurations, the final device variety ex-factory for car companies can reach an order of magnitude of up to  $3.7 \cdot 10^{24}$  (Staeblein and Aoki, 2015). This aspect results in an overall cost increase (Umpfenbach *et al.*, 2018). In order to counteract the complexity issue in vehicle options and modeling line-ups, OEMs attempt to achieve savings of up to 70% through standardization and modularization (Winkelhake, 2018).

A strategy for achieving a higher degree of standardization and reducing product complexity is the business model innovation (BMI) of “Functions on Demand” (FoD). FoD, also known as on-demand features (ODFs), on-demand car features (ODCFs) in the automotive industry, or internal product upgrades (IPUs), grant customers temporary or permanent access to functions of a product that they already own (Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). Tesla was the first OEM to provide features via over-the-air (OTA) updates in 2016 (Schmidt, 2020). Because FoD can be assigned to the connectivity trend (Carlson, 2022), an increasing number of offers are available today. Moreover, a significant range of OEMs, not only from the automotive industry, will probably introduce FoD gradually over the next years.

Despite the increasing use of FoD, there are currently no clear recommendations for OEMs. Regardless of the application of the business model (BM) by several firms, it is uncertain which FoD display customer-acceptable offers. It is also questionable how OEMs should deal with features for which they must make advance payments. Moreover, there is no defined pricing structure, as the customer’s willingness to pay (WTP) for attributes is unknown.

Today’s contributions focus mainly on the customer perspective and their perception of FoD. Schaefers *et al.* (2022) examine consumer reactions to tangibility and pricing structure. Software-based features such as smartphone integration are more accepted compared to hardware add-ons like seat heating. Moreover, behavioral intentions and justice perceptions are more in favor of a flat rate pricing compared to a pay-per-use (PPU) scheme. Garbas *et al.* (2022) investigate how perceptions of betrayal may damage the FoD image. Consumers reply less approvingly to internal vs. external upgrades, which can be understood as features that are physically disconnected and sold separately. Wiegand and Imschloss (2021) reveal that customers rate software upgrades as less positive than hardware updates, due to the fact that they believe that software technology cannot improve the quality of a standalone device.

In spite of the findings, the literature lacks a methodical categorization and suggestions for OEMs, as the research focuses mainly on the customer perspective and the car industry. To fill this gap, we address specific issues and benefits that FoD offer to OEMs and customers and categorize them. By these means, our work answers the following research question:

*“How can the current knowledge about Functions on Demand be evaluated and classified?”*

To answer our research question and gain a comprehensive knowledge, we analyze online search engines and libraries for white papers, findings from consulting institutes, and scientific texts. We refer to the procedure developed by Webster and Watson (2002) to analyze the past and prepare for the future. For this endeavor, we begin with a systematic literature overview of the current state of knowledge about FoD. In the subsequent instance, we enlarge the scope and search process by approaching a backward reference and a forward citation tracking. By these means, we go beyond the examination of traditional search engines to be able to generate an expanded knowledge about the emerging topic of FoD.

The major contribution of our literature review is that the findings about FoD can be divided into four dissimilar categories. In addition to the literature dealing with relatable BMs or business concepts, the vast majority relates to marketing-linked research that analyzes customer perceptions and responses to FoD. Moreover, a smaller share focuses on financial aspects of FoD and provides economic recommendations for OEMs by analyzing FoD payment processes and offering structures. Finally, several publications from consulting firms deliver a range of general implications for OEMs to develop FoD into a successful BMI.

The further structure of our systematic literature review on FoD is as follows. To ensure a common understanding of the relevant terminology, the terms access economy (AE), on-demand services (ODS), and connectivity are explained in more detail in the remainder of section 2.2. In this manner, using these three core concepts, we also explain the theory behind FoD, as their characteristics partially influence the FoD concept. The two approaches for the literature search method, next to the analysis and an overview of the findings, are deliberated in section 2.3. The discussion of the acquired literature results is presented in section 2.4 and displays the baseline for answering our previously formulated research question, as our contribution is being introduced. Closing our study, managerial recommendations, limitations, and potential future research directions follow in section 2.5.

## **2.2 Definition of Technical Terms**

The following section explains the terms AE, ODS, and connectivity in greater detail. Based on these findings, we will then introduce the FoD concept, which builds upon these terms.

### **2.2.1 Access Economy**

The idea behind the AE, where granting access to resources is significantly more important than ownership, can be seen as a disruptive, discontinuous, and socially innovative BM (Benoit *et al.*, 2022). Eckhardt *et al.* (2019) define the terminology as “a scalable socioeconomic system that employs technology-enabled platforms to provide users with temporary access to tangible and intangible resources that may be crowdsourced”. In addition to the right to use a device itself, the consideration of individual functions is specified. The concept is also known as collaborative economy or consumption, sharing economy (SE), platform economy, community-based economy, and gig economy. In recent years, many scholars have explored this subject, as it offers several opportunities for different BMs (Görög, 2018; Hossain, 2020).

The AE ranges from access-based service concepts to business-to-business services and contrasts with the traditional consumption model based on ownership (Schaefers, Lawson and Kukar-Kinney, 2016). It replaces the previous approach by providing initial access to industrial machinery (Schaefers, Ruffer and Böhm, 2021). This is because access-based services are used by many customers and provide temporary access rather than meeting an individual's need for unrestricted access to resources. As a result, customers can avoid the risk associated with the “burdens of ownership” by allocating the riskiness of possession to the service contributor (Schaefers, Lawson and Kukar-Kinney, 2016). The four main characteristics of the AE are the transfer of economic value, platform mediation, expanded consumer role, and crowdsourced supply, as stated by Eckhardt et al. (2019). A further advantage is the ability to meet and satisfy changing customer needs through an on-demand resource access (van der Burg *et al.*, 2019).

The AE will force OEMs to restructure their core business and partner relationships to remain competitive in the near future (Hossain, 2020). According to researchers, access-based consumption already expands into many life areas (Bardhi and Eckhardt, 2012). Corporations must set their priorities on the process of servitization to enable a smooth transition from the consumption of goods to the consumption of accessible services (Fritze *et al.*, 2018). The latter is understandable as the “transformation of a firm from taking a product- to taking a service-centric approach” (Raddats *et al.*, 2019). Only by adapting to these circumstances, OEMs can remain resolute and create an accessible value to their customer base (Raddats *et al.*, 2019).

### **2.2.2 On-Demand Services**

A promising approach to meet customer expectations of immediacy can be displayed by ODS, which connect service providers with consumers (Steinmetz, 2015). ODS are considered a sub-topic of access-based services or access over ownership (Geoff, 2016). Even though, under ODS, access is superior to ownership, the term cannot be used interchangeably with the AE, as the AE must not be on an on-demand basis (van der Burg *et al.*, 2019). Today, ODS receive only limited research attention (Schaefers *et al.*, 2016; Fehrer *et al.*, 2018). We agree with the definition by Van der Burg et al. (2019), who define an on-demand service as “an ubiquitously available service, able to instantaneously supply the exact required amount of resources for the exact required duration, at the moment they are requested by the customer”.

ODS are initially based on Software-as-a-Service (SaaS) offerings before finding their way into industries such as food delivery or taxi-like transportation (Taylor, 2016; van der Burg *et al.*, 2019). Today’s most popular on-demand business may be the movie provider Netflix. It turns out that ODS are not an invention of the car industry or a sudden phenomenon in a technical context. Much rather, ODS are spreading across many firms where they influence consumers. In this setting, the ODS implementation process exhibits a service that is retrieved by placing an order on the firm’s platform, usually making use of a mobile phone application (Shapiro, 2018). Once an order is placed, prompt processing is essential to ensure immediate access to goods or services and to guarantee customer satisfaction (Taylor, 2016).

Because the value of ODS is evident when demand is unpredictable, some challenges arise (Weinman, 2012). Customers do not necessarily want to own a product, but rather be granted the same access as owning a product would enable (Bratianu, 2018). Accordingly, firms must be able to generate the best trade-off regarding being available, responsive, and scalable without neglecting the costs. Despite customer preferences, it can be difficult for OEMs to switch to ODS. This is because finding the balance between costs and profits on the one hand and individualization on the other is complex to achieve (van der Burg *et al.*, 2019).

### **2.2.3 Connectivity**

Connectivity presents a disruptive change, as it transforms the ecosystem of BMs (Wucher *et al.*, 2019). The foundation of connectivity is laid by enabling the exchange of information through the internet and physical devices (Bosler, Burr and Ihring, 2018). The concept can be applied to various technologies that, through the development of smart products, become connected machines and influence a wide range of BMs (Porter and Heppelmann, 2015; Michels, 2016). Next to connectivity machinery (e.g., antennas), the implementation requires physical components (e.g., sensors) (Porter and Heppelmann, 2015). Technologies that enable connectivity therefore reach from RFID, Bluetooth, OTA technology, and Wi-Fi to Ethernet, allowing an internet access to be provided (Rahim *et al.*, 2021; Khurram *et al.*, 2022).

We are now focusing on the car industry, as it offers many applications for connectivity (Rahim *et al.*, 2021) and is important for OEMs (Bosler, Jud and Herzwurm, 2017). The concept that is likely to have a major impact on the future of the vehicle industry (Bargende *et al.*, 2019), is often used interchangeably with connected cars or the internet of cars (Golestan *et al.*, 2016). We perceive the Internet of Things (IoT) as the enabler of connectivity and define the idea as a “group of infrastructures interconnecting connected objects and allowing their management, data mining, and access to the data they generate”, according to Dorsemaine *et al.* (2015). All IoT products contain embedded firmware and software. This share is the invisible part of a product, as it allows the capability of being connected or connective to facilities (Nasirinejad and Sampalli, 2023). Ultimately, agreeing with Bosler *et al.* (2018), we understand connectivity as “cars, that have telematics components for exchanging data with the ecosystem, whereby digital services are enabled, which generate added value for drivers and owners in terms of safety, navigation, information, comfort, and entertainment”.

Finally, the “networking” and data exchange of connected cars leads to cyber-physical systems that combine the electronic capabilities with virtual extended telematics functions (Schäfer, Jud and Mikusz, 2015). In the following instance, the generated data can be communicated to other vehicles, infrastructure, pedestrians, and networks with cloud access via so-called vehicle-to-everything technologies (Coppola and Morisio, 2016; Rahim *et al.*, 2021). The goal of this data exchange is the creation of innovative service offerings that are mostly safety-related (e.g., traffic updates), environmentally-related (e.g., less pollution), or infotainment-related (e.g., music streaming) (Coppola and Morisio, 2016; Rahim *et al.*, 2021).

## 2.2.4 Functions on Demand

The technological trend of FoD can be observed across many industries (Wucher *et al.*, 2019). Throughout this work, we define FoD as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. By these means, FoD influence customers to transition from ownership to sharing principles (e.g., activation of individual profiles and features in car-sharing models) and represent ODS that require an internet connection to deliver a particular value in use. Accordingly, we perceive that FoD obtain characteristics of the earlier introduced AE (a customer is given access to features), ODS (these features can be accessed “on-demand”), and connectivity concept (the device must be connected to the internet in order to perform feature upgrades using OTA technology). The importance of the previously presented research areas is therefore directly reflected in the FoD subject, as Schaefer et al. (2022) already define FoD as a subset of ODS. Moreover, the authors perceive that despite some available differences (e.g., no permanent ownership of a main product), FoD are based on general AE principles. Figure 2 successfully displays the interaction between AE, ODS, and connectivity as immediate components of FoD and their respective attributes. However, we strongly point out that these terminologies cannot be used interchangeably at any given time.



Figure 2. FoD in the context of AE, ODS, and connectivity

Although the concept of FoD is currently being implemented by different OEMs (Plaß *et al.*, 2020), most research insights are opaque and lack a clear structural assignment. As a result, there are still only few publications and mostly vague definitions on this subject. By conducting a systematic literature review, we can be considered the first authors to classify the existing FoD knowledge in a more structured approach and deliver a detailed overview. We aim to provide clarity about this industry trend, which is also influenced by various related BMs. Our classification of FoD is especially helpful for OEMs who want to introduce FoD and are unaware of the various business management necessities and requirements. In the same manner, our study opens further potential research opportunities for scholars of several kinds.

## 2.3 Literature Search Method

The subsequent literature search can be divided into four separate steps. In the first step, we conducted a systematic literature review to identify the basic framework of existing research findings in the field of FoD. The collected works were then examined in more detail in terms of their citations through backward and forward citation tracking, whereby we specifically expanded our original search procedure. In this second step, we also drew on cross-industry consulting publications and white papers that deal with the topic of FoD in a broader context. Thirdly, we analyzed the results to present a complete research overview in the last step.

### 2.3.1 A Systematic Search Process

The first line of attack was a detailed review of the available publications using Google Scholar, the Web of Science, and Scopus to gain a better comprehension of the research area. In this instance, we conducted a systematic literature search under the method provided by Webster and Watson (2002) to broaden our understanding and to generate an overview of the body of research. The search incorporated different publications across various industries. Table 1 presents our initial systematic approach and illustrates how the different review steps were conducted to obtain the literature results that successfully fulfilled our research intentions.

Table 1. Systematic literature review on FoD

<u>Search query</u>				
<b>Search term</b>	<b>Synonym 1</b>	<b>Synonym 2</b>	<b>Synonym 3</b>	<b>Search field</b>
Function	Feature	Service	Upgrade	Title, abstract, keywords
On-demand	Add-on	Over-the-air	/	Title, abstract, keywords
Automotive	Car	Vehicle	Product	Title, abstract, keywords
<b>Subject areas</b>	Business, management, and accounting			
<b>Time frame</b>	2016-2024			
<b>Search query (Scopus)</b>	TITLE-ABS-KEY ( ( function OR feature OR service OR upgrade ) AND ( on-demand OR add-on OR over-the-air ) AND ( automotive OR car OR vehicle OR product ) ) AND ( LIMIT-TO ( SUBJAREA, "BUSI" ) ) AND ( LIMIT-TO ( PUBYEAR, 2024 ) OR LIMIT-TO ( PUBYEAR, 2023 ) OR LIMIT-TO ( PUBYEAR, 2022 ) OR LIMIT-TO ( PUBYEAR, 2021 ) OR LIMIT-TO ( PUBYEAR, 2020 ) OR LIMIT-TO ( PUBYEAR, 2019 ) OR LIMIT-TO ( PUBYEAR, 2018 ) OR LIMIT-TO ( PUBYEAR, 2017 ) OR LIMIT-TO ( PUBYEAR, 2016 ) )			
<b>Initial set</b>	340 publications			
<u>Review process</u>				
<b>Review step</b>	<b>Reasons for exclusion</b>		<b>Result of review</b>	
<b>Title review</b>	Area of ride-hailing, sharing economy, public transport, and autonomous vehicles		After title review: 37 publications	
<b>Abstract review</b>	Strong IT relations, such as cloud economics or other ODS (e.g., video-on-demand)		After abstract review: 19 publications	
<b>Detailed review</b>	Not specific enough for the purpose of our research		After final review: <b>5 publications</b>	

Potentially interesting literature should have fallen under the description of FoD, as shown in the search query in Table 1. This necessity led to the three keywords of function, on-demand, and automotive. We assumed that most publications dealing with the topic would approach it from the perspective of the car industry. The search query also included relevant synonyms. The keywords were connected via the AND operator, while the OR operator was used for the synonyms. The relevance of the results was ensured by including the search field for the title, abstract, or keywords of the publications. Moreover, we focused on publications in the subject areas of business, management, and accounting. Due to the novelty of the topic, we only examined articles published after 2016. The final search process was carried out on the Scopus citation database, known as “the largest abstract and citation database of peer-reviewed literature” in the fields of science, technology, and social science (Elsevier, 2017).

With the restrictions we set (e.g., search term, subject area, time frame), we generated a total of 340 results, which were subjected to our review process, as stated in Table 1. All findings that did not meet our expectations were excluded. Within the first review step, we solely analyzed the title. We were able to rule out 303 papers because they focus on different topics like ride-hailing or Mobility-as-a-Service (MaaS) and do not deal with the activation of previously installed functions. Accordingly, these findings did not correspond to our stated FoD definition. After reviewing the abstracts of the remaining 37 publications, we eliminated 18 findings. Even though these focus on cloud economics and the information sector, they do not refer to the upgrading possibilities of preinstalled features. Research in this area often examines the aspect of version updates that differ from the FoD concept. After a final detailed review, we were left with five research papers. We hence excluded 14 publications that face different research areas (e.g., AE) or just do not cover the FoD topic to our expected extent.

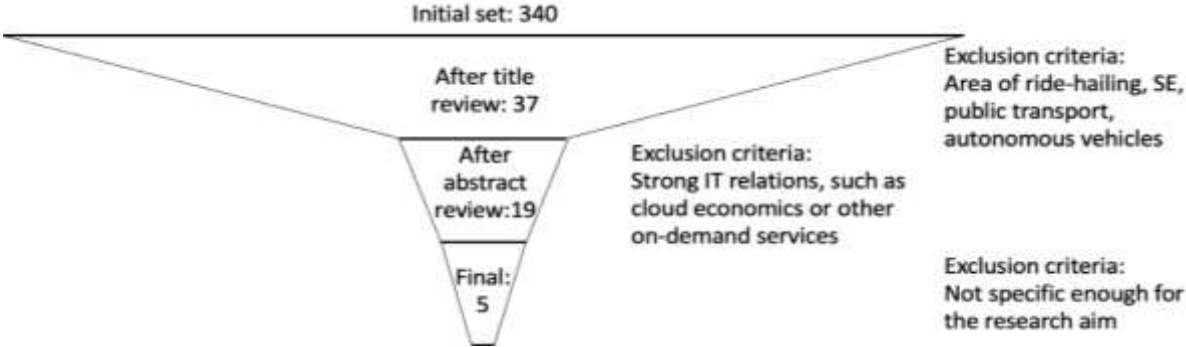


Figure 3. Exclusion criteria for the systematic literature review

Figure 3 illustrates the exclusion steps in the review process that were used to arrive at our literature scope. Despite the evaluation of 340 findings, only five publications met our focus. The articles discuss issues and benefits of FoD, as well as their impact on customers. The outcome is not surprising, as Schaefer et al. (2022) just recently defined the topic and FoD can be perceived as a new BM. However, based on these five publications, we were able to design a first overview of the literature. It became obvious that only a fraction of the papers deals with the topic of FoD in a way that is specific enough to be valuable for our research aim.

Table 2 shows the research results of our initial literature review in alphabetical order. Regarding this matter, we state the published author(s) and publication year, title, summary, and journal. As our intention was to provide an understanding of the research approach (RA) of our primary findings, we furthermore categorized these into conceptual (C) and empirical (E) works. We consider the first type to be literature with a theoretical background that does not contain any tests or data, while empirical research discoveries connect the literature to data. No distinction was made between different industries, as most judgments primarily relate to the automotive sector but can be successfully interpreted across different industries.

Table 2. Research results of the systematic literature review

	Author(s)	Title	Summary	Journal	RA <sup>1</sup>
1.	Garbas et al. (2022)	You want to sell this to me twice!? How perceptions of betrayal may undermine internal product upgrades (IPUs)	This research examines the pitfalls of IPUs that marketers and OEMs must understand. It reveals that consumers respond significantly less favorably to internal (vs. external) product upgrades.	Journal of the Academy of Marketing Science	E
2.	Ho-Dac et al. (2020)	Using product development information to spur the adaption of continuous improvement-products (CIPs)	The authors of this multimethod study find that the perceived dedication of developers to the product acts as a mediating factor in the relation between the acceptance of a current CIP version and the exchange of information about the development progress.	Journal of the Academy of Marketing Science	E
3.	Jiang et al. (2022)	Effects of On-Demand Product Adjustments on Firm's Pricing and Product Strategies	This work examines how on-demand product-adjustment capability (OPAC) affects a firm's optimal pricing and product-line decisions in a market with consumers having time-varying product needs and diverse levels of need.	Production and Operations Management	C
4.	Schaefer et al. (2022)	On-demand features: Consumer reactions to tangibility and pricing structure	Based on two experimental studies and drawings from fairness theory, the authors provide first evidence for how customers react to key characteristics of ODFs, namely their tangibility and pricing structure.	Journal of Business Research	C/E
5.	Wiegand and Imschloss (2021)	Do You Like What You (Can't) See? The Differential Effects of Hardware and Software Upgrades on High-Tech Product Evaluations	This research examines how consumers perceive and respond to the upgradability of software in durable high-tech products compared to integral product alternatives and hardware upgradability.	Journal of Interactive Marketing	C/E

### 2.3.2 Extending the Search Process

Due to the limited results of the initial investigation, a more comprehensive search was subsequently conducted. Numerous findings from Table 1 deal with the SE, security issues of OTA updates, or mobility on-demand, but do not discuss the upgrade capability of preinstalled functions. As a result, we examined these findings more closely by using a backward reference and forward citation tracking. According to Naderifar et al. (2017), this procedure is used when diverse samples of a subject are not easily accessible. We repeatedly applied this approach to achieve a wider publication coverage. Due to the novelty and limited appearance of the topic, we also analyzed the wordings of "Functions on Demand", "On-demand (car) features", "Upgradable vehicle/device", and similar non-car-related search strings in different search

<sup>1</sup> RA= Research approach, E= Empirical work, C= Conceptual work

engines. Furthermore, we covered papers that met our definition, even if they do not use the FoD wording. In this instance, we did not rely on a single kind of journal, as we were interested in findings across industries. We did not set any restrictions regarding the period or industries for the literature. By these means, we also considered gray literature, like consulting studies. Applying this procedure, we mostly included English and German articles. The final number of research findings at this point was still manageable, as FoD present a new trend among OEMs.

The results of this approach were further subdivided. On the one hand, we observed sources that are related to FoD and, on the other hand, findings that have only a limited FoD reference but still provide useful background information. Nevertheless, we will discuss both types of findings in the follow-up section 2.4, as we aim to confront the subject from a broad standpoint. Using this extended search process, we identified a further set of 25 direct and 20 indirect FoD-related discoveries that challenge the topic from a cross-industry perspective.

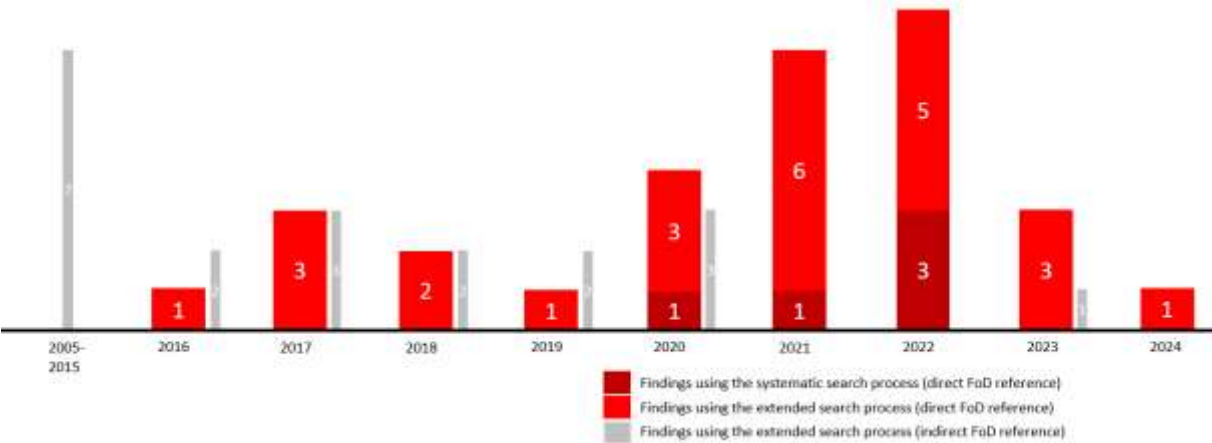


Figure 4. Increase in the literature on FoD in recent years

Figure 4 shows the changes in publications over time. By combining the results of both approaches, we were able to compile a set of 30 directly linked and 20 indirectly linked FoD publications. The dark red bars reveal the findings of the systematic search process, while the light red bars represent the outcomes of the unsystematic approach, which also relate to FoD. The gray bars reflect the sources that are indirectly related to FoD and that we will only examine in part due to the scope of our work. It becomes evident that FoD publications focus primarily on the recent past, as the topic is rather new. The most valuable sources according to the first approach were published recently, while the literature examined with the second approach covers a greater period. This can be interpreted as growing interest among scholars.

**2.3.3 Analyzing the Findings**

After examining the sources found, consisting of research papers, advisory articles, and books, these were specifically classified. Because FoD represent a (financial) BMI for OEMs in various manufacturing and digital businesses, we decided to divide the 50 publications into several categories. Our analysis proceeded as an inductive process, in which we repeatedly reviewed the sources and determined a suitable method for clustering them. This is where difficulties

arose for the first time, as there are many synonyms for FoD in the literature, not all of which can be interpreted in the same way. Moreover, some sources do not consider FoD to be the focus of their work and present only limited research findings. Accordingly, a categorization was difficult due to the limited number of results, restricted quality, and similar terms used across industries. Ultimately, we created the following four clusters, as presented in Figure 5.

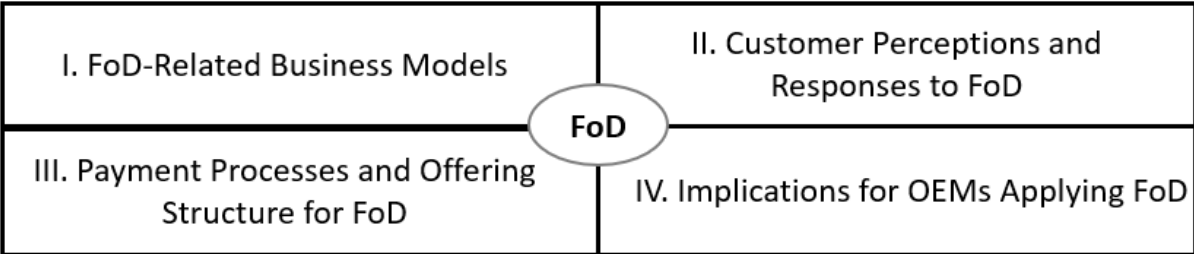


Figure 5. Clustering of research results

The final clustering of our results is as follows: We start by analyzing (I.) FoD-related BMs. (II.) Next, customer perceptions and responses to FoD are discussed before we examine findings which focus on the (III.) payment processes and offering structure for FoD. Finally, we summarize insights that observe (IV.) implications for OEMs applying FoD. This classification runs through the structure of our work and forms the outline of Chapter 2. We point out that the findings of our systematic approach, as shown in Table 2, largely relate to the first two clusters, while the results of the unsystematic approach can be assigned to all categories. In addition, we will examine the papers of Table 2 more closely, as they primarily deal with FoD.

**2.3.4 Literature Overview**

Table 3 presents all findings of our literature review. The results are grouped according to the name of the author(s), year of publication, title, published source (e.g., firm name, book title, journal title), and type of literature. We distinguish between the distinct types of research publications (P), books (B), consulting publications (C), and others (O), as many findings relate to books and consulting-based literature. We furthermore indicate in which subsection the contributions are stated, as this procedure provides the reader with a targeted structure. For this purpose, reference can also be made to the aforementioned Figure 5. Ultimately, we state whether we found a specific source in the scope of our initial systematic (2.3.1) or extended unsystematic search process (2.3.2) and if a certain finding relates directly or indirectly to FoD.

It should be noted that, as part of our literature review, we will not examine every publication that is only indirectly related to FoD. Papers that can be mentioned in this instance repeatedly deal with the topics of modularity or product versioning. We are proceeding in this matter because our focus remains on providing insights on FoD, and because many indirectly related results are available. However, for a deeper understanding of this type of literature, we refer to the recently published publications by Wiegand and Imschloss (2021) and Garbas et al. (2022). Nevertheless, with regard to the findings obtaining a direct reference to the topic of FoD, we would like to point out the completeness of Table 3 on the following three pages.

Table 3. Overview of the literature reviewed

No.	Author(s) (Year)	Title	Published source (e.g., journal title)	Type <sup>2</sup>	Section	Search process	FoD relation
1.	Agrawal et al. (2016)	Modular Upgradability in Consumer Electronics: Economic and Environmental Implications: Modular Upgradability in Consumer Electronics	Journal of Industrial Ecology	P	2.4.1	Second	Indirect
2.	A.T. Kearney (2017)	Schöne neue Kaufwelten?	A.T. Kearney	C	2.4.1, 2.4.3	Second	Direct
3.	Badurdeen et al. (2018)	A multiple lifecycle-based approach to sustainable product configuration design	Journal of Cleaner Production	P	2.4.1	Second	Indirect
4.	Bauwens et al. (2020)	Over-the-Air Software Updates in the Internet of Things: An Overview of Key Principles	IEEE Communications Magazine	P	2.4.1	Second	Indirect
5.	Bentenrieder et al. (2017)	Digital business models for automakers	Oliver Wyman	C	2.4.3	Second	Direct
6.	Bertini et al. (2009)	The Impact of Add-On Features on Consumer Product Evaluations	Journal of Consumer Research	P	2.4.1	Second	Indirect
7.	Bertoncello et al. (2021)	Unlocking the full life-cycle value from connected-car data	McKinsey & Company	C	2.4.4	Second	Direct
8.	Burkacky et al. (2018)	Rethinking car software and electronics architecture	McKinsey & Company	C	2.4.4	Second	Direct
9.	Corbett et al. (2018)	Leveraging Hardware Security to Secure Connected Vehicles	SAE International	P	2.4.4	Second	Direct
10.	Dhebar (2023)	Preinstalled functionality as a service	Business Horizons	P	2.4.1, 2.4.2	Second	Direct
11.	Döbbelin and Kayser (2020)	ODCF – Eine win win Situation für OEM und Zulieferer	Q_PERIOR (now Wavestone)	C	2.4.3	Second	Direct
12.	Ellison (2005)	A Model of Add-On Pricing	The Quarterly Journal of Economics	P	2.4.1, 2.4.3	Second	Indirect
13.	Erat and Bhas-karan (2012)	Consumer Mental Accounts and Implications to Selling Base Products and Add-ons	Marketing Science	P	2.4.1	Second	Indirect
14.	Fleischmann et al. (2016)	The role of software updates in information systems continuance — An experimental study from a user perspective	Decision Support Systems	P	2.4.1	Second	Indirect
15.	Foerderer and Heinzl (2017)	Product updates: Attracting new consumers versus alienating existing ones	International Conference on Information Systems	P	2.4.1	Second	Indirect
16.	Franzmann et al. (2019)	Continuous Improvements: How users perceive updates	European Conference on Information Systems	P	2.4.1	Second	Indirect

<sup>2</sup> P=Research publication, B=Book, C=Consulting publication, O=Other

17.	Frost & Sullivan (2021)	Trends and Growth Opportunities in the Feature On-demand (FoD) Business Models for Connected Services	Frost & Sullivan	C	2.4.1	Second	Direct
18.	Gangadharan et al. (2016)	Platform-based Plug and Play of Automotive Safety Features - Challenges and Directions	IEEE Xplore	P	2.4.4	Second	Direct
19.	Garbas (2022)	From now to next – Three essays on consumer response to innovative technology-driven business models	Ph.D. thesis	O	2.4.1 – 2.4.3	Second	Direct
20.	Garbas et al. (2022)	You want to sell this to me twice!? How perceptions of betrayal may undermine internal product upgrades (IPUs)	Journal of the Academy of Marketing Science	P	2.4.1, 2.4.2	First	Direct
21.	Gräsner and Vogt (2023)	Integrated acceptance model for on-demand car functions: Exploring determinants of driver's acceptance	Entrepreneurship and Sustainability Issues	P	2.4.1, 2.4.2	Second	Direct
22.	Gruber and Kochschmied (2022)	Der schwierige Weg zu Functions on Demand (FoD) für die Automobilindustrie	Batten & Company	C	2.4.1	Second	Direct
23.	Herzig et al. (2021)	The Car as A Digital Platform: On-Demand Car Features	Deloitte US	C	2.4.1, 2.4.3	Second	Direct
24.	Ho-Dac et al. (2020)	Using product development information to spur the adaption of continuous improvement-products (CIPs)	Journal of the Academy of Marketing Science	P	2.4.1, 2.4.2	First	Direct
25.	Jiang et al. (2022)	Effects of On-Demand Product Adjustments on Firm's Pricing and Product Strategies	Production and Operations Management	P	2.4.1, 2.4.3	First	Direct
26.	Kessler and Buck (2017)	How Digitization Affects Mobility and the Business Models of Automotive OEMs	Phantom Ex Machina	B/P	2.4.1	Second	Direct
27.	Krings et al. (2022)	Digital Auto Report 2021/22Accelerating towards the "New Normal"	PwC	C	2.4.1	Second	Direct
28.	Liebehenschel et al. (2021)	Connected Car Services – Neue Vermarktungschancen durch künstliche Intelligenz	KI in Marketing und Sales	B/P	2.4.4	Second	Direct
29.	Liu et al. (2018)	An Empirical Analysis of Consumer Purchase Behavior of Base Products and Add-ons Given Compatibility Constraints	Marketing Science	P	2.4.1	Second	Indirect
30.	Michaud et al. (2017)	Consumers' willingness to pay for sustainable and innovative products: a choice experiment with upgradeable products	International Journal of Sustainable Development	P	2.4.1	Second	Indirect
31.	Nasirinejad and Sampalli (2023)	Evaluating Consumer Behavior, Decision-making, Risks, and Challenges for Buying an IoT Product	MDPI	P	2.4.1	Second	Indirect
32.	Ng and Wakenshaw (2017)	The Internet-of-Things: Review and research directions	International Journal of Research in Marketing	P	2.4.4	Second	Indirect
33.	Petry and Moormann (2020)	Mobile Payment in the Connected Car: Developing Services Based on Process Thinking	Business Systems Research Journal	P	2.4.3	Second	Direct

34.	Pett et al. (2020)	Risk-Based Compatibility Analysis in Automotive Systems Engineering	International Conference on Model Driven Engineering Languages and Systems	P	2.4.4	Second	Indirect
35.	Plaß et al. (2020)	Functions on Demand FoD – USP der Zukunft	NTT Data	C	2.4.1 - 2.4.4	Second	Direct
36.	Ramachandran and Krishnan (2008)	Design Architecture and Introduction Timing for Rapidly Improving Industrial Products	Manufacturing & Service Operations Management	P	2.4.1	Second	Indirect
37.	Schaefers et al. (2022)	On-demand features: Consumer reactions to tangibility and pricing structure	Journal of Business Research	P	2.4.1 – 2.4.2	First	Direct
38.	Shulman and Geng (2013)	Add-on Pricing by Asymmetric Firms	Management Science	P	2.4.3	Second	Indirect
39.	Slama et al. (2023)	The Digital Playbook	/	B	2.4.1, 2.4.4	Second	Direct
40.	Sun and Zhong (2020)	How modularity influences product innovation: The mediating role of module suppliers' relationship-specific investments	Management Decision	P	2.4.1	Second	Indirect
41.	Surendra et al. (2022)	On-Demand Car Features: Readiness for a new era of customer value creation	Deloitte US	C	2.4.1 - 2.4.4	Second	Direct
42.	Reinhart and Teichgräber (2022)	Functions on Demand in der Automobilindustrie	Arborsys	C	2.4.1, 2.4.3	Second	Direct
43.	Ülkü et al. (2012)	Consumer Valuation of Modularly Upgradeable Products	Management Science	P	2.4.1	Second	Indirect
44.	Van der Burg et al. (2019)	Investigating the on-demand service characteristics: an empirical study	Journal of Service Management	P	2.2.2	Second	Indirect
45.	Wiegand and Imschloss (2021)	Do You Like What You (Can't) See? The Differential Effects of Hardware and Software Upgrades on High-Tech Product Evaluations	Journal of Interactive Marketing	P	2.4.1, 2.4.2	First	Direct
46.	Willmes and Schlegel (2021)	Die Automobilbranche im Wandel	KPMG	C	2.4.3	Second	Direct
47.	Wucher et al. (2019)	On-Demand Car Functions	/	B	2.4.1, 2.4.3	Second	Direct
48.	Zellmer et al. (2024)	Decision Making for Managing Automotive Platforms: An Interview Survey on the State-of-Practice	ACM International Conference on the Foundations of Software Engineering	P	2.4.4	Second	Direct
49.	Zhang (2014)	Product configuration: a review of the state-of-the-art and future research	International Journal of Production Research	P	2.4.1	Second	Indirect
50.	Ziegenfuss (2021)	Bewertung innovativer Geschäftsmodelle	Ph.D. thesis	O	2.4.1	Second	Direct

## 2.4 Results

We now group the findings of section 2.3 into the clusters from Figure 5. Section 2.4.1 focuses on the literature that discusses FoD and related BM concepts (cluster 1). Section 2.4.2 covers findings about customer perceptions and responses to FoD (cluster 2). Payment processes and offering structure for FoD are shown in section 2.4.3 (cluster 3). We conclude with implications for OEMs in section 2.4.4 (cluster 4). Some observations are also assigned to multiple clusters.

### 2.4.1 FoD-Related Business Models

The literature offers various insight into frequently used concepts or BMs related to FoD, as illustrated in Table 4. Section 2.4.1.1 contains general information about FoD. Subsections 2.4.1.2-2.4.1.9 enumerate eight similar BM concepts that are related to the idea of post-purchase upgrades. We point out that the terminologies of 1. FoD, 4. IPU, 7. CIP, and 9. Preinstalled functionality as a service describe the same concept and are interchangeable, even if the respective authors sometimes express different opinions, as we will observe later. Section 2.4.1.10 discusses synonyms that are used specifically in the car industry, before we provide a final overview. We close the division with further FoD related trends in 2.4.1.12.

Table 4. FoD-related business models

General description of different BM attributes							
<u>Name of BM</u>	<u>Product</u>	<u>Feature</u>	<u>Example</u>	<u>Implementer</u>	<u>Procedure</u>	<u>Time</u>	<u>Equivalent to FoD?</u>
1. FoD	Technical Products	Technical Features	Cars (lightning)	Firm (F) and consumer (C)	F restricts and C adds feature	Before (F)/ after (C) buy	/
2. Product Configurations	(Non)Tech. Products	(Non)Tech. Features	Furniture	Mostly C	Configuring main product	Before/while buy	No
3. Modular Upgradable Products	Technical Products	Mostly Technical	Personal Computer	F and C	Add/remove product component	During/after buy	No
4. IPU	Technical Products	Technical Features	Cars (engine)	F and C	F restricts and C adds feature	Before (F)/ after (C) buy	Yes
5. Add-On Features	(Non)Tech. Products	(Non)Tech. Features	Phone (memory)	Only C	Add/remove feature	During/after buy	No
6. OTA Software Updates	Technical Products	Technical Features	Phone (apps)	F and C	Add/remove feature	After buy	No
7. CIP	Technical Products	Technical Features	Smart Lightbulbs	F and C	F restricts and C adds feature	Before (F)/ after (C) buy	Yes
8. OPAC	Non-Tech. Products	Non-Tech. Features	Product delivery	Mostly C	Add/remove feature	After buy	No
9. Preinstalled Functionality as a Service	Technical Products	Technical Features	Cars (assistant)	F and C	F restricts and C adds feature	Before (F)/ after (C) buy	Yes

#### 2.4.1.1 FoD

In the past, technical devices were based on the premise that the integrated product functions were already defined at the time of purchase. This meant that they could not be easily adapted to changing personal needs during their life cycle. For example, when customers bought a vehicle, they had to consider which features they would like to access. Once a particular car had been purchased, the features could no longer be integrated retrospectively. With the advance of the digitalization, new concepts and BMIs are emerging. As a result, cars and other products are undergoing a transition from hardware-oriented to software-defined platforms that continue to evolve over their entire lifecycle through the introduction of new features.

A trend among OEMs is known as FoD, which refers to product options that can still be unlocked after the main device has left the factory. This is because technical requirements for several functions are already equipped (Wehinger and Höflich, 2018). In such an instance, a potential customer acquires a license to use the equipment and does not face the need to go to a workshop for the activation. With OTA technology and the connectivity principles, FoD are accessed wirelessly, creating the opportunity to deliver immediate on-demand upgrades (Kessler and Buck, 2017). It should be noted that only devices with basic equipment obtain access to FoD, as fully equipped products cannot be further upgraded (Proff and Fojcik, 2018).

Although FoD are linked to other concepts, as outlined in section 2.2, they also differ from one another. FoD do not grant access to the whole product, but only to certain functions. Hence, FoD cannot be seen as a form of collaborative consumption, as features are not shared. Unlike other forms of the AE, FoD obtain two unique facets. Firstly, FoD solely allow users to access features of a main product for which they have already paid. By doing so, FoD enable the expansion of the initial value offer. On the contrary, the provision of temporary admission to a resource is offered by access-based services (Schaefers, Lawson and Kukar-Kinney, 2016). Secondly, referring to Hazée et al. (2017), access-based services “grant customers the right to temporarily access a good but require them to share this particular good with other, unknown users”. Meanwhile, FoD are restricted to a single resource. For example, FoD would only be activated for a specific vehicle. From a conceptual standpoint, FoD contribute to the debate over whether the SE can be classified as “sharing” (Scaraboto, 2015). Likewise, we perceive FoD as a specific form of the broad ODS terminology, as FoD face a certain base product with already preinstalled features. Ultimately, we have already pointed out that FoD cannot be equated with the connectivity concept, as the latter merely serves as the foundation for FoD.

Because FoD display our main research objective, we will dive deeper into the topic in the following subsections. After presenting available FoD definitions (2.4.1.1.1), we will deliver potential FoD categorizations (2.4.1.1.2) and use cases (2.4.1.1.3). Subsequently, after providing knowledge about the technical FoD implementation (2.4.1.1.4) and general benefits and difficulties (2.4.1.1.5), we will classify FoD more precisely as a form of BMI (2.4.1.1.6).

#### 2.4.1.1.1 Available Definitions

Definitions of FoD are still rare. Garbas et al. (2022) refer to FoD as IPU to a so-called “base product” that contains a “fee-based activation of originally built-in, but deliberately restricted, optional features”. The definition ignores crucial traits, such as the time reference, which is mentioned more clearly by Schaefers et al. (2022). The authors see FoD as “services that allow customers to temporarily access certain features of a product for an additional fee after the initial purchase has been made”. However, considering the product structure of several OEMs, we can only partially agree with this second definition. This is since the authors do not mention the aspect that a feature must be originally built in and is restricted. Furthermore, FoD can grant access to either software or hardware functions, which may also be permanent (Gräsner and Vogt, 2023). Meanwhile, Ho-Dac et al. (2020) classify continuous improvement products (CIPs), also conceivable as FoD, rather general as “products that are designed so that the firm can make post-purchase improvements over time to the products constituent assemblages without requiring the user to fully replace the product”. Furthermore, the consulting literature contains various imprecise definitions of FoD, which we will not discuss in greater detail here.

Although we agree with the previous authors on some aspects, we refer to our more detailed definition of FoD, which considers several critical elements. As already mentioned, we understand FoD as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. Possible components of our definition of FoD, concerning the tangibility of the extended feature, the type of fee, and the respective timeframe, are presented in Figure 6.



Figure 6. Definition of FoD

Conclusively, FoD are available when the entire range of functions is existent and can be acquired thanks to OEM investments but is limited in a base product. With this premise in mind, FoD differ significantly from the idea of simply updating a device. An example can be shown by external add-on features that are sold separately from a base product and are not preinstalled. This understanding is crucial for the traceability of our study and interpretation of FoD, as various after-sales management activities come into play. Please note that, unless expressly stated otherwise, we refer to FoD in the plural form for reasons of better readability.

#### 2.4.1.1.2 Categorization

Different categorizations of FoD exist among researchers. Liebenhenschel et al. (2021) group connected car services or FoD into the four categories of navigation (e.g., navigation maps), infotainment (e.g., digital audio), safety (e.g., lightning upgrade), and comfort (e.g., parking assistant). Furthermore, they distinguish between the place of supply of services. In-car services are being used while driving (e.g., lightning upgrade), whereas this is not the case for out-of-car services (e.g., connected payments). Wucher et al. (2019) categorize FoD according to the six “areas of need” with reference to the Fraunhofer IAO (2016). These can be displayed in terms of wellbeing, information, entertainment, productivity, communication, and basic needs. Lastly, Reinhart and Teichgräber (2022) use a grouping into five different areas of need.



Figure 7. Categorization of FoD (AUDI AG, 2024)

Audi, one of Germany’s leading vehicle OEMs, classifies FoD into the areas of lighting, driving assistant systems, and infotainment, as shown in Figure 7. The firm launched its first FoD proposal in Germany and Norway in 2020 (AUDI AG, 2022). Several other premium vehicle manufacturers also offer similar on-demand online services. It can be expected that further OEMs will soon present FoD with a wider selection and expand their entire product portfolio.

Regardless of the FoD categorization in three, four, five, or six clusters, we classify FoD regarding their technical background according to Wucher et al. (2019) and AUDI AG (2024):

- Software-based FoD are present when no specific hardware must be installed into the device upfront. Features are often infotainment-based (e.g., traffic/map updates).
- Hardware or mixed FoD contain hardware and some software facets that are already preinstalled into the device (e.g., DAB radio or auxiliary seat heating). We point out that no exclusive hardware features exist in real-world applications, as all FoD contain software. Nevertheless, we use the hardware and mixed FoD wording interchangeably.

Finally, we consider FoD to be a hybrid concept, as both the company and the customer execute changes at different process phases. Before selling a product, a firm can implement features by installing technology-based and fully functional, but also limited, hardware during the “prepurchase phase”. Software functions are integrated into devices as standard to allow, restrict, or remove access to functions. Subsequently, the customer takes an active role in product customization during the “product-modification phase”, in which different FoD can be unlocked for a certain fee (Wiegand and Imschloss, 2021; Schaefers, Leban and Vogt, 2022).

### 2.4.1.1.3 Use Cases

FoD were initiated in the consumer electronics (O'Donnel, 2017), but have progressed across many industries, as shown in Figure 8. In 2008, Apple was the first OEM to integrate Bluetooth functionality into their iPod touch 2G, which customers could activate for an additional fee of \$10 (Wieselsberger, 2009). In addition to smartphones, Amazon's Kindle device can also be mentioned, as the camera was previously only available after an additional payment (Vattrodt and Brauer, 2013). Likewise, household appliances like Samsung's family hub refrigerator, hue lightbulbs by Philips, and the Cookido function by Thermomix (Vorwerk) use remote updates to imply different FoD. Other firms include Lenovo, Motorola, and Intel (Garbas *et al.*, 2022).



Figure 8. Applications for FoD

FoD in the automotive sector had their kickoff later, when OEMs were searching for ways to remain competitive and extend the product lifecycle (Herzig, Roth and V.M.G., 2021). Tesla can be considered a pioneer of today's FoD understanding. In 2016, the OEM began offering options (e.g., autopilot) at both a regular price and a higher price payable under FoD (A.T. Kearney, 2017). Tesla also locked the battery capacity of some cars to 80%, which could later be fully unlocked with an OTA upgrade for \$3,000 (Liptak, 2017). Moreover, BMW offered upgradable seat heating options as FoD (Valdes-Dapena, 2022). Like other automotive OEMs, KIA allows consumers to unlock extra motor power and more features as FoD (Charlton, 2023).

Another firm that triggered a wave of negative reactions on social media is the Austrian motorcycle OEM KTM. A demo mode offers full access to all functions of the installed onboard electronics for the first 1.500 kilometers. Afterwards, customers must decide which features they want to retain, as unpurchased functions will be disabled (Schwarz and Dervisevic, 2023).

Various FoD can be found in the software sector. Even after paying member fees, cloud storage platforms (e.g., Dropbox) charge money for increasing download speeds or accessing features (Kravchenko *et al.*, 2019; Gollapudi *et al.*, 2020; Qiao *et al.*, 2022). Similarly, smart speakers offer free functions such as music playback and answering questions. However, to unlock more integration capabilities, customers must pay a fee. Gaming add-ons can also be interpreted as FoD, as downloadable content (DLC) extends the life of a game and generates additional revenue. One example is free online video games that offer their customers DLC or purchasable gaming add-ons. Conclusively, software add-ons can be classified as FoD because they are included in the base product but are only activated after a customer purchases them.

Likewise, a future application field for FoD could be reflected in agricultural and similar industrial machinery. These business areas could soon develop into valuable service platforms for FoD (Deere, 2023). For example, they could offer a higher degree of customization by introducing on-demand features, such as the available “John Deere Performance Upgrade”.

Ultimately, Figure 8 successfully classifies the use cases of FoD, as we conclude that the idea of FoD is transferable to many different environments. To avoid drifting into a specific industry, further possible FoD use cases are present in the hotel, mobility, medicine, and insurance industry, citing Wucher et al. (2019). By these means, we ensure that FoD can be associated with both intangible software products and tangible hardware devices. However, the classification as FoD often appears to be more difficult for different software OEMs. In cases of uncertain classifications, we therefore refer to our previously stated definition of FoD.

2.4.1.1.4 Technical Implementation

The technical implementation of FoD is as follows. While a product upgrade involves changing the configuration set-up, in the case of FoD, functions are already preinstalled and simply need to be activated (Garbas et al., 2022). This activation takes place by changing the software configuration of the main device (Plaß et al., 2020). Compared to the traditional architecture of products, this imposes two main requirements: The system architecture must enable changes to the product’s software configuration, and the customer must be able to trigger these changes. Analysts at NTT Data identify the need for three ecosystem components within an automotive example of FoD, which can be described as stated below (Plaß et al., 2020):

- (1) “In-Device Platform”: System back-end for activation of FoD in control units
- (2) Centralized data and configuration management platform hosted by the OEM
- (3) “E-Commerce Platform” for the acquisition of FoD

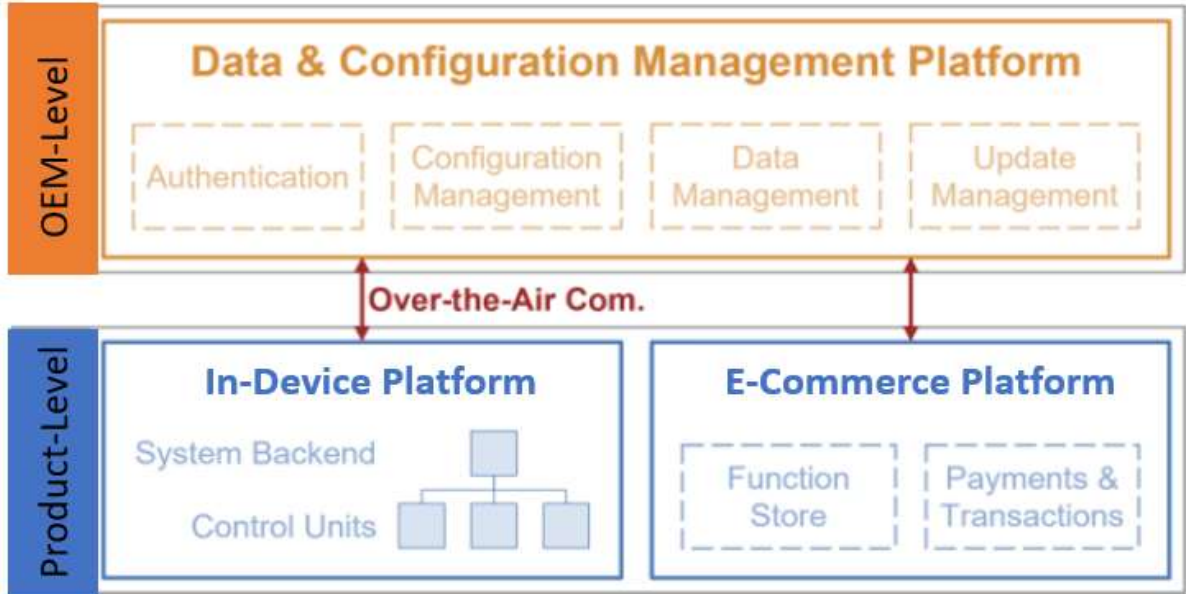


Figure 9. Technical requirements for the implementation of FoD (according to Plaß et al. (2020))

The “in-device platform” (1) needs an interface that enables configuration changes by the consumer, service staff, or an intermediate platform. This is realized via a platform hosted by the OEM (2), which manages the configuration and interacts with (1) via OTA (Plaß *et al.*, 2020). These two aspects impose extensive requirements on a product’s system architecture, which must be considered for the product platform. This contains the capability of a device to connect to the internet, the authentication between the device and an OEM’s systems (Plaß *et al.*, 2020), next to ensuring a secure data transmission (Chowdhury *et al.*, 2018). The OEM must also provide an “e-commerce platform” (3) that can be accessed via mobile devices. The latter requires the OEM to integrate payment possibilities (Plaß *et al.*, 2020). Overall, the OEM must satisfy technical necessities in three areas of the (eco-)system architecture to enable FoD. Two of the areas, as shown in Figure 9, have a critical impact on the system architecture.

#### 2.4.1.1.5 Benefits and Difficulties

FoD offer many benefits to customers, as a flexible and individual device adaptation can be granted. Traditionally, consumers had to adapt to products as they were originally designed. Regarding FoD, customers can book functions independently and adjust them to their needs. The result is greater customer enthusiasm thanks to a longer customer journey, achieved by continuous improvements, which lead to stronger brand loyalty (Plaß *et al.*, 2020). Extended customization options, lower usage and product ownership costs, and reduced risk when using third-party suppliers in the after-sales can be mentioned as well (Dhebar, 2023). Furthermore, the ability to deliver FoD via OTA technology results in fewer service visits (Inampudi *et al.*, 2019) and enables a faster response to security issues (Bordonali, Ferraresi and Richter, 2017).

OEMs also benefit from FoD. The ability to upgrade products enables higher residual values (Wucher *et al.*, 2019). Next to facilitating a dynamic product line, easy versioning, and the possibility to offer a solid architecture of product functionality, FoD allow a simultaneous product development (Schaefers, Leban and Vogt, 2022; Dhebar, 2023). Accordingly, variant reduction and cost savings can be achieved (Surendra, Roth and Stachon, 2022). With a higher degree of standardization, Winkelhake (2018) even expects savings of up to 70%. Moreover, since FoD are built into all devices, two effects in terms of scaling and complexity arise. Firstly, FoD lead to a higher number of functional units produced. Due to economies of scale, this can result in lower unit costs (Garbas *et al.*, 2022). Secondly, FoD reduce the number of variants. When an OEM offers different functions, this can lower complexity costs (Garbas *et al.*, 2022; Surendra, Roth and Stachon, 2022). According to A.T. Kearney (2017), the potential for revenue growth is 40%, which is also attributable to the flexibility of various pricing models, such as time-limited rentals, subscriptions, or permanent activation (Wucher *et al.*, 2019). In the end, the advantages of FoD for OEMs also result in recurring income streams and higher installation rates, as illustrated in Figure 10. In traditional BMs, installation rates are limited because a subsequent configuration is not possible, while FoD can increase this percentage.

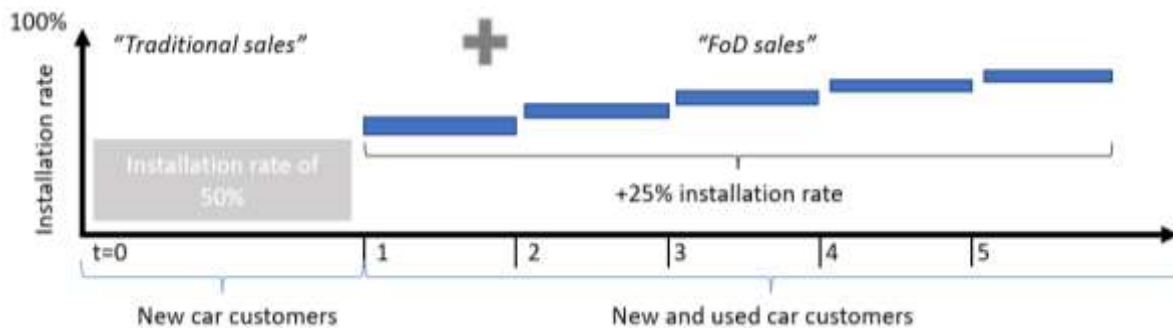


Figure 10. Increased installation rates due to FoD

Likewise, FoD cause some displeasures for customers, such as the perceived feeling of betrayal (Wiegand and Imschloss, 2021). When BMW introduced the FoD seat heating option, press reactions were negative (Viehmann, 2022). Nevertheless, the criticism that customers must pay more for a seat heating option via FoD is incomprehensible, as the latter could have also been selected in the device configurator. In this scenario, the function would be available without restrictions and at no additional cost, as FoD only expand the feature access options.

Various challenges for OEMs exist. One disadvantage is the preinstallation of hardware capabilities, which requires investments and may be viewed critically from a sustainable view if some features are not used (Wucher *et al.*, 2019; Plaß *et al.*, 2020; Garbas *et al.*, 2022). FoD must also deal with uncertainties related to guarantees, as countries impose diverse penalties for the consequences when customers damage FoD that do not belong to them. For example, if a non-activated light enhancement system is defective, the base product must be repaired at the owner's expense to ensure the vehicle's road safety. From a legal perspective, there is uncertainty that clearly affects hardware FoD. As a result, the development process must be adapted to FoD, which requires greater flexibility. The challenge lies in combining software-heavy FoD development with the project management of hardware-heavy car development. In this context, it is also challenging to ensure that FoD are not being hacked (Oswald, 2022).

#### 2.4.1.1.6 Classification as BMI

According to Dhebar (2023), FoD can be categorized as a form of BMI. The more general BM concept connects the value generation and value capture as a conceptual representation of corporate activities (Baden-Fuller and Haefliger, 2013). The aspiration to gain a competitive advantage by changing the core offering has made BM management quite popular among practitioners and researchers (Osterwalder, Pigneur and Tucci, 2005). Facing the digital transformation, OEMs are now likewise confronted with reconsidering their BM, as innovative technologies open a wide range of new possibilities. In this context, a revised logic of value creation and capture, which encompasses a new combination of products or services, market position, processes, and other changes, also understandable as BMI, is required (Björkdahl and Holmén, 2013). We intend to classify FoD as a form of BMI, as FoD enable the conception of a new value creation model, as we understand it according to the formulation by Bucherer and Uckelmann (2011). A more detailed classification of FoD as BMI also follows in Chapter 3.

#### 2.4.1.2 *Product Configurations*

In light of recently published articles about FoD, the term product configurations is frequently used, but often only superficially. The latter involves regulating the optimal component mix by selecting specific elements from a predefined set, considering several constraints (e.g., functionality, quality, and costs). By these means, an OEM aims to fulfill specified objectives. The concept can be further understood as “special design activities that take place after the design by capitalizing on design results, such as functional features, component specification, and relationships between functional features and component specifications” (Zhang, 2014).

The idea must be considered separately from the FoD BMI and our definition. This is because product configurations do not obtain the property to unlock preinstalled features but rather deal with the aspect of overall product design. We will therefore not discuss this industrial issue any further. For more research insights, we recommend taking a look at the topic of product (re)configurations as described by Badurdeen et al. (2018) and Zhang (2014).

#### 2.4.1.3 *Modular Upgradable Products*

Consumer electronics, home appliances, and vehicles own embedded software, transforming these once-integral items into modular hardware-software platforms (Prasad, 2009; Verhoef *et al.*, 2017). Modular upgradability describes “a way to reduce a customer’s costs of keeping up with new technologies”, citing Ramachandran and Krishnan (2008). An upgrade in which only the modules that need improvement (e.g., lens) are replaced allows some products (e.g., cameras) to keep pace with technological developments (Ülkü, Dimofte and Schmidt, 2012). Accordingly, a modular upgradable product’s life is increased by adding or changing parts. This also reduces development costs, as customers can experience new technologies by upgrading modules instead of the entire product (Kamrad, Schmidt and Ulku, 2013; Yamada *et al.*, 2020).

Modular upgradable products differ from FoD, as they are not necessarily preinstalled. Nevertheless, the idea is mentioned repeatedly in connection with FoD. For example, Wiegand and Imschloss (2021) discuss such BM by examining how customers respond to software upgradability in durable high-tech products. Because we do not consider the terminology to be identical to FoD, we will not observe the literature any further. More insights are stated by Agrawal et al. (2016), Sun and Zhong (2020), Ülkü et al. (2012), and van den Berge et al. (2021).

#### 2.4.1.4 *Internal Product Upgrades*

IPUs originated in the electronics industry and can be used synonymously with FoD. IPUs are defined as “fee-based activation of originally built-in, but deliberately restricted, optional features” (Garbas *et al.*, 2022). They show upgradable technical devices that enable sequential improvements during the lifecycle, as cited by Michaud et al. (2017). Since the definition and the understanding of Garbas et al. (2022) are similar to our own, IPUs and FoD are interpreted in an identical way. However, the definition could be more straightforward, as the authors neglect the crucial aspect of temporary or permanent access regarding the feature activation.

Furthermore, IPU significantly differ from the opposing external product upgrades (EPU). Within IPU, a feature is already integrated into the base product, even if it is restricted until the customer pays a certain access fee. On the other hand, regarding EPU, an assured attribute is physically detached and sold separately from the original product (Garbas, 2022). This concept applies to the previously mentioned example of a camera lens as form of modular upgradability. Due to their importance, we will repeatedly refer to the terms of IPU and EPU.

#### 2.4.1.5 Add-On Features

Add-on features display “functions that have to be consumed with a corresponding base product to provide utility” (Bertini, Ofek and Ariely, 2009). A wide range of literature tackles the topic and comes to various findings (Ellison, 2005; Bertini, Ofek and Ariely, 2009; Fruchter, Gerstner and Dobson, 2011; Erat and Bhaskaran, 2012; Liu, Derdenger and Sun, 2018). In general, add-on features enhance functions of a base product on a post-purchase modification basis, while optional downgrades also allow for the removal of functions. Accordingly, they deliver an additional value to customers, such as memory cards for higher storage capacity.

Observing the characteristics, add-on features cannot be considered as equivalent to FoD. This is since add-on features display “detachable accessories” that are not intentionally restricted by firms and are physically separated from a main device (Bertini, Ofek and Ariely, 2009; Ma, Gill and Jiang, 2015). FoD are already built into the base product, and a company intends to control them in a targeted matter (Schaefers, Leban and Vogt, 2022). The greatest overlap between these BMs is that they involve modifications to a base product after the original purchase. Despite this, add-on features can be regarded as EPU (Garbas *et al.*, 2022).

#### 2.4.1.6 OTA Software Updates

Continuous OTA software updates improve the device software remotely via Wi-Fi by adding or removing functions (Slama *et al.*, 2023). Next to the wireless elimination of bugs, they close security issues and adapt to new software designs (Fleischmann *et al.*, 2016; Foerderer and Heinzl, 2017; Franzmann, Wiewiorra and Holten, 2019; Bauwens *et al.*, 2020). We understand the concept as “self-contained modules of software that are provided to the user for free to modify or extend a software after it has been rolled out and is already in use” (Fleischmann *et al.*, 2016). Due to their characteristics, OTA updates are crucial for several connected devices (Halder, Ghosal and Conti, 2020). As an example, vehicle OEMs repeatedly apply OTA updates within the latest software environment to gradually improve digital functions (Wiegand and Imschloss, 2021). While most updates certainly improve product functionality, the technology can also be applied to slow down the device performance, as already exemplified by iPhone updates (Nasirinejad and Sampalli, 2023). Nowadays, most publications deal with OTA security issues and describe in detail how these can be avoided (Mbakoyiannis, Tomoutzoglou and Kornaros, 2019; Halder, Ghosal and Conti, 2020; Howden, Maglaras and Ferrag, 2020). By these means, the majority of available research findings are closely related to the IT sector.

OTA software updates cannot be considered as FoD. While FoD are based on unlocking built-in features, OTA updates focus on wireless software improvements (Fleischmann *et al.*, 2016; Foerderer and Heinzl, 2017; Franzmann, Wiewiorra and Holten, 2019). According to the definition, OTA updates are free of charge, which is usually not the case for FoD. We conclude that OTA updates primarily affect the attributes of EPU. However, an argumentation for IPU is feasible, as the concept enables FoD (Plaß *et al.*, 2020; Schaefers, Leban and Vogt, 2022).

#### *2.4.1.7 Continuous Improvement Products*

CIPs are “products that are designed so that the firm can make post-purchase improvements over time to the products constituent assemblages without requiring the user to fully replace the product” (Ho-Dac, Kumar and Slotegraaf, 2020). Although this definition lacks crucial aspects compared to our understanding of FoD, we consider CIPs to be synonymous. This is because CIPs enable core product functionality changes, as Ho-Dac *et al.* (2020) also mention Tesla’s battery upgrade. Despite the given interchangeability, future findings on CIPs must be treated with caution, as Ho-Dac *et al.* (2020) are the first authors to use such a formulation.

#### *2.4.1.8 On-Demand Product Adjustment Capability*

According to Jiang *et al.* (2022), “on-demand product adjustment capabilities allow customers to efficiently process their request for short-term changes of service quality to meet time-varying demands”. The focus of OPAC can be found in the service and product design industry. A disadvantage of the expression, as with CIPs, is that it is used exclusively by the authors who originally developed such industrial concept. Because there is no clear technical reference and equivalence exists only to a limited extent, the terminology cannot be equated with FoD.

#### *2.4.1.9 Preinstalled Functionality as a Service*

Dhebar (2023) understands the expression of preinstalled functionality as a service as a BM to generate recurring revenues. Since the author also makes use of the FoD wording and applies the business idea in the post-purchase automotive industry, we will use the two concepts interchangeably. However, as Dhebar (2023) does not clearly define the BM to any further extent and remains the only author to effectively use such, we always refer to our definition.

#### *2.4.1.10 Synonyms in the Automotive Industry*

FoD obtain a clear connection to the car industry, as the wording is mainly used by Audi (2022) and researchers in this field (Ziegenfuss, 2021; Reinhart and Teichgräber, 2022). OEMs simply give their comparable concepts different designations, such as “connected drive upgrades” by BMW (2022). Likewise, we can mention the expressions of on-demand features by Schaefers *et al.* (2022) and on-demand car features/functions by Gräsner and Vogt (2023), which can be applied interchangeably. The latter is also used by consulting firms that provide FoD insights (Wucher *et al.*, 2019; Herzig, Roth and V.M.G., 2021). Further synonyms are vehicle features on-demand (Krings *et al.*, 2022) and features on-demand (Frost&Sullivan, 2021). Nevertheless, we point out that we apply the FoD terminology in a more general sense and across industries.

### 2.4.1.11 Overview of the Related Terminology

This subsection provides a final classification of all the terms we faced, as shown in Figure 11. We compare these concerning their affiliation to either IPU or EPU and their automotive reference. Product configurations represent the basis of the EPU concept. According to our understanding in 2.4.1.2, we perceive the BM as EPU, as no preinstalled features are present. Due to the all-encompassing nature of the formulation, we do not directly attribute it to the automotive industry, although it can be found there (Yalcinkaya *et al.*, 2017). As discussed in subsection 2.4.1.8, OPAC puts the focus on subscription models and can be rather considered as EPU. In subsections 2.4.1.3 and 2.4.1.5, we explain why we understand modular upgradable products and add-on features to be EPUs, as their attributes are physically separated from a base product. However, especially modular upgradable products can be found in a vehicle scenario (Prasad, 2009; Verhoef *et al.*, 2017). To complete the left side of Figure 11, we apply the hardware car tuning concept, which is an EPU, as no upgradable features are preinstalled.

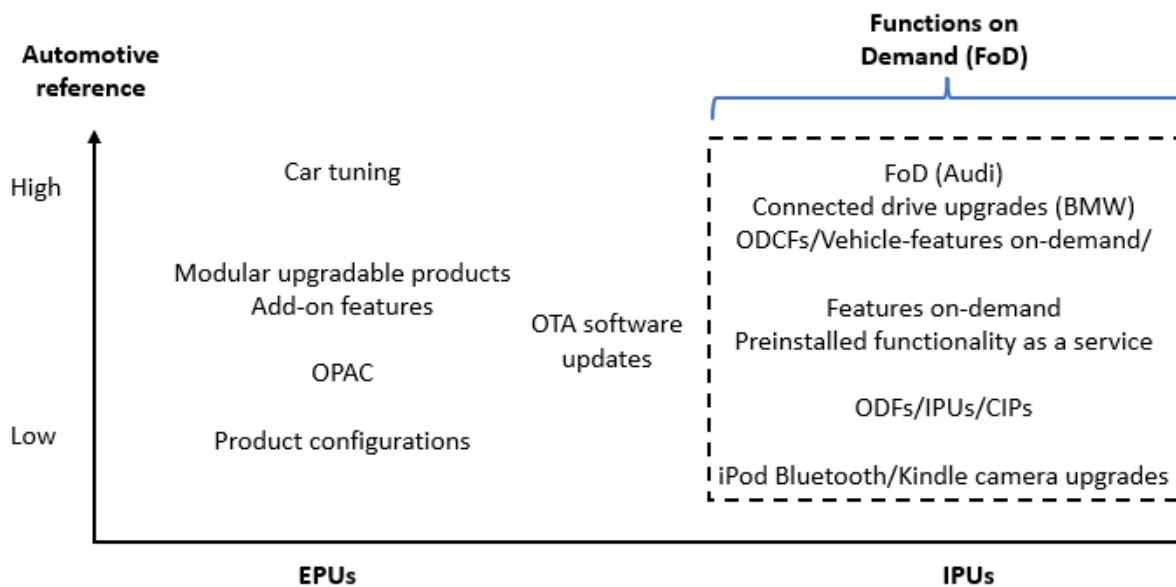


Figure 11. Strategic classification of the terminology used

Continuous OTA software updates, which appear on the verge between IPUs and EPUs because a two-sided argumentation is possible, are commonly used in the vehicle industry. Even though there is no clear correlation to FoD, OTA updates are occasionally used to activate functions, which is why parallels to FoD can be observed (Mbakoyiannis, Tomoutzoglou and Kornaros, 2019; Halder, Ghosal and Conti, 2020; Howden, Maglaras and Ferrag, 2020). In our view, OTA updates thus solely serve as the enabler of FoD, but do not constitute the BMI itself.

The final classification of IPUs or FoD is as follows. We begin the right verge of Figure 11 with two IPUs that originated in the electronic industry. Apple's iPod and Amazon's Kindle are perfect examples that fulfill the character traits of IPUs but cannot be associated with the automotive industry. Meanwhile, the terms of CIPs, IPUs, ODFs, preinstalled functionality as a service, and several synonyms within the car industry can be used interchangeably with FoD.

#### 2.4.1.12 Other Possible Industry Categorizations

In the following, we discuss terms that authors use when evaluating FoD, but which can hardly be applied to the formulation of IPU or EPU. We are seeking further designations, as it is observable that definitions of FoD and similar concepts vary and have not yet been classified. None of the following formulations are interchangeable with our understanding of FoD.

According to Plaß et al. (2020), FoD display a new after-sales BM. Because after-sales activities become more digital, traditional service BMs are being eliminated and new ones are being established. We agree with this understanding, as FoD and after-sales include technical and commercial activities. For example, they seek to maintain the product quality and ensure customer satisfaction (Tavakoli *et al.*, 2016). We thus state that FoD belong to after-sales BMs, as customers can modify their products after a purchase (Gruber and Kochschmied, 2022).

Plaß et al. (2020) assign FoD to cross-selling and up-selling. However, we agree with Schaefers et al. (2022) that while FoD allow for many decisions to be made after the purchase, cross-selling often only enables one selection. While cross-selling is a long-term service, FoD are typically perceived as a per-payment service. In the context of up-selling, the two-stage purchasing procedure, the extra price for the better product, and the greater usability show commonalities. The strategies still differ, as upselling refers more to expanding the product range than to adding new features. We therefore do not perceive FoD as cross- or up-selling.

Herzig et al. (2021) argue that data-driven BMs in the car industry are based on FoD, as they provide OEMs with information (e.g., about consumer behavior). Because data-driven BMs create value deliveries by prioritizing data and setting the focus on data acquisition, data evaluation, and data use (Hossbach-Zimmermann, 2024), FoD exhibit characteristics of such BM. This is also because data is a crucial resource and an enabler regarding the success of FoD.

FoD are defined as a component of the IoT BM. Ho-Dac et al. (2020) provide a thorough explanation, whereas Plaß et al. (2020) solely state the assertion and clarify that FoD are based on IoT premises. The concept is to be understood as a system of connected computers that transmit data to each other without human interaction (Elijah *et al.*, 2018). Due to the fact that data can be exchanged via the IoT and likewise delivers information on how to improve the customer experience, an OEM can provide required hardware or software features. We therefore agree with Ho-Dac et al. (2020) and consider FoD to be enabled by IoT technology.

Citing Herzig et al. (2021), FoD are digital services provided via the internet. A digital service involves an arithmetical component and coordinates different physical mechanisms. The concept can be defined as “an activity or benefit provided by one party to another through a digital transaction” (Williams, Chatterjee and Rossi, 2008). The unlocking of restricted functions includes digital components, as FoD can consist of pure software or a combination of software and hardware (Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). We also categorize FoD as a digital service concept, as the service unlocking is often performed online.

Schaefers et al. (2022) classify FoD as service innovation in the SE that exhibits product bundling characteristics (Dhebar, 2023). The recombination of resources to create benefits for individuals is perceivable as service innovation. The process involves a stakeholder network and a clearly defined end user (Lusch and Nambisan, 2015). Because FoD display a rebundling of resources to create an innovative product, we consider the BMI to be a service innovation.

Dhebar (2023) characterizes FoD as a subscription model, although some studies consider subscriptions merely as possible form of contract for FoD (Plaß *et al.*, 2020; Wiegand and Imschloss, 2021). Subscriptions are defined as “arrangements involving a recurring fee for access to a specified product, content, or service” (Schuh *et al.*, 2020). Dhebar (2023) states that the subscription model and the X-as-a-Service model evolve simultaneously, while the subscription model represents the most common contract model for FoD. Because some FoD offers are also accessible without a subscription, we only partially agree with the author.

The examples we have discussed show how differently the BMs associated with FoD are used in the literature and how some authors use the same term exclusively in a different sense. Our results reveal that FoD can be successfully linked to different business concepts, such as after-sales (Gruber and Kochschmied, 2022), service innovation (Schaefers, Leban and Vogt, 2022) or X-as-a-Service (Dhebar, 2023). These circumstances lead to a highly fragmented understanding of FoD, as a significant degree of subjectivity remains. There are additional BM categorizations related to the FoD BMI, such as next-generation products, product versioning, or mass-customized products (Garbas *et al.*, 2022). However, due to the scope of this study and because most concepts focus on the pre-sale phase, we will not analyze them any further.

#### **2.4.2 Customer Perceptions and Responses to FoD**

We consider seven research findings in 2.4.2.1–2.4.2.7 that reflect customer perceptions and responses to FoD before stating the key findings. Despite the increasing use of FoD, only few marketing studies analyze how customers react when they must pay for limited features of a product they already own. Due to the novelty of the topic, primarily the recent papers by Schaefers et al. (2022), Garbas et al. (2022), and Wiegand and Imschloss (2021) deliver new insights. In the following, we interpret all findings across industries and apply the terms used.

##### *2.4.2.1 Consumer Reactions to Feature Tangibility and Pricing Structure*

Schaefers et al. (2022) investigate the impact of the pricing structure and tangibility of ODFs on the purchase intentions and fairness perceptions of customers. These variables are highly important for explaining consumer behavior. To begin with, the authors find that consumers show significantly smaller purchase intentions for tangible vs. intangible feature upgrades. By these means, software-based ODFs are well received, while hardware features are considered unfair. Furthermore, the authors show that customers perceive a flat-rate pricing structure as fairer than a pay-per-use billing model. Because the study is one of the first to describe ODFs, it provides additional insights regarding the previously mentioned trends of the SE and ODS.

#### *2.4.2.2 How Perceptions of Betrayal Undermine FoD*

Garbas et al. (2022) examine the influence of IPU compared to EPU on consumer responses by observing customers' WTP and loyalty intentions towards a firm. The results reveal that customer responses to IPU are less promising. This can be attributed to the higher perception of the feature ownership and the "consumer-perceived betrayal" that arises when consumers must pay fees to access already integrated features. Moreover, the perception of betrayal comes along with the side effects of a lower WTP and a reduced loyalty towards the company.

Garbas et al. (2022) determine three additional IPU principles regarding the tangibility, responsibility for the upgrade, and relevance of the product for the consumer's identity. For example, whenever a consumer is responsible for a tangible feature upgrade with which they can identify, this leads to greater disappointment and reduced loyalty towards a company. In case of an intangible feature with which a customer can hardly identify, and if the company is responsible for the upgrade, this unfavorable view is minimized. Accordingly, an unfavorable combination of principles results in a lower acceptance and a higher perception of betrayal.

#### *2.4.2.3 Different Customer Perceptions of Hardware and Software FoD*

Wiegand and Imschloss (2021) examine how customer product evaluations differ for OTA software updates and external hardware upgrades. The authors focus on the pre-sales phase in the vehicle environment and observe different pricing influences. In general, products that can be continuously updated have a more positive impact on customer ratings. However, this phenomenon is less favorable for OTA software updates than for hardware upgrades. This is because customers view software updates as less effective in improving the product quality. Moreover, the consumer-perceived functionality is crucial, as customers might think that they are denied access to functions. To counteract this perception, bundling software updates into a larger package and emphasizing the low implementation effort are useful. It is also shown that the possibility of upgrading the hardware holds a positive influence on the purchase decision. This means that software upgradability is not dependent on the hardware quality of the base products, which may be of interest to non-premium OEMs. The reason for this occurrence is that the hardware quality is not a limiting factor for the effectiveness of software upgrades. Ultimately, regardless of whether upgrades are permanent or limited in nature, customers react negatively to FoD restrictions, highlighting the risky strategy of some OEMs.

#### *2.4.2.4 Customization of Preinstalled Functionality-as-a-Service*

Dhebar (2023) perceives "preinstalled Functionality-as-a-Service" as FoD. The author shows how FoD change perceptions of long-lasting goods, product categories, post-purchase additions, and usage rights for functionality. In this context, the discussed concept is expanded into the areas of product bundling, Everything-as-a-Service, and the subscription economy. Dhebar (2023) also explores whether and how the BMI can be put into practice. He does this by highlighting the advantages of the concept for technical OEMs and consumers and pointing out possible recommendations for action and challenges regarding the final implementation.

### 2.4.2.5 An Integrated Acceptance Model for FoD

Gräsner and Vogt (2023) offer an integrated FoD acceptance model. Despite limited research on customer reactions to FoD, it is important to identify the factors that influence consumers' willingness to accept FoD. Since available acceptance models must be modified and expanded to increase their explanatory value, the authors conduct a literature study and identify 74 acceptance factors to close this gap. By using the Unified Theory of Acceptance and Use of Technology, the Car Technology Acceptance Model, and similar, the model below is created.

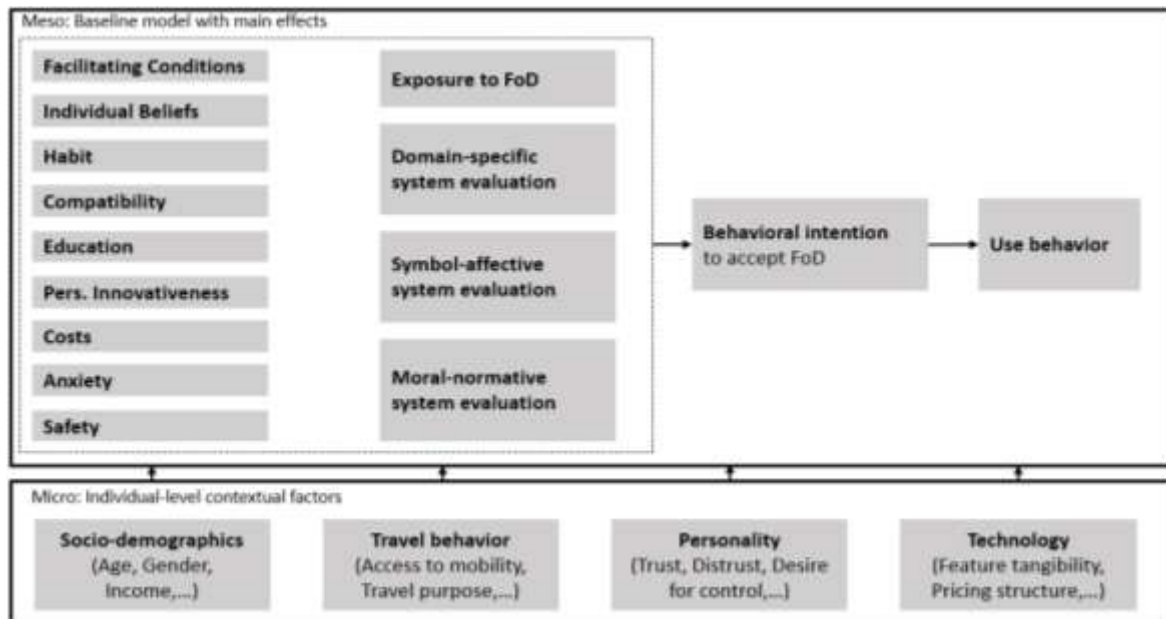


Figure 12. Integrated acceptance model for FoD (according to Gräsner and Vogt (2023))

The model highlights the key factors influencing user acceptance of FoD and states how these must be integrated to understand consumer behavior. The base model includes domain-specific, symbolic-affective, and moral-normative factors at the meso-level. The micro-level concerns discrete individual variation components, such as sociodemographic characteristics, travel-related behaviors, personality traits, and technology preferences. The factors located at the meso-level are impacted by the micro-level determinants. To optimize the paradigm, a submodel is suggested that considers cross-level influences and promotes multi-level research to discuss the effects of contextual acceptance elements. Two approaches exist to put the paradigm into practice. First, the entire model can be adapted to the research environment if the study aims to understand the acceptance of FoD. Second, a partial model can be built by adding pertinent characteristics from both levels if the research purpose is predictive.

### 2.4.2.6 Using Product Development Information in Favor of FoD

Ho-Dac et al. (2020) deliver insights about CIPs. Developmental progressive activities affect the adaptation of existing products, whereby the advantages of these development actions are not established in recent product types. Development information is used to investigate a firm's obligations to CIPs. This is highly relevant for the marketing literature, as CIPs aim to strengthen customer loyalty. While firms frequently refuse to share information about new

product development intentions, research shows that consumers see an added value in the individual customization of a product. Whenever consumers are less familiar with a product, the exchange of information on the development progress provides advantages. Accordingly, customers who have limited information about CIPs will repeatedly rely on development progressiveness. They do this to support a company in the long-term development of CIPs.

#### *2.4.2.7 Auxiliary Automotive Consulting Findings*

We now deliver automotive consulting insights. In general, the customer journey ends with the purchase of a car, unlike other industries that continue to offer services to their customers after the purchase. FoD change this perception and become a valuable innovation for OEMs, as FoD enable them to tap into new revenue streams and secure their position in the after-sales (Pläß *et al.*, 2020; Garbas, 2022). McKinsey estimates the automotive aftermarket in Europe for 2020 at \$110 billion (Kempf *et al.*, 2021), demonstrating the sizable source of income for services provided (Pläß *et al.*, 2020). However, the maintenance effort for products in this market is declining due to the electrification and enhanced driving assistance systems (Waas *et al.*, 2021). This is where FoD could come into play, as they enable functions to be offered without increasing the product complexity and expand the customer experience by providing more alternatives (Pläß *et al.*, 2020). From a marketing standpoint, FoD can be used to extend the range of features (Surendra, Roth and Stachon, 2022). Pläß *et al.* (2020) even perceive FoD as a concept that can improve the product individuality. However, OEMs must carefully reconsider their decision to offer FoD, as it can affect the overall customer journey.

#### *2.4.2.8 Summary of Key Findings*

Finally, we state the key insights from the literature discussed regarding customer perceptions and responses to FoD. Schaefers *et al.* (2022) find that intangible or software FoD and a flat rate pricing result in higher customer acceptance in contrast to tangible FoD and a PPU pricing scheme. Garbas *et al.* (2022) state that customer betrayal perceptions are lower for intangible FoD, for scenarios when OEMs deliver the improvement, and whenever the product upgrade has little relevance for consumer identity. Wiegand and Imschloss (2021) find that upgradable products obtain an influence on customer perceptions. The bundling of software upgrades into packages and emphasizing the low implementation effort show approaches to counteract negative perceptions. Despite the similarity of these papers, the procedures differ. The works by Garbas *et al.* (2022) and Schaefers *et al.* (2022) focus on the post-purchase stage, whereas Wiegand and Imschloss (2021) consider the prepurchase stage. While Schaefers *et al.* (2022) analyze non-permanent FoD without comparing them to established product configuration methods, the two remaining contributions take a different approach. Following, Dhebar (2023) compares FoD with related BMs and lists various challenges. Gräsner and Vogt (2023) offer an integrated acceptance model for FoD. Ho-Dac *et al.* (2020) find that customers who have limited information about FoD but are informed of the value rely on development progressiveness. Ultimately, we also analyze a series of further automotive consulting insights.

### **2.4.3 Payment Processes and Offering Structure for FoD**

Despite the boost within the after-sales environment, limited research findings address FoD from the financial perspective of OEMs. As of today, no profitability analyses exist that discuss preinstalled hardware features and the financial risk of not activating these functions, which may result in lost profits (A.T. Kearney, 2017). In contrast, several financial findings on related concepts such as add-on features are available. For more insights in this regard, we refer to the publications by Ellison (2005), Shulman and Geng (2013), Jiang et al. (2022), and Lin (2017).

The following section deals with the question of how the payment processes and offering structure for FoD can be designed. First, we scrutinize how FoD mobile payments can be conducted. Next, we demonstrate a decision-support model for FoD that provides three offering structures. Third, we consider various cash flow scenarios between a manufacturer and an OEM. Conclusively, we also state additional financial recommendations for OEMs.

#### *2.4.3.1 Mobile Payments for FoD*

Petry and Moormann (2020) examine the design of mobile payments (MPs) in relation to FoD in connected vehicles. They find that MPs in a business-to-customer set-up should be initiated at the point of sale (POS) to support customers with a clear payment process (Crowe, Rysman and Stavins, 2010). In this case, a differentiation between consumer-activated and merchant-activated procedures can be inspected. Customers either use a mobile device, or the OEM provides mobile terminals for payments. This process can be further divided into a proximity payment (e.g., in the connected car) and a remote payment (e.g., independently of the POS) (Ivanova, Pisani and Moormann, 2016). The proximity method enables an automatic payment process, as customers do not have to use a mobile device. Because the payment data is stored in the provider's environment, both methods provide data security and cyber resilience. Meanwhile, the merchant application is based on either hardware or software solutions. This is because the former involves components for a terminal to go through a payment process. Conclusively, it can be shown that a connectivity paradigm enhanced by MP options enables the reliable implementation of customer requests in the wider context of process thinking.

#### *2.4.3.2 Different Offering Structure for FoD*

Pläß et al. (2020) examine offer and payment models for FoD, such as PPU, subscription, and freemium. These three options are frequently used by OEMs for digital services such as FoD to increase their financial growth (Reinhart and Teichgräber, 2022). In this regard, a firm's payment mechanism does not only simplify and automate payment transactions when using a product but also increases customer loyalty. In the example provided, the authors assume that in 2023, 1% of all connected vehicle users (3.529.000 cars) will apply either a PPU or subscription model to purchase FoD. Moreover, 25% of customers (88.225.000 cars) are likely to use a freemium version that generates an advertising revenue for the OEM. The final usage structure of the decision-support model, including assumptions, user share, customer groups, usage frequency, price, and total turnover over 24 months, is stated in the following Table 5:

Table 5. Decision-support model for FoD offering structure (According to Plaß et al. (2020))

<b>Assumptions:</b>			
<ul style="list-style-type: none"> <li>- Reporting period of 24 months</li> <li>- 3.529.000 cars make use of the PPU approach</li> <li>- 3.529.000 cars make use of the subscription model</li> <li>- 88.225.000 cars make use of the freemium version</li> </ul>			
1.) 1% use PPU for a price of 4,99€			
User share	Customer group	Usage frequency	Total turnover (24 months)
25%	Frequent user	12 times per month	<b>1.655.312.740,00€</b>
25%	Share user	3 times per month	
50%	Occasional user	4 times per year	
2.) 1% use a monthly subscription model with different prices (due to different runtimes)			
User share	Subscription model	Price	Total turnover (24 months)
25%	Fixed price	17,99€ per month	<b>1.248.419.040,00€</b>
25%	Variable price	14,99€ per month	
50%	Special price	12,99€ per month	
3.) 25% use a freemium version			
User share	Usage frequency	Turnover for OEM	Total turnover (24 months)
80%	1.8 times per week	0,20€ per advertisement	<b>8.939.662.800,00€</b>
20%	unlimited	14,99€ per month	
→ Divided by the number of customers, the turnover per capita results in:			
Turnover per capita	1.) PPU	2.) Subscription	3.) Freemium
	469,06€	353,76€	101,33€

Observing the total turnover, the freemium version is the most profitable. However, if only the turnover per capita is considered, PPU is more lucrative. Meanwhile, Schaefer et al. (2022) find that flat rate fees are in favor of customers and also beneficial to service providers, as they create a predictable source of income. Accordingly, because the upper calculation is based on several assumptions, we see the latter rather as a “can-do methodology” on how OEMs could earn money with FoD. A further evaluation on our part of the model is missing, as we discuss a decision-support model for FoD in more detail in Chapter 4 of our dissertation.

### 2.4.3.3 FoD Profit Sharing

Wucher et al. (2019), alongside Döbbelin and Kayser (2020), examine three financial cash flow scenarios and profit sharing opportunities between a FoD manufacturer and OEM within the framework of the consulting firm Q\_PERIOR (now Wavestone). In the first scenario, as shown in Figure 13, an external manufacturer of FoD demands a high production fee in combination with a low share of the on-demand revenue. The advantage is that the manufacturer bears a minimal risk, as the OEM must pay a high fee. In the same manner, an intensive FoD usage can generate a significant on-demand revenue for the OEM. A drawback for the OEM can be displayed by a considerable risk, as a high production fee is charged and a dependence on the on-demand revenue exists. Moreover, the development potential of the latter is limited.

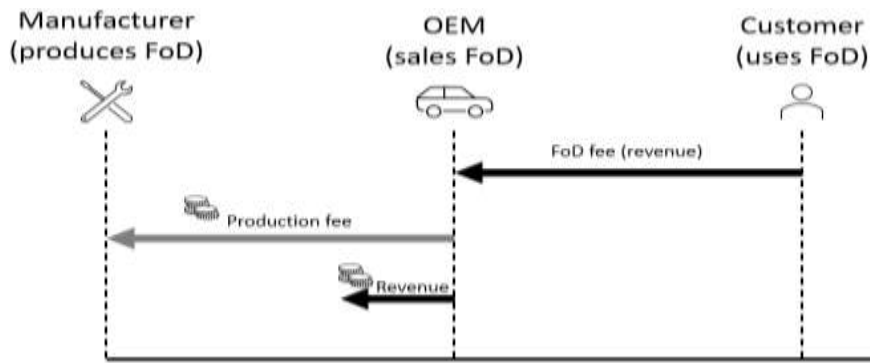


Figure 13. First scenario

In the second scenario, the FoD manufacturer charges a medium production fee and receives a moderate share of the on-demand revenue. Referring to Figure 14, the cash flow between the OEM and manufacturer is presented. With heavy FoD usage, both participants benefit from the on-demand revenue. However, a clear disadvantage can also be observed, as both parties involved are dependent on the on-demand revenue to fully cover their costs.

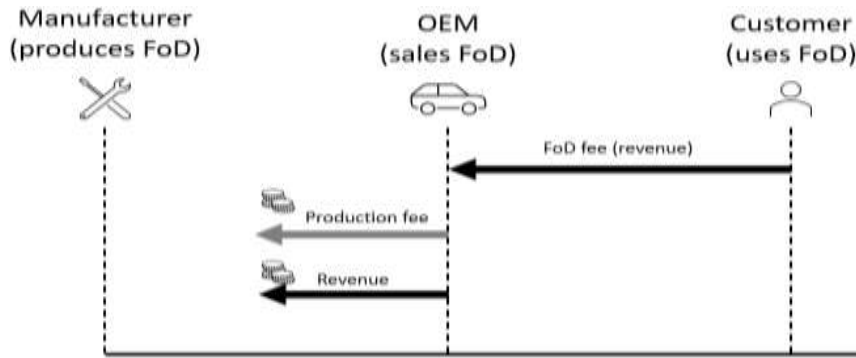


Figure 14. Second scenario

In the third scenario, as shown in Figure 15, the manufacturer receives a high share of the on-demand revenue, while a low initial production fee is billed. The OEM faces a limited financial risk due to the restricted one-time production fee, while the manufacturer achieves a high on-demand revenue with a high FoD usage rate. Meanwhile, the on-demand business for the OEM is limited. As a result, with low usage, the costs can hardly be covered. Finally, it must be analyzed which scenario is most promising in terms of revenue and usage frequency.

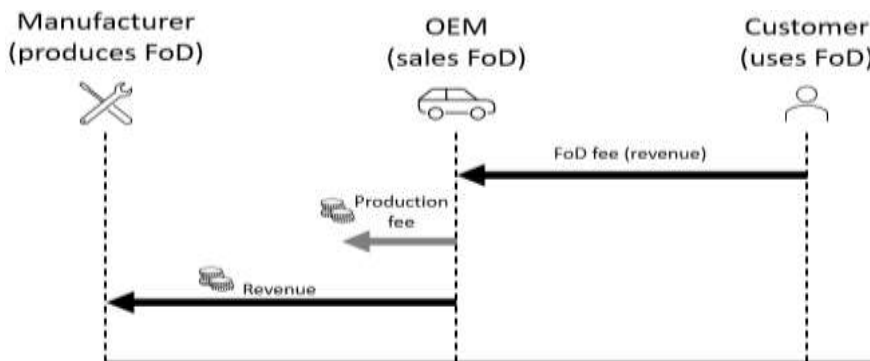


Figure 15. Third scenario

#### 2.4.3.4 Further Financial Recommendations for OEMs

Because FoD represent a promising product modification strategy, further financial insights for OEMs exist. For example, market experts forecast substantial revenues next to economies of scale by producing devices with identical features (Bentenrieder *et al.*, 2017). As a result, OEMs anticipate additional income streams. Collaborations with external parties who wish to access the “device platform” to offer their services will likewise enable revenue opportunities. However, OEMs must also become more flexible in order to respond to constantly changing requirements and regulations. Accordingly, to create a stable BMI and avoid profit losses, manufacturers must clarify suppliers, customer groups, and their FoD offering (Garbas, 2022).

Implementing FoD requires various financial measures. OEMs must spread beyond the base product sale and focus on the after-market (Herzig, Roth and V.M.G., 2021). Similarly, digital pricing and FoD concepts require a holistic optimization model, product bundling, and a clear pricing (A.T. Kearney, 2017). Firms must evaluate the data generated using machine learning to gain insights into customer preferences and purchasing behavior (Reinhart and Teichgräber, 2022). This proceeding is likely the most promising to counteract varying revenue contributions from functional offerings and the uncertainty (Willmes and Schlegel, 2021).

#### 2.4.4 Implications for OEMs Applying FoD

Below, we outline five implications for OEMs to be successful with FoD. We do this because the literature provides further insights and FoD have far-reaching consequences for OEMs.

##### 2.4.4.1 Creation of Corporate Synergies

The opening of established industry boundaries, which leads to new synergies, is a challenge for OEMs. This phenomenon enables powerful players such as Apple or Amazon and their digital interfaces to enter the OEM ecosystem, which also impacts FoD. Firms from “outside the industry” are creating more pressure to act due to an increasing level of competition for traditional OEMs. For example, in 2002, vehicle OEMs still created 35% of their total value in-house, which share fell to less than 18% in 2015 (Bauchle, Kostron and Schlesner, 2015). The importance of corporate synergies is obvious, as many partnerships already seem inevitable.

OEMs are also confronted with the possibility that tech giants will take over software functions. In the vehicle industry, Apple’s (Siri) and Amazon’s (Alexa) AI systems have already gained access to premium cars. Due to available smartphone interfaces, they compete with assistance systems and digital services offered by OEMs. It is crucial that Apple or Amazon do not set the industry standard, as this would result in the loss of data sovereignty and exclusion from BMIs. Hence, OEMs must get their customers accustomed to their digital platforms early on to maintain their loyalty. The data obtained from the base products may be the decisive factor if OEMs succeed in using it for their marketing initiatives and offering their customers a service that sets them apart (Liebehenschel, Degen and Köppl, 2021). However, OEMs must decide if the advantages outweigh the drawbacks of these cooperations (Slama *et al.*, 2023).

#### 2.4.4.2 *Smart Usage of Data Potential*

Many of the most valuable listed companies generate billions in profits from data-based services. Automotive OEMs and traditional companies are therefore closely monitoring the IT industry, while transitioning from hardware to SaaS and subscription-based BMs (Bertoncello, Husain and Möller, 2018). Generally speaking, sovereignty over the customer data obtained presents an essential basis for future growth, revenue streams, and the creation of additional mobility services to ensure long-term profitability. Accordingly, the smart usage of data holds a significant impact on the overall corporate success (Surendra, Roth and Stachon, 2022).

Vehicle data records become meaningful when they provide different insights into FoD purchases. Because FoD generate environmental, location, and usage statistics, conclusions about the usage behavior can be easily drawn (Plaß *et al.*, 2020). This analysis can then create different customer profiles and find marketing chances, as user profiles can be assigned to a purchasing behavior (Liebehenschel, Degen and Köppl, 2021). For example, long distance driving customers would be offered a massage option. The information could be the kick-off for cross-selling and up-selling more extensive offers (Schaefers, Leban and Vogt, 2022), for which customer should also be able to pay with data (Plaß *et al.*, 2020). In the end, OEMs must ask themselves whether the data information is accessible and to whom, what insights can be gained, and which analysis concept is most appropriate (Surendra, Roth and Stachon, 2022).

#### 2.4.4.3 *Handling of Safety Issues*

Protecting FoD from security conflicts is challenging. It is the responsibility of OEMs to ensure a secure data processing and vehicle networking, a protected architecture to guard the central gateway, and the protection of the car. This can be achieved by securing externally accessible interfaces. The goal must be to develop FoD that are not restricted by authorities. For this purpose, while software security initiatives protect against rudimentary software attacks, hardware security protects against hardware violence and also towards software attacks (Corbett *et al.*, 2018; Slama *et al.*, 2023). It turns out that the secure handling of customer data displays a crucial task for OEMs, as data protection violations can result in penalties. A detailed security concept will therefore be important for the success of OEMs, as cyberattacks are likely to increase with the growing availability of FoD (Surendra, Roth and Stachon, 2022).

Pett *et al.* (2020) analyze FoD security issues by proposing a risk-based analysis to find system variants that are relevant for retesting after the introduction of an update. The analysis is necessary because retesting must not impair functionality or compromise security, and to verify that upgrades are compatible with the software. Since analyzing all variants is not easy due to a combinatorial explosion, the authors prove that using their analysis leads to a smaller number of configuration tests. Similar papers were published by Gangadharan *et al.* (2016) and Burkacky *et al.* (2018). Mbakoyiannis *et al.* (2019), Halder *et al.* (2020), and Howden *et al.* (2020) also address the issue of OTA upgrade security, but do not discuss upgradable features.

#### 2.4.4.4 *Individualization vs. Standardization*

FoD reduce the offer complexity, as a later customization is feasible. By booking additional functions, the need for various variants in the equipment process can be lowered. This leads to a smaller number of device configurations, cost savings, and a smaller degree of complexity (Surendra, Roth and Stachon, 2022). However, the final number of arrangements will most likely increase, as additional FoD are constantly being added during the product life. Hence, while OEMs can reduce their overall costs and configurations, there is a growing need for tailor-made solutions to meet individual requests (Liebehenschel, Degen and Köppl, 2021).

A conflict between standardization and individualization emerges. The objectives, such as using fewer components, standardizing production processes, and saving costs, should not be lost sight of. However, it is also important to meet the individualization needs of customers so that they can customize products. The better such a transition is designed, the greater the unique selling point for an OEM. FoD may even be perceived as the critical factor in retaining customers for the right brand (Plaß *et al.*, 2020). To achieve this, OEMs should offer customers a personal experience with a promising FoD portfolio (Surendra, Roth and Stachon, 2022).

#### 2.4.4.5 *A Shift in the Mindset*

The transition from one-time sales to FoD is challenging for OEMs. To reach this state of mind, products must be seen as a platform for value-adding services that enable recurring revenue streams (Schaefer, Leban and Vogt, 2022). FoD hence require a variant management to limit complexity and to ensure a systematic management of hardware adaptability during updates (Zellmer, Krüger and Leich, 2024). The product-oriented approach is overdue, as today the customer is at the center of everything and creating value is the priority. OEMs must provide FoD from a customer perspective to secure revenue growth and brand loyalty, even though selling digital services differs from selling traditional products (Handing and Riemer, 2017).

A new mindset is required when offering FoD. In most cases, the success of disruptive BMs is given due to the combination of new technologies with an available BM that can satisfy customer needs better than the competition (Reinhold, Reuter and Bieger, 2011). As an example, Apple has always used MP3 technology. With the launch of the iTunes Store, the firm can leverage advantages to differentiate itself, as customers are tied to the OEM-specific platform. This SaaS approach is based on a software application that supports the mediation between supply and demand (Gassmann, Frankenberg and Csik, 2013). Technological developments like this and the IoT may enable OEMs to expand customized marketing (Ng and Wakenshaw, 2017). Facing FoD, the product architecture should not only focus on the main product but extend technical innovations to product-service systems. The transition to a more innovative, software-service-oriented approach must focus on individual needs to generate an added value. Ultimately, OEMs must face the pressure of innovations and accept structural changes to remain competitive and deliver new benefits to their customer base.

## 2.5 Conclusion

Because products transition from hardware-driven to software-driven IT devices, many rules of competition are being rewritten. Currently, firms strive for recurring revenues and lasting profits. As a result, OEMs of toys, medical equipment, vacuum cleaners, vehicles, refrigerators, and similar are making use of various disruptive BMIs. For example, technological innovations already enable customers to successfully unbundle and rebundle the preinstalled functions within the corresponding integrated hardware and software of a main device. This process leads to the individual adaptability of the entire product architecture (Dhebar, 2023). Within our systematic literature review, we refer to this industrial tendency as Functions on Demand.

FoD allow firms to abandon the product-centric focus and customers avoid long-term commitments to a certain product or service. While OEMs can successfully generate recurring revenue streams throughout the product lifecycle, consumers can customize devices to their requirements, creating an individual experience. Accordingly, since customers desire products tailored to their specific needs, OEMs must also rethink their value propositions. It is therefore necessary to understand customer preferences in addition to financial considerations to act economically and exploit the overall business potential. Although FoD can be applied across various industries, many OEMs lack the necessary understanding of how to apply the BMI due to a lack of theoretical foundations. Over the past, this occurrence may have led to a blind adoption, which resulted in customer dissatisfaction and financial losses for firms (Wucher *et al.*, 2019; Plaß *et al.*, 2020; Gruber and Kochschmied, 2022; Reinhart and Teichgräber, 2022).

Although FoD display a trending business innovation among OEMs, research findings are still limited. As of today, most studies focus on FoD in combination with the automotive industry and examine how customers perceive and respond to this BMI (Schaefers, Leban and Vogt, 2022). Due to the limited scientific research efforts and a lack of compiled findings, our systematic literature review is the first study to uncover the existing ambiguities and provide a fundamental strategic summary. Accordingly, to successfully research the topic of FoD, we examined the literature to answer our initial research question, which was formulated as:

*“How can the current knowledge about Functions on Demand be evaluated and classified?”*

For this purpose, we proceeded structurally as follows. We began the paper with the classification of FoD in the broader context of the AE, ODS, and connectivity. In the subsequent literature research process, we were able to discover several related findings on the topic, as we found 50 outcomes. Following, we literarily placed the FoD terminology in the context of related BMs and made a first distinction between automotive and cross-industry publications. We also separated between IPU and EPU and positioned FoD in the appropriate context of similar concepts. In the next instance, we summarized insights into how customers perceive and respond to FoD, as well as financial considerations of how OEMs should design the FoD payment processes and offering structure. We concluded our work with implications for OEMs by stating endorsements for the successful BMI implementation at the managerial level.

### **2.5.1 Contributions to Theory**

Our literature review yields several contributions that enrich the understanding of FoD. We note that the categorization of FoD in relation to AE, ODS, and connectivity is feasible. This is because FoD align with several characteristic facets of these tendencies. We also deliver the most accurate definition of FoD currently available, understanding FoD as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. Furthermore, we find that the FoD literature can be divided into four distinct categories, which we will return to in this section.

Secondly, we observe that FoD and similar expressions, which follow either an internal or external product upgrade mode and are of a (non-)car background, must be differentiated from each other. We can be considered the first researchers to successfully categorize FoD in connection with relatable BMs. We also classify these similar industry concepts according to IPU and EPU, referring to the paper by Garbas et al. (2022). Although most BMs discussed focus on the automotive sector, we ensure the applicability of our insights across industries.

Thirdly, we find that FoD insights can be classified regarding customer perceptions and responses. We highlight various important discoveries made by researchers. For example, citing Schaefer et al. (2022), software FoD are generally considered fairer than hardware FoD.

Fourthly, we observe that parts of the FoD literature can be clustered into payment processes and the offering structure. We evaluate FoD MPs (Petry and Moormann, 2020), FoD offer structures (Platz et al., 2020), and different profit sharing scenarios (Wucher et al., 2019).

Fifthly, we debate literature findings that deliver implications for OEMs applying FoD. Next to the creation of corporate synergies, the intelligent use of data potential, and handling of safety issues, a compromise between individualization and standardization must be found. Ultimately, this should lead to a mindset shift among OEMs in order to be successful with FoD.

### **2.5.2 Limitations**

Our literature review is subject to various general limitations. To begin with, our investigation is restricted to a specific period and a limited number of synonyms. Therefore, we cannot guarantee completeness, as we may have overlooked publications with an earlier publication date or missed results that were not included in our database. Furthermore, we may have left out findings published under different titles, as some authors may not apply a similar wording. Likewise, parts of the literature cited is published by consulting institutions, which means that the validity of these sources can be questioned. Since FoD exhibit a new BMI, not all findings can currently be perceived as error-free. Nevertheless, given that Schaefer et al. (2022) are among the first authors to address the topic from a scientific perspective, we assume that the most relevant findings at the time of our observation are successfully included into our review.

More specific limitations arise when interpreting our results. At the beginning of our study, we classify various BMs as either IPU or EPU. It is important to consider whether this classification, which we summarize in section 2.4.1.11, can be justified, as a similar comparison has never been made before. In the same manner, our stated distinction between hardware and software FoD may appear inaccurate. We are aware that software FoD can also be attributed to other BMs, such as subscription models. By these means, our interpretation of preinstalled functions in the software environment as FoD can be considered questionable.

Likewise, it is necessary to verify whether our findings can be transferred to other industries. We mainly observe the automotive industry and assume that the results can be transferred to different sectors. These concerns are particularly relevant when considering the research findings on customer perceptions and reactions to FoD. This is because other authors have not yet investigated the generalizability of results regarding different FoD applications.

Moreover, our financial results, particularly with regard to the offering structures for FoD, should be treated with caution due to the various assumptions made. In general, it is difficult to predict the profitability of FoD, as previous industry forecasts have often been overly optimistic. For this reason, the impact on OEMs, as discussed in section 2.4.4, must also be viewed with caution, as the final development of the FoD use case is impossible to forecast.

In the end, for further insights into related limitations, we refer to the publications and specific sections by Schaefers et al. (2022), Wiegand and Imschloss (2021), and Garbas et al. (2022). We also call on other scholars to focus their research on the above stated limitations to confirm various assumptions and significantly expand the available knowledge about FoD.

### **2.5.3 Future Research**

FoD are an unexplored topic that opens up many potential future research possibilities. Since the relation between OEMs and customers is likely to play a significant role, it remains exciting to observe in which direction the BMI will develop. It is questionable whether the focus will be on the economic perspective of OEMs or on the psychological impact on customers. However, according to our understanding, FoD must be examined from both perspectives. Likewise, it would be interesting to inspect how different researchers classify FoD in relation to other BMs, such as the service innovation, as also outlined in 2.4.1. Because we are the first authors to undertake a fundamental classification of FoD within section 2.2.4, it is crucial to validate whether experienced authors agree with this approach. In any case, researchers must categorize FoD more accurately, as the available FoD classifications often remain confusing.

Since the most valuable FoD insights relate to customer perceptions and reactions, we agree with several exemplary future research directions proposed by other authors. In this manner, the potential research questions identified by Garbas et al. (2022) can be mentioned. Their focus is on the customer and OEM perspective, the product design, communication, and similar, as presented in Table 6. Furthermore, we also agree with Schaefers et al. (2022) that

the development and acceptance of FoD should be examined based on perceptions of fairness in different industries, as FoD require broader cross-industry observations. Another research approach could be described by the influence of AI on FoD and the associated opportunities, for example through descriptive analysis methods for marketing initiatives (Liebehenschel, Degen and Köppl, 2021; Slama *et al.*, 2023). An investigation into the long-term effects of FoD on customer satisfaction and company profitability would also result in valuable insights.

Table 6. Possible future research questions (Garbas *et al.*, 2022)

Domaine	Exemplary future research questions
<b>Consumption mode/pricing</b>	What is the role of base product ownership on the negative effects of IPU vs. EPU? For example, what processes underline how a customer responds to an IPU vs. EPU on a rental car for a vacation vs. a purchased vehicle? Do short-term non-ownership consumption modes of the base product (access-based consumption, sharing) mitigate the negative effects of IPU? How does the length of base product ownership influence consumers' perceptions of IPU? Could free short-term trials backfire or alleviate the negative impact of IPU? Can upgrade price discounts attenuate the negative effects. Which consequences does permanently offering IPU at a lower price as compared to the pre-purchase situation have? How does offering IPU at a higher price after the purchase influence consumer responses?
<b>Product design</b>	Is there a difference in consumer responses to IPU in hedonic vs. utilitarian base products? What types of features are eligible for IPU? How does the centrality of the feature for the base product affect consumers' responses to IPU? Is there a difference between hedonic vs. utilitarian features, or between visible vs. invisible ones?
<b>Communication</b>	<b>Pre-purchase:</b> How should firms advertise IPU before the purchase? Does transparent communication reduce the number of features selected by consumers in the purchase phase as features can be activated during the lifecycle? <b>Post-purchase:</b> How should firms communicate corresponding offers of IPU in the product usage phase? Does anthropomorphizing the feature provide extra benefits that alleviate the negative impact of IPU? <b>Cost-based brand positioning:</b> Are the negative effects of IPU reinforced as consumers are increasingly aware of company costs as firms more and more approach cost structure transparency as part of their brand positioning?
<b>Value-selling</b>	Do consumers demand a higher willingness-to-accept for products with built-in features even if the feature has not been activated in case of one-time purchases?
<b>Contextual boundary conditions</b>	Is there a difference in consumer responses to internal product upgrades offered by a cost vs. quality leader?
<b>Other process variables</b>	Which advantages do internal product upgrades have for consumers (e.g., increased flexibility)? Can pricing schemes (e.g., monthly subscriptions, short-term rental fees) emphasize these benefits to outweigh consumers' betrayal? Are there mediators other than perceived ownership and perceived betrayal that explain why consumers react negatively to internal product upgrades (e.g., increased complexity)? Is there feature fatigue (Thompson <i>et al.</i> , 2005) for IPU?
<b>Ownership valency</b>	Is there a difference in consumers' value perceptions of IPU before vs. after the purchase of a product (e.g., would consumers value 'having the option' of an upgrade even if they decide not to use it)?
<b>Conceptual</b>	How can extant research be synthesized toward a standardized framework of reference for product reconfiguration?

In summary, it can be noted that FoD remain an elusive construct for research that opens several further research opportunities. From a financial perspective, researchers could analyze how different billing methods for FoD are used in applied use cases and whether a transfer to different industries is conceivable. The way OEMs calculate the profitability of FoD would also be of great interest to researchers and practitioners. In addition to marketing and financial insights, the focus can also be placed on the strategic, social, and environmental impacts of the consequences of FoD to better understand emerging challenges. Especially in an environment that is constantly confronted with changing customer expectations, firms can easily come under pressure. OEMs are hence compelled to make the most of the opportunities offered by FoD and, ultimately, to understand their most valuable asset: their customers. In this regard, experimental and conceptual insights are also crucial for developing improvement proposals so that FoD can evolve into a successful BMI for OEMs and customers alike.

### **3 Challenges for the Financial Implementation of Business Model Innovations: A Qualitative Case Study on Functions on Demand**

#### **Abstract**

Introducing a business model innovation (BMI) in a corporate context is difficult since applied management knowledge about the financial challenges is rare. To contribute to this under-researched topic, our case study assesses financial challenges involved in implementing BMIs by drawing lessons from the experience with the Functions on Demand (FoD) BMI. In general, FoD enable the later activation of previously installed features in a base product. This provides customer flexibility and additional revenue streams for original equipment manufacturers (OEMs). FoD are widely used by technological and automotive OEMs. However, the topic has attracted attention primarily from the customer's perspective. To gain a more comprehensive understanding, we followed how an OEM (hereafter "*Automotive Enterprises*") introduced FoD from a financial perspective. By using various data sources and expert interviews collected within the company, we generate insightful findings. Based on our results, three key financial challenges for the implementation of BMIs can be identified. Moreover, we explore six general challenges of a non-financial background. By these means, we contribute to the literature on the terminology of BMI but also regarding FoD. Observing the insights, we conclude our case study with implications for practitioners before evaluating future research fields. Ultimately, our work offers findings for academics and OEMs who want to optimize BMIs in the long term.

#### **Keywords**

Business model innovation, Functions on Demand, Case study, Implementation challenges

### 3.1 Introduction

Innovative product and service development initiatives are essential for companies that rely on constantly bringing new creations to the market (Artz *et al.*, 2010; Talay, Calantone and Voorhees, 2014). Recently, however, the commercialization of manufacturing brought about by market globalization has made it more difficult for companies to charge premium prices or capitalize on their manufacturing capabilities. It is no longer sufficient to compete solely based on products, forcing companies to rethink their entire business model (BM). Accordingly, firms must also pay more attention to the introduction of business model innovations (BMIs) to stay competitive (Björkdahl and Holmén, 2013). This phenomenon is understandable, as BMIs have the greatest impact on profit margins compared to other types of innovations (IBM, 2006).

One of the most difficult tasks for companies today is the successful introduction of new BMIs. Next to the BM concerns of value creation and capture at the firm level, BMIs raise doubts about diverse consumer value propositions, corresponding logical reformulations, and structural reconfigurations (Spieth, Schneckenberg and Ricart, 2014). This is mainly due to the speed at which technologies and the environment are changing (Chesbrough, Vanhaverbeke, and West, 2006; Johnson, 2010). As a direct result, firms have limited BMI capabilities, as they have only recently incorporated these innovative trends into their strategic agenda, paid more attention to them, and increased their overall funding capacities (Chesbrough, 2010).

Despite extensive knowledge about BMIs, little is known about the financial challenges faced by original equipment manufacturers (OEMs) when implementing them (Eppler and Hoffmann, 2013). While Voelpel *et al.* (2004) see the need for sensing customer needs and BM requirements, Chesbrough (2010) contends that the best way to select the greatest option for a BM is to experiment with BMIs in already existing firms. Even though other authors discuss general challenges in implementing BMIs (Chesbrough, 2010; Björkdahl and Holmén, 2013; Frankenberger *et al.*, 2013; Spieth, Schneckenberg and Ricart, 2014; Geissdoerfer *et al.*, 2023), due to a lack of applied research knowledge, their findings provide rather vague financial or managerial insights. Likewise, they do not deliver detailed solution approaches to the challenges that arise in an organizational environment when applying BMIs. However, the latter would significantly increase the understanding required for the introduction of BMIs.

#### 3.1.1 Formulation of the Research Questions

Given the limited corporate knowledge about the financial challenges and requirements for implementing BMIs, our qualitative case study aims to fill this gap. As of today, although initial abstract strategies are being proposed, no guidelines for implementing BMIs exist. Likewise, the available applied research is widely dispersed (DaSilva and Trkman, 2012). Therefore, we establish a link between our findings and existing publications, such as those by Schneider and Spieth (2013), Taran *et al.* (2016), and Teece (2010), by answering our main research question:

*“What financial challenges does an OEM face when implementing BMIs on behalf of a firm?”*

Our results emerge from a premium vehicle OEM that we accompanied over three years and which we refer to as “Automotive Enterprises”. In this time, a new financing method for a BMI was introduced that provided decision-making support. During the implementation, we identified several difficulties that must be overcome to apply the latter successfully. Our case study also draws on additional findings, such as those from internal documents, emails, daily observations, and expert interviews. We opted for the case study approach to reinforce theoretical BMI knowledge with a more practical-oriented method. In line with Woolcock (2013), we strive for external validity and aim to provide OEMs with applied BMI knowledge.

We contribute to the BMI literature and the challenges of the implementation process step, which, according to Wirtz and Daiser (2018), is the most important one. Since no studies exist in which investigations have been carried out over a longer period and most approaches contain poor data (e.g., Geissdoerfer *et al.*, 2023), we state new recommendations. We focus specifically on financial BMI issues, as previous works often concentrate on general challenges (e.g., Frankenberger *et al.*, 2013). We observe that potential encounters can be assigned to several clusters, as we state three financial and six universal insights to limit BMI uncertainties.

In the firm environment, we faced the Functions on Demand (FoD) BMI. FoD enable users to unlock preinstalled hardware and software functions in a main device. The increasing customer flexibility leads to recurring revenue streams and a higher overall profitability for OEMs (Wucher *et al.*, 2019; Plaß *et al.*, 2020). Although several industries apply FoD, it remains unclear what features constitute fair offers and how OEMs should deal with hardware functions that require upfront payments. There are currently no recommendations for OEMs on how to proceed. FoD also lack a sound pricing structure, as it is uncertain how much buyers are willing to pay for product upgrades (Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022).

The majority of contributions focuses on analyzing FoD from the consumer perspective and examines how they perceive such BMI (Ho-Dac, Kumar and Slotegraaf, 2020; Wiegand and Imschloss, 2021; Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022; Dhebar, 2023). Meanwhile, insights regarding financial implementation challenges are completely ignored, as most publications concentrate on promoting FoD and do not address practical dilemmas (e.g., Schaefers, Leban and Vogt, 2022). Only a few consulting studies state recommendations that OEMs can benefit from (e.g., A.T. Kearney, 2017; Wucher *et al.*, 2019; Plaß *et al.*, 2020; Frost&Sullivan, 2021). However, these have not yet been empirically verified. As a result, our case study also addresses the second research question, which centers more directly on FoD:

*“How should the FoD BMI be implemented by an OEM to achieve a financial success?”*

We contribute to the FoD literature, as research is theoretical and lacks a financial background (e.g., Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). Our contribution is to provide financial insights into the challenges of implementing FoD. Therefore, we complement existing studies but also illuminate these with a pragmatic initiative. Because practical insights are rare, our findings are especially helpful for cross-market OEMs looking to implement FoD.

### **3.1.2 Structure of the Paper**

The further structure is as follows: In the beginning, we encourage our research by explaining how the terms BM, innovation, and BMI are to be understood. In the next step, we deliver relevant literature findings. Moreover, we provide background knowledge on FoD. We are the first authors to classify FoD as BMI, as this innovation serves as the example in our case study. Subsequently, the two research gaps and contributions follow. We aim to provide new insights into the general topic of BMI, along with further findings on FoD. Section 3.3 describes our research method. Background information on case study research and the cooperating firm are provided. We furthermore present our methods for data generation and analysis. Section 3.4 exhibits the results and discussion thereof. By discussing the results and comparing them with literature findings, we can answer our research questions and contribute to the state of knowledge. We close our study with remarks, limitations, and possible research opportunities.

## **3.2 Research Background**

We begin our research background with the BM characteristics, the innovation process, and results regarding BMIs, before motivating the main research question. Following, we deliver research findings from FoD and classify such trend as BMI. We provide findings on the subject before stating our second research question. We hence conclude each review by identifying a research gap and discussing how our contributions are valuable in the field of BMIs and FoD.

### **3.2.1 Background on Business Model Innovations**

#### *3.2.1.1 The Business Model Concept*

Scholars from various disciplines are participating in the scientific discussion on BMs. Starting around the 1990s, the BM concept has been examined by various researchers in numerous articles published across peer-reviewed journals (e.g., Amit and Zott, 2001; Chesbrough, Vanhaverbeke, and West, 2006). In addition, an increasing amount of practice-focused BM research projects exists nowadays. Despite these given circumstances, there is no universally accepted understanding of the terminology, even though this would enable researchers who approach the BM construct from different perspectives to effectively draw on each other's work (Zott, Amit and Massa, 2011). As a result, there remain differences of opinion regarding the definition, design, and suitability of BMs for different economies (Goyal *et al.*, 2017).

Throughout our work, we interpret the BM concept according to Osterwalder and Pigneur (2013) as follows: "A business model describes the rationale of how an organization creates, delivers, and captures value". By these means, a BM is more frequently used by competitors and is more universal than what we perceive as business strategy. This is because BMs focus on the value creation aspect (Teece, 2010). The BM advantages enable OEMs to stand out from competitors, build stronger client bonds, achieve economic growth, and gain a competitive edge. The final goal is to combine the BM dimensions (customer, usage, value, partner, and finance) in a way that they successfully reinforce each other (Schallmo, 2013).

### 3.2.1.2 *The Process of Innovation*

We understand innovation as “the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, to advance, compete, and differentiate themselves successfully in their marketplace” (Baregheh, Rowley and Sambrook, 2009). For companies, innovations are a tool to influence their industries. They provide a channel for the gradual introduction of new products and the increase in production capacity through process changes (Lopes *et al.*, 2016). Scientifically, the concept is referred to in several ways, including theories such as technological innovation (e.g., Shea, 2005), process innovation (e.g., Tidd and Bessant, 2021), open innovation (e.g., Chesbrough, Vanhaverbeke, and West, 2006), and product development (e.g., Wheelwright and Clark, 1992). We classify the term according to the OECD (2009) into the types of product, process, organizational, and marketing innovation.

The combination of services and products is referred to as product-service systems (PSS) or “servitization”. PSS display a strategy with the intention of achieving a higher profitability, competitiveness, and sustainability (Barquet *et al.*, 2016). To develop PSS that can create a value, firms must acquire innovative skills (Moro, Cauchick-Miguel and Mendes, 2021). Since the trend impacts firm performance, PSS have been studied over decades (Shin *et al.*, 2022). Citing Goedkoop *et al.* (1999): “A PSS is a system of products, services, networks of players and supporting infrastructure, that continuously strives to be competitive, satisfy customer needs, and has a lower environmental impact than traditional business models”. The goal is to offer advantages, while unnecessary risks and costs should be avoidable (Baines *et al.*, 2007). One example is Rolls-Royce’s “Power by the hour” program. The OEM assumes responsibility for product maintenance and hence rather sells the service (Mahut *et al.*, 2015).

Conclusively, innovative revenue models, process innovations, and similar are often related to BMs. Henceforth, a BMI represents a new logic that explains how a firm can create far-reaching added value for its customers. Accordingly, agreeing with this perspective, a BMI is not distinct from process, product, or service innovations, as it is even superior to them. We therefore conclude that PSS and the innovation aspect reflect the general idea of BMIs, as also explained in the following (Sousa-Zomer and Cauchick-Miguel, 2019; Yang and Evans, 2019).

### 3.2.1.3 *The Business Model Innovation Concept*

The revised logic of value creation and capture, which includes a new combination of products or services, market position, processes, and other changes, is our understanding of a BMI (Björkdahl and Holmén, 2013). For a BM to be considered BMI, it must be integrated into the firm and generate a new profit (Trapp, Voigt and Brem, 2018). Citing Lindgarth *et al.* (2012), innovation becomes BMI when two or more of the BM dimensions are reinvented. Hence, “a BMI promotes the innovation of the total BM of an organization to become client-driven. It identifies human involvements and interactions with customized products according to customer’s specific needs as the core activity of the new BM” (Steenkamp and Arnoldi-van Der Walt, 2004). Despite existing studies, there is no theoretical basis (Foss and Saebi, 2017).

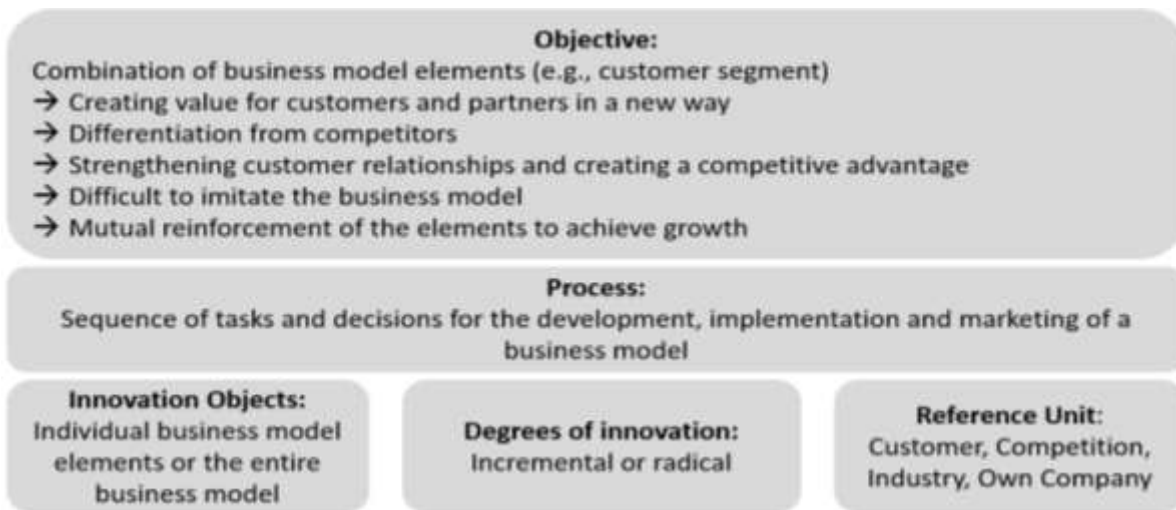


Figure 16. BMI components (according to Schallmo (2013))

Figure 16 presents the BMI components according to Schallmo (2013). The objective, process, and the impact of innovations are depicted. In this context, innovations initiate the development of a BM to achieve an improved value. The starting point is a firm's products or processes, as the goal of product development is to increase sales (Utterback, 2006). Process innovations can also raise productivity by increasing the organization's efficiency. As a result, all functional areas can serve as further innovation centers (Utterback, 2006; Schallmo, 2013).

Since the invention of the internet, firms have been paying more attention to BMIs. The general interest is growing, as BMIs can provide a competitive advantage (Rub, Bahemia and Schleyer, 2017). One benefit is that BMIs are difficult to imitate (Lindgardt *et al.*, 2012), as Nestlé can demonstrate in an exemplary manner. The Swiss firm was able to achieve higher profits when beginning to sell its coffee machines at low margins, while selling the capsules at high margins. However, a disadvantage is that the BMI implementation remains difficult to achieve, as many attempts fail (Chesbrough, 2010). However, in a study by IBM, CEOs of high-end firms rank BMIs as the most significant type of innovation (Pohle and Chapman, 2006).

#### 3.2.1.4 Relevant Research Insights on BMIs

This section deals with research findings on BMIs. We begin with general observations before focusing on more specific aspects. The importance of BMIs has grown over the recent years, especially in dynamic competitive situations (Wirtz and Thomas, 2014). Starting around the year 2000, many consulting firms (Linder and Cantrell, 2001; Barsh, Capozzi and Davidson, 2008) and scholars (Keen and Qureshi, 2006; Zott and Amit, 2007; Deck, 2008) have examined the topic from most theoretical perspectives. However, a certain amount of curiosity in the requirements, structure, and application of innovations at the BM level remains, as most efforts focus on enhancing the firm's value. In the following, we will discuss a spectrum of the seven most common research areas that meet our requirements, as illustrated in Figure 17. We expand on the work of Kraus *et al.* (2020) by focusing on a wider range of literature areas. Our overview is intended solely as an introduction into the field of BMIs and is not exhaustive.

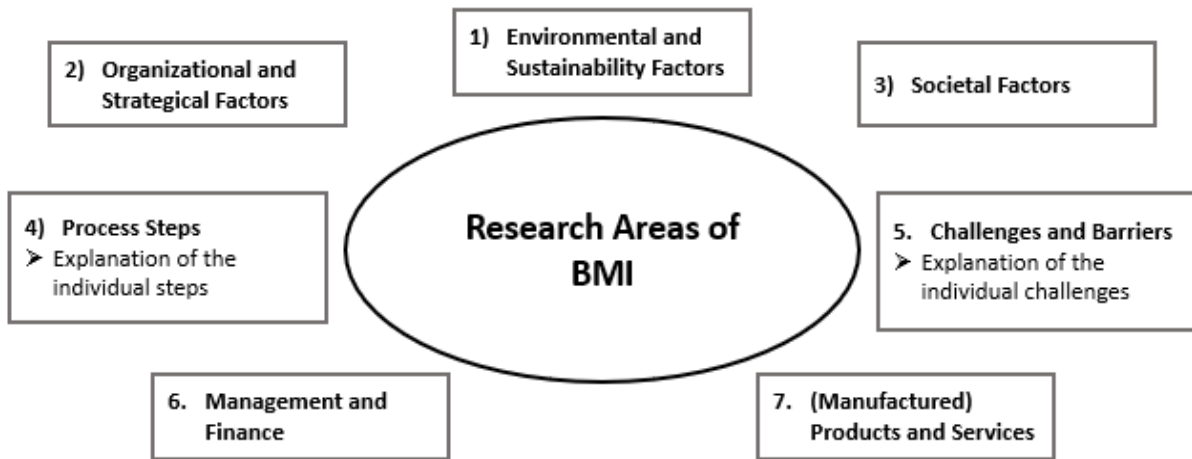


Figure 17. BMI research areas

First, many studies focus on the combination of BMIs and the impact on *environmental and sustainability factors* (e.g., Evans *et al.*, 2017; Geissdoerfer, Vladimirova and Evans, 2018; Shakeel *et al.*, 2020). The general connection is well known, as sustainability-oriented BMIs are indispensable for OEMs (Baldassarre *et al.*, 2017). Most findings analyze value creation in a set-up of environmental instability. Schneider and Spieth (2013) recognize that “within the corporate practice, BMI has been identified as a promising approach for firms to respond to changing sources of value creation in times of high environmental volatility”. Further studies discuss the circular economy and sustainability achievements (Spieth, Schneckenberg and Ricart, 2014; Evans *et al.*, 2017; Geissdoerfer, Vladimirova and Evans, 2018; Pieroni, McAlone and Pigosso, 2019; Egfjord and Sund, 2020). For example, Guldman *et al.* (2020) provide an overview of the issues hindering the adaption of circular BMs. Citing Inigo *et al.* (2017), the focus of sustainable BMIs is becoming more important, as stakeholders expect firms to be sustainable. Moreover, organizational measures must consider the environment and society, as it is assumable that the aspects are interlinked and impact BMIs. Agreeing with Yang *et al.* (2017), BMIs are more about finding innovative ways to manufacture and deliver products or services than discovering new ones. Accordingly, many studies investigate new technologies. For example, Karlsson *et al.* (2017) emphasize the importance of BMIs for renewable energies, as they offer chances for property values, value chains, or customer interactions. Van Waes *et al.* (2018) state that sharing economy platforms with digital capabilities can also be considered innovative technologies, as they occur with BMIs. For more insights, we refer to the papers by Kraus *et al.* (2020), Evans *et al.* (2017), Schaltegger *et al.* (2012) and Geissdoerfer *et al.* (2018).

Second, several authors examine the effects of *organizational and strategical factors* on BMIs (e.g., Abraham, 2013; Leih, Linden and Teece, 2015). Companies face most obstacles at the organizational level, followed by the ones at the value chain, among employees, in the market, and in the institution. However, differences between firms regarding the nature and number of obstacles exist (Antikainen *et al.*, 2017; Franceschelli, Santoro and Candelo, 2018; Ranta, Aarikka-Stenroos and Väisänen, 2021; Reim, Sjödin and Parida, 2021). Clauss (2017) analyzes BMI concepts and divides the BMI approach into three dimensions (value creation

innovation, new proposition innovation, and value capture innovation) and ten substructures. Meanwhile, Spieth et al. (2016) examine the relationship between BM, BMI, and a corporate strategy. The authors note that when firms offer comparable products but have different BMs, the interaction between strategy and BM is beneficial, as OEMs with identical products attract the same customers. An explanation of the methods used by a company's value system to assess its BMI capabilities should still be derived from the corporate culture. Related findings are stated by Foss and Saebi (2018), Von Delft et al. (2019), Snihur and Wiklund (2019), and Hacklin et al. (2018). Fütterer et al. (2018) investigate BMI efficacy and success concerning internal company ventures and conduct research in three areas: The general impact of BMIs on internal company venture performance, the linkages between these impacts and industry growth, and the effects of effectuation and causation of BMIs. It is specified that effectuation and causality impact BMIs, while internal corporate ventures display the best practice. Similar publications are provided by Trimi and Berbegal-Mirabent (2012) and Asemokha et al. (2019).

Third, the BMI literature discusses *societal factors* (Weerawardena et al., 2021). The reason for this is that social enterprises seek to generate social values and require BMIs, even if difficulties can arise (Tykkyläinen and Ritala, 2021). Referring to Dentchev et al. (2018), there is a need for more in-depth research on social entrepreneurship and BMI development caused by societal developments. The authors question the intentions of BMs to minimize damage to the society and environment. The results show that the financial budget of social enterprises and the process by which they accumulate resources present difficulties. By these means, the question of how a social BM differs from a regular profit BM is of interest. For this purpose, a definition of social entrepreneurship is given by Mongelli and Rullani (2017) and Olofsson et al. (2018). The authors emphasize how important it is to use an appropriate BMI to achieve a valuable social impact. This often leads to critical conflicts, as it can be difficult to reconcile economic considerations with social consequences. Olofsson et al. (2018) and Dentchev et al. (2018) also highlight the importance of BMIs for more comprehensive ecological and social changes within a company. Nevertheless, despite these first insights, the relationship between social enterprises and BMIs often remains difficult to predict, as stated by Kraus et al. (2020).

Fourth, we provide insights about the BMI *process steps* (Andreini et al., 2022), which, referring to Figure 16, display the center of a BMI. In view of this significance, Schneider and Spieth (2013) called for findings that "create a better understanding of the potential process and elements of BMIs". As a result, various prototypes are now available, although they vary in terms of the process steps (also referred to as "process phases" in the following) and divergence in orientation (Geissdoerfer, Savaget and Evans, 2017). Potential drafts are stated by Pramataris et al. (2001), Voelpel et al. (2004), Osterwalder et al. (2013), Teece (2010), and Frankenberger et al. (2013). We mostly agree with the representation by Wirtz and Daiser (2018). This is due to the fact that the authors review the BMI process steps of twenty (non-) empirical research insights on the process step level and identify significant commonalities.

We will now state the seven-step BMI process developed by Wirtz and Daiser (2018). The process begins with the *Analysis* of the BM's current situation to gain an understanding of its strengths, weaknesses, and the business environment. *Ideation*, the next process step, occurs when an organization's mission is defined and concepts, narratives, and scenarios are developed. Methods are used to generate different perceptions and build the BMI foundation. Evaluating the impact and practicality of a BMI is the primary goal of the *Feasibility* phase. This implies that the result of the *Ideation*, the conceptual draft, must be evaluated in terms of its viability. A discrete *Prototyping* of a BMI should be built to assess BMI design alternatives and refine a BMI until a satisfactory prototype is present. The process then moves to the *Decision-making* step, in which options are evaluated, and a development decision is made. The design-oriented part ends with the *Decision-making*, and the operations-oriented part, which deals with the BMI *Implementation*, begins. The final *Sustainability* phase is necessary since an OEM must ensure that a BMI is introduced with adjustments to secure sustainability aspects. Academics usually discuss the first three process steps. Moreover, many prototypes include the *Implementation* phase as a crucial component (C. Pramataris, Dimitris A. Papakyri, 2001; Frankenberger et al., 2013; Osterwalder and Pigneur, 2013; Teece, 2010; Voelpel et al., 2004). This is because the latter is the most commonly used process step among other drafts (e.g., Osterwalder and Pigneur, 2013) and displays the operations-oriented part of a BMI. Diverse designations exist, such as "change the BM" (Linder and Cantrell, 2001), "adaption" (Enkel and Mezger, 2013), or "execution" (Yang, You and Kwon, 2014). This process step covers the testing, realization, and go-live of the BMI, as well as the required change management (Wirtz, 2020). The *Implementation* phase obtains a strong project management character (e.g., Leih, Linden and Teece, 2015; Reim, Åström and Eriksson, 2020) and is the focus of our attention.

Fifth, many papers address *challenges and barriers* (e.g., Chesbrough, 2010; Björkdahl and Holmén, 2013; Spieth, Schneckenberg and Ricart, 2014). Most studies focus on internal factors like leadership, skills, and cognition (Berglund and Sandström, 2013; Frankenberger et al., 2013; Spieth, Schneckenberg and Ricart, 2014). This is since, as Chesbrough (2010) notes, BMIs are generally challenging to attain. Several tools for BM improvements exist, but most of them (e.g., the Canvas BM by Osterwalder and Pigneur (2013)) are largely inadequate. Since BMIs can assist firms in breaking free from their existing BMs and promote economic growth, OEMs must ensure that emerging challenges do not hinder them. This issue is addressed in the study by Klang and Hacklin (2013), which highlights behavioral patterns that promote BMI.

We will now list BMI challenges. Chesbrough (2010) terms *cognitive challenges* as "the uncertainty around the appropriate BM" and *organizational challenges* as "the impediments caused by the internal structures and procedures of the company". Eppler and Hoffmann (2013) assign (1) the complexity of the task, (2) the existing dominant logic of a firm, and (3) the knowledge required to *cognitive challenges*, while *organizational challenges* are mainly influenced by (1) the resources, (2) the values, and (3) the team. Björkdahl and Holmén (2013) state a detailed agenda on BMI challenges, applying the following aspects: (1) Definition and

characterization of BMI; (2) Managing BMI (in established firms); (3) Experimenting, testing, and implementing BMI; (4) BMI scalability; (5) Profiting from BMI; (6) BMI and changes in the ecosystem; and (7) The role of capabilities for BMI. All issues focus on internal challenges such as resource inertia (Tripsas and Gavetti, 2000; Amit and Zott, 2001), cognitive barriers (Chesbrough, 2002), lack of leadership (Doz and Kosonen, 2010), and organizational structures (Santos, Spector and Van Der Heyden, 2009). Meanwhile, Berglund and Sandström (2013) also discuss external challenges, with BMIs addressing the challenges of managerial coordination between actors, alongside challenges related to restricted control, networks, complexity, and uncertainty. Frankenberger et al. (2013) outline key challenges in four BMI process steps. The challenges of (1) the initiation phase, which is centered on the analysis of the ecosystem, are the *understanding of the needs of the players* and the *identification of change drivers*. OEMs must *overcome the current business logic, concentrate on thinking in BMs, and use systematic tools to develop new BM ideas* during (2) the ideation phase, which displays current ideas. The challenges of (3) the integration phase, which involves creating a BM, are the *integration of all pieces of their new BM* and the *management of partners*. Two main challenges remain in the decisive step, (4) the implementation phase. Firms must *overcome internal resistance* and gradually introduce the new BM through *pilots, trial-and-error, and experimentation*. Rub et al. (2017), Bashir et al. (2020), Halecker et al. (2014), Von den Eichen et al. (2015), and Geissdoerfer et al. (2023) deliver similar insights. Since the units of analysis for BMIs are often not fully defined, future research possibilities exist (Spieth, Schneckenberg and Ricart, 2014).

Sixth, *management and finance* papers deal with BMIs (e.g., Aspara, Hietanen and Tikkanen, 2010; Bucherer, Eisert and Gassmann, 2012). Innovation is a sequence of activities intended to lead to a new product or service (Gerpott, 2005). The process is uncertain, as most decisions are complex (Gerybadze, 2004). Hence, management accounting (MA) or financial data sources can support the decision-making in favor of BMIs (Nielsen, Mitchell and Nørreklit, 2015). Recently, BMIs and decision-making have received academic attention, as we have already pointed out that the latter is a component of the BMI process. Schneckenberg et al. (2017) discover how decision-makers handle uncertainty in BMIs (customer centricity, value co-creation, capability evolution, ecosystem growth, and adaptive pricing). Another article analyzes the need to adapt BMIs in times of competitive market change when innovation is inevitable to remain successful (Martínez-Velasco and Terán-Bustamante, 2022). Brenk et al. (2019) also ascertain that firms can apply the logic of effectiveness or causality when assessing uncertainty. Furthermore, Andersen et al. (2022) examine decision-making challenges in the digital context of SMEs. However, the direct observation of MA practices and BMIs receives only limited attention. Al-Baghdadi et al. (2021), Kumarasinghe and Athambawa (2020), and Aaltola (2018) deliver first findings. Nevertheless, additional perceptions can be found when investigating publications on MA practices in connection with product innovation (Mouritsen, Hansen and Hansen, 2009; Ferreira, Moulang and Hendro, 2010). This approach provides OEMs with insights into financial challenges faced by BMIs (e.g., Pohle and Chapman, 2006).

The seventh research area focuses on *(manufactured) products and services* in BMIs and presents a driver for successful adaptation (Kraus *et al.*, 2020). Visnjic *et al.* (2016) highlight findings on the relationship between service BMIs and product innovations. The authors note that expanding a company's existing range of services beyond its current product range is part of the servitization strategy. Similar insights were published by Kastalli and Van Looy (2013), Paiola and Gebauer (2020), and Frank *et al.* (2019). Rantala *et al.* (2018) investigate BMIs and their relationship to sustainable opportunities, given the growing importance of the service sector for economic growth. Rosca *et al.* (2017) examine sustainable BMIs in economic goods and services. According to their findings, frugal BMIs can reorganize resources, reengineer goods and services, and reintegrate value chains. Additional insights reach from the appliance in an industry 4.0 surrounding (e.g., Burmeister, Luettgens and Piller, 2015; Ibarra, Ganzarain and Igartua, 2018; Müller, 2019), to different industry activities (Trimi and Berbegal-Mirabent, 2012), PSS (e.g., Sousa-Zomer and Cauchick-Miguel, 2019), various digital environments (e.g., Rachinger *et al.*, 2019), and auxiliary organizational BMI dimensions (Foss and Saebi, 2015).

Conclusively, despite the research attention, BMIs are “a slippery construct to study” (Casadesus-Masanell and Zhu, 2013). The fuzziness results from a conflict in the conceptual BMI framework, which straddles the boundaries of business strategy and economics without having a foundation in either discipline (Teece, 2010). Nevertheless, these circumstances also offer the academic community an interesting research opportunity, as BMIs are an emerging phenomenon that is becoming increasingly important for OEMs (Spieth, Schneckenberg and Ricart, 2014). In this context, we seek to analyze the fourth and fifth research area from Figure 17 in greater detail, namely the BMI challenges involved in the implementation process step.

#### 3.2.1.5 *Research Gap and Contribution to BMIs*

Considering the research findings, a gap becomes visible. Although examples of theoretical challenges associated with BMIs are provided, little is known about experiences with the practical implementation. Most studies that do address this topic investigate entrepreneurial (Trimi and Berbegal-Mirabent, 2012; Rummel, Hüsigg and Steinhauser, 2022) or SME settings (Anwar, 2018; Albats, Podmetina and Vanhaverbeke, 2023). However, larger firm structures are frequently left out. Although empirical studies exist, they tend to focus on multiple OEMs with fewer experts rather than on a single company over a longer period (Schneckenberg *et al.*, 2017; Aaltola, 2018; Broekhuizen, Bakker and Postma, 2018; Geissdoerfer *et al.*, 2023). Similarly, while most findings analyze a range of internal corporate elements, only few studies address the business challenges associated with the financial BMI implementation. In general, it appears that academics struggle to make sense of the interest in the topic, as BMIs do not seem to fit well with the classical management research (Jacobides and Winter, 2012). In this manner, our approach addresses Schneider and Spieth's (2013) call for additional research that finally “enables a better understanding of the potential process and elements of BMI”.

Our qualitative case study provides real-world insights about potential BMI challenges. To better understand financial BMI encounters, we deliver the first explicit recommendations for OEMs faced with implementing BMIs. In this regard, we take a different perspective than previous works, as we focus exclusively on one of the many management obstacles mentioned by Björkdahl and Holmén (2013), namely the implementation step of a BMI. Because the BMI implementation is fairly difficult (Broekhuizen, Bakker and Postma, 2018), Frankenberger et al. (2013) are one of the few researchers to address this issue. The authors even perceive this confrontation as “the hardest tasks of all”. However, we aim to state more detailed insights regarding BMI challenges than the studies by Frankenberger et al. (2013) and Geissdoerfer et al. (2023). We do so by emphasizing the financial aspects of a single technical case study over a longer period of time. By these means, our study focuses on identifying key challenges to help OEMs in incorporating innovative ideas into their BMIs. Our research thus offers an initial approach to closing the aforementioned gap and builds on the BMI literature by providing a detailed implementation framework that addresses the following research question:

*“What financial challenges does an OEM face when implementing BMIs on behalf of a firm?”*

### **3.2.2 Background on Functions on Demand**

FoD refer to features that can be activated after a product leaves the manufacturing site, as the necessary components are already preinstalled (Wehinger and Höflich, 2018). FoD provide OEMs with recurring revenue streams and allow customers to customize products. Although the concept is not new, especially among vehicle OEMs, definitions remain limited. Garbas et al. (2022) understand FoD as “fee-based activation of originally built-in, but deliberately restricted, optional features”. Schaefers et al. (2022) perceive FoD as “services that allow customers to temporarily access certain features of a product for an additional fee after the initial purchase has been made”. Meanwhile, product structures of some OEMs prove that the access to features can also be permanent (Pläß *et al.*, 2020). Consequently, we define FoD as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. In other words, FoD are available when a device holds all of its functions, even if they are severely limited.

#### *3.2.2.1 Classification of FoD as a Business Model Innovation*

We now categorize FoD as BMI according to Figure 18. Dhebar (2023) classifies the concept of “preinstalled functionality as a service”, which is similar to FoD, as BMI. Meanwhile, Schaefers et al. (2022) view FoD as a service innovation in the sharing economy that grants users access to additional features of a product they own. OEMs can create recurring revenues through FoD by integrating servitization and innovative sharing economy concepts into their product-oriented BMs. As a result, it can be argued that FoD have innovative traits of a PSS and can be assigned to the BMI approach. We agree with this view, as the combination of products and services offered with FoD did not exist before and poses a new value for customers and OEMs.

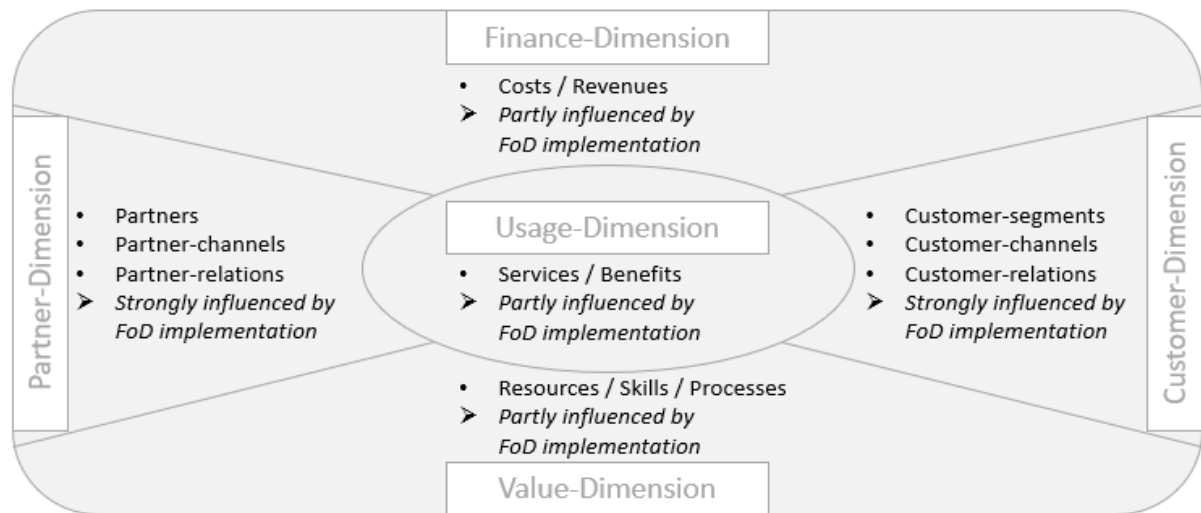


Figure 18. Dimensions of a business model and influence of FoD (according to Schallmo (2013))

Citing Lindgardt et al. (2012), innovation becomes BMI when two or more dimensions of a BM are redesigned or offer a value in an innovative way. We examine the dimensions identified by Schallmo (2013) and investigate how these change with the introduction of FoD compared to a conventional product configuration approach. The BM logic describes what and how customer benefits are created, and how a revenue flows back to an OEM. Ultimately, the associated benefits can set a firm apart from the competition and improve customer relations.

The *customer-dimension* focuses on customer segments, customer channels, and customer-relations, and delivers insight into who BM services are provided for. The availability of FoD appeals to the same customer segments as configurable features. However, FoD offer greater flexibility, as the modification takes place after the initial product sale. This also turns FoD into an interesting alternative for leasing customers who desire flexibility (Wucher *et al.*, 2019; Garbas *et al.*, 2022). Accordingly, we can witness a change in the customer channels. In terms of the customer relations, FoD can lead to a negative perception due to feelings of betrayal, as features are initially restricted (Wiegand and Imschloss, 2021; Garbas *et al.*, 2022).

The *usage-dimension* defines the services and the resulting BM benefits. The question of what is offered to the customer is answered. Facing FoD, the service provided remains unchanged. Conversely, the way in which the latter is transferred differs, as a reconfiguration is now possible (Schaefer, Leban and Vogt, 2022). This leads to benefits such as greater brand loyalty and customer satisfaction. These are achieved through personalization thanks to a longer customer journey, which is ensured by continuous improvements (Plaß *et al.*, 2020).

The *value-dimension* states the BM resources, capabilities, and processes, and answers the question of how a BM provides services. The resources that affect a feature via FoD or the configurator do not differ, as the offer remains identical. However, FoD change the capability spectrum, as functions can be configured retrospectively, which was not possible before (Plaß *et al.*, 2020). The process structure is also affected, as functions must be installed in advance. We therefore agree with Bucherer and Uckelmann (2011) that FoD create a new value model.

The question of who to collaborate with to complete a BM is answered in the *partner-dimension*, as partners, partner channels, and partner relations are evaluated. FoD have an open structure that allows unconventional players with their digital interfaces, such as Apple, to influence them. In 2002, OEMs generated 35% of their value internally, which percentage fell to 18% by 2015 (Bauchle, Kostron and Schlesner, 2015). In case of the car industry, partner relations are necessary because the IT appears as a shaper of advances and an outsourcing already seems inevitable (Kessler and Buck, 2017). Collaborations are essential, as efficient transactions and a fast introduction of FoD require various payment methods. These can only be achieved with regional telcos for 5G or similar collaborations (Frost&Sullivan, 2021). In this context, relations are often money-driven, as Wucher et al. (2019) and Döbbelin and Kayser (2020) note when discussing cash flow scenarios for an OEM and a manufacturer of FoD.

Finally, the *finance-dimension* defines potential BM costs and profits. The latter is intended to answer the question of how costs occur and how revenues can be generated. Facing FoD, additional costs for the provision of hardware functions arise if these are not used by the customer, as the OEM must make financial advance payments for the installation. Meanwhile, the total revenue can be significantly increased through different payment approaches such as pay-per-use (PPU), subscription, freemium, and similar (Pläß *et al.*, 2020).

In summary, the analysis of Figure 18 reveals a deviation in the purchase of vehicle equipment via a traditional product configurator or with FoD, so that the latter can be defined as BMI. As previously described, the introduction of FoD primarily affects the partner- and customer-dimensions. In addition, FoD also partially reshape the value-, finance-, and usage-dimensions, as according to Bucherer and Uckelmann (2011), a new value creation model is created. Because various dimensions provide a new value in use, we understand the FoD concept, in accordance to the comprehension of Lindgardt et al. (2012), as a form of BMI. However, this classification must be treated with caution, as we are the first authors to classify FoD as BMI, and variations between different industries may exist (e.g., consumer electronics).

#### 3.2.2.2 *Relevant Research Insights on FoD*

Most studies focus on how customers perceive FoD and contain a marketing background. Schaefers et al. (2022) examine how customers respond to the tangibility and pricing of FoD. Behavioral intentions and perceptions of fairness are more favorable with flat rate pricing than with a PPU scheme. Moreover, software updates are perceived more positively than hardware FoD. Wiegand and Imschloss (2021) underline this finding, as consumers believe that software products are less successful in increasing the overall use of a product. Furthermore, Garbas et al. (2022) state that customers respond less favorably to FoD than to external upgrades. In the latter case, an attribute is physically detached and sold separately from the original product. Additional insights into customer perceptions of FoD are delivered by Ho-Dac et al. (2020), Dhebar (2023), and Gräsner and Vogt (2023). Kessler and Buck (2017), Liebehenschel (2021), Slama (2023), and Wucher et al. (2019) also discuss advices for OEMs regarding various FoD.

Meanwhile, research on the financial aspects of FoD is limited. One of the few papers inspecting financial difficulties is by Petry and Moormann (2020). The authors analyze the FoD mobile payment design. Furthermore, Plaß et al. (2020) state potential FoD offer and payment structures. Finally, Wucher et al. (2019) and Döbbelin and Kayser (2020) discuss three financial FoD cash flow scenarios. Additional financial-based FoD publications have been published by a series of consulting firms (Herzig, Roth and V.M.G., 2021; Gruber and Kochschmied, 2022; Reinhart and Teichgräber, 2022). However, it still remains unclear how OEMs should manage hardware FoD that require upfront payments, and what a pricing structure should look like.

### 3.2.2.3 *Research Gap and Contribution to FoD*

A FoD research gap emerges, as most publications focus on customer perceptions and include a strong marketing background (Wiegand and Imschloss, 2021; Garbas *et al.*, 2022; Schaefer, Leban and Vogt, 2022). Published articles that consider the perspective of OEMs and analyze implementation challenges are rare, as limited applied data was available prior to our study (Garbas *et al.*, 2022). Most financial visions and management insights result from consulting agencies whose recommendations are not based on concrete knowledge of OEMs. As a result, practical deliverables are often neglected. Nevertheless, insights in favor of OEMs are required to clarify how FoD must be implemented and what burdens may arise in the overall process.

Our second contribution is focused on FoD, as we provide insights on how OEMs must face challenges when implementing such a BMI. We address the under-researched managerial facet by providing perceptions from an OEM. We take this approach because little is known about the challenges involved in implementing FoD in technical environments. By listing several challenges, OEMs that want to offer FoD can achieve more targeted success with our recommendations. However, these can also be transferred to a more universal context. All things considered, we contribute to the literature by answering our second research question:

*“How should the FoD BMI be implemented by an OEM to achieve a financial success?”*

## **3.3 Research Method**

Our case study states new perceptions into the challenges of implementing BMIs. We applied a qualitative approach, as empirical insights are rare. We investigated a phenomenon in a real-life scenario to provide external validity (Yin, 2018). For this matter, a case study can be used to increase comprehensions, broaden the scope of observations, and generate a deeper understanding of recurring themes (Cousin, 2005). With the emphasis on current occurrences and lack of control over behavioral characteristics, a case study is suitable for answering how and why questions in an organizational context (Yin, 2018). Because case studies combine evidence from various sources, such as observations, interview transcripts, archival papers, and artifacts, the concept is employed to investigate practical applications of theoretical methods (Scapens, 1990). Compared to methods based on quantitative data, case studies are more detailed, which is helpful for our purposes, as we examine how OEMs implement BMIs.

We generated our findings through the long-term interventional research technique. The latter ensures a meticulous comprehension of intricate systems and problems (Jönsson and Lukka, 2006). This uniqueness can be understood as the potential to build close relations with partner organizations by granting access to specific data (Lukka and Wouters, 2022). Our applied approach was fully consistent with this definition. Accordingly, we differ from previous case studies, which, although they deal with BMI aspects, focus on several smaller case companies or a shorter period (Schneckenberg *et al.*, 2017; Aaltola, 2018; Broekhuizen, Bakker and Postma, 2018; Geissdoerfer *et al.*, 2023). Meanwhile, our study is characterized by the fact that we observed a longer time horizon and a significantly larger corporate structure.

### **3.3.1 The Cooperating Company**

The three-year case study, conducted from January 2022 until December 2024, took place at an international premium vehicle manufacturer, which we refer to as *Automotive Enterprises*. The company (also referred to as firm in the following) characterizes a high-end OEM with a long history of creating, producing, and marketing a wide range of different vehicles. The company operates independently inside a global multi-brand OEM group and aims to offer its customers innovative products worldwide. Accordingly, *Automotive Enterprises* is confronted with various technological changes, new competitors, and increasing pressure to reduce product costs across their entire vehicle range.

Many criteria must be fulfilled to choose a suitable research environment. This is since our study is not based solely on data, but also on collaborating with corporate staff to build trust and a knowledge of procedures. *Automotive Enterprises* was selected because the firm placed particular emphasis on the technical performance of its innovations to maintain its quality position and brand promise. One of the company's goals was to connect the industry with digitalization to take a step towards modern mobility. Significant expectations were also placed on BMIs to gain market advantages. We hence decided on a cooperation to be able to generate far-reaching industry insights. However, we point out that *Automotive Enterprises* is not the only company that makes use of BMIs. Cross-industry imitations and adaptations of ideas are highly evident in the field of innovative management (Enkel and Gassmann, 2010).

The company, which also classifies FoD as BMI, introduced the idea in the summer of 2019. After a trial month, bookings can be made easily via an online application. Once the engagement of a feature is done, the activation follows subsequently to a vehicle restart. A workshop visit is not necessary, turning the offer into a comfortable option to improve vehicle functionality. FoD from dissimilar categories, like infotainment (e.g., smartphone-interface), lighting technology (e.g., LED package), driver assistance system (e.g., parking assistant), or air conditioning (e.g., two-zone comfort automatic climate control) are available to customers. In addition, flexible booking periods are offered. By these means, customers can select between a short-term (1 or 6 months), medium-term (1 or 3 years), or a lifetime booking of certain FoD.

**3.3.2 Data Gathering**

As a so-called “junior researcher,” the author participated in cost-control projects to gain an in-depth knowledge in the field of FoD. Next to the revenue estimation, the author assisted project teams in applying data analysis. This also granted the access to the OEM’s technical databases. In the same manner, the junior researcher participated in the project team that implemented FoD in the accounting department. By doing so, he supported the improvement of the financial calculation logic as an innovative standard for estimating FoD projects and was tasked with maintaining it. This led to a deepened understanding into the successful financial application of FoD. The process was enhanced by a broad knowledge of the BMI thanks to the access to internal discussions, meetings, and other confidential documents. Ultimately, this workflow enabled us to gain several findings to answer our earlier stated research questions.

Further organizational prerequisites were necessary. While the junior researcher spent most of the time on site of the company to collect insights, a “senior researcher” accompanied him. Regular visits from the senior researcher, who was offsite and guided the study process, were made to the company at least twice a year. In addition, the junior researcher kept a separate research diary to review the research process, which gradually became more specific. By doing so, the author granted that all relevant observations were recorded in the everyday work. Moreover, it was ensured that documents relating to the FoD procedure were collected. This proceeding led to a thorough grasp of the FoD strategy, enabling us to offer this study.

*Table 7. Data and knowledge sources for the qualitative case study*

<b>Source</b>	<b>Description</b>
Research diary	>50 pages of note-keeping after discussions, observations, and similar.
E-mails	Numerous e-mails, obtaining several insights during the case study.
Documents	>30 PDFs/PPTXs/Excels, which covered the FoD implementation logic.
FoD expert interviews	Ten discussion-style interviews with cross-departmental employees, who participated in the (financial) implementation of FoD.
FoD calculation scheme	Our long-term involvement in the creation/management of the revised FoD calculation scheme provided us with further financial BMI insights.

Summarized, we conducted a detailed data recording, including many documents such as presentations, protocols, and e-mails, as stated in Table 7. The notes in the research diary served as the basis for knowledge and observations in the empirical data analysis. In addition, the expert interviews resulted in further insights that supported us in the research evaluation. More financial knowledge was gained from the introduction of the renewed FoD calculation scheme (CS). Overall, these data and knowledge sources served as the foundation for the

empirical portion of our study and were the premise for answering our research questions. We point out that we conceal sensitive information throughout our work, as the foundation of this research study is proprietary industrial data that was collected at the case company. In the following, we will go into more detail about the FoD expert interviews and the FoD CS.

3.3.2.1 FoD Expert Interviews

We conducted semi-structured interviews with experts involved in the FoD implementation process. The interviews lacked a rigid framework and exhibited a conversational tone on FoD and the interviewees views on financial challenges during the BMI implementation process. While Microsoft Teams and PowerPoint were used, no sound and video recordings were present. Every conversation lasted one hour and was only documented with a blank paper and a pen. Subsequently, notes were taken to record any ideas that surfaced after each discussion.

The ten participating employees listed in Table 8 largely corresponded to the stated company but also came from two firms belonging to the multi-brand OEM group. We refer to these companies as *Auto X* and *Auto Y*. All interviewed expert partners (EPs) had at least one year of experience in their departments and obtained in-depth knowledge about FoD and the potential challenges involved in the implementation process. Most EPs also worked on the employment of further BMIs, which contained different financial challenges. The interviewees were therefore familiar of the significant need to implement FoD from a financial perspective.

Table 8. Experts participating in the interviews

Expert Partners	Company	Department	Function
EP1	<i>Automotive Enterprises</i>	Finance	Manager
EP2	<i>Automotive Enterprises</i>	Finance	Team leader
EP3	<i>Automotive Enterprises</i>	Finance	FoD expert
EP4	<i>Automotive Enterprises</i>	Finance	FoD expert
EP5	<i>Automotive Enterprises</i>	Sales	FoD expert
EP6	<i>Automotive Enterprises</i>	Sales	FoD expert
EP7	<i>Automotive Enterprises</i>	Sales	FoD expert
EP8	<i>Automotive Enterprises</i>	Series	Project manager
EP9	<i>Auto X</i>	Finance	Team leader
EP10	<i>Auto Y</i>	Finance	Team leader

Our guideline-based interviews followed a semi-standardized process. When applying expert interviews, a decision must be made between two options (Helfferich, 2014). The sequence of questions can follow a fixed, standardized pattern or be open-ended and consist of a few predetermined questions. Applying an empirical research study, a semi-standardized method is commonly used, as interviews that lie between the two extremes described are more flexible (Flick, Kardorff and Steinke, 2022). This variant was also selected for our study. The advantages of such procedure arise from a dense data collection and rapid access to the observed research area, which is achieved by shortening extensive survey processes with manageable effort (Bogner, Littig and Menz, 2009). Therefore, a pragmatic structure served as our interview guideline. A detailed PowerPoint version of this can be found in the Appendix.

3.3.2.2 FoD Calculation Scheme

At the start of 2022, *Automotive Enterprises* revised the CS for the FoD revenue estimation. This incident occurred due to a series of insights into how the profitability of FoD could be better assessed. Ultimately, this revision offered us a promising research opportunity, as management and financial expertise about FoD and BMIs remains rare. The edited CS followed the original calculation method that had been applied since the introduction of FoD in the company. However, the previous method obtained various weaknesses, such as inadequate traceability due to increased complexity. Moreover, a separate worksheet had to be used if a vehicle contained multiple FoD, which led to severe analysis issues. It was also difficult to compare financial figures between planning rounds, as the actual values were often not clearly traceable. In the new CS, each vehicle that offered FoD contained only one worksheet, while the final profit potential was easily calculable using Microsoft Excel. As a result, the workload regarding volatility and complexity decreased, while the total clarity increased. Since the firm was no longer applying the old CS, we took most of our insights from the new CS. Nevertheless, this respective revision obtains a similar basic structure to the previous approach in use.

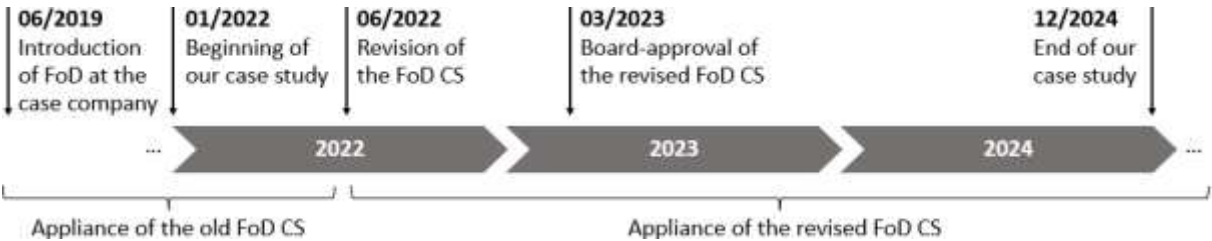


Figure 19. The FoD CS at Automotive Enterprises

Conclusively, we participated in all measures related to the FoD CS and continuously supported the company’s employees, as illustrated in Figure 19. While actively attending the introduction of the new FoD CS, we identified several challenges for the implementation of a financial BMI, in this case FoD. However, our applied approach also enabled us to generate insights on how to effectively counteract these incidents. Accordingly, we would like to point out that various understandings were gained from participating in the revision of the CS. To address our research questions, we build on these observations and on our participating role.

**3.3.3 Data Analysis**

Ultimately, the data insights were analyzed. An iterative procedure was applied, as e-mails, the research diary, and other data sources were repeatedly examined. By doing so, we aimed to identify recurring patterns in the difficulties that arose during the BMI implementation. Moreover, a detailed examination and comparison of the information gathered during the interviews was part of this evaluation. Because no interview transcripts were present, but the responses of each partner followed a uniform framework, the format used has proven to be effective. Every case was analyzed separately. E-mail correspondence was solely applied to clarify follow-up interview questions. After employing inductive reasoning, categories were discovered from the knowledge acquired during the interviews. Whenever several experts considered aspects to be a challenge in the BMI implementation process, the characteristics were taken up. This led to the creation of a framework that systematized the most important financial challenges. Finally, a repetitive proceeding of analyzing the literature, contrasting the results with theory, talking to other researchers about the results, and drawing further conclusions from actual practice ensued the process. Conclusively, all BMI implementation challenges listed in the next section were hence derived from the insights of our data sources.

**3.4 Results and Discussion**

The structure of our results and discussion section is as shown in Figure 20. In 3.4.1–3.4.3, we highlight the three key financial BMI implementation challenges and derive insights from FoD. Our findings do not only cover the implementation phase but also the corresponding decision-making and sustainability phase. Likewise, the order in which we list our results has nothing to do with their importance. The illustrations presented may also differ slightly from the original representations, thereby ensuring the neutrality of the OEM. Similarly, quotes from the experts have been shortened in some cases, while the core messages remain unchanged. In 3.4.4-3.4.9, we mention more general challenges regarding the BMI implementation, which were also addressed by EPs but played a subordinate role within our evaluations. Encounters in this matter have less financial relevance, but for the sake of completeness, we still want to examine these issues. Finally, we summarize the findings in section 3.4.10 and discuss them.

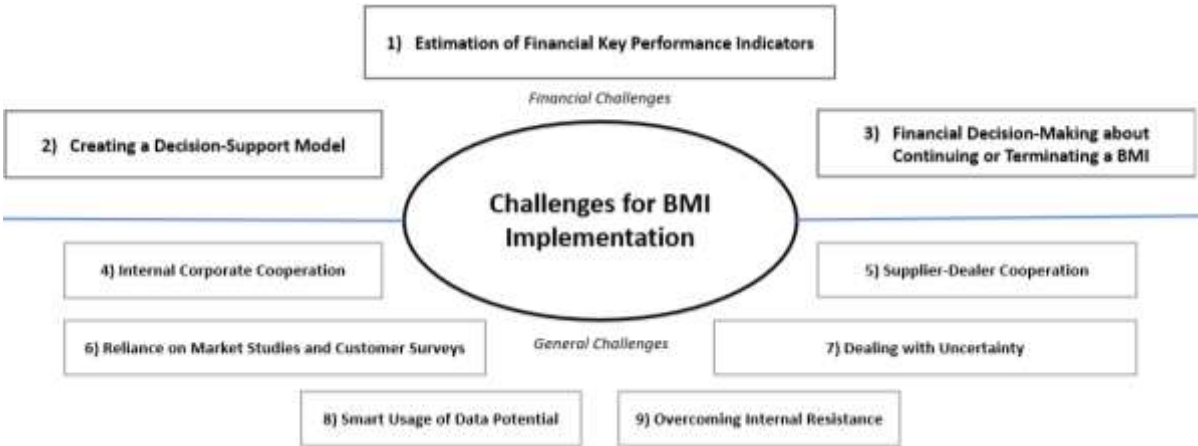


Figure 20. Challenges for BMI implementation

### 3.4.1 Estimation of Financial Key Performance Indicators

The first financial challenge can be stated as “the estimation of mathematical and financial key performance indicators (KPIs) that serve as input variables for the subsequent calculation and determination of the profitability of a BMI”. The detailed forecast of various future financial parameters for the valuation of BMIs repeatedly posed a challenge for the company’s management and various employees involved. In this environment, the OEM faced several significant and interrelated difficulties, which we will discuss in more detail in the following.

Firstly, different financial KPIs varied regarding the complexity of their estimation. A colleague who collaborated with us on obtaining the FoD data confirmed: “Expenses or cost variables can be easily predicted based on internal company data. However, this is not the case for KPIs that are dependent on the market acceptance or the appealing customer base. An estimate is problematic if there are no insights from other companies or the literature and the OEM is only able to rely on customer surveys or market studies” (EP7). Conversely, these data sources were of little help to BMIs, as in most cases, limited insights were available. Moreover, not all cost estimates were easy to predict. “While development and material costs for Functions on Demand are clearly foreseeable, this is not the case for other cost factors such as personnel. Therefore, multi-year innovation cycles do not only increase complexity costs in a scenario, but also make it more challenging to predict revenues. Hence, several business model innovations, like Functions on Demand, involve an enormous amount of time” (EP5). Another colleague concluded that “market assessment and development are more difficult to forecast for business model innovations than for [regular products], as innovations represent an uncertain undertaking” (EP10). In the FoD project round, the focus from spring 2023 onwards was thus on relying on internal findings in cases of unstable parameter ratings. This proved to be the most appropriate approach for addressing the emerging uncertainties.

Secondly, the number of estimated KPIs posed a key challenge. In April 2022, a financial expert who engaged in updating the CS criticized the following to the management: “Due to a lack of experience and comparability, it is difficult to assess the number of possible success values, as business model innovations are not usually subject to a comprehensive competition. In general, fewer but easily trackable KPIs should be estimated with a high degree of accuracy” (EP3). Another colleague stated that “value appraisals require a clear responsibility structure and must be reviewed across departments. The questioning of the outcome is important, as business innovations are accompanied by limited empirical values” (EP1). After June 2022, the OEM therefore based the new CS on fewer assumptions, as knowledge was limited and the firm focused on positive BMI revenues. Citing EPs, the biggest challenge remained the revenue estimation due to poor empirical values and a lack of knowledge. It was important for the firm not to get lost in detail and to only estimate necessary KPIs. Even though having multiple KPIs was thought to provide greater certainty, this was often misleading. Estimations such as “what percentage of customers will continue to book a feature after a year?” were hence neglected.

Finally, the indicators had to be estimated rather conservatively. The financial FoD team lead stated: “Because Functions on Demand are intended for the secondary market after the initial [...] vehicle sales, which means that the actual turnover is in the future, a general profit estimate is more difficult to obtain. However, the assessment across departments involved is often too positive nowadays, even if it is influenced by uncertainty” (EP2). Still, if a BMI was successfully established on the market, the OEM gained more experience over time, which made value prediction an easier task. In addition, responsibility for the financial figures could then be assigned more clearly. As BMIs progressed, value assessments and responsibility structures became clearer due to the determination of empirical values. They also improved with more experience, e.g., when a car went through an entire market cycle, as stated by EPs.

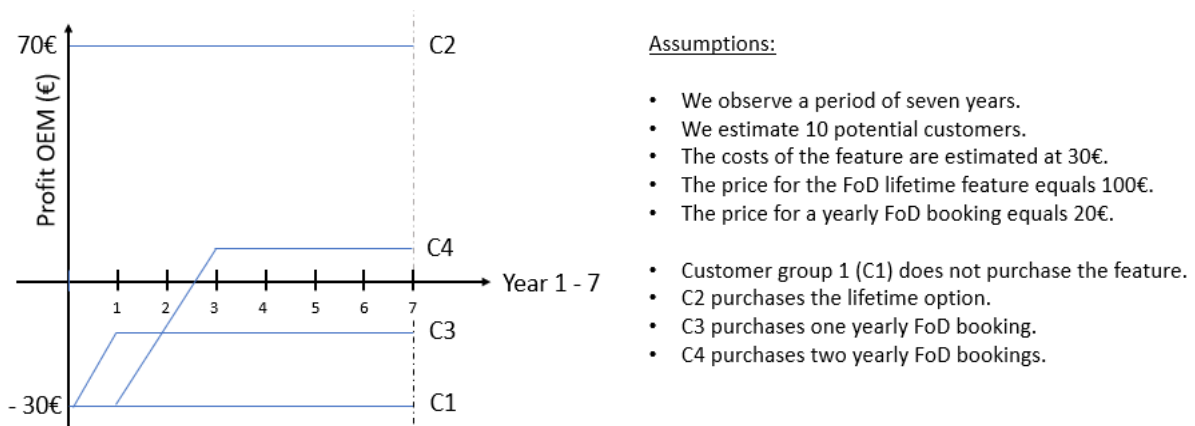


Figure 21. Estimation of potential FoD profit scenarios

Figure 21 illustrates the challenge of KPI estimation, using FoD as an example, which was presented in a similar form by EP2 in May 2022. Supposing that 30% of customers each belong to groups C1 and C2, and 20% to C3 and C4, the total revenue equals 120€. “The stated example, which does not consider all influencing parameters such as warranty costs, clarifies that estimations must be simplified. A plain procedure should be used so that only indicative recommendations are made, and the firm does not get bogged down in the details. It is clearly demonstrated why an outcome is difficult to assess without any empirical insights, as is often the case with innovations” (EP10). Finally, several BMI overestimations were counteracted by using simplified assumptions with fewer variables that were not characterized by euphoria.

The literature contains various research approaches for estimating financial indicators. In general, value estimation decisions are an important manager task, as each project phase requires valuations to make investment decisions (Thore Olsson, Johannesson and Schweizer, 2018). Hence, many authors focus on new product development (NPD) cost estimations (e.g., Marques, Gourc and Lauras, 2011; Wouters *et al.*, 2016). For example, Thore Olsson *et al.* (2018) contemplate decision-making for NPD and product architectures (PAs). The authors suggest that many factors influence long-term decisions in the event of cost deviations. These are not limited to the trade-offs between time and cost but consider management analysis.

Facing BMIs, limited knowledge about value estimation is available. Because BMIs can change the revenue generation, it becomes evident that a plain value estimation is required (Chesbrough, 2010). We agree with Gorissen et al. (2016), who emphasize the time aspect as a crucial success component. Rashed et al. (2022) also confirm that a clear responsibility for cost estimates is essential. Nevertheless, especially for BMIs that are confronted with a new revenue model, assessing the profit potential alongside cost structures is challenging (Claus, 2017). In this regard, market segmentation presents an initial solution (Dmitriev *et al.*, 2014). Moreover, the literature confirms our mentioned aspect of financial uncertainty in BMIs due to high investment costs (Schneckenberg *et al.*, 2017). This also includes recurring insecurity regarding customer acceptance, which hardens the value estimation process (Trimi and Berbegal-Mirabent, 2012; Planing, 2015; Heidenreich, Freisinger and Landau, 2022). As a direct countermeasure, Gebauer and Saul (2014) cite activity-based cost estimates for BMIs.

In summary, even though researchers consider parameter estimation to be a challenge regarding BMIs, no results offer practical solutions. This is why our recommendations can be perceived as more unambiguous. Starting, an OEM should exclusively rely on internal findings and insights for insecure parameter estimates to counteract various potential uncertainties. Likewise, fewer market parameters should be estimated as part of a verifiable process, as competitive values are often not available for BMIs. Lastly, an OEM should carefully examine its financial results and pursue a conservative trend rather than an open investment plan. However, an in-depth knowledge of BMIs and experience are likely to lead to better forecasts.

### **3.4.2 Creating a Decision-Support Model**

The second financial BMI implementation challenge was “the creation of a decision-support model that incorporates the financial inputs and summarizes them in an assessment of the overall business impact”. *Automotive Enterprises* also referred to this type of internal decision-support model as a financial business case (BC) or CS. Citing the FoD project manager, “a decision-support model must be successfully implemented in a commercial context to analyze the profitability and to review investments. For the company, a concept that serves as a basis for judgment plays a leading [...] role, as internal decision-making requires support in various instances” (EP8). The strategic goal of a CS was to present and weigh up the projected financial and strategic effects of a project and its outlays. The generated data sources corresponded with the statements by the EPs and revealed that a tool for weighing up decisions regarding influencing factors portrayed a fundamental BMI challenge. We point out that the difficulty of KPI estimation obtains a direct influence, as a financial CS requires input estimates to deliver specific recommendations. Hereinafter, we observed three related components in this regard.

At first, it was necessary to create a clear structure of the CS. In a conversation about the design of the CS, we were told the following: “Because the entrepreneurial experience of business model innovations often remains limited, a calculation should first be conducted roughly to estimate the potential. An assessment that clarifies whether an investment in a

[BMI] is positive or negative is already [...] sufficient. Further assumptions can be included over time to improve the accuracy, as more data insights will likely be available” (EP4). Various EPs confirmed the statement that the CS should first follow an easy pattern to ensure its feasibility. A second colleague added that “[*Automotive Enterprises*] applies a decision-support model for the profit assessment. More precisely, the firm decides whether it is financially worthwhile to preinstall features using Functions on Demand to recoup the costs over a car’s lifetime, or whether it would make more sense to offer features exclusively in the configurator” (EP3). Hence, the economic efficiency of FoD was initially examined using such a decision-support model. Subsequently, decisions on the FoD implementation, as well as special equipment, and other vehicle-related issues were made in management committees. Similar insights were provided by other observations, like BMI feasibility studies, which were recorded in our diary.

Secondly, a resulting confrontation was that the CS should not exceed complexity. At the beginning of a project, a prototype had to represent reality in an understandable way. Despite BMIs should first be calculated roughly, this was not the case with FoD. A team lead reported that “in [...] the first environment of Functions on Demand, the calculation scheme was complex, although those responsible, like [departments managers], contained little experience. The mathematical logic faced an overly complicated format because too many uncertain inputs were used without any knowledge of external influences. Thus, [*Automotive Enterprises*] likely pounced on too many KPIs that were hard to control. Nowadays, the firm considers fewer assumptions, resulting in a more realistic estimation” (EP2). In addition, the management admitted that “[*Automotive Enterprises*] tended to complicate calculations, as the company made a variety of suppositions. However, these often conveyed a false sense of security, as they led the implementer to assume that all scenarios had been considered. As a result, estimates often differed from the actual outcome, as the targeted revenue structure for innovations was difficult to predict. With clearer empirical values and calculations, these issues decreased” (EP1). Conclusively, an explicit CS was essential, especially for scenarios with limited firm knowledge, which was confirmed by EPs and the revision of the FoD CS. After such a redesign, the management agreed that fewer KPIs should be used at the start of the BMI implementation, as this proceeding would be less prone to error, and it would be unrealistic to cover all eventualities anyway. As a result, the FoD CS evolved from a multi-stage approach to a rule-of-three calculation, as this simplified method was able to provide better estimations.

The final critical aspect for the CS was a continuous questioning of the financial output by the departments involved. During the revision of the CS, we received the following e-mail by an innovation manager: “Since [the OEM] obtains little experience, one must interrogate highly positive results, as the theoretical execution differs significantly from the final real-world implementation. This phenomenon is exacerbated by the reality that various business model innovations are confronted with limited access to data, such as studies about customer acceptance, as well as a lack of overall knowledge” (EP9). Due to the fact that the OEM had limited expertise in the field of BMIs, from that point on, it was necessary to involve all

affected departments in the development of the CS. Likewise, it was essential to question all CS input factors, as some variables merely suggested a greater accuracy, which sometimes led to wrong decisions. This procedure, which was finally decided upon at an executive board meeting at the end of 2022, enabled the company to create a more realistic FoD CS in the end.

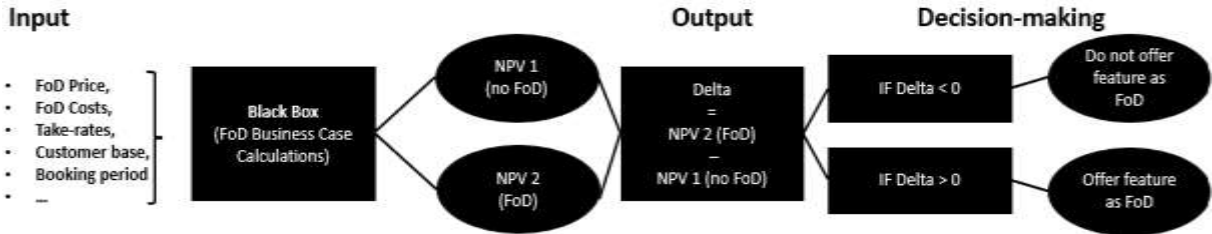


Figure 22. An illustrative overview of a decision-support model for FoD

Figure 22, which was presented in a similar format after the CS was revised, shows how such can be structured. This includes input values, an output, and a final decision-making. The most vital component is the scheming itself, which leads to a recommendation for action. The estimation of KPIs as input variables and the decision-making show direct elements of the CS. In Chapter 4, we provide a more detailed FoD decision-support model. We assess whether investments are advisable or if features should only be offered in the configurator. We present decisions regarding the PA by providing input parameters, the CS, an example, and extensions.

Today’s knowledge about BCs is widespread. The benefits of BCs are the identification of impacts that can influence and impair a company’s profitability (Grøndalen, Lähteenoja and Grønsund, 2010). Nevertheless, researchers often do not deal with models per se, but analyze current approaches based on various case studies and industries. Accordingly, available use cases range from sustainability studies (e.g., Schaltegger, Freund and Hansen, 2012), over cloud computing (e.g., Bieber, Grivas and Giovanoli, 2015), to the car industry (Irfan Ul Haque et al., 2021), and general literature analyses (e.g., Maes, Van Grembergen and De Haes, 2014).

The issue regarding the necessity of BCs for BMIs is supported by researchers. While Schaltegger et al. (2012) mention that concepts are required to facilitate a sustainable BMI development, Lüdeke-Freund et al. (2019) discuss BCs as drivers of sustainable BMIs. It is also proven that BC-like tools like the BM canvas (e.g., França et al., 2017) or road mapping (e.g., Schaller, Vatananan-Thesenvitz and Stefania, 2018) reduce the BMI implementation issue. Since the development of a BC for different undertakings is difficult to implement (Tesch and Brillinger, 2017), the available approaches remain a BMI barrier (França et al., 2017; Goldmann and Huulgaard, 2020). As a result, OEMs must overcome their old logics and think “out-of-the-box” (Geissdoerfer et al., 2023), as internal expertise is required (Frankenberger et al., 2013).

In summary, given the limited research attention this topic has received, our findings provide new insights. An initial decision-support model should have a simple and transparent structure, include fewer KPIs, involve all relevant departments, and allow for the continuous questioning of the results. As expertise in the field grows, a more detailed concept can follow.

### 3.4.3 Financial Decision-Making about Continuing or Terminating a BMI

The third challenge was “the targeted decision-making based on data insights and calculations whether a BMI should be initiated, continued or terminated”. Despite uncertainties regarding financial circumstances, the OEM pushed the decision to implement various BMIs. In the initial FoD presentation in 2018, the BMI was referred to as a “Billion Dollar Project”, while first sales revenues in 2020 were rather in the millions. An examination of documents revealed that the firm deliberately overestimated the potential of BMIs. An accounting employee reported that “the expected potential of business model innovations is deliberately set higher than realistic, as this is the easiest way to persuade management to accept innovations” (EP3). Several EPs supported this assertion. As a result, many BMIs were significantly overestimated, as internal decisions were made based on euphoric expectations, since it was in the OEM's interest for BMIs to be successful. Below, we describe the main components that made up this challenge.

To begin with, after the initiation of a BMI, it was challenging to decide if such would be profitable overall and should be continued. At a meeting in the summer of 2022, when the question arose whether the FoD BMI should be pursued despite the limited financial turnover, a financial expert emphasized: “Although excessive optimism often distorts reality and skews the potential monetary outcome of a business model innovation, due to a lack of experience, we have no choice but to proceed in this manner. With more insights and a clearer decision-making logic, we will be able to assess better whether an innovation should be pursued” (EP4). This realization led to the FoD CS being revised in 2022. A FoD project manager also confirmed that the decision-support model was changed because “[*Automotive Enterprises*] did not set any requirements for business model innovations in terms of what they should achieve. This occurred since the advantages were difficult to assess and were not based on empirical values, as it is the case with [...] traditional business models” (EP8). Similar observations were made during further approval phases of the BMI and in internal discussion rounds with some EPs. Consequently, the revision of the CS for a better assessment of the success of FoD attempted to counteract this uncertainty and made future investment decisions more comprehensible.

Secondly, BMI investments were rarely scaled back. Prior to the renewal of the FoD CS, EPs mentioned the “preservation of the brand image” as a reason that would have been damaged by leaving a BMI. Henceforth, *Automotive Enterprises* neglected to focus on the total firm successes and to stop a BMI if it was not profitable. At the end of 2022, several financial key metrics for FoD were presented, showing that the BMI was falling short of its expectations. As a result, the FoD team lead stated that “a continuation of FoD is not in our economic interest” (EP2). Nevertheless, there were several instances of management circumventing the recommended course of action proposed by experts involved, who made statements based on better knowledge. In April 2022, the OEM admitted that such a behavior appeared due to “a false entrepreneurial pride and brand presence” (EP1), and that “a series of overvaluations occurred to convey an innovative image of the firm” (EP10). Moreover, it was expected that

“the withdrawal from innovations can lead to a media shitstorm” (EP9). The misconduct was admitted when management confessed the following: “We allowed ourselves to be guided by unclear customer surveys or the findings of consulting partners” (EP1). It was determined that “these sources provide little knowledge about business innovations. Therefore, it is necessary to examine all information, like calculation schemes or customer surveys, whenever no further corporate experience is present. Those responsible must also be given more trust.” (EP2).

Finally, the premature termination of a BMI was critical. When asked why FoD were not stopped despite the poor situation, we received the following e-mail: “The termination of a business model innovation must be carefully considered, as previous investments by [an OEM] would be lost. Similarly, experience shows that the success of an innovation sometimes occurs rather suddenly. The decision to continue the [FoD BMI] after all was not based solely on financial metrics. It was also assumed that the technology used would be regarded as the standard in the future, which is currently proving to be correct” (EP4). As a result, in addition to financial aspects, strategic factors were examined, as further offers could also be sold profitably via the FoD channel. A sales expert justified the concession to FoD as follows: “For Functions on Demand, it was important to look beyond financial indicators, as negative media reports had already led to a decline of the initial success. It is crucial to evaluate a business model innovation based on (non-)financial parameters and make a valid future forecast to determine the success potential” (EP6). Henceforth, after the summer of 2023, *Automotive Enterprises* would only continue a BMI if a specified target range had been achieved. A BMI also required a so-called “business owner” with a deepened knowledge and an available budget. In this way, decisions would no longer be made exclusively at the management level.

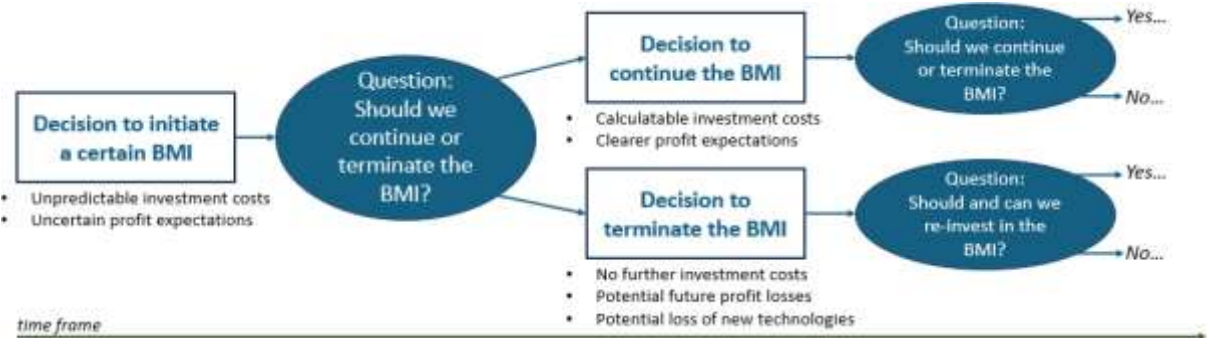


Figure 23. Financial decision-making scheme for BMIs

Figure 23 illustrates the decision-making for BMIs, which was presented at a FoD board meeting. With increasing time and experience, more informed decisions can be made, as costs and profits are easier to predict. It is nevertheless important to consider that terminating BMIs may result in future technologies not being offered because the necessary PA is not available.

Because decision-making plays a major facet in the introduction of BMIs (Thore Olsson, Johannesson and Schweizer, 2018; Wirtz and Daiser, 2018), many results exist. Stampfl (2016) assigns the decision-making during innovations to system-related barriers. Schneckenberg et al. (2017) ask “which coping mechanism supports decision-making during the development of

new BMs?”. Strategies for customer focus, value creation, skills development, ecosystem growth, and adaptive pricing are shown, which OEMs use to deal with BMI uncertainties. Next to the aspects we have identified, such as the difficulty of exiting BMI investments, we share their assessment. Andersen et al. (2022), Andreini et al. (2022), and Wirtz and Daiser (2018) support the findings. We also agree with Martínez-Velasco and Terán-Bustamante (2022), who claim that decision-makers must adapt to market trends to stay competitive. Similarly, we concur with Brenk et al. (2019) that BMIs need a new decision-making logic, which is caused by an innovative form of value creation. However, as most strategic choices are marked by uncertainty (Büyükoçkan and Feyzioğlu, 2004; Berglund and Sandström, 2013; Schneckenberg *et al.*, 2017), OEMs still need to overcome internal resistance and introduce BMIs sequentially (Frankenberger *et al.*, 2013), as they obtain a lagged performance effect (Menter *et al.*, 2023).

Summarized, because no researchers address the question under what circumstances a BMI investment should be continued or terminated, our findings deliver new insights. We can successfully conclude that a BMI decision-making process must be analyzed for potential success with clear premises and a defined target corridor. An exit scenario must be available, an OEM should not be guided by external opinions, and if so, these should be questioned continuously. Ultimately, a so-called “business owner” should be incorporated so that not all responsibilities remain at the management level with a misleading entrepreneurial pride.

#### **3.4.4 Internal Corporate Cooperation**

The first non-financial challenge for a BMI implementation was “the securing of a clear internal cooperation between the departments”. The decision-support model or CS (*second challenge*) displayed a task of the finance department, which was based on several estimated values (*first challenge*) determined by the sales department. Next, the decision-making (*third challenge*) took place across various departments. Nevertheless, “facing business model innovations, cross-departmental collaboration is not always evident. Likewise, the latter is often not easy to achieve due to the separation of powers and different divisional goals” (EP7). This aspect was criticized by a marketing colleague during the revision of the FoD CS. A financial employee added: “To ensure a smooth cooperation, a structure of responsibility between the divisions is necessary. To avoid ambiguities, a uniform database is required that can be easily accessed by various parties involved” (EP4). However, internal processes for a precise cooperation were often lacking. It was not until early 2023 that an agile committee was established to enable all departments to stay up to date on current issues and to respond faster to market trends. A continuous, cross-departmental weekly exchange of information developed, enabling the employees to gain a uniform understanding of the FoD BMI and its objectives. This proceeding proved to be a significant step, as the FoD project manager agreed that “to successfully realize business model innovations, all departments involved need a collective understanding. To achieve this, we must eliminate knowledge opacity and must not get lost in the details” (EP8).

In a research context, collaboration and team building can be observed as key activities of BMIs (Wirtz and Daiser, 2018). Generating a profound level of expertise, a solid leadership vision, and a corporate culture is of fundamental importance (Chesbrough, 2010; Björkdahl and Holmén, 2013; Frankenberger *et al.*, 2013; Rub, Bahemia and Schleyer, 2017). Likewise, the challenge is also mentioned by Fruhwirth *et al.* (2018), who agree that a close cooperation between departments remains a crucial prerequisite for a successful BMI introduction. Poorly defined BMIs can lead to misalignment in firms if there are no performance indicators or clear objectives. For more general insights into strategic management regarding vision definition and success methods, we refer to Tavasolli and Karlsson (2015) and Lima *et al.* (2008).

### **3.4.5 Supplier-Dealer Cooperation**

A further challenge was “the traceable financial cooperation with intermediaries to maximize internal profits”. We gained our insights through EPs and departmental meetings. Facing FoD, the OEM generated and kept all of its profits in this area, even though dealers sold the main product. Since dealers were excluded from the profits, it was not in their interest to promote FoD, although they faced an increased customer contact. As a possible solution, the firm could have distributed profit shares to dealers, which most likely would have brought BMIs closer to customers and led to increased sales figures. However, the OEM opposed such cooperative procedure. On a request, we received the following e-mail: “Since business model innovations enhance the customer experience alongside our core products, and we manage all marketing activities, we have decided to exclude [...] retailers from all involved revenue processes” (EP1).

Little research attention has been paid to BMIs and the cooperation between suppliers and dealers. For example, Skinner *et al.* (1992) apply different modeling techniques to analyze the cooperation in a supplier-dealer system without specifically addressing BMIs. For further insights into how supplier-dealer relations are treated in the car industry, we refer to Brandes *et al.* (2013) and Van Riel *et al.* (2011). We also refer to section 2.4.3.3 and 2.4.4.1 in Chapter 2. In these scopes, we present the FoD supplier-dealer profit sharing model by Wucher *et al.* (2019) and clarify that the creation of business synergies have a significant impact on OEMs.

### **3.4.6 Reliance on Market Studies and Customer Surveys**

“The blind reliance on market studies or customer surveys with little informational value” was a challenge for the introduction of BMIs. Although this confrontation is related to the earlier-mentioned difficulty of estimating financial KPIs, we now deliver more insights. A FoD project manager explained the following in the summer of 2022: “Market studies serve exclusively as a partial basis for predicting the future success or customer acceptance of BMIs at [*Automotive Enterprises*], as there is a lack of experience with innovative concepts” (EP8). Despite this clear position, the reality within the firm was quite different. Considerable funds were continuously spent on market studies and consulting reports that were of little relevance to BMIs. However, data analyses and EPs proved that the market situation often deviates from external forecasts. This was likely because consulting agencies also had limited knowledge of BMI expectations.

The literature regarding the dependence of BMIs on market studies is limited. Weking (2021) asserts that market studies are the preferred method for integrating BMIs. On the other hand, according to Sainio et al. (2012), there is no denying that BMIs are causing a considerable degree of market uncertainty. This means that the probability of default is higher compared to traditional BMs. Accordingly, our findings raise the question of whether and why customer surveys and market studies are less meaningful for BMIs in contrast for more established BMs. We assume that this is due to lower awareness and limited opportunities to come into contact with new BMIs. Because there is currently no evidence available to support the findings of Weking (2021) or our own, we are awaiting further information on this matter.

### **3.4.7 Dealing with Uncertainty**

“The well-founded and structured handling of internal uncertainty regarding the firm and the employees involved” represented the next challenge. The success of BMIs was more difficult to achieve if no consistency in the processing of the structures was present, as this often led to uncertainties. We have been told that “at [*Automotive Enterprises*], all employees working on implementing business model innovations should engage with the respective topic over an extended period of time” (EP9). This proceeding, which was also discernible in various internal documents, was prioritized in most instances. Citing EPs, the main reason for this was that a constant staff turnover in the past had led to a certain loss of knowledge. To counteract such, road mapping in combination with BMIs was introduced in early 2023 to avoid uncertainties.

A series of research publications confirm our finding that road mapping represents a promising line of attack in order to reduce BMI process uncertainty across industries. Agreeing with Schaller et al. (2018), OEMs in the BMI environment apply road mapping to create innovative business plans that can cope with disruptive changes. Further authors that discuss road mapping for the introduction of BMIs to counteract uncertainty aspects are Minatogawa et al. (2022) and Georgieva (2022). However, in direct combination with FoD, road mapping has not yet been mentioned as a direct countermeasure to internal process uncertainty.

### **3.4.8 Smart Usage of Data Potential**

A subsequent challenge was “the intelligent use of data potential when applying BMIs in the operational environment to achieve the highest possible turnover”. With the introduction of FoD, all relevant qualitative and quantitative data aspects from the corporate environment were analyzed. This proceeding enabled the creation of the first CS. Further data analysis led to improvements in the latter in 2022. According to the financial FoD team lead, “a structured data usage enables us to exploit the best possible potential for business model innovations. This is since internal data analyses are more meaningful than comparable recommendations for action from external partners who do not have access to a [...] database” (EP2). As a result, with increasing age of a BMI, the significance of the generated data increased considerably.

Research findings confirm that data is of immense importance to OEMs that want to create and maintain a competitive advantage with BMIs. Since value creation depends on data as a crucial resource, companies must redesign innovative BMs, citing Mosig et al. (2021). One can even argue that the digital transformation forces OEMs to switch to more data-driven and innovative BMs. Ylijoki et al. (2018) offer an approach that exhibits how innovation capabilities function to connect BMIs and large data sets. The authors create a framework using the design science concept. Fruhwirth et al. (2020) also point out research on applications that support data-driven BMIs. Regarding FoD, the personalized offer creation through data can be the impulse for cross-selling further services, next to up-selling more extensive offers (Schaefer, Leban and Vogt, 2022). Plaß et al. (2020) and Wucher et al. (2019) deliver comparable insights.

### **3.4.9 Overcoming Internal Resistance**

The last noticeable BMI implementation challenge was “the overcoming of internal resistance within the firm to exploit the potential of BMIs”. The various parties involved had to be fully committed so that the BMI implementation would not fail. The management board stated that “an insufficient knowledge and a lack of willingness to sacrifice are among the greatest implementation challenges of a business innovation. Consequently, only selected employees are commissioned with the realization of business model innovations” (EP1). A different sales expert complemented that “an innovative business model should never be characterized by the uncertainty of the employees, as this would likely doom it to failure from the outset” (EP5).

The challenge of overcoming internal resistance has been extensively researched. Bashir and Verma (2019) present a BMI model that examines how internal factors such as leadership, technology, corporate culture, and structure influence the success of BMIs. Geissdoerfer et al. (2023) mention internal resistance as a barrier to the triumph of BMIs, as a result of locked-in culture, investments, or structures. Frankenberger et al. (2013) state that overcoming internal resistance is crucial within the BMI implementation process, as we have already revealed in 3.2.1.4. Despite identifying the challenge, it remains unclear how such can be addressed. By these means, our findings merely reflect the current state of knowledge.

### **3.4.10 Summary of the Investigation**

Additional insights into the financial challenges mentioned can be observed, as we see a linear correlation within sections 3.4.1–3.4.3. To initially launch a BMI, potential financial KPIs must be estimated. This should be done across the departments involved. Once the necessary data has been gathered, OEMs can present a financial CS. This allows decisions to be justified based on the influence of KPIs. Hereafter, OEMs must reevaluate the circumstances and thresholds under which a certain action is taken. A decision-support model for the judgment on whether to initiate, continue, or terminate a BMI is hence required. All three challenges show internal corporate problems that are partly interdependent. Given the available research findings, this is not surprising, as the focus is on internal barriers (Chesbrough, 2002; Friedrich Von Den Eichen, Freiling and Matzler, 2015), whereas only a few external factors are covered (Birkin,

Polesie and Lewis, 2009; Lange *et al.*, 2015). Citing Von den Eichen *et al.* (2015), throughout the BMI process, internal challenges must be addressed to prevent business disruptions. We argue that the issues identified can be classified as cognitive and organizational challenges, as a team is forced to overthink the existing dominant logic of the company (Chesbrough, 2010). Conclusively, we also agree with Björkdahl and Holmén (2013) and Frankenberger *et al.* (2013) that the BMI implementation itself can be perceived as challenging, and that such a process must be carried out step by step, through pilots, trial-and-error, and several experimentations.

In sections 3.4.4–3.4.9, we state six more general BMI implementing challenges. Apart from internal corporate cooperation and overcoming internal resistance, the remaining issues are all external in nature. This is because outside parties are directly involved. It should be noted that most challenges do not only concern the implementation phase. The decision-making and sustainability phase, as shown in the publication by Wirtz and Daiser (2018), are also affected. This is because the individual process steps are not separated and often overlap.

Further challenges must be overcome in the implementation of FoD. Even though FoD are offered for all car projects, the BMI causes difficulties for the parties involved. OEMs must manage internal resistance, customer acceptance, and financial sustainability, while striking a balance between resource allocation and organizational flexibility. Stakeholder responsibility must also be considered. Likewise, to leverage FoD in the car industry, it is important to focus on the customer perspective. While the commercial side of FoD certainly appears promising, the practical challenges make it obvious that research needs to place greater emphasis on the consumer acceptance (e.g., Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). As we have already established in Chapter 2, FoD hence continue to offer an exciting research potential.

Nevertheless, we have most likely not identified all BMI implementation challenges. For universal BMI barriers, we refer to the stated sources in section 3.2.1.4. In particular, we point out to the publications by Frankenberger *et al.* (2013) and Geissdoerfer *et al.* (2023). The authors mention initial barriers for BMIs, focusing on legal affairs, market situation, technical surroundings, organizational appliances, and the value chain. Additional FoD implementation challenges can be found in our literature review or in the papers by Schaefers *et al.* (2022), Garbas *et al.* (2022), and Wiegand and Imschloss (2021). These observations primarily provide insights into customer perceptions. Gruber and Kochschmied (2022), next to Dhebar (2023), illustrate how important it is for OEMs to communicate FoD and the added value to customers more clearly. A series of more technical and legal affairs are discussed by Wucher *et al.* (2019).

In summary, many difficulties for a successful BMI or FoD implementation exist. When dealing with internal obstacles, difficult partner dynamics, low customer acceptance, and legal clues, OEMs must strike a balance between a clearer distribution of resources, organizational flexibility, and awareness among stakeholders. For implementing FoD, analyzing the customer perspective is of significant importance and must be examined more closely by scientists and practitioners. In either way, our study confirms many previous findings and states new results.

### 3.5 Conclusion

A clear strategy is required to successfully implement BMIs (Trapp, Voigt and Brem, 2018), as a careless risk management approach can have disastrous consequences for a company's core activities (Taran, Gouscheit and Boer, 2019). Like many comparable business endeavors, BMI processes involve a certain amount of ambiguity, complexity, and risk. Nevertheless, because BMIs are becoming a crucial business practice among firms (Bucherer, Eisert and Gassmann, 2012; Brenk *et al.*, 2019), it is essential that managers learn more about how to effectively implement BMIs and counteract the barriers that arise (Oh and Hong, 2021). As a result, the BMI literature has already highlighted the growing significance of different BMI challenges (Chesbrough, 2010; Frankenberger *et al.*, 2013; Geissdoerfer *et al.*, 2023). Nevertheless, most authors do not concentrate on the crucial implementation phase as described by Wirtz and Daiser (2018). Furthermore, financial challenges are largely neglected in case studies within this research environment, as most qualitative studies do not provide progressive insights.

Our qualitative case study, which examines financial BMI implementation challenges, has successfully addressed this research gap. We have been involved as an active member of the management accounting team of a premium vehicle OEM called *Automotive Enterprises*. This participatory process enabled us to collect distinct types of data over a three-year period, including relevant documents, emails, and expert interviews. In this manner, we gained comprehensive insights into the process of BMI implementation to answer our originally formulated main research question. The latter was initially formulated as follows:

*“What financial challenges does an OEM face when implementing BMIs on behalf of a firm?”*

We furthermore applied our findings in the broader context of BMIs by using FoD as an applied example within the company to gain specific insights regarding such innovation. This enabled us to successfully answer our second research question, which focused on FoD:

*“How should the FoD BMI be implemented by an OEM to achieve a financial success?”*

#### 3.5.1 Contributions to Theory

Our case study contributes to the emerging research field of BMIs. We demonstrate that the estimation of various financial KPIs, the creation of a decision-support model, and the financial decision-making process to either initiate, continue or terminate a BMI represent the major financial encounters for a successful BMI implementation on behalf of a company. We also point out that the challenges found obtain a linear connection and are interdependent. This is due to the fact that a certain decision-making process requires a preliminary decision-support model, which is based on several KPIs. Accordingly, we emphasize that OEMs must estimate KPIs for a BMI to determine the final profitability within a decision-support model. Ultimately, it is crucial to decide whether BMIs should be implemented. Nevertheless, despite their dependence, all respective challenges must be addressed separately and sequentially.

Furthermore, we illustrate how these challenges can be overcome in the context of FoD. By these means, next to the more general contributions on BMIs, we provide insights into the under-researched field of FoD. Our findings are particularly helpful for companies that apply FoD, as previous studies have focused primarily on the customer perception of this new BMI (e.g., Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). However, despite the need, applied and financial recommendations for OEMs have been largely neglected by researchers.

In addition, we highlight six non-financial BMI implementation challenges. These can be formulated as internal corporate cooperation, supplier-dealer cooperation, reliance on market studies and customer surveys, dealing with uncertainty, smart usage of data potential, and overcoming internal resistance. By doing so, we successfully refer to findings that tackle BMI challenges in a broader context and across different process steps (Frankenberger *et al.*, 2013; Geissdoerfer *et al.*, 2023), as these issues have not been addressed prior to our study.

In summary, our contributions are of immense value to scientists and managers. This is since the BMI introduction is associated with a high degree of risk and failure. Consequently, OEMs must intensify their understanding of BMI to remain successful (Ulvenblad *et al.*, 2018).

### **3.5.2 Limitations and Future Research**

Our case study is subject to several limitations and opens potential future research directions. Because our insights are concentrated on FoD, it is questionable whether these visions can be transferred to the general construct of BMIs. Our goal is to encourage researchers to expand our findings through innovative studies on the challenges of BMIs and to validate our results with further use cases. Hence, it would be helpful to address empirical challenges in various BMI process steps of several companies, industries, and BMIs. For example, researchers could cover different BMIs in consumer electronics of various company sizes in several geographic locations. Moreover, although our research project lasted three years, a longer investigation could have improved the overall assessment of the difficulties involved. This is particularly evident given that the BMI process takes many years to complete. Likewise, the most relevant information was collected through interviews. This suggests that the data observed could be biased due to personal beliefs. We aimed to solve the issue by selecting experts who had a clear understanding of the use case and by comparing information with field notes. In the end, since our findings are not full in line with observations by other researchers (e.g., Chesbrough, 2002; Frankenberger *et al.*, 2013; Geissdoerfer *et al.*, 2023), the validity of our discoveries must be confirmed in a more in-depth manner. We suggest that future scholars combine our research approach with the aspects of the (product) innovation cycle, change management, open innovation, and road mapping, as these terms are important in the BMI literature (Schaller, Vatananan-Thesenvitz and Stefania, 2018; Minatogawa *et al.*, 2019; Abdulkader *et al.*, 2020). To give BMIs a strong basis in terms of relevant data sources, we also recommend making use of different analytical methods to enhance knowledge management procedures.

## **4 A Decision-Support Model for Functions on Demand**

### **Abstract**

New product development (NPD) initiatives require efficient decision-making regarding the product architecture (PA) and a reassessment of product performance and innovation costs. For example, technical advances across different industries are motivating original equipment manufacturers (OEMs) to preinstall software and hardware-based offerings in their products. This trend introduces so-called Functions on Demand (FoD). FoD are integrated into a device, with access deliberately restricted. Customers can later activate these functions for a fee. Accordingly, FoD open new opportunities for OEMs in terms of after-sales revenue and also influence several early-stage PA decisions. Nonetheless, there are hardly any management recommendations or financial insights regarding this business model innovation (BMI). As a countermeasure, our methodological study demonstrates a decision-support model for the valuation of introducing FoD. This set-up is compared to the traditional approach of offering features in the configurator when a product is first purchased. Since FoD are widely used in the car industry, our model was developed in collaboration with an international vehicle OEM. Following the introduction of the decision-support model, we present a real-life industry approach and further improvements of our basic model. By these means, our decision-support model for FoD can assist OEMs in PA and internal investment decisions regarding this BMI.

### **Keywords**

Functions on Demand, Decision-support model, Decision-making, New product development, Product architecture decision

## 4.1 Introduction

Most business models (BMs) focus heavily on possible earning potentials at the point of sale (Osterwalder and Pigneur, 2013; Remane *et al.*, 2017; Vrontis *et al.*, 2021). Currently, a change can be observed in the research environment that indicates that business model innovations (BMIs) with downstream earning capabilities and various new value creation processes are becoming more popular (Wirtz, 2020; Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022; Dhebar, 2023). A prime example are so-called Functions on Demand (FoD), which enable additional income streams after the sale of a certain base product. Also designated as internal product upgrades (IPUs) or on-demand features (ODFs), FoD imply a “fee-based activation of originally built-in, but deliberately restricted, optional features” (Garbas *et al.*, 2022). The trend is already well known among managers and researchers, as familiar technologies like over-the-air (OTA) updates and the connectivity concept form the basis for this cross-industry innovation (Wucher *et al.*, 2019; Wiegand and Imschloss, 2021; Gräsner and Vogt, 2023).

However, researchers have paid little attention to FoD from a monetary and business perspective. This occurrence is surprising, as FoD provide an original equipment manufacturer (OEM) with additional revenues as well as economies of scale by achieving outcomes with identical features (Bentenrieder *et al.*, 2017; Garbas *et al.*, 2022). The few publications available mostly deal with superficial aspects. As an example, the procedure for FoD mobile payments (Petry and Moormann, 2020), different pricing structures (Plaß *et al.*, 2020), and profit sharing possibilities between OEMs and third parties are considered (Wucher *et al.*, 2019; Döbbelin and Kayser, 2020). The lack of information, which includes issues such as a missing profitability analysis for preinstalled hardware features and the financial risk of a customer choosing not to activate FoD, which would lead to financial losses for an OEM, is remarkable (A.T. Kearney, 2017). As of today, the literature does not provide suggestions on how OEMs can make decisions if features should be offered as FoD. The majority of findings observe customer perceptions and responses (Wiegand and Imschloss, 2021; Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). Conversely, we expect the interest to increase soon, as this disruptive BMI is still in its infancy and OEMs are likely to withhold financial insights.

We continue our study as follows. After the introduction, we present our contribution, the research question, our knowledge generation process, and the structure. Since we are the first authors to examine FoD from a solid financial perspective, such a proceeding is crucial.

### 4.1.1 Formulation of the Research Question

Our methodological study contributes a financial decision-support model, which can be used to assess in advance whether functions should be integrated into the product architecture (PA) as FoD. The question arises in which scenarios it is senseful to offer functions also as FoD or exclusively within the product configurator, as OEMs are often unable to fully recoup their initial investments. By these means, we intend to answer the following research question:

*“How should a mathematical decision-support model for investment decisions be structured in order to correctly evaluate decisions on product architectures within the framework of FoD, which oblige an OEM to make upfront financial contributions?”*

Our model was developed over a period of three years and is based on several sources of knowledge. Within our main occupation as a Ph.D. student, we gained practical insights into FoD calculations in the car industry, from which we were able to draw interesting perceptions. Further understandings for the approach were gained from the literature and our reflections.

#### **4.1.2 Structure of the Paper**

As regards the structure of our methodological study, we first provide an overview of the relevant research background. We define FoD before analyzing the latter in the context of product development, PA, and related PA decision models in section 4.2. After explaining the research method in section 4.3, our FoD decision-support model is shown in 4.4 and examines if an investment in FoD is senseful. For this purpose, we also list necessary assumptions, input parameters, and variables before demonstrating the final FoD calculation scheme (CS) next to an example. In section 4.5, we present potential decision-support model extensions. The last section of our study concludes with the contributions achieved, limitations, and an outlook on future research possibilities. This allows other researchers to discuss the topic in more detail.

## **4.2 Research Background**

We deliver insights on the following subjects. First, we provide general knowledge about FoD, which serves as a basis for the understanding of our methodological study. Next, we discuss related concepts such as the product development process and PA, highlighting the available literature findings and the difficulties faced by FoD in these research areas. In addition, we present exemplary PA decision-support models from the literature and illustrate how a FoD calculation would differ from these. Conclusively, the gap in the literature and our stated contribution are outlined. We therefore move from a general to a more specific structure with direct reference to FoD in all instances, as this new BMI presents the main focus of our study.

### **4.2.1 Functions on Demand**

As products evolve from hardware-oriented to software-defined platforms, a trend towards FoD can be observed. Citing Wehinger and Höflich (2018), FoD refer to device options that already include the essential components for various functions, so that these can be enabled once a product leaves manufacturing. One example is a preinstalled seat heating. FoD can provide OEMs with recurring revenue streams and allow customers to individually customize devices. Although definitions and articles are rare, the idea is not new. Garbas et al. (2022) understand FoD as a “fee-based activation of originally built-in, but deliberately restricted, optional features”. Schaefers et al. (2022) classify FoD as “services that allow customers to temporarily access certain features of a product for an additional fee after the initial purchase has been made”. Moreover, just recently, Dhebar (2023) also labels FoD as a form of BMI.

We only partially agree with the available FoD definitions. This is because the product structure of OEMs makes it clear that the access to the hardware or software aspects of a product can also be permanent. Our interpretation of FoD can be more precisely formulated as “services that allow customers a temporary or enduring access to certain previously restricted hard- and software features of a base product, based on already built-in hardware or software capabilities, for an additional fee after the initial purchase has been made”. We include elements from Garbas et al. (2022) and Schaefers et al. (2022), who are among the authors who have dealt most intensively with FoD and who focus on customer perceptions.

Summarized, FoD can be understood as functions that are available in a configurable product due to certain preinstallations, whereby some restrictions remain for activating these functions. FoD hence enable a smartphone-like alignment by integrating adjustable products into people’s routines. Despite their similarity, each product can be individually customized to suit a customer after the purchase. This also means that a unique user experience can be created, as every device owner may generate a different environment. Nevertheless, the key takeaway is that FoD require a significant upfront investment by OEMs, while at the same time only a fraction of customers may purchase FoD over a device’s lifetime (Wucher *et al.*, 2019).

#### **4.2.2 Product Development Process**

Many new product functionalities, such as FoD, are often determined early in the new product development (NPD) process and therefore involve crucial decision-making steps (Sörensen, 2006). Because FoD display an innovative trend with limited applied market knowledge, OEMs face difficult decision-making regarding various NPD initiatives. This is because it must first be clarified whether a functional installation in a product is financially worthwhile at the time of the NPD. By these means, the decision-making will always display a significant key component in the framework of several NPD processes (Thore Olsson, Johannesson and Schweizer, 2018).

Because FoD are directly linked to the NPD process, we provide a general overview of the concept hereinafter. We perceive the terminology according to Clark and Fujimoto (1991) as follows: “Product development is the process by which an organization transforms market opportunities and technical possibilities into valuable information for commercial production”. In general, the field of NPD is widely studied by numerous researchers from various backgrounds, resulting in a wealth of knowledge (Frishammar, 2005; Carvalho and Mello, 2011; Reitsma, Hilletofth and Johansson, 2023). For example, in financial surroundings, management accounting scholars like Nielsen et al. (2015), Quattrone (2016), and Krishnan and Ulrich (2001) examine decision-making processes in the context of NPD. It becomes apparent that OEMs should center their NPD strategies around the changing needs of their customers in order to capitalize on changing market opportunities (Hemant M. Patil *et al.*, 2017). By these means, we conclude that NPD is crucial for promoting commercialization and expansion across industries. Nevertheless, as of today, determining the best strategy for enhancing a firm’s NPD processes remains challenging (Eriksson, Johnsson and Olsson, 2008).

Only a few publications link FoD with NPD considerations. Ho-Dac et al. (2020) find that OEMs offering FoD should use NPD information to emphasize their commitment to a product's development and encourage the purchase of the current FoD version. Next to Dhebar (2023), Wiegand and Imschloss (2021) examine NPD decisions within FoD. The focus remains on how customers perceive FoD, as no decision-support models for OEMs are stated. As a result, it remains unclear what criteria OEMs apply to decide if features are installed as FoD or not. The literature does not provide clear judgments on how and whether a FoD investment should be made. Accordingly, it becomes apparent that a FoD decision-support model is useful to OEMs.

#### **4.2.3 Product Architecture**

Decision-making regarding FoD during the NPD can be considered a choice about the PA, as it presents a NPD component, referring to Pashaei and Olhager (2017). In general, citing Ulrich (1995), the PA contains (1) the arrangement of functional elements, (2) the mapping from functional elements to physical components, and (3) the specification of interfaces among interacting physical components. According to Wouters et al. (2011), the PA is furthermore used to elaborate between alternatives in the early design phase, enabling flexibility for the NPD management under uncertainty (Verganti, 1997). Since PA objectives are characterized by functional product changes after the design process, with the aim of reducing time and cost expenses (Buganza and Verganti, 2006), OEMs face important decisions (Tan *et al.*, 2022).

Diverse PA definitions and classifications exist. Krause and Gebhardt (2018) state that “the PA summarizes the product structure as a physical structure and the functional structure as a functional description of a product and relates their elements to each other. The PA is the totality of the functional and physical descriptions of a product”. A complex mapping between functional elements and physical components as well as connected interfaces between components are characteristics of an *integrated PA* (Ulrich, 1995). A *modular PA* establishes decoupled interfaces between components and includes a one-to-one mapping of functional elements in the structure to the physical components, which better serves the goals of variety or economies of scale (Ulrich, 1995; Dahmus, Gonzalez-Zugasti and Otto, 2000; Fixson, 2005).

Since a basic PA agreement implies that products must be constantly developed to be economically successful (Krause *et al.*, 2021), today's research directions are manifold (Yassine and Wissmann, 2007). Most literature insights focus on the subject of modularity (Dahmus, Gonzalez-Zugasti and Otto, 2000; Muffatto and Roveda, 2002), supply chain design (Ülkü and Schmidt, 2011; Pashaei and Olhager, 2015), or NPD issues (Krishnan and Ulrich, 2001; Sosa, Eppinger and Rowles, 2004; Gokpinar, Hopp and Iravani, 2010). Although, according to Gil (2007), PA decision-making is crucial in the design phase, few papers make financial references (Wouters, Workum and Hissel, 2011; Bellos, Ferguson and Toktay, 2017), as the evaluation of managerial PA decisions is only dealt with slightly (e.g., Sharman and Yassine, 2007). This leads to limited approaches for evaluating PA decisions (Shahin, Liang and Khayyambashi, 2009).

Few research findings exist that discuss the combination of FoD and PA. Wiegand and Imschloss (2021) prove that FoD should include a modular PA so that offerings can be made accessible via mass customization, thereby enabling recurring revenues. Dhebar (2023) notes that a clear PA is required to allow OEMs to unbundle and re-bundle FoD. However, there are no models for financial PA decisions in the literature based on which OEMs can decide to offer features as FoD. Likewise, no study has previously linked FoD more closely to the PA concept.

Accordingly, we now illustrate for the first time how FoD could influence the general PA design, as illustrated in Figure 24. The concept is guided by overarching objectives such as time, costs, quality, and flexibility. Bender and Gericke (2021) create ambitions for the PA regarding four different quadrants, which we will discuss in more detail below.

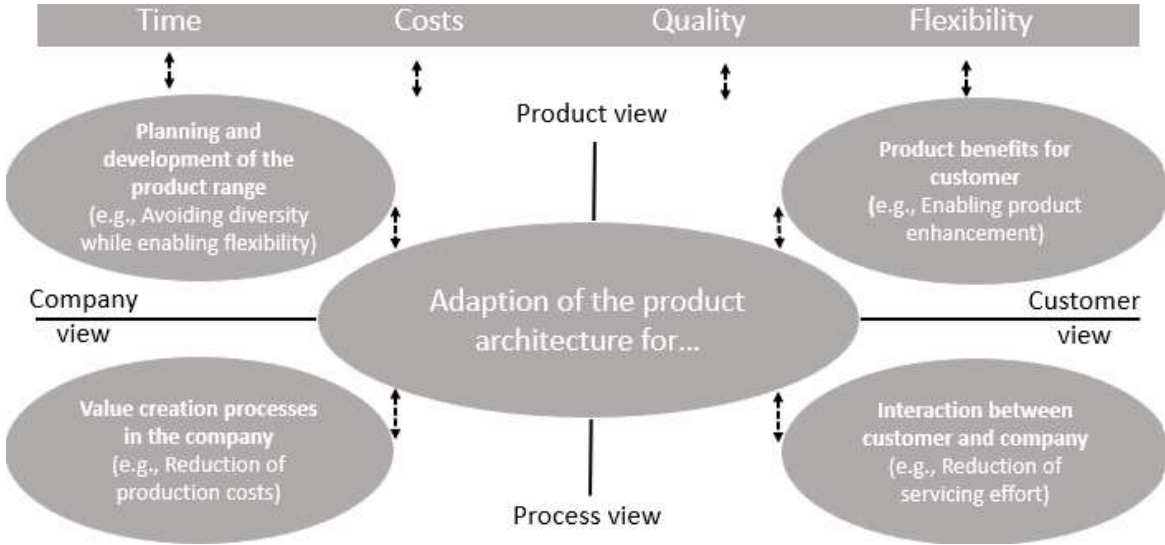


Figure 24. Product architecture design (according to Bender and Gericke (2021))

Firstly, within the *product benefits for customers*, the fulfillment of customer-specific requirements is in the foreground. Facing FoD, individual improvements and enhancements of a product can be named, as features would be easier to implement during the usage phase.

Secondly, the *planning and development of the product range* illustrates that, from the firm’s perspective, smart PA designs can provide an added value for customers. Due to lower production fluctuations and economies of scale, OEMs can achieve cost savings with FoD by avoiding product diversity. Meanwhile, customers would gain a greater degree of flexibility, as they could customize products to their individual needs after purchasing preinstalled FoD.

Thirdly, the *value creation processes in the company* engage with the contemporary development of products and their functions. The availability of upgradable devices with FoD could lead to a reduction in production costs due to the above-mentioned economies of scale.

The fourth and last quadrant presents possible objectives when adapting the PA with effects on process design from a customer’s viewpoint. Accordingly, the *interaction between customer and company* is addressed. The FoD outline could result in an overall reduction in services. This is because digital upgrade requirements would not demand a workshop visit.

#### 4.2.4 Product Architecture Decision-Support Models

We conclude that, to the best of our knowledge, no PA decision-support models that relate to FoD exist. It is therefore questionable what financial decisions need to be made when an OEM makes advance payments and integrates FoD that can be monetized later. Accordingly, many far-reaching and challenging PA choices may appear. For example, the (non-)implementation of the PA maintaining a solution space to be able to install FoD can be considered. This is due to the fact that the PA impacts the after-sales service requirements of a device (Szwejcowski, Goffin and Anagnostopoulos, 2015) and many critical decisions must be recognized. Because we focus on the decision-making process within the PA and FoD, which also displays our earlier stated research objective, we want to provide more clarity in this respective instance.

Table 9 shows an overview of comparable financial trade-off models for PA decisions, from which valuable insights can be gained for our later described FoD approach. All concepts were found using different online search engines with the keywords of PA, product design, decision model, decision-support model, and decision-making. We present the models according to the published authors, the year of publication, the title, the applied industry, number of decision stages, the main decision, and whether the idea of preinstalled functions is discussed. Moreover, we investigate the input (I) and output (O) variables and whether the so-called real options (RO) approach is applied. All things considered, we want to understand which aspects and research findings could be applicable to our later introduced FoD decision-support model. In the following, we therefore discuss the similarities and differences of all the models listed in Table 9 for a potential FoD approach, following a decreasing importance.

We point out that we exclusively analyze models that offer an added value for the development of our resulting approach. This is due to the high availability of concepts, as some models show more significant similarities to our later procedure, and we can only imply few similar model elements in accordance with our final CS. Accordingly, there are a number of further PA models, which are, however, only partially applicable to FoD. For example, a series of qualitative and nonfinancial PA models are available (Fixson, 2005; De Weerd-Nederhof *et al.*, 2007), which focus primarily on the supply chain (Shahzad and Hadj-Hamou, 2013; Pashaei and Olhager, 2015) or software environment (e.g., Koziolok *et al.*, 2016; Tang *et al.*, 2017; Razavian, Paech and Tang, 2019). Because these concepts provide only limited insights and transmissibility regarding FoD, we will not discuss them any further in the context of our work.

Table 9. Different PA decision-support models

	Author(s)	Year	Title	Industry	Decision stages	Main decision	Preinstalled functions <sup>3</sup>	Input (I), Output (O)	Real options
X)	Jaedeke ( <i>present study</i> )	2025	A Decision-Support Model for Functions on Demand	Automotive	Two	Preinstallation of features (FoD)	Yes	I: Costs, client base, ... O: NPV Option A or B	Partly
1)	Wouters et al.	2011	Assessing the Product Architecture Decision About Product Features - A Real Options Approach	Medical (Scanning device)	Two	Four PA options regarding diverse product features	Yes	I: Demand fluctuation O: Profit of PA choice	Yes
2)	Bellos et al.	2017	The Car Sharing Economy: Interaction of Business Model Choice and Product Line Design	Automotive	Two	Car sharing or car sales choice	No	I: Customer demand O: Product line design	No
3)	Plaß et al.	2020	Functions on Demand FoD – USP der Zukunft	Automotive	One	Three FoD offer structures	Yes	I: Customers, costs, ... O: Revenue	No
4)	Tan et al.	2022	Integrating Optimal Process and Supplier Selection in Personalized PA Design	Bicycles	One	Different PA design decisions	No	I: Open PA O: Personalized product	No
5)	Yamada et al.	2020	Decision Support Method for Upgrade Cycle Planning and Product Architecture Design of an Upgradable Product	Electronics (Computer)	One	Different product upgrade cycles	No	I: (Environmental) costs O: PA upgrade cycle	No
6)	Krishnan and Ramachandran	2011	Integrated Product Architecture and Pricing for Managing Sequential Innovation	Overarching	Two	Choice of device improvement	No	I: Design inconsistency O: Joint PA and pricing	No
7)	Yin et al.	2014	PA, Product Development Process, System Integrator, and Product Global Performance	Electronics (VHS/DVD)	One	Hybrid, integral, or modular design	No	I: Product performance O: PA choice	No
8)	Oh and Hong	2021	Managing Market Risk Caused by Customer Preference Uncertainty in Product Family Design with Launch Flexibility: Product Option Strategy	Electronics (Television)	Two	Choice of product family design	No	I: Uncertainty, costs, ... O: Product opt. strategy	Reference
9)	Ford and Sobek	2005	Adapting Real Options to NPD by Modeling the Second Toyota Paradox	Automotive	Three	Delaying alternate NPD selections	No	I: Time alternatives O: Flexible design	Yes
10)	Ripperda and Krause	2017	Cost Effects of Modular Product Family Structures: Methods and Quantification of Impacts to Support Decision-making	Overarching	One	Application of modular PA	No	I: Modularization mode O: Cost effects	No
11)	Ming Dong et al.	2010	Optimal Decisions in Product Modularity Design Using Real Option Approach	Electronics (Phones)	One	Function adding or removing	No	I: Modularity decisions O: NPV	Yes
12)	Kim and Park	2008	Optimal Pricing, EOL Warranty, and Spare Parts Manufacturing Strategy amid Product Transition	Industrial Products	Two	Optimal warranty and product price	No	I: Price, warranty, ... O: Company profit	No

<sup>3</sup> Is the concept of FoD covered to a certain extent?

#### 4.2.4.1 The Model by Wouters et al. (2011)

The PA choice of how to include future features into a base product is addressed by Wouters et al. (2011) in collaboration with Philips and concerns a medical scanning device. Product attributes usually require specific PA design choices that must be made early in the NPD process. As a result, OEMs may suffer from uncertainty regarding consumer approval and willingness to pay (WTP) when creating features that are not yet commercialized. This leads to the dilemma that even if a feature is incorporated into the base product, it is unclear if later profits can be generated. Nevertheless, despite the uncertainty if customers would purchase a feature, as a Wi-Fi-chip would then be implemented in the device, Wouters et al. (2011) focus on the required decision-making steps that must be taken to incorporate the PA. The authors conclude that the product costs are justified by increased flexibility to cope with financial uncertainties and that developing a PA for future performance flexibility is beneficial.

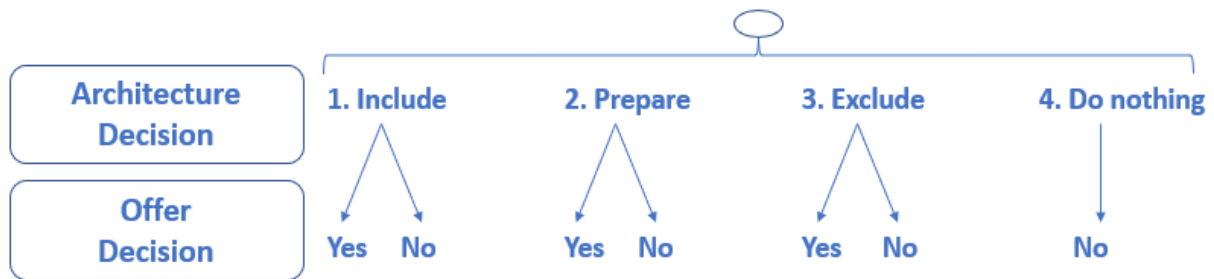


Figure 25. Decision framework of the model by Wouters et al. (2011)

Contributions are divided into different decisions on whether and when to integrate a feature in a two-stage PA model, as also illustrated in Figure 25. The first stage (“architecture decision”) occurs during model implementation, while the second stage (“offer decision”) is future oriented. The firm faces four options for feature integration in the first stage: (1) Adding it to every base product unit, (2) getting units ready for its future equipment, (3) leaving the feature out of all units, or (4) delaying action (“doing nothing”) at the risk of higher integration costs. Decisions (1) and (2) require an investment in the first stage. Before the launch in the second stage, an OEM must choose to integrate a feature for decisions (2) and (4) or to monetize it for decision (1). Regarding the assumed probability distributions of the different parameters, the model outputs the profit for each decision. This makes it possible to calculate the financial outcomes of the options, each of which has its own strengths and weaknesses.

The model employs a real option (RO) strategy to evaluate market entry possibilities. We agree with Kogut and Kulatilaka (2001), who perceive a RO as “an investment decision that is defined by uncertainty, the provision of managerial discretion to exercise at the appropriate time and irreversibility”. Similar past approaches use the net present value (NPV) method to find the best option. However, given the uncertainty regarding consumer acceptance, the NPV is often insufficient. Meanwhile, ROs can be recognized as an attempt to evaluate projects economically under unclear conditions (Marreco and Carpio, 2006), as they face projects that obtain the ability to delay investments and gain more insights (Wouters, Workum and Hissel,

2011; Mondello, 2022). This flexibility enables OEMs to change investments, such as (do not) invest, take advantage of better future chances, and to cut back on losses (Fernandes, Cunha and Ferreira, 2011). Accordingly, one RO principle states that investing in flexible methods can increase the project value when future conditions are unpredictable (Ford and Sobek, 2005). This versatility is important, as the profitability of an OEM depends on investment decisions.

Our approach contains a similar two-stage decision framework, but there are also differences. After the OEM makes a first stage PA decision (investment only in a configurable function or also in FoD), the second stage faces the customer decision (acquire nothing, a configurable function, or FoD). There are analogies of (2) “prepare” to a configurable function and of (1) “include” to FoD in the first stage. The second stage differs from the method by Wouters et al. (2011) due to different input variables (e.g., feature prices and takes-rates for the configurator and FoD) and the financial formulation. For example, regarding FoD, we deal with a PA that is more expensive for OEMs, but which opens potential future revenue streams and greater flexibility, as uncertainties can be offset in many cases. This is important because PA decisions are of interest in markets with changing customer needs or where technical improvements drive NPD (Bleda, Querbes and Healey, 2019). FoD accurately reflect such market situation. However, we would also like to point out that we do not include the RO theory in our basic model version, but in the extensions to our general model in section 4.5.7.

4.2.4.2 The Model by Bellos et al. (2017)

The two-stage OEM decision framework in Figure 26, which affects vehicle performance, is modeled by Bellos et al. (2017) by providing one vehicle for standard sales and one for a car-sharing program. In general, the connection between product design, environmental rules, and BM selection is investigated. Therefore, the authors balance the trade-off between driving performance and fuel efficiency regarding regulations to establish an ideal BM for the OEM. The firm decides on performance in the initial stage, which we refer to as “design decision”, while the WTP and costs of the consumer are still unknown. The second stage, the “customer decision”, which is dependent on the previous stage, determines the WTP. It should be noted that enhanced performance increases WTP, but also raises manufacturing and fuel expenses, which are factored into the sharing charge. In contrast to the model by Wouters et al. (2011), both stages are continuous. By understanding and resolving the optimization model, Bellos et al. (2017) anticipate finding the best product design performance for such existing trade-off.

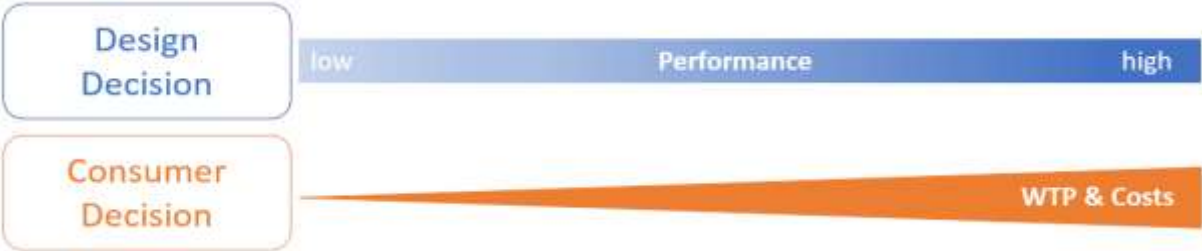


Figure 26. Decision framework of the model by Bellos et al. (2017)

Even if the optimization problem does not align with our goals, we are inspired by similarities. This is since both models deal with additional functions (performance and FoD) in related surroundings (mobility car services and FoD). Moreover, we incorporate the aspect of a two-stage decision framework, as we deal with the company's design or PA decision (stage 1), which depends on a future customer buying decision (stage 2). While the example by Bellos et al. (2017) finds the best course of action, our model considers a specific course of action.

#### *4.2.4.3 The Model by Plaß et al. (2020)*

Plaß et al. (2020) propose an approach for calculating FoD revenues by identifying different offer structures. Although their method is not comprehensive enough to consider all FoD in one framework, there are some similarities to our model, such as the input values. This is particularly true since the model is the only one available that directly describes FoD decisions, as we have already analyzed in section 2.4.3.2. However, while we focus on the PA and the question if FoD should be preinstalled by an OEM, Plaß et al. (2020) examine different offer and payment models for FoD, such as PPU, subscription, and freemium. By these means, the authors neglect the crucial PA tradeoff, as FoD are installed in all scenarios. Furthermore, the assumptions regarding user share, pricing, and frequency of use seem to be rather unrealistic. Likewise, the result that a PPU model is more profitable than a flat rate contradicts the findings of Schaefers et al. (2022) and can hence also be viewed critically from a scientific perspective.

#### *4.2.4.4 The Model by Tan et al. (2022)*

Tan et al. (2022) discover that an open PA that permits the integration of customized modules to produce one-of-a-kind items is an enabler for personalized product establishments. Facing customized PAs, decisions for product variety, module combinations, and customized modules must be coordinated. However, some NPD levels enable independent decisions of producers, suppliers, procedures, and PAs. Because PA processes and suppliers are not linked during such sequential design process, this can lead to impossible design solutions. The approach, which refers to bicycles, states a simultaneous optimization to integrate supplier selection and OEM processes into a customized PA design. First, a cost model is created at the interface between PA, process, and supplier. Following, the potential profit of a product family is maximized using a mixed-integer optimization that considers consumer preference, process resource, supplier, and manufacturing costs. In comparison to comparable sequential design methods, the results show that simultaneous optimization can lead to design solutions with improved profitability.

Despite numerous insights into decision-making, the authors analyze open PAs that differ from the FoD approach. Some crucial commonalities, such as profit maximization and cost targets, can still be observed. However, because the focus of Tan et al. (2022) is on the customer's product design prior to sales, we believe that a transfer to our ensuing FoD model is only possible to a limited extent. This is because the decision for the process and supplier selection for personalized PAs is more complex than the basic investment decision for FoD.

#### *4.2.4.5 The Model by Yamada et al. (2020)*

The case study by Yamada et al. (2020) focuses on an upgradable PA and suggests a decision-support technique that creates the ideal product design and upgrade cycle combination. An issue in the design of a computer's motherboard module serves as an example. Starting, the authors state various assessment models for costs, customer dissatisfaction, and sustainable impact, next to a wide-ranging assessment index based on these approaches. From the set of potential PAs and upgrade cycle candidates, all combinations are determined at a later date. In the end, various assessments are used to assign a preference to the available combinations. The results reveal that the suggested strategy is able to assist an OEM in creating upgradable products by selecting the best pairing from possible PAs and upgrading cycle types.

In spite of valuable insights, the model is only partially transferrable to our approach. This is because the authors focus on the time when modular upgradable products should be upgraded and certain module parts require replacement. Accordingly, it strongly differs from the preinstalled premise of FoD. Nevertheless, the stated decision-support technique and the associated literature provide new insights on how modular PA assessments can be addressed.

#### *4.2.4.6 The Model by Krishnan and Ramachandran (2011)*

Krishnan and Ramachandran (2011) identify the design inconsistency concept, which relates to the monopolist firm's unwillingness to commit to PAs. For OEMs, product design, especially a modular upgradable PA in which improved and stable subsystems of a product are separated and updated selectively, presents an effective strategy. However, an approach based on the PA also brings difficulties, as firms must carefully coordinate cross-functional decision-making. The authors discover that even when OEMs can commit to future prices, firms still encounter design inconsistency. The researchers therefore state a joint PA and price strategy to address this issue, which enables a company to introduce modular upgradable products as efficiently as possible. Next to a guided pricing and product design decisions for managing sequential innovation, the model provides insight into the types of markets and products for which modular upgradability is appropriate. Despite valuable perceptions that we can transfer to our FoD approach, the authors focus mainly on a comparison of modular and integrated concepts.

#### *4.2.4.7 The Model by Yin et al. (2014)*

Yin et al. (2012) create analytical models that use a modular, hybrid, and integral design to determine a product's performance. In general, a firm's PA choice during the NPD displays a strategic selection. However, as no single design is ideal in every situation, analytical models are required to verify certain trade-offs when selecting the best PA. For this purpose, the costs and benefits are analyzed. The models are then formalized, and the effects of performance characteristics are illustrated using examples with multifunctional elements. In this manner, the authors also examine how exogenous expenses of system integrators affect the ideal PA. Because the product features are not preinstalled, the models are not transferrable to FoD.

#### *4.2.4.8 The Model by Oh and Hong (2021)*

Oh and Hong (2021) suggest a product option strategy for a modular-based product. Their model enables OEMs to launch flexible goods, meet market uncertainty, and market products with client preferences. Heuristic algorithms are applied to determine two product choices. First, the structure of the decision-making concept must meet the requirements of the project managers. Next, decision-making is needed to persuade stakeholders. The study confirms that the product option method outperforms the product family design strategies due to launch flexibility. However, apart from the two-stage decision process, the concept differs from FoD.

#### *4.2.4.9 The Model by Ford and Sobek (2005)*

Ford and Sobek (2005) analyze Toyota's NPD decisions using ROs and a simulation model. The authors discuss the emerging difficulties and propose a methodological strategy for the final implementation. The main goal is to provide OEMs with an understanding of the impact and value of flexible development plans. However, the model's simulation methodology and the various decision steps make it unsuitable to transpose it to our two-dimensional FoD scenario. Nevertheless, it generates an awareness of the decision procedure for an overall PA design.

#### *4.2.4.10 The Model by Ripperda and Krause (2017)*

The "complexity cost management" approach by Ripperda and Krause (2017) evaluates costs in modular product families. Most modularization methods offer little support for decision-making in terms of costs. Hence, cost impacts of management strategies and modularization methods must be observed. To enhance concept selection during the modular product family design, a method for quantifying the cost implications is shown. Although an examination of the decreased FoD complexity costs would yield new insights, this is not the goal of our work.

#### *4.2.4.11 The Model by Ming Dong et al. (2010)*

Ming Dong et al. (2010) propose an option pricing model to decide whether to introduce a module. A mobile phone design serves as given example. The decision maker has the option to add, remove, or merge modules at any level of the module introduction process to create configurations. The findings illustrate that the suggested decision model can successfully meet customer expectations and increase the NPV. However, the model bears little resemblance to FoD, even if the NPV evaluations of the design options are calculated similarly to our concept.

#### *4.2.4.12 The Model by Kim and Park (2008)*

A firm's decision model about the time length for which an OEM offers customer warranty and after-sales services is presented by Kim and Park (2008). The model provides guidance on how to choose the best price and warranty when a product's life cycle is limited, and the OEM must continue to serve consumers after the current product scheme is no longer produced. Although our scheme estimates future cash flows and faces a two-stage decision process, the evaluation of warranty or spare parts is not relevant regarding our decision-support model.

## 4.2.5 Summary

The insights on PA decision-support models reveal that there are no concepts that discuss both issues: Firstly, FoD in the after-sales, and secondly, a relatable industry (e.g., vehicles). Accordingly, we only examined models that address at least one of these issues. Wouters et al. (2011) evaluate product design decisions, such as the preinstallation of features, applying a RO method (subsection 4.2.4.1). In a car-sharing business, Bellos et al. (2017) consider the decision-making process regarding a vehicle's performance, which may also be interpreted as a function (subsection 4.2.4.2). As part of our research, we also analyzed further approaches, some of which are more relevant to the topic of FoD than others (subsection 4.2.4.3–4.2.4.12).

### 4.2.5.1 Research Gap

Since there is no decision-support model for FoD investment decisions, the gap in the research becomes clear. The literature findings we discussed do not address the crucial aspect of preinstalled features within a two-stage decision process to either invest or not invest in FoD. Furthermore, most of the available PA models do not take into account the profit potential for an OEM. It becomes obvious that no model from Table 9 faces the necessary characteristics of a decision-support model for FoD. The gap also results from the overall limited findings of FoD research. As of today, most authors analyze customer responses to FoD but neglect financial consequences. Many areas of research hence remain unexplored and questions unanswered.

### 4.2.5.2 Contribution

We provide OEMs with managerial insights by combining PA decision-making and FoD in one combined model. Generally speaking, FoD require a financial preinvestment because features are integrated into every variant of a device, regardless of whether customers ultimately decide to purchase these. As a result, OEMs must estimate the revenue potential of different FoD. Enhancing the research understandings of section 4.2, we provide answers on how OEMs can make financial decisions on the design of the respective PA of FoD. In this regard, we analyze whether it is senseful to preinstall functions as FoD or not. By stating a decision-support model for FoD, we aim to answer our initial formulated research question:

*“How should a mathematical decision-support model for investment decisions be structured in order to correctly evaluate decisions on product architectures within the framework of FoD, which oblige an OEM to make upfront financial contributions?”*

The key contribution of our research is the creation of a PA decision-support model for FoD. We do not exclusively contribute to the literature regarding PA decision-support models but also provide insights regarding the BMI of FoD itself. This is caused by the fact that earlier published FoD findings focus primarily on customer perceptions. However, a decision-support model for OEMs, which is important due to the novelty of the BMI, does not exist. Our impact is thus in the areas of PA decisions and FoD, as these fields have not yet been studied together.

### 4.3 Research Method

We generated the necessary knowledge for our FoD decision-support model through active participation in a newly introduced FoD decision-making project at a car company. Within this work, we refer to the firm as “*Automotive Enterprises*”. During the time of our occupation, the OEM established a new tool for the early-phase cost and profit control of diverse FoD projects, which provided valuable insights. In this capacity, we worked as a member of a project team that put the process into practice and made it the new norm for estimating FoD projects. We were furthermore responsible for maintaining and revising the FoD decision-support model. Our detailed knowledge creation ensured that we only included realistic assumptions within our model, while no empirical data (e.g., firm records) influenced the later introduced CS in any instance. Accordingly, the model presented in our study is not identical to the model used by *Automotive Enterprises*, as the collaboration served exclusively as inspiration for our final concept. Nevertheless, we have acquired pragmatic knowledge, as a significant part of the inspiration for the decision-support model comes from the practical experience of the vehicle OEM. In either way, the delivery of our study is not exclusively based on the realizations by *Automotive Enterprises*. In addition to general knowledge and discussions with some experts, the above-stated decision-support models from the literature also influenced our approach.

Combining the theoretical and applied insights for the creation of a FoD decision-support model gives our study a methodological framework. Our work should not be seen as empirical but as a “methodological study”, as we evaluate the design, analysis, or reporting of other research-related insights (Mbuagbaw *et al.*, 2020). We comprehend a model to be an abstraction or a conceptual structure that facilitates a system study. Such an approach faces a simplified representation of a real-world phenomenon (Busha and Harter, 1980; Connaway and Powell, 2010). This perspective reflects the nature of our research to the greatest extent.

### 4.4 Basic Decision-Support Model for FoD Investment Decisions

This section presents the decision-support model to calculate whether FoD investments are profitable. We create an approach that can easily adjust to several architectural issues without becoming overly complicated, using the example of seat heating in vehicles. Traditionally, seat heating is offered as a configurable add-on when purchasing a car. A vehicle will only come factory-equipped with the upgrade if it is configured in that way. Meanwhile, the FoD version presumes that all cars are equipped with seat heating capabilities. Customers can activate the seat heating as FoD whenever they want via the vehicle application using OTA technology.

The decision-making process described above is shown in Figure 27. It is demonstrated that in Option A, the purchase of a feature is made via a configurator before the product is delivered to a customer. In Option B, every car is equipped with seat heating, as this scenario includes the configurator and FoD. Accordingly, our model ultimately compares the decisions to offer a feature exclusively in the configurator (Option A) or additionally as FoD (Option B).

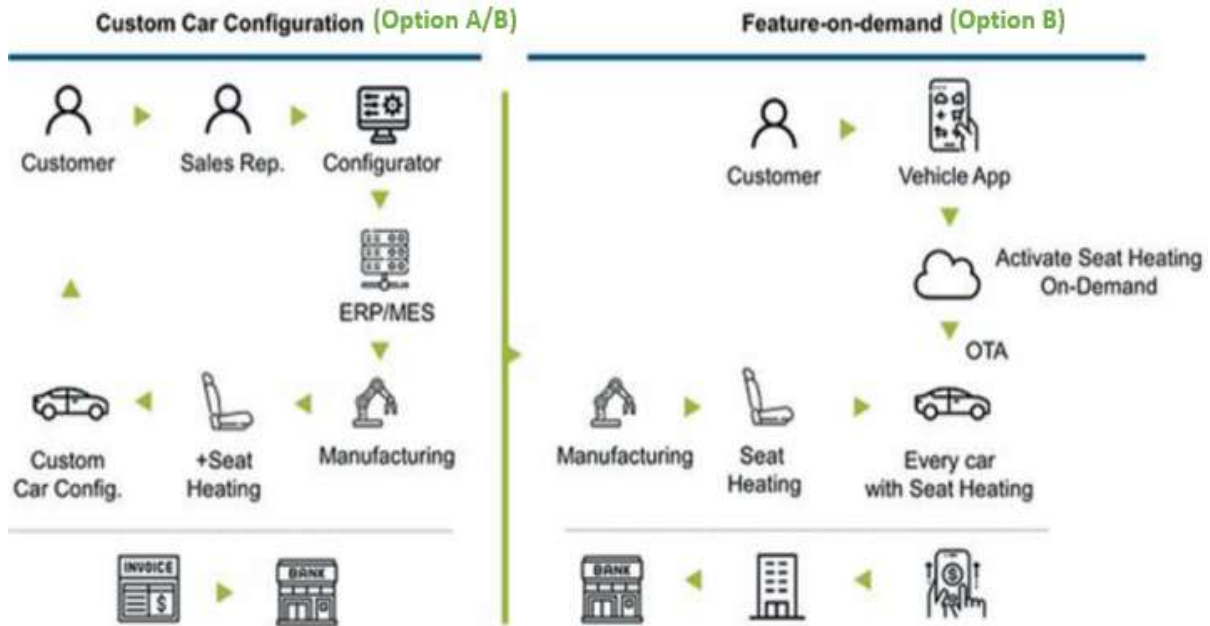


Figure 27. Seat heating as FoD (Slama et al., 2023)

The further structure of section 4.4 is as follows. After describing our understanding of the PA decision-making process that an OEM encounters when offering FoD (4.4.1), we list all required assumptions and necessary input parameters for our decision-support model (4.4.2). Subsequently, we explain the CS behind the configurator scenario before applying it to a real-world example (4.4.3). We then describe how to model the FoD CS and deliver a numerical example in this instance as well (4.4.4). Finally, we provide a summary of our findings (4.4.5).

#### 4.4.1 Architecture Decisions

We consider the PA implementation of FoD as a two-stage investment decision that affects the company and its customer base, as shown in Figure 28. The company’s initial “architecture decision” is made in the first stage regarding the inclusion of a potential function, followed by the “customer decision” on whether or not to purchase the function in the second stage. With regard to our model, a firm can only develop an indirect influence on the second stage through marketing implications, pricing, and similar activities. By these means, the profitability results of the two options during the first stage are of greater importance to us. Nonetheless, this stage still depends on the distribution of the second stage. Hereinafter, we are going to explain the two stages in more detail due to their significance for our final decision-support model.

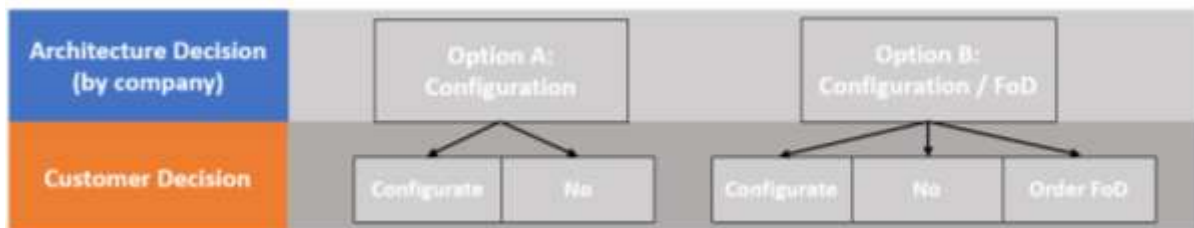


Figure 28. Decision framework of our model

In the first stage (“architecture decision”), the OEM must decide whether it is more profitable to implement features only as configurable functions (Option A) or additionally as FoD (Option B). However, Option B still includes the possibility of obtaining features via the configurator. We assume that there is never a PA for an exclusive FoD equipment. Such a scenario (e.g., Option C) would display the exclusion of bookings utilizing the car configurator.

Thereafter, a customer decides in the second stage (“customer decision”) to either configure a feature, buy a Function on Demand (only possible in Option B), or to do nothing. If “No” is selected in Option A, merely the required standard equipment is installed, meaning that the customer does not receive the premium seat heating capability. Meanwhile, the configurator choice (“Configure”) by the consumer grants the desired upgrade. The decision to purchase a Function on Demand in Option B is only conceivable for the customer if the company has previously installed this opportunity within the PA. If that is the given case, the customer is either able to purchase upgrades (“Order FoD”) or leave them unused. However, regarding Option B, it is also possible to purchase the seat heating in the conventional way as part of the configurator (“Configure”) at the beginning of the vehicle purchase or to leave out such an opportunity (“No”). Accordingly, we conclude that the FoD choice is made during the vehicle’s lifetime and effectively grants the upgrade to the premium seat heating option.

#### **4.4.2 Assumptions and Input Parameters**

In the following, we state necessary assumptions and input parameters. The resulting output parameters are explained during the model description. Furthermore, since we deliver various extensions of our basic approach in section 4.5, additional assumptions can be found there.

##### *4.4.2.1 Basic Assumptions*

Our decision-support model is based on several basic assumptions, some of which will also be explained in more detail during the CS. We calculate the total contribution margin (CM) from the entire number of products sold and apply the notation for European currencies. The occurrence of a vehicle and function sale take place at the beginning of a year, and we observe a period under consideration of six years. We hence streamline the model by modifying it from continuous to annual data, as most financial rules and objectives of an OEM are established annually. This scope also displays the general case for management accounting calculations. The prices and costs of a feature are identical across different sales regions considered, while the refunding of a booking is not available. However, for FoD, we assume that the price will decrease as the vehicle ages. Furthermore, we solely observe one customer category (e.g., no leasing customer) and consider a single FoD that is used in one product. For a specific feature, we hence take a constant installation rate over different sale regions and annual periods into account. We moreover assume that there is no correlation between the number of features purchased in the configurator and as FoD. Nevertheless, we suppose that more customers will likely purchase a function in Option B. This is since FoD allow customers to think longer about purchasing additional features. We also view FoD exclusively as lifetime option, as a customer

can only buy a feature once. Monthly or daily FoD purchases are not discussed. Nevertheless, we provide an example of how to model yearly FoD bookings in section 4.5.3. Finally, various logical factors are excluded. We do not consider situations in which cars are taken out of service due to accidents or similar events. We also do not reflect the effects of economies of scale due to the production of identical features and the resulting cost savings. However, we will discuss some of these issues to a more detailed extent in section 4.5 on model extensions.

#### 4.4.2.2 Market Parameters

The following input market parameters are determined exogenously for the decision-making and refer to the perspective of an OEM. This is since they are either specified by the objectives of the company management, like the observation period of a car (also referred to as vehicle in the following), or because the decision of the feature implementation has little or no impact on them. We differ between parameters that are used for both Option A and Option B in Table 10, and input parameters that are used for only one of the options in Table 11 and Table 12.

Table 10. General input parameters

General Parameters	Abbreviation	Explanation
Sales Region (R)	$i=1\dots n$ [N]	Areas in which a vehicle can be sold to customers.
Calendar Year (CY)	$j=RY\dots m$ [N]	Years in which a vehicle can be sold to customers.
Vehicle Volume	$VV_{i,j}$ [N]	The total number of vehicles sold across specific sales regions and calendar years.
Reference Year	$RY$ [N]	Equals the first calendar year of an observation.
Discount Rate	$dr$ [0,1]	A certain factor to discount cash flows to calculate a financial present value.

The general input parameters in Table 10 are used for both options, as the comparison of the profitability is conducted with the same vehicle volume and the same period under consideration. We observe various sales regions, as each region could possibly face a different market environment, for example due to a varying vehicle volume. Calendar years display the time period in which vehicles are sold to customers. The reference year is applied to discount future cash flows using the discount rate in order to determine the financial present value.

Table 11. Input parameters for Option A

Opt. A Parameters	Abbreviation	Explanation
Installation Rate A	$IR_{C,opt.A}$ [0,1]	Activation ratio in the configurator for Option A.
Configurator Price	$P_C$ [N]	Feature price when bought in the configurator.
Config. Revenue Factor	$RF_C$ [0,1]	Revenue share for an OEM with the configurator.

Input parameters for Option A are stated in Table 11. Because it is unlikely that all customers will purchase a feature in the configurator, we are facing a specific installation rate. By including the configurator price and revenue factor, we can later calculate the profitability.

Table 12. Input parameters for Option B

Opt. B Parameters	Abbreviation	Explanation
Installation Rate B	$IR_{C,Opt.B} [0,1]$	Activation ratio in the configurator for Option B.
Vehicle Year (VY)	$k=1...I[N]$	Years in which potential FoD bookings take place.
Total FoD Take-Rate	$TR_{FoD,total} [0,1]$	Total booking quota of FoD across all CYs and VYs.
FoD Take-Rate	$TR_{j,k} [0,1]$	Certain booking quota of FoD in specific CY and VY.
FoD Lifetime Price	$P_{FoD,k} [N]$	One-time fee to permanently purchase a feature under consideration as FoD in a certain VY.
FoD Price Variation	$X [0,1]$	FoD price factor to differ between the prices for VY1 and VY2, VY3 and VY4, and VY5 and VY6.
FoD Revenue Factor	$RF_{FoD} [0,1]$	Revenue share for an OEM with the FoD option.

Table 12 lists the input parameters for Option B. The configurator installation rate will likely be lower than before, as a customer can now also purchase features via FoD. Therefore, we must consider vehicle years, as a car secures profits through FoD bookings over a certain observation period. The FoD take-rate indicates the booking share of a function as FoD, which is associated with the FoD lifetime price in a certain VY to be paid. Due to the increased customer flexibility, the FoD price will be higher than the configurator price in the first VYs. However, this price will decrease over the VYs, as the OEM wants to create incentives to sell a feature in order to avoid wasting its upfront investment. We display this effect with the FoD price variation factor  $X$ . As technology continues to evolve and solely new features can be ordered via the configurator, we expect prices in the latter to remain constant. Moreover, the FoD revenue factor for Option B is greater, as no dealer margin exists. Bookings could possibly vary among regions, although we consider a similar regional feature installation and take-rate.

#### 4.4.2.3 Cost Parameters

Table 13 presents input cost parameters. Material costs occur for both options. FoD billing, warranty, and additional development costs only arise for FoD. Hence, Option B entails higher costs. FoD billing costs accumulate when functions are booked online via FoD. These costs are incurred by the OEM in favor of the service provider who manages the billing for the customer. FoD warranty costs include all equipment features that are available as FoD and require warranty fees. Additional FoD development costs grant the enablement of the FoD capability of certain features. Costs incurred after the delivery of a car to a customer are not reflected.

Table 13. Input cost parameters

Cost Parameters	Abbreviation	Explanation
Material Costs	$MC (\text{€}/\text{car})$	Material expenses associated with purchasing components for functions under consideration.
FoD Billing Costs	$BC (\text{€}/\text{car})$	FoD expenses for the service provider who manages the billing for the customer.
FoD Warranty Costs	$WC (\text{€}/\text{car})$	FoD warranty fees (e.g., for material damage).
FoD Development Costs	$DC (\text{total in €})$	Expenses for the additional development and enablement of the FoD capability of a function.

#### 4.4.3 Calculation Scheme for the Configurator

We now introduce the calculation scheme for Option A or the configurator before delivering an example. Ultimately, the decision-support model provides the annual cumulative profits.

##### 4.4.3.1 Option A (Configurator)

We start by unfolding the first alternative, displaying the “classical” Option A of Figure 28, in which no FoD selections are possible. An OEM faces no costs when a feature is not requested by a customer in the configurator scenario. However, if a configuration takes place, the share of vehicles in which the installation occurs must be calculated. If we consider a specific year, e.g., the first CY, as the RY and assume a sales lifecycle of six years for a certain product, the first known input data of the vehicle volume  $VV_{i,j}$  can be obtained. This occurrence takes place over the different regions and CYs considered. We therefore assume multiple sales regions to better illustrate possible vehicle fluctuations, as is also presented in the following Table 14.

Table 14. Vehicle volume across sales regions and CYs

$R \ i \ \backslash \ \text{CY } j$	CY1	CY2	CY3	CY4	CY5	CY6	Sum
<b>R1</b>	$VV_{R1,CY1}$	$VV_{R1,CY2}$	$VV_{R1,CY3}$	$VV_{R1,CY4}$	$VV_{R1,CY5}$	$VV_{R1,CY6}$	$\sum_{j=RY}^m VV_{R1,j}$
<b>R2</b>	$VV_{R2,CY1}$	$VV_{R2,CY2}$	$VV_{R2,CY3}$	$VV_{R2,CY4}$	$VV_{R2,CY5}$	$VV_{R2,CY6}$	$\sum_{j=RY}^m VV_{R2,j}$
<b>R3</b>	$VV_{R3,CY1}$	$VV_{R3,CY2}$	$VV_{R3,CY3}$	$VV_{R3,CY4}$	$VV_{R3,CY5}$	$VV_{R3,CY6}$	$\sum_{j=RY}^m VV_{R3,j}$
<b>Sum</b>	$\sum_{i=1}^n VV_{i,CY1}$	$\sum_{i=1}^n VV_{i,CY2}$	$\sum_{i=1}^n VV_{i,CY3}$	$\sum_{i=1}^n VV_{i,CY4}$	$\sum_{i=1}^n VV_{i,CY5}$	$\sum_{i=1}^n VV_{i,CY6}$	<b>=TVV</b>

The total vehicle volume  $TVV$  represents the first output value and indicates the total number of vehicles being sold across all respective regions and CYs. The calculation follows as:

$$TVV = \sum_{i=1}^n \sum_{j=RY}^m VV_{i,j}$$

Assuming a constant installation rate over regions and CYs, we can calculate the total specific vehicle volume  $SVV_{C,Opt.A}$ . This output parameter displays the final number of cars that configure a feature regarding Option A. A presentation on an annual basis is also feasible to increase the overall level of detail. In terms of values, we must multiply the yearly or total vehicle volume with the constant configurator installation rate to obtain the yearly specific vehicle volume  $SVV_{C,Opt.A,j}$  and the total specific vehicle volume  $SVV_{C,Opt.A}$  within Option A:

$$SVV_{C,Opt.A,j} = \sum_{i=1}^n VV_{i,j} \cdot IR_{C,Opt.A}$$

$$SVV_{C,Opt.A} = \sum_{i=1}^n \sum_{j=RY}^m VV_{i,j} \cdot IR_{C,Opt.A} = TVV \cdot IR_{C,Opt.A}$$

Material costs only occur when a function is installed in the configurator. The yearly or total costs for the configurator of Option A,  $TC_{C,Opt.A,j}$  and  $TC_{C,Opt.A}$ , are calculated as stated:

$$TC_{C,Opt.A,j} = SVV_{C,Opt.A,j} \cdot MC$$

$$TC_{C,Opt.A} = SVV_{C,Opt.A} \cdot MC$$

The revenue factor  $RF_C$  determines what remains of the financial revenue and what share an OEM receives. If the prices and costs for installing a function in the configurator are identical across all regions, the yearly or total contribution margin of Option A,  $CM_{Opt.A,j}$  and  $CM_{Opt.A}$ , can be specified as shown below. We point out that the formula for  $CM_{Opt.A,j}$  requires not only the annual special vehicle volume  $SVV_{C,Opt.A,j}$  but also the yearly costs  $TC_{C,Opt.A,j}$ .

$$CM_{Opt.A,j} = SVV_{C,Opt.A,j} \cdot P_c \cdot RF_C - TC_{C,Opt.A,j}$$

$$CM_{Opt.A} = SVV_{C,Opt.A} \cdot P_c \cdot RF_C - TC_{C,Opt.A}$$

Because we generate future revenues, the yearly contribution margin of Option A  $CM_{Opt.A,j}$  must be considered to obtain the final net present value of Option A  $NPV_{Opt.A}$ . With the usage of a certain RY and a discount rate  $dr$ ,  $NPV_{Opt.A}$  can be specified as follows:

$$NPV_{Opt.A} = \sum_{j=RY}^m \frac{CM_{Opt.A,j}}{(1 + dr)^{j-RY}}$$

#### 4.4.3.2 Numerical Example

We now present an example for Option A. We imagine the launch of a car in the RY 2023. The car is sold across the sales regions of Germany, USA, and England over the next six CYs. The following sales figures, leading to a total vehicle volume of 2.040 cars, are shown in Table 15:

Table 15. Sample vehicle volume across sales regions and CYs

<b>R i \ CY j</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>Sum</b>
<b>1. Germany</b>	100 cars	200 cars	300 cars	300 cars	200 cars	100 cars	1.200 cars
<b>2. USA</b>	50 cars	100 cars	150 cars	150 cars	100 cars	50 cars	600 cars
<b>3. England</b>	20 cars	40 cars	60 cars	60 cars	40 cars	20 cars	240 cars
<b>Sum</b>	170 cars	340 cars	510 cars	510 cars	340 cars	170 cars	<b>TVV= 2.040 cars</b>

Within the configurator, we assume that 80% of customers would install the feature upgrade. Using  $IR_{C,Opt.A}$ , the total special vehicle volume  $SVV_{C,Opt.A}$  is calculated as follows:

$$SVV_{C,Opt.A} = \sum_{i=1}^3 \sum_{j=2023}^{2028} VV_{i,j} \cdot IR_{C,Opt.A} = TVV \cdot IR_{C,Opt.A} = 2.040 \text{ cars} \cdot 80\% = 1.632 \text{ cars}$$

Since the installation will be performed only on the vehicles selected for the upgrade, the total costs  $TC_{C,Opt.A}$  can be calculated next, including material costs  $MC$  of 100€ per car:

$$TC_{C,Opt.A} = SVV_{C,Opt.A} \cdot MC = 1.632 \text{ cars} \cdot 100 \frac{\text{€}}{\text{car}} = 163.200\text{€}$$

In the end, the total CM of Option A  $CM_{Opt.A}$  can be derived. We presume a final sales price  $P_c$  of the function of 600€ per car and a resulting revenue factor  $RF_C$  of 50%:

$$CM_{Opt.A} = SVV_{C,Opt.A} \cdot P_c \cdot RF_C - TC_{C,Opt.A} = 1.632 \text{ cars} \cdot 600 \frac{\text{€}}{\text{car}} \cdot 50\% - 163.200\text{€} = 326.400\text{€}$$

To calculate the  $NPV_{Opt.A}$ , we must consider the yearly  $CM_{Opt.A,j}$  with a discount rate  $dr$  of 10%. Table 16 also contains a detailed description of our calculation steps for Option A.

$$NPV_{Opt.A} = \sum_{j=2023}^{2028} \frac{CM_{Opt.A,j}}{(1+dr)^{j-2023}} = \frac{27.200\text{€}}{1,1^0} + \frac{54.400\text{€}}{1,1^1} + \frac{81.600\text{€}}{1,1^2} + \dots \approx 259.445\text{€}$$

Table 16. NPV calculation for Option A

<b>CY j</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>Sum</b>
<b><math>SVV_{C,Opt.A,j}</math></b>	136 cars	272 cars	408 cars	408 cars	272 cars	136 cars	<b>1.632 cars</b>
<b><math>TC_{C,Opt.A,j}</math></b>	13.600€	27.200€	40.800€	40.800€	27.200€	13.600€	<b>163.200€</b>
<b><math>CM_{Opt.A,j}</math></b>	27.200€	54.400€	81.600€	81.600€	54.400€	27.200€	<b>326.400€</b>
<b><math>NPV_{Opt.A,j}</math></b>	27.200€	49.455€	67.438€	61.307€	37.156€	16.889€	<b>259.445€</b>

#### 4.4.4 Calculation Scheme for FoD

We now introduce the calculation scheme for Option B or FoD before stating an example. We focus on total values, while a yearly statement is shown in the example. This is because many calculations of the yearly or total output figures are identical to the CS of Option A in 4.4.3.

##### 4.4.4.1 Option B (FoD)

In Option B, all vehicles are equipped with a function, even if there is a possibility that it will not be used, which increases total costs. If we consider a vehicle that is sold in the first CY and a feature has not yet been ordered in the configurator, there is an observation period of six years over which the feature can be purchased as FoD. Accordingly, as the FoD booking may occur in the future, such occurrence must be included in our model and is expressed by VYs.

The breakdown of the total FoD take-rate  $TR_{FoD,total}$  can be represented over the different regions and VYs, as also illustrated in Table 17. The total take-rate must be divided accordingly, as a booking can be made over several periods and may vary within an annual observation period. We furthermore assume that a function is more likely to be booked at the beginning of a vehicle's service life and that the regional total value always adds up to 100%.

Table 17. Distribution of the total take-rate across sales regions and VYs

<b>R i</b> \ <b>VY k</b>	<b>VY1</b>	<b>VY2</b>	<b>VY3</b>	<b>VY4</b>	<b>VY5</b>	<b>VY6</b>	<b>Sum</b>
<b>R1</b>	$TR_{R1,VY1}$	$TR_{R1,VY2}$	$TR_{R1,VY3}$	$TR_{R1,VY4}$	$TR_{R1,VY5}$	$TR_{R1,VY6}$	<b>=100%</b>
<b>R2</b>	$TR_{R2,VY1}$	$TR_{R2,VY2}$	$TR_{R2,VY3}$	$TR_{R2,VY4}$	$TR_{R2,VY5}$	$TR_{R2,VY6}$	<b>=100%</b>
<b>R3</b>	$TR_{R3,VY1}$	$TR_{R3,VY2}$	$TR_{R3,VY3}$	$TR_{R3,VY4}$	$TR_{R3,VY5}$	$TR_{R3,VY6}$	<b>=100%</b>

We connect the CYs and VYs for R1 in Table 18 to explain the concept in more detail:

Table 18. Distribution of take-rates for the first sales region across CYs and VYs

<b>CY j</b> \ <b>VY k</b>	<b>VY1</b>	<b>VY2</b>	<b>VY3</b>	<b>VY4</b>	<b>VY5</b>	<b>VY6</b>	<b>Sum</b>
<b>CY1</b>	$TR_{CY1,VY1}$	$TR_{CY1,VY2}$	$TR_{CY1,VY3}$	$TR_{CY1,VY4}$	$TR_{CY1,VY5}$	$TR_{CY1,VY6}$	<b>=100%</b>
<b>CY2</b>	$TR_{CY2,VY1}$	$TR_{CY2,VY2}$	$TR_{CY2,VY3}$	$TR_{CY2,VY4}$	$TR_{CY2,VY5}$	$TR_{CY2,VY6}$	<b>=100%</b>
<b>CY3</b>	$TR_{CY3,VY1}$	$TR_{CY3,VY2}$	$TR_{CY3,VY3}$	$TR_{CY3,VY4}$	$TR_{CY3,VY5}$	$TR_{CY3,VY6}$	<b>=100%</b>
<b>CY4</b>	$TR_{CY4,VY1}$	$TR_{CY4,VY2}$	$TR_{CY4,VY3}$	$TR_{CY4,VY4}$	$TR_{CY4,VY5}$	$TR_{CY4,VY6}$	<b>=100%</b>
<b>CY5</b>	$TR_{CY5,VY1}$	$TR_{CY5,VY2}$	$TR_{CY5,VY3}$	$TR_{CY5,VY4}$	$TR_{CY5,VY5}$	$TR_{CY5,VY6}$	<b>=100%</b>
<b>CY6</b>	$TR_{CY6,VY1}$	$TR_{CY6,VY2}$	$TR_{CY6,VY3}$	$TR_{CY6,VY4}$	$TR_{CY6,VY5}$	$TR_{CY6,VY6}$	<b>=100%</b>

Table 18 illustrates the phenomenon that occurs with FoD. A vehicle that is sold in CY1 can generate a profit until VY6. For a vehicle being sold in 2023, potential income streams up to 2028 must be considered. A vehicle that is sold in 2028 may generate an income up to 2033 and so forth. It should also be assumed that take-rates are identical across different CYs, as  $TR_{1,1} = TR_{2,1} = TR_{3,1} = \dots, TR_{1,2} = TR_{2,2} = TR_{3,2} = \dots$ . However, for certain scenarios, it might be necessary to take various specific deviations into account. Summarizing,  $TR_{FoD,total}$  can be regionally distributed across CYs and VYs, whilst the following logical supposition must apply:

$$TR_{FoD,total} + IR_{C,opt.B} \leq 100\%$$

The absolute number of regional bookings  $AB_{j,k}$  across CYs and VYs is calculated next. This output value demonstrates the entire FoD ordering amount over a specific CY and VY. To do so, we must multiply the region-specific vehicle potential by the total FoD take-rate and the annual breakdown of entire bookings. Therefore, we proceed according to the respective region and CY. For example, the absolute number of regional bookings  $AB_{j,k}$  for R1 follows as:

$$AB_{j,k} = VV_{1,j} \cdot TR_{j,k} \cdot TR_{FoD,total}$$

Referring to the latter, the following values of absolute bookings, separated over CYs and VYs, can be calculated. For region R1, we obtain the absolute values as shown in Table 19:

Table 19. Absolute bookings for the first sales region across CYs and VYs

CY j \ VY k	VY1	VY2	VY3	VY4	VY5	VY6
CY1	$AB_{CY1,VY1}$	$AB_{CY1,VY2}$	$AB_{CY1,VY3}$	$AB_{CY1,VY4}$	$AB_{CY1,VY5}$	$AB_{CY1,VY6}$
CY2	$AB_{CY2,VY1}$	$AB_{CY2,VY2}$	$AB_{CY2,VY3}$	$AB_{CY2,VY4}$	$AB_{CY2,VY5}$	$AB_{CY2,VY6}$
CY3	$AB_{CY3,VY1}$	$AB_{CY3,VY2}$	$AB_{CY3,VY3}$	$AB_{CY3,VY4}$	$AB_{CY3,VY5}$	$AB_{CY3,VY6}$
CY4	$AB_{CY4,VY1}$	$AB_{CY4,VY2}$	$AB_{CY4,VY3}$	$AB_{CY4,VY4}$	$AB_{CY4,VY5}$	$AB_{CY4,VY6}$
CY5	$AB_{CY5,VY1}$	$AB_{CY5,VY2}$	$AB_{CY5,VY3}$	$AB_{CY5,VY4}$	$AB_{CY5,VY5}$	$AB_{CY5,VY6}$
CY6	$AB_{CY6,VY1}$	$AB_{CY6,VY2}$	$AB_{CY6,VY3}$	$AB_{CY6,VY4}$	$AB_{CY6,VY5}$	$AB_{CY6,VY6}$

The comprehensibility of what has just been explained is important, as we assume that FoD prices in Option B are not constant. Regardless of the CY,  $P_C$  should be acknowledged as steady, as it is incurred within a new vehicle and VYs have no impact. However, due to various customer advantages, e.g., increased flexibility, the FoD price is supposed to be higher within the first two VYs before a price drop to the dimensions of  $P_C$  takes place. In the fifth and sixth VY, the FoD price should then be lowered to create an incentive to buy and ensure that the OEM is unlikely to be left with the preinvestment in FoD. Depending on the percentage price difference, FoD fees continue to depend on the age of the vehicle and a certain price factor X.

This “price variation factor”  $X$ , which is greater than zero and smaller than one, is based on the FoD timeliness and depends on the VY. Over the period under review, FoD experience a price decline with increasing service life. Less consideration leads to minor price deviations, while a larger factor causes higher fluctuations. This applied logic is explained in Table 20:

Table 20. FoD pricing assumptions over VYs

	$k = VY1 \dots VY2$	$k = VY3 \dots VY4$	$k = VY5 \dots VY6$
$P_{FoD,k}$	$= P_{FoD,3-4} \cdot (1 + X)$	$= P_C = P_{FoD,3-4}$	$= P_{FoD,3-4} \cdot (1 + X)$

Ultimately, we can calculate the cumulated CM of Option B  $CM_{Opt.B}$ , which consists of three components. First, just like in Option A, a certain customer share will equip the feature via the configurator. The initial component of the total CM can therefore be displayed by the amount of configurator purchases  $CM_{Configurator}$ , which is identical to the previous  $CM_{Opt.A}$ .

$$CM_{Configurator} = SVV_{C,Opt.B} \cdot P_C \cdot RF_C - TC_{C,Opt.B}$$

Despite the similarity in the structure of the formula, the outcome will most likely be smaller. This is due to a minor installation rate  $IR_{C,Opt.B}$ . As before, such value influences the total specific vehicle volume  $SVV_{C,Opt.B}$  and the total costs  $TC_{C,Opt.B}$ . The reason for a reduced installation rate  $IR_{C,Opt.B}$  is that fewer customers choose to install a feature in advance, as this will also be possible later with the flexible FoD offer. We hence state the following supposition:

$$IR_{C,Opt.B} < IR_{C,Opt.A}$$

Meanwhile, the total FoD installation rate remains at 100% since the feature is always installed, even if the customer does not select the latter in the configurator. This logic intends to generate additional income streams after the vehicle sale, as customers can still unlock the feature afterward. In this sense, one of the main differences between the two options, which leads to advance payments by the OEM, becomes clear. Costs occur since vehicle equipment is required that was not originally ordered by the customer when purchasing the car and as a result does not generate any profit. This so-called FoD investment  $Invest_{FoD}$  is of a negative proportion, displays the second component of the cumulated CM of Option B, and follows as:

$$Invest_{FoD} = -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot MC - DC$$

Observing the resulting formula, additional technical development costs  $DC$  can be monitored. In addition to the expected material costs  $MC$ , there exist greater supplementary expenses for developing and activating the FoD capability of a certain function. These costs are incurred as a result of the technical implementation of FoD and can be of significant extent. Furthermore, it must likewise be noted that while the material costs are specified per vehicle, the additional FoD development costs amount to a total value of millions in €.

Finally, for the last component of  $CM_{Opt.B}$ , we consider the revenue streams from the FoD installation after the vehicle sale. Because FoD take-rates and prices may differ regarding the VYs, the specific regional FoD contribution margin  $CM_{FoD,i}$  is calculated as stated below:

$$CM_{FoD,i} = RF_{FoD} \cdot \left( \sum_{k=1}^l \left( \sum_{j=RY}^m AB_{j,k} \cdot P_{FoD,k} \right) \right) - TR_{FoD,total} \cdot \sum_{j=RY}^m VV_{i,j} \cdot TC_{FoD}$$

The logic behind this formula is as follows: On an annual basis of the VYs, the absolute number of bookings for all CYs is determined and multiplied by the variable FoD price. This approach is essential, as prices vary depending on the VYs. The CM potential obtained from this procedure is then multiplied by the FoD revenue factor, which has a greater share than the previous configurator revenue factor. This is because a dealer only receives a margin from the OEM for selling the feature in the regular trade (configurator), but not for an online FoD sale. In the end, the costs for the employing of FoD in Option B or  $TC_{FoD}$ , which are influenced by the take-rate and the regional vehicle volume, are deducted and can be derived as follows:

$$TC_{FoD} = BC + WC$$

We emphasize that the total number of vehicles that book FoD in a region must be calculated in advance to obtain  $TC_{FoD}$ . In contrast to  $Invest_{FoD}$ , this only includes the vehicles that actually buy a feature. The final calculated number of vehicles must then be considered concerning billing and warranty costs. Billing costs are FoD expenses for the service provider who manages the billing for the customer. Warranty costs arise due to potentially faulty FoD. Both cost factors are rather low, are specified per car, and are interpreted as fixed. Ultimately, across all regions, FoD results provide the total FoD contribution margin  $CM_{FoD}$ , statable as:

$$CM_{FoD} = \sum_{i=1}^n CM_{FoD,i}$$

All things considered, the cumulated CM for Option B, consisting of three components, can be calculated by adding the CM via the configurator and FoD, minus the advance payment by the OEM and certain additional costs to be paid. The formula  $CM_{Opt.B}$  is equal to:

$$CM_{Opt.B} = CM_{Configurator} + Invest_{FoD} + CM_{FoD}$$

As stated beforehand, the yearly contribution margin of Option B  $CM_{Opt.B,j}$  must be considered to obtain the final  $NPV_{Opt.B}$ , which also requires a RY and a discount rate  $dr$ :

$$NPV_{Opt.B} = \sum_{j=RY}^m \frac{CM_{Opt.B,j}}{(1 + dr)^{j-RY}}$$

The ultimate value of Option B is now compared to the outcome of Option A to decide on the more profitable investment. The NPV of Option B most likely contains a slightly more negative trend, as an OEM must make financial advance payments to install features as FoD. However, if the input parameters are in favor of FoD, Option B can also be more promising.

#### 4.4.4.2 Numerical Example

Subsequently, we present a numerical example for Option B, which focuses on the same regions and vehicle volumes as our previous findings from section 4.4.3.2. The  $NPV_{Opt.A}$  must be compared to the FoD set-up and the resulting  $NPV_{Opt.B}$ . To begin with, due to the increasing design flexibility, as customers can also choose FoD, we assume that 75% of customers aim to purchase the feature upgrade in advance, which is shown by the value of  $IR_{C,Opt.B}$ . A maximum of 25% of customers can hence activate the feature via FoD. This straightforward assumption of the maximum FoD take-rate  $TR_{FoD,max}$  ensures that every customer can select the desired function throughout the service life of a vehicle. These two suppositions are outlined below:

$$IR_{C,Opt.B} = 75\%$$

$$TR_{FoD,max} = 100\% - IR_{C,Opt.B} = 25\%$$

Multiplying  $TR_{FoD,max}$  with the total vehicle volume gives us a potential of 510 FoD-capable vehicles. Since not the full FoD potential will be exploited, we assume a more realistic total FoD take-rate  $TR_{FoD,total}$  of 15%. Regarding our assumptions, 90% of customers purchase the feature either through the configurator or as FoD. For Option A, this percentage was 80%. The increase is due to more flexible booking options throughout the vehicle's entire lifespan.

$$TR_{FoD,total} = 15\%$$

$TR_{FoD,total}$  will be achieved simultaneously in all regions, as initially assumed. Likewise, this value is spread over six VYs, with 2023 indicating the RY. Accordingly,  $TR_{FoD,total}$  is divided into the resulting specific FoD take-rates, which leads to a fluctuation across different regions and VYs. We assume that the booking probability is the highest in the second and third VY before the latter declines at the end of a car's observation period. This proceeding generates the ensuing FoD take-rate distributions across the sales regions and VYs, as stated in Table 21:

Table 21. Sample distribution of the total take-rate across sales regions and VYs

<b>R i \ VY k</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>Sum</b>
<b>1. Germany</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2. USA</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>3. England</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>

Hereinafter, Table 22 presents the distribution of take-rates  $TR_{j,k}$  for the German sales region across CYs and VYs. We refer repeatedly to the German region, whereby the calculation for the remaining regions is performed in the same way. Regarding the regions, a distinction must be made between CYs and VYs. This is because, for example, a German vehicle launched in 2024 may have a different FoD booking probability than a vehicle from 2026. However, for reasons of simplicity, we assume an even distribution across the CYs, as also presented below.

Table 22. Distribution of take-rates for the German sales region across CYs and VYs

CY j \ VY k	1	2	3	4	5	6	Sum
<b>2023</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2024</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2025</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2026</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2027</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>
<b>2028</b>	10%	30%	30%	20%	5%	5%	<b>100%</b>

For example, in CY 2023, 100 cars (see Table 15) are sold in the German sales region, enabling a FoD potential of 15 cars for the next six VYs. Regarding the bookings, 10% occur in the first VY, which equals 1,5 FoD bookings, while 30% occur in the second VY, equaling 4,5 FoD bookings. In CY 2024, 200 cars are being sold in Germany, resulting in a FoD potential of 30 cars. Again, 10% or 3 FoD bookings occur in the respective first VY, which is 2024 in this case, and 30% or 9 FoD bookings result in the VY 2025. These absolute booking numbers for the German sales region are also indicated in Table 23. Explained in more detail, the absolute booking value  $AB_{2024,1}$  for a vehicle that will be launched in the CY of 2024 and is about to enter its first VY can be calculated for the German sales region with  $i=1$  or  $i=Ger$  as follows:

$$AB_{2024,1} = VV_{Ger,2024} \cdot TR_{2024,1} \cdot TR_{FoD,total} = 200 \text{ cars} \cdot 10\% \cdot 15\% = 3 \text{ cars}$$

Table 23. Absolute bookings for the German sales region across CYs and VYs

CY j \ VY k	1	2	3	4	5	6	Sum
<b>2023</b>	1,5 cars	4,5 cars	4,5 cars	3 cars	0,75 cars	0,75 cars	15 cars
<b>2024</b>	3 cars	9 cars	9 cars	6 cars	1,5 cars	1,5 cars	30 cars
<b>2025</b>	4,5 cars	13,5 cars	13,5 cars	9 cars	2,25 cars	2,25 cars	45 cars
<b>2026</b>	4,5 cars	13,5 cars	13,5 cars	9 cars	2,25 cars	2,25 cars	45 cars
<b>2027</b>	3 cars	9 cars	9 cars	6 cars	1,5 cars	1,5 cars	30 cars
<b>2028</b>	1,5 cars	4,5 cars	4,5 cars	3 cars	0,75 cars	0,75 cars	15 cars
<b>Sum</b>	18 cars	54 cars	54 cars	36 cars	9 cars	9 cars	180 cars

The distribution of absolute booking frequencies over VYs is important, as we suppose a FoD price decline. Our assumptions are as follows: While the FoD price for VY3 and VY4 corresponds to the configurator price, the FoD price variation factor  $X=0,25$  directly influences the remaining VYs. This results in the ensuing charges to be paid over the different VYs:

Table 24. Sample pricing assumptions for FoD over VYs

	$k = VY1 \dots VY2$	$k = VY3 \dots VY4$	$k = VY5 \dots VY6$
$P_{FoD,k}$	$= P_{FoD,3-4} \cdot (1 + X)$ $= 600€ \cdot 1,25 = 750€$	$= P_C = P_{FoD,3-4}$ $= 600€$	$= P_{FoD,3-4} : (1 + X)$ $= 600€ : 1,2 = 480€$

Next, we calculate the three CM components of Option B. We first estimate the CM of the configurator across sales regions using the formula below, which was similar for Option A:

$$CM_{Configurator} = SVV_{C,Opt.B} \cdot P_C \cdot RF_C - TC_{C,Opt.B}$$

Assuming a lower installation rate  $IR_{C,Opt.B}$  of 75% due to the reasons mentioned, the special vehicle volume  $SVV_{C,Opt.B}$  and the total costs  $TC_{C,Opt.B}$  for Option B can be calculated:

$$SVV_{C,Opt.B} = TVV \cdot IR_{C,Opt.B} = 2.040 \text{ cars} \cdot 75\% = 1.530 \text{ cars}$$

$$TC_{C,Opt.B} = SVV_{C,Opt.B} \cdot MC = 1.530 \text{ cars} \cdot 100 \frac{€}{\text{car}} = 153.000€$$

Accordingly, the total contribution margin of the configurator across regions results in:

$$CM_{Configurator} = 1.530 \text{ cars} \cdot 600€ \cdot 50\% - 153.000€ = 306.000€$$

Secondly, since the feature is installed in the remaining 25% of vehicles, a financial FoD preinvestment is required. We also assume additional total development costs  $DC$  of 10.000€, which are incurred in the first CY. The FoD investment  $Invest_{FoD}$  across regions follows as:

$$Invest_{FoD} = -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot MC - DC$$

$$= -2.040 \text{ cars} \cdot (100\% - 75\%) \cdot 100 \frac{€}{\text{car}} - 10.000€ = -61.000€$$

Ultimately, we must determine the potential FoD CM over the lifetime of a car. Hence, the absolute bookings  $AB_{j,k}$  across CYs and VYs for a specific region are required. For example, when the German sales region is reevaluated, the CM through FoD sales  $CM_{FoD,Ger}$  results in:

$$CM_{FoD,Ger} = RF_{FoD} \cdot \left( \sum_{k=1}^l \left( \sum_{j=2023}^m AB_{j,k} \cdot P_{FoD,k} \right) \right) - TR_{FoD,total} \cdot \sum_{j=2023}^m VV_{Ger,j} \cdot TC_{FoD}$$

Assuming that the costs for billing and warranty purposes amount to 5€ per car, we are able to deviate the necessary FoD total costs  $TC_{FoD}$  as stated below:

$$TC_{FoD} = BC + WC = 5 \frac{€}{\text{car}} + 5 \frac{€}{\text{car}} = 10 \frac{€}{\text{car}}$$

As a result, the CM through FoD sales for the German sales region  $CM_{FoD, Ger}$  follows with a greater FoD applied revenue factor  $RF_{FoD}$  of 65% according to:

$$CM_{FoD, Ger} = 0,65 \cdot \left( 18 \text{ cars} \cdot 750 \frac{\text{€}}{\text{car}} + 54 \text{ cars} \cdot 750 \frac{\text{€}}{\text{car}} + 54 \text{ cars} \cdot 600 \frac{\text{€}}{\text{car}} + 36 \text{ cars} \cdot 600 \frac{\text{€}}{\text{car}} + 9 \text{ cars} \cdot 480 \frac{\text{€}}{\text{car}} + 9 \text{ cars} \cdot 480 \frac{\text{€}}{\text{car}} \right) - 15\% \cdot 1200 \text{ cars} \cdot 10 \frac{\text{€}}{\text{car}} = 74.016\text{€}$$

The CM for the two remaining two sales regions,  $CM_{FoD, USA}$  and  $CM_{FoD, Eng}$ , can then be calculated alongside the total CM through FoD sales  $CM_{FoD}$ . The final results are:

$$CM_{FoD, USA} = 37.008\text{€}$$

$$CM_{FoD, Eng} \approx 14.803\text{€}$$

$$CM_{FoD} = \sum_{i=1}^n CM_{FoD, i} = CM_{FoD, Ger} + CM_{FoD, USA} + CM_{FoD, Eng} \approx 125.827\text{€}$$

Afterward, we can calculate the profitability using the total CM of the second option  $CM_{Opt.B}$ , which consists of the three stated formula components and delivers the final result:

$$CM_{Opt.B} = CM_{Configurator} + Invest_{FoD} + CM_{FoD} = 306.000\text{€} - 61.000\text{€} + 125.827\text{€} \approx 370.827\text{€}$$

Considering a yearly consideration of the CM of Option B or  $CM_{Opt.B, j}$ , the  $NPV_{Opt.B}$  can be calculated with an assumed discount rate  $dr$  of 10%. Besides, the investment of 10.000€ for the development costs  $DC$  must be observed in the first CY. The calculation is shown below.

Table 25. NPV calculation for Option B

CY j	2023	2024	2025	2026	2027	2028	Sum
$CM_{Config.j}$	25.500€	51.000€	76.500€	76.500€	51.000€	25.500€	<b>306.000€</b>
$Invest_{FoD, j}$	-14.250€	-8.500€	-12.750€	-12.750€	-8.500€	-4.250€	<b>-61.000€</b>
$CM_{FoD, Ger, j}$	6.168€	12.336€	18.504€	18.504€	12.336€	6.168€	<b>74.016€</b>
$CM_{FoD, USA, j}$	3.084€	6.168€	9.252€	9.252€	6.168€	3.084€	<b>37.008€</b>
$CM_{FoD, Eng, j}$	1.234€	2.467€	3.701€	3.701€	2.467€	1.234€	<b>14.803€</b>
$CM_{Opt.B, j}$	21.736€	63.471€	95.207€	95.207€	63.471€	31.736€	<b>370.827€</b>
$NPV_{Opt.B, j}$	21.736€	57.701€	78.683€	71.530€	43.352€	19.705€	<b>292.707€</b>

Finally, we provide the exact procedure for all exemplary values of CY 2023, while the remaining CYs are also listed in the representation above, before we calculate  $NPV_{Opt.B}$ .

$$\begin{aligned}
 CM_{Configurator,2023} &= 170 \text{ cars} \cdot 75\% \cdot 600\text{€} \cdot 50\% - 12.750\text{€} = 25.500\text{€} \\
 Invest_{FoD,2023} &= -170 \text{ cars} \cdot (100\% - 75\%) \cdot 100\text{€} - 10.000\text{€} = -14.250\text{€} \\
 CM_{FoD,GER,2023} &= 65\% \cdot \left( 1,5 \text{ cars} \cdot 750 \frac{\text{€}}{\text{car}} + \dots \right) - 15 \text{ cars} \cdot 10 \frac{\text{€}}{\text{car}} = 6.168\text{€} \\
 CM_{FoD,USA,2023} &= 65\% \cdot \left( 0,75 \text{ cars} \cdot 750 \frac{\text{€}}{\text{car}} + \dots \right) - 7,5 \text{ cars} \cdot 10 \frac{\text{€}}{\text{car}} = 3.084\text{€} \\
 CM_{FoD,ENG,2023} &= 65\% \cdot \left( 0,3 \text{ cars} \cdot 750 \frac{\text{€}}{\text{car}} + \dots \right) - 3 \text{ cars} \cdot 10 \frac{\text{€}}{\text{car}} \approx 1.234\text{€} \\
 CM_{Opt.B,2023} &= 25.500\text{€} - 14.250\text{€} + 6.168\text{€} + 3.084\text{€} + 1.234\text{€} \approx 21.736\text{€} \\
 NPV_{Opt.B,2023} &= \frac{21.736\text{€}}{1,1^0} \approx 21.736\text{€} \\
 NPV_{Opt.B} &= \sum_{j=2023}^{2028} \frac{CM_{Opt.B,j}}{(1+dr)^{j-2023}} = \frac{21.736\text{€}}{1,1^0} + \frac{63.471\text{€}}{1,1^1} + \frac{95.207\text{€}}{1,1^2} + \dots \approx 292.707\text{€}
 \end{aligned}$$

Because  $CM_{Opt.B} > CM_{Opt.A}$ , as well as  $NPV_{Opt.B} > NPV_{Opt.A}$ , we can conclude that a preinvestment made by the OEM in FoD is profitable and should be pursued.

#### 4.4.5 Summary

Finally, we state a summary of the decision-support model. We determine the delta of the two options by subtracting the key figures of the first from the second alternative. Because  $Delta = NPV_{Opt.B} - NPV_{Opt.A} \approx 33.262\text{€} > 0$ , the seat-heating option should also be offered as FoD. If the corresponding result is negative, FoD should not be installed. The considerations regarding which investment decision is supposed to be pursued are also shown in Figure 29.

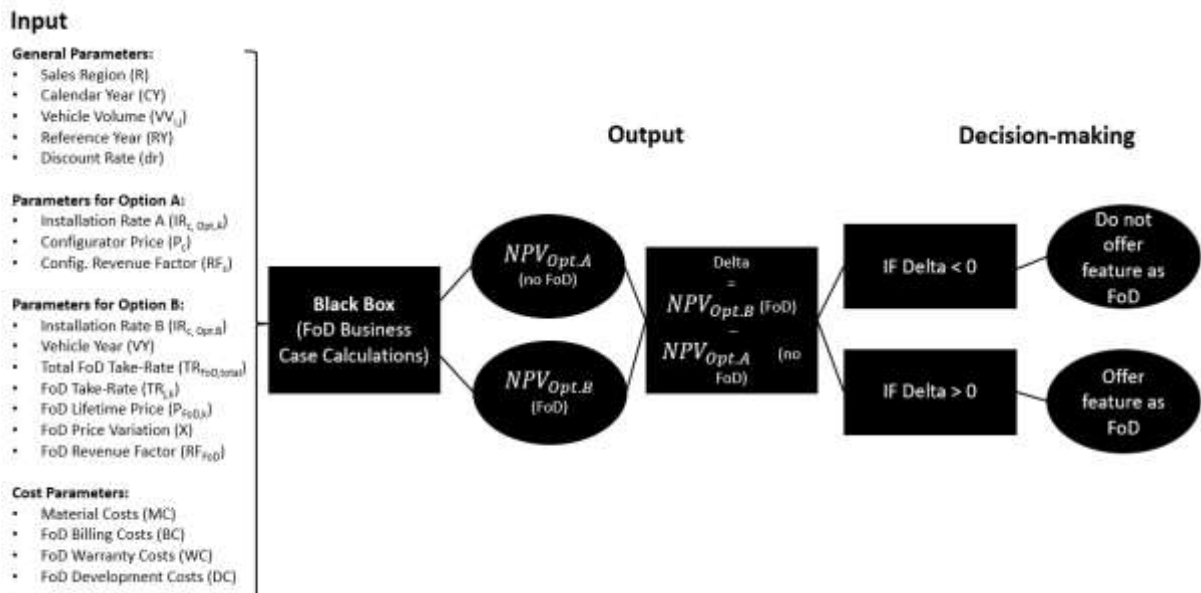


Figure 29. Summary of the decision-making process

Table 26. Summary of the numerical example

IR	TR	VV	Price	RF	MC	BC	WC	DC	CM (Profit)	NPV
<b>Option A</b>										
80%	/	2.040	600€	0,5	100€	/	/	/	<b>326.400€</b>	<b>259.445€</b>
<b>Option B</b>										
Profit Configurator										
75%	/	2.040	600€	0,5	100€	/	/	/	306.000€	/
Invest FoD										
25%	/	2.040	/	/	100€	/	/	10.000€	-61.000€	/
Profit FoD										
/	15%	2.040	750€-480€	0,65	/	5€	5€	/	125.827€	/
<b>Total values of Option B</b>									<b>370.827€</b>	<b>292.707€</b>
<i>Delta = NPV<sub>Opt.B</sub> - NPV<sub>Opt.A</sub> ≈ 33.262€ &gt; 0 = Invest in FoD</i>										

A mathematical summary of our example is provided in Table 26. It becomes apparent that Option B is more economically promising, although the feature is installed in 100% of all vehicles, not just 80% as in Option A. This is primarily due to the pricing policy and the FoD revenue factor, next to other financial influences. However, it is necessary to record how easily the output fluctuates. For example, Option B would yield the same NPV as Option A if the FoD take-rate were to fall to the following value, while the FoD prices would remain unchanged:

$$TR_{FoD,total} = 10,01\%$$

At the same time, the NPVs of the two options would also yield the same results if we were confronted with the following FoD prices and a total FoD take-rate  $TR_{FoD,total}$  of 15%:

$$P_{FoD,1-2} = 516,60€, P_{FoD,3-4} = 400,00€, P_{FoD,5-6} = 309,72€$$

## 4.5 Decision-Support Model Extensions

Following the introduction of our basic decision-support model, possible extensions can be implemented next. We consider more differentiated input parameters, product deterioration, yearly FoD bookings, economies of scale, the headroom concept, sustainability aspects, and ROs. We will first introduce extensions that do not significantly alter the logic of our basic approach, before moving on to more substantial variations of our decision-support model. Because we only discuss a limited number of extensions, we also refer to section 4.6.2 on future research opportunities, in which we propose even more variations of our basic model.

#### 4.5.1 Differentiated Input Parameters

To begin with, our model could face more differentiated parameters to increase the level of detail, while the fundamental concept would remain unchanged. With reference to subsection 4.4.2.1, various general decision-support model improvements come to mind. For example, the sale and the costs of a booking may not be incurred at the beginning of the year but be spread over the entire observation period. Hence, a variation of prices and costs, which would lead to fluctuating installation and take-rates over the regions and observed times, could also be included in the decision-support model. While our basic approach covers only one specific customer group across the different sales regions, these could be further subdivided (e.g., into leasing customers). In such a given environment, price promotions would also influence the customer groups, as it is assumable that a lower price leads to a higher demand. Likewise, the observation of different software functions, such as a navigation map update, would have a different impact on the total costs, as material costs would account for a smaller overall share.

Additional modifiable assumptions were also mentioned subsequently to subsection 4.4.2.1, when further input parameters and the CS of the decision model were considered. Starting, the observed vehicle or product lifespan and the sale regions could be altered to suit more diverse industrial settings. Furthermore, the installation and take-rates could vary, e.g., across regions and time horizons, to make the model more realistic for individual business scenarios. In view of the various cost categories mentioned, the additional FoD development costs could also be displayed as a value per vehicle to better illustrate the exact impact of these factors. Ultimately, we assume that the price of the configurator will remain constant over the period under consideration and that the introduction of FoD will lead to a higher overall rate of feature selection. This supposition could be viewed critically, as differentiated input parameters may result in a variable output and could lead to a different investment decision. By these means, it is observable that our model is subject to a multitude of general changes that are able to significantly increase the level of detail.

#### 4.5.2 Product Deterioration

One aspect that we do not consider in our basic model is that some vehicles are unlikely to be used for the entire six-year period but will fail earlier, thereby negating the possibility of FoD bookings. Within Option A, the feature sale can be guaranteed for a certain percentage of the vehicle volume, as we are exclusively facing the delivery of new cars. In Option B, however, functions can furthermore be purchased on the used car market via FoD over six VYs. During this period, potential vehicle breakdowns may occur, which would lead to a decline in the vehicle volume. Accordingly, the realistic absolute bookings must decrease with increasing VYs. Based on this assumption, the basic model changes regarding Option B. Due to possible product defects, the “realistic” vehicle volume  $rVV_{j,k}$  of a certain region, now displayable across CYs and VYs, must continue to decrease with increasing product age (VYs). This results in the following values for Option B, as illustrated in the following Table 27.

Table 27. Realistic vehicle volume for a certain region across CYs and VYs

CY j \ VY k	VY1	VY2	VY3	VY4	VY5	VY6
CY1	$rVV_{j,k}$	$rVV_{j,k}$	$rVV_{j,k}$	$rVV_{j,k}$	$rVV_{j,k}$	$rVV_{j,k}$
...	...	...	...	...	...	...

$rVV_{j,k}$  is calculated by multiplying the expected vehicle volume (see Table 14) with an expiry factor  $ef_k$  [0,1], which systematically declines with increasing VYs. If we reclassify the German sales region, the first row of Table 14 would equal the first column of Table 27, as no product expiry occurs in the first VY. The equation for the remaining values is as follows:

$$rVV_{j,k} = VV_{j,k} \cdot ef_k$$

Assuming the following expiry factors:  $ef_1 = ef_2 = 1$ ,  $ef_3 = ef_4 = 0,9$ ,  $ef_5 = ef_6 = 0,8$ , we can determine the absolute values for the realistic German vehicle volume in Table 28:

Table 28. Realistic vehicle volume for the German sales region across CYs and VYs

CY j \ VY k	1	2	3	4	5	6
2023	100 cars	100 cars	90 cars	90 cars	80 cars	80 cars
2024	200 cars	200 cars	180 cars	180 cars	160 cars	160 cars
...	...	...	...	...	...	...
<b>Sum</b>	1.200 cars	1.200 cars	1.080 cars	1.080 cars	960 cars	960 cars

The rows in Table 28 present the vehicle deterioration across the various VYs, which also affect the absolute bookings. Considering the same values for the specific and total take-rate of subsection 4.4.4.2, the following “realistic” absolute bookings  $rAB_{j,k}$  result in:

Table 29. Realistic absolute bookings for the German sales region across CYs and VYs

CY j \ VY k	1	2	3	4	5	6	Sum
2023	1,5 cars	4,5 cars	4,05 cars	2,7 cars	0,6 cars	0,6 cars	13,95 cars
2024	3 cars	9 cars	8,1 cars	5,4 cars	1,2 cars	1,2 cars	27,9 cars
...	...	...	...	...	...	...	...
<b>Sum</b>	18 cars	54 cars	48,6 cars	32,4 cars	7,2 cars	7,2 cars	167,4 cars

For example, the realistic absolute booking value  $rAB_{j,k}$  for a vehicle in the German sales region regarding CY 2024 and the third VY can be calculated as follows using Table 29:

$$rAB_{2024,3} = rVV_{2024,3} \cdot TR_{2024,3} \cdot TR_{FoD,total} = 180 \text{ cars} \cdot 30\% \cdot 15\% = 8,1 \text{ cars}$$

Ultimately, the decline relating to the feature booking quota occurs in the remaining sales regions as well, leading to a reduction in the  $CM_{Opt.B}$  and  $NPV_{Opt.B}$ , which now result in:

$$CM_{Opt.B} \approx 363.165\text{€}$$

$$NPV_{Opt.B} \approx 286.617\text{€}$$

### 4.5.3 Yearly FoD Bookings

Next to the FoD lifetime upgrade, it should also be possible to book FoD for just one year. Several OEMs that offer FoD already provide a flexible runtime on a yearly basis, such as the AUDI AG (2024). Regarding the modification of our basic model, Option A remains unchanged, while Option B differs. This is because we must consider income streams from the annual FoD bookings. We assume a constant price  $P_{FoD(yearly)}$ , which does not decrease over the VYs, as this price does not refer to  $P_C$  and therefore the FoD price variation factor  $X$  holds no further influence. While the other formulas mentioned previously remain unchanged, yearly bookings affect the regional FoD contribution margin  $CM_{FoD,i}$ . The respective formula changes to:

$$CM_{FoD,i} = RF_{FoD} \cdot \left( \sum_{k=1}^l \left( \sum_{j=RY}^m AB_{j,k} \cdot (P_{FoD,k} + P_{FoD(yearly)}) \right) \right) - 2 \cdot TR_{FoD,total} \cdot \sum_{j=RY}^m VV_{1,j} \cdot TC_{FoD}$$

For example, regarding Option B, we reduce the total FoD take-rate  $TR_{FoD,total}$ , which indicates the permanent acquisition of a function. This is primarily due to the greater flexibility resulting from the annual FoD bookings. As a result, the value can now be assumed as follows:

$$TR_{FoD,total} = 10\%$$

With the same vehicle volume and distribution of the take-rates for all regions across CYs and VYs, we face a decline in the absolute bookings due to the lower  $TR_{FoD,total}$  for the German sales region. The adjusted values are thus lower than the previous ones in Table 23:

Table 30. Absolute bookings for the German sales region across CYs and VYs

CY j \ VY k	1	2	3	4	5	6	Sum
2023	1	3	3	2	0,5	0,5	10
...	...	...	...	...	...	...	...
Sum	12	36	36	24	6	6	120

Because the total take-rate does not influence  $CM_{Configurator}$  and  $Invest_{FoD}$ , these components remain unchanged. If all other input parameters stay identical to those of the basic model,  $CM_{FoD}$  shrinks significantly. Accordingly, the following outcome can be derived:

$$\begin{aligned}
CM_{Configurator} &= SVV_{C,Opt.B} \cdot P_C \cdot RF_C - TC_{C,Opt.B} \\
&= 1.530 \text{ cars} \cdot 600\text{€} \cdot 50\% - 153.000\text{€} = 306.000\text{€} \\
Invest_{FoD} &= -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot MC - DC \\
&= -2.040 \text{ cars} \cdot (100\% - 75\%) \cdot 100 \frac{\text{€}}{\text{car}} - 10.000\text{€} = -61.000\text{€} \\
CM_{FoD} &= \sum_{i=1}^n CM_{FoD,i} = 49.344\text{€} + 24.672\text{€} + 9.869\text{€} \approx 83.885\text{€} \\
CM_{Opt.B} &= CM_{Configurator} + Invest_{FoD} + CM_{FoD} = 328.885\text{€} \\
NPV_{Opt.B} &= \sum_{j=2023}^{2028} \frac{CM_{Opt.B,j}}{(1 + dr)^{j-2023}} \approx 259.369\text{€}
\end{aligned}$$

In addition, we must now also take into account the sources of income through annual FoD bookings. For this matter, we specify a constant yearly FoD price  $P_{FoD(yearly)}$ :

$$P_{FoD(yearly)} = 150\text{€}$$

Next, we must determine the potential  $CM_{FoD}$  over the lifetime. Therefore, we require the absolute bookings per VY for a specific region, which we assume to be identical for the lifetime and the yearly booking. In addition, the costs for the annual bookings must be reduced as well. Within the first sales region, the CM through FoD sales  $CM_{FoD,Ger}$  can be stated as:

$$\begin{aligned}
CM_{FoD,Ger} &= \\
&RF_{FoD} \cdot \left( \sum_{k=1}^l \left( \sum_{j=2023}^m AB_{j,k} \cdot (P_{FoD,k} + P_{FoD(yearly)}) \right) \right) - 2 \cdot TR_{FoD,total} \cdot \sum_{j=2023}^m VV_{1,Ger} \cdot TC_{FoD} \\
&= 59.844\text{€}
\end{aligned}$$

The CMs for the remaining sales regions are calculated in the same way and, in addition to the increased absolute value of  $CM_{FoD}$ , yield the following figures:

$$CM_{FoD,USA} = 29.922\text{€}$$

$$CM_{FoD,Eng} \approx 11.969\text{€}$$

$$CM_{FoD} = \sum_{i=1}^n CM_{FoD,i} = CM_{FoD,Ger} + CM_{FoD,USA} + CM_{FoD,Eng} \approx 101.735\text{€}$$

Finally, we are capable of calculating the profitability or CM of Option B  $CM_{Opt.B}$ , which leads to the following financial outcome:

$$CM_{Opt.B} = CM_{Configurator} + Invest_{FoD} + CM_{FoD} \approx 346.735\text{€}$$

Furthermore, considering an annual view of the  $CM_{Opt.B}$ , the following calculation for  $NPV_{Opt.B}$  can be formulated, which leads to an increase in the value of:

$$NPV_{Opt.B} = \sum_{j=2023}^{2028} \frac{CM_{Opt.B,j}}{(1+dr)^{j-2023}} = \frac{19.728\text{€}}{1,1^0} + \frac{59.456\text{€}}{1,1^1} + \frac{89.184\text{€}}{1,1^2} + \dots \approx 273.557\text{€}$$

The impact of the yearly FoD bookings is evident, as the resulting values of Option B are lower in contrast to those in section 4.4.4.2. Nevertheless, since  $CM_{Opt.B} > CM_{Opt.A}$ , as well as  $NPV_{Opt.B} > NPV_{Opt.A}$ , a preinvestment made by the OEM in FoD remains profitable.

#### 4.5.4 Economies of Scale

Regarding FoD, economies of scale must be taken into account, as OEMs can reduce costs by integrating features into every vehicle or device sold (Williams, 2017; Wiegand and Imschloss, 2021; Garbas *et al.*, 2022). In terms of financial benefits, researchers repeatedly address the positive impact and potential cost savings achieved through economies of scale in a business environment (e.g., Chun-Che Huang and Kusiak, 1998; Doucette and Grover, 2000). Facing our decision-support model, an increased vehicle volume with identical features would most likely lead to previously unrecognized cost advantages. However, the phenomenon of economies of scale only applies to hardware-based FoD, as software-based functions do not incur significant procurement and installation costs. Moreover, the effects likely differ between FoD industries.

Regarding Option A, all values remain unchanged, as features are only installed for customers who have ordered them through the configurator. However, because the entire vehicle range is already equipped with a specific function in Option B, the total costs per car must be reduced when economies of scale are considered. For our model, we assume an economy of scale factor  $EcS$  [0,1]. The amount of the latter depends on the observed vehicle volume and linearly reduces the material costs incurred. Ultimately,  $EcS$  leads to different formulations of the previous formulas from section 4.4.4.1, which now result more clearly in:

$$TC_{C,Opt.B} = SVV_{C,Opt.B} \cdot (MC - MC \cdot EcS)$$

$$CM_{Configurator} = SVV_{C,Opt.B} \cdot P_c \cdot RF_C - TC_{C,Opt.B}$$

$$Invest_{FoD} = -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot (MC - MC \cdot EcS) - DC$$

Because economies of scale do not influence  $CM_{FoD}$ , as billing and warranty costs are not addressed, we can calculate  $CM_{Opt.B}$  and  $NPV_{Opt.B}$  as usual, making use of  $CM_{Opt.B,j}$ :

$$CM_{Opt.B} = CM_{Configurator} + Invest_{FoD} + CM_{FoD}$$

$$NPV_{Opt.B} = \sum_{j=RY}^m \frac{CM_{Opt.B,j}}{(1+dr)^{j-RY}}$$

In the following example, we assume an economy of scale factor of  $EcS = 5\%$ . While the total costs for Option A remain unchanged, we face the following outcome for Option B:

$$TC_{C,Opt.B} = SVV_{C,Opt.B} \cdot (MC - MC \cdot EcS) = 1.530 \text{ cars} \cdot 95 \frac{\text{€}}{\text{car}} = 145.350\text{€}$$

$$\begin{aligned} CM_{Configurator} &= SVV_{C,Opt.B} \cdot P_c \cdot RF_C - TC_{C,Opt.B} \\ &= 1.530 \text{ cars} \cdot 600\text{€} \cdot 0,5 - 145.350\text{€} = 313.650\text{€} \end{aligned}$$

$$\begin{aligned} Invest_{FoD} &= -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot (MC - MC \cdot EcS) - DC \\ &= -2.040 \text{ cars} \cdot 25\% \cdot 95 \frac{\text{€}}{\text{car}} - 10.000\text{€} = -58.450\text{€} \end{aligned}$$

$$\begin{aligned} CM_{Opt.B} &= CM_{Configurator} + Invest_{FoD} + CM_{FoD} \\ &= 313.650\text{€} - 58.450\text{€} + 125.827\text{€} \approx 381.027\text{€} \end{aligned}$$

$$NPV_{Opt.B} = \sum_{j=2023}^{2028} \frac{CM_{Opt.B,j}}{(1 + dr)^{j-2023}} \approx 300.815\text{€}$$

Economies of scale effects that reduce the material costs of Option B result in an enlargement of  $CM_{Opt.B}$  and  $NPV_{Opt.B}$ . The choice is in favor of Option B, as  $CM_{Opt.B} > CM_{Opt.A}$ , as well as  $NPV_{Opt.B} > NPV_{Opt.A}$ . Economies of scale can therefore influence a recommended action, as a cost reduction for Option B occurs. Please note that exponential modeling using learning curves display a further way to successfully model the effects of economies of scale. An increase in vehicle volume would then lead to an exponential decline in the material costs.

#### 4.5.5 Headroom

Across different industries, software is becoming increasingly important for a series of new technological developments. For example, facing the automotive sector, a transformation from hardware to software defined vehicles is clearly noticeable (Wucher *et al.*, 2019; Plaß *et al.*, 2020). Facing FoD, the activation of software upgrades requires an initial upfront hardware investment to manufacture a base product with memory and logic capacities so that future customer offerings can be enabled. Accordingly, to ensure the effective upgradability between the various electronic control units (ECUs) in a product, a so-called headroom (HR) is required.

The HR terminology can be understood as the storage and software capacity in ECUs, which ensures that a product can be continuously upgraded. Using the term “effectiveness gap”, Rothery *et al.* (2017) first developed the concept of HR analysis. HR assigns a significant role in NPD decisions, as Girling *et al.* (2015) notice, and also for the planning of software or storage capacity (Bjarnason, Wnuk and Regnell, 2010; Trovao, 2020). Because new functions demand additional memory and computing power, a reserve of memory and processors must be provided for the ECUs. A conflict arises because the required HR is not known at the start of production (SOP). Accordingly, additional material costs for the enablement of FoD must be incurred for the implementation, given that more storage space is essential to ensure the respective product upgradability. This understanding successfully enables the introduction of ongoing innovations from software OEMs as part of updates and the rapid introduction of new features (Huppertz and Kracht, 2022). For additional insights, we refer to section 2.4.1.1.4.

We examine the HR conflict through additional required material components. First, we must distinguish between different material costs, as FoD now demand a supplementary HR component. We assume that larger costs apply for Option B to ensure the implementation of FoD. However, these costs would continue to have a negative influence on  $NPV_{Opt.B}$ . The costs for Option A remain unchanged, as only ordered functions are installed and no HR exists. Assuming a headroom factor  $hr$  [0,1] of 10% for the material costs, the output follows as:

$$MC_A = MC = 100 \frac{\text{€}}{\text{car}}$$

$$MC_B = MC \cdot (1 + hr) = 100 \frac{\text{€}}{\text{car}} \cdot 1,1 = 110 \frac{\text{€}}{\text{car}}$$

Regarding our previous stated calculation, while the final results for Option A remain unchanged,  $CM_{Opt.B}$  and  $NPV_{Opt.B}$  significantly decrease to the following values:

$$CM_{Opt.B} \approx 350.427\text{€}$$

$$NPV_{Opt.B} \approx 276.492\text{€}$$

#### 4.5.6 Sustainability

A sustainable brand appearance is crucial, as FoD depend on investments and installations of features to ensure configuration flexibility. This may result in unused features if a consumer is not interested in the purchase. The issue is particularly relevant for hardware FoD, especially in terms of varying installation rates, as the integration of additional hardware into products can appear wasteful (e.g., Arkes, 1996). It is not surprising that BMW has already discontinued its hardware FoD due to the low acceptance rate among customers (Greis, 2023). Likewise, citing Schaefers et al. (2022), software FoD are often considered to be the fairer alternative.

A two-sided argument regarding the sustainability issue is observable. Garbas et al. (2022) note that the integration of hardware into devices that consumers do not use is harmful to the environment. Furthermore, a significant weight gain due to the hardware components, the associated increase in emissions, and the processing of unused modules argue against the sustainability. Conversely, reusable FoD could lengthen product lifecycles, as customers could modify their products. This aspect, which also results in fewer variants, is in favor of the FoD sustainability. In contrast to Garbas et al. (2022), we take the entrepreneurial perspective and question what impact hardware FoD hold on the environment and how OEMs justify them. We hence analyze the net environmental effect to recognize if hardware FoD are justifiable.

We state a modified version of our model, which considers the negative environmental impact of Option B. As the FoD sustainability disadvantages outweigh the advantages, we only consider this scenario. A distinction must be made between software and hardware FoD, as software has a minor impact on sustainability. The inclusion of a coefficient for sustainability deficiencies must be integrated into the process step relating to  $Invest_{FoD}$ , as the percentage of customers who do not activate a function is taken into account. We modify the formula to:

$$Invest_{FoD} = -TVV \cdot (100\% - IR_{C,Opt.B}) \cdot (MC + MC \cdot sf) - DC$$

The revised formula contains the sustainability factor  $sf[0,1]$ . The magnitude of this factor should be greater if certain FoD hold a large hardware component (e.g., seat heating). For example, assuming a sustainability factor  $sf$  of 30%, we obtain the reduced result of:

$$Invest_{FoD} = -2.040 \text{ cars} \cdot 25\% \cdot 130\text{€} - 10.000\text{€} = -76.300\text{€}$$

$$CM_{Opt.B} \approx 355.527\text{€}$$

$$NPV_{Opt.B} \approx 280.546\text{€}$$

#### 4.5.7 Real Options

We are now investigating ROs, which we have already previously mentioned in 4.2.4. ROs are the result of business flexibility and provide room for maneuver when making decisions related to investment projects. OEMs can decide whether to make expansion investments, to scale back, or abandon processes. By these means, ROs can capture the dynamics of active management, which are not explicitly considered in traditional cash flow models. They also embody the added value that emerges from flexible investment decisions (Wouters, Workum and Hissel, 2011; Mondello, 2022). Most available use cases range from NPD projects (Huchzermeier and Loch, 2001; Ford and Sobek, 2005) to infrastructure projects (e.g., Athwal, Harmantzis and Tanguturi, 2010) and telecommunication approaches (e.g., Gil, 2007), to the energy sector (e.g., Fernandes, Cunha and Ferreira, 2011). Within these settings, ROs are often applied as a decision-support tool (e.g., Lint and Pennings, 2001). This is because NPD decision-makers deal with uncertainties in their investments (Davila, 2000) and project abandonment represents a popular strategy for managing poor portfolios (Klingebiel and Adner, 2015).

Their presence in research makes us believe that ROs represent an interesting line of attack for FoD, as ROs can value flexible product options (Banerjee and deWeck, 2004). We perceive the necessity for managerial flexibility within the manifestation of innovative BMs as a critical success factor (Richter, Sadek and Steven, 2010). In today's competitive environment, flexibility is essential for responding to changing customer needs. However, the appliance of RO models to decide on FoD investments requires many steps to adapt to economic situations.

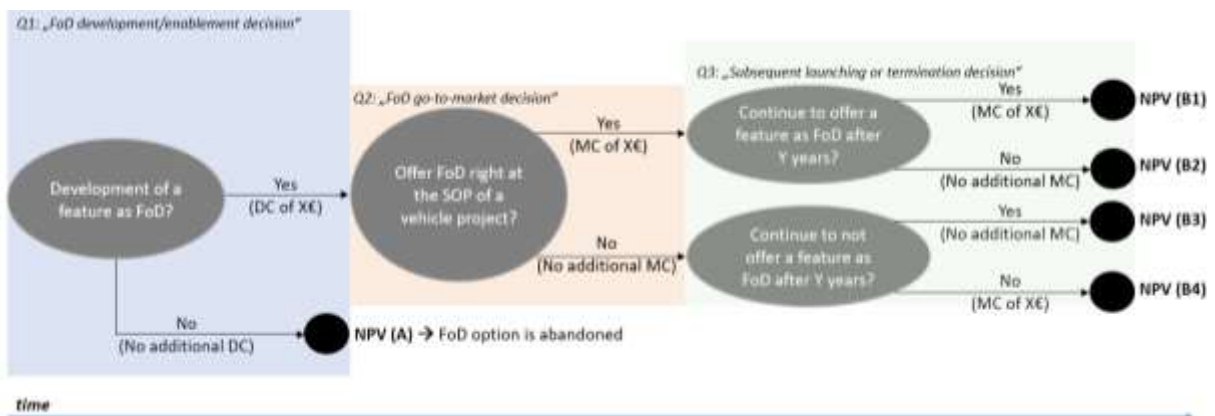


Figure 30. An approach to modeling FoD with ROs

In the following, we introduce an initial approach to modeling FoD using ROs, as also represented in Figure 30. For this matter, we will discuss a detailed three-part decision-making process on the part of an OEM to demonstrate the increased flexibility. Our example contains elements from option pricing theory and is based on the NPV methodology. A number of suggestions influenced our approach, mainly from the publications by Liu et al. (2017), De Reyck et al. (2008), Arnold et al. (2022), Girling et al. (2015), and Mondello (2022).

First, an OEM must decide whether a particular function should be developed as FoD, which is referred to as the *“FoD development/enablement decision”*. If an OEM rules out this opportunity, a function is exclusively offered in the configurator, and no development costs occur. This corresponds to Option A presented earlier. However, all events that relate to FoD, formerly known as Option B, are now offset in time. We hence assume that the development and material costs associated with implementing a feature as FoD are not incurred simultaneously. Only when an OEM decides to develop features as FoD does the company gain access to more meaningful figures at a later stage. As an example, after the development costs have been paid, the feature take-rate and customer acceptance will be accessible to the OEM. This supposition also reflects the previously mentioned flexibility aspect of ROs.

With the information provided, an OEM can decide in the *“FoD go-to-market decision”* whether FoD should be offered directly at the SOP of a vehicle project. Material costs are incurred only when FoD are launched on the market. This allows the OEM to defer further financial investments in FoD, as acceptance rates and comparable customer-related metrics are more predictable at this stage. This could be the case, for example, if the development of a feature leads to certain errors or if the expected NPV does not meet the firm's expectations. Accordingly, the increased flexibility can save an OEM from having to pursue the second investment. This is because there are no material costs for vehicles that have not already been equipped with a specific function. However, the avoidance of the auxiliary FoD investments must still consider the development costs of the first stage.

Ultimately, the OEM faces the *“Subsequent launching or termination decision”*. The assessment of whether a particular function within the configurator or as FoD was successful ultimately offers various possible actions. Whenever a feature proposal has led to a financial success, it is possible and advisable to continue offering it also as FoD. Therefore, the deferral of the initial investment and the ability to terminate or initiate a FoD investment represent promising approaches for the OEM, as they offer greater flexibility.

Because a consumer's WTP for FoD is subject to considerable uncertainty, further approaches could be explored. Citing Wouters et al. (2011), a more detailed examination of probability distributions and the implementation of various ROs models could provide more insights for modeling uncertainties. Therefore, next to the Black-Scholes method or binomial modeling, multi-objective or Pareto optimizations could deliver an additional value for OEMs.

#### 4.5.8 Summary

Considering our decision-support model for FoD and the inclusion of possible extensions, the overall process is summarized in Figure 31. The italic input factors supplement our basic model. Although we understand these factors in terms of the input, they have a direct impact on the output. More differentiated input parameters can be perceived as a general input parameter. Product deterioration and yearly FoD bookings affect the input parameters of Option A and B. Economies of scale are considered for Option B and only impact input costs. Likewise, the sustainability and the HR issue can be named in these regards. Meanwhile, ROs influence all stated input parameters. Summarized, we have only included a limited range of potential improvements to our decision-support model for FoD. Hence, we refer to a series of further interesting research areas and possible improvements within the last section 4.6.2.

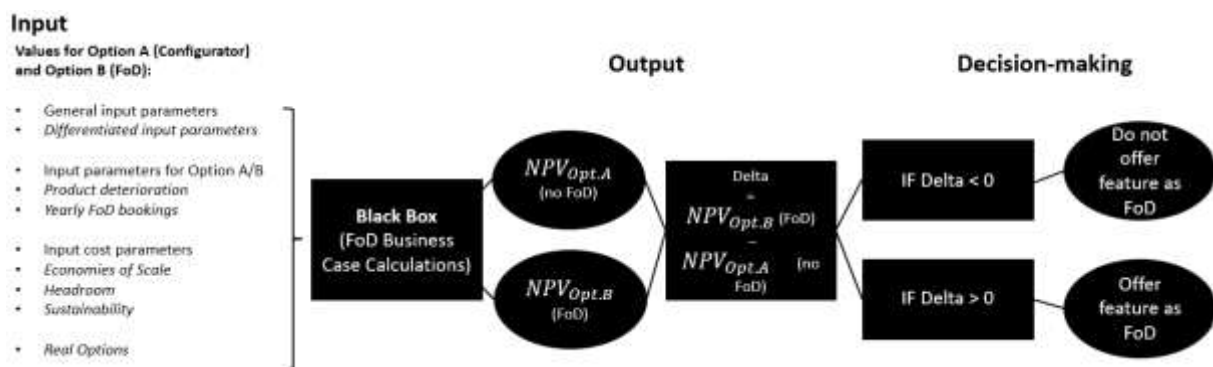


Figure 31. Possible FoD decision-support model extensions

#### 4.6 Conclusion

Engineers and managers establish a product's functionalities, ergonomics, and production during the NPD process. Ultimately, the outcome created within these instances leads to the result that the decisions taken by the development teams obtain significant and far-reaching consequences. Accordingly, NPD measures affect businesses and their economic success in the same way that they generate long-term, profitable returns on financial investments. To successfully maximize the potential of their employed PAs, OEMs must furthermore recognize and anticipate the impacts of their actions related to their projects and companies (Windheim *et al.*, 2016). By these means, an explicit defined PA is of great significance for the continuous creation of future product adaptations, even if this may be highly time-consuming (Gil, 2007).

Our study delivers a decision-support model for evaluating the inclusion of FoD in the PA from a financial perspective. We first provided an overview of the general implications that FoD obtain on the product development process and the PA. We also included the OEM's perspective and observed how decisions are made within general PA models. After presenting our methodological research method, we stated various assumptions and hereinafter the first decision-support model for FoD. In the same manner, we provided an example and evaluated possible decision-support model extensions. As of today, we are the first authors who faced the topic from a scientific perspective. We delivered a series of contributions, as most current knowledge on FoD focuses on marketing insights and how customers respond to this new BMI.

#### **4.6.1 Contributions to Theory**

Since decision-making in the field of FoD has not yet been widely studied and there is no model that describes the financial trade-offs, our work contributes to the field of FoD research and successfully refers to the management perspective. The metrics for the assessment of the two PA decisions can be perceived as our first intellectual contribution. However, these figures do not only correspond to the overall structure of comparable models but are specifically tailored to FoD. As a result, we successfully tackled the subject from a financial perspective by presenting a FoD model in the context of PA decisions. Previous decision-support models, such as by Plaß et al. (2020), observe FoD from a rather superficial standpoint, as the authors solely compare different offer structures. Meanwhile, the creation of our industrial FoD approach sets itself apart and is able to successfully answer our initially stated research question:

*“How should a mathematical decision-support model for investment decisions be structured in order to correctly evaluate decisions on product architectures within the framework of FoD, which oblige an OEM to make upfront financial contributions?”*

Our main contribution is to highlight the parametric decision-support model for FoD. This is because we successfully conducted the first detailed investigation of a financial FoD model, the effects on the PA, and the challenges in a management context. We also contribute to the research regarding the effectiveness of FoD investment decisions in the NPD context by incorporating a variety of financial factors into our analytical approach. As a result, the findings are especially useful for revenue estimations from OEMs in the initial stages of production. By providing possible model extensions that specify the input parameters of the two investment decisions and are able to display the critical PA ratings, we are making a further contribution.

Summarized, our methodological study provides insights and decision-making support regarding the effectiveness of applying FoD in the organizational context of PA improvements. It should be noted that our model can never be fully completed in this sense, as it will always be conceivable to perform more detailed estimates or to include additional parameters that can better forecast the financial result. Nevertheless, practitioners and researchers can gain valuable insights into the necessary input parameters and the mode layout, leading to an understanding of the conditions under which FoD display an attractive investment for OEMs.

#### **4.6.2 Limitations and Future Research**

We face several limitations, as our decision-support model is based on various assumptions and simplifications. However, we would like to point out that our outlined approach strictly requires suppositions, as these make the model more comprehensible to the reader. To begin with, it is doubtful that an OEM would perform calculations using the same assumptions we have made, as PA decisions are influenced by multiple factors, many of which cannot be easily quantified. For example, an irrational customer behavior can be mentioned. Ignoring similar qualitative factors in our model and focusing exclusively on rather plain data assumptions can lead to a distorted problem solving. These circumstances present the greatest limitation of our model. In our examined case, however, it should be mentioned that extensions, especially

across industries, are almost unlimited. Accordingly, addressing all extensions made possible by the limitations of the model would result in an almost real-life scenario. For this reason, we will now examine only a few potential improvements of our model that could be addressed by researchers to increase the level of detail. Figure 32 states a first overview of these aspects.

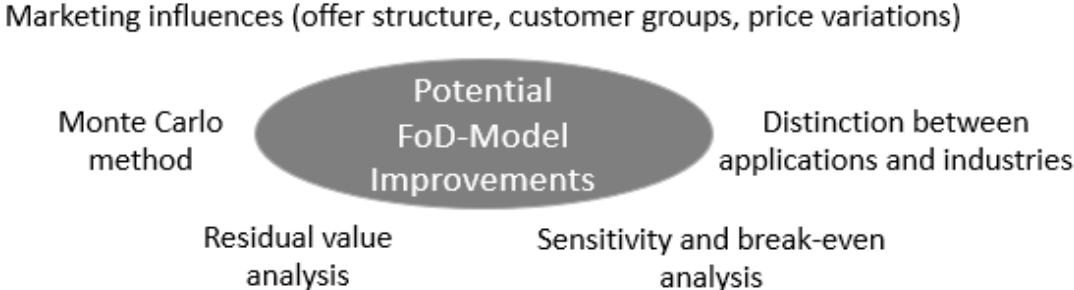


Figure 32. Possible FoD decision-support model improvements

To begin with, additional marketing influences could be considered. Next to a broader offer structure, such as pay-per-use, freemium, or pay-by-data, as also shown by Schaefers et al. (2022) and Plaß et al. (2020), it would be interesting to understand what influence different pricing models and variations have on the decision-support model. Likewise, a more complex customer structure, involving business customers or families, could increase the level of detail.

Future studies could focus on applying the model across applications and industries. Insights into the applicability of the approach may be gained and better decisions made. Since our applied method focuses on a specific PA decision, the level of detail could likewise be increased by distinguishing between the brand value and the general reputation. These factors are important since a consumer’s perception of betrayal could damage a brand’s value. Facing FoD, intangible offers are more accepted by customers than tangible offers (Schaefers, Leban and Vogt, 2022). Henceforth, a distinction between the feature take-rate could be recorded in the approach. Similarly, future studies could also concentrate on more general but interrelated PA decisions. Possible questions include whether the current product design can integrate modern technologies, or how the design could be used across product generations.

Furthermore, a sensitivity and break-even analysis could improve the decision-making. The influence of various FoD input parameters (e.g., take-rate and price) are of great interest, as a variation could affect the decision in either direction. In general, a sensitivity analysis would address the uncertainty regarding the take-rate and its correlation with the price. Based on such analysis and the existing correlation between the variables, the maximum NPV of the two options could be calculated, using optimization methods like Excel Solver. An analysis of the sensitivity at which the break-even point would be reached could follow subsequently. An OEM would then be able to review the FoD price and take-rate required to achieve a break-even point. Therefore, managers could also apply a predicted take-rate and a target break-even point to set FoD pricing more effectively. Ultimately, the outcomes of varying prices and take-rates on the NPV could also be modeled with a simulation to discover an optimal input.

The residual value analysis reveals a further potential for improvement. If a device is equipped with FoD, this will most likely result in a higher residual value on the used market. It can hence be assumed that the consistent FoD introduction will lead to rapid changes on the secondary car market. In general, FoD would simplify the selection of a used vehicle that suits personal needs by reducing the hardware variety options and allowing the adding of features. Likewise, software FoD that are available after the market launch could also result in recurring revenues. Accordingly, the possibility of retrofitting a worn-out vehicle makes FoD significantly more attractive due to a higher residual value (Wucher *et al.*, 2019). In the same manner, this also affects OEMs, as products with a higher financial residual value would similarly justify the advanced prices of new products. It is surprising that this approach has been explored only superficially in current research (Quak, Nesterova and Van Rooijen, 2016; Fallahi *et al.*, 2023), which is why we will not deliver potential model improvements, but rather create an incentive for researchers. In either way, the modeling of the residual value likely presents a challenging undertaking for a decision model, as the effects of the used values are difficult to predict.

Our model could also be expanded by the Monte Carlo method. The approach has been applied by several authors over the past years (e.g., Cheah and Liu, 2006; Fernandes, Cunha and Ferreira, 2011; Wouters, Workum and Hissel, 2011; Nadarajah, Margot and Secomandi, 2017). In general, the Monte Carlo method would offer a great potential for incorporating the uncertainty aspect into our currently rather static decision-support model, as various input parameters still cannot be estimated accurately. This is because the approach could consider a variety of real-world conditions, such as complex decision rules next to links between the option value and the underlying asset, while being less computationally intensive (Fernandes, Cunha and Ferreira, 2011). The improvements over the basic decision-support model would be clearly noticeable, as instead of a single point estimate, a specific estimation range could be specified. Due to the uncertainty surrounding feature enhancements after a product is sold, this rough estimate, which considers various influencing factors such as price and acceptance rate, could be of immense value. In most scenarios, previous decisions would be reviewed and, if necessary, measures would be taken to turn FoD into the more attractive option.

Ultimately, we conclude that the selection of PA decision-support models should always be clearly guided by the specific characteristics of the development problem at hand. However, it becomes obvious that researchers have almost unlimited opportunities to expand on the basic model we have provided and could deliver endless valuable insights. Therefore, in addition to the improvements listed, we would also like to call for the FoD decision-support model to be evaluated in various industries, such as consumer electronics. In this way, we hope to encourage scientists to expand our basic decision-support model and implement the proposed improvements so that the FoD potential can be better predicted. Nevertheless, as further suggestions come to mind, the model will probably never result in a final formulation.

## 5 Conclusion

Due to significant changes in various areas of technology, original equipment manufacturers (OEMs) must adjust their strategic orientation to remain competitive. This creates unexpected complexity in the areas of development, production, and customer service. Even traditional companies that focus on “real goods” find themselves at the forefront of the digital revolution and its challenges. Moreover, there are new competitors and a shift in customer preferences, with access to products and services becoming more important than ownership. OEMs are hence forced to digitize their operations to make them more customer-centric and automate repetitive tasks. In such an environment, regular updates also put considerable pressure on the development and life cycle processes of cross-industry OEMs (Wucher *et al.*, 2019). Smart connected products that enable digital functions are likely to represent the next major step in the development of physical products (Plaß *et al.*, 2020; Schaefers, Leban and Vogt, 2022). In this context, we introduced the Functions on Demand (FoD) business model innovation (BMI).

This Chapter 5 provides a summary of our dissertation, highlighting the contributions, outlining our shortcomings, and stating future research possibilities. Our research objective was to improve the comprehension of the financial FoD management. As part of a three-year research project in cooperation with an automotive OEM, we were able to conduct three studies to gain insights about FoD. We provided a systematic literature review, a case study, and a methodological study to examine the uncertain decision-making process faced by OEMs.

The systematic literature review on FoD delivers diverse insights. First, we define the FoD terminology in the context of the access economy, on-demand services, and connectivity, as the available definitions of FoD are incomplete and contradictory (e.g., Garbas *et al.*, 2022; Schaefers, Leban and Vogt, 2022). Subsequently, our search delivered 50 publications related to FoD. We classify these results to four categories: FoD-related business models, customer perceptions and responses to FoD, payment processes and offering structure for FoD, and implications for OEMs applying FoD. With regard to the first cluster, next to general findings on FoD, we compare FoD to related concepts such as add-on features and modular upgradable products. By doing so, our contributions become visible, as we propose a distinct classification of FoD, conduct the first FoD literature review, and open up future research possibilities.

In the case study, we combine FoD with a broader background knowledge about BMIs. Alongside Dhebar (2023), we are among the first authors to define FoD in this way. By stating current research insights, we set our focus on the financial challenges that OEMs face when implementing BMIs and FoD specifically. Moreover, we analyzed the FoD BMI in the everyday work of the automotive company. We hence examined various sources over a period of three years, including expert interviews and company data such as protocols, e-mails, and similar that accompanied the OEM. Finally, we reveal three major financial challenges for a successful BMI implementation. These are estimating financial key performance indicators, introducing

a financial decision-support model, and making a decision on whether a BMI should be initiated or not. We also find six more general challenges. Summarized, we contribute to the literature in that we highlight challenges in implementing BMIs based on findings from a case study conducted over an extended period. Likewise, we identify numerous opportunities for future research, as there is a need to examine different BMIs, process steps, and industries.

The last study deals with a methodological approach to the decision-making problem when offering FoD. This builds on the previous chapters, which highlight FoD decision-making from an OEM's financial perspective as a critical implementation challenge. Starting, we give a comprehensive knowledge on the topic of product architecture (PA) and how the decision-making process can be modeled in such instances. We also analyze in which PA set-ups OEMs are affected by the FoD application. After stating model assumptions, we deliver our approach for the financial application by OEMs. Our decision-support model can determine whether features should be offered as FoD or exclusively in the car configurator. Accordingly, the model offers a management support of whether an investment in FoD is financially ambitious. We likewise provide a numerical example, model enhancements, and future research directions.

Just as any study, our dissertation reveals limitations. Since study-specific limitations have already been discussed in the main chapters, we now focus on more general limitations. Due to the research design and the novelty of the subject, we cannot ensure that we only refer to high-quality results in the literature review. The biggest limitation of the case study is the possibility of bias due to the researcher's involvement in the company. Furthermore, there are limitations to the qualitative case study that stem from the research design, as only one case during a specific period is observed. It can be challenging to generalize across different industries and BMIs, as the results regarding individual cases may be based on distorted qualitative data or on subjective interpretations. The methodological background of the last study could highlight errors in the assumptions of the variables, as no comparable decision-support models are given. Therefore, the conclusions cannot be automatically transferred to other industrial settings. Despite the drawbacks, our dissertation states valuable contributions to the FoD research environment through its in-depth examination in financial management.

The research findings open possibilities for more insightful investigations. First, we note that there is a lack of field research in the literature that provides practitioners and scholars with significant insights into the FoD implementation. Further research approaches and case studies regarding FoD in an industrial environment could contribute to a better understanding of this issue. To gain more understandings regarding the customer perceptions and offering structures of FoD, it would be helpful to observe the operationalization level of FoD in cost management during the development process. We also assume that one of the many focuses of future FoD research could be the financial decision-making. Therefore, we propose expanding the scope of the research field by examining other influencing factors and different organizational conditions in order to ensure the transferability of our stated results.

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# Appendix 1: Experteninterviews

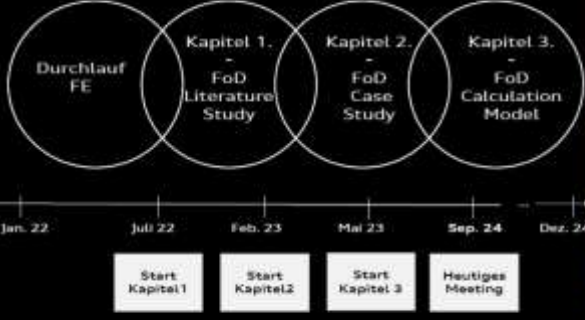
Herausforderungen und Notwendigkeiten für die Implementierung eines innovativen Geschäftsmodells (FoD) 

- Experten Interviews -



Ingotstadt | 09/2024 | Herausforderungen für die Implementierung innovativer GoMox (FoD) – Experten Interviews


01 Aufbau meiner Doktorarbeit



Jan. 22      Juli 22      Feb. 23      Mai 23      Sep. 24      Dez. 24

Durchlauf FE      Kapitel 1. - FoD Literature Study      Kapitel 2. - FoD Case Study      Kapitel 3. - FoD Calculation Model

Start Kapitel 1      Start Kapitel 2      Start Kapitel 3      Heutiges Meeting



Ingotstadt | 09/2024 | Herausforderungen für die Implementierung innovativer GoMox (FoD) – Experten Interviews

01 Sören Jaedeke @ AUDI Doktorandenprogramm



Geboren am 25.04.1996, Lößecker Buch

- Studium: B.Sc. Wing (Universität Hamburg), AUB Beirut, M.Sc. Wing (KIT).
- Berufliche Erfahrungen: Praktika in der Medizintechnik/ Automobilindustrie, Werkstudent in strategischen Management-Holding und Institut für Produktionstechnik.
- Was treibt mich an: Meinen Teil zu der Mobilität von Morgen mitzugestalten.
- Welche drei Dinge sollte man über mich wissen: Direkt, emphatisch, zielstrebig.
- Bei unbegrenztem Budget, welchen Audi würde ich mir kaufen: R8.

➤ Ich habe mich für das Audi Doktorandenprogramm entschieden, weil...

...sich in den nächsten Jahren die Automobilindustrie grundlegend ändern wird und ich ein Teil dieser Transformation sein möchte. Zusätzlich habe ich mich bei meinen Betreuern (Audi u. Universität) sehr gut aufgehoben gefühlt.

➤ **Projekttitle:** Functions on Demand (FoD) bei der FE-55 (seit Juni 2022).

➤ **Partneruniversität:** KIT Karlsruhe.

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02 Grundwissen zu Geschäftsmodellinnovationen (z.B. FoD)

- FoD werden bei Audi unter der Geschäftsrubrik „neue Geschäftsmodelle“ aufgefasst.
- Im literarischen Bezug nähert sich diese Begrifflichkeit den Geschäftsmodellinnovationen (BMI) an.

- BMI fördert die Innovation des gesamten Geschäftsmodells einer Organisation, um kundenorientiert zu werden. Es identifiziert die menschliche Beteiligung an und die Interaktion mit kundenspezifischen Produkten entsprechend den spezifischen Bedürfnissen des Kunden als Kernaktivität des neuen Geschäftsmodells (Steenkamp and Arnoldi-van Der Walt, 2004).
- Innovation wird zum BMI, wenn zwei oder mehr Elemente eines Geschäftsmodells (Kunde, Nutzen, Wert, Partner, Finanz) neu erfunden werden oder einen bestimmten Wert auf eine neue Art und Weise liefern, was die Notwendigkeit einer kontinuierlichen Weiterentwicklung eines Geschäftsmodells für eine verbesserte Wertgrundlage aufzeigt (Lindgarth et al., 2012).
- **Beispiel:** Nespresso Kaffeekapseln oder Ikea's Ausrichtung Möbel vom Kunden selbst zusammen bauen zu lassen.



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### 03 Art und Ziel des Interviews

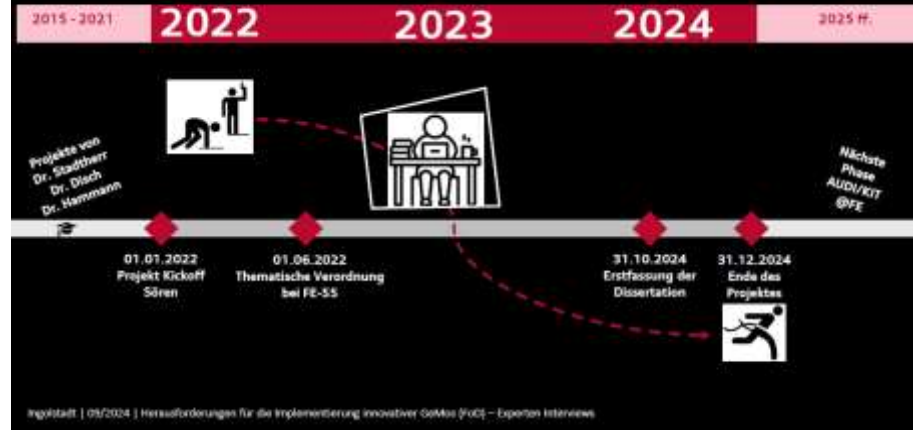
- **Thematik:** Geschäftsmodellinnovationen (z. B. FoD) und deren finanziellen (!) Herausforderungen bei der Implementierung.
- **Zweck:** Ein besseres Verständnis und Umgang von DEMs bei der Einführung von Innovationen im Geschäftsumfang und dem Beitrag zur Literatur.
- **Aufbau:** Semistrukturiert, da es sich vielmehr um eine Diskussion unter vier Augen als reine Frage-Antwort handelt. (Abschweifen ist erwünscht).
- **Dauer:** ca. 50 Minuten.
- **Teilnahme:** per MS Teams.
- **Aufzeichnungen:** Keine Video- und Tonaufzeichnungen.



Gibt es Fragen?

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### 05 Ausblick meiner Doktorarbeit



### 04 Das Experteninterview

- Vor welchen finanziellen (!) Entscheidungen, Herausforderungen und Anforderungen steht ein OEM, für die erfolgreiche Umsetzung einer Business Model Innovation (z.B. FoD)?
- Warum werden BMI (wie FoD) seitens der Unternehmen oft finanziell (!) überbewertet?
- Was macht es so schwer mögliche Umsätze und Kosten von BMI hervorzusagen und wie kann das verbessert werden?
- Wie muss ein Business Case für BMI im Unternehmen finanziell (!) berechnet werden?
- Was sind weiche Faktoren, welche für den finanziellen (!) Erfolg von BMI notwendig sind?



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## Appendix 2: Eidesstattliche Versicherung

Sören Jaedeke  
Pönitzer Chaussee 16f  
23683 Scharbeutz

gemäß § 13 Abs. 2 Ziff. 3 der Promotionsordnung des Karlsruher  
Instituts für Technologie für die KIT-Fakultät für Wirtschaftswissenschaften

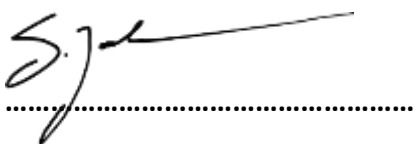
1. Bei der eingereichten Dissertation zu dem Thema

*The Financial Management of Functions on Demand:  
A Study on the Application of Functions on Demand as a Recent Business Model  
Innovation in the Automotive Industry*

handelt es sich um meine eigenständig erbrachte Leistung.

2. Ich habe nur die angegebenen Quellen und Hilfsmittel benutzt und mich keiner unzulässigen Hilfe Dritter bedient. Insbesondere habe ich wörtlich oder sinngemäß aus anderen Werken übernommene Inhalte als solche kenntlich gemacht.
3. Die Arbeit oder Teile davon habe ich bislang nicht an einer Hochschule des In- oder Auslands als Bestandteil einer Prüfungs- oder Qualifikationsleistung vorgelegt.
4. Die Richtigkeit der vorstehenden Erklärungen bestätige ich.
5. Die Bedeutung der eidesstattlichen Versicherung und die strafrechtlichen Folgen einer unrichtigen oder unvollständigen eidesstattlichen Versicherung sind mir bekannt. Ich versichere an Eides statt, dass ich nach bestem Wissen die reine Wahrheit erkläre und nichts verschwiegen habe.

Karlsruhe, den 23.03.2026



(Sören Jaedeke)