Blending access-based services and triadic frameworks: an empirical evaluation of Packaging-as-a-Service

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Abstract

Purpose – Recently emerged Packaging-as-a-Service (PaaS) systems adopt aspects of access-based services and triadic frameworks, which have typically been treated as conceptually separate. The purpose of this paper is to investigate the implications of blending the two in what we call "access-based triadic systems," by empirically evaluating intentions to adopt PaaS systems for takeaway food among restaurants and consumers.

Design/methodology/approach – We derived relevant attributes of PaaS systems from a qualitative pre-study with restaurants and consumers. Next, we conducted two factorial survey experiments with restaurants ($N = 176$) and consumers ($N = 245$) in Germany to quantitatively test the effects of those system attributes on their adoption intentions.

Findings – This paper highlights that the role of access-based triadic system providers as both the owners of shared assets and the operators of a triadic system is associated with a novel set of challenges and opportunities: System providers need to attract a critical mass of business and end customers while balancing asset protection and system complexity. At the same time, asset ownership introduces opportunities for improved quality control and differentiation from competition.

Originality/value – Conceptually, this paper extends research on access-based services and triadic frameworks by describing an unexplored hybrid form of non-ownership consumption we call "access-based triadic systems." Empirically, this paper addresses the need to account for the demands of two distinct target groups in triadic systems and demonstrates how factorial survey experiments can be leveraged in this field.

Keywords Packaging-as-a-Service, Access-based services, Triadic frameworks, Reuse, Factorial surveys

Paper type Research paper

Introduction

Initially driven by faster and more convenience-seeking lifestyles (Jiang *et al.*, 2020), the COVID-19 pandemic exacerbated the consumption of single-use packaging for takeaway and delivered food (Kochańska *et al.*, 2021). This poses environmental challenges both in terms of resource use and waste generation (Kleinhueckelkotten *et al.*, 2021). In response, regulators increasingly restrict the use of conventional single-use food packaging and promote reusable alternatives. For example, as of January 2023, most restaurants in Germany have to offer a reusable packaging alternative for takeaway food and drinks (BMU, 2021). In the Netherlands, restaurants have to charge takeaway customers a fee for most single-use

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plastic packaging and are obliged to offer a reusable alternative since July 2023 (Netherlands Enterprise Agency, 2023).

Life cycle assessments indicate that reusable food containers deliver environmental benefits compared to single-use packaging as long as containers are reused sufficiently often (Greenwood *et al.*, 2021; Gallego-Schmid *et al.*, 2019). Furthermore, extant research suggests that collectively using shared containers that are professionally cleaned is less energy and water-intensive compared to refilling consumers' own containers that are washed at home (Greenwood *et al.*, 2021). At the same time, sharing containers between restaurants increases usage intensity and reduces the total number of containers required across the system. Thus, environmental break-even points are likely to be reached more quickly in systems that facilitate the collective use of containers by many restaurants and consumers as opposed to using containers owned by individual restaurants or consumers.

Packaging-as-a-Service (PaaS) providers aim to replace single-use packaging with reusable food containers and promote intensive usage of individual reusable containers. To this end, PaaS providers supply whole networks of partnering restaurants (including cafés, diners, delis, etc.) with reusable food containers. These restaurants then serve takeaway food to their customers in reusable containers instead of single-use packaging. After finishing their meals, consumers can return reusable containers to participating restaurants or return stations operated by the PaaS provider. This provides benefits of non-ownership consumption to both restaurants and consumers. By using PaaS systems, restaurants address environmental issues and regulatory demands without having to invest in their own reusable containers or operate a return scheme. At the same time, consumers enjoy the flexibility of not having to own reusable containers suitable for different types of food and not having to bring their own containers to restaurants.

Conceptually, PaaS systems apply aspects of access-based services (Hazée *et al.*, 2017; Schaefers *et al.*, 2016) because reusable containers are owned by the PaaS provider that offers flexible short-term access to restaurants and consumers without ownership transfer. At the same time, PaaS shares characteristics with triadic frameworks (Andreassen *et al.*, 2018; Benoit *et al.*, 2017) because three actors are involved. While access-based services and triadic frameworks have oftentimes been treated separately in the service literature (e.g. Benoit *et al.*, 2017; Hazée *et al.*, 2017; Hazée *et al.*, 2020), this research investigates the case of PaaS to explore the implications of blending the two in what we call "access-based triadic systems." On a theoretical level, we thereby complement the literature on the adoption of access-based services and triadic frameworks. To this end, we examine PaaS for reusable food containers and are guided by the following case-specific research question: Which attributes of access-based triadic systems for reusable food containers influence adoption intentions of restaurants and consumers?

In doing so, this paper responds to calls for research on success factors of platform providers serving two-sided markets (Benoit *et al.*, 2017) with platform-provided assets (Wirtz *et al.*, 2019) in specific contexts (Hazée *et al.*, 2020). In particular, this paper acknowledges that providers of triadic systems need to develop two distinct value propositions to encourage adoption by service suppliers and consumers (Andreassen *et al.*, 2018). As suggested by research on two-sided markets, platform providers have to optimize their services to "get both sides of the market on board" (Rochet and Tirole, 2003, p. 990). Thus, we conduct factorial survey experiments with both target groups, namely, restaurants and consumers. This way, we provide novel quantitative insights using a method that enables a systematic comparison of different market actors' adoption intentions. Importantly, we complement the more commonly studied consumer acceptance by adding the supplier perspective to account for both sides of the market (Andreassen *et al.*, 2018; Hazée *et al.*, 2020). The need to go beyond the consumer perspective is also evident in the literature on reusable food and beverage containers: With few exceptions (Jiang *et al.*, 2020; Lofthouse *et al.*, 2009), research has focused on consumer behavior (Dorn and Stöckli, 2018; Ertz *et al.*, 2017; Greenwood *et al.*, 2021; Keller *et al.*, 2021; Loschelder *et al.*, 2019; Novoradovskaya *et al.*, 2021). In contrast, the important role of restaurants that facilitate the use of the system's reusable containers has received less attention. By measuring influences on restaurants' and consumers' intentions to use PaaS for takeaway food, our insights support PaaS practitioners to establish more effective reusable packaging services that can reduce resource use and waste generation.

This paper proceeds as follows. The next section describes the case of PaaS for reusable food containers. Afterward, the key commonalities and differences of PaaS systems with typical access-based services and triadic frameworks are highlighted and a new conceptual hybrid we call "access-based triadic systems" is introduced. The overall empirical approach is described next. Subsequently, our qualitative pre-study is presented, outlining relevant PaaS system attributes for restaurants and consumers. Next, our quantitative main study tests the effects of these attributes on adoption intentions among restaurants and consumers with two factorial survey experiments. Afterward, we use results on PaaS for takeaway food to discuss the theoretical and practical implications of blending access-based services and triadic frameworks in access-based triadic systems. Finally, we outline limitations and future research avenues.

The case of Packaging-as-a-Service for reusable food containers

Currently, two types of PaaS systems for takeaway food are most prevalent: deposit systems and app-based, digital systems. Both system types involve three actor groups: a PaaS provider, restaurants, and consumers (see Figure 1). As represented by the physical asset flow in Figure 1 (bold arrows), PaaS providers supply reusable containers to a network of participating restaurants. When consumers order takeaway food from participating restaurants (e.g. by calling or visiting the restaurant directly or through a delivery service), restaurants serve takeaway meals in the PaaS provider's reusable containers. After finishing their meals, consumers return reusable containers to participating restaurants or to return stations operated by the PaaS provider. To ensure that containers are readily available at participating restaurants, PaaS providers also redistribute containers from overstocked restaurants or return stations to understocked restaurants.

Regarding the monetary flow (solid arrows in Figure 1), restaurants typically pay a fixed or use-based fee to the PaaS provider to access reusable containers. In deposit systems (Panel a), consumers pay a deposit to the restaurant, which is refunded when containers are returned. In app-based, digital systems (Panel b), consumers register for free on the provider's

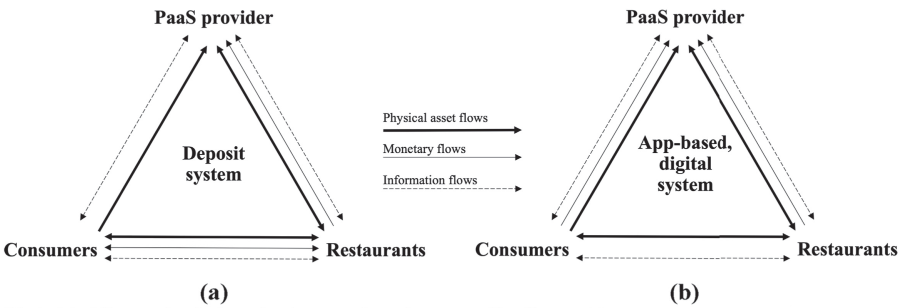

Figure 1. PaaS systems for reusable food containers

Note(s): Figure depicting the interactions between PaaS providers, restaurants, and consumers in deposit and app-based, digital systems
Source(s): Figure by authors

app, through which containers are traceable to consumers. This way, upfront deposits are replaced. Yet, in some digital systems consumers also pay small fees to the PaaS provider, for example, to extend container usage periods.

Finally, information (dashed arrows in Figure 1) flows between the PaaS provider and restaurants. For example, PaaS providers communicate new functionalities to restaurants and restaurants report their current inventory. At the same time, there are information flows between PaaS providers and consumers. PaaS providers directly market their service to consumers (e.g. social media, billboard advertising) and run websites that list participating restaurants. Furthermore, PaaS providers receive information about consumers' system usage. In deposit systems, these information flows are more limited than in digital, app-based systems, in which PaaS providers obtain rich data on user engagement through the app. Yet, in deposit systems with return stations, PaaS providers may also collect some information on consumers' return behaviors. Similarly, information flows between restaurants and consumers. For example, restaurants inform consumers about the PaaS at the point-of-sale (e.g. posters, personal explanation by staff) and consumers provide feedback on their experience with the PaaS.

Overall, PaaS systems facilitate the exchange of reusable containers (i.e. physical assets), money, and information between a PaaS provider, restaurants, and consumers. The specific nature and direction of these exchange activities depend on the system type (i.e. deposit or app-based, digital).

Conceptual foundations: access-based services and triadic frameworks

This paper examines PaaS for reusable food containers as an example of an increasingly relevant service concept that blends aspects of access-based services (Hazée *et al.*, 2017; Schaefers *et al.*, 2016) and triadic frameworks for non-ownership consumption (Andreassen *et al.*, 2018; Benoit *et al.*, 2017). To outline the conceptual foundations of PaaS, this chapter matches PaaS systems' characteristics with accounts of access-based services and triadic frameworks based on the respective service literature. Concepts are defined and their commonalities and differences are highlighted along three guiding questions: (1) *Who* is involved? (2) *What* types of assets are shared? (3) *How* are assets shared? Overall, it becomes evident that PaaS systems are best positioned between access-based services and triadic frameworks, as illustrated in Table 1. On a conceptual level, we propose that PaaS belongs to an unexplored hybrid form of non-ownership consumption we call "access-based triadic systems."

To evaluate PaaS in relation to access-based services and triadic frameworks, we begin with summarizing common definitions of each concept. Access-based services (ABS) are characterized by flexible short-term provision of tangible or intangible assets from a service provider to a customer in return for an access fee, whereby ownership of assets remains with the provider (Hazée *et al.*, 2017; Schaefers *et al.*, 2016). Notably, ABS are distinct from traditional renting as they facilitate more flexible access for shorter time periods using digital technologies. These technologies enable self-service access without the need for frontline employees to facilitate the exchange (Bardhi and Eckhardt, 2012; Benoit *et al.*, 2017; Habibi *et al.*, 2016). For example, one of the most frequently cited applications of ABS is carsharing (Bardhi and Eckhardt, 2012; Hahn *et al.*, 2020; Schaefers *et al.*, 2016). In contrast to traditional car rentals, carsharing users self-administer access to cars for flexible time periods as short as a few minutes using mobile apps. The term "triadic frameworks" is used in this paper to refer to collaborative consumption frameworks (Benoit *et al.*, 2017) and triadic business models (T-models; Andreassen *et al.*, 2018). Triadic frameworks conceptualize triangular systems in which technology-enabled platform providers act as middlemen to match customers with equivalently positioned suppliers (usually peer-to-peer). Peer-to-peer suppliers in triadic frameworks typically offer

Concepts / Key characteristics		Access-based services (Hazée *et al.*, 2017; Schaefers *et al.*, 2016)	Access-based triadic systems (unexplored hybrid) Specific case: Packaging-as-a-Service systems	Triadic frameworks • Collaborative consumption (Benoit *et al.*, 2017) • Triadic business models (Andreassen *et al.*, 2018)
Who?	Number of actors	Dyadic: two actor groups	Triadic: three actor groups	
	Types of actors	Asset provider (owner) to customers	Asset provider (owner) to business customers and end customers	Platform provider matches peers (owners) with peers
What?	Types of assets shared	Tangible or intangible assets specifically produced for the service	Tangible assets specifically produced for reuse	Tangible or intangible assets that are underutilized or idle, thus light on assets
	Ownership of assets	Assets owned by professional asset provider		Crowdsourced supply
How?	Technology reliance	Integral	Varying	Integral

Source(s): Table by authors

Table 1.
Conceptual overview

temporary access to underutilized assets they own (such as vehicles on Uber or accommodation on Airbnb; Hazée *et al.*, 2020) [1].

Regarding the number and types of actors involved (*who?*), ABS typically rely on two actors: a service provider (e.g. ShareNow) and a customer (e.g. carsharing user). In contrast, triadic frameworks involve three actors: a platform provider (e.g. Uber), a service supplier (e.g. driver), and a customer (e.g. passenger). Thus, as highlighted in Table 1, the number of actors is a key commonality of PaaS systems and triadic frameworks. In both cases, three actors interact in a triangular structure to engage in temporary non-ownership transfers of assets. Accordingly, the number of actors is a key difference between PaaS systems and ABS that typically only involve two actors.

The types of actors involved in PaaS systems, however, differ from triadic frameworks because peers do not share assets with fellow peers (Benoit *et al.*, 2017). Instead, reusable containers are provided to and shared among restaurants (i.e. businesses) and consumers. Consequently, whereas triadic frameworks match peer suppliers with peer customers, PaaS systems provide services to two different types of customers (restaurants and consumers). Thus, in terms of actor types, PaaS providers are more similar to ABS providers, with the key difference that PaaS providers simultaneously serve two distinct customer groups rather than one: business customers (i.e. restaurants) and end customers (i.e. consumers).

Turning to the types of shared assets (*what?*), ABS can involve both tangible (e.g. physical goods) or intangible assets (e.g. labor; Schaefers *et al.*, 2016). Typically, these assets are specifically produced or allocated for the offered service, such as cars designated for carsharing. In contrast, triadic frameworks typically draw on the use of underutilized or idle assets, such as unused vehicles, space, or time (Andreassen *et al.*, 2018; Benoit *et al.*, 2017). PaaS systems for takeaway food provide reusable food containers specifically produced to be shared among restaurants and consumers. Thus, PaaS is limited to tangible assets. As opposed to triadic frameworks, PaaS systems do not draw on underutilized assets. Instead, PaaS systems supply specifically produced goods, similar to ABS for tangible assets.

Regarding the ownership of shared assets, PaaS providers own reusable containers and equip restaurants with containers so restaurants can offer reusable packaging to their customers. This differentiates PaaS providers from platform providers in triadic frameworks in which assets are usually provided by peers (i.e. crowdsourced; Benoit *et al.*, 2022; Eckhardt *et al.*, 2019) and in which platform providers act as middlemen that match crowdsourced supply with demand (Andreassen *et al.*, 2018; Benoit *et al.*, 2017). Asset ownership is a core characteristic of PaaS providers, which is a commonality with professional asset providers in ABS, as highlighted in Table 1. In the service literature, this is also referred to as "firm-enabled sharing" (Benoit *et al.*, 2022, p. 208) of "platform-provided assets" (Wirtz *et al.*, 2019, p. 458).

Finally, we examine the way non-ownership transfers are facilitated in different systems (*how?*), specifically focusing on systems' reliance on digital technologies. ABS typically use digital technologies to facilitate flexible short-term access to assets (e.g. carsharing facilitated through apps). Similarly, triadic frameworks and many broader conceptualizations of the sharing economy rely heavily on the use of technology-based digital platforms to connect supply and demand (Andreassen *et al.*, 2018; Benoit *et al.*, 2022; Perren and Kozinets, 2018; Wirtz *et al.*, 2019). In contrast to ABS and triadic frameworks, some PaaS systems only require limited use of digital technologies. For example, while deposit systems usually operate websites to allow partnering restaurants to be located, consumers simply leave a cash deposit for each reusable container they use. App-based, digital systems, however, fully rely on digital technologies to facilitate exchanges of containers. Thus, the degree of technology reliance varies more strongly in PaaS systems than among typically technology-enabled ABS and triadic frameworks.

Against this conceptual background, PaaS represents an unexplored hybrid form of non-ownership consumption, which we call "access-based triadic systems." Such systems are access-based in the sense that they provide flexible short-term access to specifically produced assets owned by the system provider. At the same time, providers in access-based triadic systems offer their services to two distinct customer groups, resulting in systems that are triadic in nature.

So far, ABS and triadic frameworks have usually been treated as separate concepts (Benoit *et al.*, 2017; Hazée *et al.*, 2017, 2020). Thus, the implications of blending the two concepts for system adoption are not yet understood. Therefore, this paper empirically investigates PaaS as a type of access-based triadic system to respond to the following case-specific research question: Which attributes of access-based triadic systems for reusable food containers influence adoption intentions of restaurants and consumers? This way, we address several empirical research needs: First, we extend research on ABS adoption, which focuses on dyadic relationships between asset providers and customers. Furthermore, we complement studies on triadic frameworks as we look beyond well-researched peer-to-peer platforms and account for the need to study systems that rely on platform-provided assets (Wirtz *et al.*, 2019). At the same time, we include the underexplored yet essential perspective of service suppliers (i.e. restaurants), acknowledging that both market sides in triadic systems need to be considered (Andreassen *et al.*, 2018; Hazée *et al.*, 2020). The next section presents the methodological approach we applied to answer our research question and to address these research needs.

Materials and methods

This research empirically investigates influences of system attributes on restaurants' and consumers' intentions to adopt PaaS systems. In line with recent research with a similar methodological approach (Hahn *et al.*, 2020), a qualitative pre-study was used to identify which system attributes are relevant for restaurants and consumers. Afterward, the effects of these system attributes on adoption intentions were quantitatively tested in factorial survey experiments (FSEs). This follows recommendations by Atzmüller and Steiner (2010) who suggest using qualitative preliminary studies if existing theory is not sufficient to derive relevant dimensions for an FSE.

In FSEs, choice alternatives are described in vignettes, which are systematically varied along a number of dimensions (Aguinis and Bradley, 2014). As opposed to directly asking participants about their preferences regarding individual dimensions, FSEs capture participants' adoption intentions more implicitly based on a holistic impression of a choice alternative (Wallander, 2009). This way, FSEs leverage the advantages of survey research and experimental methods, which enhances the internal and external validity of FSEs (Aguinis and Bradley, 2014) and makes responses less prone to social desirability bias (Auspurg and Hinz, 2015). Moreover, the systematic design of FSEs along vignette dimensions enabled us to survey two distinct target groups (restaurants and consumers) in a consistent way and to systematically compare the effects of PaaS system attributes on adoption intentions of both groups. In addition, a set of questions also captured participants' individual-level characteristics such as demographic information, technology acceptance, and value orientations. This design allowed us to compare effects of system attributes and control for effects of individual-level variables (Oll *et al.*, 2018).

Pre-study: interviews and focus groups

To identify PaaS system attributes that are relevant for restaurants and consumers, semi-structured interviews and focus groups were conducted with each target group, respectively. In planning, conducting, and analyzing interviews and focus groups, we followed recommendations by Krueger and Casey (2015). An interview guide was developed covering questions on general perceptions and attitudes as well as drivers and barriers to adopt PaaS systems for takeaway food (see Appendix 1). Participants were recruited through convenience sampling and snowballing, using both lead authors' professional networks. Restaurant representatives were offered a €20 Amazon voucher and consumers were offered a €15 takeaway food voucher for their participation. Due to the limited availability of restaurant representatives, it was not possible to run focus groups with restaurants. We conducted six individual expert interviews (3.25 h; 32,349 words) with representatives of restaurants located in Germany and three focus groups (2.5 h; 22,145 words) with 11 German consumers in total. Participating consumers indicated in an online sign-up form whether they had used systems for reusable containers in the past. This way, consumers were assigned to groups with (two groups) and without (one group) prior experience. The respective interview guides were adapted accordingly. Interviews with restaurant representatives took place in January and February 2022, consumer focus groups were held in July 2021. Both interviews and focus groups were conducted as online video conferences and were recorded and subsequently transcribed. Afterward, transcripts were independently coded by both lead authors of this paper before results were jointly discussed and summarized. The following paragraphs present a synopsis of all interviews and focus groups and outline the derived vignette dimensions included in subsequent FSEs. For each dimension, two levels emerged from the qualitative pre-study (see overview in Table 2).

Overall, participating restaurant representatives and consumers were familiar with systems for reusable food containers and were generally open to adopting them. At the same time, both actor groups shared concerns regarding the limitations, costs, and efforts associated with such systems compared to single-use packaging. Some restaurant representatives reported that PaaS systems provide an opportunity to reduce costs compared to more environmentally friendly single-use containers (e.g. from recycled or biodegradable material). Other restaurant representatives highlighted the costs of offering PaaS systems and the associated efforts of operating the system compared to single-use

Dimension	Level 1	Level 2
System[a]	Deposit system	App-based, digital, no deposit
Access	Self-pick-up	Self-pick-up and delivery service
Container types	Standard-sized	Customized to meals served
Partner restaurants	5 partners within 2 km radius	20 partners within 2 km radius
Users	80 users within 2 km radius	950 users within 2 km radius
Place of return	Restaurants	Restaurants and return stations
Impact information	Collective impact of the system	Restaurant's/consumer's impact

Note(s): [a]This research's main purpose was to compare the effects of different vignette dimensions on restaurants' and consumers' adoption intentions. In practice, the system type of PaaS systems determines the commercial model and associated costs for restaurants. To increase the experiments' external validity, costs associated with each system type (deposit or app-based, digital) were set based on current price levels and held constant across all respective vignettes (Kleinhueckelkotten *et al.*, 2021). In particular, deposit systems were associated with a monthly fee of €30 and a refundable deposit payment of €5 for each container. App-based, digital systems were associated with a one-off sign-up fee of €100 and a usage fee of €0.20 for each reusable container filled by the restaurant (see Appendix 2 for two vignette examples).
Source(s): Table by authors

Table 2. Dimensions and levels of FSEs derived from qualitative pre-study

packaging. Yet, additional operational efforts (e.g. storage, cleaning) were perceived to be acceptable if the system can be easily integrated into existing routines. Regarding different types of systems for reusable food containers, deposit systems were generally perceived as more convenient than app-based, digital systems, especially among consumers (vignette dimension: *System type*). In terms of accessing containers, both restaurants and consumers perceived a potential integration of PaaS systems with established delivery services to be desirable alongside self-pick-up options (vignette dimension: *Access*).

In addition to system type and access, the design of offered containers was frequently mentioned by both actor groups. For restaurant representatives, it was of utmost importance that reusable containers are not standard-sized but customized to their food (e.g. with partitioning, sushi box, pizza box, etc.). More specifically, using customized reusable containers was seen as a way to maintain or even increase food quality: "If there was a system [. . .] where the food would arrive at the end consumer with the same quality as now, maybe even better, I would be the first one to participate" (Participant R1). Similarly, consumers regarded appealing and durable containers made of safe and flavorless materials as an advantage compared to single-use containers, as more robust reusable containers improve the experience of a takeaway or delivery meal (vignette dimension: *Container types*).

Moreover, consumers' main concerns revolved around the number of participating partner restaurants. Systems that are only available at a few restaurants were perceived to limit food choice, invoke search costs, and most importantly, cause additional effort to return containers. For instance, one consumer stated: "If I could use it everywhere it wouldn't be a problem. Then I can always take it [the container] to the next one [restaurant] and exchange it and now I always have to see where I can return it [the container]" (Participant C2). Thus, consumers demanded a dense network of participating partner restaurants at which they could receive and return reusable containers (vignette dimension: *Number of partner restaurants*). Accordingly, restaurant representatives saw an increase in consumer demand for reusables as the main driver for introducing such a system (vignette dimension: *Number of users*).

To simplify the return process, both actor groups suggested the introduction of return stations as drop-off points outside restaurants' opening hours (vignette dimension: *Place of return*). Additionally, the issue of cleaning reusable containers arose. Notably, both restaurant representatives and consumers primarily raised concerns around efforts and responsibilities associated with cleaning rather than issues around hygiene and potential contamination of containers. German food safety regulations require containers to be cleaned professionally and PaaS providers typically outsource container cleaning to partnering restaurants. Therefore, cleaning responsibilities are not a differentiating factor between systems for reusable food containers and were not taken forward as a separate dimension. Finally, protecting the environment by avoiding waste from single-use packaging was mentioned as a driver of adoption by both groups and was the most widely reported motivational factor by consumers. To substantiate the environmental contribution of reuse, some consumers demanded increased transparency about the impact of using systems for reusable containers, for example, in terms of waste reduction compared to single-use alternatives (vignette dimension: *Impact information*).

Main study: factorial survey experiments

Method

The seven dimensions of systems for reusable food containers brought up by both groups in our pre-study (see Table 2) were quantitatively tested in two separate FSEs with restaurants and consumers. Each of the seven vignette dimensions had two levels (see Table 2), leading to a total of 128 (2^7) possible combinations. As a result, there were 128 vignettes in the universe (for two vignette examples, see Appendix 2). Using the R package “FrF2” (Grömping, 2014), we obtained a fractional factorial design, which included a subpopulation of 64 vignettes of the full vignette universe. Furthermore, we used the “FrF2” package to split the 64 vignettes into eight vignette sets, in which dimensions’ main effects and two-way interactions were unconfounded with each other and with vignette sets. This provided an advantage compared to randomly drawing vignettes from the full vignette universe, which does not account for the confounding structure of main and interaction effects (Atzmüller and Steiner, 2010). Additionally, by randomly assigning each participant to one vignette set we were able to control for potential vignette set effects. As different groups of participants were randomly assigned to different vignette sets, but participants within each vignette set were shown the same vignettes, we implemented a mixed design (Atzmüller and Steiner, 2010). The same mixed fractional factorial design was used for the two FSEs with restaurants and consumers to ensure consistency and comparability.

Each FSE was structured as follows: After providing some demographic information, participants were informed about different types of systems for reusable food containers. The introduction explained the functionality of the two prevalent system types outlined in Figure 1: In deposit systems, consumers pay a refundable deposit when ordering takeaway food in a reusable container. In app-based, digital systems, consumers sign up in an app and reusable containers are assigned to them through a consumer-specific QR code without having to pay a deposit. To address potential questions about cleaning responsibilities, survey participants were also informed that, regardless of the system type, German food safety regulations require restaurants to professionally clean containers before redistributing them. The order in which the two system types were explained was randomly alternated to avoid order effects.

Next, participants were assigned to a vignette set and rated the probability of using eight different systems for reusable food containers on a scale from 1 (very low) to 11 (very high) (see Appendix 2). Again, the order of presented vignettes in each vignette set was randomized for each participant to prevent order effects. Eight vignette ratings per respondent are well within the acceptable range of rating tasks in FSEs, which often ask participants to rate 10–20 different vignettes (Auspurg and Hinz, 2015). Furthermore, each vignette was presented in a table format and on a separate page to reduce cognitive load (Shamon *et al.*, 2019). Both the introduction of systems for reusable food containers and the vignette descriptions depicted systems from the perspective of restaurants or consumers, respectively (see Appendix 2). Regarding the rating itself, restaurant representatives were asked to rate the probability that the system would be adopted in their restaurant. Consumers rated the probability of using the described system themselves. In line with previous research (Hahn *et al.*, 2020), the probability to adopt each system was measured on a scale from 1 to 11, as recommended to allow for linear modeling (Oll *et al.*, 2018).

After the vignette rating task, we measured a range of restaurant-level and consumer-level control variables. Restaurant representatives were asked about the area in which their restaurant is located, the types of food they serve, the proportion of takeaway food of their total business, and whether they are restaurant managers. Consumers were asked for information about their area of living, income level, and what types of takeaway food they consume. To ensure that respondents were at all familiar with ordering takeaway food, a screening question recorded consumers' frequency of takeaway orders along with initial demographic information in the beginning of the survey. This allowed us to screen out respondents who never order takeaway food, in line with methodological recommendations to avoid artificial responses (Aguinis and Bradley, 2014).

Following these restaurant and consumer-level control questions, restaurant representatives and consumers were asked about their technology acceptance and environmental values. These variables were measured because for many restaurants and consumers, adopting a PaaS system is a new pro-environmental behavior that is (in some cases) enabled by digital technologies. Thus, it is conceivable that technology acceptance can influence preferences for an app-based, digital (vs deposit) system. Furthermore, environmental impact information may be more relevant to people with stronger environmental values. Technology acceptance was measured using the four technology acceptance items of the technology commitment scale by Neyer *et al.* (2012) and were adopted in German from the original scale. Environmental values were measured using three of the four biospheric value orientation items of the Environmental Portrait Value Questionnaire by Bouman *et al.* (2018) (see Appendix 3). These items were translated to German by both lead authors and verified through back-translation by a native English speaker. Depending on whether restaurant representatives managed the restaurant or not, scales in the restaurant FSE were either phrased to refer to participants themselves (if they were managers) or to refer to the restaurant's management. Items of both constructs were measured on a seven-point Likert scale. Finally, both groups were asked if their restaurant or they as consumers had used a system for reusable food containers in the past and if so, which ones.

It is recommended to collect at least five ratings per vignette in FSEs (Auspurg and Hinz, 2015). However, to be able to measure the effects of individual-level characteristics and cross-level interactions, researchers are advised to take a more conservative approach and aim for a larger sample (Auspurg and Hinz, 2015). To determine the sample size, we followed recent FSE research and targeted 20 ratings per vignette (Hahn *et al.*, 2020). For the 64 vignettes included in the survey, at least 1,280 vignette ratings (64×20) would be needed. Given that each participant rates eight vignettes, the targeted 1,280 vignette ratings require a minimum sample of 160 participants (1,280/8). Restaurant representatives were recruited as a convenience sample through communication channels of Germany's largest hospitality industry group covering more than 200,000 hospitality businesses. Responses from this sample were collected in August and September 2022 and participants had the opportunity to win one of five €100 vouchers for a large German food wholesaler. Consumers were recruited through a market research agency and completed the FSE in April and May 2022. The consumer sample was representative of German takeaway consumers by age and gender, based on market research on takeaway food consumption in Germany (VuMa, 2022). Both

FSEs were implemented in Qualtrics and pre-tested with small convenience samples of individuals from the hospitality industry (restaurant FSE) and consumers (consumer FSE).

To analyze both FSEs we followed recommendations to use multilevel analysis, which accounts for the nested data structure that emerges as each respondent provides multiple vignette ratings (Atzmüller and Steiner, 2010). To validate that multilevel models were required, null models were specified with adoption intentions (grand mean centered) as the dependent variable and random intercepts for each participant. Intraclass correlation coefficients of 0.41 for restaurants and 0.60 for consumers confirmed that multilevel modeling was appropriate for our datasets (Heck *et al.*, 2014). Afterward, results for restaurants and consumers were modeled separately but following the same logic. In line with the stepwise modeling approach proposed by Heck *et al.* (2014), we compiled models in five steps (see overview in Table 3).

First, we compiled Model 1 with adoption intentions (grand mean centered) as the dependent variable and vignette dimensions as explanatory variables, including random intercepts for participants and vignette set dummies. Second, restaurant representatives' and consumers' individual-level variables (technology acceptance and biospheric value orientation) were added to compile Model 2. Third, we tested whether dimensions' effects varied significantly between participants and should therefore be modeled with random slopes variables. One by one, we included each of the seven dimensions as random slopes variables and inspected the significance of the respective slope variance. This modeling step provided evidence that two of the seven dimensions should be included as random slopes variables for both samples (restaurants and consumers). Thus, Model 3 introduced required random slopes to Model 2. Fourth, we added relevant interaction effects of system attributes with individual-level factors to specify Model 4. Finally, we introduced restaurant and consumer-level control variables in Model 5 to ensure that effects were robust to the inclusion of additional controls [2]. We applied maximum likelihood estimation for all models to be able to compare nested models using likelihood ratio tests. For both samples, likelihood ratio tests suggested that Model 5 delivered the best model fit. Therefore, the following section presents and interprets the parameters of Model 5 (see Table 4).

Results

A total of 243 complete responses by restaurant representatives were recorded. The fastest 27.5% of all participants were excluded from our dataset due to concerns that these respondents did not take enough time to fully read and understand the content of the FSE. This proportion was derived from the FSE with consumers, in which 27.5% of participants

Model parameters	Model 1	Model 2	Model 3	Model 4	Model 5
Random intercepts for all participants	X	X	X	X	X
Vignette set dummy variables	X	X	X	X	X
Main effects of Level 1 variables (vignette dimensions)	X	X	X	X	X
Main effects of Level 2 variables (individual characteristics)		X	X	X	X
Random slopes for Level 1 variables, if applicable			X	X	X
Relevant interaction effects of Level 1 variables (vignette dimensions) and Level 2 variables (individual characteristics)				X	X
Restaurant or consumer-specific control variables					X

Source(s): Table by authors reflecting stepwise modelling approach proposed by Heck *et al.* (2014)

Table 3.
Stepwise model specifications

Dependent variable[a]: intention to use offered system for reusable food containers	Restaurants[b] (N = 176) Coefficients (Standard errors)	Consumers[b] (N = 245)
Constant	−0.147 (0.167)	0.082 (0.161)
System: app-based, digital (baseline: deposit)[c]	0.023 (0.072)	−0.414 (0.041)***
Access: delivery included (baseline: excluded)	−0.011 (0.025)	0.037 (0.021)†
Container types: customized (baseline: standard containers)[c]	0.399 (0.047)***	0.176 (0.029)***
Partners: many (20) (baseline: few (5))	0.044 (0.025)†	0.161 (0.021)***
Users: many (950) (baseline: few (80))	0.076 (0.025)**	0.053 (0.021)*
Place of return: return stations offered (baseline: no return stations offered)	−0.005 (0.025)	0.070 (0.021)***
Impact information: individual/restaurant (baseline: collective)	−0.010 (0.025)	0.018 (0.021)
Technology acceptance[a]	0.061 (0.059)	0.069 (0.053)
Biospheric values[a]	0.074 (0.051)	0.279 (0.048)***
System: digital[c] × technology acceptance[a]	0.112 (0.072)	0.104 (0.041)*
Impact: individual/restaurant × biospheric values[a]	0.006 (0.025)	0.018 (0.021)
Age[a]	−0.118 (0.050)*	−0.099 (0.048)*
Proportion/frequency of takeaway orders[a,d]	0.059 (0.048)	0.088 (0.050)†
Used reusable system in the past: yes	0.249 (0.125)*	0.345 (0.162)*
Log Likelihood	−1465.640	−1858.270
Number of vignette ratings	1408	1960

Note(s): Estimation method: Maximum likelihood
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$, †$p < 0.1$
[a]Grand-mean centered and standardized by one standard deviation
[b]Control variables: Gender of participant, area of restaurant location or area of living, vignette set effects
[c]Included as random-slopes variable
[d]Measured as the proportion of takeaway orders for restaurants and the frequency of orders for consumers
Source(s): Table by authors

Table 4.
FSE model tables

were faster than the minimum time threshold of eight minutes, which was determined by a pre-test [3]. The final sample consisted of 176 restaurant representatives (see Appendix 4 for sample characteristics), which exceeds the minimum required sample size of 160 participants explained above. Each vignette set (and accordingly, each vignette), was rated at least 17 times.

Consumers were asked how frequently they order takeaway food on the first page of the FSE. Consumers who reported that they do not order takeaway food at all did not enter the FSE, due to concerns that they are not familiar with the situation described in the vignettes. Thus, the sample included respondents who consume takeaway food, regardless of whether they used PaaS systems for reusable food containers in the past. To ensure that consumers recruited through a market research agency properly read and understood the survey, respondents were excluded from the analyses if they failed at least one of two attention checks and if they completed the FSE in less than eight minutes. This minimum time threshold was defined based on a pre-test with consumers. 245 complete and valid responses from consumers were collected (see Appendix 4 for sample characteristics), again exceeding the minimum required sample size of 160. Each vignette set received at least 27 ratings.

Results of our core models of interest are presented in Table 4. The availability of containers that are customized to the served food was the key priority for restaurants ($\beta = 0.399$, $p < 0.001$). Moreover, restaurant representatives preferred more established, widely adopted systems. Both more existing partners ($\beta = 0.044$, $p < 0.1$) and more existing users ($\beta = 0.076, p < 0.01$) were associated with higher intentions to use a system. Notably, system type, offering delivery options, return stations, or restaurant-specific information about the environmental impact of the system did not show any significant effects on adoption intentions by restaurant representatives. Control variables demonstrated that intentions to adopt PaaS systems decreased as restaurant representatives' age increased ($\beta = -0.118, p < 0.05$). Furthermore, representatives of restaurants that had used a system in the past reported higher adoption intentions ($\beta = 0.249, p < 0.05$).

Consumers' intentions were most strongly influenced by the system type: The significant negative effect of offering a digital system ($\beta = -0.414$, $p < 0.001$) demonstrates a strong preference for deposit systems for reusable food containers over app-based, digital systems. We did, however, find a positive interaction effect of technology acceptance and digital systems ($\beta = 0.104, p < 0.05$). This interaction effect indicates that consumers who were more open to new technologies had higher intentions to use digital systems for reusable food containers.

Additionally, offering customized container types was associated with higher adoption intentions among consumers ($\beta = 0.176, p < 0.001$). Network density, that is, the number of participating partners ($\beta = 0.161, p < 0.001$) and users ($\beta = 0.053, p < 0.05$), also positively affected consumers' use intentions. In terms of container access and returns, we found a small positive effect of offering delivery options ($\beta = 0.037, p < 0.1$) and return stations ($\beta = 0.070$, $p < 0.001$). Different types of impact information did not have a significant effect on adoption intentions. Finally, control variables showed that older consumers had lower ($\beta = -0.099$, $p < 0.05$) and more environmentally oriented consumers had higher intentions ($\beta = 0.279$, $p < 0.001$) to use systems for reusable food containers. There was a marginally significant positive association of takeaway order frequency with higher adoption intentions ($\beta = 0.088$, $p < 0.1$) and a significant positive effect of having used such systems in the past ($\beta = 0.345, p < 0.05$).

Discussion

Core to this research is the case-specific question which attributes of access-based triadic systems for reusable food containers influence adoption intentions of restaurants and consumers. The results of our FSEs point toward a range of common and divergent influences on both groups' intentions to adopt PaaS systems. Notably, while effect sizes of system attributes differ between restaurants and consumers, we do not find evidence for contradicting preferences of both groups. That is, we do not identify opposing preferences that would force PaaS providers to prioritize the needs of one group over those of the other.

Regarding common preferences for system attributes, our results highlight that customized containers and a large network of participating restaurants and consumers are crucial success factors for PaaS systems. Customized containers (e.g. with partitioning, sushi box, pizza box, etc.) have a sizeable positive direct effect on both restaurants' and consumers' adoption intentions. At the same time, we find a positive effect of a larger number of restaurants on users' adoption intentions and vice versa. Considering that customized containers have the largest positive direct effect on restaurants, PaaS providers offering a diverse range of containers could trigger a virtuous cycle: Customized containers motivate more restaurants to adopt the PaaS system, which motivates additional consumers to join, which positively affects restaurant participation and so forth.

In terms of divergent influences, the type of PaaS system is a system attribute that does not affect restaurants' adoption intentions but shows the strongest effect on consumers. More specifically, we find a strong consumer preference for deposit systems over app-based, digital PaaS systems. The positive interaction effect of technology acceptance and digital PaaS systems, however, supports the notion that there are different consumer segments

(Kleinhueckelkotten *et al.*, 2021). Although consumers generally prefer deposit systems, more technology-accepting consumers are more open toward app-based, digital PaaS systems. As a result, the system type chosen by PaaS providers plays a key role in convincing consumers to use the system and must consider the target group's openness to new technologies.

Other system attributes such as delivery services, return stations, or providing environmental impact information play a secondary role for the adoption of PaaS systems. While delivery services and return stations could increase the complexity of managing the system, they only show moderate positive effects on consumers' adoption intentions and no effects on restaurants. Notably, environmental benefits were highlighted as motivating factors in interviews and focus groups by both actor groups. However, we did not find significant effects of providing individualized (rather than collective) information about the positive environmental impact of using the PaaS system in our FSEs. This discrepancy may be explained by more socially desirable responses in direct in-person interviews and focus groups about personal preferences in the qualitative pre-study, compared to the more subtle questioning embedded in the multidimensional vignettes of the FSEs (Auspurg and Hinz, 2015).

In addition to influences of system attributes, FSEs also enabled us to test effects of restaurant representatives' and consumers' characteristics on PaaS adoption intentions. In both groups, adoption intentions are higher among respondents who used PaaS systems before and among younger participants. Furthermore, consumers who order takeaway food more frequently show higher intentions to use PaaS systems. This provides evidence for the importance of system compatibility with lifestyles and usage patterns (Hazée *et al.*, 2017, 2020). Furthermore, biospheric values are positively associated with higher adoption intentions among consumers. This is in line with previous findings that environmental benefits of non-ownership consumption motivate users (Hamari *et al.*, 2016) and contrasts other contributions that do not find associations of intrinsic sustainability motivations with interest in non-ownership consumption (Habibi *et al.*, 2016; Lamberton and Rose, 2012; Möhlmann, 2015). To conclude, next to system attributes, it is also relevant for PaaS providers to consider characteristics of the different target groups when developing PaaS systems.

Implications for theory and research

Based on these empirical findings on PaaS, we now discuss the implications of blending ABS and triadic frameworks for system adoption. To do so, we address the key characteristics outlined in the conceptual foundations and consider the actors (*who?*), shared assets (*what?*), and systems' technology reliance (*how?*). This way, we evaluate to what extent hybrid access-based triadic systems face novel challenges and opportunities compared to ABS and triadic frameworks.

In terms of the number of actors involved (*who?*), access-based triadic systems are similar to triadic frameworks, which operate in a triangle of actors. One of the challenges of platforms in triadic frameworks is building a critical mass of supply and demand at the same time (Andreassen *et al.*, 2018). The positive effects of additional participating restaurants and consumers on both target groups' PaaS adoption intentions indicate that access-based triadic systems face the same challenge of simultaneously attracting two market sides. These preferences for PaaS systems with more participating restaurants and consumers also point toward positive network effects in PaaS systems. Notably, we provide empirical evidence that indirect network effects are stronger than direct network effects (Wirtz *et al.*, 2019) in both samples: Consumers' adoption intentions are more strongly affected by additional partnering restaurants than by additional consumers. At the same time, restaurants are more strongly motivated by additional consumers than by additional restaurants.

With regard to the types of shared assets (*what?*), access-based triadic systems resemble ABS with tangible assets. That is, assets are specifically produced to deliver a service and are owned by the system provider. In PaaS, reusable food containers are tangible assets that are produced with the intention to replace single-use containers. Our results show that containers customized to different meals are a key attribute of PaaS systems for both restaurants and consumers. This highlights that asset ownership creates opportunities for access-based triadic system providers to differentiate themselves from competitors and alternative packaging solutions. Furthermore, asset ownership enables system providers to deliver consistent, high-quality services throughout their system. These are important advantages compared to platform providers in triadic frameworks with crowdsourced supply: As highlighted by prior research, triadic frameworks often face challenges regarding the control of service quality (Eckhardt *et al.*, 2019) because assets are owned and controlled by peer-to-peer suppliers, which increases heterogeneity (Andreassen *et al.*, 2018; Wirtz *et al.*, 2019).

Nevertheless, to leverage the opportunities of asset ownership, access-based triadic system providers need to take a more active role in product design and distribution. This reduces system providers' flexibility and introduces additional investment costs compared to triadic platform providers that are typically light on assets (Andreassen *et al.*, 2018; Wirtz *et al.*, 2019). Additionally, previous research highlights that non-ownership consumption can promote opportunistic behaviors at the expense of other system participants and shared assets (Bardhi and Eckhardt, 2012; Guyader, 2018; Schaefers *et al.*, 2016). Compared to matchmakers in triadic frameworks that do not own physical assets, it is particularly important for providers of access-based triadic systems that own physical assets to design appropriate system mechanisms that protect their own assets from damages and losses (e.g. through deposits or digital tracking).

This leads over to the question to what extent technologies are employed to manage the system (*how?*). As opposed to ABS and triadic frameworks that typically rely on digital technologies, the extent to which digital technologies are used varies more strongly in access-based triadic systems. In PaaS, the system's technology reliance is mostly determined by the system type, which we identify as a key determinant of consumers' adoption intentions. The degree to which a deposit or digital PaaS system relies on technology is essential here: Our results show a clear consumer preference for deposit systems over app-based, digital systems. This finding links to research that identifies system complexity as a functional barrier in ABS and triadic frameworks (Hazée *et al.*, 2017, 2020). In other words, higher technical costs of familiarizing oneself with the system (Habibi *et al.*, 2016; Lamberton and Rose, 2012), including upfront registration and the technology-mediated use of the system, can discourage consumers from using app-based, digital PaaS systems. In conjunction with the abovementioned aspect of asset protection, this highlights a trade-off faced by access-based triadic system providers: On the one hand, technologically complex systems may protect their assets and enable PaaS providers to run their systems more efficiently but attract fewer consumers. On the other hand, more simplified system mechanisms are more popular among consumers but may not be sufficient to manage owned assets because assets cannot be traced and redistributed as efficiently.

In sum, our findings shed light on the implications of blending access-based service provision with triadic frameworks, accounting for *who* is involved in the system, *what* assets are shared, and *how* assets are shared. We show that access-based triadic systems come with additional challenges while introducing opportunities for competitive advantages: On the one hand, actors on two market sides must be attracted simultaneously and owned assets must meet functional demands. At the same time, system mechanisms must be sufficiently advanced to protect assets and efficiently distribute them throughout the system without introducing prohibitively high complexities for consumers. On the other hand, asset ownership allows for greater control over service quality and provides opportunities for differentiation from competition. These findings contribute to a growing body of literature that aims to specify characteristics of sharing economy concepts and their implications in more detail (Benoit *et al.*, 2022; Eckhardt *et al.*, 2019; Perren and Kozinets, 2018; Wirtz *et al.*, 2019).

Implications for practice

It is crucial for providers of access-based triadic systems to understand the influences on adoption intentions of the two market actors their systems serve. This paper proposes FSEs as a suitable method to consistently analyze the preferences of both market sides. This helps system providers to evaluate their system design choices and identify potential trade-offs. Thus, the first practical contribution of this paper is to provide a replicable research framework that could be applied to derive practical insights for businesses in two-sided markets. The following paragraphs outline several managerial implications for PaaS for takeaway food before proposing different contexts in which access-based triadic systems offering PaaS could be applied.

Customized containers are the most important system attribute for restaurants and have significant positive effects on consumers' adoption intentions. Therefore, developing an adequate container offering is a key concern for PaaS providers. Yet, while customized containers may help to attract both restaurants and consumers, they also increase the complexity of scaling the system due to additional logistical challenges. As opposed to systems with one standard container type for participating restaurants, customized containers may not be useful to all participating restaurants. For example, a sushi restaurant does not see any value in reusable pizza boxes and vice versa. Thus, a more diverse container offering may require PaaS system providers to put additional effort into the tracking and distribution of containers. Notably, not all PaaS system types are equally well-equipped to tackle these logistical challenges. Specifically, in systems with cash deposits containers are not tracked, which makes it much more challenging to monitor and distribute containers in the system. At the same time, our results show that consumers prefer less complex systems. Therefore, PaaS providers must strike a balance between offering sufficiently customized containers without imposing unmanageable operational complexities on themselves, on restaurants, and on consumers.

Apart from questions on logistics and convenience, heterogenous containers may limit the environmental benefits of a PaaS system because individual containers may not reach the required number of uses to deliver environmental benefits compared to single-use packaging. This minimum threshold is even more difficult to reach, the more different providers of reusable food containers enter the market with their own containers, as is currently the case in Germany and Europe (Kleinhueckelkotten *et al.*, 2021). In response, policymakers may want to support a consolidation of systems to ensure environmental benefits by reducing asset heterogeneity between different PaaS systems.

This work considered the specific, innovative case of reusable containers for takeaway and delivered food as an example for PaaS. Yet, we expect the challenges and opportunities PaaS providers face as both asset owner and platform provider to extend to other use cases: In the food sector, packaged food is offered by supermarkets (in particular, fresh food counters), bakeries, canteens (at work, in schools, and at universities), as well as in leisure contexts (e.g. cinemas, festivals, and other events). Beyond the food sector, PaaS can be introduced for drugstore articles (e.g. shampoo, laundry detergent, etc.) or in e-commerce to enable sellers to ship goods in reusable boxes. However, different use cases may introduce new responsibilities for PaaS providers as well. For example, PaaS systems for takeaway food from restaurants benefit from the availability of dishwashing facilities at restaurants. In contrast, other use cases will require PaaS providers to offer central washing services to clean containers because, for example, supermarkets, cinemas, or drugstores may be reluctant to clean containers. While this increases logistical complexity, it can also be an opportunity for PaaS providers to add value for their customers and differentiate themselves from competitors and alternative packaging solutions.

Limitations and future research

Some limitations concerning sample composition and the studied case should be noted. First, while we build on a comprehensive survey dataset of restaurants, it constitutes a convenience sample, which may not be representative of the hospitality sector in Germany and beyond. Moreover, cultural differences may impact adoption intentions of different PaaS systems. This affects both our qualitative pre-study and our quantitative FSEs. Thus, the identified system attributes and their effects on restaurants' and consumers' adoption intentions most likely reflect the German context in which data were collected. Specifically, deposit systems may be more popular in Germany because many consumers are familiar with the long-existing bottle deposit system. It is conceivable that introducing a digital system will be easier in countries where neither of the two systems is known yet. Thus, it is important to replicate our work in other cultural contexts to support PaaS providers to successfully expand their businesses globally.

Second, our findings on access-based triadic systems are based on the specific case of PaaS for reusable food containers. While we expect the implications of asset ownership in access-based triadic systems to translate to other contexts as well, we encourage future research to investigate similar use cases such as PaaS for drugstores or e-commerce. Beyond PaaS, platform business models with platform-provided assets (Wirtz *et al.*, 2019) have emerged in the transportation sector (Eckhardt *et al.*, 2019). For example, Uber has experimented with Uber-owned cars as an alternative to cars owned by drivers. Notably, this example demonstrates the potential downsides of not seizing the opportunities of asset ownership, as Uber was criticized for offering unsafe cars with known defects bought from unauthorized dealers (Horwitz, 2017). If firm-enabled sharing with platform-provided assets (Benoit *et al.*, 2022; Wirtz *et al.*, 2019) gains traction beyond PaaS and transportation in years to come, we encourage future research to evaluate these applications and continue to explore the conceptual spectrum between ABS and triadic frameworks, in which we place "access-based triadic systems". In doing so, we invite researchers to consider FSEs as a methodological tool to elicit adoption intentions of different target groups in two-sided markets in a systematic way.

Conclusion

Acknowledging that platform providers in triadic systems must fulfil the demands of two market sides, this paper investigated adoption intentions for PaaS systems for takeaway food that blend aspects of ABS and triadic frameworks. With a qualitative pre-study and quantitative FSEs, we empirically identify and evaluate influences of PaaS system attributes and individual characteristics on adoption intentions of both restaurants and consumers. We find that access-based triadic systems that use platform-owned assets in a triadic system confront PaaS providers with a new set of challenges and opportunities: On the one hand, PaaS providers need to attract a critical mass of business and end customers while balancing asset protection and system complexity. On the other hand, owning reusable containers presents PaaS providers with opportunities for higher quality control and differentiation from competition. Our insights contribute to a growing body of literature on non-ownership consumption and specifically address access-based triadic systems that apply aspects of ABS and triadic frameworks. Furthermore, our findings support PaaS practitioners to scale their services and thereby increase the positive environmental impacts of switching from single-use packaging to reusable alternatives.

Notes

1. The terms "access-based services" and "collaborative consumption" have been used in different ways by prior research. On the one hand, "collaborative consumption" is either used as an umbrella term that includes ABS (e.g. Habibi *et al.*, 2016; Möhlmann, 2015) or as a subset thereof (e.g. Wirtz *et al.*, 2019). On the other hand, some authors distinguish between the two as parallel concepts: "Access-based services" are provided by a professional service provider to customers in a dyadic relationship, whereas "collaborative consumption" depicts a triadic relationship based on peer-to-peer exchanges of crowdsourced assets mediated by a matchmaker (Benoit *et al.*, 2017). We follow this distinction and conceptualize the two as separate, parallel concepts rather than as a subset of one another.
2. As is common in experimental research, we included age, gender, and geographic location as demographic control variables. Additionally, models controlled for key activities related to reusable food containers that may influence PaaS adoption intentions: The proportion of takeaway orders (restaurants) or the frequency of takeaway orders (consumers) and past experience with systems for reusable food containers were included to control for potential effects of familiarity with takeaway orders and reusables. Finally, we controlled for vignette set effects, as recommended by the methodological literature on FSEs (Atzmüller and Steiner, 2010).
3. Due to the complexities of recruiting a sufficiently large sample of restaurant representatives, it was not possible to conduct a large pre-test with restaurants and the time threshold was derived from the consumer pre-test.

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(The Appendix follows overleaf)

Appendices

Appendix 1

Question type		Questions to restaurant representatives and consumers *without* past experience of using systems for reusable containers for takeaway food	Questions to restaurant representatives and consumers *with* past experience of using systems for reusable containers for takeaway food
Introduction		• Which systems for reusable containers do you know?	• Which systems for reusable containers do you know, do you currently use, or did you use in the past?
		• Can you briefly describe the reuse systems?	• Can you briefly describe the reuse system?
			• When, where, and how do you use it?
		• How do these systems differ?	• How do these systems differ?
Main questions: Attributes of reuse systems	General	• What do you think of such reuse systems?	• What do you think of such reuse systems?
		• If you were to tell a friend about reuse systems, what would you say?	• If you were to tell a friend about reuse systems, what would you say?
	Drivers		• What works well?
			• Which positive/good experiences did you have?
		• Which attributes would motivate you to use such a system?	• Which attributes motivated you to use such a system?
		• What must the system fulfill for you to use it?	• What does the system fulfill that makes you use it?
		• What must not be missing from the system in any case?	
	Barriers		• What works less well?
			• Which negative/bad experiences did you have?
		• What kept you from using a reuse system in the past?	• Which attributes would keep you from using such a system?
			• Did you ever switch systems? Why?
	Ideal system	• What would an ideal reuse system look like (for you)?	• What would an ideal reuse system look like (for you)
			• What could be better about the system you use? How could the system still be improved?
Wrap-up		• Of all the things we've talked about, what is most important to you?	• Of all the things we've talked about, what is most important to you?
		• All in all: Would you participate in a reuse system?	
		• If yes, which one?	
		• If not, what would you use instead?	

Note(s): The interview guides were translated from German to English and were identical for interviews with restaurant representatives and focus groups with consumers. The questions only varied depending on whether respondents had used any system for reusable containers for takeaway food before (right column) or not (left column).
Source(s): Table by authors

Table A1. Interview guides used in qualitative pre-study

Appendix 2

	Vignette for restaurants		Vignette for consumers
Is it a deposit or digital system?	**Digital system:** Customers who are **registered** in the system provider's **app** can borrow the containers free of charge **for 14 days**. **Costs** for my restaurant**:** • **Usage fee** of **20 cents** for each reusable container filled • **One-time entry fee** of **100 euros**	**System type**	**Deposit system:** You can borrow reusable containers from participating partners **for an indefinite period for a deposit of 5 euros.** After returning them, you will get the deposit back.
How can I offer the system?	• Via **delivery services** to the customers • Via **self-collection** directly at the restaurant	**Access to containers**	You receive containers when you order your food **directly from partners for self-collection**
Which container types exist?	• Containers **customized to my dishes** (e.g., with partitioning, sushi box, pizza box, etc.)	**Container types**	The system provides access to **standardized 1250ml containers**
How many partners participate?	• **20 partners** within a 2km radius around my restaurant	**Partners**	Currently, **5 partners** participate in the system within a **2km radius** around you
How many active users are there?	• **950 active users** within a 2km radius around my restaurant	**Users**	Currently, there are **80 active users** of the system within a **2km radius** around you
How are containers returned?	• **At any time** at stationary **return stations** • During **opening hours** at all participating **partners**	**Place of return**	You can return borrowed containers to **all participating partners during opening hours**
What do I learn about the environmental impact?	• Number of single-use containers saved by **all partners**	**Impact information**	You regularly learn how many single-use containers **you have personally** saved by using the reuse system

The probability that we would use the described system in my restaurant is:

Very low										Very high
1	2	3	4	5	6	7	8	9	10	11

The probability that I would use the described system is:

Very low										Very high
1	2	3	4	5	6	7	8	9	10	11

Note(s): All seven PaaS system attributes reflected in the vignettes of our FSEs were derived from our qualitative pre-study (see Table 2 for an overview of results). The specific wording of vignettes was adapted to the perspective of the respective sample (i.e., restaurants or consumers). To decrease cognitive load, vignettes for restaurant representatives (see example on the left) were simplified by formulating each system attribute as a straightforward question and by using bullet points to reduce the amount of text.
Source(s): Tables by authors

Table A2. Two exemplary vignettes showing PaaS system attributes

Appendix 3

Construct	Items	Restaurant sample (N = 176)	Consumer sample (N = 245)
Technology acceptance[a] (Neyer *et al.*, 2012)		M = 4.328, SD = 1.689, α = 0.926	M = 4.484, SD = 1.527, α = 0.931
	[I am/My restaurant's management is] very curious about new technological developments		
	[I quickly take/My restaurant's management quickly takes] a liking to new technological developments		
	[I am/my restaurant's management is] always interested in using the latest technological devices		
	If [I/my restaurant's management] had the opportunity, [I/they] would use tech products much more often than [I/they] currently do		
Biospheric values[b] (Bouman *et al.*, 2018)		M = 6.095, SD = 0.963, α = 0.896	M = 5.698, SD = 1.153, α = 0.891
	It is important to [this person/to my restaurant's management] to prevent environmental pollution		
	It is important to [this person/to my restaurant's management] to protect the environment		
	It is important to [this person/to my restaurant's management] to respect nature		

Note(s): In the restaurant sample, question items referred to a restaurant's management if the participant indicated that he or she has no management role

[a]Items were answered on a seven-point Likert scale from 1 = strongly disagree to 7 = strongly agree

[b]Items were answered on a seven-point Likert scale from 1 = not like me at all to 7 = very much like me. The item "It is important to this person to be in unity with nature" was dropped because the pre-test of our restaurant FSE showed that its meaning was unclear to some participants.

Source(s): Table by authors

Table A3.
Measured constructs

Appendix 4

	Restaurant sample (N = 176)		Consumer sample (N = 245)	
Gender	Female	45.5%	Female	46.5%
	Male	54%	Male	53.5%
	Non-binary	0.6%	Non-binary	0%
Age	*M*	52.6	*M*	40.1
	SD	11.1	*SD*	14.6
Location of restaurant	Rural community	38.6%	Rural community	20.4%
Area of consumer's residence	Small city	25%	Small city	22.4%
	Mid-sized city	14.8%	Mid-sized city	20.8%
	Large city	8%	Large city	15.1%
	Major city	13.6%	Major city	21.2%
Hotels		35.2%		
Manager role		86.4%		
Education			None	0.4%
			High school	14.7%
			Qualified to go to university	16.3%
			Apprenticeship	40%
			University degree	28.2%
			PhD	0.4%
Net income			Less than €500	4.5%
			€501–€1.000	10.6%
			€1.001–€1.500	10.2%
			€1.501–€2.000	12.2%
			€2.001–€3.000	22.4%
			€3.001–€4.000	14.7%
			€4.001 or more	16.3%
			Prefer not to say	9%

Source(s): Table by authors

Table A4. Characteristics of restaurant and consumer samples

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