A strategic outlook on Manufacturing-as-a-Service (MaaS) Platforms: differences and inspirations from "traditional" platforms ecosystems

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Abstract

Digital platforms represent one of the pillars of the modern economy and they have been widely discussed in the literature. We can observe a certain consolidation in approaches to create a platform and manage different sides of a platform in order to succeed. Recently, after a long process of conceptualization, this kind of platforms is also appearing in the manufacturing sector: we are approaching Cloud Manufacturing (CM) platforms where resources (e.g. capabilities of designing, simulating, manufacturing) are virtualized and made available on-demand to users, as it happens in Cloud Computing (CC), where Users are focused on the flexibility of the service requested. Manufacturing-as-a-Service (MaaS) platforms are a subset of CM platforms where users ask for manufacturing services (e.g. mechanical parts).

On one hand, MaaS model is interesting for its idea of reduced lead times, increased flexibility ("on-demand manufacturing"). On the other, this model attracts the attention of many people as it is based on a platform architecture. In the future manufacturing context, the largest company in the world could produce without any production facilities, nor any logistic assets (as it happens in other context, e.g. Uber in "mobility", Airbnb in "accommodation").

Surprisingly, to the best of authors knowledge, there is a consistent gap in the research between these two domains. In this conceptual paper the authors review the literature on domains of "MaaS" and "Platforms" and identify some interesting questions for future joint research. MaaS platforms deserve specific research as they are very peculiar from "traditional" digital companies (e.g. they deal with physical products). Although they are inspired by the model of traditional digital platforms and supported by new technologies available today, they struggle to take off. Several arguments are shown from the analysis of the literature and other insights can come from future cross-domain studies.

Keywords: Platform Economy; Manufacturing-as-a-Service (MaaS); Cloud Manufacturing.

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1. Introduction

Digital platforms represent one of the pillar of the modern economy (Clauss, Harengel, & Hock, 2019). We may refer to this phenomenon as "Sharing Economy", "Gig Economy" or a more neutral term "Platform economy": platform owners could become more powerful than were those factory owners in the early industrial revolution. They have been developed with the advent of the Internet and today - after years of exploration – these platforms are moving towards a certain consolidation in approaches and strategies (D Trabucchi, Muzellec, Ronteau, & Buganza, 2021). This is especially true in the case of platforms exchanging digital services, or where the value of the platform lies mainly in the reduction of transaction costs (Hentel and Windekilde, 2015).

In recent years, after a long process of conceptualization, this kind of platforms is also appearing in the manufacturing sector: we are approaching Cloud Manufacturing (CM) platforms. In a Cloud Manufacturing environment customers use manufacturing resources (e.g. Design, Simulation, Manufacturing) through a cloud-based platform. One of the most interesting outcomes of CM is represented by platforms realizing Manufacturing-as-a-Service (MaaS) , where users get manufacturing services (i.e. physical products) from the suppliers side of the platform.

According to the literature of CM we are quite far from seeing a completed implemented CM platform because of many unsolved technical issues (related to the complexity of the product and/or complex production process) and/or business characteristics to be considered when MaaS model is applied (e.g. intellectual property, supply chain responsiveness) (Lu & Xu, 2019; Tedaldi & Miragliotta, 2020). Most prominent academic authors in this field agree that after more than ten years of debate we still do not know how CM will be successfully implemented (Liu, Wang, Wang, Xu, & Jiang, 2019).

MaaS platforms are indeed very peculiar because - although they are inspired by the model of traditional digital platforms and supported by new technologies available today - they struggle to take off (Tedaldi & Miragliotta, 2021).

Brynjolfsson and McAfee (2014) reported that "platforms take advantage of the economics of free, perfect, and instant". They state that platforms are characterized by near-zero marginal cost of access, reproduction, and distribution of services. On the contrary, we find that MaaS platforms are completely different from "traditional" digital platforms. For this reason, MaaS platforms represent an interesting new element compared to the literature on the existing platforms which have been operating up to now.

Furthermore - as an additional reason of interest - they can represent a big change in the Manufacturing sector, which still is very important in many developed countries (in some cases it counts more than 40% of Gross Domestic Product (GDP)[1]).

This conceptual paper aims to start doing research on the joint topic of "MaaS" and "Platforms", and it opens the discussion on some elements which could be interesting to be further investigated in the future. The paper is organized as follows. In the next two chapters the theoretical background about Platform Economy and MaaS is presented. Then the paper proceeds with a chapter showing the gap we try to cover and the objective of this study, i.e. finding links between two domains which have not yet been studied together (Platforms and MaaS). The subsequent chapter discusses the research questions leveraging the debates on the two domains and shows a first research agenda for this new area of investigation.

2. Theoretical Background

2.1 Platform Economy

In general, platforms are objects facilitating the interaction between different groups of users (Ardolino, Saccani, & Perona, 2016), namely "sides" of the platform. In many cases the platform is "two-sided", i.e. it mitigates the friction between two distinct group of users doing a transaction (Williamson, 1989). Nowadays the success of platforms is due to the reduction of transaction costs between two sides, but also on four other drivers such as trustworthy environment, data-driven extensions, personalised services, engagement mechanisms aiming at building a sort of platform community (D Trabucchi, Muzellec, et al., 2021).

In the literature we can find several taxonomies defined on the basis of different variables: "open" vs "closed" of the platform's sides (Eisenmann, Parker, & Van Alstyne, 2008); "transactional vs non-transactional" (Filistrucchi, Geradin, Van Damme, & Affeldt, 2013); "internal or company-specific platforms" vs "external or industry-wide platforms" (Gawer & Cusumano, 2014). On the basis of the kind of interaction enabled by the platform, (Ardolino et al., 2016) distinguish: "Matchmaking", "External- / "Internal-Exchange", "Maker". Matchmaking platforms just make a connection between different groups of users but the transaction is still up to the parties involved. (Internal-) Exchange platforms enable users to use the platform to directly manage the flows (data, product, money) even if, in some cases, users can choose to bypass the platform ("External-Exchange") and use it as it was a simple matchmaker. Finally, Maker platforms provide the user appropriate tools to realize new products which can be transacted with other sides of the platforms.

Recently (Daniel Trabucchi & Buganza, 2021) review the literature about two-sided platforms and differentiate "transactional" vs "orthogonal" platforms (Fig. 1). On one hand, transactional platforms act as intermediaries and stand in between a single flow which comes from one-side and goes to the other one (Airbnb, Uber and Deliveroo). On the other hand, orthogonal platforms represent environments in

[1] For example, in Italy (2015) the gross value added from manufacturing and directly connected services was 716 billions (https://www.istat.it/it/files//2018/04/Report-Risultati-economici-imprese-2015.pdf), compared to the overall Italian gross value added of about € 1620 billions (https://data.worldbank.org/indicator/NY.GDP.FCST.CD?locations=IT).

which one side receive a product/service from the platform but part of the value is generated "orthogonally" by third parties which are external to the focal transaction of product/service. These platforms create a critical mass on one side (e.g. readers of a newspaper) that can be further exposed to stimuli coming from the second side (e.g. advertisers). (Gawer, 2021) and (Cusumano, 2022) differentiate "transactional" vs "innovation" platforms. Innovation platforms serves just as a technological foundation upon which other firms develop complementary innovations. According to (Daniel Trabucchi & Buganza, 2021) "transactional" and/or "orthogonal" usually are two-sided but they can evolve towards more complex models, i.e. "Hybrid Multi-sided platforms".

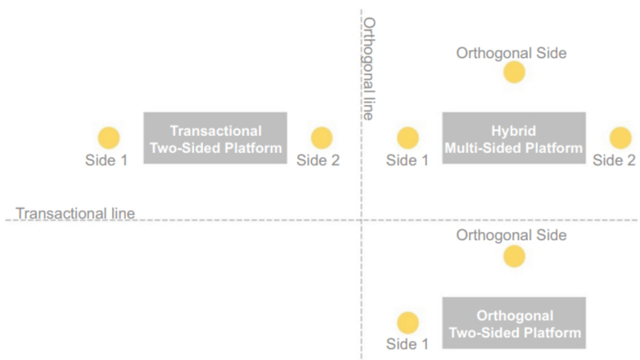

Fig. 1 - Transactional vs Orthogonal platforms by (Daniel Trabucchi & Buganza, 2021)

2.2 MaaS: back in the limelight with Cloud Manufacturing platforms

MaaS is a concept introduced in the 90s and it was quite interesting because it could represent a new source of flexibility (and competitiveness) for enterprises (Goldhar & Jelinek, 1990), aligned with the purpose of other distributed manufacturing paradigms debated in the literature, such as the "Agile", "Grid" and "Holonic Manufacturing". Nevertheless, despite of its interest, it didn't succeed. Today we are living a completely changed context and MaaS seems to have a concrete chance to succeed on a large scale. The reason is threefold (Tedaldi & Miragliotta, 2021). First, the need of flexibility is still out there in the market and it has increased during the last 20 years because of the increased globalization, uncertainty in the demand, reduced time-to-market required to be competitive. Secondly, MaaS didn't succeed in the past because of the lack of enabling technologies. During the last 10 years, the rise of the fourth industrial revolution - characterized by new digital technologies – opens new opportunities to deeply reshape processes within the organizations, factories, along the supply chains (Meindl, Ayala, Mendonça, & Frank, 2021). In this context, the success of Cloud Computing originates the Cloud Manufacturing concept (Xu, 2012) in which MaaS comes back to the fore as a possible CM outcome. Thirdly, Cloud Manufacturing environments are based on the creation of a Platform which stands between two groups of users. This last point mentioned is of great importance as platform economy is completely redefining parts of our economy (Kenney & Zysman, 2016) (such as Uber for mobility, Booking for traveling, Airbnb for accommodation) and now it could affect the manufacturing domain.

CM can be defined as the manufacturing version of cloud computing where resources are virtualized and provided as-a-service over the Internet (Xu, 2012). These resources could be different in kind: they can be either manufacturing, designing, or simulation resources; academics refer to Manufacturing-as-a-Service (MaaS) platforms when these platforms deal with manufacturing resources (Adamson, Wang, Holm, & Moore, 2017).

Although technological issues are still challenging the full implementation of this paradigm, today we can observe several empirical examples of web-based platforms which have been launched in the mechanics field with the idea of "on-demand manufacturing", "flexible sourcing", "fast and transparent deliveries" and they resemble most of the characteristics of Cloud Manufacturing and MaaS (Tedaldi & Miragliotta, 2021). Some examples are the following: Xometry.com, Weerg.com, Sculpteo.com, and Fractory.com.

From an operational point of view, users register to the web-based platforms, upload their CAD (Computer Aided Design) files and receive a quote in a blink of an eye. Moreover, users can change finishing, colours, delivery date on the basis of her/his needs; prices are immediately updated, and parts are ready for being added to the virtual chart. At this point users can accept quotations and start waiting for their products; they will arrive at their facilities when they ask, as we use to do with e-commerce B2C (Business to Consumers) platforms. This manufacturing model is absolutely new and interesting with regards to the flexibility offered, reduced lead times, and the high transaction costs usually experienced by buyers in sourcing processes of mechanical parts (i.e. users usually send emails to suppliers, wait for quotations, compare different quotes, and finally accept and confirm the order to one of the suppliers involved).

2.3 MaaS platforms

In a MaaS platform ecosystem, mainly three participants are involved: the User, the Cloud Operator and the Resource Provider(s). A CM system acts as a two-sided platform as it facilitates the relationship between two distinct groups of users (Wu et al. 2013) and enables a transaction of manufacturing services. On the one hand, the users access to a wide network of providers representing a new source of flexibility from a procurement perspective. On the other, Resource Providers mainly benefit from CM as they increase efficiency of their production systems (e.g. reducing idle capacity, getting in contact with a higher number of potential customers through the internet).

The history of MaaS platforms is quite recent (most of the platforms have been launched after 2015) and the market is still immature, as it demonstrated by the heterogeneity of the solutions on the market. On one hand, all of these platforms share that they are more than a simple marketplace (they go beyond the simplest platform instance of "matchmaking", where users just meet suppliers). Here we have two sides of a market ("two-sided" platforms) where a transaction is facilitated by the platform (i.e. "transactional" and "Exchange platforms"). Moreover, they share a common approach, i.e. being "open" to the general public of users and so they can be defined as "external" platforms (and not limited to the use of a specific company).

On the other, different business models and architectures can be observed among them. For example, Weerg has developed a platform while owning the resources involved in the manufacturing processes; Xometry doesn't own anything beyond the platform leveraging thousands of suppliers distributed in USA and Europe.

3. Gaps and Objective

During the last ten years MaaS concept has been widely debated within the literature of Cloud Manufacturing but most of the papers have focused their attention on technological issues related to the implementation of this new manufacturing model. This is justified by the fact that companies adopting MaaS model struggle to have a seamless integration of resources and IT systems (mainly due to the lack of interoperability between machineries, different communication protocols and standards adopted by companies). Nevertheless, there are other business aspects to be considered when we aim to apply MaaS concept in a specific sector/context (e.g. idle asset presence, high transaction costs, data sharing criticalities) (Fisher et al., 2018).

Besides those technical and business aspects, we think that, at a higher level, the success of a MaaS initiative could be highly affected by the choices it makes as a "platform"; its sides management, configuration in terms of platform's participants (i.e. its business model).

This conceptual paper aims to study the MaaS phenomenon under the lense of platforms, as the literature in this field is almost absent and we think it is a major gap to be covered.

According to Brynjolfsson and McAfee (2014), platforms leverage the "economics of free, perfect, and instant". They state that platforms are characterized by near-zero marginal cost of access, reproduction, and distribution of services. Nevertheless, we find that MaaS platforms are completely different from "traditional" digital platforms as they deal with physical products which cannot be instantaneously manufactured by someone and delivered to others (Tab. 1).

The worldwide release of mobile applications can be instantaneous, perfectly reproducible without loss of quality, and free as developers can sell apps through the platform with near-zero marginal cost. In the case of transportation (or accommodation services) platforms can create standards to ensure near-zero marginal cost and same quality of their services but their services cannot be instant as platforms should have drivers or houses (resource providers) wherever users ask for them. Then, platforms offering engineering services aims to facilitate the connection between service demanders with potential solution providers. In this case, the service can be instantaneously offered, for free, but the service cannot be replayed with same outcomes because of the heterogeneity of services requested and solution providers.

Object	**Instant?**	**Perfect?**	**Free?**	**Example of Platforms**
Mobile App	Yes	Yes	Yes	Apple Store
Transportation / Accomodation Services	No	Yes	Yes	Uber // Airbnb
Innovation & Engineering services	Yes	No	Yes	Ninesight by ninesigma.com
e-commerce	Yes	Yes	No	Alibaba.com
Manufacturing	No	No	No	Xometry.com // 247Tailorsteel.com

Table 1. – Comparison of MaaS with other different platforms

In the e-commerce, sales can be reproduced with the same quality and – under some circumstances - it can be an instantaneous service; for sure it cannot be free because of the cost structure of logistics.

The research questions addressed in this paper aim to create a bridge between “MaaS” vs “Traditional” platforms and they are the following:

- *RQ1: What approaches and lessons learned emerged in recent years (from "traditional" digital platforms) may also be applicable to MaaS platforms? Which of them will be able to anticipate some dynamics of the development of MaaS platforms?*

- *RQ2: Which of the peculiarities observed in the MaaS Platforms could inspire or anticipate some development directions of traditional platforms?*

4. Results

With regard to RQ1, we can see that several topics debated in the platform literature can be further researched in the MaaS platform market. The following subchapters identify some points for the discussion.

Opening the sides?

Fifteen years ago (Eisenmann et al., 2008) show that platform-mediated networks involve different participants (users, platform operators, complementors, et cetera) and each one of these roles can be “opened” or “closed”. Platforms owners make this first strategic choice characterizing their business model which originates the value created by the platform.

Today it seems that our age is moving from a closed approach versus an open approach (Pellizzoni, Trabucchi, & Buganza, 2019). (Gawer, 2021) recently discussed the openness of the boundaries on the basis of the kind of platform (“transactional” vs “innovation”) and its maturity phase (“Launch” vs “Maturity”). (D Trabucchi & Buganza, 2020) say there are three main strategies to boost platform success, and they are related to the platform boundaries: Supply (Side) Expansion, Transactional Advertising, and Data Trading.

In MaaS environment the provider side is usually subsidized and the revenues come exclusively from the users buying manufacturing services. It seems that the user-side should be kept “opened” to everyone (not just in a B2B environment, but also B2C) in order to amortize the investments made to build the platform; instead, it is not clear what could happen to the other side of the platform of resource provider(s). In fact, two different strategies seem to be currently possible on the supplier-side: “opened” vs “closed”. Some companies (e.g. Xometry, Fractory) aim at a higher scalability of the business leaving the door opened to manufacturing suppliers largely distributed, while other players (Weerg, 247Tailorsteel) aim to a higher efficiency and integration of their manufacturing resources while closing the doors to other potential suppliers. As also shown in Fig. 2, (Helo, Hao, Toshev, & Boldosova, 2021) identified three different types of platforms (they call them “portals”) where Type 2 and Type 3 are “open” to different resource provider, while Type 1 is reserved to a single specific manufacturer.

We wonder whether – in the context of MaaS - this is a strategical (and fixed) choice or it is something that can change along the maturity process of a platform.

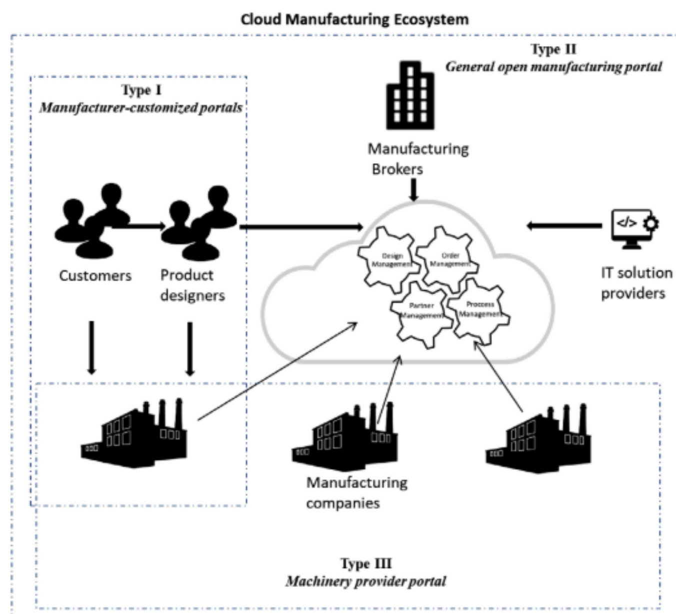

Fig. 2 - Manufacturing ecosystem portals (Helo et al., 2021)

Broaden the MaaS scope: towards Hybrid Multi-side platforms?

Uber and Amazon are examples of complex multi-sided platforms but today they are really different from what they were at the time of their launch. Multi-sided business models undergo three evolutionary phases: they solve the market friction; they exploit the critical mass they develop; and they unveil and capture new value derived from cocreation based on data. (D Trabucchi, Sanasi, Ghezzi, & Buganza, 2021).

Today MaaS enterprises are basically "transactional", "two-sided" platforms and they can be framed as simple "exchange platforms" between two groups of users, but – maybe - they could increase their complexity and evolve in hybrid multi-sided platforms as other digital platforms do (Daniel Trabucchi & Buganza, 2021).

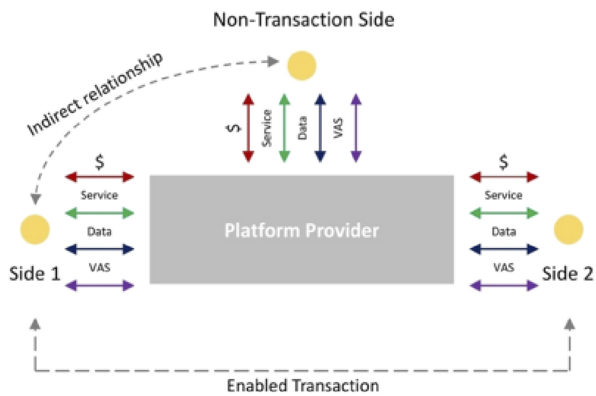

Fig. 3 - Towards Hybrid Multi-Sided Platforms (Daniel Trabucchi & Buganza, 2021)

MaaS platforms as a new source of innovation?

(Gawer & Cusumano, 2014) review the literature of industrial platforms and explain that external industry-wide platforms could be used as a new source of innovation. Innovation can be product-related or even business model-related.

In some context MaaS platforms could change the way companies source mechanical parts. We expect that designers will tend to incorporate these manufacturing services into their offering methods. Therefore, the design of new products and services will be oriented towards those products/sub-products that can be realized better by these platforms (i.e. simpler products, standardized components, etc) than traditional sourcing channels.

In the footwear supply chain, an intermediary MaaS platform could be developed to increase flexibility in sourcing as well as enabler of new business model: "on-demand", highly customized shoes (e.g. an evolution of the Italian Artisan platfom, https://italian-artisan.com/).

Which platforms competition and dynamics?

In some contexts platform cooperates in the first phase of dissemination of a new product/service (Daniel Trabucchi & Buganza, 2020). Then, in many digital contexts we can see that the competition increases and network effects provide the potential of exponential growth and a winner-takes-all-or-most outcome (Cusumano, 2022).

In the MaaS context, it will be interesting to understand whether a winners-take-it-all will happen or whether there is space for several platforms specialized in different sectors with different approaches and strategies.

During the last years, we observed that several young platforms have already started acquiring each other in order to scale up in suppliers and users (Maketime and Shift acquired by Xometry, 3D Hubs acquired by Protolabs).

With regard to the RQ2, it is interesting to understand which of the peculiarities observed in the MaaS Platforms could inspire or anticipate some development directions of traditional platforms.

From digital to increasingly physical services?

The platform model is increasingly moving towards the production of physical goods, not just digital services or goods. Therefore, the experience that takes place on physical platforms could soon be able to be integrated on digital platforms. In the future a design platform (such as ninesigma.com) could also combine manufacturing capabilities and maybe we would have – for example – the possibility to order a custom-made shoe through an e-commerce platform.

Technical contributors as enablers?

In the development of MaaS model, we observe a decisive role played by producers of capital goods in the development of MaaS platforms. 247tailorsteel.com has arisen thanks to machinery manufacturers who contributed with their peculiar skills and competencies (Tedaldi & Miragliotta, 2020): a bridge between the futuristic idea of MaaS and the technical skills actually necessary for its implementation was needed. If we could generalize this result, we could also see something similar in the evolution of traditional platforms, with partnerships or acquisitions in the physical-digital interface area.

5. Conclusion

This paper merges two interesting domains which have not yet been studied together, and it is a major gap to be covered. Thus, the authors suggest to open a new area of investigation about "MaaS platform economy".

This conceptual paper introduces some possible future debates in this field but some contributions can be already showed to academics and practitioners.

From an academic perspective, we suggest to study MaaS platforms under the lense of the “Platform Economy”, as it is a more mature research area and it could provide interesting insight for future developments of MaaS. On the contrary, platforms researchers meet MaaS platforms, the first instance of manufacturing platforms to be investigated. Here, researchers should take into consideration that MaaS platforms could unveil different practices to sustain their business as they are quite different from traditional digital platforms.

Then, even though this paper origins a research agenda for academics, the contribution can be relevant also from a managerial perspective. We suggest MaaS plaforms operators to compare their business model with other platforms (and not necessarily the only MaaS competitors). Some insights about their business model can be valuable for managing platform in MaaS business.

If platforms of all kinds will continue to exist, we can imagine a growing integration between these models, to the point that the largest (capitalized) mobility company in the world does not have any car and the largest accommodation company does not own any hotel, apartment. In the manufacturing context, the largest company in the world could have no production facilities, nor any logistic assets.

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