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## Treading new ground in household sector innovation research: Scope, emergence, business implications, and diffusion

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### ABSTRACT

Individual consumers in the household sector increasingly develop products, services and processes, in their discretionary time without payment. Household sector innovation is becoming a pervasive phenomenon, representing a significant share of the innovation activity in any economy. Such innovation emerges from personal needs or self-rewards, and is distinct from and complementary to producer innovations motivated by commercial gains. In this introductory paper to the special issue on household sector innovation, we take stock of emerging research on the topic. We categorize the research into four areas: scope, emergence, implications for business, and diffusion. We develop a conceptual basis for the phenomenon, introduce the articles in the special issue, and show how each article contributes new insights. We end by offering a research agenda for scholars interested in the salient phenomenon of household sector innovation.

### 1. Introduction

Household sector (HHS) innovation is the ideation and development of functionally novel products, processes, or other applications by consumers, in their discretionary time without payment (von Hippel, 2017). HHS innovation complements so-called producer innovation—which emerges from the motivation to generate value by introducing novel processes, commercializing new products and services, and appropriating value that others derive from adoption, and thus earn a profit. In contrast, HHS innovations are self-rewarded: consumers innovate solutions to problems they experience, satisfy personal needs, or in other ways derive auxiliary benefits from the process of innovation (e.g., fun, helping out others, learning new skills). Consumers not only create innovative solutions for their own use, but frequently reveal them to others and allow others to use their designs for free. Under many common conditions, keeping innovation private would not garner additional benefits to the consumer.

HHS innovation differs from what is known as “user innovation” (von Hippel, 1988; 2005). User innovations are developed by firms or individual consumers who expect to benefit from using a product or a service. HHS innovation emerged from user innovation research, but differs in two important ways. First, it focuses strictly on individuals and their innovations in their role as members of the household sector.

Notably, many individuals also have a role in other sectors, e.g. as employees in a firm or the public sector, and might innovate in this role – but this is not within the domain of HHS innovation. Second, HHS innovation studies have identified that individual consumer can innovate for reasons beyond personal needs; hedonic motives and benefits derived from the innovation process are important too (von Hippel, 2017).

Innovation in the household sector has been prevalent throughout the history of humanity (Franke & Lüthje, 2020). In the past forty years, however, consumers have proven to be increasingly willing and capable of innovation and producing products, processes, and services for themselves—a phenomenon labeled as ‘third wave do-it-yourself’ or ‘prosumption’ (Toffler, 1980; Kotler, 1986; Fox, 2014). Accelerated by personal computers, the Internet, online communities, and tools like CAD software and 3D printers, consumers are increasingly capable of developing products with functional novelty (Fox, 2014; Dafermos, 2015).

Along with these changes, we are currently witnessing a stream of research on HHS innovation which is both novel and of critical importance for society and the economy. Yet, while research activity accelerated rapidly and dozens of scholars are now involved, HHS innovation is still a poorly understood phenomenon vastly underestimated by decision-makers (Bradonjic et al., 2019). Aiming to advance theory and

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empirical research on HHS innovation, this special issue sheds light on its scope, emergence, implications for business, and diffusion. In what follows, we first discuss key concepts in the HHS innovation literature. Next, we introduce the articles in the special issue and discuss opportunities and challenges for future HHS innovation research.

## 2. Household sector innovation

Early accounts of consumers innovating for personal need were found in sporting equipment (Shah, 2003) and mountain bikes (Lüthje et al., 2005). A more recent body of literature showed that innovators in the household sector can engage in open-source communities, being driven by a desire to learn, advance reputation, connect with like-minded others, and pleasure (von Krogh & von Hippel, 2006). Household innovation also includes frugal innovators who are driven by personal needs, necessity, a lack of alternatives, and particular market circumstances (Zeschky et al., 2011).

More recently, scholars have confirmed that consumers can also innovate purely for participation-related motives, referring to the benefits people derive from the innovation process rather than its anticipated outcomes (Raasch & von Hippel, 2013; von Hippel and von Krogh, 2003). Accordingly, von Hippel (2017) defined household sector innovations as functionally novel products or processes developed at private cost by individuals during their unpaid discretionary time. HHS innovations are self-rewarding and do not require adoption by others for the innovator to benefit. Moreover, HHS innovations typically remain unprotected by its originator; potentially available for free to anyone.

Household innovation is embedded in a broader range of behaviors in which consumers tinker with, produce, and consume products that they create (Toffler, 1980; Fox, 2014). Toffler (1980) coined the term ‘third wave’ do-it-yourself, recognizing that consumers in the information society not only produce for subsistence and industrial purposes, but also for self-actualization and hedonic motives. Toffler also coined the term ‘prosumption’, which implies that consumers create value, such as novel product concepts, that result in the production of products they eventually consume and form their consumption experience (Kotler, 1986). In the past two decades prosumption behaviors have accelerated with the emergence of the Internet, digital manufacturing technologies, and facilities such as Fab Labs (Fox, 2014). It is in this context that HHS innovation, i.e. products, processes, services, and applications with functional novelty, emerge. The internet-driven extension of the do-it-yourself culture has resulted in vast “maker” and “hacker” communities, which can be considered another subset of third wave do-it-yourself/prosumption. A common feature of members of such communities and HHS innovators is their intent to move beyond consumption, and enrich their lives by creating something new, learning new skills, and engaging with objects in new ways (Mauroner, 2017).

Household sector innovators develop a broad range of product types. Table 1 provides examples as reported in a survey of Finnish consumers by de Jong et al., (2015).

Since 2012, surveys in over ten countries found that HHS innovation constitutes a major share of an economy’s innovation activity and output. The share of HHS innovators in broad, representative consumer samples is at least in the 4-6 percent range, with some exceptions (Japan, Sweden), and so represents millions of consumers (de Jong, 2016a, Franke et al., 2016). Also, consumers collectively spend billions of dollars annually, to create novel products by and for themselves, all during their unpaid discretionary time and independent of their professions. Larger and more complex innovations, such as those encountered in open source projects, are generally done collaboratively (e.g., Lakhani & Wolf, 2005), and may be highly impactful in various fields of application. Examples include the development of the artificial pancreas by Type 1 diabetes patients for their own use, and the development of project collaboration software tools for and by software developers on GitHub.

Household innovation differs in important ways from producer

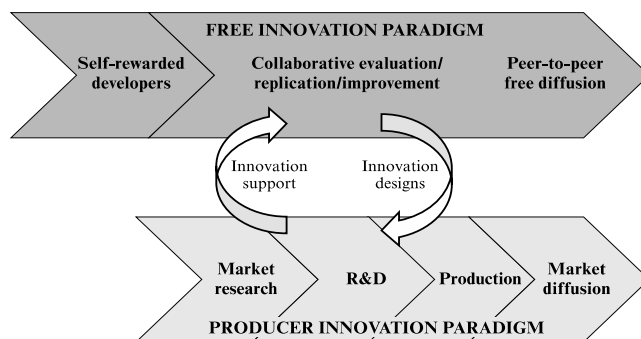
**Table 1**  
Examples of household sector innovations developed by individual consumers.

Object	Examples
Tools & equipment	I created a tool that helps me change tires with less back pain. There are no similar products on the market. This one is for personal use.
Household fixtures & furnishing	My innovation is a foldaway bathtub. I am having a small bathroom and wanted to avoid big and expensive renovation work.
Sports, hobby & entertainment	I developed a new device for bee keeping. It helps lifting the compartments of the beehive. This is usually heavy lifting which needs to be done by two persons, but not anymore.
Food and clothing	I built my personal hamburger mold, as I could not find one in the shops. I wanted extra-large hamburgers, but the tools were not available.
Transport & vehicle	I have made my own stunt bike foot rests. They are much stronger, lighter and safer than available commercial products
Help, care & medical	This was concerned with tools to help my brother who is disabled and who can only use one arm. He can now peel, dice and slice and work with anything from bread to fruit with one hand.
Computer software	What I did was developing software to take multiple screenshots simultaneously, from several cameras. I like to see what happens in my street.
Children & education	I created a seat belt control that guides the belt to come down over the collarbone/shoulder and not for example over the throat. My child does not get frustrated anymore when the seatbelt is in his face. He no longer wears it only partly, e.g. only on the hip, so it is safer.

Source: de Jong et al., (2015): p.1859.

innovation—the focus of Schumpeterian innovation studies concerned with innovation by profit-seeking firms (von Hippel, 2017). Figure 1 illustrates some of the key differences: In the bottom arrow, traditional producer innovators identify market opportunities by acquiring information on unfilled needs, new technologies that will enable first-of-kind applications, or market imperfections (Ardichvili et al., 2003). Profit-seeking firms then invest in developing an innovation (e.g., product, service, process) to develop, produce and sell it. In this paradigm firms appropriate innovation benefits, or capture value, by intellectual property rights and other means, and seek to avoid knowledge spillovers so that other actors in the economic system would not dilute these benefits (Teece, 1986).

The top arrow represents the process of free household sector innovation, where innovators develop new products, processes, and services in their discretionary time. They are motivated by hedonic motives and the satisfaction of personal needs. Typically, in this regime, innovators do not have strong incentives to protect with intellectual property. This implies their innovations are potentially available to anyone (von Hippel, 2017; von Hippel & von Krogh, 2003). HHS innovators may collaborate with others to improve the innovation. Next, diffusion may occur by freely sharing designs with other consumers. As such their



**Fig. 1.** Household sector versus producer innovation paradigm. Source: von Hippel (2017): p.4.

innovations can make significant contributions to social welfare. Household innovators can afford to engage in these practices because they are self-rewarded (Raasch & von Hippel, 2013). Their benefits derive from personal use of the innovations, the fun and learning associated with the development process, or pro-social motives - the satisfaction they get from helping others. Because household sector innovators carry their own cost of innovating and freely share those once completed, there are no compensating transactions involved in the HHS innovation process.

Overall, while HHS innovation complements producer innovation (von Hippel, 2017), interactions between both models are quite possible. Firms can benefit from householders' designs, and also support their efforts by supplying resources (Haefliger et al., 2010). Next, firms can adopt and improve HHS innovations to bring them to the market for general sale. Doing so is attractive, because household innovators are often early to try out new ideas and solutions—especially when householders are lead users with a deep and rare understanding of emerging trends, and high personal benefits garnered from their own solution to problems (Franke et al., 2006). Indeed, it has been shown that many of the most important products sold by producers were first developed by consumers (e.g., Riggs & von Hippel, 1994).

We have advanced research on this important innovation phenomenon with a special issue of Research Policy on household sector innovations. We received a high number of submissions, of which several studies improved and expanded our understanding of the phenomenon. Those papers will be presented next.

### 3. Articles in the special issue

The articles comprising this special issue cover four fundamental topics in household sector innovation: its scope, emergence, business implications, and diffusion. We discuss each topic and elaborate how the articles help us to better understand the phenomenon.

#### 3.1. Scope of household sector innovation

Past studies of HHS innovation have generally focused on material or tangible objects. Early studies investigated consumers innovating specific products such as extreme sporting equipment (Franke & Shah, 2003) and mountain bikes (Lüthje et al., 2005). More recently surveys were done using nationally representative samples, demonstrating the important role of HHS innovation in national economies; but again with a strict focus on tangible objects (de Jong, 2016b). The main reason for this focus is that tangible objects are easier to identify when respondents can be offered cues to trigger their recall. Yet, it is widely acknowledged that household innovation is not limited to tangible objects. For example, scholars have reported new services first developed by consumers (Oliveira & von Hippel, 2011), techniques to operate physical objects and/or to enable object innovation (Hienerth et al., 2014) and entertainment products such as animated movies (Haefliger et al., 2010).

In the article “Behavioral innovation: Pilot study and new big data analysis approach in household sector user innovation”, Christiana von Hippel and Andrew Cann (2021) recognize the broad scope of HHS innovation, and the need for conceptual clarity as the number of intangible innovation concepts grows. They introduce a new, overarching construct “behavioral innovation”, defined as one or a connected sequence of intangible problem-solving activities that provide a functionally novel benefit to its user developer relative to previous practice, and including new services, techniques and other varieties. Behavioral innovation is a high-level category that complements tangible product innovation. C. von Hippel and Cann (2021) demonstrate the presence of behavioral innovation and its three subcategories in the context of an online discussion forum on Parenting on Reddit. Their analysis shows that 76% to 91% of the innovations shared on the platform are behavioral, not products or product-behavior hybrids. They

also find that technique and service innovations constitute only a small subset of all behavioral innovations, showing that behavioral innovation is a useful step towards capturing the full spectrum of HHS innovation.

In his conceptual article “Social movement and free innovation”, Jeppesen (2021) complements household sector innovation focused on the efforts of individuals or collectives, by proposing a third mode of innovation relying on social movements. Early accounts of HHS innovation identified individuals as key actors, known as “lead users” (von Hippel, 1986). More recently collective innovations have been documented, as observed in open-source software development (von Hippel & von Krogh, 2003; von Krogh et al., 2003). Whereas individual and collective household innovation emerges from personal use and self-reward motivations, Jeppesen argues that social movements constitute a phenomenon in which another motive plays an important role, namely “common cause”—the quest for a new life order or societal change—and create innovations that address a cause and “system change,” rather than individual goals. Building on human values theory, Jeppesen proposes that individual HHS innovators are driven by self-enhancement, collaborative innovators are driven by a mix of self-enhancement and in-group self-transcendence values, but social movement innovators are mostly driven by universal self-transcendence, motivated by a common cause. An example is the tactical maneuvers invented by protesters to avoid confrontations with authorities (e.g., in the recent Hong Kong protests). Jeppesen explains how innovation in social movements can be related to products, behaviors, and symbols. Also, social movement innovation necessitates adoption by others to help achieve the common cause, typically resulting in proactive and successful diffusion efforts by innovators – which is in contrast with the diffusion problem typically encountered for other types of HHS innovation (de Jong et al., 2015).

#### 3.2. Emergence of household sector innovation

In exploring how and when HHS innovation emerges, scholars have identified numerous factors. These include competence-related variables such as education, technical training, and technical job experience (von Hippel et al., 2011), personal resources such as discretionary time and income (Chen et al., 2020), individual lead usersness (Franke et al., 2006), personality traits (Stock et al., 2016), and demographic variables (von Hippel et al., 2011). The articles included in this special issue elaborate our knowledge of determinants with contributions at the individual, network, and industry level, and shed new light on some of the earlier findings.

In their article “Need-solution pair recognition by household sector individuals: Evidence, and a cognitive mechanism explanation” Stock-Homburg and colleagues (2021) develop new insights into the individual process of HHS innovation. They offer empirical evidence for the ‘need-solution pair’ problem-solving theory introduced by von Hippel and von Krogh (2016). Classical problem-solving studies counsel that individuals first define or formulate a problem, then explore and search to fix the problem at hand. Need-solution pair theory suggests that scenarios in which solutions follow problem formulation captures only a part of mundane problem solving. Individuals sometimes simultaneously discover solutions together with needs. Stock-Homburg and colleagues provide evidence for the emergence of HHS innovation by need-solution pair recognition, and suggest a cognitive mechanism explaining this process. Drawing on insights from psychology and neuroscience they hypothesize that need-solution pair recognition is positively influenced by (low) problem-solving orientation and (limited) functional object understanding i.e., when individuals are confronted with unfamiliar objects. Using an experiment with 74 participants at a German university, they demonstrate that need-solution pair recognition dominates solutions found from traditional problem solving in environments with unfamiliar objects where participants are not directed to solve specific problems. Their study underscores that consumers in the household sector do not always innovate through traditional

problem-solving processes, but they may well arrive at solutions when they recognize and reason about objects.

The article “The influence of information depth and information breadth on brokers’ idea newness in online maker communities” by Resch and Kock (2021) investigates how personal networks influence innovation emergence. While broker positions are generally thought to benefit innovation, Resch and Kock show that a broker position mainly pays off with the ‘right’ kind of information exchange. Analyzing an online maker community, they find that brokers are more likely to create ideas with high newness, impact, and popularity when they tap deep information from their social ties. Repeated interaction with deep-and-similar knowledge domains allows a broker to better interpret and process information, which is beneficial for the innovation process. In contrast when interactions within social ties are marked by high information breadth, then the newness, impact and popularity of ideas diminish. Resch and Kock explain that broad information leads to brokers being overloaded and unable to process all received information, so that the innovation process is hampered. Recognizing that broker status is a proxy for “lead usersness” (Kratzer et al., 2016), their study suggests that lead users generate newer ideas when focusing on similar knowledge domains important for realizing their ideas, instead of highly diverse-but-unrelated domains.

The article “Exploring collective consumer innovation in healthcare: Cases and formal modeling” (Lakomaa & Sanandaji, 2021) models industry-level determinants of HHS innovation in the context of innovations collectively developed by patients. Lakomaa and Sanandaji explain that many important healthcare innovations are piloted by consumers. Institutionally constrained producers may later adopt and improve these innovations, resulting in change at the system level. Historical examples include health insurance schemes which were preceded by risk-sharing behaviors between members of medieval craft guilds, hospitals which emerged from free care organizations ran by local elites in the industrial revolution, and HIV/AIDS treatments developed by patients in the 1980s. Lakomaa and Sanandaji’s model shows that collaborative consumer innovation is more likely under stricter regulation, and when production cost disadvantages of consumers (vis-à-vis producers) are small. Their model also proposes a curvilinear relationship between market size and the scale of technological change. Collective consumer innovation is most likely when the consumer community and/or scale of technological change is moderate. If either market size is large or technological change extensive, producers are more likely to innovate first, as in the case of new drug development. If either is small or constrained, no innovation will emerge (although individual patients may develop and share solutions tailored to their individual needs; see Oliveira et al., 2015). Their article provides an important indication that HHS innovation can be driven by factors in the regulatory context and shows that HHS innovation can be a viable alternative to producer innovation when initial experimentation is too risky for producers.

Challenging the commonly held belief that men are more likely to innovate, the study by C. von Hippel and Cann (2021) shows that prior findings of male dominance may be an artifact of HHS innovation measurement, and in particular, the focus on tangible objects. Their study shows that when it concerns behavioral solutions such as new techniques and services based on local, direct, grounded experience and expertise—such as those concerning child-rearing problems—women are the main originators of innovation.

### 3.3. Business implications

HHS innovation has important implications for commercial businesses. Specifically, four interactions between HHS innovation and producer innovation can be distinguished (Gambardella et al., 2016). First, HHS innovations can be absorbed by incumbent producers to be developed further and brought to the market for general sale. Past examples of such transfers include mountain biking and kitesurfing

equipment. Second, HHS innovations diffusing to communities of peers may compete with incumbent producers’ offerings, such as in the case of the competition between the Linux and Microsoft Windows operating systems. Third, HHS innovations can complement commercial products and enhance their revenue potential. Examples include consumers developing and adding modules to computer games produced by large studios. Fourth, producers can support consumers to leverage their innovative contributions. In this vein new innovation management tools have been introduced, such as innovation toolkits, the lead-user method and crowd-sourcing (von Hippel, 2005).

The article “Next-generation consumer innovation research: Identifying early-stage need-solution pairs on the web” (von Hippel and Kaulartz, 2021) discusses a novel method for screening HHS innovations. In line with Kaminski and colleagues’ (2017) approach to detect HHS innovations from online sources, von Hippel and Kaulartz apply a semantic search method which leverages machine learning techniques for natural language understanding. As a proof of concept they develop a case study in which they crawl the Internet for kiteboarding innovations with high diffusion potential. Steps include user-generated content scraping, innovation concept identification and filtering, subject matter expert validation, and user innovation trend analyses. Scraping 234,017 English user-generated posts from 9,617 websites, they identify five innovations that are radically different from previous kiteboarding practices, and which online trend analysis suggests to be commercially promising. Semantic search can be considered as a next-generation form of the lead user method (Lilien et al., 2002) that focuses on *a priori* defined consumer trends (a necessary limitation to avoid the search being too broad). Machine learning techniques avoid the pit of advance funneling i.e. enable searching all innovations shared on the Internet which gain traction. These techniques can be applied to the analysis of social media data, by scholars, producers, and consumers seeking information about emerging trends and product features that may gain relevance in the future (Shrestra et al., 2021). In this vein C. von Hippel and Cann (2021) apply a similar method to identify behavioral innovations revealed in an online discussion forum.

The importance and added value of involving HHS innovators in commercial product development is demonstrated in Pollok et al.’s (2021) article “Knowledge diversity and team creativity: How hobbyists beat professional designers in creating novel board games”. Pollok and colleagues investigate how consumer and professional designer teams differ in their ability to leverage knowledge into creative output. They argue that compared to professional designers, consumer volunteers utilize different stocks of knowledge (i.e., personal need information), are driven by different motives (enjoyment, learning and personal use rather than income generation), and exercise different levels of control over the team’s direction (less internal rivalry, more freedom to self-select into developer teams). Analyzing 5,000 board game design projects, they compare the novelty and usefulness of new games designed by professional versus consumer teams. Consumer teams are found to be better able to translate diverse knowledge into novel game designs, and in general they are more likely to develop truly creative (novel and useful) board games. To businesses interested in leveraging HHS innovation, the study suggests that teams of consumer designers are able to conduct collective development work more effectively than teams of professional designers.

Rather than having their innovations be commercialized by existing businesses, consumers may start ventures to commercialize their own innovations (Shah & Tripsas, 2007; Haefliger et al., 2010). Consumers are usually first to discover a broader need to a problem they initially solved for themselves—a well-known example being that of Jack O’Neill who developed the wetsuit so that he could surf in cold waters, then commercialized his invention when his friends kept asking for a copy of his invention. This is a critical but rare event (von Hippel, 2017) as research has shown that HHS innovators are often not interested in the marketing or branding activities related to commercializing their innovations (Fuller et al., 2013).

In their article “Pricing decisions of consumer innovators” [Ebbing and Lüthje \(2021\)](#) take an important step in researching entrepreneurship based on HHS innovation. Their study explores how consumers market their innovations and focuses on the differences with commercial/professional organizations. The authors argue that marketing practices differ from producers, as consumers are initially driven by personal needs and innovation process benefits. They specifically focus on the pricing decisions of consumers who commercialize self-developed games on the online platform Steam. Arguing that consumers’ innovation motives are salient in their marketing decisions, they propose that HHS innovators charge lower prices, and that their prices are less related to development costs and more to perceived quality and competition intensity. Drawing on a matched-pair analysis of 4,242 computer games and interviews with 29 developers, they find that consumers indeed charge lower prices. Also, their prices are less cost-driven and more quality-driven compared to producers.

### 3.4. Diffusion of household sector innovation

Diffusion of HHS innovations is not self-evident; it often fails due to individuals’ weak incentives to inform other consumers about their innovations—even if innovations are potentially highly valuable to others ([de Jong et al., 2015](#); [de Jong et al., 2018](#)). As HHS innovators derive benefits from personal use or direct engagement in the innovation process, value to others is an externality to them. This differs from the traditional producer innovation model, in which diffusion (by sales) is warranted for the innovator to benefit. It is therefore believed that policy makers could play a role in stimulating HHS innovation diffusion ([von Hippel, 2017](#)).

In their article “The role of pre-innovation platform activity for diffusion success: Evidence from consumer innovations on a 3D printing platform”, [Claussen and Halbinger \(2021\)](#) explore what drives diffusion. Their focus is on consumers who share their first innovative design on the knowledge-sharing platform Thingiverse. First-sharing is an important step towards alleviating the diffusion failure problem ([de Jong et al., 2015](#)). Claussen and Halbinger hypothesize that platform activities of consumers prior to their first sharing of a design are paramount for subsequent diffusion success. Analyzing 79,186 designs on Thingiverse, they find that the frequency, quality and relatedness of pre-innovation platform activities all have a positive effect on diffusion. Moreover, the study explains how pre-innovation platform activity influences diffusion, by leading to innovative designs of better quality. Pre-innovation platform activity also results in innovative designs that recombine other platform members’ work into recombinant innovation, and it stimulates HHS innovators to better document their first design. (An analogy in the academic environment is an author sending his paper to “friendly reviewers” getting their feedback, and improving it, before submitting to a journal.)

Other articles in the special issue shed light on situations in which the diffusion problem is alleviated. In their paper on collective consumer innovation, [Lakomaa and Sanandaji \(2021\)](#) conclude that producer adoption of HHS innovations can lead to a system change in the provision of healthcare services. This is most likely when producers face high institutional innovation barriers, when consumers have low initial production costs, and when the degree of technological change and the number of consumers facing a problem is moderate. [C. von Hippel and Cann \(2021\)](#) find that the majority of behavioral innovations in their sample were diffused by their consumer-developers in response to specific requests for help or advice from peers in their online community—a perspective overlooked in prior research. Finally, [Jeppesen’s \(2021\)](#) common-cause innovations imply a new dimension to the diffusion challenge. Social movement innovation can only be considered successful if adoption by a significant number of others is accomplished. By default, social movement innovators have strong incentives to diffuse their innovations, so that the diffusion problem identified by [de Jong et al \(2015\)](#) is not applicable. Instead, other diffusion-related problems

arise, such as the innovators’ ability to influence and persuade others to have their products, behaviors or symbols adopted.

## 4. Research agenda

As we collectively continue to explore the phenomenon of HHS innovation, there are several novel and exciting research areas emerging. We discuss the most salient opportunities related to scope, emergence, business implications, and diffusion.

### 4.1. Scope

A first challenge is to investigate how HHS innovation relates to broader concepts like prosumption and ‘third-wave’ do-it-yourself ([Toffler, 1980](#); [Fox, 2014](#)). There are obvious parallels between both concepts: initiated for similar reasons (personal needs, hedonic motives, self-expression), conducted in consumers’ leisure time, generally not appropriated, influenced by the availability of low-cost design tools, and marked by a culture of openness and collective action. The main difference seems to be that HHS innovation concepts are marked by functional novelty (e.g., [de Jong et al., 2015](#); [C. von Hippel & Cann, 2021](#)) while prosumption/do-it-yourself are not. The HHS innovation literature has so far ignored parallels with this related literature, and we suggest investigating how HHS innovation is embedded, when the objects developed by prosumers/do-it-yourselfers become innovative, and whether antecedents, business implications and diffusion issues differ.

The behavioral and social movement concepts introduced in the special issue imply that the spectrum of HHS innovation is broader than previously thought. Obvious next steps are to provide (more) empirical evidence; to investigate implications for emergence, business and diffusion; and to see if and how these differ from HHS innovations related to products. Behavioral and social movement innovations seem to have different antecedents and diffusion problems. Recall that [C. von Hippel and Cann \(2021\)](#) found a majority of behavioral innovations developed by females, while [Jeppesen \(2021\)](#) argues that innovations in social movements are deemed successful after being diffused/adopted by others – which is in stark contrast with the diffusion problem identified in studies of tangible product innovations in the HHS sector ([de Jong et al., 2015](#)). Also, [Jeppesen \(2021\)](#) identifies a third type emerging from social movements in particular, namely innovation in symbols. By doing so, he provides an important conceptual contribution with the potential to open up new research avenues in HHS innovation.

### 4.2. Emergence

The articles in the special issue show that it is worth moving beyond factors at the level of the individual innovator, by delineating emergence mechanisms ([Stock-Homburg et al., 2021](#)), network factors ([Resch & Kock, 2021](#)) and industry-level factors ([Lakomaa & Sanandaji, 2021](#)). Continued work in any of these directions is merited.

Another under-investigated context is HHS innovations emerging from communities, such as those in open-source projects. Thus far, much work has centered on how such communities create and capture value (e.g., [Dahlander & Frederiksen, 2012](#)), but less on the intricate social dynamics that make or break such activity. For example, in a recent study of open source development projects hosted on GitHub, [He et al. \(2020\)](#) found that in order to develop their software, communities first had to resolve thorny issues around the choice of a license under which to publish their work. The study found that when communities managed to switch (through what is conceptualized as “reflective agency”) the discussion from license alternatives (e.g., GNU/GPL, etc.) to preferred licenses attributes (e.g. permissiveness, ease of corporate use, ease of contribution), the community could proceed to collectively choose the license that best fitted their attribute preferences. This and other studies (e.g., [Klapper & Reitzig, 2018](#)) underscore that community dynamics are multifaceted and complex. More research is needed to understand the

sources of community dynamics and how to effectively manage them in order for collaborative work between household innovators to persist and advance.

Next, the importance of technological enablers has been previously recognized (Baldwin & von Hippel, 2011; Chen et al., 2020), and this is reinforced in this special issue (e.g., Clausen & Halbinger, 2021; Resch & Kock, 2021; C. von Hippel & Cann, 2021) - but it has not been empirically investigated. Technologies like the Internet, personal computers and low-cost design tools have been paramount for HHS innovation, but there is a lot more to come. New developments like blockchain technology, the Internet of Things, robotic process automation, augmented and virtual reality, and machine learning, stand to further empower individuals in creating products, services, processes, and behaviors in the household sector. These new general-purpose technologies are rapidly becoming accessible outside industrial domains. Given their decentralized nature, we are likely to witness a new generation of household innovators applying these enhanced tools. Important research questions and methods (like the ones demonstrated by Kaminski et al. (2017) and von Hippel & Kaulartz (2021)) are likely to ensue. For example, research opportunities lie in understanding the role of household innovators not only in using, but also in developing general-purpose technologies (such as de Jong & de Bruijn (2013) observed in 3D printing).

Finally, household sector innovation is not completely disconnected from the work context. In a recent paper Lukoschek and Stock-Homburg (2021) demonstrate that innovation activities at work may spill over to HHS innovation. They found that job innovativeness helps to acquire job-related resources which are useful in the household context. Interestingly, in specific circumstances boredom at work is also associated with individual household innovation. We recommend continued work to explore the parallels between innovation at work and at home, to see if work and household innovation coincide and help to create economic and societal value. Also, the aforementioned technological enablers may influence the locus and mode of household and workplace innovation.

#### 4.3. Business implications

The interaction between producer innovators and household innovators remains a critical issue. Several papers in this special issue uncover aspects of their interactions, but more research and theory building is needed.

One promising starting point is to examine the nature of expectations in producer sponsorship and household sector innovators. For example, in a study of a sponsored open source community, Spaeth et al (2015) found that, while voluntary open source developers expected the sponsor to behave according to the social identity and “rules” of the community - such as communicating their plans for developing a product, their openness manifest in the sponsors willingness to freely share all of their software was less relevant. This underscores that the interactions between corporate sponsors and household innovators may be more complex than we often assume, which demands much more scrutiny in future work.

Related to this, we do not yet understand what happens if freely revealed HHS sector innovations are taken up and commercialized by firms. From a strictly economic perspective, household innovators should be content with this (as their initial motivation was non-monetary, and they revealed unconditionally) or even welcome this (because the diffusion may be beneficial to them – see Harhoff et al. 2003). However, “money changes everything” and there is initial research indicating that household innovators perceive commercial adoption also through the lens of fairness, sometimes resulting in disappointment, withdrawal, or conflict (Franke et al. 2013). We recommend more research into underlying perceptual, cognitive, and affective patterns in order to pave the ground for understanding the complementary relationship of household and producer innovation.

Next, firms may proactively initiate cooperation with household

sector innovators (as also shown by Pollok et al. (2021) in this special issue). Firms can launch crowd-sourcing competitions, conduct lead user studies, or provide toolkits for user innovation, to name but a few options (von Hippel, 2005). All these methods have been developed by producer companies and, furthermore, most research has focused on the perspective of the firm. We still know little as seen from the perspective of the household sector innovators: their perceptions, motivations, and problem-solving behaviors, and hence the ideal design of these methods.

Finally, the pathway of household innovators starting new ventures to commercialize innovations merits attention. Ebbing and Lüthje's (2021) study demonstrates that householders' initial motivations are still salient when they continue commercializing their innovations in a venture. Seemingly the decisions of entrepreneurs emerging from HHS innovation differ from those who those with a strictly commercial orientation. This opens up opportunities for a range of studies comparing the commercial and/or business development practices of (former) HHS innovators.

#### 4.4. Diffusion

With regard to diffusion, the special issue papers suggest a list of factors in the presence of which the probability of diffusion failure diminishes: in specific industrial circumstances (Lakomaa & Sanandaji, 2021), when potential adopters proactively ask for solutions to similar problems they are facing (C. von Hippel & Cann, 2021) and for innovations which are only successful if others adopt them (Jeppesen, 2021). Each of these factors is worth further investigation: in particular, when producers are more likely to encourage or facilitate household innovation, how demand for HHS innovations can be mobilized, and how social movement participants try to get others adopt their innovations.

Policy makers are believed to be important for the diffusion of HHS innovation, but what their policies should look like is uncharted territory. Dafermos (2015) suggested that the most important policy issues include (a) free knowledge sharing, (b) active consumer communities, and (c) leveraging the Internet for distributed collaboration. Following this line of thinking, HHS innovation and diffusion will benefit from policies which, in contrast to producer innovation, enable and support distributed technological infrastructures. This implies granting consumers broad Internet access and hardware such as personal computers and 3D printers. Also, a well-developed infrastructure for crowd-funding may be important, as producer investment in freely available knowledge is more complicated (Dafermos, 2015). The effectiveness of a range of suggested interventions still has to be investigated, including the effects of deviant intellectual property systems, Fablabs/Makerspaces, and online knowledge-sharing platforms. In this vein recent experiments show that on knowledge-sharing platforms, proactive communication is helpful to turn passive knowledge seekers into active knowledge contributors (de Jong & Lindsen, 2021).

Diffusion is also hampered by HHS innovation not yet being visible in official statistics. A recent definition change as to what comprises innovation will help (Gault, 2015), but we are awaiting applications in social/consumer surveys conducted by statistical authorities. HHS innovation surveys are costly, and do not yet capture the full range of the phenomenon (e.g., behavioral innovations are missing) (de Jong, 2016b). Developing new ways to capture and measure HHS innovation is challenging, and new methods based on machine learning (as demonstrated by von Hippel and Kaulartz (2021) in this special issue) may be useful to collect complementary data about HHS innovations actively revealed on the Internet.

Finally, we advocate research in contexts where diffusion is most paramount to advance societal welfare. Healthcare, we suggest, is one such context. For example, when patients suffer from rare diseases, they face strong unmet needs, and many HHS innovations can be expected (Kanstrup et al., 2015). Nevertheless, their new medical treatments and devices diffuse slowly (Berwick, 2003). A second example is emerging

industries. When householders develop first-of-kind applications, producers initially refrain from market entry as broad demand is still lacking. In the early stages of an industry life cycle, individual consumers make the largest contributions (Oudshoorn & Pinch, 2003). Beyond their societal relevance, we expect that in these contexts the scope, emergence, business implications and diffusion of HHS innovations will more likely be amplified, and merit further attention.

## 5. Outlook and conclusion

The papers presented in this special issue tread new ground concerning the scope, emergence, business implications, and diffusion of HHS innovations. We believe that there is a lot more exciting research to come. In the past decades we have seen a general decline in the importance of production (e.g., material labor in factories) while individual consumer design, services, and do-it-yourself activities have become more important. Production is becoming more immaterial, and happens systemically throughout society rather than within factory walls. We increasingly live in an “experience economy” in which, rather than just material goods, immaterial experiences (designed or co-designed by consumers) are considered important (Ritzer et al., 2012). Moreover, the availability of personal computers, the Internet and easy-to-operate design tools nowadays empower consumers to connect, create and share innovations more than ever, while across the globe individuals become increasingly better educated and prosperous, so that classical innovation bottlenecks (e.g., lack of time, resources, access to design tools) diminish (Baldwin & von Hippel, 2011; Chen et al., 2020). As a consequence, HHS innovation driven by personal needs and/or self-rewards will represent an increasing part of the overall innovation space.

Jointly, the papers in this special issue demonstrate the increased significance of the household sector to shape innovations to the benefit of all. It is obvious that the future will bring more household innovation, and that we will spend a growing amount of time studying, and being, household sector innovators ourselves.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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