

From Value Chain to Recurring Value Creation – Challenges in the Automotive Industry

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KEYWORDS	ABSTRACT
Automotive industry Digital value loop Value creation Value capture Case study	The automotive sector has undergone a major digital transformation over the last few years, from a hardware-centered to a software-centered industry. An important part of this shift is moving from one-time sales, enabled by Porter’s value chain, to recurring sales and value generation through a digital value loop. Using a case study approach, this essay analyzes what technical, organizational, and structural factors prevent legacy automotive manufacturers from enabling recurring, real-time value creation, drawing on Volkswagen (VW) as the primary case and Tesla as a benchmark. Applying Yoo’s (2023b) digital value loop concept, this essay argues that these companies face three critical barriers. Technically, VW is constrained by sensing capabilities designed for diagnostics rather than behavioral insights, which limit the loop’s depth. Organizationally, dealer and board-level incentive structures are tied to one-time vehicle sales rather than promoting long-term value creation. Structurally, the loop is constrained by non-mandatory user registration and missing direct-to-consumer relationships that prevent large-scale user entry into the loop. This essay highlights that these factors are not independent. While the technical and structural barriers constrain value creation, organizational disincentives remove pressure to resolve them.

1. Introduction

Cars are increasingly defined by their software rather than hardware, a shift commonly referred to as software on wheels (Krishnan, 2024). A related concept is the software defined vehicle (SDV), which can be defined as ‘an automotive vehicle whose core value proposition [...] is predominantly enabled, controlled, and continually enhanced by software [...]’ (Otto et al., 2025, p. 2). This has enabled digital-native newcomers such as Tesla, Inc. (Tesla) or BYD to gain substantial market shares (Focus2move & Statista, 2025; Forbes, 2025). As the product has changed, so have the business models behind it.

Digital-native car manufacturers have an inherent advantage in this, as they can build their business models without the constraints of existing partner networks. As an example, Tesla has successfully built an ecosystem characterized by a high degree of vertical integration, consisting of a direct-to-consumer sales model, a charging network, and software capabilities (Lang et al., 2021; Stolze, 2015; Teece, 2010). One key element is the establishment of a digital value loop (Yoo, 2023a), a process of constant improvement in user experience through more data, thus creating more value for the customer. Nevertheless,

legacy manufacturers have also started to digitize and servitize their product portfolio and business models and have created a more digital experience (Bolduc, 2024; Genzlinger et al., 2020). However, execution remains limited, and attention remains on the physical product.

Therefore, the essay aims to answer the following question: What technical, organizational, and structural factors prevent legacy automotive manufacturers from establishing a digital value loop?

To answer this question, the essay utilizes a case study approach examining Volkswagen Group (VW) as a legacy manufacturer while drawing comparisons to Tesla. Unless specified explicitly, VW in this essay refers to the whole group including subsidiary brands such as Audi, Porsche, or Skoda. The analysis is based on secondary data, including investor relations publications, press releases, and annual financial statements.

2. Digital Value Loop in the Automotive Industry

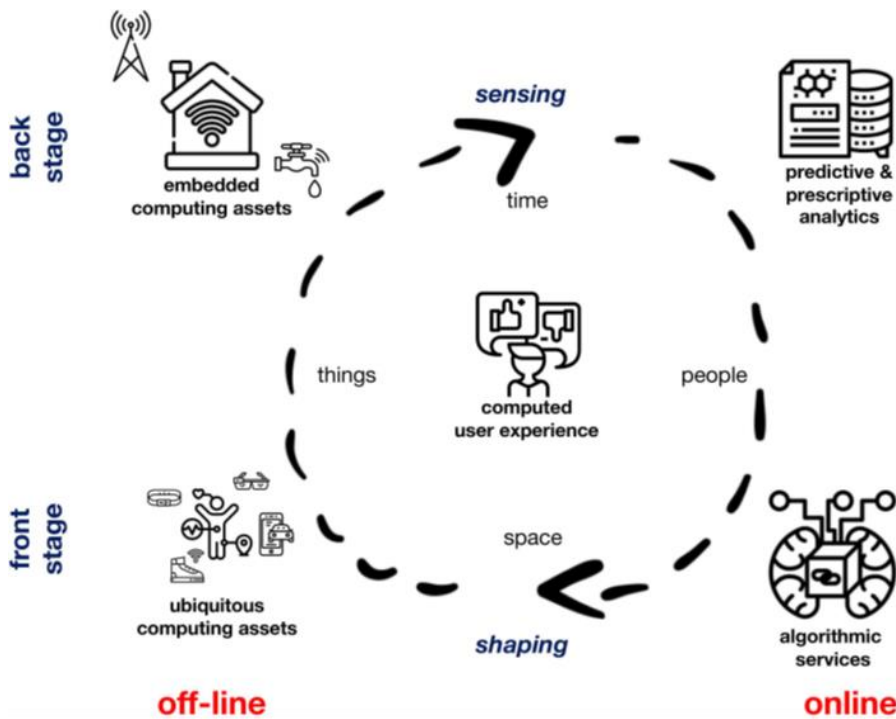
As a long-standing industry, the automotive sector is based on the value creation logic of the value chain. This model, consisting of five primary activities, describes how each step from Inbound Logistics, Operations, Outbound Logistics, Marketing & Sales, to Service creates

value in the form of a finished manufactured product. The value creation happens as soon as these activities are completed, and value is captured exclusively at the time and point of sale (Porter, 1985). All value beyond this point in time is created and captured solely by the user (Yoo & Euchner, 2020). One of the only exceptions is in the case of faults and breakdowns, in which repair, as a service activity, creates additional value.

In contrast, the concept of the digital value loop emphasizes value creation in use, in which companies utilize data and knowledge about their customers (Yoo, 2023a). Value in this model is not embedded in the purchased good but co-created by firms and users at the moment of use (Yoo, 2026).

A digital value loop consists of four activities: inferring, predicting, generating, and orchestrating. Inferring is described as using collected data to identify patterns and insights. Predicting involves forecasting trends and future events, such as customers' buying behavior. Generating focuses on creating personalized digital offerings, recommendations, or content. Lastly, orchestrating refers to the seamless coordination of the different elements to deliver an end-to-end customer experience (Yoo, 2023a). Figure 1 illustrates the Digital Value Loop and its steps.

Figure 1. Digital Value Loop (Yoo & Euchner, 2020, p. 15)



Examples from the television industry show that starting user-specific data collection becomes a challenge if customers do not set up an account (Yoo, 2025). Tesla addresses this by requiring customers to register and use the Tesla App before ordering a car. After the purchase, the vehicle is connected automatically to the user account (Tesla, Inc., 2026b). For this essay, I define ‘establishing a digital value loop’ as a two-step process consisting of the technical construction of the loop and the value capture mechanism.

The technical design of a digital value loop requires four design parameters – velocity, veracity, depth, and granularity – to become effective. Yoo (2023b) refers to velocity as the speed at which the cycle is completed, veracity as the accuracy of information, depth as the number of activities the company influences, and granularity as the level of detail the loop is able to use.

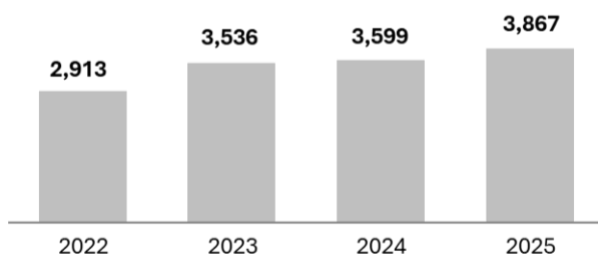
Among automotive OEMs, this essay identifies Tesla as having designed and implemented one of the most advanced digital value loops (Lang

et al., 2021), as demonstrated below through its sensing, inferring, and generating capabilities, and the value it captures through monetizing them. It senses user behavior through sensors, cameras, charging behavior, and feature utilization. Based on this data, Tesla infers patterns and insights on required maintenance before failures happen, trains autonomous driving abilities, and optimizes charging infrastructure. These insights are used to generate new features and updates that create value for the user and are integrated remotely through ‘over-the-air’ (OTA) implementation (Tesla, Inc., 2026c). OTA implementation refers to remote software updates without a physical workshop or dealer visit. This completes the loop, as more use of the car translates to better features, which leads to improved user experience.

Tesla captures value from this loop through multiple streams, such as ‘Full Self-Driving subscriptions (FSD)’ (USD 99/month¹), usage-based insurance, and pay-per-use Supercharging. By 2025, this approach generated \$3.867 billion

in deferred revenue from digital services, representing 4% of total revenue (Tesla, Inc., 2026c). Therefore, it remains a minor but increasingly important component compared to physical vehicle sales. Figure 2 shows the increase in deferred revenue over the last years from USD 2.9 billion in 2022 to USD 3.9 billion in 2025.

Figure 2. Tesla Inc. Deferred Revenue from Digital Services, 2022-2025 [USD million]



Source: Author's analysis based on Tesla, Inc. (2024, 2026c) 10-K filings

The main reason for the lower figure compared to Tesla's total revenue is that the OTA updates, as the main value loop feature, are offered for free for the first eight years (Tesla, Inc., 2026a). Value capture, thus, is included in the sales price of Tesla's models rather than sold as standalone services.

3. Volkswagen Case Study

This essay applies the digital value loop to the case study of VW. The VW Group is the largest automaker worldwide as of 2025, with USD 351 billion in revenue (Forbes, 2025). Despite its market-leading position, profits have decreased in 2024 (Volkswagen, 2025), and share price has declined steadily since 2021 from over EUR 300 to less than EUR 100 in 2026². Investors have attributed this decline to competitive disadvantages in electric vehicles (EV) and digital capabilities (Kesteloo, 2025). VW has started to address these limitations by designing models with a software-first approach. Nevertheless, the new generation of SDVs

developed together with Rivian is expected to be launched no sooner than 2027 (Volkswagen, 2025).

3.1 Technical design of the loop

The technical design of the digital value loop at VW is restricted both by failed technical implementation and by organizational constraints that prevent successful sensing and shaping cycles.

An example of these organizational constraints is the software unit CARIAD, founded in 2020 and responsible for the development of most group-wide software solutions. Its goal is to utilize scale effects by developing automated driving solutions, infotainment systems, and cloud infrastructure across brands (CARIAD, 2026). Since then, the subsidiary has been criticized for not meeting its targets, with almost the entire board being replaced in 2023. Misalignment between development processes and delays in the development of a unified software platform led to postponed launches of models at both Audi and Porsche (Muessgens & Peitsmeier, 2023; Otto et al., 2025).

Unlike Tesla's data collection capabilities, VW lacks the mechanisms to sense user behavior and generate insights for continuous improvement. While the company offers digital services with its VW Connect solution, these provide mainly remote-control features (mobile vehicle key, AC pre-setting, service planning) rather than functions enabling behavioral insights. VW's connectivity infrastructure was designed for vehicle diagnostics, not for understanding user patterns to inform product evolution. The company collects minimal behavioral data on how customers use vehicles, limiting its capacity to identify improvement opportunities or personalize experiences. Exceptions to this are the identification of crashes for the EU-wide mandatory eCall system (Volkswagen, 2026b) and in-vehicle sensing of aspects such as fueling status and location (Volkswagen, 2026a), which enable a starting point towards generative

solutions at the point of use.

In narrower application areas, VW has started to implement personalized live recommendations via its VW Connect service that identify when fuel is getting low and suggest suitable filling stations nearby. In partnership with selected retailers, VW offers discounts on coffee or snacks (Volkswagen, 2026a). However, the described sensing limitations prevent far greater personalization and more detailed shaping. A more granular digital value loop would consider personal preferences based on the stations or shops a driver usually goes to and recommend a coffee stop when driving behavior suggests tiredness or when a user's typical coffee time arrives. Access to the existing recommendations and services is restricted to users with a 'Volkswagen ID' and a VW Connect contract, resulting in a major barrier to establishing a comprehensive value loop (Volkswagen, 2026b). VW's OTA update functionality remains limited to bug fixes rather than improvements or new functions. Even the Audi Q6 e-tron, arguably one of the most digitally advanced models, remains insufficient for value loop creation. It is built on the newest Audi and Porsche joint electric vehicle platform called 'Premium Platform Electric' (PPE) and Android Automotive infrastructure (AUDI AG, 2025). Users mention that certain updates still require a physical visit to the dealer, and certain features are not available for the previous season's model (e-tron Forum, 2025). According to a Digital Lifecycle Management professional at Audi, the company's current software strategy focuses on ensuring customers 'receive new OTA updates at regular intervals', with ambitions to create 'personalized digital user experiences that go far beyond classic software updates', characterized as long-term goals (Schupritt, 2025, author's translation).

Consequently, I argue that VW's loop can fundamentally be described as incomplete. Its 'velocity' is reduced due to infrequent updates

that occasionally still require a visit to the dealer. The 'depth' is limited to very narrow use cases, such as fueling-related recommendations, and the 'granularity' is restricted, as it does not make use of most sensing opportunities. The 'veracity' is likely the most advanced component, as all features seem to be based on reliable data sources.

Further, an analysis of related keywords between Tesla's 10-K filing and VW's Annual Report shows that recurring value creation receives less management attention at VW than at Tesla. While Tesla frequently mentions OTA, full self-driving, connectivity, or subscription models in its 139-page filing, these terms appear considerably less frequently in VW's 673-page annual report. Table 1 shows an overview of the frequency of digital service terms between the two firms.

Table 1. Frequency Analysis of Digital Service Terms in Annual Reports

Keyword	Tesla 10-K (2025)	VW Annual Report (2025)
Over-the-air (OTA)	9	1
Software update	8	8
Full self-driving (FSD)	32	3
Connectivity	12	9
Subscription	8	3

Note: Analysis conducted using keyword search in SEC/annual report filings. Different variations for each keyword were used.

3.2 Value capture of the loop

Besides the technical value loop design, VW also needs to identify how it can capture value and take advantage of it. Many of its available services are pre-determined rather than generated in the moment of use. Examples of this include subscriptions for unlocking additional

horsepower or VW Connect Plus features, such as online parking heater setting, which resemble rent-seeking behavior rather than personalized value creation. Due to the premium sales price of VW cars, users' acceptance has been limited (Rogelberg, 2025; Volkswagen, 2026b). The infotainment app store, in collaboration with CARIAD and HARMAN, provides a more promising income stream, with apps from third-party developers such as Microsoft and Booking.com being offered (HARMAN, 2024). The only concrete figure available is in the form of CARIAD's software revenue, which, however, represents internal transfer pricing rather than external monetization. For 2025, the sales revenue of CARIAD was €1,775 million with an operating loss of €2,180 million (Volkswagen, 2026c). This highlights the gap between technology investments and external monetization.

VW's value capture potential is organizationally constrained by incentive structures such as performance bonuses. While VW has adapted its dealer agreements to equalize online and offline sales and incentivize more direct-to-consumer revenue (McKinsey & Company, 2020), there is no indication that dealers and sales representatives participate in long-term revenue generation through subscriptions or related models. Similarly, board-level variable remuneration is based on net cash flow in the automotive division and operating return on sales, which incentivizes vehicle sales rather than recurring revenue streams (Volkswagen, 2026c).

Another limitation is the absence of direct-to-consumer relationships which makes it difficult to monetize digital services. Dealers remain the main point of contact for customers while the VW Connect Plus subscription contract is signed exclusively online. In the absence of sales incentives for dealers, there exists a substantial disconnect in the allocation of who manages customer relationships and who captures the

value (Volkswagen, 2026b).

4. Discussion

The case study analysis of VW reveals major technical, organizational, and structural constraints. While existing literature on digital value loops emphasizes design parameters for effective sensing-shaping cycles, establishing a value loop in practice requires both constructing these technical cycles and architecting viable value capture mechanisms. This essay argues that VW lacks both.

VW lacks the technical capabilities to collect data that can be translated into behavioral insights. Consequently, the company cannot shape meaningful solutions for the customer. Technical limitations can be explained by dynamic capability theory, which argues that success in rapidly changing technological environments depends on a firm's ability to build and reconfigure its internal processes (Teece et al., 1997). VW, as a legacy car manufacturer, does not possess the internal capabilities to seize new technological opportunities. Tesla, by contrast, has managed to utilize its dynamic capabilities in software development to overtake many legacy manufacturers in market capitalization (Teece, 2018).

From an internal organizational perspective, VW has failed to combine traditional model sales cycles with the company-wide mission to design an overarching software platform that can compete with Tesla's. Misaligned incentive structures for both dealers and VW management hinder the shift towards an integrated approach. Thus, VW restricts itself to value capture that defaults to rent-seeking based on pre-determined value rather than real-time creation. Neither the dealer network nor the management board is incentivized to fix the technical limitations, as the compensation and commission structure is focused on one-time sales rather than recurring income streams.

Structurally speaking, even if VW were to implement a powerful digital value loop for its new car models today, it would still face constraints for its already distributed models. All cars currently on the road would still lack the necessary software capabilities to establish a cycle of sensing and shaping. As discussed in the case study, the technical development of a digital value loop is not sufficient for a firm's success. Personalized offerings require some sort of user authentication, which Tesla and VW both achieve through user registration. However, if this condition is not mandatory, the loop remains incomplete. While no precise numbers are available, the required independent setup of both a 'Volkswagen ID' and a VW Connect contract limits VW's ability to build a powerful loop. Every missed data point fundamentally weakens the loop, which Tesla simply avoids by enforcing a Tesla user ID (Tesla, Inc., 2026b; Volkswagen, 2026b). Following the insights from Svahn et al. (2017) on a case study of Volvo, further structural barriers can be found in the hierarchical tension due to competing concerns between legacy commitments and digital innovation. In VW's case, that especially concerns the relationship between the manufacturer and its dealers.

These barriers are self-reinforcing, with technical sensing limitations constraining what can be meaningfully monetized, while organizational incentives focused on vehicle sales remove internal pressure to resolve those technical gaps.

Further, as illustrated by Tesla's income streams for its digital solutions, the value capture mechanism in the automotive industry does not arise automatically but must be designed deliberately. Potential business models include premium vehicle pricing, subscription models, or pay-per-use. However, car owners are not used to paying for additional services after the purchase beyond repairs, especially when it comes to premium vehicles, making the latter

two difficult to justify.

Following the insights from the case study, I argue that the example of Tesla successfully demonstrates that a digital value loop is not only an achievable goal but also a useful analytical lens for generative software solutions in the automotive industry.

5. Conclusion

This essay applies the concept of Yoo's digital value loop to the case of VW to examine what technical, organizational, and structural factors prevent legacy automotive OEMs from establishing one. Despite the hardware-focused characteristics of the automotive industry, Tesla demonstrates that establishing a digital value loop is not only possible but economically valuable, creating \$3.867 billion in deferred digital service revenue in 2025 (Tesla, Inc., 2026c).

The establishment of the digital value loop for VW is constrained by the mutual reinforcement of three barriers. Technically, VW's sensing capabilities are restricted to diagnostic data rather than behavioral insights. OTA updates remain limited to bug fixes without providing additional features, which limits the depth of the loop. Organizationally, the dealer incentive structure, as well as management compensation, remains heavily shaped by one-time sales, discouraging the establishment of recurring revenue streams. Structurally, the absence of mandatory user registration for 'Volkswagen ID' and VW Connect and fragmented direct-to-consumer relationships prevent consistent data collection for the value loop to become powerful. The analysis shows that technical abilities and value capture mechanisms are distinct, interdependent, and equally relevant. A perfectly functional loop fails without a deliberate value capture mechanism. Additionally, value capture becomes ineffective if user entry into the loop is treated as given instead of being part of the design.

Notes

1. FSD subscription: As of 9 April 2026, available in the U.S., Canada, China, Mexico, Puerto Rico, Australia, New Zealand, and South Korea
2. Share price information from Yahoo Finance (accessed 4 March 2026)

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