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THE BUSINESS ECOSYSTEM OF MOBILITY-AS-A-SERVICE AS A PRODUCT-SERVICE SYSTEM: AN ECO-INNOVATION

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INTRODUCTION

By presenting a shift away from the existing ownership-based transport system and towards an access-based one, the concept of Mobility-as-a-Service (MaaS) has been gaining ground in recent years and becoming a market option (Ambrosino, Nelson, Boero, & Pettinelli, 2016; Jittrapirom et al., 2017; Mulley, 2017). The essential idea of MaaS is to see transport or mobility not as a physical asset to purchase (e.g. a car) but as a single service available on demand and incorporating all transport services from cars to buses to rail (Ambrosino et al., 2016).

Despite the growing number of studies regarding MaaS in the past years (2017 and 2018 see Utriainen & Pöllänen (2018)), it still not possible to define which are the theoretical field underlying this concept (Hünewaldt, 2018), phenomenon, transport solution (Jittrapirom et al., 2017), or anything else MaaS could be fitted and we still don't know. Furthermore, SAE (Society of Automotive Engineers) International states that MaaS is an evolving concept that could be defined by them in future revisions of the J3163 standard (SAE International, 2018). Also, there are still some misunderstood related to which kind of mobility service is or not a MaaS.

In preliminary analyses, we observe that the concept behind MaaS relates to Product-Service System (PSS) approach. A PSS can be defined as an innovation strategy that alters the focus of the business of designing (and selling) only physical products, to designing (and selling) a system of products and services that are jointly able to meet specific customer demands, where customers' demands are met by service satisfaction, rather than the supply of a product (Manzini & Vezzoli, 2003). In this sense, if MaaS is able to fulfil users' needs it will not be necessary, for example, cars' ownership. In fact "for many, owning a car to commute will make as much sense as owning a cell tower to scroll Instagram" (Neff, 2019, p.1).

However, some studies illustrate the eventual negative implications of the rebound effects caused by a PSS (Manzini & Vezzoli, 2003; Tukker, 2015), that might also affect MaaS schemes. For instance, the promise of not owning a vehicle proposed by peer-to-peer (P2P) companies brought unexpected impacts to urban mobility. Thus, the migration of public transportation users toward P2P services negatively impacted bus companies (Marques, 2018), that had to disable bus schedules in the outskirts neighborhoods, notwithstanding the environmental impacts due to the insertion of more automobiles on the roads instead of collective solutions.

Therefore, sustainability is not an intrinsic characteristic in a PSS (Doualle et al., 2016). In this sense, the eco-innovation concept can be inserted in MaaS approach as a PSS, as long as it represents an innovation that brings a reduction on the environmental impacts. According to Fussler & James (1996), eco-innovation consists of new products and processes which provide customer and business value and mainly a significantly decrease in environmental impacts.

Furthermore, as a complex and integrated model, MaaS should be analyzed in a business ecosystem perspective (Karmagianni and Matyas, 2017; Jittrapirom et al., 2017). Business ecosystems bring together multiple players of different types and sizes in order to create and capture value in a synergic and networked way, resulting in new sources of employment and growth (Mulas, Minges & Applebaum, 2016).

Considering the aforementioned, this study purposes at answering the following research question: Do MaaS fit the PSS model? Which are the main concepts behind MaaS? Can MaaS be considered an eco-innovation? What is the main difference between mobility levels and MaaS schemes? In this sense, this paper aims to analyze MaaS as a Product-Service

System and as an Eco-innovation under the Business Ecosystem concept, as well as propose a schematic model for different mobility services.

This paper addressed three main contributions. First, by analyzing MaaS via the theoretical tripod of PSS, Eco-Innovation and Business Ecosystem, we sought to contribute to the state-of-the-art of these knowledge fields. Second, by comparing different mobility offerings (including MaaS), we attempted to improve the proper use of MaaS. Third, we endeavored to find trends for MaaS by proposing an evolution on its typology based on the integration of the aforementioned theoretical tripod.

LITERATURE REVIEW

Mobility-as-a-Service as a Product-Service System

According to Boehm & Thomas (2013), a PSS is an integrated bundle of products and services which aims at creating customer utility and generating value. In the same way, Annarelli et al. (2016) states that a PSS is a business model focused toward the provision of a marketable set of products and services, designed to be economically, socially and environmentally sustainable, with the final aim of fulfilling customer's needs. Also, according to Centenera and Hasan (2014) a PSS is an integrated combination of products and services for optimal consumption.

In order to establish relations among MaaS and the PSS concept, we choose the archetypical PSS from Tukker, (2004). The author drew a categorization of eight PSS models that vary on a spectrum in which on one end the man value rests on products content and on the other service content (Figure 1).

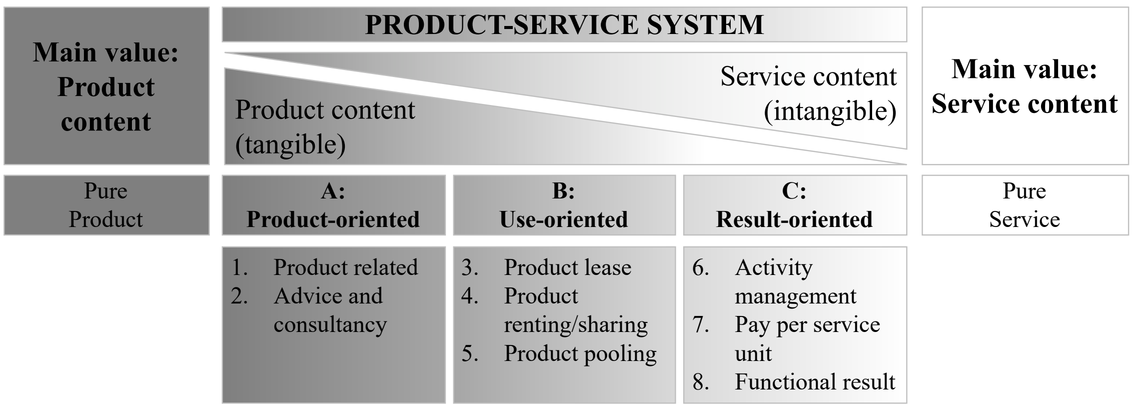

Fig. 1 Archetypical Product-Service System models
Source: Adapted from (Tukker, 2004, p. 248)

According to the author the classification makes a distinction between three macro-categories; **A: Product-oriented service** - the business model is still mainly geared towards sales of products, but some extra services are added; **B: Use-oriented service** - the traditional product still plays a central role, but the business model is not geared towards selling products. The product stays in ownership with the provide, and is made available in a different form, and sometimes shared by a number of users; **C: Result-oriented services** - the client and provider in principle agree on a result, and there is no pre-determined product involved (Tukker, 2004, p. 248).

Given the MaaS concepts (Kamargianni et al., 2018; Hietanen, 2019; Ambrosino et al., 2016; Jittrapirom et al., 2017; Mulley, 2017), and core characteristics (see Jittrapirom et al., 2017) and based on the PSS' macro categories we propose that MaaS are likely to be positioned on category C: Result-oriented service. According to Tukker (2004) this category is composed of three different PSSs: i) **Activity management/outsourcing**: Here a part of an activity of a company is outsourced to a third party; ii) **Pay per service unit**: The PSS still has a fairly common product as a basis, but the user no longer buys the product, only the *output* of the product according to the level of use; iii) **Functional result**: Here, the provider agrees with the client the delivery of a result (Tukker, 2004, p. 249). The analyzes and discussion section will go further on this topic.

Still, in the mobility context, new consumption trends have emerged in past years (e.g. short-term hire models of use for cars, bicycle, and scooters, ride-hailing service, and ride-sharing). However, these cannot be classified as result-oriented services since they present a user-oriented business mode, when specifying a modal. On the other hand, they still present environmental characteristics which characterize some of them as an innovation that regards with environmental aspects, since the asset use is optimized varying the necessity and usage of some modals in the urban environment. This sort of innovation can be named as eco-innovation (Aloise & Macke, 2017).

Eco-innovation

The concept of eco-innovation was proposed by Rennings (2000) after his analysis of the innovation definition by the Oslo-Manual of the OECD (2005). According to the manual, eco-innovation cannot be conceived because it does not provide information on the difference between environmental and non-environmental innovation, and, hence, the challenges of sustainable development, innovation household, and institutional changes are not considered. Thus, in a nutshell, by including these elements, eco-innovation can be conceived as a conventional innovation when they are concerned with the environment and sustainability (Aloise & Macke, 2017).

According to Rennings (2000), eco-innovation can be developed by companies or by non-profit organizations with technological, social or institutional nature. Thus, eco-innovation has the attribute to reduce environmental burdens related to, at least, one type of natural resource. In consequence, the technological focus is changed from the economic efficiency of the productive systems toward the technological innovation seeking environmental protection in a preventive and corrective manner (Rennings, 2000).

Hence, eco-innovation encompasses broad aspects of organizational elements such as "product, process, marketing, and organizational innovations, leading to a noticeable reduction in environmental burdens" (Horbach et al. 2012, p., 119). As a result, explicit positive or collateral effects of innovation can occur with: (i) the companies involved or; (ii) customers, through better use of products and services (Horbach et al., 2012).

Therefore, eco-innovation asks from actors throughout the whole product/service lifecycle seeking to optimize the assets use, reducing environmental risks, pollution, negative impacts of resources use (including energy use) comparing to other alternatives (Kemp and Pearson, 2007 p.16). To achieve this, effort from relevant actors (firms, politicians, unions, associations, private households), to develop new ideas, behavior, products and processes, apply or introduce them contribute to a reduction of environmental burdens or to ecologically specified sustainability targets (Klemmer, Leher, & Löbbe, 1999; Rennings, 2000).

Correlated, the Eco-Innovation Observatory (2012) states that eco-innovation is the "introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water, and land) and decreases the release of harmful substances across the whole life-cycle" (p.8).

Besides of these multiples definitions, according to (Hojnik & Ruzzier, 2016, p. 32) “eco-innovation reflects two main consequences: fewer adverse effects on the environment and more efficient use of resources”. However, to orchestrate these effects several stakeholders are involved toward an environmental approach. Thus, a Business Ecosystem perspective is also needed.

Business Ecosystem

The business ecosystem approach comes from a seminal work by James Moore (1993). The author stated that are parallels with business and natural ecosystem, when environmental conditions change too radically. “In a business ecosystem, companies coevolve capabilities toward innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations” (Moore, 1993 p. 76). Since then, several authors agree that the definition and concept of ecosystem are unclear and there still a lot of work to be done to establish it (Iivari, 2016; Koenig, 2012; Daidji, 2011; Peltomiemi & Vuori, 2004).

In this way, many different definitions of business ecosystem emerge. Iivari et al. (2016) affirms that business ecosystem refers to a network of organizations, involved in the development and delivery of a specific product/service through both competition and cooperation. However, for Peltoniemi & Vuori (2004) there is no need for government interventions in order to a business ecosystem survivor because they are self-sustaining.

Also, Daidji (2011) states that other factors should be considered in business ecosystems such as the existence of leader companies (keystones), the decentralized business ecosystem control notion and the business platform concept. According to the aforementioned author, although the business ecosystem presents decentralized control, a company leader exists in order to coordinate other companies immersed in the same system Daidji (2011) through business platforms that acts centrally bridging the ecosystem innovation (Evans et al., 2008; Gawer and Cusumano, 2013).

On the other hand, platforms are considered one within the 4 types of business ecosystems (Koenig, 2012). The author proposes that there are specific mechanisms to each type of business ecosystem suggesting a typology based on key resource control (centralized or decentralized) and type of interdependency (reciprocal or clustering). With reference to the control upon the centralized key resource, 2 typologies emerge; supply systems and platforms, respectively reciprocal and pooled interdependency. When the control of the key resource is decentralized, 2 typologies emerge; communities of destiny and expanding communities. On the former the interdependence is reciprocal, for the latter, the interdependency is pooled.

It is important to highlight that the reciprocal interdependence supports qualitative development, deepening the individual relationship. As for the pooled, there is a propensity to a quantitative development corresponding to the expansion process, which the technological development favored its dissemination (Koenig, 2012). In the same way, the technological development was also favorable for the development and evolution of MaaS allowing the stakeholders’ integration and the users (Lyons et al., 2019).

In this sense, Jittrapirom (2017) states that MaaS ecosystem is built on interactions between different groups of actors through a digital platform: demanders of mobility (i.e. private customer or business customer), a supplier of transport services (i.e. public or private) and platform owners (i.e. third party, PT provider, public authorities). Other actors can also cooperate to enable the functioning of the service and improve its efficiency: local authorities, payment clearing, telecommunication and data management companies.

Based on business ecosystem precepts suggested by Moore (1993), Kamargianni & Matyas (2017) classified different actors based on the relationships with MaaS providers under layers. According to the authors a business ecosystem is composed of several layers, which correspond to differing levels of commitment to the MaaS providers (core, 1, 2, 3 layers – which 3 has the lowest commitment). Also, they suggest that regulators and researchers are positioned in the third layer, which corresponds to the less commitment to the business ecosystem, "even though they are perhaps not directly involved in the business operations, these parties may have a significant effect on the success of the MaaS model" (Karmagianni & Matyas, 2017 p. 6).

METHODOLOGICAL APPROACH

With the aim of analyze MaaS as a Product-Service System and as an Eco-innovation under the Business Ecosystem concept, as well as propose a schematic model for different mobility services this study is characterized as a qualitative approach of exploratory-descriptive nature. Figure 2 presents the research design.

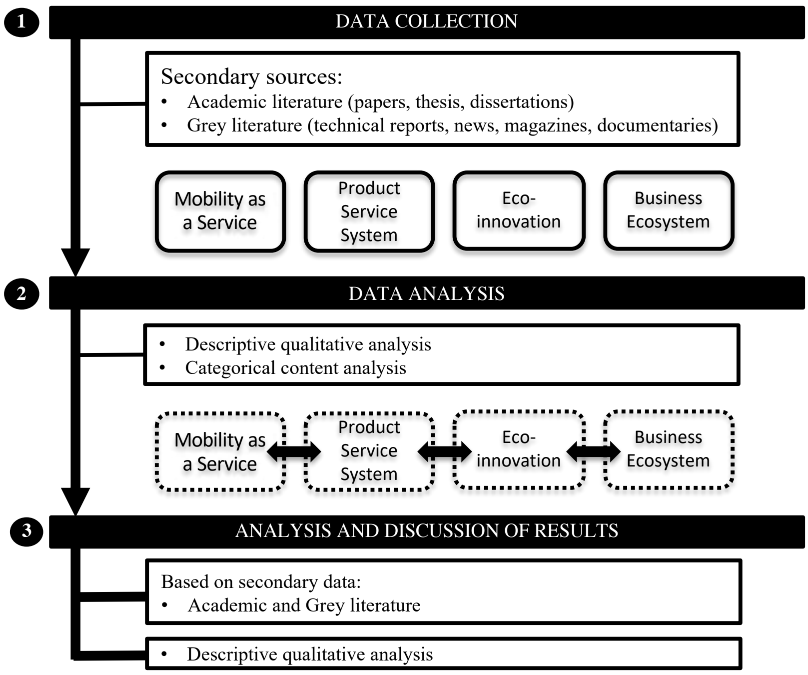

Fig. 2 Research design.

The first step carried out in this study was the collection of secondary data (from both on academic and grey literature) from the topics of; Mobility-as-a-Service (MaaS), Product Service System (PSS), Eco-innovation and, Business Ecosystem. At this stage, saturation criteria were used as a stopping point (Fontanella, Ricas & Turato, 2008).

Next, on step 2, data was structured and analyzed via descriptive qualitative analysis (Sanderlowski, 2000; 2010; Kim, Sefcik & Bradway, 2016) and content categorical analysis (Bardin, 2010; Vergara, 2005). At this point, the fields of knowledge were analyzed not only isolated but also considering relations among them. It is worth to highlight that, in this study, the analysis of content was used qualitatively and not quantification through frequency distribution and other statistical techniques.

At last, stage 3 consisted on analyzing and discussing the results based on secondary data in order to support the findings (academic and grey literature) – via descriptive qualitative analysis (Sanderlowski, 2000; 2010; Kim, Sefcik & Bradway, 2016).

ANALYSES AND DISCUSSION

First, we present relations among MaaS and the concepts of PSS, Business Ecosystem and Eco-innovation. Next, we propose a comparison between mobility service levels, taking as a starting point the relations found in the literature. Finally, based on the PSS, Business

Ecosystem and Eco-innovation approaches found in the literature, we suggest an evolution of the MaaS concept.

Business Ecosystem of MaaS as a PSS: an Eco-innovation

As depicted by Figure 3, the theoretical approaches of PSS, Eco-Innovation, and Business Ecosystem, presents density to support the concept of MaaS. In this sense, we unveiled MaaS under the theoretical tripod of each field of knowledge above mentioned, considering them as MaaS pillars. Also, it's worth to highlighted that the connections between some of those fields of knowledge are close enough to suggest other concepts. These new concepts may be also used in the construction of theoretical frame of MaaS, however there were not considered in this study (i.e. PSS and Eco-innovation present the concept of Sustainable PSS (Roy, 2000)).

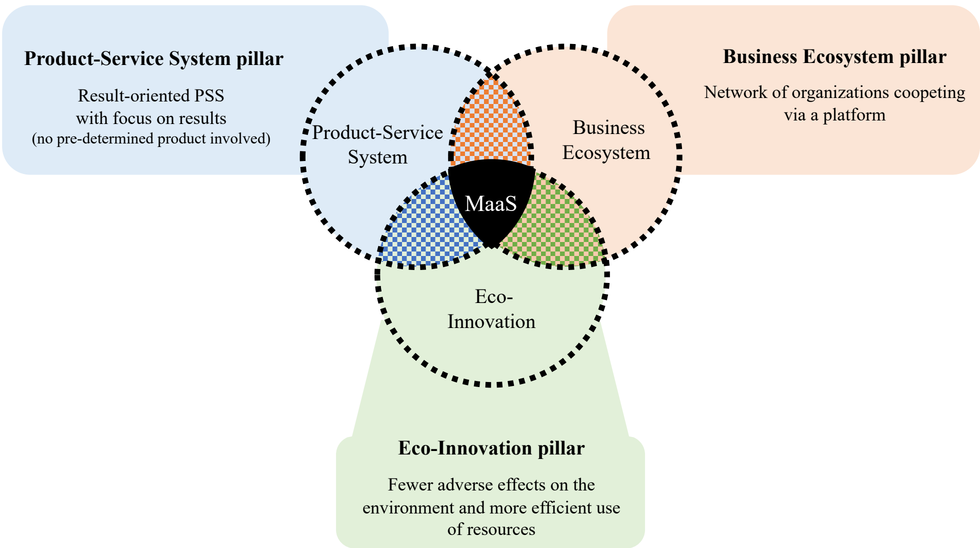

Fig. 3 MaaS under the theoretical tripod of PSS, Business Ecosystem, and Eco-Innovation.

Unveiling MaaS: Product-Service System pillar

Besides the multiple definitions, we observed that a PSS aims to create value for users by setting products and services. In the same way, the main idea of MaaS is to integrating transport modes (i.e. combine multiples products/services) in a unique platform to fulfill customer needs. Corroborating with this, Hietanen (2019) describes MaaS as a distribution model of mobility that delivers users' transport needs through a single interface of a service provider by combining different transport modes to offer a tailored mobility package.

Hence, by combining/integrating the transportation modes, a MaaS operator delivers "mobility" as a result of their business. As opposed to a unique transport mode (product) pre-established, there are a bunch of options for the customer. Corroborating with this, Melis et al. (2018) affirms that in MaaS, instead of passengers be committed on specific means they will enjoy a broad spectrum of alternatives from which to choose, taking into account their current needs.

Therefore, MaaS as a PSS can be understood as result-oriented (Tukker, 2004). More specifically, MaaS may offer options for payment which mainly includes "pay-as-you-go" or "monthly packages" pre-established between operator and consumer (Jittrapirom, 2017). These options are respectively related to pay-per-service unit and functional results' PSS (Tukker, 2004). In the former, the user buys the output of the product according to the level of use. Meanwhile, in the latter, the provider is completely free as how to deliver the result, which, in theory, offers the highest potential to design a low-impact system (Tukker, 2004).

Also, we observe that stakeholder behavior is different inside and outside a MaaS scheme. When analyzed isolated, some of these stakeholders may be positioned in different categories from Tukker's PSS model. According to Kamargianni & Matyas (2017) to establish a MaaS model, it is necessary several stakeholders, such as: transport operators, data providers, technology and platform providers, ICT infrastructure, insurance companies, regulatory organizations, universities, and research institutions. Some of these stakeholders may offer a pure product, product-oriented' PSS, use-oriented' PSS or a pure service (Tukker, 2004).

For instance, in a future scenario, Antonialli et al. (2018) states that autonomous vehicles better fit within Tukker's PPS use-oriented category. Autonomous vehicles will have a shifting focus from the vehicle as a privately owned asset to a service with a mobility function Antonialli et al., 2018). In the same way, Blomsma et al. (2018) affirms that Riversimple, a company that sells hydrogen cars' miles instead of traditional car ownership, presents an user-oriented service. For the authors, product ownership remains with the service provider, but the customer has access to the product (Blomsma et al., 2018).

However, when those stakeholders are inserted in a MaaS scheme, this sum changes their behavior to a result-oriented PSS. We suggest that the result-oriented characteristics in MaaS occur due to its Business Ecosystem aspect (Figure 4).

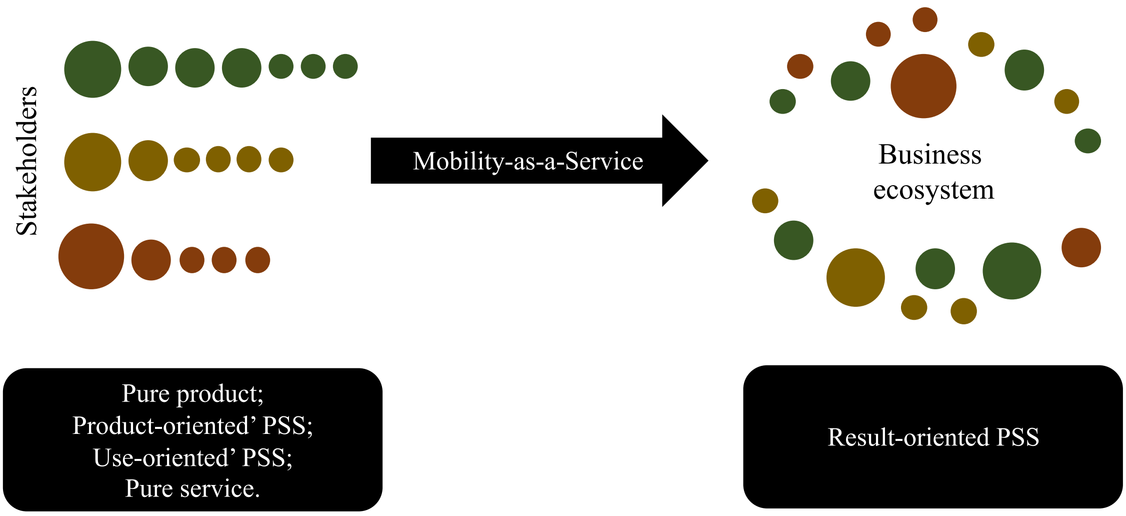

Fig. 4 Stakeholders' ecosystem transition in Mobility-as-a-Service context

Therefore, in a "business ecosystem, multiple organizations act in collaboration, mixing the traditional boundaries of business sectors and companies, and involving users in the co-creation" (Karmaggiani & Matyas, 2017 p. 3). In the same way, from a customer perspective, being offered an integrated solution allows for 'one-stop-shopping' and thus enhanced efficiency and effectiveness (Kuijken, Gemser & Wijnberg, 2017).

Unveiling MaaS: Business Ecosystem pillar

The main idea of MaaS is to offer a unique and seamless interface to its users, aggregating heterogeneous transport options offered by different mobility providers handling the whole experience of traveling, from providing information, to travel planning, and payments (Callegati et al., 2016). However, the more stakeholders a MaaS platform comprises, the more complex the business ecosystem becomes. According to Mäntymäki et al. (2018), one of the main tensions related to the concept of business ecosystem is the regulation by one actor of a complex and interconnected system.

In the same way, Tukker (2004) states that the function-oriented PSS needs attention concerning operationalization. Corroborating with this, in research concerning implementation hurdles of MaaS around experts and academics, the higher level (49%) is related to the difficult to integrate different players (Hünewaldt, 2018). Thus, in our perspective, the first step to solve this concern is to clearly understand how the MaaS business ecosystem as a result-oriented PSS can be structured.

Many authors point out that MaaS has to be established as a platform (Jittrapirom, 2017; Kamargianni et al., 2017; Utriainen & Pöllänen, 2018). Also, some advanced level MaaS schemes (e.g., UbiGo and Whim) already use digital platforms to integrate mobility operators and customers. We did not find in the literature the reasons that leads a MaaS scheme to be integrated in a platform, but we think that the concept of business ecosystem found in Koenig (2012) may explain this.z

According to Hensher (2017), MaaS initiatives are not new and are similar in intent makes transport services flexible including demand-responsive transit. What is different today is the ability to bring such flexible options direct to any interested user via the digital app capability available on smartphones (Lyons et al., 2019; Hensher, 2017). In the same way, the concept of Business Ecosystem is not radically new and the key factor that brings the innovator aspect is the platform utilization, which was enabled by the technological progress (Koenig, 2012; Daidji, 2011).

Thus, Mäntymäki et al. (2018) affirms that the ecosystem concept appears to fit particularly well to situations where there is a focal firm or platform leading the network. Also, Koenig (2012) states that a platform in a business ecosystem presents a centralized control of key resources and interdependence pooled. This means that the central actor establishes only the platform use rules not defining players' tasks neither its contribution. In this sense, we understand that the MaaS operator (see Kamargianni et al., 2018) is a central actor from a network that establishes platform rules, but does not determine tasks and contributions of each stakeholder (Figure 5).

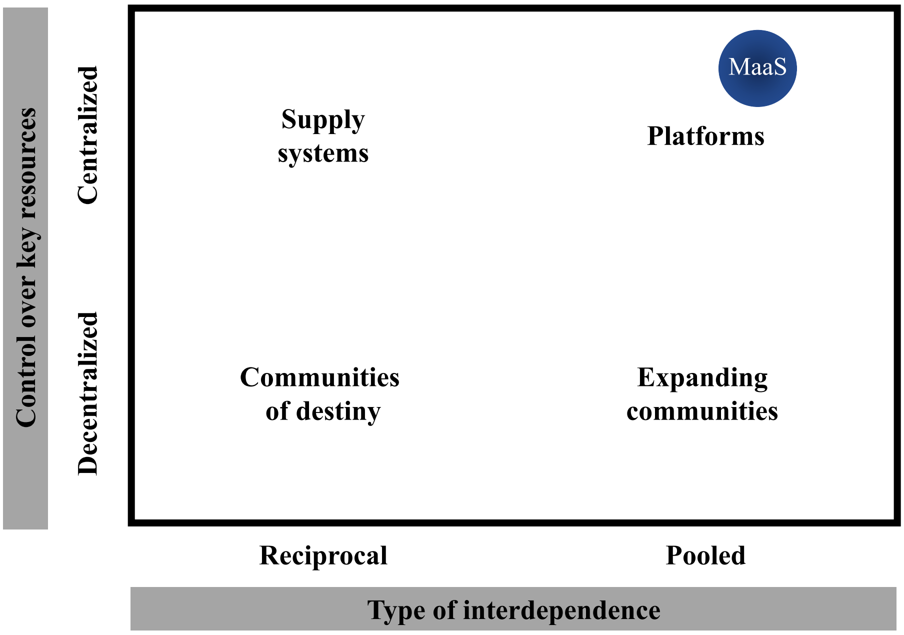

Fig. 5 Typologies for a MaaS' Business Ecosystem
Source: Adapted from Koenig (2012).

Bring the result-oriented PSS perspective for the Business Ecosystem lead by platforms, we understand that the MaaS operator should provide mobility for the commuters, and build an ecosystem guided by rules to deliverer it, but not determining tasks for the stakeholders.

Unveiling MaaS: Eco-innovation pillar

In the current mobility paradigm private car ownership and usage contributes with significant issues in our transport system being responsible for a variety of negative environmental impacts, both on a global and local level (Utriainen & Pöllänen, 2018; Epprecht et al., 2014) such as noise and air pollution, emission of greenhouse gases, traffic jams, road accidents, fragmentation of ecologically valuable land, increased health costs.

In this sense, MaaS aims to move away from car ownership by using alternative bundles of sustainable transport modes (Utriainen & Pöllänen, 2018) which are aligned with the eco-innovation approach. Even though, sustainability is not an intrinsic characteristic in a PSS (Doualle et al., 2016). Thus, the eco-innovation concept can be inserted in MaaS approach as a PSS, as long as it represents an innovation that brings a reduction on the environmental impacts (OECD, 2009).

In the same way, eco-innovations are alternatives that can be used in PSS mixing sustainability and business (Jesus Pacheco, D. A.et al., 2019). Specifically, result-oriented PSS is the most promising in environmental terms (Tukker, 2004), which fits the approach that MaaS is sustained. However, it's important highlight that our eco-innovation approach for MaaS schemes is only applicable in optimal scenarios. In other words, if the shift from private car user to MaaS occurs, as theoretical assumed by MaaS concepts, we understand that the eco-innovation pillar is not part of MaaS.

For this, is important to consider the rebound effect in a PSS (Manzini & Vezzoli, 2003). For instance, P2P services can be a good option to users, even though in the urban mobility ecosystem context, it might have as much negative impacts as the car ownership, or even bigger in certain cases. A user that owns a car could opt to sell it and use exclusively P2P services. Hence, a car that would not need to be on the road, still there with two users (service provider and commuter), still presenting idle capacity.

In another situation, which is more serious in urban mobility ecosystem context, is when a commuter change from PT (bus or trains) to P2P services. In this case, the commuter changes to a less eco-efficient modal, increasing idle capacity, disabling bus lines, hence losing capilla in the urban mobility.

Thus, we argue that a successful MaaS scheme is one that not only integrates transport modals, but one that considers the eco-innovation concept by attracting to its platform both PT users and car owners. Mainly for MaaS we consider eco-innovation as the reduction of car ownership or more efficiently use of it by user and "not-sharing" P2P commuters

The Distinct Levels of Urban Mobility Services

In order to promote a bird's-eye view of our findings, we drew a framework that aimed to compare distinct urban mobility services (Figure 6). For doing so, we took into account the compilation of main MaaS features (Jittrapirom et al., 2017; Stopka, Pessier & Günther, 2018) supported by our theoretical tripod model (Figure 3). By considering MaaS as a result-oriented PSS, from an ecosystemic perspective, we assumed that the more stakeholders, the higher the managerial complexity. As for Eco-Innovation, the greater the need to own a vehicle (or less efficient usage of it), the lower the levels of Eco-Innovation.

Fig. 6 Comparison of distinct levels of urban mobility services

The first MaaS characteristic is the integration of infrastructure (physical and virtual): it corresponds to the level sync level among the real conditions of transportation modals and how the users know about it (app, website, so on). For instance, a bus is 5 minutes late; Uber is 3 minutes from user's location; to arrive from point to B take the bus and the train, so on.

Another MaaS characteristic is the tariff option: (a) pay-as-you-go: the option to one-way trip (e.g. Uber, individual bus or metro ticket); (b) package: daily/monthly/annual plans (e.g. Navigo in France, Oyster Card in London; UbiGo in Stockholm); (c) full package: we understand that in advanced levels of MaaS (full MaaS) the ecosystem can add stakeholders different from the mobility context. Therefore, the tariff may vary according to the included options besides of mobility, like restaurants, food or even rent (e.g. app WeChat in China; DenCity project).

More than integrating the infrastructure, MaaS also integrates transport means, such as: (d) public: integration among PT operators, only (e.g. Navigo in France; Oyster card in London); (e) private: integration with private transport means such as taxis, P2P services.

Also, MaaS allows customization to user's preferences. When an user is allowed to modify the offered service option according to their preference and the level has a demanding orientation. For instance, an user don't like to bicycle, and the MaaS operator never bike-sharing's models for them.

Finally, MaaS comprises multiple actors: (f) mobility stakeholders: interaction between mobility stakeholders, only; and (g) variety of stakeholders: which corresponds to the interactions between different actors, not only related to transport, but also from another industries (e.g. food, retailers, entertainment industry, so on).

As depicted in Figure X, five comparative mobility services levels are proposed: 0) Private car commute; 1) Peer-to-peer transport service; 2) Public transport integration; 3) Current MaaS schemes and; 4) MaaS 2.0. Also, we found a Multimodal planner category, which we believe that act as staff for others levels, especial for the level 2 "public transport integration".

The multimodal planner is not considered as a level, but a staff to others levels. Google Maps, CityMapper and Moovit are examples of multimodal planner which integrated information in physical and virtual environment regarding best routes, public and private transport schedules and disturbs in its routes. It makes easier the utilization of other mobility services by commuters. However, this staff is useless without physical infrastructure. Therefore, we opt to not consider this category as a service level, but as a support to other levels.

In Level 0 (private car commuter) we assume that users own a transportation modal, thus no characteristic of MaaS is found. This category is the biggest the since user have not access to the same convenience to commute in the other levels. In this level we consider the PT presence without integration. That is, it might exist bus routes operating in parallel with bike-sharing, train and/or taxi, however, they operate isolated. In our perspective this scenario is more able to occurs in fewer inhabitant cities, where the PT is poorly and P2P services still haven't appeared. In this sense, the private car needed is higher, and the ecosystem is less complex than other.

The Level 1 (peer-to-peer transport services) user can have access to the information of a physical transportation modal in a digital platform (app). For instance, user are able to call an Uber through the app and; visualize the real time location, waiting time, license plate, model, driver, rating, run price, among other information that integrate physical and virtual infrastructure through the platform.

With respect to the pricing model, in, general P2P apps offer pay-as-you-go option, which charges commuters according to their utilization. At this level, the need to use exclusively a is slightly reduced when compared to Level 0. However, the choice for single trips payment, besides monthly plans may decrease the trips because the liberty to may recur to P2P options just in case, while seeking other mobility options whenever is possible. Another factor that should be considered is the pool option which fosters better vehicle utilization providing better prices for commuters. Also, pool option provides reduction of idle capacity and positive environmental implications (e.g. less traffic on the road, less emission of pollutants). However, presents a disadvantage if compared to PT. Also, rebound effects are detected in this level. The ecosystem in Level 1 is more complex than Level 0. Number of stakeholders and infrastructure' integration are responsible for this complexity.

Level 2, considers the infrastructure integration between PT players offering to commuters different transport modals information. Multimodal planners (e.g. Google Maps, CityMapper, and Moovit) aid this integration by establishing routes and presenting modal schedules. Tariff options are presented as pay-as-you-go or package. With respect to the former user buy a single ticket and uses several means of transportation for a limited time. As for the latter, a monthly payment enables unlimited access to all modals (e.g. Oyster Card in London or NaviGo in Paris).

Still with reference to Level 2, ecosystem complexity is higher than previous levels due to the high numbers of players integrating the same system. Also, large cities that present railway options such as train, are more likely to develop this level. We suggest that in places that Level 2 are inserted, the necessity to use exclusively a isicle are fewer than previous levels due to the integration of PT improve the mobility seamless.

Level 3 presents current MaaS schemes. At this level, all fundamental MaaS features are present. Users get known about the physical world being able to choose between public and/or private transport, being charged by pay-as-you-go or periodic packages (weekly/monthly/etc.). Comparing to other levels, current MaaS schemes add a customization layer according to user's preferences. For instance, in a rainy day, commuters might avoid PT, or to pay for a faster modal in case of hurry or a user can avoid bike or sharing a vehicle. Some real examples are already operating in Finland (Whim) and Sweden (UbiGo).

With respect to the mobility multiple actors, the ones evolved are the only needed to make MaaS works. Hence, this is the second more complex ecosystem. In fact, according to Hünewald (2018), MaaS implementation is not easy due to the necessity to integrate different players. As public transportation represents the backbone of MaaS (Pangbourne et al., 2018) to implement it is necessary an efficient PT.

In addition, previous studies show MaaS applied only in developed countries (Figure 7). However we propose that MaaS is adaptive and modular, suiting also in cities that PT is not efficient (i.g. being replaced for other transport solutions like hitchhiking, bus shuttles or other transport solutions). Also, emergent countries, claimed for transportation solutions and an adaptive and modular MaaS can be well fitted in, though there are no preliminary tests. Corroborating with this, Hietanen (2019) states that MaaS is a viable answer in most places, because the modal split can be adjustable.

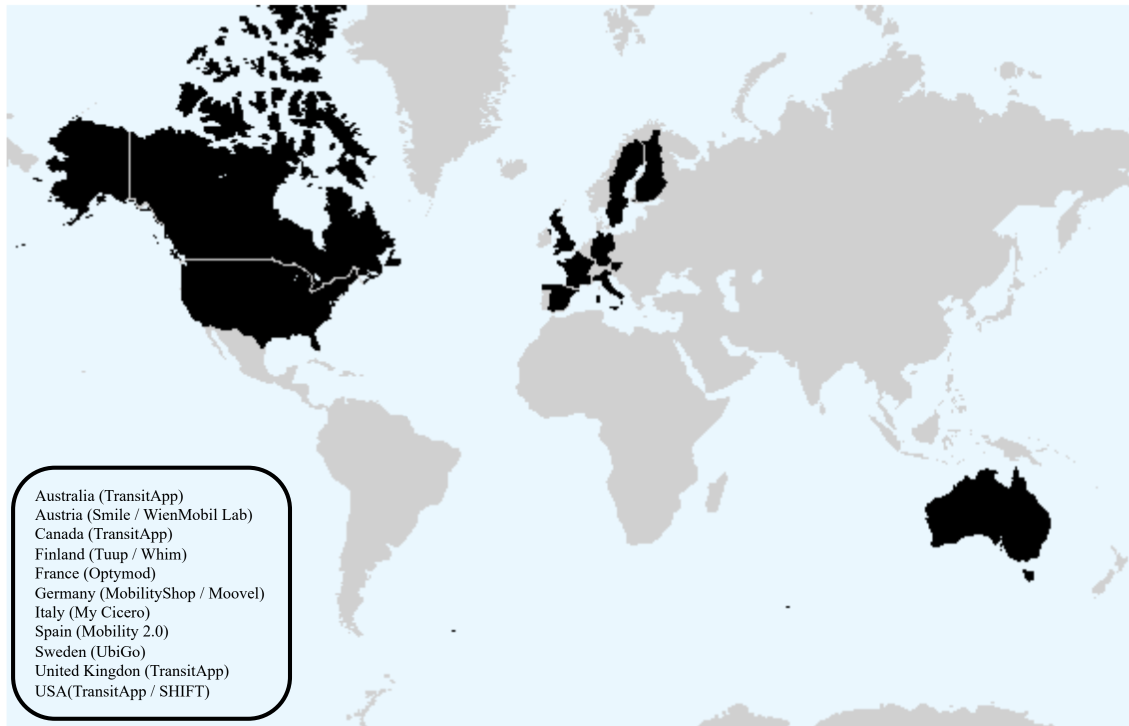

Fig. 7 Current MaaS schemes worldwide
Source: Adapted from Jittrapirom et al. (2017).

Finally, we proposed a Level 4 named MaaS 2.0. We understand that this current MaaS' evolution must not only seek sharing and integration of transport modes but also integrate other stakeholders (not directly related to mobility). Also, we suggest a full package payment mode, bringing private-car users to into their ecosystem (with aims to solve not only their mobility problems but also creates higher value propositions, trying to mitigate their car dependency). For this, other industries such as; entertainment, retailers, food service, and even housing can be a part of MaaS 2.0. At this level, the need to own a car could be drastically reduced while the ecosystem complexity would increase.

For instance, a MaaS 2.0 scheme could include housing, which could be built without garages, and the rent could be part of the full package. In other words, user would pay a single and monthly fee for rent and transport. Likewise, DenCity project (being tested in Stockholm and Gothenburg) suggest a collaborative form between academy, industry and society building integrated smart cities as an alternative of car use (Closer, 2019).

Another example that sustains this broaden ecosystem, is the app WeChat, which has almost 1 billion users in China. In this app is possible to order food, seek for medical advice, book a trip, flirt, buy any kind of product, call a cab, see friends posts, check fan pages, pay and be possibly work as official identification in Chinese government (Silveira, 2018). The future belongs to ecosystem, the users don't want to have this information spreads in apps, but condensed in one (Hietanem, 2019).

Hence, we consider that the necessity to own a car could reduce drastically while the ecosystem complexity would increase, proportionally. Corroborating, Tukker (2004) states while the result-oriented PSS is the most promising in environmental terms, this scheme is also the one that demands most risk and attention regarding its operationalization.

In addition, it is important to be alert to factors like regulation and consumption behavior. As pointed by Hojnik & Ruzzier (2016) those factors are critical drivers for an eco-innovation. Some evidences point out that consumers, in all age groups but special the Millennials, are increasingly expecting their experiences in transport and other sectors, to be delivered as a service, and to get more value as a result. Also, changes in mobility consumption means greater adoption of new mobility models and this may lead to a move away from car ownership (Mulley, 2017).

Thus, we propose MaaS 2.0 as “a business model that should, via a single platform, integrate result-oriented services among different stakeholders in an ecosystem with a value proposition sufficiently greater for private car users to switch to the platform or use their vehicles more efficiently”.

CONCLUDING REMARKS

The theoretical tripod of Product-Service System, Business Ecosystem, and Eco-Innovation may be a used as foundation to Mobility-as-a-Service. We observe that all of those knowledge fields present relation with body of MaaS founded in literature.

MaaS can be considered a result-oriented PSS. From this perspective, the mobility function is what should be considered as a result of a MaaS. To this end, the business ecosystem contributes by the concept of coopetition with distinct stakeholders creating value for users in terms of mobility through a platform. In this sense, Mobility-as-a-Service can be thought not only as a concept, phenomenon or transportation solution (Jittrapirom et al., 2017) but also as a business model. More specifically, MaaS as a PSS can be named as a result-oriented business model.

Nevertheless, as a PSS we observe that the environmental issue should not be considered as an intrinsic factor. Thus, an analysis from the eco-innovation perspective has made us reflect upon the real need for vehicle ownership and its efficient use. However, from such perspective, current MaaS schemes are subject to rebound effects. Private car users may not find the value needed to replace their vehicles, which, in consequence, would not characterize MaaS as an eco-innovation.

Through the lens of eco-innovation, the main drivers of MaaS are regulations and the market pull. In this sense, assumed that MaaS will replace private car ownership in any context, designed in the same way as current MaaS schemes would neglect the legal and cultural specificities of each place. We assumed that this perspective occurs because all current MaaS schemes still take place in developed countries with efficient public transport.

We believe that MaaS is a modular and adaptive and should create value from a range of distinct actors and thus be compatible with eco-innovation concepts, due to its sustainable essence. In this way, we propose an evolution of the current MaaS concept: MaaS 2.0. This level is the most promising in environmental terms, however, it comes with higher risks and governance and operationalization challenges. In fact, all of mobility services levels analyzed may succeed or not, with has to take account is the risks to implement and environmental concerns of each locality.

Although this study needs more in-depth analysis, we have brought initial toughs about Maas through a theoretical perspective not yet addressed in the literature. As a future agenda, we suggest analyzes pillar on each of the theoretical tripod. Also, we believe it is worth to look at consumer behavior and regulatory approach of MaaS in developing countries. In addition, understand whether the perspective of a results-oriented PSS is related to the configuration of a business ecosystem could aid in theoretical advances in this field. Finally, we assume that a MaaS business model is only configured as disruptive if it is eco-innovative, however this proposition still requires future analysis.

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