Does Sharing Lead to Smarter Products? Managing Information Flows for Collective Servitization

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Abstract Peer-to-peer sharing induces persistent changes in product design. Besides bifurcating product durability, this adaptation increases the compatibility of collaborative use with rent extraction—from a producer's viewpoint. For owners it decreases the commitment required for taking the item into possession, while for nonowners it standardizes sharing transactions. The resulting sharing-induced design-ideal aligns the flow of utility from shared consumption with the flow of monetary compensation to the seller, thus mimicking a collective lease agreement between seller and an *ex ante* unknown group of users. Sustaining such a "collective servitization" requires an embedded capacity of user sensing and transmission of information flows *ex post* the initial product sale, thus implying a fundamental need for smart products in an access-based society.

Keywords Collaborative Consumption · Collective Servitization · Design Principles · Internet of Things · Sharing Economy · Smart Products

1 Introduction

With the advent of platforms that are able to solve the problem of matching interested parties (so as to create liquidity) and to overcome the moral hazard inherent in short-term lending (so as to leverage trust) [12, 13], the collaborative consumption of durable goods has increased significantly over the past two decades. A *paradigm shift* from ownership to access has been widely noted, where the flexible use of durable goods at the place and time of need begins to dominate the traditional model of having to purchase a product so as to be able to consume it [1, 2, 4]. While there are many interesting first-order problems associated with optimizing market matching and the design of short-term contracts on the various sharing markets, we are concerned here primarily with the more pertinent shifts in product design and the

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way products can be expected to interact with their environment. These higher-order effects are arguably more fundamental and long-lasting than the solutions to the aforementioned operational problems, but of course they are not entirely disassociated. With the access-versus-ownership question being intrinsically dynamic, sharing decisions are about the intertemporal allocation of stochastic flows of availabilities and needs. At the producer's level, sharing-induced product design responds to a logic of dynamic usage transitions. Indeed, there is no reason to believe that post-paradigm-shift products would look like pre-paradigm-shift products. Thus, the core of our inquiry is: *What are the sharing-induced design traits that products are likely to feature in a world of collaborative consumption?* Beyond the questions of durability and configurability, we ask: *What are the flows of information that such products need to support?* And: *Does supporting such flows make products designed for sharing "smarter" than products designed for ownership?* Finally, we briefly turn our attention to the broader societal implications of sharing-induced design traits on the sustainable production and consumption, in view of using natural resources responsibly.

2 Sharing-Induced Design Principles

To understand how best to design shareable products, it is necessary to analyze the notion of shareability together with the decision processes in a peer-to-peer sharing market.

"A *shareable* product is such that it can be transferred from its owner to another agent for temporary use without significant degradation" [8]. This implies that completely disposable products cannot be shared, as full degradation is attained after just one use. Shareability therefore increases in product durability. It also increases in the ease-of-transfer between users. Figure 1 provides an overview of various products and iso-shareability frontiers in the corresponding (durability, ease-of-transfer)-space.

2.1 Supply and Demand Dynamics

Sharing is fundamentally about consumption dynamics [9]. Unlike in traditional markets, product users appear on either side of the market, depending on whether they are owners or nonowners and on whether they need to consume the item in a given period or not. For example, the owner of a power drill can become a supplier on the sharing market whenever he does not need the item, whereas a nonowner turns to the sharing market for access to the item whenever a need arises. Thus, in anticipation of the stochastic needs and the effective transaction price (=posted price, adjusted by the market-maker's commission) in the sharing market, consumers decide about becoming an owner or a nonowner. Since consumers are heterogeneous in their anticipated needs and consumption values, the user base is naturally partitioned

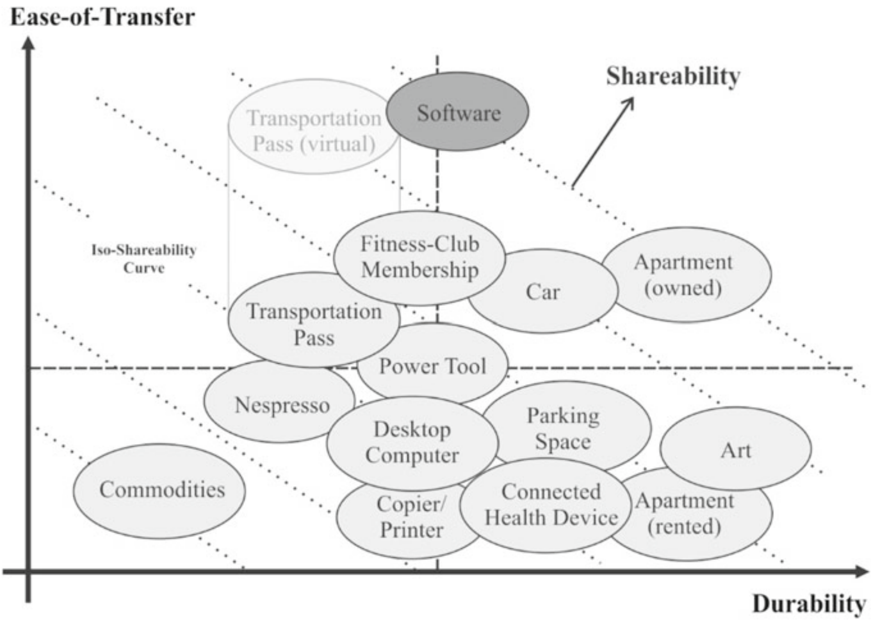

Fig. 1 Common products on sharing markets, together with iso-shareability curves in the (durability, ease-of-transfer)-space.

into owners and nonowners. Hence, we can deduce the first two key features of peer-to-peer sharing economics.

F1. [**Heterogeneity**] *Sharing requires owners and nonowners.*

F2. [**Balancedness**] *For a sharing market to clear, the nonowners with need and owners without need (for own consumption) must be balanced—at a given effective transaction price.*[1]

Whereas the traditional ownership model is about sharp transitions from nonownership to ownership (and vice-versa), together with an alignment of ownership and usership, the sharing model—by spreading usership over a collective of potential users (including the owner and an *ex ante* random number of nonowners)—blurs the non/ownership boundaries and dissolves the ownership-usership alignment in the traditional modes of consumption [10, 11]. It follows therefore a principle of residual difference.

F3. [**Residual Claims**] *The main difference between an owner and a nonowner consists in the residual claims to the product (e.g., related to maintenance, private-usage and resale options, as well as unforeseen contingencies).*

[1] Balancedness may not be required when the products are "nonrival" (e.g., software), that is, several agents may be able to use it simultaneously; see Fig. 2.

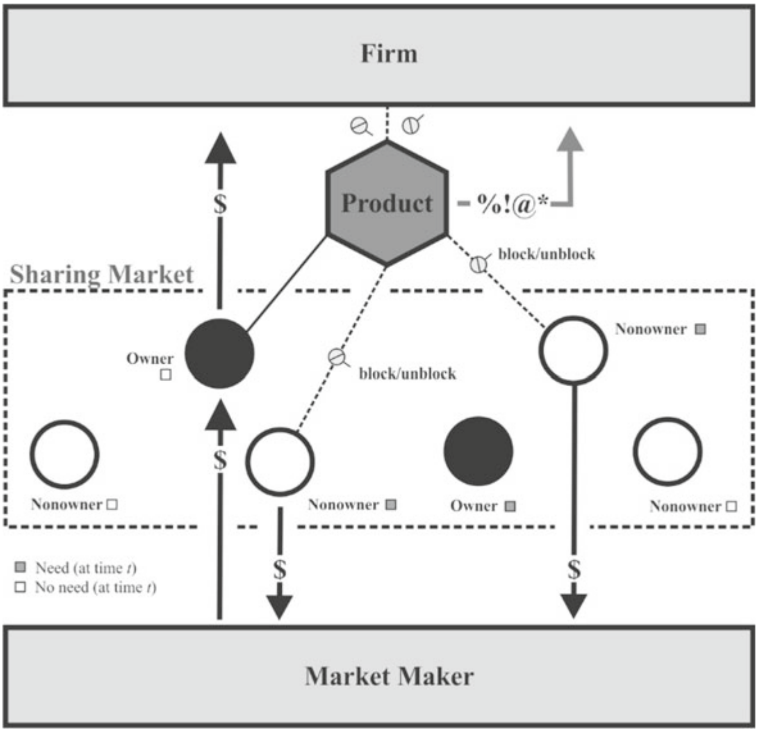

Fig. 2 Collective servitization of a nonrival product, authorized by firm, facilitated by market maker (at time t).

2.2 Market-Maker Incentives

A peer-to-peer market is usually enabled by a third party, especially in environments where traditional barriers for the sharing parties must be overcome, such as high costs of matching and shareproofing, or the lack of trust systems. By providing an environment for sharing transactions, the market maker can extract a portion of the gains from trade, up to all of the improvement over platform-free sharing interactions [13].

F4. [**Intermediary Self-Interest**] *Market makers both enable and distort supply and demand on sharing markets through a system of commissions and transaction rules, so as to extract value from sharing transactions.*

2.3 Aftermarket Control and Information

In order to extract rents from a user of its products, a manufacturer can optimize design, including—relative to shareability—the product's durability and its ease-of-transfer among different users.

F5. [**Manufacturer Self-Interest**] *Manufacturers prefer design features that maximize expected net present value in the long run.*

While in the traditional consumption model, there is a strong interest for the manufacturer to control and limit durability, considering the product lifetime as an essential design variable, this logic is transformed in the presence of liquid sharing markets.

F6. [**Flow Efficiency**] *To provide a flow of utility efficiently, it is best for the manufacturer to not artificially limit product durability.*

Finally, the manufacturer's capacity to extract rents at the points of consumption requires aftermarket control, which we view as its user-sensing ability (so as to be able to detect usage transitions) and blocking ability (so as to be able to block usage transitions).

F7. [**Dynamic Rent-Extraction**] *The firm's ability to extract rents over time from different users critically depends on the aftermarket control embedded in the product.*

2.4 Product-Design Principles

From the key features F1—F7, we now derive the following five product-design principles, induced by sharing markets. First, shared products must remember their owners and detect users different from their owners.

D1. [**User Awareness**] *The product can distinguish different users.*

By designating the product owner as a special user, D1 implies the ability to distinguish owners and nonowners.

D2. [**Usage Awareness**] *The product can sense if and how much it is being used.*

By being able to detect the intensity of use (including zero intensity), the product can harbor information related to the flow of utility it provides.

D3. [**Informativeness**] *The product can store or transmit reliable information about users and usage intensity.*

This information may be used cumulatively, to predict future usage as well.

D4. [**Robustness**] *The product accommodates heterogeneous user types (e.g., by being able to be customized and reset, or by accommodating different usage profiles).*

Product design specifically for the shared use across different users, with heterogeneous preferences and usage patterns requires robust features which can be customized or else respond to the median preferences of the target base, thus guaranteeing a positive experience even at the boundaries of the user spectrum.

D5. [**Efficient Durability**] *Avoiding artificial obsolescence the product strives for an efficient provision of a utility stream at minimum cost (e.g., by a modular design so as to retain functional parts despite unavoidable obsolescence of other parts).* [5, 6]

In addition to the design principles D1—D5, there is naturally the overarching principle of *Compliance*, meaning that the product is realized according to the prevailing regulations (e.g., regarding privacy or safety standards).

3 Collective Servitization

Achieving the design targets D1—D5 allows the manufacturer to convert the utility stream from the collaborative consumption of its product into a dynamic revenue stream fed by the community of users, which we refer to as collective servitization (generalizing the notion of mere servitization in [7]); see Fig. 2. Therefore, the sales contract with the initial owner includes a provision that specifies contingent fees to be paid by the owner at usage-transition events, possibly depending on the usage intensity. For the scheme to remain incentive-compatible the settlement of the fees would naturally leave the current owner with a net benefit at any time.

In this manner, the total monetary transfer from the owner to the firm depends on the collective usage of the product. The owner may or may not be treated differently than the other users, in the sense that his payment to the firm may also be usage-contingent.

Optimizing the retail of its shareable products, to accommodate for different types of owners the firm may offer different combinations of purchase price and contingent payments, thereby implementing a screening mechanism (also known as nonlinear pricing) so as to extract the pertinent private information from the owners as much as economically possible (i.e., taking into account the fundamental tradeoff between rent-extraction and information revelation) [8].

The corresponding information flow from product to the firm may be shared with the market maker so as to harmonize the joint fee structure, subject to antitrust compliance (which may limit such horizontal information exchange).

4 Product Intelligence

Broadly speaking, “intelligent products” have the capability to collect and transmit information about themselves and their usage. Within a secure and interoperable framework this information can be accessed by authorized parties (such as the manufacturer or initial seller). The augmentation of awareness about time-varying product properties (such as the fitness of key components and its current or cumulative use) can provide operational assistance and economic incentives. For example, the fact that an asset such as a power drill is projected to be idle over a two-week period could trigger an automatic availability notice to a sharing market, thus reducing the transaction cost for the owner, who now has to respond to a concrete request for a transaction only if a suitable counterparty was identified by the market maker.

Product intelligence can also be used to better align the flow of payments from the product users to the manufacturer (or intermediary) with the flow of value the various usage options create over time. This reduces risk of over-commitment in ownership, e.g., guarding against the contingency of low use after having purchased the product. Using the product’s intelligence, a manufacturer can enable and authorize the transfer of a product to a different user and ask for a commission. In effect, retaining forms of aftermarket control allows for a continuum of product-transfer options between the extremes of outright purchase on the one side and short-term lease on the other.

The economic incentives for the necessary changes in the product design (according to the identified design principles D1—D5), as far as durability, modularity, and embedded intelligence are concerned, can sometimes be expected to arise endogenously because of the prospect for additional rents. For example, in the ensured presence of a sharing market, a manufacturer has an intrinsic incentive to provide more durable products because that increases the “sharing premium” that can be charged to owners who take advantage of the possibility of renting out an unused product in the future. At other times, however, an outside policy intervention may be required to nudge parties into the right equilibrium. For example, if the manufacturer sees a possibility to disable the sharing market by aggressive pricing, it may opt to do so, and—in order to compensate for the reduced margins— increase the sales volume by making its products less durable. The latter manufacturer-induced “sharing shutdown” [5] can be forestalled by promoting the existence of sharing markets, supporting standards for network protocols for the visibility of idle assets, and subsidizing sharing-market operators, e.g., by offering tax incentives market.

5 Conclusion

The creation of product ecosystems that envelop consumers with products from a single firm or a group of allied partners has enabled unprecedented access to information about customer behavior and other hitherto private information. It also increased the producers' post-purchase control over the operation of their products, through updates, user- and usage-sensing, and access control. The consequent challenge (and opportunity) lies in the design and management of the associated information flows [3] and in finding new ways of extracting a portion of the utility flows that consumers realize over time. Sharing markets extend this endeavor for each product to a broad potential user base. They increase product utilization and thus also the collective utility gained through usage, and therefore also the firm's revenue-extraction prospects.

Overall, we have argued that by retaining aftermarket control over the shareability of items, in the sense of being able to meter usage-transitions in sharing markets, a firm (which could be the producer/manufacturer of the product, a retailer, or a system integrator) may be able to extract revenues over time, as the product is being used by various parties in the sharing market, thus leading to collective servitization.

During any transition to a regime of smart, shareable, and "intelligently disposable" products (meaning that requests for the modular components of the product can be aggregated and transmitted to the places of disposal), there will be a mixed regime where intelligent assets coexist with legacy products. The level of penetration, including expectations about the future evolution of the diffusion of smart products, paired with the prospects of economic rents determine the manufacturer's endogenous incentives for implementing design changes. Exogenous incentives include public standards and requirements, as well as a shift in consumer preferences.

The diffusion of smart products may be desirable not only from the perspective of individual firms but also from a societal viewpoint, as product intelligence, with active sensing, may offer numerous side-benefits, such as usage traceability, predictive maintenance, closed-loop tracking, and intrinsically motivated efficient durability (cf. design principle D5). These side-benefits altogether support a more responsible use of natural resources.

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