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Taxonomy of Platform-based New Ventures in an Emerging Industry

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Abstract

The aim of the study is to understand how a well-established business model as platforms can be applied to a fast-growing market such as the new space economy. This objective is pursued through the development of a taxonomy of platforms operating in the new space economy in Europe. Following an iterative method based on the use of cluster analysis applied to a database of 134 platform startups belonging to the reference context, five main platform archetypes are identified. The research highlights the fundamental value generation processes implemented by companies sharing a platform business model. Furthermore, a set of dimensions and characteristics useful for the classification of platform startups in the new space economy are defined. Moreover, the study proposes a set of criteria, starting from the relative literature streams, about the platform scalability, both by highlighting the level of this feature for the single clusters and comparing them with one of the most scalable platforms outside the new space economy. The developed taxonomy can benefit researchers, investors and regulators by fostering the adoption of a common terminology useful for categorising similar companies within the same group.

Key-words: business model, platforms, new space economy, taxonomy, scalability

Abstract in italiano

L'obiettivo dello studio è comprendere come un modello di business ormai consolidato come quello della piattaforma possa essere applicato ad un mercato in forte crescita come quello della nuova economia dello spazio. Tale scopo è perseguito attraverso lo sviluppo di una tassonomia delle piattaforme operanti nella new space economy in Europa. Seguendo un metodo iterativo basato sull'utilizzo della cluster analysis applicata ad un database di 134 platform startups appartenenti al contesto di riferimento, sono stati identificati cinque principali archetipi di piattaforme. La ricerca consente di evidenziare i fondamentali processi di generazione del valore implementati dalle compagnie che condividono un platform business model. Inoltre, sono definite una serie di dimensioni e caratteristiche utili per la classificazione di platform startups nella new space economy. Inoltre, lo studio propone una serie di criteri, a partire dai relativi filoni di letteratura, riguardo la scalabilità delle piattaforme, sia evidenziando il livello di questa caratteristica per i singoli cluster, sia confrontandoli con una delle piattaforme più scalabili al di fuori della new space economy. La tassonomia sviluppata può generare beneficio a ricercatori, investitori e regolatori, favorendo l'adozione di una terminologia comune, utile a categorizzare imprese simili all'interno di uno stesso gruppo.

Parole chiave: business model, piattaforma, new space economy, tassonomia, scalabilità

Contents

Introduction

The nature of platform new ventures, and their role in emerging economies, is a matter of intense debate. Since the Eighties, platforms have started to play a key role in various industries, giving rise to different meanings of the platform concept depending on the field of application. Born as a strategy for a company to reduce the time to market of an innovative product, platforms first enlarged their boundaries to a wider set of players belonging to the same industry and then started to represent infrastructures able to connect different sides of the market. Nowadays, thanks to the pervasive adoption of digital technologies, platforms can benefit from the collection of significant amount of data and connect the actors involved in a more efficient way. For these reasons, an increasing number of new ventures is exploiting this business model, thanks to its potentially high scalability and the opportunity to win the market if successfully implemented. Therefore, their features can be effectively exploited in most of the emerging industries characterized by high level of digitalization, such as the new space economy, which can be considered as the evolution of the traditional space economy. In particular, starting from the beginning of the twenty-first century, the space economy has seen an increasing amount of investments and participation from the private actors, in an industry typically characterised by the proprietary presence of governments. This gave rise to the introduction of a series of activities, all encompassed in the new space framework, that often leverage on new technologies, among which machine learning and AI.

The increasing relevance of platforms business models and the attractiveness of the new space economy generate the need of a comprehensive understanding of platforms behaviours in this specific context. Therefore, the objective of the research is the development of a taxonomy of platform business models in the new space economy. The main contribution of this study is the provision to both regulators and investors of an exhaustive framework able to identify the most significant archetypes of new space economy platforms, resuming their related key characteristics.

Following the method suggested by Nickerson et al. (2013) [1] for the development of a taxonomy in the information systems domain, a cluster analysis on 134 European new space economy platform start-ups was carried out. This process led to the identification of five clusters, namely "Scientific and technological foundation platforms", "New space economy cloud platforms", "Crowdinvesting platforms for SDG", "Public-private information platforms", and "Space enabled service marketplace platforms", that represent the most widespread typologies of platforms operating in the context. The objective of this taxonomy is therefore to provide a common terminology that all stakeholders can refer to, in order to facilitate the diffusion and the adoption of certain standards within the new space economy.

1 Literature review

In the present chapter a literature review regarding platform and emerging industries topics is presented in order to provide a solid theoretical background useful for the purpose of the research. It is important to highlight that only papers belonging to journals ranked in the first quarter by Scimago Journal are considered. First, following the evolution over the years of platforms' connotation, the most relevant stream of the underlying literature was consulted to collect a set of the most cited definitions and to obtain information on their crucial aspects. Starting from platforms' meanings, the chapter addresses the range of shades that the term may assume according to the field of application. Subsequently, the literature review focuses on the platforms' archetypes, the relative key aspects, and their scalability, that represent the basis for the following analysis. Once analysed platforms in their entireness, it is necessary to perform a literature review in the field of emerging industries. This operation allows a better understanding of the theoretical frameworks and notions regarding this specific type of industry, that includes the New Space Economy, which represents the empirical context of the underlying study.

1.1. Definition of platform

The term platform belongs to different fields, ranging from the IT industry to the management field and its meaning depends on the scope of analysis. In particular, a preliminary way to classify platforms comes from the different perspectives belonging to two streams of literature, the engineering-design and the economic views, that, over time, have deeply analysed the underpinning structure and the functioning of platforms throughout different lenses. In order to provide the reader with a comprehensive set of platform definitions, it is necessary to address several theoretical topics included in the descriptions reported in Table 1.1.

The first concept to be explained is represented by network externalities which describe the trend of users' utility according to the number of the same good consumers and they can be either positive or negative. According to Katz and

Shapiro (1985) [2], if “the utility that a user derives from consumption of the good increases with the number of other agents consuming the good”, then the underlying product or service is affected by positive network externalities. Consequently, if the user’s utility declines as the number of consumers of the same good rises, it is possible to state the existence of negative externalities.

Furthermore, network externalities can either affect customers belonging to a single typology or extend their action to other sides involved. In the former case, it is possible to claim the presence of “Direct network externalities [whose] effect refers to the phenomenon that the value of a product increases with a larger installed base of users” (Yang and Mai, 2010) [3]. For the sake of clarity, even the previous mentioned definition provided by Katz and Shapiro can be exploited to describe direct network externalities. The second scenario describes the concept of indirect network externalities that, assuming they are positive, “display an increased sense of user value from using a product or service, as the effect the user obtains from such product or service increases with the increase of related complementary products” (Lin and Lu, 2011) [4]. Finally, considering two distinct groups of users A & B affected by indirect network externalities, independently if they are positive or negative, it is possible to furtherly emphasizes whether these effects are reciprocal or unidirectional. In the first case, the utility of A depends on the numerosity of B and vice versa; in the latter scenario only the utility of a group of users is affected by indirect network effects.

Among its different natures, a platform can be the starting point for several innovations represented by derivative products and services. In addition to platform-assets’ providers, other players are often required to bring innovation both to the company and to the market. These types of actors are called complementors and represent another relevant theoretical concept. According to McIntyre, Srinivasan, Chintakananda, 2020 [5], “the existence of complementors, or independent providers of complementary goods, enhances the value of a core good to a network such that “the value of the core good is greater in tandem with the complement than without it” (McIntyre and Srinivasan, 2017 [6]; Boudreau and Jeppesen, 2015 [7]; Yoffie and Kwak, 2006 [8])”. In addition, there are some differences between the owner and the complementors of the platform. Following the previous-mentioned paper, the latter have a more flexible organizational structure than the former and are more likely to bring radical innovation (Jugend et al, 2018) [9]. Platform owners should pay attention to the engagement of complementors and decide wisely which strategy to adopt in order to manage the relationship with them. Among the different possibilities, the single-homing and multi-homing solutions are the most relevant, however they will be described in the following chapters after having provided the reader with more knowledge about platform characteristics and elements.

Focusing on more technical aspects, it is required to clarify the meaning and the characteristics of a module and an interface. In the informatic field, the former can be described as a logically separable and distinguishable part of a program. Extending this definition to a more general context, it represents a set of components needed to accomplish a specific function. In computer science, the interface is intended as a connection device capable of ensuring communication between two otherwise incompatible systems, or between a central and a peripheral unit. In the platform field, this definition allows to represent the relationships between the platform owner, the complementors and the other entities involved in the ecosystem.

If the previous concepts can belong both to the engineering-design and economic view, the following are strictly related to the latter subset of the literature since they represent costs an actor can face in the market. Among them, the most relevant are transaction costs, defined as the total outlay sustained to conclude a transaction including search and information costs, bargaining costs and policing and enforcement costs. It is possible to highlight that "transaction costs arise because of information uncertainty and as a result of the actions that transactors must take to manage this uncertainty. Transaction cost generating actions include searching for contract partners, gaining knowledge of materials and production, negotiating and concluding contracts and monitoring and enforcing contracts over time" (Coggan, Whitten, Bennett, 2010) [10].

In the following table some definitions of platform, that will be further explained in the later chapters, are presented according to the interpretation of different streams of the literature.

Table 1.1: Definitions of platform

	Definition	Author
Def1	Platform projects generate major changes to the design and/or manufacturing of an existing product that provide a base for the refinement of a product or process family.	Sanderson and Uzumeri, 1995 [11] Research Policy
Def2	A product platform is a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced.	Muffatto and Roveda, 2002 [12] International Journal of Technology Management
Def3	A set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components.	Baldwin and Woodard, 2009 [13] Platform, Markets and Innovation
Def4	A set of subsystems and interfaces that form a common structure for/from which derivative applications can be developed and distributed.	Xu et al., 2010 [14] Management Science Journal
Def5	Set of components used in common across a product family whose functionality can be extended by applications.	Ceccagnoli et al, 2012 [15] Journal of Management Information Systems
Def6	Set of assets organized in a common structure from which a company can efficiently develop and produce a stream of derivative products.	Gawer, Cusumano, 2014 [16] Journal Product Innovation Management
Def7	The extensible codebase of a software-based system that provides core functionality shared by the modules that	Tiwana et al., 2010 [17]

	interoperate with it and the interfaces through which they interoperate.	Information Systems Research
Def8	A platform is a building block that provides an essential function to a technological system and serves as a foundation upon which complementary products, technologies, or services can be developed.	Spagnoletti et al, 2015 [18] Journal of Information Technology
Def9	A commercial network of suppliers, producers, intermediaries, customers […] and producers of complementary products and services termed "complementors" […] that are held together through formal contracting and/or mutual dependency.	Tan et al, 2015 [19] Journal of the Association for Information Systems
Def10	A defining feature of platform ecosystems is the interdependence between a stable core or "platform" that interfaces with a dynamic and heterogeneous set of complementary components to generate a stream of derivative products.	Kretschmer, 2020 [20] Strategic Management Journal
Def11	A platform mediates the relationship between end users and the universe of potential complementary goods.	Cennamo and Santalo, 2013 [21] Strategic Management Journal
Def12	A platform brings together two or more distinct groups of customers (sides) that need each other in some way, and where the company builds an infrastructure (platform) that creates value by reducing distribution, transaction, and search costs incurred when these groups interact with one another.	Pagani, 2013 [22] MIS Quarterly: Management Information Systems
Def13	The multi-sided platform model (MSP) involves contractual relationships between buyers and professionals, to	Hagiu and Wright, 2015 [23]

	which the focal firm is not a party, but merely an enabler of those contractual relationships.	International Journal of Industrial Organization
Def14	Platforms can be conceptualized as interfaces—often embodied in products, services, or technologies—that can serve to mediate transactions between two or more sides, such as networks of buyers and sellers or complementors and users.	Mcintyre and Srinivasan, 2017 [6] Strategic Management Journal
Def15	Platforms serve as a standardized digital interface and utilize digital technologies to facilitate interactions between different parties.	Chen et al, 2022 [24] Journal of Management
Def16	Platform technology that acts as a data hub channeling and integrating information from/to users and from/to multiple connected products and services, and as market infrastructure connecting users and suppliers of goods [...] platforms are the “new” market infrastructures that enable firms’ interconnected products and services to create and deliver value to final users [...] Platforms can vary in their strategies to attract on the different sides of the platform market, and activate and leverage the indirect network effects.	Cennamo, 2023 [25] Academy of Management Perspectives

1.2. Industrial economic and engineering-design view of platform

After having addressed the necessary theoretical elements, it is possible to introduce the different meanings that platform can assume. As previously described, there are two main streams of the literature regarding the topic, the engineering-design and the economic ones. Each of them studies the platforms under specific perspectives and therefore the object of the analyses and the characteristics underlined can be different.

Following a chronological order, the first concept of platforms belongs to the engineering-design view, according to which platforms act as a basis for the delivery of derivative products and services. Indeed, Wheelwright and Clark (1992) [26], define platform as products able to satisfy customer needs by adding and removing features. Furthermore, according to Gawer et al (2020) [27], platforms are "foundation technologies with modular architectures that facilitate innovation through open interfaces". The innovation process can either involve only the platform owner or a wider set of actors called complementors. This distinction allows to identify two different platforms' archetypes, respectively *internal platforms to enhance new product development* and *industrywide platforms*. However, the latter have the role of conjunction point between the engineering-design and the economic view, as explained in the dedicated subsection.

On the other hand, according to the industrial economics view, platforms are usually referred to as two-sided or multi-sided markets. The economic stream sees these platforms as facilitators between different kinds of agents that, without platform interactions, could not execute transactions (Armstrong, 2006 [28]; Rochet and Tirole, 2003 [29]). They are mainly characterized by network effects between the two - or multi - sides of the market at a point that, according to Rysman (2009) [30], "the literature on two-sided markets could be seen as a subset of the literature on network effects". This stream of literature allows to establish a third archetype of platforms called *two-sided (multi-sided) market*.

The Figure 1.1 summarizes the main characteristics of the platform, according to the two streams of the literature.

Literature	Economics	Engineering design
Conceptualization	Platforms as markets	Platforms as technological architectures
Perspective	Demand	Supply
Focus	Competition	Innovation
Value created through	Economies of scope in demand	Economies of scope in supply and innovation
Role	Coordinating device among buyers	Coordinating device among innovators
Empirical settings	ICT	Manufacturing and ICT

Figure 1.1: Platform characteristics in the literature streams, Gawer (2014) [31].

1.2.1. Internal platform to enhance new product development

An internal platform to enhance new product development can be defined as a set of resources or a set of components, along with the linkages among them, owned by a firm and combined in a certain structure in order to efficiently develop and provide derivative products, generating value both for the company and the market (Meyer and Lehnerd, 1997 [32]; Muffatto and Roveda, 2002 [12]). An internal platform allows the company to reduce its time-to-market, i.e. the time between the beginning of the development process of a new product and the start of its commercialization, making the firm more efficient in reacting to market shifts, and to increase its market share by launching a wide set of derivative products and additional services, therefore increasing the ability of the firm to develop innovations. "A firm …. can build a family of related products or sets of new features by deploying these components" (Gawer and Cusumano 2014 [16]), where the previously mentioned components are the elements of the internal platform. Furthermore, internal platforms can bring several advantages, such as savings on fixed costs and the achievement of economies of scale and scope thanks to the core elements shared by the derivative products. Economies of scope in the innovation framework are defined "as when the cost of jointly innovating on Product A and B is lower than the cost of innovating on A independently of innovating on B" (Gawer, 2014 [16]). On the other hand, the initial investment to sustain this organizational structure is much higher than the one necessary for the development of a single product as well as the risk run by the company that could not be able to foresee the evolution of customers' desires in the medium and long-term time horizon. The previously mentioned advantages leverage the concept of modularity, defined by

Baldwin and Clark (2000) [33]as a cluster of modules, structured around a core and a periphery, connected through interfaces. These last can have both the role of divider between different modules' function and of connector, by conducting information facilitating their interconnection (Baldwin, 2008) [34]. Modular architectures enable innovation by dividing, organizing and managing the required innovative labour. They allow autonomous innovation within single modules and mixed innovation by recombining and matching modules with each other (Parnas, 1972 [35]; Langlois, 2002 [36]; Garud and Kumaraswamy, 1995 [37]). It is important to specify that the optimization of each module does not necessarily imply the optimization of the whole system (Meyer and Lehnerd, 1997 [32]), and therefore internal platforms are more likely to bring to the market incremental rather than radical innovations. For the sake of completeness, the former "does not break with previous products, processes or organizational methods, because it is a significant improvement of previous products, processes or organizational methods", whereas the latter "is an innovation with a high degree of novelty, which breaks with what existed previously and is the result of non-obvious paths or ideas. Consequently, a radical innovation involves great challenges and opportunities." (Souto, 2015 [38]).

This archetype concept identifies therefore platforms as enablers throughout the innovation process mainly due to their modular architecture that facilitates firms to develop derivative products (Sanderson and Uzumeri, 1995 [11]), and increase their ability to more quickly and systematically innovate by re-using common assets (Krishnan and Gupta, 2001) [39]. It is important to highlight that, according to Krishnan and Gupta, the innovation capability through the reusage of the same set of components does not exceed the platform owner boundaries. Indeed, the core product is completely realized within the company, allowing the existence of complementary products and services delivered by other actors, that however do not exploit the same assets deployed by the platform owner. Therefore, the intrinsic value of the platform lies entirely on the firm strategy, without being affected by any network effect. This aspect is the discriminant between an internal and an industrywide platform, that will be explained in the following chapter.

The only exception to the previous reasoning is represented by the so-called supply-chain platforms, a special case of the internal ones, in which "a set of firms follow specific guidelines to supply intermediate products or components to the platform owner or the final product assembler" (Gawer and Cusumano, 2014 [16]). Supply-chain platforms are not considered as part of the industrywide subset since the suppliers do not contribute to the realization of derivative products, but rather assist the platform owner throughout the delivery of the final product.

After having presented and deeply analysed the main features of internal platforms, it can be interesting to investigate the pertaining definitions encompassed in Table 1. Starting with the definition provided by Sanderson and Uzumeri (1995) [11] that states "platform projects generate major changes to the design and/or manufacturing of an existing product that provide a base for the refinement of a product or process family", it is highlighted the capability of an internal platform to introduce new features to an existing product, that represents the starting point to reduce the time to market and exploit economies of scope. In line with this description, Gawer and Cusumano (2014) [16] consider internal platforms as a "set of assets organized in a common structure from which a company can efficiently develop and produce a stream of derivative products". A more emphasis on modularity and interfaces is given by Baldwin and Woodard (2008) [13] and Xu et al., (2010) [14], that respectively define platform as "a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components" and "a set of subsystems and interfaces that form a common structure for/from which derivative applications can be developed and distributed". The two previous concepts allow the decomposition of the complex problem of designing a product or a service in more manageable tasks. Indeed, each module can be considered as a black box with specific features, without knowing exactly how it works. In order to achieve the final objective, the modules are connected through interfaces. The last definition focuses again on modules and interfaces, but it gives a more digital view of internal platforms rather than the more common manufacturing connotation. Indeed, Tiwana et al. (2010) [17] sustain that platforms are "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate".

1.2.2. Industrywide platforms

The second archetype of platforms is represented by the industrywide or external platforms. According to Teece (1986) [40], industrywide platforms are game changers in the competition since they can provide some complementary assets, complementary technologies and services necessary to realize the final product. External platforms can be more generally defined as "products, services, or technologies that act as a foundation upon which external innovators, organized as an innovative business ecosystem, can develop their own complementary products, technologies, or services." (Gawer and Cusumano, 2014 [16]). The authors highlight the crucial role of industrywide platforms as innovation catalysts by involving a wide range of complementors which determine the final value of the end products and services exploiting their ability to build upon the resources shared by the platform owner. Consequently, the stand-alone vale of an industrywide platform is negligible, and the successfulness of the platform heavily relies on the magnitude of the network effects generated by third parties' interactions. To better understand the context and the dynamics explained above, it is useful to provide a description of the two types of actors involved.

The platform owners, in this specific case, take the name of platform leaders, defined as "organizations that successfully establish their product, service, or technology as an industry platform and rise to a position where they can influence the trajectory of the overall technological and business system of which the platform is a core element" (Gawer and Cusumano, 2014 [16]). This allows the platform owner to have an architectural advantage, that can be preserved managing effectively the trade-off between the competition among complementors, in order to maintain its bargaining power over each of them, and the incentives to keep them on board. Therefore, "the platform leader must create economic incentives for ecosystem members to invest in creating complementary innovations and to keep doing so over time. In addition, platform-leader wannabes need to protect their ability to profit financially from their innovations, just as any innovator company should." (Gawer and Cusumano, 2008 [41]). As a result, the platform leader should focus on the degree of openness of the platform to allow third parties to plug-in additional features in order to foster innovation and obtain derivative products and services able to generate value for the final users. In particular, a wider set of complementors allows a higher level of differentiation of the products and services offering. Another advantage arising from an increasing numerosity of complementors, if the platform is successful, is the possibility to adopt a revenue sharing business model. According to this strategy, complementors have to pay a portion of their revenues to the platform leaders if they want to exploit the platform network for the distribution of their goods (West & Mace, 2009 [42]).

A complementor in industrywide platforms assumes the role of a third-party developer who "on behalf of someone else, the platform owner, develops applications, services or systems for satisfying end-users of the platform." (Ghazawneh and Henfridsson, 2013 [43]). The main incentive for the third-party developer is not represented by a direct economic compensation provided by the platform leader, rather by the possibility of delivering its final products and services through marketplaces generated by the platform connections (West and Mace, 2009 [42]). According to the difference in bargaining power between the core firm and the complementor, the relationship could be different, ranging from a long-term collaborative relationship to an opportunistic behaviour from one of the two counterparties. The degree of openness of the resources to external agents can vary from one platform to another one according to different criteria, such as the amount of information, the cost to access them and the type of governance.

Once the main parties of industrywide platforms are described, it is possible to highlight the necessary conditions that must be satisfied for its establishment. In particular, according to Gawer and Cusumano (2008) [41], the external platform must:

- "Perform a function that is essential to a broader technological system"
- "Solve a business problem for many firms and users in the industry"

The authors specify that these conditions are necessary, but not sufficient for the success of a platform, indeed they, emphasizing again the crucial activity of managing the complementors. Platform leaders should "stimulate complementary innovations by other firms, including some competitors, while simultaneously taking advantage of owning the platform."

The literature highlights the importance for the platform to reach the critical mass in the early stages of its lifecycle, in order to increase the chances of success. Critical mass can be defined as the 'minimum network size that can be sustained in equilibrium, given the cost and market structure of the industry' (Economides and Himmelberg, 1995 [44]). If this target is not achieved, the network is likely to fail, otherwise once the threshold is overtaken, the network size will probably increase at a high rate. If a platform reaches this milestone, it means that it manged to survive against the high level of uncertainty of platform initiation.

If the platform managed to reach the critical mass and therefore to go beyond the initial stage, both types of actors involved will benefit from the high rate of growth of the network size. However, the magnitude of advantages perceived by the platform owner will be more significant with respect to the one of complementors. This can be justified considering that the platform leader will have a bigger amount of resources to exploit and a more central position in the architecture of the ecosystem with respect to complementors. These conditions entitle the platform owner with a significant bargaining power, allowing it to reach highly favourable contractual conditions towards complementors. According to Zhu and Liu (2018) [45], "complementors may be more reluctant to participate in the focal platform, since the platform owner firms would have less need and commitment to cooperate with complementors, but more resources and motives to compete with them. This finding is also consistent with real world cases (e.g. Microsoft), and findings from related prior studies."

In Figure 1.2, three different types on platform are compared according to two dimensions, the likelihood of competition among platform's constitutive agents and platform's constitutive agents' autonomy to innovate. Moreover, it is described how the degree of openness of the interfaces increases through the internal, supply-chain and industry, intended as industrywide, platforms. The level of competition in the first archetype is lower since the only actor involved is the platform owner, while industrywide platforms are characterized by a higher level of competition given the participation of different actors. Finally, supply-chain platforms are defined by an intermediate level of competition. An increasing number of complementors is associated with a higher degree of autonomy to innovate, and with an increasing openness of interfaces.

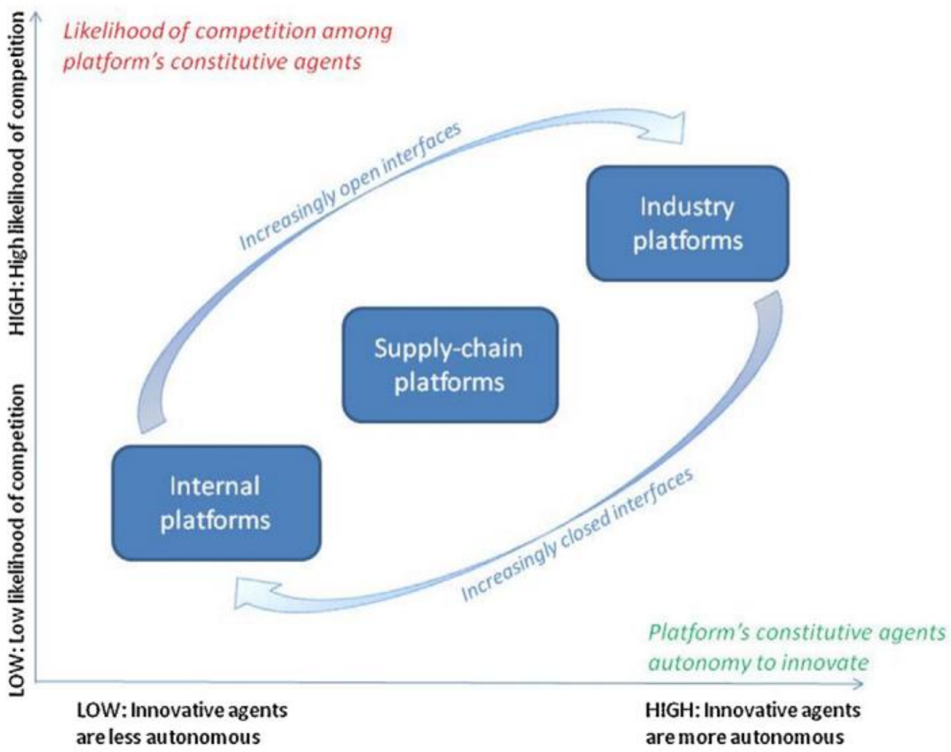

Figure 1.2: Likelihood of competition and agents autonomy in platforms, Gawer (2014) [31].

Given the interdependent relationship between platform owners and complementors, industrywide platforms can be seen as the conjunction point between the engineering-design and the economic view, embedding characteristics belonging to both perspectives. Indeed, according to the former, complementors are necessary actors to deliver value to the final user building derivative products and services starting from the resources shared by the platform owner. On the other hand, platform leaders enable the connection between third parties and final users representing the way through which two or more sides of the same market can get in contact. This aspect resumes the key feature of the economic view that will be furtherly analysed in the following section.

As done before, after having the analyses of the main characteristics of industrywide platforms, the related definitions in Table 1 are presented and discussed. Starting from Muffatto and Roveda (2002) [12] according to which "a product platform is a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced", it is possible to shift from internal to industrywide platforms depending on the contribution of external actors to the innovation process. If derivative products and services are developed within the platform owner boundaries, the definition sticks to the internal platforms' domain, otherwise it can be encompassed in the industrywide realm. The definition provided by Xu et al. (2010) [14] focuses additionally on the concept of distribution of derivative application exploiting resources provided by the platform owner. Indeed, industrywide platforms are seen as "a set of subsystems and interfaces that form a common structure for/from which derivative applications can be developed and distributed". Part of the literature emphasizes the role of complementors in this type of platforms, as sustained by Spagnoletti et al. (2015) [18]that see a platform as "a building block that provides an essential function to a technological system and serves as a foundation upon which complementary products, technologies, or services can be developed". A similar but more network-oriented definition is the one of Tan et al. (2015) [19], according to which an industrywide platform is "a commercial network of suppliers, producers, intermediaries, customers …. and producers of complementary products and services termed "complementors" …. that are held together through formal contracting and/or mutual dependency". It is useful to point out that the concept of mutual dependency implies the existence of indirect network externalities. Kretschmer (2020) [20] focuses instead on the ecosystem perspective that provides for a central role of the platform owner and a peripheral position of the complementors involved. He states that "a defining feature of platform ecosystems is the interdependence between a stable core or "platform" that interfaces with a dynamic and heterogeneous set of complementary components to generate a stream of derivative products". Cennamo and Santalo

(2013) [21] and Chen et al. (2022) [24] focus instead on the intermediation action of platforms between different parties including end users and therefore bridging the engineering-design and the industrial economic views. According to the former, “a platform mediates the relationship between end users and the universe of potential complementary goods”, whereas for the latter “platforms serve as a standardized digital interface and utilize digital technologies to facilitate interactions between different parties”.

1.2.3. Platforms as two-sided (multi-sided) markets

Platforms as two-sided (multi-sided) markets act as matchmakers between different sides of the market and are characterized by indirect network externalities, where the utility of at least one group of users increases as the numerosity of the other group(s) grow (Hagiu and Wrigth, 2015) [23]. Since the platform concept is applied to markets, economic transactions are involved and therefore pricing dynamics cover a key role in their functioning. Indeed, Rochet and Tirole (2006) [46], focusing on this aspect, propose an alternative definition, describing platform as two-sided (multi-sided) markets as “markets in which one or several platforms enable interactions between end-users and try to get the two (or multiple) sides ‘on board’ by appropriately charging each side”. Starting from this statement, it is possible to point out the non-neutrality of the pricing strategy, meaning that the fees charged by the platform owner to the different sides involved affect the volume of transactions that take place within the network. Another pricing-oriented definition is provided by Evans, Hagiu and Schmalensee (2008) [47], according to which platform as two-sided (multi-sided) markets are “businesses in which pricing and other strategies are strongly affected by the indirect network effects between the two sides of the platform”. According to Gawer (2014) [31], this type of externalities allows the achievement of demand-side economies of scope, whereas direct network effects lead to demand-side economies of scale. Indeed, direct network effects increases the ability of product to penetrate the same market, since the higher the number of users the higher the utility of each of them, facilitating the realization of economies of scale. On the other hand, considering that economies of scope are generated by the accomplishment of efficiencies through the variety of the demand-side, indirect network externalities ease their achievement since they imply the presence of different groups of customers with different needs. Additionally, Evans (2003) [48], affirms that platforms “coordinate the demand of distinct groups of customers who need each other in some way”.

According to Evans (2003) [49], it is necessary to satisfy three conditions to be considered as a two-sided or multi-sided market:

- Two or more distinct groups of customers are required.
- Cross-side (or indirect) network effects associated with two or more groups of customers must exist. In some cases, the indirect effects have got a reciprocal impact (then there are two indirect network effects), but one suffices.
- An intermediary, usually represented by the platform, that can internalize the externalities, must exist.

Another necessary condition is defined by Rochet and Tirole (2006) [46], who sustains that the Coase theorem must not be valid to allow the presence of platform as two-sided (multi-sided) market. This theorem states that "if agents are rational and the costs of transacting are zero, resources will be allocated efficiently independent of how rights over those resources are initially distributed. Moreover, if utility functions are uniformly affine in private goods and the registration of subjective values is not wealth-constrained, this efficient allocation of resources is independent of the initial rights structure." (Steven G. Medema, 2020) [50].

The Figure 1.3, provided by Hagiu and Wright (2015) [23], shows the different organizational structure of a company, highlighting the relationships between the sides and the firm itself.

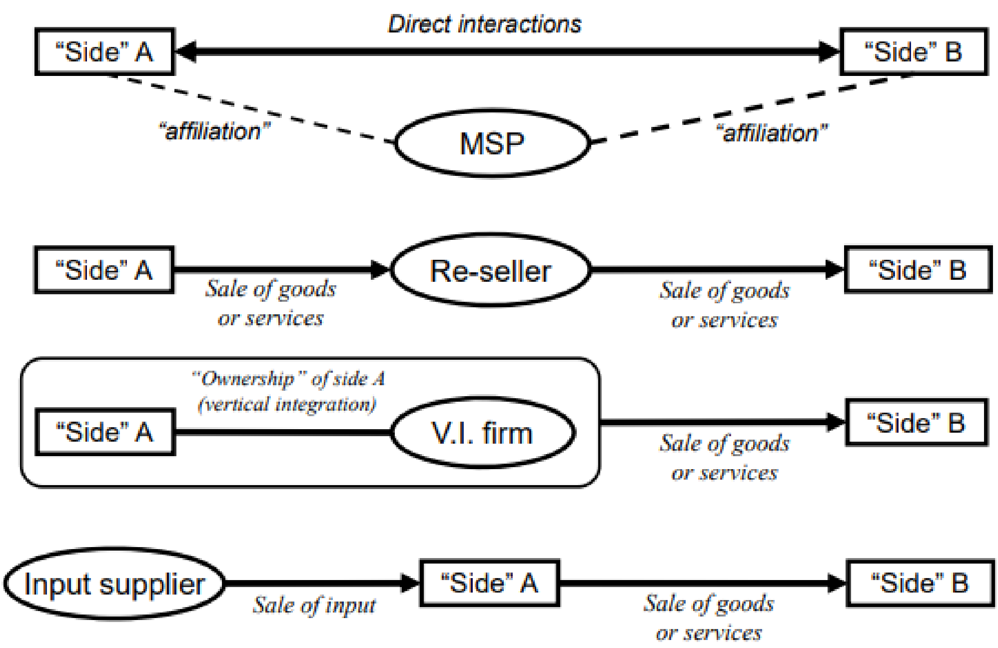

Figure 1.3: relationships between the sides of the market, Hagiu and Wright (2015) [23].

Beyond the re-seller, the vertical Integrated and the input supplier firms, representing the most traditional organizational structures, the authors focus their attention on the multisided platform, by highlighting its peculiarities with respect to the other business models. Indeed, multisided platform is the only configuration able to connect two sides which interact directly and in both the directions, without representing an intermediate step along the supply chain. Finally, the multisided platform is related to the sides through the so-called affiliation, meaning that "users on each side consciously make platform-specific investments that are necessary in order for them to be able to directly interact with each other." (Hagiu and Wright, 2015) [23]. From this consideration, emerges the role of two-sided (multi-sided) platforms as facilitators of the interaction between two different parties that would otherwise not be able to efficiently connect with each other. The intermediation role embodied in this platforms' archetype allows sides to reduce transaction costs generated by this attempt of interconnection. Therefore, one of the main differences between these platforms and the industrywide ones is represented by the determinants of the platform value itself. If the intrinsic value of the latter is not null even without customers, the value of the former exists only if their intermediation role is accomplished by bringing on board two different groups of users. It is important to highlight that "the demand on each side tends to vanish if there is no demand on the other" (Evans, 2003) [49].

The previous statement resumes the so-called chicken-and-egg problem. This kind of paradox can be easily explained: it usually happens that one side of the market does not see any value in the platform until the other side's presence is significant. The crucial point stands therefore in understanding which side to bring first in a way in which is convenient for the other to access the platform. The quicker and easiest way to address this issue and get on board the critical mass is subsidizing the side of the market more necessary in order to attract the other one and solve the coordination problem (Parker and Van Alstyne, 2005) [51].

Two-sided (multi-sided) markets can be further classified according to the existence of transactions between the customer and the platform. This gives rise to the distinction between non-transactional or orthogonal platforms and transactional platforms.

Transactional platforms are systems able to connect two sides there is a transaction between. From the point of view of platform owner revenues, the mechanism and the idea behind this type of archetype is more intuitive with respect to non-transactional ones. The platform can charge either a side or both sides involved in the transactional with a fee that can be proportional to the amount of transaction itself or it can be even a fixed quantity. As in the industrywide case, the platform owner must manage a key trade-off to build a successful and profitable platform. Indeed, the choice of charging a side with a high fee implies a great amount of revenue collected for each transaction; however, it could lead to a lower amount of transactions or even to a decreasing number of users belonging to this side. The other alternative, i.e. a smaller fee, has the benefit of increasing the quantity of transactions and even the number of users relying on the platform. In the second scenario, the revenue earned by the platform for each transaction could however be not sufficient for the economic sustainability of the platform.

In non-transactional or orthogonal platforms, the customer does not pay anything, or he/she is charged a considerably modest sum to access the product or service, that cannot represent the only source of revenue to ensure the two-sided (multi-sided) platform's profitability. To obtain the necessary funding, these markets rely on advertisers who pay a certain amount in order to make their offering appear on the platform itself. In particular, the higher the number of users in the platform, the higher the value for the advertisers. Therefore, it is possible to highlight the presence of unidirectional cross-side network externalities since an increasing number of advertisers does not bring any additional value to the users. For this reason, one side of the market, the customers, benefit from the platform's products and services without facing any costs, whereas the other side, the advertisers, sustain the system economically, according to a client-as-target strategy. Among the platforms that adopt this strategy, some firms also represent an example of *freeconomics*, a business model in which a product is offered for free and supported by the sales of a premium version. Finally, other non-transaction platforms, such as social media, are based on the client-as-source model. This approach is based on the collection of users data, that the platform owner can exploit to attract third parties. For these actors, the interest to be part of the platform increases with the number of users in the network itself, originating therefore cross-side network externalities. There are three main strategies to capture value using the client-as-source model:

- Enhanced advertising: leveraging the data collected to target customers with the highest interest in specific products, the platform makes the relative advertising appear on the user's interface.
- E-ethnography: data collected by the company are leveraged by the firm itself to improve their product and services according to customers' needs and preferences.
- Data trading: data are sold to third parties.

It is important to mention that client-as-target and client-as-source model are not mutually exclusive, but they can coexist in a so-called hybrid strategy.

Finally, an increasing phenomenon is represented by data-driven innovation, where platforms have the role to collect and sell relevant amount of data useful to improve other companies' performances.

Following the procedure of the previous sections, here follows an examination of the pertaining definitions in Table 1.1. Mcintyre, Srinivasan and Chintakananda (2017) [6] connect the industrywide platforms and the two-sided (multi-sided) markets by combining elements belonging to the two different archetypes, such as complementors, buyers and sellers, and users. According to their definition, "platforms can be conceptualized as interfaces—often embodied in products, services, or technologies—that can serve to mediate transactions between two or more sides, such as networks of buyers and sellers or complementors and users". Hagiu and Wright (2015) [23] state that "The multi-sided platform model (MSP) involves contractual relationships between buyers and professionals, to which the focal firm is not a party, but merely an enabler of those contractual relationships", and therefore focus their attention on the enabling role of the platform. Finally, Pagani (2013) [22] explains that "A platform brings together two or more distinct groups of customers (sides) that need each other in some way, and where the company builds an infrastructure (platform) that creates value by reducing distribution, transaction, and search costs incurred when these groups interact with one another". In this case, the platform does not simply intermediate between the sides, but it reduces the transaction costs.

A separate mention is deserved by the definition of Cennamo (2023) [25], since it can be encompassed within the two literature stream views and includes more than one platform archetype. He identifies platforms as "technology that acts as a data hub channeling and integrating information from/to users and from/to multiple connected products and services, and as market infrastructure connecting users and suppliers of goods […] platforms are the "new" market infrastructures that enable firms' interconnected products and services to create and deliver value to final users […] Platforms can vary in their strategies to attract on the different sides of the platform market, and activate and leverage the indirect network effects".

1.3. Digital platforms and digital servitization

1.3.1. Digital platforms

A common trend affecting the three platform archetypes is represented by the digitalization, a phenomenon arisen from the servitization process, described as the introduction of complementary services to an already existing core product to widen and differentiate the offering of a firm (Vandermerwe and Rada, 1988) [52]. Nowadays, therefore, the literature often refers to platforms as digital platforms.

Digital platforms are a subset of platforms that "serve as a standardized digital interface and utilize digital technologies to facilitate interactions between different parties" (Chen et al. 2022) [24]. There are anyway more detailed and refined definitions in the related literature field, according to a technical or non-technical conceptualization view. Definitions belonging to the first view focus more on technical aspects and functionalities, while the second view is more centred on the interactions between different groups of users that join the platform. The former stream can be represented by Gawer (2009) [53] who defines digital platforms as "a building block, providing an essential function to a technological system—which acts as a foundation upon which other firms can develop complementary products, technologies or services". On the other hand, the non-technical view can be explained by Koh and Fichman (2014) [54] that refer instead as "Two-sided networks […] that facilitate interactions between distinct but interdependent groups of users, such as buyers and suppliers". The former definition witnesses the existence of digital platforms in the industrywide set, highlighting the role of complementors as therefore the built derivative products and services. The latter represents the extension of two-sided markets to the digital subset, leaving unaffected the roles of the platform as described in the relative archetype. Therefore, the way in which the value is generated by the platform is unchanged as defined by Ye et al. (2012) [55], according to which "[…] value is created by facilitating the interaction between two or more mutually interdependent groups of customers". The reason why digital platforms have moulded and transformed major industries (e.g. transportation, hospitality, software development…) stands in the advantages that their organizational model implies. First, the reduction of economic frictions and transaction costs among which distribution, search, monitoring costs (Eisenmann et al. 2011 [56]). Second, digital platforms architecture and modularity are functional for the development of complementary products and for the innovation journey along its phases. Other two characteristics identified as crucial in digital platform business model are generativity and cross-side network effects, already deepened in the paragraphs before. Generativity can be defined as "the ability of a technology to generate new outcomes driven by large and heterogeneous users" (Zittrain, 2006 [57]). According to Gawer (2021) [58], digital platforms make strategic decisions over three different but intertwined kind id boundaries: the scope of the platform firm, defined as assets owned, labour employed, and activities performed; the composition of the platform's sides, i.e. the distinct groups of users that have access to the platform; and the digital interfaces that allow the exchange of data between the platform and its sides. Starting from the firm's scope, the literature focuses on platforms' choices on the number of sides to get on board and the composition of these sides. They can be referred to as either customers or users and they can be individuals or businesses. This decision has an impact on the way the platform can generate value and benefit from the network effect arisen by users' interactions and the possible trade-offs generated by managing different users. By opting for more than one side, pricing strategies toward customers can be different and usually there's the need to subsidize one side while generating money from the other one, that pays more than the marginal cost sustained by the firm. Therefore, platforms' profitability is affected by the number of sides and the pricing models implemented. Intuitively, having more sides on board leads to greater cross-side positive externalities and potentially more sources of revenues, but, on the other hand, it increases complexity and managerial implications (Gawer, 2021 [58]). While designing technological interfaces, platforms decide how to connect the agents within the ecosystem and the architecture and modularity of the ecosystem itself. An interface is defined as "a technological boundary situated between elements or modules within the architecture of a product or system" (Gawer, 2021 [58]), since they "indicate how the various modules interact between each other and within the larger system" (Baldwin and Clark, 2000 [33]). The level of accessibility of interfaces defines their openness. The more an interface is open, the more external agents in the ecosystem can acquire information and build complementary innovation, generating value for the platform and the ecosystem itself. On the other hand, being more open implies a lower degree of control over the sides involved that the platform firm can exert. The third boundary a platform can act upon is its scope, intended as the decision-making process on the asset structure, activities and resources to deploy in order to carry out the business. Focusing on digital platforms and in general moving within the digitalization framework, the way in which firms operate has dramatically changed. According to Gawer (2021) [58], "on the one hand, digitalization enables the control of assets without ownership and the remote control of workers without employment; this tends to make the narrowing of the platform firm's scope cost-effective. On the other hand, digitalization increases the ease of exploiting synergies across digitally connected markets; this eases entry into adjacent markets, hence facilitating platform scope expansion". Autio et al. (2018) [59] sustain that digital firms redesigned their value creation and capture processes and the way in which they deliver that value and exploit synergies. This is mainly due to the implications that digitalization brings with it, such as connectivity, fungibility of digital assets, reduction of transaction costs, monitoring and control of resources.

1.3.2. Digital servitization

As already underlined at the beginning of the paragraph, servitization became a relevant trend the late 80's, when firms started widening their offerings by adding to core products a set of additional related services in order to differentiate themselves from competitors. One of the main advantages of servitization is its capability to facilitate companies to achieve economies of scale through high production volumes while satisfying different customers' needs. Economies of scale arise from the fact that the core product remains the same in the production process but is now produced on a larger scale due to the stream of additional services that can be entangled in the main offering. On the other end, this allows firms to tackle different market needs thanks to the distinct features added to the primary product (Cenamor et al, 2017 [60]). The servitization phenomenon was accelerated by the so-called digitalization, since digital technologies can be exploited to deliver seamlessly several services related to the focal product (Srivastava and Shainesh, 2015 [61]; Vendrell-Herrero et al, 2017 [62]; Rajala et al, 2019 [63]). Moreover, digitalization has always played a fundamental role in defining the strategy and the structure of servitization-based activities both at macro and micro levels (Rabetino et al, 2018 [64]). The latter encompasses the company activities performed on a regular basis using digital technologies and therefore are more oriented towards an operative framework. The macro level is the aggregation of the micro activities to undertake decision from both a strategic and a tactical perspective.

The link between servitization and digitalization is addressed by the literature under the name of digital servitization phenomenon, defined by Kohtamäki et al. (2019) [65] as "the transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function". With the aim of successfully integrating the digital servitization model and taking advantages from its implementation, companies have to leverage on software capabilities and integrate in their business model the continuous acquisition and processing of data (Hasselblatt et al, 2018 [66]). Indeed, digital servitization involves "the transformation in processes, capabilities, and offerings within industrial firms and their associate ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies" (Sjodin et al, 2020 [67]). If the servitization has the goal of increasing the appeal of a product, on the other hand it could cause the so-called service paradox, explained as a "substantial investment in extending the service business leads to increased service offerings and higher costs, but does not generate the expected correspondingly higher returns" (Gebauer et al, 2005 [68]). The literature suggests that firms can tackle this paradox by adopting a business model that relies on platform (Marion et al, 2014 [69]), and, in particular, leveraging on a digitalization enabled platform approach (Eloranta and Turunen, 2016 [70]; Pekkarinen and Ulkuniemi, 2008 [71]). As proposed by Thomas et al (2014) [72], in this context the platform approach represents an efficient way in which a firm can organize to exploit "the value of digital technologies based on modularity and IT-enabled interactions" (Cenamor et al, 2017 [60]). More specifically, a modular architecture allows the company to optimize its investments by experimenting with combinations of modules and therefore widening the range of the offering in a flexible way (Meyer and Schwager, 2007 [73]; Bask et al, 2010 [74]). Deepening the topic of modules in the platform approach, the information ones cover a crucial role, allowing companies to increase operational efficiency and customization analysing the customer needs and how they interact with the product. Furthermore, different studies highlight the necessity of a company to adopt a new configuration with external firms, defining a whole new set of roles. In particular, the back-end units must take the figure of system orchestrator, i.e. platform owner, exploiting product, service and information modules to manage front-end units responsible for delivering the final offering to the customer (Cenamor et al, 2017 [60]). The previous mechanism is also able to provide a constant introduction of innovation in the system. in the literature the necessity of managing in a proper way the set of different digital technologies to deliver advanced services is studied (Opresnik and Taisch, 2015 [75]). The migration towards digital servitization implies an evolutionary process characterized both by continuous and discontinuous features (Chen et al, 2021 [76]). Continuousness is related to the linear evolutionary trajectory of the servitization trend, while the digitalization path, being characterized by a set of evolutionary stages, can generate discontinuities within the business model. The previous sentence can be explained by the fact that a company could need to create a completely new business model in order to implement digitalization (Christensen et al., 2013 [77]).

The digital servitization brings innovation both in the value delivery and value capture mechanisms. The former is affected at internal level since all companies belonging to the ecosystem must adapt to the same digital technologies to foster the efficiency of the internal centralized decision-making process, product and service optimization and a seamless connection between the front-end and the back-end. Considering the external level, the value generation process is innovated by the introduction of digital technologies along the whole supply-chain. The digital servitization and the consequently enabled ecosystem integration allows the acceleration in the rate of service innovation by changing therefore the traditional capture value mechanisms (Chen et al, 2021 [76]). Digital servitization can contribute to develop a collaboration ecosystem among firms which are based on a product-service-software offering and use autonomous systems. Smarts solutions require to involve all actors involved in the ecosystem, starting from the manufacturers, final customers and distributors. The process involves not only the technological capabilities of the focal firm, but it needs a holistic approach that should be supported consistently by a proper business model oriented to interactions and collaboration. For example, make-or-buy decisions become make-or-collaborate-or-buy decisions, and it explains that the value is not only generated by the ecosystem, but it also captured by the player themselves.

According to Kohtamaki et al (2019) [65], there are five different company business model archetypes that can be impacted by digital servitization:

- Product-oriented service provider
- Industrializer
- Customized integrated solution provider
- Platform provider
- Outcome provider

The product-oriented service provider is the closer archetype to a traditional business model since the final product represents almost the totality of the company value proposition and the basis for the pricing strategy. Services have a marginal role and often are necessary to allow the reduction of transaction costs since they can be sold and purchased effortlessly. The industrializer function is to effectively address the increasing customization needs of the demand, while preserving a high level of efficiency exploiting economies of scale, by delivering modular products and services. Indeed, according to the different combination of standard components, the offering can be aligned with the users' requests. This approach leads to several advantages, such as the reduction of transaction costs in upstream and downstream interactions. The customized integrated solution provider approach is based on an offering in which products and services are entangled in a unified solution that however allows for a satisfying level of customization. For the sake of effectiveness, actors that adopt this archetype must have a complete knowledge of their customers and technology, since they define their bargaining power with their partners. However, this complexity results in the increase of transaction costs. The platform provider is oriented towards a service-cantered business model enabled by a digital infrastructure through which solution providers and customers connect each other. This archetype is related to the opportunity to exploit idle assets and therefore to minimize wastes thanks to the optimization of the delivery process. The central position of the platform provider is also due to the amount of collected data necessary for the players in the ecosystem to increase their ability to generate value. Moreover, data can be useful to accelerate the entry in new markets and therefore to enlarge the portfolio offering and revenue streams. Thanks to the platform, transaction costs are reduced to a significant extent. The outcome provider, as the name suggests, does not deliver products and services, instead it maintains their ownership while selling the value generated by them. Therefore, the ability of the company to sell outcome-based contracts is crucial, as well as its capability to measure the outcomes themselves. This business model is highly centred on technologies, therefore a large set of ecosystem actors to bring on board the necessary knowledge. On the other hand, involving a wide set of players could increase the so-called technology uncertainty, defined as the complexity that arises from the introduction of an unknown technology in a process.

A stream of the literature has analysed the complex interconnection generated within a service network and the best practices in order to deal with them. According to Eloranta and Turunen (2016) [70], some of the key aspects are represented by the ability of the firms to leverage the interorganizational relationships, anticipate future trends, innovate the value delivery process and embrace the co-production. Starting from this assumption, it is possible to highlight that digital servitization has an impact on the three platform archetypes. Internal platforms can be affected by the introduction of digital components that can be combined in order to deliver new products and services in a faster way. For example, a set of codebases can be created and then easily deployed in different offerings according to customer requirements. The same reasoning can be applied to the industrywide where new products and services are developed externally. Finally, two-sided (multi-sided) markets can exploit the digital infrastructures to connect the sides involved in the exchange, also by reducing transaction costs. According to Kowalkowski et al (2013) [78], platform can have two different roles in connecting ecosystem participants in the context of small and medium enterprises. From an operative point of view, third parties can act as providers of complementary services to the core product offered by the platform. The second purpose is the one of the marketplace, where the company cover the role of "customer to-customer intermediary". Finally, another possible interpretation of platforms is the one of a network of opportunities where it not defined in a specific way which company is the responsible for the introduction of innovation and delivery of products and services. Therefore, it cannot be defined which is the provider of the proprietary assets, that can be different according to the solution that is necessary in the specific case. It is possible to highlight a shift from an intra-perspective to an external meaning of the way in which the customer needs are satisfied.

1.4. Platforms as ecosystems and meta-organizations

The previous chapters sections have analysed platforms as companies able to connect other firms and customers, however a subset of the literature interpretates platforms as an interconnected set of actors, including the platform itself, that collectively generate an ecosystem.

According to Kapoor et al. (2021) [79], "a platform ecosystem (PE) is an assemblage of a platform, its actors and the offerings developed on that platform", where it is possible to identify three main categories of actors:

- Platform leader, the focal firm and orchestrator of the ecosystem that determine the access and control of the platform
- External innovators, also called complementors, who exploit the resources of the platform to realize innovative goods, that represent the offering for the final customers
- Final customers, who benefit from the offerings of the two previous-mentioned players

Finally, other elements of the platform ecosystem can be represented by technical and software artifacts, content providers and advertisers (Perks, 2017 [80]; Qiu, Gopal & Hann, 2017 [81]).

One of the main advantages of platform ecosystem organization is the lower amount of costs necessary to sustain to get the same amount of revenues, respect to the traditional business models. However, this type of organization implies running specific risks related to the choice of pricing strategy and timing to enter the market. Contrary to traditional business models, that are based on the internal operative control, platform ecosystems leverage the coordination of several external sources of value to reach the final customer (Kapoor et al, 2021 [79]). In this configuration, the platform leader is not a master designer or assembler but provides a set of key components, representing a wider modular structure. Without knowing exactly what the final product will be, the platform owner provides this modular structure, on which complementors build the goods that will reach the final customer (Gawer and Cusumano, 2014 [16]). Even if leader is highly dependent on the complementors, it cannot be completely subject to their decisions, therefore the literature proposes the most important strategic decisions the platform should address to guarantee its sustainability:

- Firm scope: it is necessary to understand whether the platform leader realizes some complements in house or not, if yes which
- Technology design and intellectual property strategy: platform leader should define the degree of modularity in the platform and decide which resources have open access and which not
- External relations with complementors: how complementors can be convinced to invest in complementary innovations
- Internal organization: how the platform leader can organize in order to reduce conflicts in the ecosystem.

Starting from these considerations, the system orchestrator needs to take on board the desired firms and, once they are part of the platform ecosystem, it must be able to manage them and to exercise the so-called ecosystem leadership. This concept resumes the ability of the platform leader to manage complementors, the innovation process and the transactions that can be performed on the market. "For platform firms, it also consists in sending credible commitments to ecosystem members so that they continue to be affiliated with the platform" (Gawer, 2022 [82]). The platform leader needs to pay high attention to the competition among complementors that gives rise to a relevant trade-off. If a higher number of complementors increases the possibilities of innovation and the benefit of network effects, on the other hand, the complexity of the system increases and therefore complementors could be not willing to enter the system. Furthermore, it could be necessary to prevent the entry of other complementors, since they could represent a threat for the firms already in platform ecosystem. Finally, platform leader must which complementors provide the central components for the final products, trying to build a strong relationship and to prevent them from exploiting their strong bargaining power. The strategic development of the platform ecosystem can be realized properly only if all dynamics characterizing the actors involved are understood by the managers of the focal firm, that must be able to reach its objectives while increasing the value for the complementors. Further analysis on this topic will be carried out in the paragraph dedicated to platform governance.

Another important feature of the ecosystem is the possibility to add new opportunities for developing an international business. The platform could leverage many levers, such as internationalization, expansion of knowledge and relationships, and the creation of new revenue streams from a geographic point of view. Exploiting the internationalization tool, a member of the ecosystem can expand its geographical scope without owning any assets in another country, simply relying on the shared resources of the ecosystem, such as tangible assets, brand recognizability and the customer base. In addition, the high connectivity inside a platform ecosystem allows a member to learn from other firms and to increase the value proposition of the different parts of the ecosystem itself, building new knowledge and relationships: Finally, a company in the ecosystem can create and deliver value to a set of global customers. Indeed, a higher level of flexibility can be achieved thanks to the customer base of the ecosystem, leading to a higher number of declinations of focal value proposition (Nambisan et al, 2019 [83]).

Another perspective on platform ecosystems encompassed by the literature interprets platforms as meta-organizations or organizations of organizations. In line with this stream of researchers, platform ecosystems are considered as a combination of organizations and markets (Gawer, 2014 [31]; Kretschmer et al, 2020 [20]; McIntyre et al, 2021 [84]). According to Kretscmher et al (2020) [20], platform ecosystems "can be viewed as hybrid structures between organizations and markets, providing a mixture of market-based and hierarchical power, and a mixture of market-based and hierarchical incentives". This view of platforms ecosystems considers the platform owner as both the provider of the common set of interfaces upon which the complementors deliver innovative goods, and the market infrastructure where these products are sold by complementors to the final customers. In order to be successful, the platform can intervene by exploiting three levers to work on three main strategic dimensions.

Meta-organizational features	Strategic dimensions: Platform entry	Between-platforms competition	Within-platform competition
Sources of power and authority	Technological and/or relational hub to facilitate coordination; enables modularity and loose coupling for participant autonomy and flexibility	Architectural control of the ecosystem to capture more value	Power to influence the distribution of profits across stakeholders
Sources of motivation for participation	Incentives to attract participants under uncertainty	Incentives for users, and participants to offer high quality complements that create value in the platform ecosystem; incentives to encourage loyalty	Incentives to balance cooperation and competition with participants
Modes of governance and coordination	Use technology to lower coordination costs and enable search and matching; create technology-based trust and security	Balance rules and decision rights with openness; balance coordination and participant contributions; balance cooperation and competition with other platforms	(De)centralize decision rights to manage cooperation and competition among complementors

Figure 1.4: Meta-organizational features and strategic dimensions, Kretschemer et al (2020) [20].

Among meta-organizational features, i.e., the distinctive characteristics that differentiate platform ecosystem from traditional business model, it is possible to highlight the power and authority of the system orchestrator, the sources of motivation and participation and the modes of governance and coordination, and they can be leveraged to affect the ecosystem dynamics. The former entails the concepts of access and control of complementors and the relative advantages and disadvantages they can respectively benefit or suffer from the choices of the platform leader. The motivation considers the reasons why the third party is incentivised to belong to the platform ecosystem. Contrary to traditional business models, a transaction between two members of the platform is often able to generate value for both sides. This aspect is fundamental to get on board enough users of each group and therefore to generate network effects, allowing the platform to be sustainable and profitable over time. The governance encompasses the extent to which decision rights are allocated among users and complementors. Once explained the meta-organizational features, it is possible to describe the strategic dimensions the platform owner should pay attention to. The Platform entry is related to the entry of the platform in a market where among the competitors there are incumbents with a traditional organization form. Another important decision is the between-platform competition, i.e. how the platform manage the competition against other platforms in the same market. While the within-platform competition includes the choices related to resolution of interest conflicts between the main actors in the ecosystem. It is possible now to analyse how the meta-organizational features can affect the strategic decisions. Leveraging the power and authority lever, the platform can intervene on the flexibility of the ecosystem facilitating the interaction among complementors, can change the way in which the value is generated and how the profits are distributed among the parties. The incentives the platform can provide can help the ecosystem to disrupt the entry market by involving the targeted firms, preventing them from joining other platforms and to balance the trade-off between cooperative and competitive behaviour in the system. By regulating the strictness of the governance and coordinating the system dynamics, it is possible to reduce the transaction costs, to manage the competition and collaboration with other platforms and the autonomy of decisional actions of the actors involved.

This stream of the literature highlights the importance of strategic decisions focusing on the complementary assets and how they can be exploited to attribute a central role to the platform (Helfata & Raubitschek, 2018 [85]). Finally, platforms as meta-organizations are viewed as an alternative to firm vs market to manage the activities to realize an output. (Chen et al, 2022 [24]).

1.5. Governance

“Platform governance requires addressing tensions related to platform openness and control but also managing simultaneous collaboration and competition with complementors.” (Jovanovic et al. 2022 [86]). Therefore, among the most relevant topics in the platform governance field, it possible to mention the dynamic management of the platform openness degree over its lifecycle. The platform owner needs to get on board both the supply and demand sides, creating network effects among them in order to ensure the sustainability of the platform. According to Jovanovic et al, (2022 [86]), the process should start from the supply-side by proposing the platform to the involved actors and providing them with incentives consistent with their strategic priorities. The aim of these actions is the extension of the value chain, building a favourable environment to collect the players belonging to the demand side, that, on the other hand, can foster the value system expansion of the platform. The last lever a platform owner can exploit to increase expand the ecosystem is represented by the level of openness of the interfaces. A higher level of interfaces interoperability allows the creation of an open marketplace, where complementors can develop and deliver value-adding products and services.

Chen et al. (2022) [24] defines platform governance and design as "strategies developed and implemented by platform owner firms to create and appropriate value." This set of rules implemented by the platform owner should focus on the limitation of market frictions and on the deployment of co-specialized supply-side capabilities (Boudreau and Hagiu, 2008 [87]). However, the platform owner can maintain its leading role leveraging the exclusive ownership of the enabling assets necessary for the creation of the ecosystem value. Therefore, it has the power to decide which actors to involve and to which extent. Complementary to this capability of regulating the access of external players, the platform owner should address the issue of managing the control, namely "the right to determine the rules guiding a platform's usage and technical trajectory" (Chen et al. 2021 [76]), over the participants in the ecosystem. Indeed, the higher the level of openness the higher the risk for the platform owner to lose its leading role, whereas the increasing level of control can lead to a lower ability of complementors to develop innovation leveraging network externalities (Boudreau, 2010 [88]). A strongly open strategy can lead to "permissionless innovation" (Parker and Van Alstyne, 2014 [89]), in which complementors provide value to the platform without bargaining with the focal firm. The risk for complementors is the appropriation of the innovation by the platform owner, which can provide complementors with contracts guaranteeing longer time without competition. According to Shapiro and Varian (1999) [90] and West (2003) [91] this dynamic generates a trade-off between the concept of adoption, characterized by more openness, and appropriation, where the platform leader exerts more control. In addition, an open platform governance could lead to an excessive complementors freedom in customizing their products, increasing the complexity of the market and the costs necessary to realize the products themselves. Under certain circumstances, these costs can deter third parties from entering the market, reducing therefore the indirect network effects that are often positively correlated to a high number of complementors in the platform (Cennamo and Santalo, 2013 [21]).

Beyond the innovation process, platform governance can have an impact in terms of welfare and revenue generation dynamics. Focusing on two-sided (multi-sided) markets, the number of transactions and therefore the economic benefit of the of the system orchestrator. According to Cremer, de Montjoye and Schweitzer (2019) [92], "Platforms impose rules and institutions that reach beyond the pure matching service and shape the functioning of the marketplace and, potentially, the relationship between the various platform sides, e.g. by regulating access to and exclusion from the platform, by regulating the way in which sellers can present their offers, the data and APIs they can access, setting up grading systems, regulating access to information that is generated on the platform, imposing minimum standards... Such rule-setting and 'market design' determine the way in which competition takes place [on a platform]." This definition allows to highlight the crucial role of platform governance in two-sided (multi-sided) markets, affecting their dynamic and therefore the welfare of agents involved in the system. According to Teh (2022) [93], the proprietary platform can decide to maximize the total welfare of the systems or to increase its profit as much as possible. In fact, the platform can steer from the achievement of total maximum welfare, in favour of its profit maximization, by setting rules that affect the total amount of transactions and the competition among sellers in the market. This action could lead to a higher reduction in complementors welfare than the increase of platform owner one. Therefore, the trade-off is between the profitability and the sustainability of the platform.

The actors involved in the ecosystem can interact with the platform at different level of participation. At the lowest degree of intensity, external firms have a minimal engagement with the platform, whereas the medium and high levels of participation are characterized by businesses that provide the platform with technical contributions and leadership assistance respectively. Furthermore, the behaviour of complementors can be either opportunistic or cooperative according to their usage of platform's proprietary assets. In the first scenario the external company exploits these resources to generate value for itself, without apporting any additional contribution to the achievement of the platform strategic objectives. On the other hand, a cooperative behaviour makes the entire ecosystem benefit from the derivative products and services built on the proprietary assets. According to O'Mahony and Karp (2020) [94], by intersecting the level of participation and the behaviour of third parties, it is possible to highlight six possible strategies that complementors can implement to contribute to platform strategy:

- Observing (cooperative-low)
- Integrating (cooperative-medium)
- Expanding (cooperative-high)
- Front-running (opportunistic-low)
- Selling-up (opportunistic-medium)
- Redirecting (opportunistic-high)

As its name suggests, companies that adopt the first strategy neither directly contribute nor freeride the proprietary assets of the platform, with a minimum level of engagement. The integrating strategy entails third companies that realize products and services aligned with platform strategy, but without contributing to the expansion of platform complementary assets and therefore to any form of innovation. Differently from the previous one, the expanding approach leverage the higher participation intensity in order to develop an innovative stream of goods able to widen the generation of value across industries. This strategy enhances the achievement of platform owner strategic objectives, that overlap with the ones of complementors. In the front-running case, participants exploit platform resources to reach their own goals without sharing any generated value and therefore without contributing to the success of any other actor involved in the ecosystem. In the selling-up strategy, complementors leverage on the platform proprietary assets marginally contributing to the platform development and focusing on differentiating their own products and services from the others. Finally, in the redirecting approach, companies can provide innovation to a limited extent, maintaining however an opportunistic behaviour.

From a platform user perspective, the third party can decide whether to belong only to a platform or not, to look for needed goods or to build its products and services basing exploiting different platforms. In the first scenario, the agent is defined as single-homing, while in the latter case, is named as multi-homing. Focusing on complementors, the platform owner has a strong bargaining power on the single-homing ones since the customers of the third party coincide with the ones of the system orchestrator. Therefore, it is important for the platform owner to involve single-homing complementors in order to have favourable economic conditions toward each of them. In the case of multi-homing complementors, the platform can exert a limited bargaining power considering that third parties have a wider set of customers than the single-homing ones and therefore can freely decide to leave the ecosystem.

Focusing on the two-sided markets, as suggested by Armstrong (2006) [28], it is possible to consider three cases according to the single-homing or multi-homing nature of the two sides involved, "(i) both groups single-home; (ii) one group single-homes while the other multi-homes, and (iii) both groups multi-home." If the target of a side is to join the platform to interact with the other one, the third case is the less probable. Indeed, if every member of a group is on a platform, there is no need for the other side to join many platforms. Case (ii) is often defined as competitive bottlenecks, since if multi-homing users want to reach the single-homing ones, they need to join on that specific platform. The peculiarity of this scenario is the ability of platform owner to exercise bargaining power even over the multi-homing users, and therefore charging them with higher prices. Finally, the case (i) is the most favourable scenario for the platform ceteris paribus. Indeed, system orchestrator has bargaining power over both the types of users and therefore it can obtain economic advantages from both.

1.6. Pricing and competition

The competitive landscape in which platforms operate is mainly characterized by frictions among different actors involved that can lead to different dynamics, entangled by the presence of network effects. In economic models, platform competition is pushed by consumers' adoption of the platform itself. Since the value of the platform stands mainly in its ability to efficiently connect the two (or more) different sides interfacing, the principal question becomes how to bring them on board (Evans, 2003 [49]; Rochet and Tirole, 2006 [46]). In order to do so, platforms have to understand where to start and how to solve the "chicken-or-egg problem", already described in the previous paragraph (Caillaud and Jullien, 2003 [95]). The crucial point stands therefore in understanding which side to bring first in a way in which is convenient for the other to access the platform. The quicker and easiest way to address this issue and get on board the critical mass is subsidizing the side of the market more necessary in order to attract the other one and solve the coordination problem (Parker and Van Alstyne, 2005 [51]). The research stream beyond platform competition moves around four main conceptual themes (Rietveld and Shilling, 2021 [96]):

- Network effects
- Corporate scope
- Platform heterogeneity
- Platform governance

Network externalities are strictly related to the adoption rate of the platform in the sense that the more the network effects can be captured by the different market sides, the more the returns to adoption increase. The growing rate of adoption is also linked to learning curve effects (i.e. products quality and production efficiency increase while increasing the units processed) and to the quality and availability of complementors, especially in those industries where product compatibility is important. A key pattern discovered by researchers is that not always the best-in-class technology win in the market (Arthur, 1989 [97]; David, 1985 [98]; Katz and Shapiro, 1985 [2]). An inferior technology in terms of technological standards can anyway be disruptive in the market due to network effects and its adoption timing.

If critical mass is reached and network effects are strong, it is difficult for customers to switch to another technology even though it can be considered as more performant (Schilling, 1998 [99]; Suarez, 2004 [100]). Furthermore, increasing the return to adoption can generate the "winner-takes-all" dynamic, i.e. when just one or few players in the market exert consistent power thanks to the exploitation of the network effect generated by the platform itself. Therefore, attracting complementors becomes crucial in order to enhance the abovementioned impact and attract in turn more customers. This way of operating changes the business scope of companies, oriented towards the creation of an actual business ecosystem in which symbiotic relationships between firms are the connection point (Ceccagnoli et al., 2012 [15]; Ghazawneh and Henfridsson, 2013 [43]; Tiwana, 2015 [101]). There are different ways in which a platform can create an ecosystem along with its complementors: subsidize them, collaborate with them, or produce complementary products itself. These different strategies can be implemented according to the life cycle of the platform and can be changed over time. The second point is the corporate scope and, according to Gawer (2021) [58], "all firms (whether they be traditional or digital, platform or non-platform) have a scope that they make decisions upon deciding what assets, activities, and resources they will own and what kind of labour they will employ". The third theme is related to platform heterogeneity, i.e. the differences in the characteristics and typologies of actors involved in the ecosystem dynamics, ranging from complementors to final users with their specific needs. According to Eisenmann et al (2011) [56], platform competition and heterogeneity can modify the scope of platform and therefore the way in which it reaches the customer. Finally, platform governance was already deeply explained in the previous paragraph.

Starting from the previously described themes, it can be highlighted the need of platforms to reach as fast as possible a high number of users. In order to do that, the platform should focus on several levers to win the competition in the market, and one of the most important aspects is represented by the pricing strategy. Considering a two-sided market, according to Evans, 2003 [49], the platform has the objective to combine the two demand curves, which depend on the "quality-adjusted quantity" purchased by the other agents. Furthermore, the platform must sustain two different typologies of costs to provide the service for each side. Some costs are fixed, such as the resources necessary to build and maintain the technological infrastructure, while other have a variable nature. They depend both on the number of transactions on the platform and their characteristics. The price a platform should charge to a side in order to be involved in the ecosystem depends on the elasticity of the demand of the side itself to join the platform, how the other side will react to the changes in the number of players in the first side caused by the chosen price and the variable costs sustained to connect the sides. According to Armstrong (2006) [28], “to be able to compete effectively on one side of the market, a platform needs to perform well on the other side (and vice versa)”. Starting therefore from the hypothesis of a model in which the demand of a side is an increasing function of the demand of the other side, Parker and Van Alstyne (2005) [51] demonstrate a series of results. First, if the indirect network effects are higher in one direction than in the other, the platform will charge with a higher price the side which is more dependent on the number of players in the other. Hence, it is possible to highlight that if a platform is able to build strong network externalities between the types of actors, it will benefit from a higher profitability. In order to reach the critical mass, a platform can exploit the indirect network externalities between the players. In particular, if sides a is strongly reliant on the number of users on side b, the platform can charge low prices to the latter and consequently involve the former. The previous prices can be lowered until a point where they can reach negative values. In the related literature, this phenomenon is called subsidization. Another important choice a platform must address is the adoption of fixed or per-transactions fees. The former imply that the users pay a fixed amount independently from the number or the total value of the transactions performed. The latter encompasses the payment of a fee that is often proportional to one of the two previous elements. The main difference between the two strategies lies in the fact that “cross-group externalities are weaker with per-transaction charges, since a fraction of the benefit of interacting with an extra agent on the other side is eroded by the extra payment incurred” (Armstrong, 2006 [28]). In the case of per-transaction fees, if the exchange does not take place, the user must not pay any sum to the platform, therefore the consumer is shielded against a not successful engagement strategy of the platform itself. Instead, if the platform is able to connect effectively the two-sides, this approach is often the most profitable. Succeeding in the market competition allows the platform to increase the number of users and therefore the set of needs that must be satisfied. In order to do so, the platform should enlarge the offering of products and services and consequently reaching benefits from a wider set of possibilities in the allocation of joint costs, i.e. those costs not directly attributable to a single item. Leveraging these advantages, the platform could adopt an aggressive pricing strategy in order to jeopardize competitors and therefore attracting the interest of the antitrust authority. Finally, the pricing strategy and the indirect network effects can result in the increase of lock-in effects and therefore higher switching costs for platform users. The lock-in effect arises if a user keeps on relying on the current technology, even if he or she would individually benefit from the adoption a new one, exclusively because of network effects generated by the high number of its users. Finally, switching costs can be defined as the costs a user has to sustain if he or she decides to adopt a new asset. Platforms can enter one or more markets, and therefore they must compete with other platforms in the same sectors. A multihoming user, i.e., a consumer who relies on more than a platform for the same service, prevents the platform itself from charging him or her with a high price because of the existence of potential substitutes (Rochet and Tirole, 2003 [29]). On the other hand, single-homing consumers represent an opportunity for the platform to exploit its bargaining power facilitating profitable transaction. Independently from the type of consumers, platforms in multi sided markets have to sustain consistent fixed costs to build up the required structure to launch the platform itself. Indeed, benefits arising from network externalities can be limited considering the effort needed to internalize them acting as an intermediary between users. Hence, multi sided markets usually see few companies competing for the same customers' target. This dynamic could undermine the effective generation of social welfare through a perfect competition market structure, and therefore leaves room for government intervention (Evans, 2003 [48]).

Considering the digital nature of the majority of today's markets, it is also necessary to focus on platform competition in this specific context. According to Cennamo (2023) [25], "embracing the information and connectivity properties of the digital, digital markets emerge around and because of a central platform connecting multiple product offerings from external, independent firms to provide customers with integrated service solutions". Therefore, a consequence of digitalization is the redefinition of market boundaries and the opening of the competitive arena. The competition in digital markets does not provide for a predefined set of actors, but the competitors involved can change dynamically by entering in and exiting from the market. Furthermore, the competition is not a zero-sum game (Priem, 2007 [102]) anymore since the value to be shared is not a constant but can increase thanks to the introduction of innovation in the ecosystem. The possible outcomes of platform competition can be encompassed in two main logics, namely winner-take-all and platform distinctiveness. The former result is based on the platform size and the achievement of the critical mass of users. This milestone guarantees a strong network externality intensity, that implies a strong users' attachment to the platform and the generation of a higher quantity of contents able to satisfy customers' requirements. Consequently, strong lock-in effects take place disincentivizing the migration of users from the platform to another. Therefore, the platform with the biggest size is the one that wins the market. From a managerial perspective, two main aspects must be considered, namely the chicken-and-egg problem and the administration of a wide network. The winner of the competition is one that is able to impose the dominant design, that is the set of technological features that become a de facto standard and even if the performance is not necessarily the best, it is the most adopted framework in the market (Utterback and Abernathy, 1975 [103]). The platform distinctiveness logic is based on the platform identity concept; therefore, a platform does not aim to attract all sort of customers, but it wants to differentiate from the other platforms through a predefined positioning strategy. The platform could even decide not to let enter some users in the market, if they are not considered in line with platform identity. This strategy can lead to higher sunk costs since it entails platform-specific investments oriented toward the complementors in order to strengthen the relationship. In some cases, the platform can even decide to apply screening mechanisms to verify the alignment of complementors with its own fundamentals. The strict relationship with the complementors constrain the innovation to be path dependent and makes more difficult for the platform to replicate competitors' behaviours. Therefore, the distinctiveness logic leads the specialization of a platform in a specific sector and can be also achieved by providing contents that are not present on the other platforms (Cennamo, 2023 [25]).

1.7. Platform scalability

Business model scalability is defined as "the extent to which a business model design may achieve its desired value creation and capture targets when user/customer numbers increase and their needs change, without adding proportionate extra resources" (Zhang et al, 2015 [104]). Therefore, a scalable business model is able to increase its outputs and profitability without sustaining consistent additional costs and preserving the quality of its offering with a rising number of users.

According to Arthur (1989) [97], there are four main factors behind the scalability of a platform business model, i.e, network externalities, production economies, informational increasing returns and technological interrelatedness. Focusing on the first aspect, network externalities can foster the enlargement of the user base of a specific business whatever they are direct or indirect. Indeed, both typologies of the effect generate a growth in the number of customers which is more than proportional to the already existing customer base, if sufficiently large. The ability of a company to develop a business model characterized by network effects could facilitate the company in reaching a large number of users, but it is not necessarily able to ensure an efficient deployment of resources to manage the increasing demand. The production economies are highly related to the previous topic, indeed a company, able to reduce the costs necessary to produce and distribute the output requested by the customer when the quantity required increases, benefits from the efficiency needed to achieve high levels of scalability. This feature can be reached, for example, if the costs sustained by the company are mainly fixed, and the marginal costs are negligible (Chandler, 1990 [105]). The third characteristic able to improve the scalability of a business model is represented by the increasing informational return. According to Arthur (1989) [97], a product or a service is perceived as less risky the higher the number of users which adopt it. Thanks also to diffusion of digital technologies, customers trust toward a good can be improved by the word-of-mouth and by positive reviews of other users which have tried it before. The last feature, I.e. the technological interrelatedness, provides for a technology, if it is adopted by a large number of users, attract actors who build derived goods generating a business ecosystem.

According to Zhang et al. (2015) [104], three main aspects of a business model are related to the scalability level of the firm. The first one is represented by the customer identification, focusing on the distinction between the set of paying and non-paying users. Indeed, according to the choice of targeting only a typology or both, the value delivery system implemented by the firm could be different. Freemium model is currently adopted by several businesses, and it provides a group of users which do not pay for the service while the other one guarantees the economic sustainability of the firm. The second aspect linked to the scalability is the customer engagement, which, in this context, is represented by the level of customization given to the user. In fact, a high level of customization could reduce the business model scalability since exploited resources to satisfy the customer needs could not be implemented in an efficient way. The third characteristic of a business model which can have an effect on its scalability is embodied by value chain linkages, which are related to methods exploited by the company to deliver the goods to the customers.

Based on the different literature stream related to business model scalability, it is possible to identify five main ways to manage and increase the ability for a company to scale up:

- Adding differentiated distribution channels, as long as they do not cannibalize existing revenue streams, can be a useful tool for companies in order to generate value by leveraging already deployed resources and therefore distributing costs among all channels

- Implementing disruptive technologies to overcome capacity constraints can facilitate firms to make their processes more efficient, creating opportunities for scaling up the business
- Leveraging the capabilities of partners, or of the ecosystem in the case of platforms, allows enterprises to partially internalize third parties generated value and, building on that, increasing the range of offerings toward customers
- Implementing a suitable business model based on collaboration, such as platforms, can facilitate companies to achieve higher levels of scalability

Firms which adopt a digital business can often reach high level pf scalability, allowing even companies in the early growth stage to win the competition in several markets. The high dematerialization of the processes enables companies with similar business models to benefit from economies of scale since the costs sustained are often fixed and concentrated in the first stages of their activity. This allows the firms to have low marginal costs and therefore to enlarge their user base without deploying additional resources. Moreover, companies can expand in other geographical markets almost without any effort and they can also enlarge their value proposition as long as they offer digital goods. The digital business is not sufficient to guarantee a high level of scalability, in fact managers are necessary to organize the resources of the firms with the aim of achieving high level of scalability (Zhang et al, 2015 [104]). Indeed, these businesses should invest in processes which are able to generate increasing return with the higher number of users, even when the firm is not profitable yet.

The platform business model and in particular its digital features can facilitate companies to scale up their scope and size since they already exploit network externalities. Moreover, according to the level of dematerialization of the processes, the customer base and the value generation can be respectively increased and enhanced by incurring different amounts of marginal costs and therefore achieving different levels of scalability.

1.8. Emerging industries

Alongside traditional industries, the economic landscape is characterized by the presence of emerging industries often associated with innovation, creativity and entrepreneurial development that are fundamental for the economic growth (Feldman and Lendel, 2010 [106]; Tanner, 2014 [107]) and for a transition to sustainability (Binz and Truffer, 2017 [108]; Trippl et al, 2020 [109]).

The definition of emerging industry is not unique, and can be explained from different points of view, namely the life-cycle approach, the evolutionary economic geography approach and the systemic approach. According to the former, emerging industries are industries in the earliest stage of development. A similar definition is given by Phaal et al. (2011) [110], who states that industry emergence is represented by the first phases of an industry, characterized by a small population, the lack of a dominant design and product architecture and product innovation is common (Forbes and Kirsch, 2011 [111]; Phaal et al, 2011 [110]). During the emergence of industry, there are three main phases:

- The initial phase in which the context for the emergent industry is created
- The co-evolutionary stage in which different elements and actors start to evolve and to collaborate
- The growth stage in which the transactions regarding product and services start to increase (Gustafsson et al, 2016 [112])

Another meaning of emerging industries is highlighted by Porter, who emphasizes the driving forces making possible the realization of a new industry. According to him, emerging industries are "newly formed or re-formed industries that have been created by technological innovations, shifts in relative cost relationships, emergence of new consumer needs, or other economic and sociological changes that elevate a new product or service to the level of a potentially viable business opportunity." (Porter, 1980 [113]). There are several ways according to which an emerging industry can appear, one of them is the so-called path creation, that is an intentional deviation from pre-existing infrastructures to generate from scratch new frameworks of applications (Garud and Karnoe, 2001 [114]). Another possibility is represented by radical innovations (Baumgartinger-Seiringer et al, 2021 [115]; Miörner and Trippl, 2019 [116]) and recombination activities in existing industries (Frenken et al, 2007 [117]). The previous possibilities are technology-oriented, however it is possible to additional driving forces that allow the establishment of a new industry, such as market dynamics, changes in the needs of customers and institutional roles. The forces that cause an evolution from one phase to another can be technological, knowledge-oriented or firm-based learning and innovation patterns, even geographical aggregation and industrial specialization are driving forces. According to the evolutionary economic geography, the probability that an emerging industry can be born, it is affected by the industrial ecosystem existing before the industry itself and the knowledge in that specific sector. The regional branching theory explains that an industry is more likely to take place in countries or regions where the pertaining competences are already present, consistently with the principle of relatedness. Institutions can play a significant role in supporting the development of emerging industries providing knowledge and other enabling factors. In the related literature it is addressed the phenomenon of the so called "institutional hysteresis", that represents the macro-level feature that sets the "path-depended trajectory" that regional industries follow when they emerge (Gong et al, 2022 [118]). Systematic approach is based on the assumption that the already existing industrial presence in a specific region is a necessary condition, but not sufficient, to allow the development of an emerging industry. Indeed, the third approach highlights the role of firms belonging to the emerging industry in creating a new path rather than following the consequent steps defined by the already existing system. Since companies do not follow a path-dependent trajectory, they need to coordinate and collaborate in order to create a profitable environment without the guidelines of institutions.

New industries can be generated by the entry of two different types of firms, the de alio and de novo. De alio companies are the ones which already operate in existing industries and decide to enter in new ones, whereas de novo businesses are those that start their economic activities directly in a novel context. Therefore, de alio enterprises are already existing companies, while de novo ones are a novelty from the industry and company point of view, and for this reason they are interesting for the entrepreneurial literature. It is important to highlight that in emerging industries, even if de novo firms are more likely to enter than de alio ones, the latter are often more successful than the former (Forbs and Kirsch, 2011 [111]). This evidence can be explained by the fact that de alio companies, thanks to their resources, can obtain a competitive advantage over the de novo firms. In particular, the former can rely on a developed productive capacity and their brand awareness, which can in turn provide the company with strong bargaining power over suppliers and attract the already existing customer base. However, these businesses could have some industry-specific investments that prevent them from entering new markets. While de novo firms have more flexibility in the deployment of assets and therefore in which industry to enter. This distinction on a firm level can be extended to an industry context. According to Yun et al. (2019) [119], new industries can be either emerging in the strictest sense or converted. In the second case, the new market is derived from already existing one thanks to technologies development and the evolution of customers' needs. The first case represents instead a completely new scenario since it does not have any relationship with consolidated industries, and it is able to address consumers' needs that were not satisfied nor defined yet.

New industries can emerge thanks to technology-push and market-pull innovations. The former entails the existence of a new technology that however is not at the base of any industry, while in the latter the new customer needs are explicated and current technologies are deployed to satisfy them. Technology-push strategy is often associated with start-ups and small firms which try to bring high level of innovation to the market. On the other hand, big companies are more likely to follow market-pull paths since they are less risky and can be easily built on the already owned resources. Finally, a way that incumbents can follow to implement the first strategy is by acquiring small firms which have developed technology-driven innovation.

	Market-pull		Technology-push	
	Established firm	Start-up	Established firm	Start-up
Market factors	Market demand relatively well known/predictable Market recognition and acceptance is rapid Readily adaptable to the firm's existing marketing, sales and distribution policies	Market demand assumed or interpreted by entrepreneur Market recognition more rapid than technology-push companies More readily adaptable to existing market infrastructure due to entrepreneurial experience	Potentially large but unpredictable demand Significant risk of failure Market acceptance may be slow Imitation may be slow May require unique distribution and sales policies including customer education May cut across existing traditional market segments, responsibilities and products	Potentially unrealistic market assumptions Significant risk of failure Longer time to market Potentially high ROI and market penetration Potentially disruptive to other firms' existing market infrastructure Will likely cut across existing market segments and value chains
Production-technology factors	Affords use of existing facilities, processes and value chain position Designs can usually be made consistent product lines Cost reduction through streamlined design, production rationalization and increased scale economies Presents minimal manufacturing, product quality and product liability risks	Little or no existing facilities, therefore nothing internal to interrupt Developing technology, high start-up costs and production uncertainties Introduces large uncertainties in manufactured operations	Makes existing labour, manufacturing and value chain obsolete and requires investment in new ones May undermine existing product standardization and modularization Unfamiliar technology, high start-up costs and production uncertainties Introduces large uncertainties in manufactured operations	Little or no existing facilities, therefore nothing internal to interrupt Developing technology, high start-up costs and production uncertainties Introduces large uncertainties in manufactured operations in the focal firm and often partner/customer firms

Figure 1.5: Market-pull and technology-push strategies, Lubik et al (2012) [120].

In the Figure 1.5, a comparison about how the market-pull and technology-push strategies are deployed by established firms and startups is performed, where the former can be associated to de alio companies, while the latter are similar to de novo enterprises. Strating from the market-pull strategy, it can provide several advantages to both the firms, such as the faster understanding of the customer needs and the higher adaptability of the innovation to firms' activities and market infrastructure. However, the established firms already know their demand, while the start-ups must be able to sense what is required by the users. The differences between the incumbent and the new entrant are more evident in production technology factors. The former can leverage their already existing assets and their position in the supply chain, while the latter must build them from scratch. Focusing on the technology-push innovation, the understanding of the market is more difficult for both the established firm and the startup, as well as the risks associated to a bad comprehension of customer requirements. On the other hand, if the intuition is correct both firms, especially startups, can obtain significant economic returns and win the market. The technology production assets of the established firm might need to be substituted and therefore creating uncertainties in the already consolidated production process. Startups, instead, can organize the value creation process from the ground up and therefore they can choose the best way to implement it; however, the uncertainty about the ability to design a profitable business model could increase.

Innovations can be also classified as incremental or radical according to the increase in the level of performance they provide. The former deliver a relatively small improvement, while the latter allows to bring the performance to a new level. The incremental approach is a safer strategy since the innovative product is obtained by slightly modifying the current one. Therefore, the company can rely on the fact that its offering will remain successful after the improvements. On the other hand, radical innovations could entail a complete change in the product architecture. The main risk is related to the readiness of the customers for the new offering, which sometimes could represent a disruptive innovation able to wipe out competitors from the market. This type of strategy requires a "probe and learn" process and therefore the collaboration of upper management and the overcome of organizational inertia (Hayes and Wheelwright, 1984 [121]). It is also necessary to satisfy customer needs, to have enough productive capacity and a reliable network of distributors to make the final user try out the product and therefore to understand if it can be successful (Maine and Garnsey, 2006 [122]). Emerging industries are usually associated with radical innovations thanks to their ability to generate from the beginning new ways to implement business models and their capability to destroy and replace current value chains, forcing the origination of new markets where uncovered needs can be satisfied. Another perspective of disruptive technologies sustains that they "may not completely destroy an existing value structure but may completely reorganize relationships and markets, displacing some components and requiring new ones. From this reorganization, firms can often find new uses for old capabilities or match old capabilities to newly discovered market needs" (Lubik et al, 2012 [120]). In this case emerging industries are not seen as a destroyer of value chains but rather as a reorganizer of the existing current mechanism implemented in consolidated industries.

In order to become established markets emerging industries need to be supported not only by private investors, but even by the government, and subsidies are among the most powerful tools owned by public agents. The public sector could benefit from the development of an emerging industry thanks to the high level of innovation that it can bring and the consequent increase in the competitiveness of the countries in which the new market arises. After having described the motivations for a region to foster the creation of an emerging industry, it is possible to highlight how subsidies can be exploited to reach this objective. The first distinction about this tool is represented by the side of the market the government wants to target and therefore to sustain, resulting in either customers or companies' subsidies (Lin and Jiang, 2011 [123]). The former are oriented to the demand-side of the market and aim to increase the product penetration, while the latter are supply-side instruments, with the aim to allow companies to reach more efficient production processes. According to Mowery and Rosenberg (1979) [124], the demand is a strong driver for innovation, however customer demand is often affected by lock-in effects that prevent customers from changing technology and therefore introduce uncertainty about the success of a new one (Hoeffler et al, 2006 [125]). The advantages of consumer subsidies are the possibility to defend innovative products from the competitiveness of the traditional ones, and to signal their quality, incentivizing the customers to buy them and to foster innovation. Companies' subsidies are designed to prevent the market failure and incentivize the supply-side to coordinate among themselves in order to deliver innovative goods. These types of products usually need some time and investments before becoming competitive; however, the proper amount of resources is rarely deployed in time due to the risk of spillovers. Companies' subsidies can reduce the costs arising from the spillover effect and therefore incentivize firms to invest in innovation. The impact of customer subsidies can be higher than the effect of companies' ones in increasing the number of early adopters, especially for costly and less mature technologies. The upfront price strategy is the most effective to raise the number of the new technology users, while policies that take into account consumers income and the purchase location can increase the social welfare by the highest quantity (Bjerkan et al, 2016 [126]). Companies' subsidies represent a way to accelerate the R&D of new technologies, however, according to a stream of the literature, they could lead to opportunistic behaviour of the firms. Specifically, they could modify their operations to reach required values of specific parameters, and therefore obtain the subsidy without however being able to exploit it for the designed objective. In order to avoid these inefficiencies, a third party could be necessary to verify the ability of the businesses and a project-mode could be implemented (Sun et al, 2019 [127]). According to this specific framework, companies are granted with a certain amount at the beginning of the project and will continue to receive resources only if they are able to reach fixed goals over time, otherwise the government can decide to stop the subsidy.Literature gap

2 Empirical context

In the following chapter, a comprehensive analysis about the empirical context of the research, i.e. the new space economy, is provided to give a better understanding of the scenario in which platforms are contextualized. The focus of the chapter is on the new space economy that differs from the traditional one for a series of reasons. New space economy encompasses a set of actors whose nature can be different from the ones in the traditional space industry, as well as the activities performed which can rely on advanced technologies and business strategies. The following sections address the development of the new space industry and the actors involved, highlighting the evolution of the value capture mechanism and the value generation process, both in Europe and US. Finally, an overview of the information systems applied to the new space economy is provided to introduce the opportunities for the platform business model within this emerging industry.

2.1. The evolution of the space economy

Even if the space industry was born on 4 October 1947, when Soviet Union launched Sputnik 1, and it was mainly related to the space race, today, the space activities' range of scope has significantly widened. If the early stages of space economy were mainly oriented to space exploration and the launch of scientific and commercial satellites, the most recent phase is characterized by a shift from the previous mentioned activities to completely new ones, such as asteroid mining, space tourism and data analysis and management. This phenomenon is related to an increasing presence of startups and private investments in the industry, which was once characterized by the proprietary presence of governments. Therefore, it is possible to distinguish two different stages in the industry, namely the traditional and the new space economy.

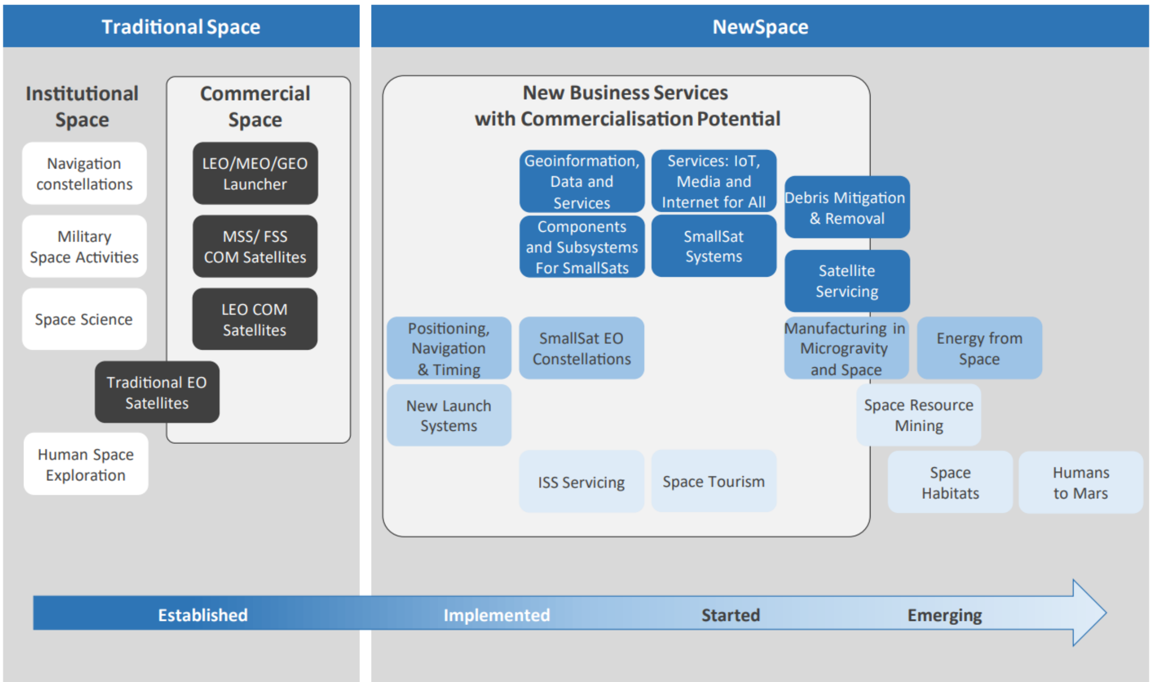

Figure 2.1: Business activities in the traditional and new space economy, European Investment Bank (2019) [128].

Focusing on the new space economy, it is possible to analyse its developments over time taking into account the industry lifecycle framework provided by Porter (1980) [113]. This model provides for four different phases along which an industry evolves starting from its introduction, passing through its growth and maturity, and reaching its decline. During the first phase, characterized by a lack of knowledge about the product's features and performance, the market size is limited as well as the customer demand and revenues. Over the growth stage, customer awareness about the product increases and the first complementary products and services start to appear on the market, leading to the soar of revenues and attracting significative investments. The maturity phase is characterized by the establishment of the industry and the achievement of the market's largest size. Revenues continue to grow, although at a slower pace compared to the previous stage. Finally, the last stage is characterized by the lack of new investment, for example due to the presence of substitute products, and the profitability of the sector starts decreasing in a relevant way. A stream of the literature identifies an additional stage that can be achieved after the maturity and can avoid the reaching of the decline phase. Leveraging technological innovation or value proposition shifts the industry can indeed prevent a contraction in revenue growth by moving again in a new paradigm within the market boundaries and restart its lifecycle from the beginning.

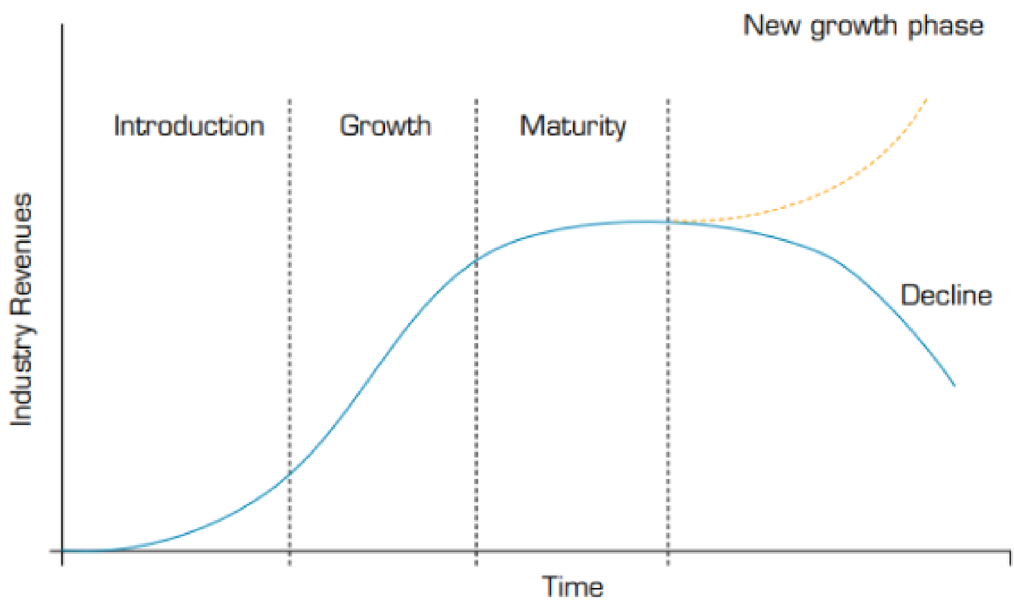

Figure 2.2: Industry lifecycle, adaptation from Porter (1980) [113].

It is important to highlight that new space economy is not a completely new industry, but it derives from the entry of private agents in the traditional space economy, a sector where almost the totality of investments was public. As previously highlighted, the introduction stage of the new space economy is represented by a shift in the proportion between public and private fundings. Nowadays, this industry is considered to be in the growth stage for different reasons. Indeed, the size of the market is still growing at a relevant pace - from $370 billion in 2021 to an estimate of $641.2 billion in 2030 (Space Economy Report – Euroconsult [129]) and the amount of funds invested is increasing, attracting a wider range of players. According to the Space Foundation [130], the turnover of the global space economy in 2021 is set at $469.3 billion, almost $100 billion more if compared with data from the Space Economy Report. The reason behind this difference lies in the fact that the Space Economy Report mainly focuses on the direct impact of space activities in the industry, whereas the Space Foundation attributes a broader connotation of the space economy and therefore includes second order impacts generated by the industry, i.e. advantages indirectly benefited by related markets.

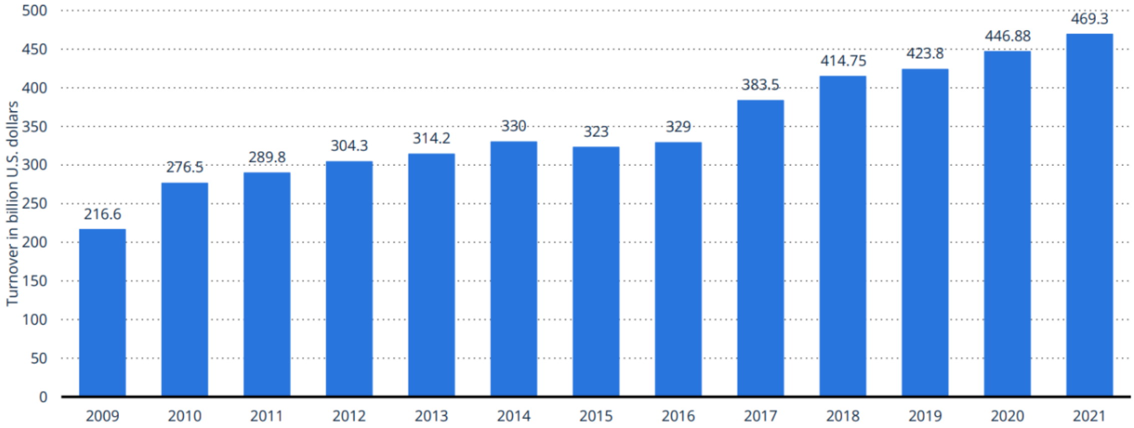

Figure 2.3: Global turnover of the space economy 2009-2021, Space Foundation [130].

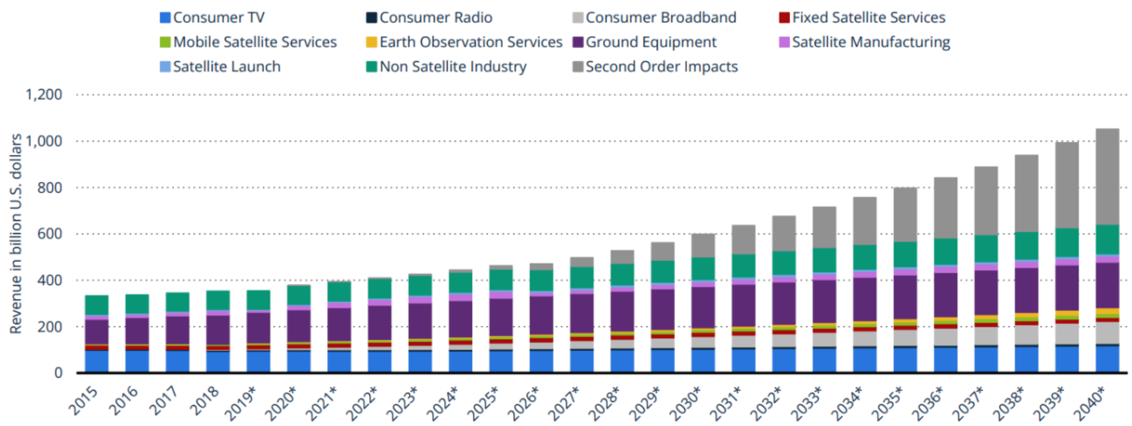

Figure 2.4: Global space economy revenue 2015- 2040 by segment, Haver Analytics.

Looking at the Figure 2.4, it is possible to highlight the upward trend of the space economy revenues broken down by application industries. The growth is mainly due to the increase of second order impacts and consumer broadband, which is necessary to satisfy requirements of consumer applications efficiently and effectively.

Thanks to its origin from the traditional space economy, the new space economy benefits from several characteristics belonging to an industry that is in the maturity phase, such as a high customer awareness and a wide range of complementary products and services. This is made possible because reusable space launcher systems and other technological shifts, such as digitalization, miniaturization, artificial intelligence, 3D printing, and advanced materials, are reducing the cost of accessing and using space. The public sector has a strong role to play in stimulating market demand and technology uptake by promoting more favourable policies and regulatory frameworks.

Another evidence that the space economy is currently in the growth stage is the increasing amount of investments that the industry is benefiting, especially from the increasing contribution of private funding. According to the Figure 2.5, private investments reached $5.7 billion mainly coming from business angels, specialized venture capital funds and private equity firms.

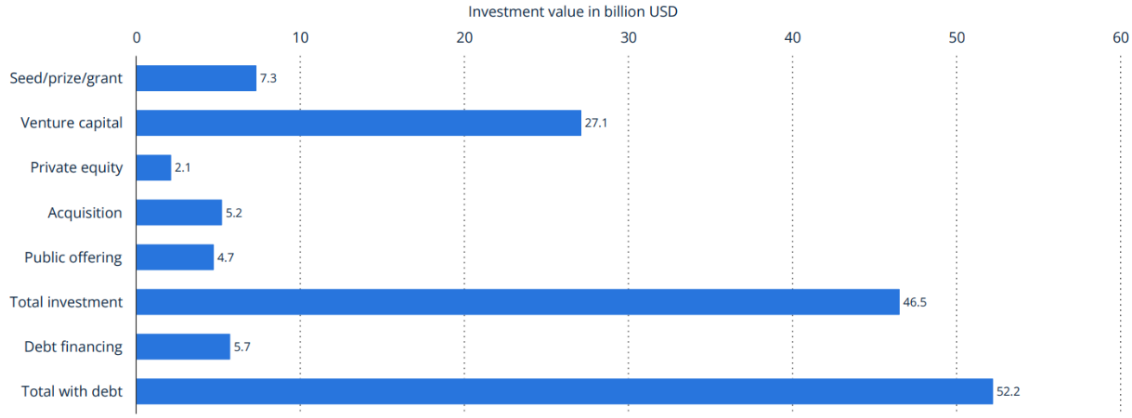

Figure 2.5: Value of investments in space ventures worldwide 2020-2021, Bryce Space and Technology.

Among the sources of fundings for start-ups in the new space economy, in addition to the previously mentioned typologies of private investors, governments and large aerospace and defence firms can have a key role. The latter are incumbents which created their own venture capital funds in order to invest in specific companies both to enlarge their investments portfolio and to obtain the know-how in technologies, such as artificial intelligence, sensors and autonomous vehicles, that are crucial for the improvement of their own performances. This allows an increasing number of small commercial satellites launches, necessary to perform a wide range of activities, such as earth observation and satellite communication.

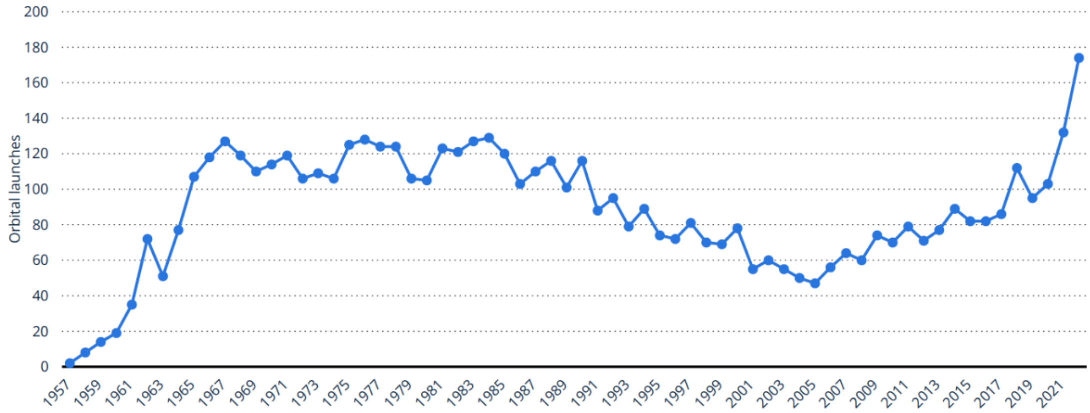

Figure 2.6: Number of orbital space launches worldwide 1957- 2022, Aerospace Security Project.

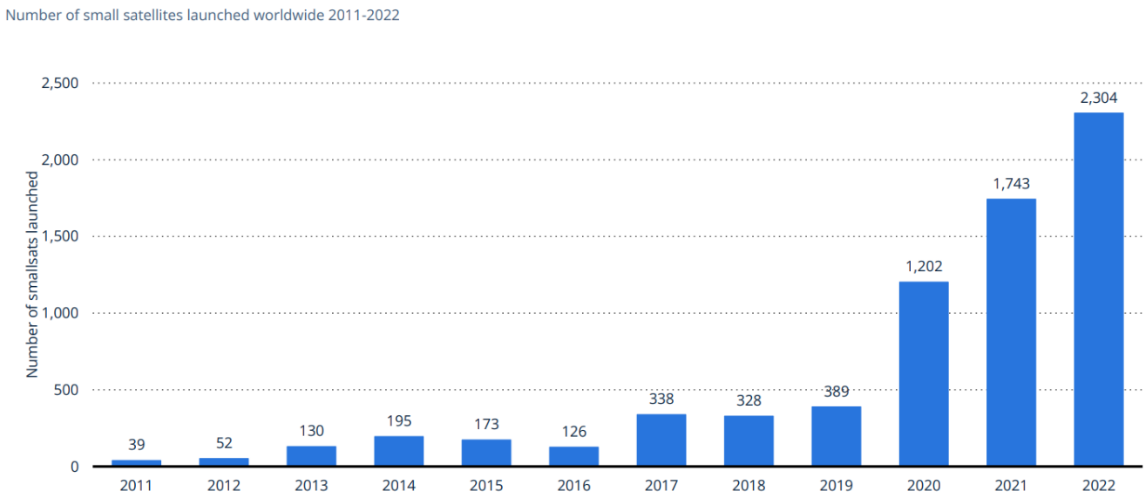

Figure 2.7: Number of small satellites launched worldwide 2011-2022, Bryce Space and Technology.

Focusing on angel investors, who are individuals with relevant financial resources, they are increasing their investments in the new space economies, looking for high returns and collaborating with other investors in order to achieve the diversification of the risk. According to Parella et al (2022) [131], incubators and accelerators are often related to these investors because they provide the start-ups both with both fundings and mentoring during the pre-seed and seed stage. The investment size often ranges from $50,000 to $1 billion. Another set of investors is represented by venture capital funds which cover a key role in the industry funding. They invest in the early stage of the company lifecycle and provide fundings in rounds with amounts that vary from $2 million to $10 million. It is important to highlight that they invest in the equity of the company, obtaining therefore a part of the start-up ownership, which can be often transformed into a number of common stocks in case of an IPO. The business model of these investors is therefore to exit from the company once the value of their investments has reached or overcome the target return. A similar business model is adopted by private equity firms, which however can decide to invest in already established companies or even to acquire them. It is important to highlight that the funds they can rely on are obtained as the sum of contributions from different players, such as pension funds, institutional investors, sovereign funds, and other forms of mutual investments. The size on private equity investments is the highest among the players mentioned, indeed they can reach several billion dollars. In the recent 15 years, they targeted especially the satellite communication sector and other government projects (Parella et al, 2022 [131]). Finally, incumbents in the industry can acquire or participate in new space economy start-ups able to deliver innovation to the market or to improve the company performances. A quite frequent phenomenon in the industry is the acquisition of a small start-up by an established firm to foster R&D activities of the buyer.

In recent years, mainly due to the attractiveness of the space economy and related industries, there was an increase in the presence of startups and private equity and venture capital funds. Furthermore, it is often possible to see the birth of Private Public Partnerships (PPP), defined as ''partnerships between the public sector and the private sector (industry), for the purpose of delivering a project or a service traditionally provided by the public sector'' (Parrella et al, 2022 [131]). Often modelled as long-term relationships, they provide for a combination of public and private investments and a partial transfer of responsibility and risk from public to private players. PPP are frequent in several sectors and are becoming more popular in the new space economy, since they can provide a series of advantages. Indeed, the private actor is incentivized to maximize its revenues and operational efficiency in order to attract public resources and their financial power to scale up its business. On the other hand, the public player can leverage the high level of service they private firm is able to deliver and can exploit the opportunity of sharing costs and risks resulting from this collaboration. Given the increasing relevance of the space industry, the role of the public is not restricted in financing the activities, but it comprises even the function of regulator. Governments must be able to avoid adverse scenarios in which the individuals could be harmed by monopolistic behaviours or unethical exploitation of the collected data. Despite the rise of private investments, the public ones continue to represent most of the new space economy fundings. Given the research objective, it is necessary to focus on the European new space economy framework, where the most relevant institution is represented by the European Space Agency (ESA).

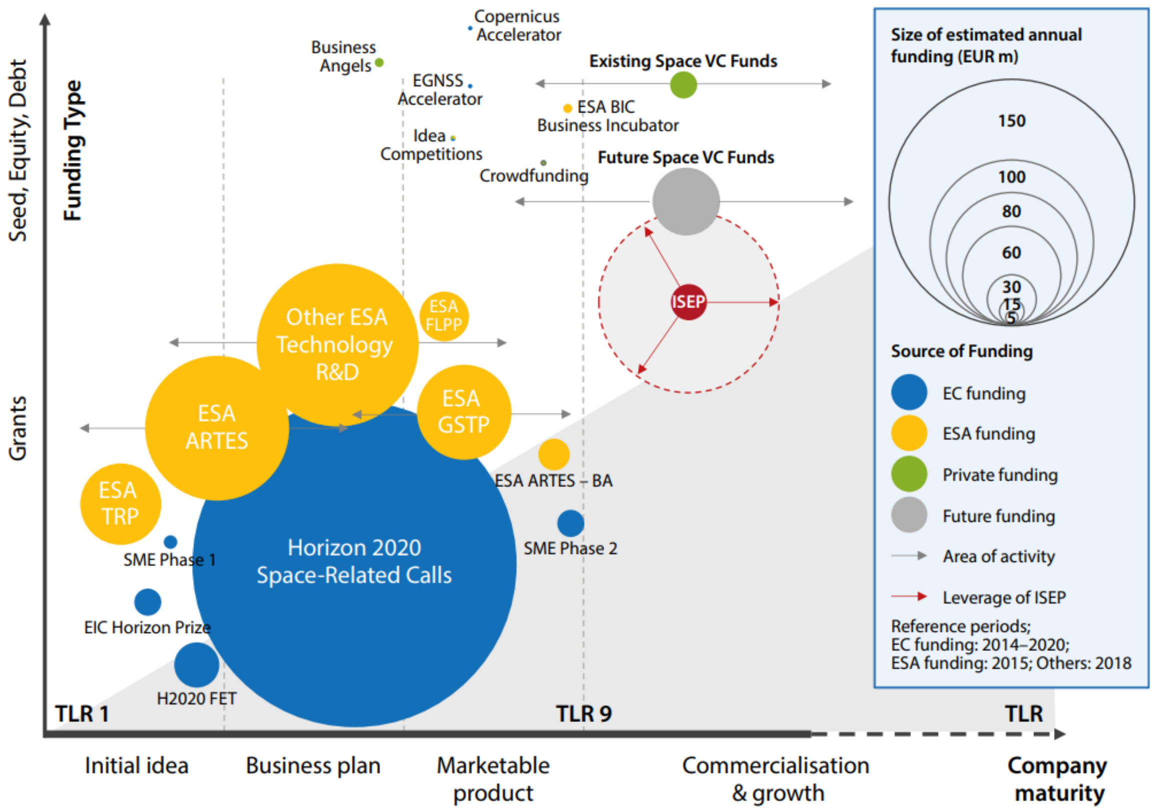

Figure 2.8: Overview of space-focused financial instruments in Europe and estimated annual funding volume, European Investment Bank (2019) [128].

The Figure 2.8 represents the different types of financial instruments, and their volume, a new space economy start-up can receive from the ESA, the EU and private actors, according to the maturity stage of its offering. In the first phases public fundings are the most frequent and this is also due to the fact that the EU and the ESA launched the EU Horizon 2020 and the ESA Artes project respectively. The objective of these initiatives is the facilitation of innovative firms' development in this sector. With the aim of supporting the progress of space start-ups, ESA launched its own Business Incubation Centers (ESA BICs) which encompasses 20 centres across Europe and has incubated more than 700 firms over the years. Beyond incubation centres, ARTES is another relevant partnership project between public and private institutions that has been developed by ESA to support satcom systems, increasing the competitiveness of the European space industry. The direct EU contribution to the new space economy is manifested by different initiatives among which Copernicus and Galileo masters, introduced starting from 2018. Their objective is to reward with financial support the most promising enterprises in the field of earth observation and global navigation satellite system (GNSS) based solutions. Starting from the commercialization and growth stage, businesses in the new space economy start to be consistently supported also by private investors through venture capital funds, business angels and crowdfunding initiatives.

2.2. The structure of the space economy

In order to understand the dynamics characterizing the empirical context of the new space economy, it is necessary to determine first which are the boundaries of the traditional space economy. Starting from this point, the expression space economy, without specifying whether it is traditional or new, refers to both possible concepts. According to OECD (2022) [132], the space economy is defined as "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilizing space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities". All the actors involved in the space economy are collectively called space industry, and include businesses operating in TV, communications, satellite and launch manufacturing, earth observation, ground equipment, environmental protection and natural resources management. OECD (2022) provides the set of main applications that can be included in the space economy:

- Satellite communications, this application includes the activities related to the delivery of mobile and fixed communication and broadcasting, starting from the development and usage of satellites and other systems to send signals to earth.
- Positioning, navigation and timing, it considers the provision of timing, positioning and localisation services and the development of the necessary products to perform these activities. This sector includes navigation apps, mobility app providers, GPS-enabled products for logistic purposes;
- Earth observation, it includes all the value chain activities that allows to measure relevant characteristics of the Earth, such as weather-related

measurements, forestry imagery, sea and ocean parameters and CO_2monitoring;

- Space transportation, the application is mainly related to Earth-to-space activities and considers development, realization and management of the space launches, spaceports and in-space logistic;
- Space exploration, it entails all the activities necessary to explore the universe beyond atmosphere with spacecrafts either able to bring people on board or not. This segment represents the birth of the traditional space economy;
- Science, this includes all the scientific research required to understand space related aspects which allow the delivery of products and services exploited both in space and on Earth. All activities that focus on the R&D of spacecrafts, the understanding of the astronomy context and the deployment of data can be included in this sector;
- Space technologies, all the aspect related to the technologies for space missions are in this application, therefore they include engineering and manufacturing activities of spacecrafts and launch bases and the training of astronauts;
- Generic technologies or components that may enable space capabilities, they are directly in the space economy, but they can lead to new space-related goods.

Following OECD (2022) [132] definitions, it is possible to mention the existence of at least three main segments of the space economy, namely the upstream space sector, the downstream space sector and space-derived activities in other sectors.

2.2.1. Upstream space segment

The upstream segment includes " Scientific and technological foundations of space programmes, manufacturing and production of space infrastructure" (OECD, 2022 [132]). The outputs of the upstream segments, i.e. the revenues generated, or the number of products realized, are relatively easy to measure exploiting official industry statistics. The activities belonging to this sector are numerous ranging from research activities, carried out by higher education's institutions, privates, public and non-profit organizations, to other services such as legal services, consultancy, insurance and finance. Therefore, all actors involved in the scientific and engineering support, material supply, design and manufacture of spacecrafts, satellites, ground systems and other types of space vehicles are in the space upstream. Finally, companies that integrate the previously mentioned systems into more complex products are considered as elements of this segment. It is important to specify that this sector is the enabler of all activities performed in other space fields. The traditional activities in the upstream segment are the building of the required infrastructure, the launch of spacecrafts and the management of satellites platform. The building activities oversee realizing from scratch the infrastructure and technologies necessary for the space economy, focusing on the implementation of space hardware and software. The former encompasses satellite manufacturing and maintenance, the building of propulsion systems and the design of mobility solutions in space. Additionally, it comprehends the engineering of auxiliary subsystems of space infrastructures, such as photovoltaic panels, the instrumentation inside the satellite carriage and the radio communication system. The latter involves the design and development of both in-space and terrestrial software, according to the location of the related hardware. Firms that operate in the launch domain can be divided into launchers, in charge of sending different infrastructures in space, and space tugs, that are specialized in moving satellites from one orbit to another. The last set of activities is represented by the management of platform, whose meaning in this context is different from the one given in the previous chapters since it does not encompass any market perspective. In this sector, a platform can be defined as a set of satellites, organized in a constellation, and HAPS collaborating to deliver a specific service, such as remote sensing, connectivity or IoT. For the sake of completeness, according to International Telecommunications Union [133], HAPS are “stations located on an object at an altitude of 20-50 kilometres and at a specified, nominal, fixed point relative to the Earth”. Finally, the most recent activities included in the upstream are the ones related to in-space services such as on-orbit servicing, active debris removal, on-orbit manufacturing, resource extraction, and space tourism. These activities can be included in the new space economy domain due to private investments rather than public ones to support their development.

Main groups of activity	Subgroups	Selected products and services	Type of organisations involved
Research, engineering and other services	Fundamental and applied research	• Fundamental and applied research	Universities, public and not-for-profit research organisations
	Ancillary activities	• Insurance and legal services • Market research • Finance	Insurance, law and research consulting firms, venture capital firms
	Scientific and engineering support	• Research and development services • Engineering services (design, testing, etc.)	Engineering firms, universities, public research organisations and agencies
Space manufacturing	Supply of materials and components	• Materials and components for both space and ground systems: Passive parts (around 70% of components in space sub-systems: Cables, connectors, relays, capacitors, transformers, RF devices, etc.) and active parts (e.g. diodes, transistors, power converters, semiconductors)	Suppliers and component manufacturers. Includes both off-the-shelf and specialised suppliers
	Design and manufacturing of space equipment and subsystems	• Electronic equipment and software for space and ground systems • Spacecraft/satellite platform structure and data handling subsystem (e.g. on-board computer, interface unit, satellite and launcher electronics) • Guidance, navigation and control subsystems, and actuators (e.g. gyroscopes, sun and star sensors rendezvous- and docking sensor) • Power subsystems (e.g. electrical propulsion, power processing unit, solar array systems, photo voltaic assembly) • Communications subsystems (e.g. receivers and converters, fibre optic gyro, solid state power amplifier, microwave power module, downlink subsystem, transponders, quartz reference oscillators, antenna pointing mechanism) • Propulsion subsystems (e.g. propellant systems, tanks, valves, electric propulsion systems) • Other satellite payload specific subsystems	Equipment and subsystem manufacturers with increasing degree of specialisation, often also catering to aeronautics and defence Many SMEs; and in recent years, an increasing number of manufacturers of very small satellite subsystems
	Integration and supply of full systems	• Complete satellite/orbital systems • Launch vehicles (and related launch services) • Control centres and telemetry, tracking and command stations	+20 big actors worldwide, with suppliers often also catering to aeronautics and defence and governments generally forming an important part of the customer base. In recent years, increasing number of integrators of much smaller systems
Space launch and transportation		• Government and commercial spaceports	+10 licenced spaceports in the United States and several projects worldwide

Figure 2.9: Main groups of activities in the upstream, OECD (2022) [132].

2.2.2. Downstream space segment

The downstream space segment entails "space infrastructure operations and "down-to-earth" products and services that directly rely on satellite data and signals to operate and function" (OECD, 2022 [132]). It is evident that the downstream sector could not therefore exist without the activities performed in the upstream. Among the most significative tasks in this sector, it is possible to mention all operations that exploit and manage space and ground systems and that allows the delivery of products and services for the consumer markets, such as GPS-enabled devices, communication devices and GIS. For example, earth observation service providers can enter several markets, representing therefore one of the most important players in the downstream. A key role is also covered by mobility and logistic app providers as well as by companies involved in the sell or lease of the satellite capacity. It is important to highlight that all businesses that manage the collection, the elaboration and the distribution of data are necessary to connect the upstream segment with actors that deliver products and services to the final customers. Finally, since the range of possible commercial space application increased at high speed over the last years, downstream is gaining increasing attention from private investors, making therefore more complex the measurement of the outputs. However, using official industries statistics, it is possible to obtain reliable results. As for the upstream sectors, activities with the higher degree of innovation are often supported through private investments. In particular, cloud computing and artificial intelligence are among the most important technologies that allowed the shift from the traditional to the new space economy. Their introduction allows the companies to benefit from a greater data elaboration capacity that can be exploited to improve already existing products and services, such as in the insurance industry, or to create new business models, as shown by the rise of data platforms. It is possible to further divide these activities into three categories, i.e., downlink, data analysis and product and service development. The downlink can be defined as a telecommunications link for signals coming to the earth from a satellite, spacecraft, or aircraft. Therefore, firms operating in this stage of the value chain deal with communications, security and storage of data, and the collection of space signals through ground terminals. Data analysis enterprises leverage geospatial technology combining advanced machine learning algorithms, cloud infrastructure and sensors to deliver critical information to the downstream of the value chain. This data can be used as a basis for final products or for the management of natural and artificial assets on a large scale. The final stage of the value chains encompasses all the actors involved in the delivery of products and services to the end customer, relying on data coming from the space ecosystem. The collected information can be applied to different fields, including climate monitoring, logistics, insurance, location and mapping, agriculture, and other applications.

Activity	Selected products and services	Examples of organisations
Operations of space and ground systems	• Satellite operations, including lease or sale of satellite capacity (telecom: Commercial fixed- and mobile satellite services operators; earth observation operators) • Provision of control centres services to third parties	More than 50 satellite communications operators around the world. Category also comprises ground station networks including domestic and foreign-owned ground stations as well as collaborative ground stations at polar and mid-latitude locations
Supply of devices and products supporting the consumer markets	• Very small aperture terminal networks • Satnav and telecom equipment and connectivity devices • Chipsets	Geospatial products, chipset and device manufacturers
Supply of services supporting consumer markets	• Direct-to-home (DTH) services • Location-based signals services • Cloud-based services to host and/or process geospatial data • Data-derived commercial services providers (sometimes called value-adders: Telematics, surveying, meteorology)	Actors included in the space economy as far as a share of their activity directly relies on the provision of satellite signals or data. Providers of satellite broadcasting services tend to dominate this category in terms of revenues

Figure 2.10: Main groups of activities in the downstream, OECD (2022) [132].

2.2.3. Other space-derived activities

The third segment is represented by the space-derived activities, that are "derived/induced from space activities but are not dependent on it to function" (OECD, 2022 [132]). Therefore, this sector is referred to product and services that are not strictly included in the space industry. Indeed, even if these goods exploit some investments in the space economy, they are no more directly related to data or other elements coming from the previous mentioned segment. These activities allow to understand the range of industries that can benefit, even indirectly, from the space economy. In order to measure the outputs of this segment, it is necessary to adopt specific techniques due to the complexity of the task.

2.2.4. Earth-to-space, space-to-Earth and in-space activities

Starting from the fact the activities in new space economy can be performed both on Earth and on space and that can target customers in both the locations, it is possible to divide the operation in three categories, i.e. the Earth-to-space, the space-to-Earth and the in-space activities. In the first case products and services are developed on Earth and find their destination in space. For instance, the manufacturing of satellites and their components, the management of satellites' constellation in orbit and the realization of specific software are enabling tasks for the functioning of the upstream infrastructure that cannot be performed directly in space. Space-to-Earth processes rely instead on data collected from satellites and spacecrafts that are necessary to deliver products and services which target terrestrial industries and their final customers. Navigation apps, data providers and Earth observation actors leverage on this kind of information in order to develop derivative goods addressing different markets requirements. Finally, in-space activities allow to generate revenues using and targeting assets in orbit or beyond Earth. In-space economy represents therefore the extraterrestrial space industries and oversees all activities related to the building and maintenance of space infrastructure exploiting other assets already in space. Moreover, space exploration and related services are key activities in this sector.

2.3. European and US new space economy

The study focuses on European startups in the new space economy; however, it is important to highlight the differences between the European and American context from a financial and economic perspective. Indeed, the latter benefits from a larger size than the former and it is often considered as the reference point when the attention is on space activities.

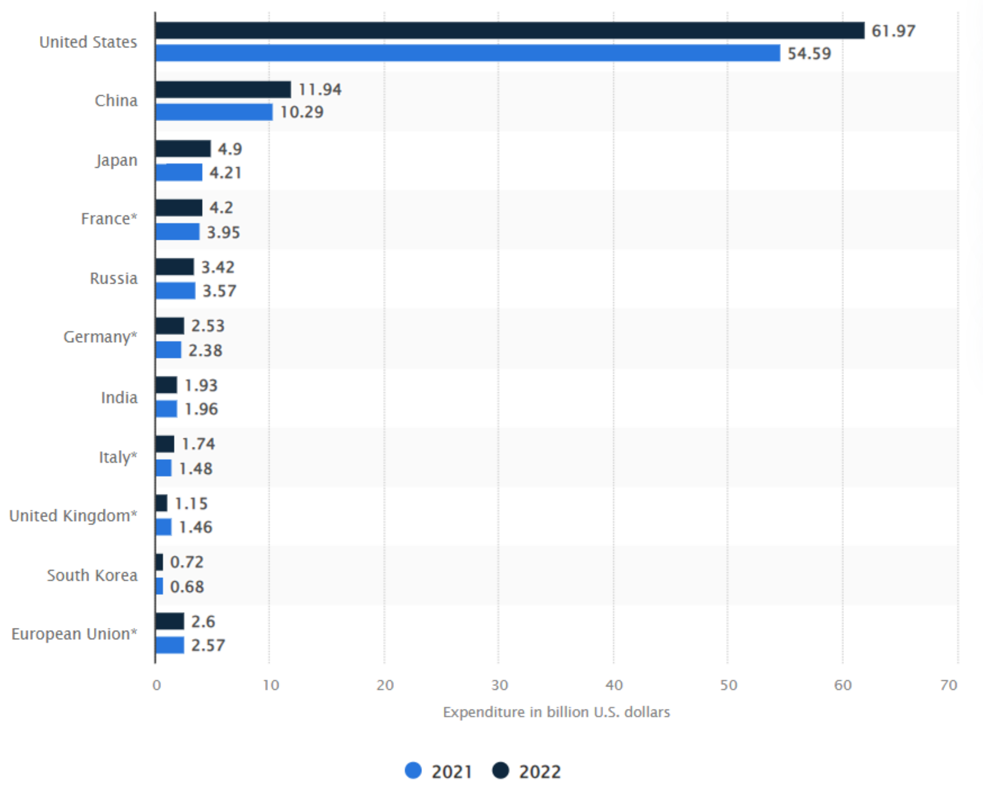

Figure 2.11: Government expenditure on space programs in 2020 and 2022, by major country, in billion US dollars, Euroconsult (2022).

The Figure 2.11 allows to understand the higher budget allocated from the US than other countries in space programs. Despite space programs are only one of the activities performed in the new space economy, the gap in investments allocated by US and the rest of the world, including EU, is replicated also in the other sectors of this context. The Figure 2.12 highlights the higher commitment toward the space industry of US Government with respect to other countries as percentage of GDP. US invest 0.25% of their GDP in this sector, while the closest European country is France with a percentage about 0,12%, which is the half of the American one.

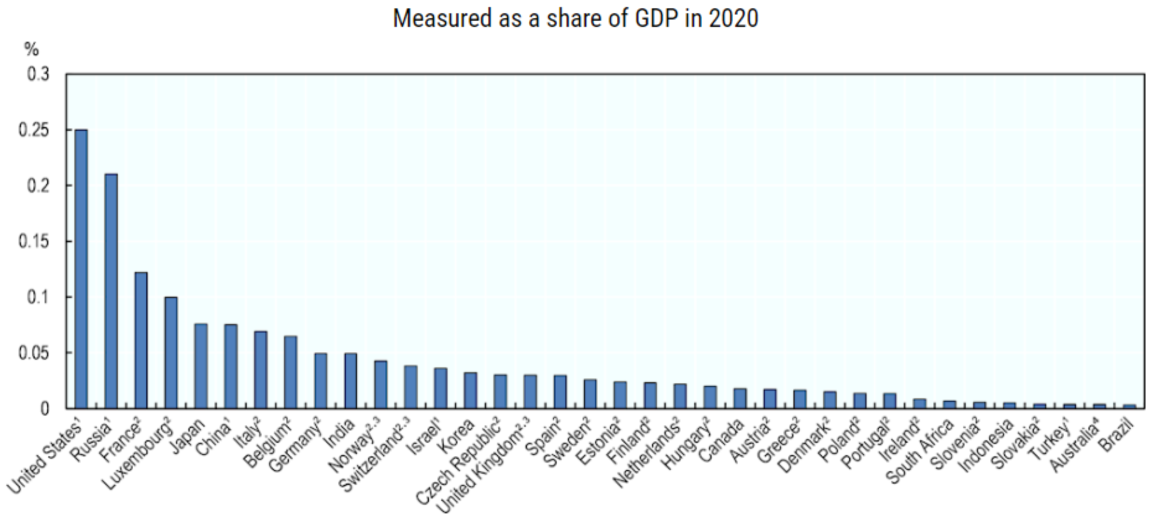

Figure 2.12: Government space budget allocations for selected countries and economies, OECD (2022) [132].

Focusing on US space industry output segmentation, it is possible to notice that, in the last decade, the proportion among macro sectors is quite similar, and the overall gross output rise by 17.16% with a CAGR of 1.59%

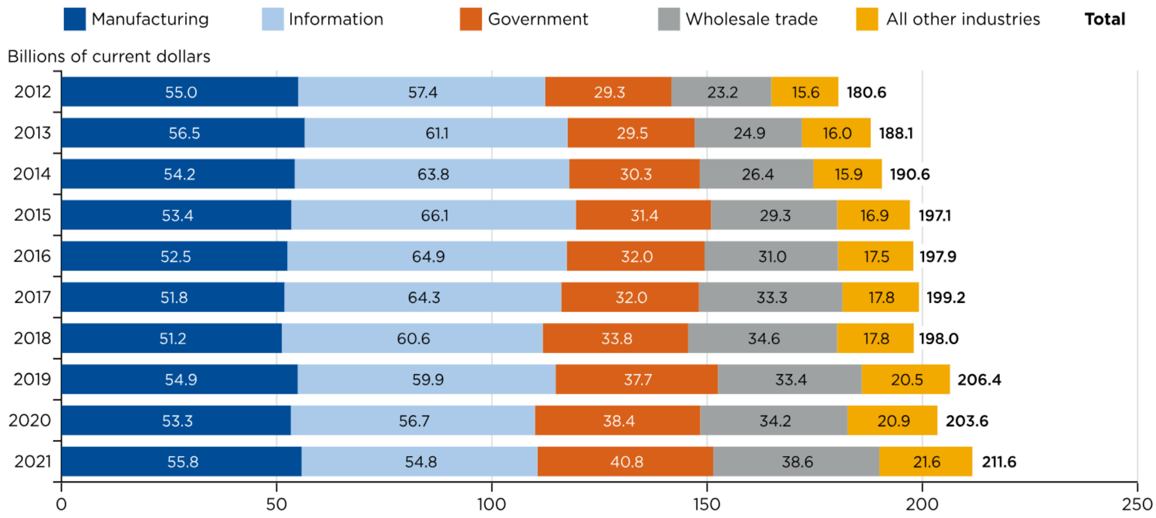

Figure 2.13: Space economy gross output by industry 2012-2021, Bureau of Economic Analysis (2023)

Another important topic is represented by the lower amount of investments that European startups receive comparing them to the American ones. From 2016 to 2019, the European unicorns in the space sector are 26, while the American are 109. The reason behind this numbers does not lie in the lack of knowledge and scientific research, but it arises from several macroeconomics trends which characterizes the European context.

The collaboration between private and public sectors materialized in the US highlights the higher maturity of the American new space economy with respect to the European one. Among the most important partnerships, the one between NASA and SpaceX can represent a milestone of the new space economy context. The partnership between public and private sectors in Europe is more likely to happen in the projects related to R&D of space infrastructure, rather than in the other stages of the space value chain.

2.4. Information systems in the new space economy

In order to complete the description about the empirical context, it is necessary to address the development of Information Systems in the new space economy. Indeed, beyond their relevant role in this industry, information systems are also related to the concept of platform, representing the theoretical background of the research. The need to deepen this topic is therefore useful to facilitate a better understanding of the results highlighted in the next chapters.

Since the space economy includes all activities necessary both to collect spatial information and to deliver the products and services based on this kind of data, information systems can widen their scope by being involved in the industry processes. It is interesting to notice that, since data must be collected in space or sent from there, different aspects must be considered. For example, inputs collected from satellites represent a completely new source for big data and a different type of information. Furthermore, beyond the engineering of the necessary instruments, it is also necessary to pay attention to the physical and mental health of people sent to space to collect data. Finally, Wooten and Tang (2018) [134] highlight four different challenges, strictly related to the physic laws of space, that must be overcome, represented by the distance, the gravity, the inhospitable environments, and the information.

- The distance of the low Earth orbit from the ground is about 2000 km; therefore, sending data from a location to another could take a significant amount of time, resulting in the difficultness of satisfying the timeliness requirement of information;
- The gravity on Earth is different from the one in outer space, where this force is a third of the terrestrial one. This phenomenon obviously must be taken into account during the design stage of spacecrafts and other objects which must exit from the Earth orbit and land on other bodies in space, such as asteroids or planets. Beyond the technical aspects of landing and launching the spacecraft, it is also necessary to consider the effect of the different gravity in products performances since they could not satisfy the expectations built by the customers when they experienced a similar product or a service on Earth;
- Space is an inhospitable environment for several reasons, such as the lack of water, air and food. It is necessary to find solutions in order to provide these needs in an efficient way;
- There are some phenomena in space that can make the collection, the transfer and the usage of the information more difficult. For example, the speed of light can limit the conveyance of data. The requirements to allow these operations are difficult to reach and represent one of the biggest improvements for the performances of the space economy.

According to McKelvey et al. (2015) [135], space exploration and the related activities can provide benefits to a wider range of industries, and in particular, Lei et al (2022) [136], explains that IS in the new space economy bring agents pay attention to three sectors, i.e. digital commerce, data analytics leveraging space-based data and information security.

Information systems are enabler of the digital commerce in the space economy, allowing the establishment of marketplaces in which space-based products and services are exchanged between buyers and sellers. Since these markets are in the early development stage, these digital infrastructures can facilitate the research of the required goods and therefore reduce the transaction costs. The products and services traded thanks to the digital commerce can be classified according to the origin-destination matrix provided by Wooten and Tang (2018) [134]. The goods are divided in four categories, identified by the combinations of the manufacturing and consumption location.

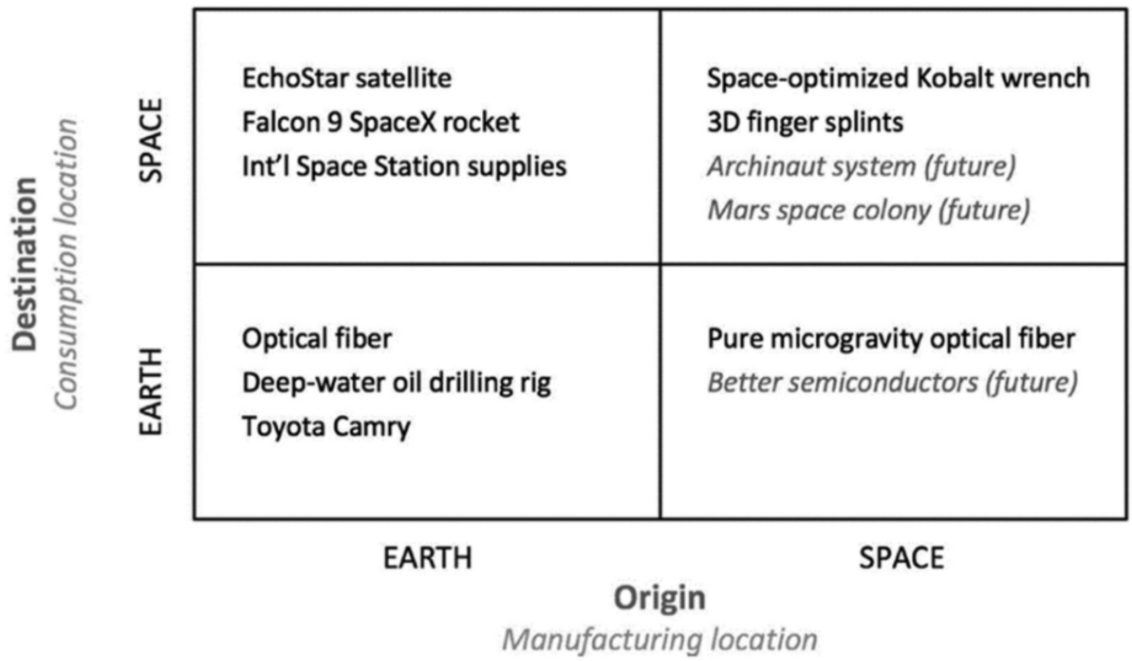

Figure 2.14: New space economy goods origin-destination matrix, Wooten and Tang (2018) [134].

It is important to highlight that the Earth-Earth are not part of the space economy, and they are presented in the graph just to provide some examples. Earth-space products are related to the provision of satellite subsystems or related services, such as the management of satellite constellation or launch operations. Space-Earth goods are innovative artifacts develop and manufactured in space, exploiting the specific characteristics of the environment, in order to be implemented on the Earth. Among the most important examples, it is possible to highlight the pure microgravity optical fibre, which is a semiconductor with higher performances than the current implemented and designed on Earth. Finally, products and services manufactured and consumed in space encompasses those objects that are at some point needed by spatial infrastructures and realized by the infrastructure itself, leveraging on technologies such as 3D printers and AI-enabled tools. Therefore, this kind of activities is strictly related to the in-space economy segment. These marketplaces are categorized according to the nature of the actors involved in the transaction and therefore they can be business to business (B2B), business to consumer (B2C) and consumer to consumer (C2C). Benefiting from the characteristics of the space environment, especially from microgravity and high vacuum, B2B marketplaces can target those terrestrial industries that rely on highly specific metal components and semiconductors. Indeed, it is easier and quicker to manufacture these products in absence of gravity. On the other hand, doing this activity in the outer space requires significant expenses related to the transportation and the quality control of the products. Therefore, a trade-off is generated between the operational advantages of building components in space and the costs necessary to realize them. In the B2C context, it is possible to observe marketplaces where product, services and other experiences are exchanged. The first category entails well-known products, such as GPS-enabled navigation systems or mobility apps. Among services, data provider relevance is increasing thanks to the rising value of information and other type of experiences, such as the spatial tourism are slowly becoming more popular among wealthier people. Both B2B and B2C digital commerce must overcome an important aspect of their business, represented by the logistic costs and therefore must focus on the optimization of the supply chain management. According to Briggs et al. (2015) [137] and Vakulenko et al. (2018) [138], the focus of this improvement should be on the last mile delivery, whereas Lei et al. (2022) [136], turn their attention to the first mile. C2C marketplaces often comprehend the transaction of products and services between individuals, leveraging space technologies necessary, for example, to enable the positioning of goods such as peer-to-peer car sharing applications.

Since spatial data represent a new type of information, data analytics can leverage them in order to obtain new trends or insights about a large set of industries. Indeed, several measures, that cannot be surveyed with existing technologies, can be collected thanks to satellite images and other instruments located in orbit or in the outer space. Based on the location in which it is collected, information can be generated either in space or on Earth. The former entail all data about spacecrafts, spatial debris and satellite image, while the latter take into account measures coming from terrestrial activities, such as the supply chain management. Exploiting the last sort of information generated in space, it is possible to have a better understanding of the Earth itself and especially about the seas and ocean, which can be more difficult to measure. Data generated in space can be applied also for avoid collision between spacecrafts or to organize the spatial debris. Another possible field of application for data coming from satellite constellations is represented by the management of supply chain networks. Among the advantages that satellites can provide to all industries, high relevance should be given to the capability of collecting data, often in real time, that could not be obtained on Earth, such as visible light, infrared and microwaves. This feature allows to exploit more effectively data driven and forecast systems, by combining the new sort of information with the more traditional.

According to the International Telecommunication Union [139], "cybersecurity is the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organization and user's assets". Since space economy is able to collect a big quantity of data, the information security has a key role in this industry. The data are subject to possible hacker attacks both when they flow from space to Earth and in the other direction. "The security of space-based infrastructure depends on the safety of Earth-space interactions. In addition, the security of systems relying on data from space depends upon the safety of space-Earth interactions" (Lei et al, 2022 [136]). The privacy of spatial data is a high relevance topic, and authorities are required to design the necessary laws to guarantee this right both to individual and companies. It is needed to understand how the data can be collected, presented and accessed from and by consumers and businesses without overcome the privacy of the related actors. There could be some moral and legal reasons that can make the collection of individuals data more difficult, while companies could prefer not to share business information to protect themselves from competitors. Since the relevance of spatial data will increase over the years, it is necessary to focus on the regulation about intellectual property rights to protect the owner of the information, which can represent a competitive advantage.

3 Research Objective and Methodology

3.1. Research questions and research purpose

The literature review on platform business models analyses several topics and it has been applied to different industries and sectors. Other possible fields of application are embodied by emerging industries, such as the new space economy, which, thanks to its characterizing features and dynamics, represents an interesting context in which platforms can be established to generate value for a large set of actors. The literature gap identified is represented by the application of the platform business model in the new space economy.

The literature gap gives rise to five research questions, which allow to enlarge the set of fields in which the platform business models literature is applied and to improve the theoretical knowledge of the new space economy. The research questions are the following:

1. What are the archetypes of European platforms in the new space economy?
2. Does the new space economy context have an impact on the scalability of these platform startups?
3. What is a possible reference terminology for platforms in the new space economy?

The objective of the study is to analyse the platform business models operating in the new space economy, by understanding their key features and therefore identifying the different archetypes of platforms existing in this context. In order to do so a taxonomy about platform business model in the new space economy is developed with the aim of providing a common reference terminology useful to a wide range of actors, such as regulators, researchers and investors.

3.2. Methodology

In order to carry out the development of the taxonomy of platform business model in the new space economy, it is necessary to define specific guidelines to follow during the process. In particular, the first step encompasses the choice of the new space economy definition and the identification of criteria to be satisfied to consider a company belonging to this context. The second step involves the same actives performed in the previous phase but applied to the platform domain. Once the boundaries of the research are defined, several business databanks are consulted in order to identify the new space economy platforms settled in Europe, and some of their key characteristics. The fourth task entails the replication of an iterative method suggested for the development of taxonomies, exploiting both qualitative and quantitative approaches. Given the data available, the cluster analysis is chosen as the most suitable tool to perform the investigation. In order to ensure the scientific rigorousness of the method and the results obtained, some of the most relevant papers in the literature are consulted.

3.2.1. New space economy boundaries

In order to perform the first step, and therefore to choose the definition of the new space economy, it is necessary to understand the characteristics of the traditional one. Several sources were consulted to find the most suitable definition of this domain. For example, the Ministero dello Sviluppo Economico (MISE) considers it as the value chain that, starting from the research, development, and implementation of enabling space infrastructures reaches the generation of innovative "enabled" products and services (telecommunication, navigation and positioning services, environmental monitoring weather prediction, etc.). However, thanks to its exhaustiveness, the chosen definition is the one provided by the OECD [140], according to which “the space economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilizing space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the space economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society” (OECD, 2012 [140]). Furthermore, in 2014 OECD [141] extended this definition specifying that “TV and communications, satellite and launch manufacturing, Earth Observation, ground equipment are some core elements of the space sector, but the space economy goes beyond that. “Space economy” does not only cover this sector, but it is a broader umbrella term that includes all industries linked to it. For instance, it also includes services and products in other fields connected to satellite technology and services such as agriculture, environmental protection, natural resources management, and transportation.” In particular, according to Parrella et al (2022) [131], a space firm can be described as ‘‘a company involved in the space economy, and providing goods and services related to space.”

According to the MIT, the New Space economy can be defined as “the rising commercialization of space exploration. Private investors, companies, and start-ups are investing and contributing to space exploration. The difference between traditional space exploration and the current one—sometimes referred to as NewSpace— is that the government no longer has to intervene entirely.”

Starting from the previous definitions, a company is considered as part of the new space economy if it is involved in the realization of space infrastructures, or it provides products and services which rely on them.

According to OECD (2022) [132] and as already highlighted in the empirical context, new space economy can be divided in three sectors, namely the upstream, the downstream and space derived activities in other sectors.

The upstream space sector is represented by the “scientific and technological foundations of space programmes, manufacturing and production of space infrastructure”. Among the firms in this segment there are all enterprises that perform activities related to the realization of satellites, launch systems and other space vehicles. Therefore, all players involved in the material supply, engineering and manufacturing of the previous-mentioned object belong to this category. Also, space exploration can be included in this sector of New Space Economy.

The downstream sector, on the other hand, involves all the “daily operations of space infrastructure and “down-to-earth" activities that directly rely on the provision of a space capacity (satellite technology, signals or data) to exist and function.” All agents that exploit space infrastructure and data coming from them to realize a product or a service can be considered as part of this segment.

Finally, space-derived activities in other sectors are “new activities in various economic sectors that derive from or have relied on space technology transfers.” Therefore, the business model of these companies does not belong to the new space economy. The same activities are defined by the European Space Agency as Transfer

Technology and consistently are not included in the new space economy boundaries.

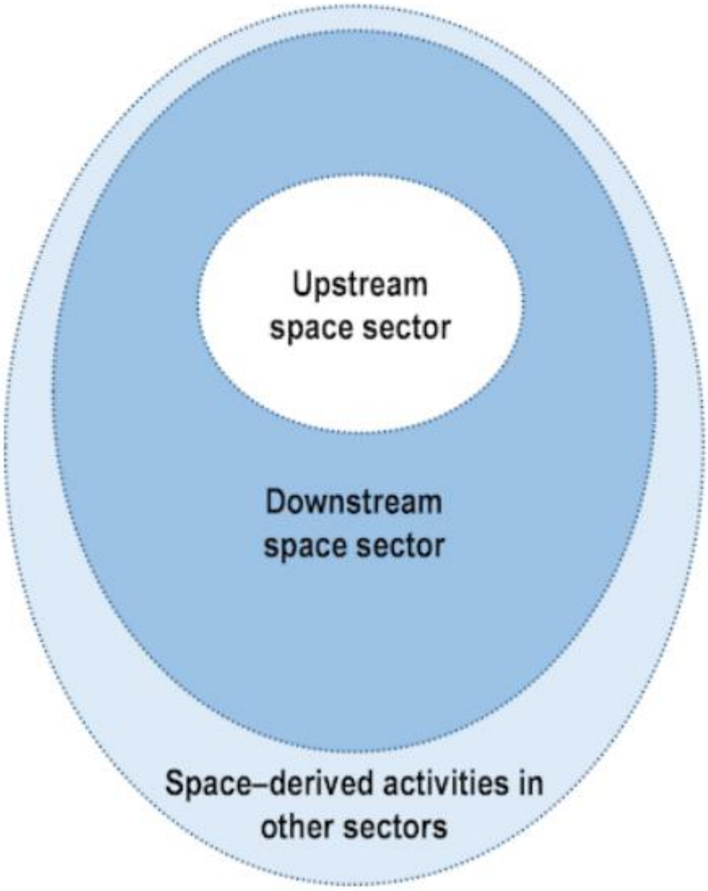

Figure 3.1: Representation of the new space economy segments, OECD (2022) [132].

Following OECD (2022) [132] classification, it is possible to furtherly categorize the companies according to the following space applications:

- Satellite communication: all activities related to the exploitation of satellites to send signals to Earth to enable satellite related devices such as TVs and radios.
- Positioning, navigation and timing: all activities that leverage satellites and other systems to track the positioning and navigation of different objects and that provide the universal referential time
- Earth observation: all activities useful to measure some Earth related figures, by exploiting satellites
- Space transportation: all activities which allows the launch of spacecrafts from Earth to space, and the last mile delivery within orbits

- Space exploration: all activities which encompass the exploration of the outer space, e.g. planets, asteroids and beyond atmosphere phenomena
- Science: all range of activities which study the space physical laws, the space flight and the space related earth science, i.e, research about Earth that are not possible to carry out on the ground
- Space technologies: all activities which include the manufacturing of hardware and software exploited by spacecrafts and other objects in orbit
- Generic technologies or components that may enable space capabilities: all the activities whose outputs are not initially targeted for the space economy, which however can generate benefits to this context

Another interesting aspect to take into account is what industries a space activity can have an impact on. The European Space Agency identifies the most targeted industries in the upstream and the downstream sector. In the former it is possible to mention in space services and manufacturing and mining, while in the latter ESA points out food and agriculture, transport and logistic, energy and environment conservation and finance – investment and insurance.

3.2.2. Platform boundaries

In order to complete the framing of the research boundaries, it is necessary to provide a platform business model reference definition and consistently to specify the required criteria a startup must satisfy to be considered a platform. With the aim of choosing the most suitable platform definition, several papers in the literature were consulted, and, for each of them, the meaning attributed to the platform concept was analysed taking into account the key aspects. Indeed, different streams of the literature could focus on some platform archetypes, such as internal platforms for the new product development, not aligned with the aim of the thesis, or that require specific features which could represent restrictive constraints for the analysis.

The choice of the reference definition starts from the article of Tan et al (2015) [19], according to which a platform represents "a commercial network of suppliers, producers, intermediaries, customers […] and producers of complementary products and services termed "complementors" […] that are held together through formal contracting and/or mutual dependency". Despite it highlights the involvement of different types of actors, the definition considers the presence of complementors as a necessary condition for the acknowledgement of a platform, preventing therefore a consistent number of interesting firms to be included in the analysis. On the other hand, a more suitable option is the one provided by Cennamo and Santalo (2013) [21] sustaining that "a platform mediates the relationship between end users and the universe of potential complementary goods". According to this statement, complementors are not necessarily a platform element; however, there is no explanation about the different modalities to connect the sides involved. A more exhaustive definition, but however not sufficiently detailed, is provided by Pagani (2013) [22], who sustains that "a platform brings together two or more distinct groups of customers (sides) that need each other in some way, and where the company builds an infrastructure (platform) that creates value by reducing distribution, transaction, and search costs incurred when these groups interact with one another". According to the paper, therefore indirect network externalities between the sides are required to be reciprocal, however the real world shows that many platforms can exist thanks to unidirectional indirect network effects. Hagiu and Wright (2015) [23] state that "the multi-sided platform model (MSP) involves contractual relationships between buyers and professionals, to which the focal firm is not a party, but merely an enabler of those contractual relationships". Therefore, the focus is shifted on the monetary transaction, leaving almost no room for other types of exchanges, such as the sharing of data and information, or collaborative partnerships between entities. After the analysis of several options, the most suitable definition of platform is the one suggested by Cennamo (2023) [25]: "Platform technology that acts as a data hub channelling and integrating information from/to users and from/to multiple connected products and services, and as market infrastructure connecting users and suppliers of goods …. platforms are the "new" market infrastructures that enable firms' interconnected products and services to create and deliver value to final users …. Platforms can vary in their strategies to attract on the different sides of the platform market and activate and leverage the indirect network effects". This definition is preferrable thanks to its completeness and since it emphasizes the role of platforms both as market infrastructure and data and information hub, being therefore more aligned with the perspective adopted in the analysis.

Starting from this interpretation, the following step consists in determining the criteria a company must satisfy to be classified as a platform. In particular, the identified necessary characteristics are:

- The presence of two or more sides connected by the firm that acts as an intermediary
- The existence of indirect network effects, either unidirectional or multidirectional

- The role of the company either as s transaction market, a data hub or an information provider

3.2.3. Building process of the database

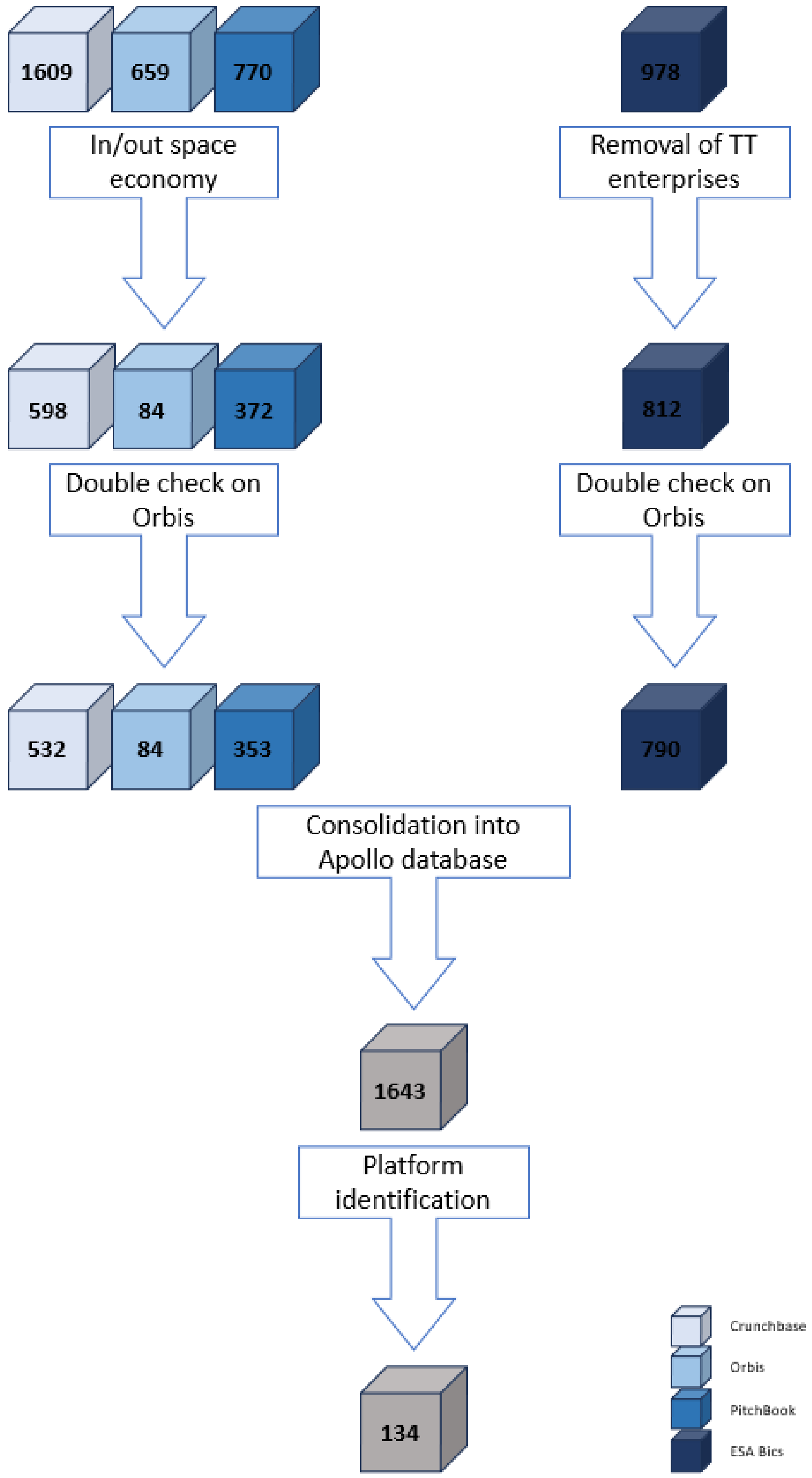

Figure 3.2: Building process of the database

In order to obtain the final database useful to address the research questions, a preliminary analysis on five main bases of data is performed. These initial samples are chosen from the most valuable and reliable business databanks available in Europe, and it is useful to specify that only companies that have declared their headquarters in the EU are considered, regardless of the countries in which they run their business, and that are established from 2005. In order to build the final database with 134 European start-up platforms in the new space economy, three main phases can be mentioned and shown in Figure 3.2. In the first one, the objective is to understand whether a company belongs to the new space economy or not. The second phase is aimed to specifying the space sector and the industry of application of the selected companies. The third phase has the goal of understanding which ones, among the filtered companies, rely on a platform business model, by checking their adherence to the chosen definition.

In each of the previous phases, the quantitative and qualitative assessment on companies is performed by completing three subsequent tasks:

1. the allocation of the five samples to each of the master thesis students involved in the project and the execution of the individual analysis;
2. the cross-validation analysis to check the individual work and agree a common output;
3. the building of the common updated database necessary to carry out the following phase.

Firms included in several sources were consulted and filtered according to an array of selected keyword intended to capture the essence of new space economy activities. These keywords were validated by experts in the new space economy field. The resulting sample of firms was then further cleaned. However, it is important to highlight that the keywords do not guarantee that a firm belongs to the new space economy, indeed some of the chosen terms are simply included in the name of the company, or belong to the semantic sphere of another context, leading therefore to possible misunderstandings. Considering the former issue, for example, the word "orbit" is often part of the company name and therefore even firms in industries not related with the new space economy are included in the first samples. On the other hand, among some possible misleading keywords, the term "space" causes the presence of some businesses operating in the interior design or the building industry and therefore completely unrelated with the domain of interest. Another interesting example is represented by "artificial intelligence" and "machine learning". Indeed, despite their increasing importance in the context and the consequent need to include them in the list of keywords, they can be applied to a wide set of other industries and therefore they make some out-of-scope companies appear in the samples. These possible inconsistencies require students to check one by one the companies to properly determine which ones belong to the new space economy. Taking as example the company alpha, it is possible to show how the skimming process is not able to filter all companies which do not operate in the new space economy domain. Indeed, even though its business description contains the word "space", the company alpha is specialized in the optimization of buildings internal space and factories layouts, therefore it cannot be included in the boundaries of the new space economy. Another example that shows the need of the additional human check is represented by company beta, whose core activity is the development of videogames simulating battles which take place in space. It is interesting the highlight that, in this case, the meaning of the word space is effectively in line with the interest of the research, however it is not a sufficient condition to guarantee the belonging of the firm to the research field.

The data banks from which companies were drafted are the following:

- Crunchbase, a company that provides business insights about enterprises, both public and private, and information regarding their founding members and corporate governance structures, the rounds of investment and relevant investors;
- Orbis, the biggest worldwide available database on businesses and the most updated. Data are collected and elaborated in a standardized way so that companies can be easily identified through an ID and compared seamlessly;
- Pitchbook, a data provider company that collects and displays companies' details such as their deal histories, stock information, investors and executives. It deals with PE and VC valuations, startups and hedge funds;
- ESA Business Incubation Centers, a network of incubators that supports space related projects and startups across Europe. It is an innovation centre with the aim to help entrepreneurs develop their business ideas and boost the growth of the space industry. Included in the enterprises encompassed in the ESA BICs, there are also the firms under the ESA definition of Transfer Technologies (TT) startups and therefore excluded in the final analysis. For the sake of clarity, ESA BICs database provides start-ups belonging to New Space Economy, specifying the relative sector. The terminology implemented by ESA for the new space economy segments is the same as the one adopted by OECD, however the space-derived activities in other sectors are defined as Transfer Technology. In order to provide two examples of TT firms, it is possible to mention company gamma and theta, which both started their activities in space, but then have moved to other sectors. In

particular, company gamma developed a refrigeration system implemented in astronauts' suites, which today is applied in the pharmaceutical industry with the aim to conserve laboratory samples. On the other hand, company theta is specialized in lightweighting constructions which were originally exploited in the space context and nowadays find application in several sectors, such as the automotive, the pharmaceutical and sport.

Each of the extracted datasets is structured as an excel file with a variable number of columns, depending on the information that is provided. Some features, such as the name, description, website, country (headquarter) and date of birth of a company, are provided by all databanks, while others such as the entry and exit year of incubation are given only by ESA BIC.

An additional double check is then carried out by exporting on Orbis the files obtained at the end of the preliminary analysis on the other databases. As highlighted before, Orbis is the most updated dataset available and thus the purpose of this process is to identify and revise those companies that have changed their name across time and exclude those firms that decided to modify their business model and therefore that are not operating anymore in the space economy (pivoting).

Once obtained these preliminary databanks, the subsequent process focused on the identification and classification of firms in the sector of relevance and their application according to the OECD (2022) [132] definitions outlined in the previous sections. The aim of this step is to collect additional relevant information and categorize companies to better compare the different findings. In order to better explain the results of this phase, two example companies are reported. The firm epsilon manufactures components for satellites and spacecrafts; therefore, it is classified as a business in the upstream sector whose application, according to the OECD (2022) [132] definitions, is space tech and it targets the satellites and space transport industries. Another reference is represented by company phi, which provides high precision satellite positioning leveraging the blockchain technology. This firm operates in the downstream sector and finds application in the positioning, navigation and timing category, by contributing to the transport and logistic industry.

The final step encompasses the identification of companies adopting a platform business model starting from the ones already filtered in the previous phases. In order to do this, consistently with the definition provided by Cennamo (2023) [25], a firm is considered as a platform whenever:

- it allows the interaction among different sides acting as an intermediary
- indirect network effects subsist between at least two sides
- the company acts as infrastructure either:
    - to market products and services
    - to develop innovative goods
    - to collect and distribute information

For example, the company epsilon satisfies all the criteria above, since:

- It acts an intermediary by connecting and providing some services to the sides involved, i.e. GNSS station operators and GNSS data users.
- A higher quantity of station operators provides data users with higher benefit, since they can rely on a wider set of information, and vice versa, the more are the users, the higher is the interest of GNSS station operators to be involved in the platform for economic reasons.
- The company is a collector and distributor of information.

Focusing on data provider companies, it is necessary to point out an important remark about their inclusion in the final database used as starting point of the taxonomy. Indeed, these firms can either adopt a platform business model or simply obtain data, by acquiring them from different suppliers or by exploiting their own satellites, and then sell the information to data users. In the second case, the enterprise does not act as intermediary. In fact, the demand side is fully reduced to the only data provider, causing the transition from a many-to-many type of connection to a one-to-many. Therefore, it is impossible to speak about indirect network externalities between the data collectors and the data users, preventing the company from being classified as a platform.

3.2.4. Taxonomy development method

In order to design the underlying taxonomy, it is necessary to start with its definition. According to Nickerson et al. (2013), "a taxonomy T is a set of its n dimensions $Di(i=1, \ldots, n)$ each consisting of $ki(ki \geq 2)$ mutually exclusive and collectively exhaustive characteristics $Cij(j=1, \ldots, ki)$ such that each object under consideration has one and only one Ci,j for each Di". Therefore, the aim of this taxonomy is to provide an exhaustive number of dimensions consisting in a set of characteristics sufficient to properly describe the archetypes of the platform business model in the new space economy, highlighting the key features for each group. Consistently with the methodology provided by Nickerson et al. (2013) [1] the meta-characteristic was defined. It can be considered as "the most comprehensive characteristic that will serve as the basis for the choice of characteristics in the taxonomy". In this taxonomy the meta-characteristic is represented by how platforms are able to generate value in the new space economy, considering for example which is their core value proposition, or the nature of the actors involved. The meta-characteristic should reflect the purpose of the taxonomy itself which in turn should be determined based on the taxonomy users, embodied by investors, regulators and researchers. The final objective is to understand how an established business model, i.e. platforms, can be applied to an emerging context like the new space economy, which affect a large set of related industries. The taxonomy development suggested by Nickerson et al. (2013) [1] is based on an iterative process, in which dimensions and characteristic are added and modified until the ending conditions are reached. They represent the necessary requirements to conclude the process and can be either objective or subjective. The former entirely rely on the definition of taxonomy and they are necessary to ensure the mutual exclusivity of the characteristics, securing that none of them is unnecessary. The verification of objective ending conditions can be validated in an undisputable way. The latter depends instead on the aim and the level of detail required by the developer of the taxonomy; indeed, it is not possible to objectively verify whether they are met or not.

Objective ending condition	*Comments*
All objects or a representative sample of objects have been examined	If all objects have not been examined, then the additional objects need to be studied
No object was merged with a similar object or split into multiple objects in the last iteration	If objects were merged or split, then we need to examine the impact of these changes and determine if changes need to be made in the dimensions or characteristics
At least one object is classified under every characteristics of every dimension	If at least one object is not found under a characteristic, then the taxonomy has a 'null' characteristic. We must either identify an object with the characteristic or remove the characteristic from the taxonomy
No new dimensions or characteristics were added in the last iteration	If new dimensions were found, then more characteristics of the dimensions may be identified. If new characteristics were found, then more dimensions may be identified that include these characteristics
No dimensions or characteristics were merged or split in the last iteration	If dimensions or characteristics were merged or split, then we need to examine the impact of these changes and determine if other dimensions or characteristics need to be merged or split
Every dimension is unique and not repeated (i.e., there is no dimension duplication)	If dimensions are not unique, then there is redundancy/duplication among dimensions that needs to be eliminated
Every characteristic is unique within its dimension (i.e., there is no characteristic duplication within a dimension)	If characteristics within a dimension are not unique, then there is redundancy/duplication in characteristics that needs to be eliminated. (This condition follows from mutual exclusivity of characteristics.)
Each cell (combination of characteristics) is unique and is not repeated (i.e., there is no cell duplication)	If cells are not unique, then there is redundancy/duplication in cells that needs to be eliminated

Figure 3.3: Objective ending conditions, Nickerson et al. (2013) [1].

Subjective ending condition	*Questions*
Concise	Does the number of dimensions allow the taxonomy to be meaningful without being unwieldy or overwhelming? (A possible objective criteria for this condition is that the number of dimensions falls in the range of seven plus or minus two; Miller, 1956.)
Robust	Do the dimensions and characteristics provide for differentiation among objects sufficient to be of interest? Given the characteristics of sample objects, what can we say about the objects?
Comprehensive	Can all objects or a (random) sample of objects within the domain of interest be classified? Are all dimensions of the objects of interest identified?
Extendible	Can a new dimension or a new characteristic of an existing dimension be easily added?
Explanatory	What do the dimensions and characteristic explain about an object?

Figure 3.4: Subjective ending conditions, Nickerson et al. (2013) [1].

After having described these necessary features, it is useful to explain the different approaches that can be implemented in order to develop a comprehensive taxonomy. According to the exemplar paper, three possible methodologies can be adopted:

- Inductive or empirical: starting from observing the available sample, the researcher aims to find significative dimensions or characteristics through the identification of patterns exploiting cluster analysis or other descriptive and statistical techniques
- Intuitive: according to the level of comprehension of the context, useful dimensions and characteristic are developed ad hoc in line with the purpose of the taxonomy
- Deductive or conceptual: exploiting theoretical knowledge and academic background in the related fields of application, the researcher identifies dimensions and characteristics without directly relying on the empirical set.

These approaches should be implemented in an iterative way, until both the objective and subjective ending conditions are satisfied. It is important to highlight that the iterative process could lead the researcher to slightly modify the meta-characteristic previously defined, according to additional findings arising during the procedure.

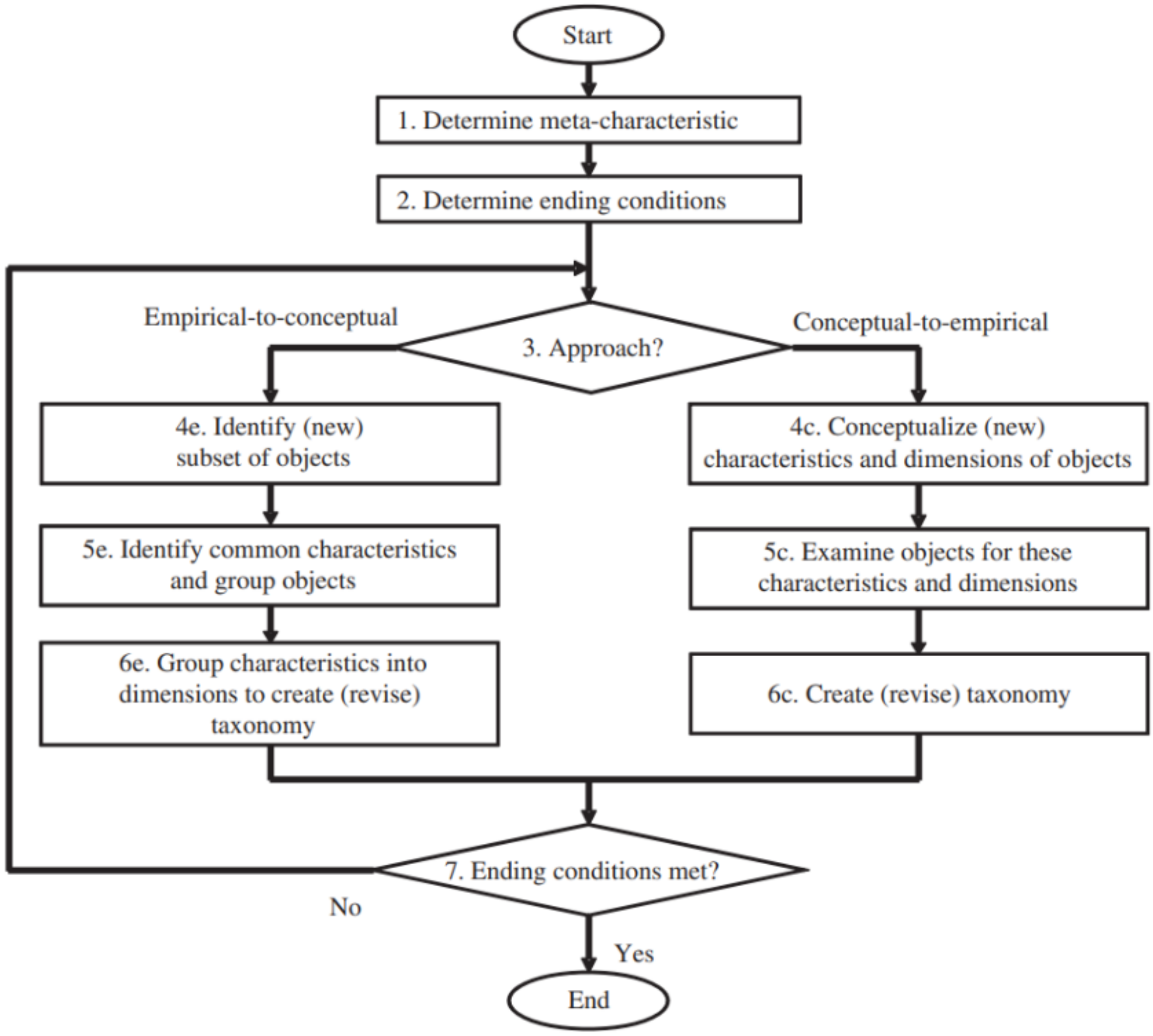

Figure 3.5: Iterative process for the development of the taxonomy, Nickerson et al. (2013) [1].

3.2.5. Cluster analysis

As mentioned in the previous section, a possible quantitative method, which can be adopted in the iterations to develop the taxonomy, is represented by the cluster analysis. According to Ketchen and Shook (1996) [142], cluster analysis is "is a statistical technique that sorts observations into similar sets or groups". This paper highlights that strategic management research takes into account several aspects belonging to different fields; therefore, the multidimensionality characterizing the cluster analysis makes this method one of the most effective among the ones available. The main objective of this statistical technique is the identification of similar elements to be pooled in the same group, that therefore shows homogeneous characteristics in within, and the generation of different groups heterogeneous from one another. Indeed, according to Ketchen and Shook (1996) [142], the cluster analysis "takes a sample of elements (e.g., organizations) and groups them such that the statistical variance among elements grouped together is minimized while between-group variance is maximized". Even though this method is able to obtain the clusters without any theoretical foundation, in this case the obtained results would be meaningless. With the aim of running a structured cluster analysis, it is necessary to follow four different steps, focusing on the key aspects related to each of them. The four subsequent phases are:

1. Selection of the clustering variables
2. Selection of the clustering algorithm
3. Determining the number of clusters
4. Validation of clusters

Clustering variables

The selection of variables is probably the most important step of the cluster analysis; therefore, a proper choice is necessary to obtain meaningful results. This stage requires the identification of the variables upon which the clusters are determined, and encompasses three key aspects, namely "(1) how to select variables; (2) whether or not to standardize variables; and (3) how to address multicollinearity among variables" (Ketchen and Shook, 1996 [142]). The first question can be addressed through three different approaches:

1. Inductive, since there are no expectations about the number and type of variables and clusters, the inductive approach provides for the inclusion of as many variables as possible in order to understand their magnitude on the identification of the groups
2. Deductive, the number and type of variables and clusters is strongly linked to the theory, therefore, one of the most significant benefits of this approach is the theoretical consistency which supports the results achieved
3. Cognitive, this method is similar to the inductive one since both are not based on theory, however, in this case, the number and type of variables and clusters are suggested by the experts of the context where the cluster analysis is carried out

The most suitable method to follow depends on the aim of the research, which can be either the building or the testing of the theory. In the former case, the inductive and cognitive approaches are the most effective since they do not rely on the theory. It is important to highlight that the second one should be preferrable to the first one since the suggestion of experts could provide the results with a solid background, preventing clusters to exclusively depend on a statistical technique. The former objective can be reached in a most efficient way following the deductive approach, since it is based on the theory and benefit the results with a solid theoretical consistency.

The choice whether to standardize the variables or not depends on the variables themselves and their values. Indeed, the target of the cluster analysis is to determine groups, maximizing the distance between them. Therefore, variables with a wide range of values can have a more relevant impact than the ones characterized by a narrower interval of values. In order to address this issue, the standardization process, i.e. the transformation of a variable distribution into a normal distributed outcome, represent a possible instrument to be implemented.

It is important to highlight that a high value of multicollinearity can have a strong impact on the cluster analysis, since it could overweight the effect of a set of dimensions with respect to the other considered in the analysis. The literature suggests a set of measures to cope with multicollinearity with the aim of both standardizing and reducing the effects of high correlations.

Clustering algorithms

In order to obtain reliable results, it is required to choose the proper clustering algorithm, selecting between hierarchical and non-hierarchical methods. The former are based on a tree structure and can be furtherly categorized according to their agglomerative or divisive nature, i.e. the way in which results are achieved either by respectively combining different features or erasing elements in the process. Agglomerative techniques, such as single linkage, complete linkage, average linkage, centroid method and Ward's method, aim to measure the distance between clusters leveraging different mathematical procedures. Since each of these approaches has systematic proclivities, the most suitable solution to adopt strictly depends on the characteristics of datasets available. Divisive methods can be either monothetic or polythetic, applied respectively if variables are dichotomic or not. In the first case, clusters are divided considering the presence or absence of a specific characteristic and this iterative process is then applied to individual observations. In the second technique the whole sample is taken as a single cluster, and then divided till each of its elements becomes a stand-alone group. Polythetic approaches can therefore be considered as specular to agglomerative methods. Hierarchical algorithms can generate unstable clusters whenever the number of observations is limited reducing consequently the scientific validity of the results. Differently from hierarchical processes, non-hierarchical techniques provide for the definition of the number of clusters at the beginning of the analysis. The iterative steps to be followed in order to obtain the final results are the same for each of the different approaches that can be implemented while running predetermined clustering. Indeed, k-means and similar methods start from the evaluation of centroids for each cluster, i.e. "the 'center points' of clusters along input variable" (Ketchen and Shook, 1996 [142]). The following phase consists in associating each sample element to the cluster whose centroid has the lowest distance from the considered observation. These two steps are repeated until no element moves to a different cluster with respect to the belonging one in the previous iteration. Broadly speaking, non-hierarchical methods, which are based on subsequent aggregations, benefit from a lower effect of outliers in groups determination and both from a higher homogeneity in within clusters and heterogeneity between different clusters. These advantages come from the possibility of elements to change the cluster to which they belong in the iteration process.

Determining the number of clusters

When determining the optimal number of clusters, different methods can be exploited according to the clustering algorithms implemented in the analysis. For instance, dendrograms can be applied while relying on hierarchical approaches since they are based on the sequence in which elements are associated to clusters.

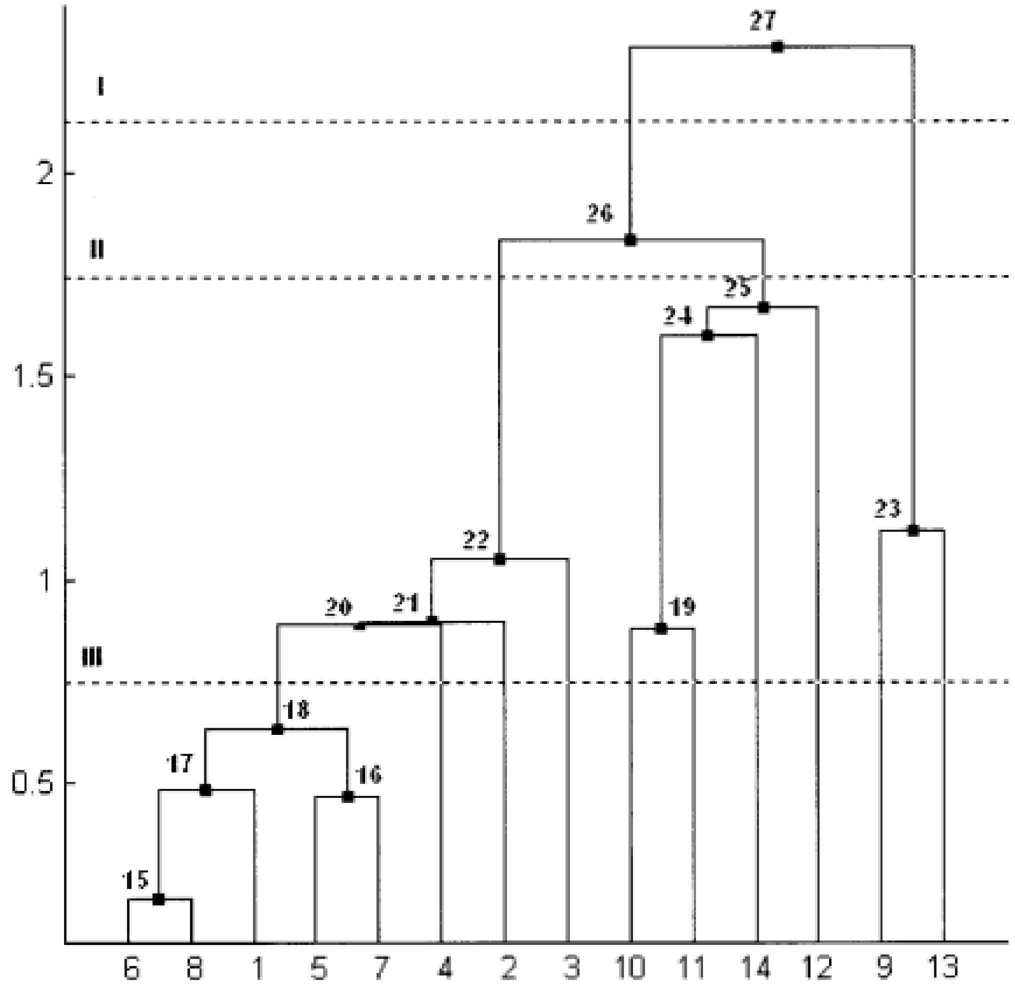

Figure 3.6: Dendrograms representation, Stanberry et al. (2003) [143].

In non-hierarchical methods, instead, the quality and effectiveness of the aggregation process can be measured by specific parameters such as the agglomeration coefficient. By evaluating this measure for different number of clusters, it is possible to determine their optimal amount by drawing the so-called Elbow graph.

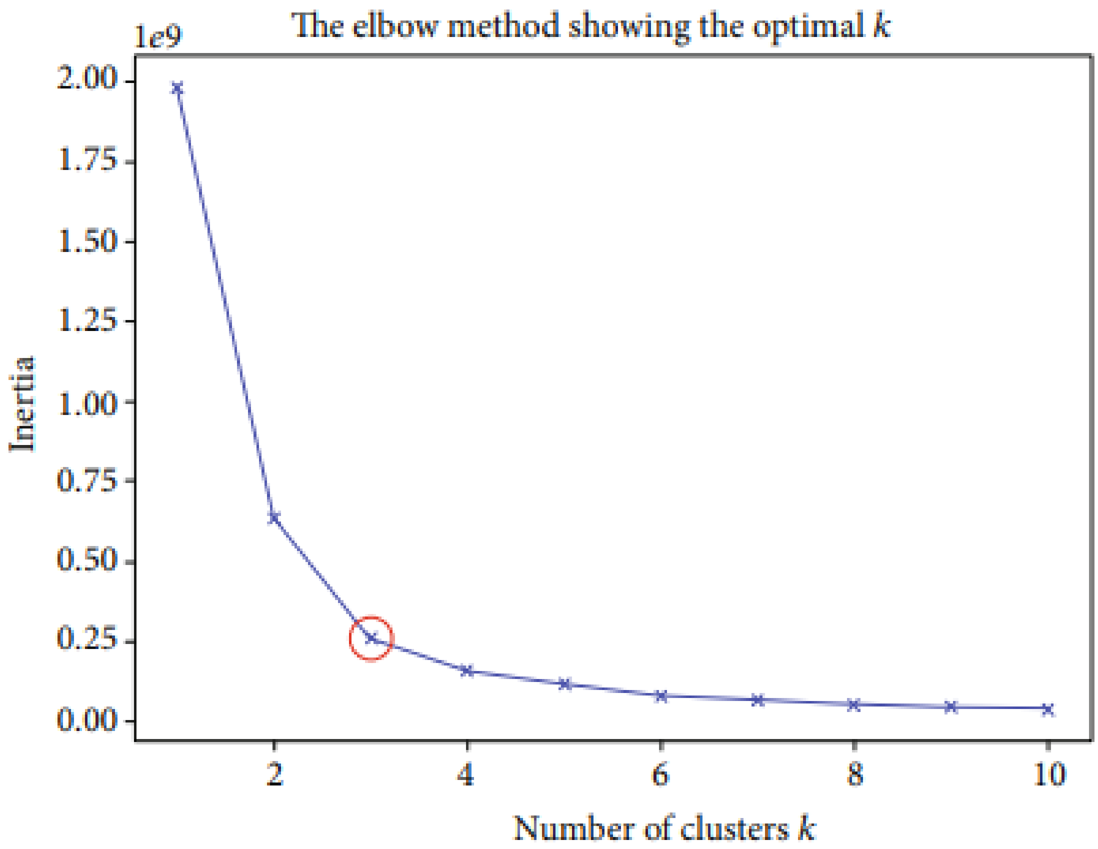

Figure 3.7: Elbow method representation, Et-taleby et al. (2020) [144].

When the obtained line starts to flatten, adding another cluster does not bring any improvement in the results since the generated groups are enough heterogeneous among each other. Despite the intuitiveness of the Elbow graph, its interpretation can be complex whenever there is not an evident difference in the steepness of the line that links agglomeration coefficients. Another possible technique is the cubic clustering criterion (CCC), which rely on both the heterogeneity among clusters and the homogeneity in within them. The most efficient number of clusters is the one in which the CCC has the highest value, despite a stream of the literature sustains that this measure leads to an excessive amount of clusters.

Validating clusters

Clusters validation is a process necessary to guarantee the soundness of the obtained results to optimize the representation of the sample through related outcomes. If a cluster analysis is run several times changing the clustering methods and the results obtained are similar, the outcome benefits from a sufficient reliability. After the reliability is ensured, it is possible to test the validity of the identified clusters. Several methods can be followed in order to obtain statistical figures able to check the solidity of the clustering process outcome. Among the most intuitive ones, it is possible to mention the silhouette test that evaluates the extent to which an object is similar to the related cluster. This measure ranges from –1 to +1 and the higher the value obtained, the more valid is the cluster analysis. Other possible techniques are the MANOVA and the F-statistic. The former is the multivariate analysis of the variance and can be implemented to compare multivariate sample means whenever there are at least two dependent variables. The latter can be exploited to understand whether the means of two different populations are considerably different.

3.2.6. Application of methodology

After having described the theoretical background upon which the taxonomy of the platform business model in the new space economy, it is necessary to apply the methodology explained in the previous sections to the specific context of the research.

Meta-characteristic and users

In order to do so, it is required to start with the identification of the meta-characteristic, represented by the platforms capability to generate value in the new space economy. The objective of the research is to understand how the peculiarities of the platform business model can be applied to the dynamics of the new space economy. By highlighting the presence of patterns within the sample, the archetypes of platforms and of the respective value generation processes are described by focusing on which sides are involved and the mechanisms platforms exploit to make users join the network. The new space economy represents a profitable context of application for the platform business model thanks to a series of features, such as its cross-industry nature and the consequent interactions between actors who belong to different markets and value chains. This leaves rooms to the possibility to generate benefits leveraging strong indirect network effects and giving the opportunity to enter different markets with more easiness, avoiding a massive redeployment of resources. Moreover, the outputs of the new space economy are not represented exclusively by goods, indeed satellite data represent the core offering of several firms belonging to the context. This aspect can be exploited by platforms in their value generation processes by leveraging the improvements of specific technologies, such as the machine learning.

The meta-characteristic should reflect the purpose of the taxonomy itself which in turn should be determined based on the taxonomy users, embodied by investors, regulators and researchers. The choice of these actors arises from the novelty of the study and the need to discover and analyse the consequent business opportunities. Investors are the ones responsible for the growth and the development of new industries through their financial resources and their business knowledge. Regulators are accountable for the establishment of laws necessary to ensure competition and to protect the social welfare. Academic researchers can provide new value to the context by deepening the results obtained in the study and generating insights in this field of application. The final objective is therefore to provide these actors with a framework about how an established business model, i.e. platforms, can be applied to an emerging context like the new space economy, which affect a large set of related industries.

Dimensions and characteristics

In order to develop the taxonomy, the definition of the dimensions and the characteristics, which represent respectively the variables and their possible values in the cluster analysis, is the first step to be implemented. This choice relies on both platforms and new space economy literature and aims to define independent variables able to properly identify key features of the value generation process. The following table summarizes the dimensions and the characteristics, giving an overview of their meanings and their theoretical references.

Table 3.1: Dimensions and characteristics

Dimension	Description	Characteristic	Theoretical reference
Scalability	Variable that explains the level of scalability of a platform in the new space economy	Low Medium High	"It is the digitized, non-material nature of such goods and services that gives them the potential for high scalability [...] Business model scalability is the extent to which a business model design may achieve its desired value creation

			and capture targets when user/customer numbers increase and their needs change, without adding proportionate extra resources [...] scale economies are particularly obvious in digital businesses, as the development costs of products and services are high, but the marginal cost of adding another customer is negligible […] scalability is enhanced by the dynamics of learning by using, network externalities […]" Zhang et al. (2015)
Platform typology	Variable that explains whether the platform acts as marketplace, information/data provider or innovation hub	Complementary innovation Information Multi-sided transaction	"In complementary innovation markets platforms are primarily innovation engines, providing the core technological architecture other firms build upon to create new products that extend the core functionality and reach of the platform to final users [..] In information markets, the platform serves primarily as an information channelling infrastructure that enables the categorization and search of relevant information, and facilitates users' exchange of

			information and matching [..] In a multi-sided transaction market, the platform's main role is providing the infrastructure to connect providers of goods and services with final customers, and facilitate value-exchange transactions among them" Cennamo (2023) [25]
Network architecture	Variable that identifies whether users represent both the demand and the supply side	Peer-to-peer (distributed) Not distributed	"A distributed network architecture may be called a Peer-to-Peer (P-to-P, PZP, ...) network, if […] the participants of such a network are thus resource (Service and content) providers as well as resource (Service and content) requestors" Schollmeier (2001) [145]
Competitive domain	Variable that identifies whether the platforms' scope is s limited to a single industry or affects adjacent markets	Core domain Core domain and adjacent markets	"Also, platform envelopment and competitive dynamics can lead to the shifting of the competitive domain and redefinition of the market boundaries; platforms may soon find themselves competing into a larger market domain resulting from convergence of previously separate, adjacent markets"

			Cennamo (2023) [25]
Space segment	Variable that describes if a company operates in the downstream of the upstream segment of the space economy	Downstream Upstream	"The upstream segment representing the scientific and technological foundations of space programmes (e.g. science, R&D, manufacturing and launch) […]. The downstream segment (space infrastructure operations and "down-to-earth" products and services that directly rely on satellite data and signals to operate and function)" OECD Handbook on Measuring the Space Economy (2022) [132]

Business model scalability is defined as "the extent to which a business model design may achieve its desired value creation and capture targets when user/customer numbers increase and their needs change, without adding proportionate extra resources" (Zhang et al, 2015 [104]). Platform scalability is currently a discussed topic and therefore deserving of attention while carrying out a structured analysis on the value generation process. If it is true that platform business model is considered as easily scalable (Varga et al, 2023 [146]), it is interesting to evaluate if, in a particular context as the new space economy, the archetypes of identified platforms can still rely on a high degree of scalability peculiar to actors operating in broader industries. Amazon is the best fitting example of an extreme scalable business model, since it can be replicated everywhere without the deployment of any additional fixed resources. In order to properly quantify the level of scalability for each company in the sample, relying on Zhang et al. (2015) [104], four criteria are identified:

- The ability of the business model to improve the performance of the existing offering or to enlarge its scope effortlessly unlocking new capabilities to generate and deliver value
- The digitalization of the business model in term of the dematerialization of its internal structure and activities
- The limited amount of additional resources to be deployed to increase the size of the business
- The ability to exploit network externalities

According to the satisfaction of a specific number of criteria, each firm is classified with a degree of scalability ranging from low to high limited to the context of the new space economy. Indeed, among the 134 platforms in sample none of them is characterized by a scalability comparable to Amazon and similar business models. It is important to point out that, considering the adoption of the platform business model for all the startups included in the final sample, the degree of scalability is already higher than traditional companies, characterized by an extreme difficulty in scaling up their businesses. In fact, being platforms, the totality of enterprises in the sample satisfies the fourth criterion since indirect network externalities are a necessary condition for their business model. Consequently, according to the number of met criteria among the remaining three, a company level of scalability can be either low, medium or high. In the first case, even if the interface connecting the sides of the market is digital, the provision of value is based on some physical activities. Moreover, the capability to enlarge the business scope is limited and the required amount of resources to achieve this objective is consistent. The medium level requires a high extent of digitalization and the possibility to increase the customer base sustaining almost null marginal costs. However, the ability to exploit new sources of value creation is limited since it depends on the ability of the business to get on board both sides of the entry market. A high level of scalability is characterised by the satisfaction of all the four criteria.

The second dimension is represented by the platform typology, i.e. the core value proposition of the focal firm and consequently the relationships among the users of the network. According to Cennamo (2023) [25], there are three typologies of platform according to the type of market in which they run their business. Platforms can operate either in complementary innovation market, information market or multi-sided transaction market. "In complementary innovation markets platforms are primarily innovation engines, providing the core technological architecture other firms build upon to create new products that extend the core functionality and reach of the platform to final users". Consequently, the focal firm does not directly shape the final offering, that is modelled by the collaboration among the different sides of the network. “In information markets, the platform serves primarily as an information channelling infrastructure that enables the categorization and search of relevant information, and facilitates users’ exchange of information and matching”. The role of the platform is to collect and provide the actors involved with the information necessary to carry out their activities. “In a multi-sided transaction market, the platform’s main role is providing the infrastructure to connect providers of goods and services with final customers, and facilitate value-exchange transactions among them”. In this case, the platform acts as a marketplace in which transaction costs are strongly reduced and therefore facilitating the exchange between the buyer and the seller.

The network architecture focuses on the platform users and their role in the platform ecosystems. According to Schollmeier (2001) [145], a network is defined as a peer-to-peer if an actor covers the role both of the demand and the supply, otherwise its architecture is not distributed. BlaBlaCar is an example of the first typology, since a user can exploit the platform both to look for a ride and to find people which need it. Apple Store can represent a not distributed architecture since the final user can not directly upload an application on the platform. It is important to highlight that, if a person works in a firm which develop apps, it is more correct to consider the company itself as the supply side and not the single individual.

Competitive domain is a variable which connects the platform context to the new space economy. Indeed, since an activity of the new space economy can have an impact on several industries, it is interesting to understand whether a platform, whose objective is to increase the number of users in order to better exploit network externalities, can benefit from providing value to different markets. According to Cennamo (2023) [25], a platform can either compete only in its core domain or in it and the adjacent markets. The first possibility implies that a firm connects actors belonging to a single industry, while, in the second case, a company aims to bring on board actors from different industries.

The space segment is necessary to understand which is the position of a company in the new space economy value chain, following the definition of the OECD [132]. “The upstream segment representing the scientific and technological foundations of space programmes (e.g. science, R&D, manufacturing and launch)”, whereas “the downstream segment (space infrastructure operations and “down-to-earth” products and services that directly rely on satellite data and signals to operate and function)”.

Iterative process

After having provided an explanation about the dimensions and the related characteristics, following the method for a taxonomy development suggested by Nickerson et al. (2013) [1], an iterative process is carried out until the ending conditions are met. As previously explained in the section 3.4, subjective and objective ending conditions are the ones in tables in section 3. The clusters are obtained after three iterations in which a deductive approach is followed, i.e. running a cluster analysis progressively adding dimensions in order to guarantee both completeness and accuracy of the taxonomy. The main aspects of the iterations are highlighted in the following table.

Iteration 1

- Dimensions considered → "Platform typology", "Network architecture", "Scalability"
- Clusters obtained → Four
- Objective conditions → "No new dimensions or characteristics were added in the last iteration" not satisfied
- Subjective conditions → "Robust", "Comprehensive" and "Explanatory" not satisfied

Iteration 2

- Dimensions considered → "Platform typology", "Network architecture", "Scalability", "Core domain"
- Clusters obtained → Four
- Objective conditions → "No new dimensions or characteristics were added in the last iteration" not satisfied
- Subjective conditions → "Robust", "Comprehensive" and "Explanatory" not satisfied

Iteration 3

- Dimensions considered → "Platform typology", "Network architecture", "Scalability", "Core domain", "Space segment"
- Clusters obtained → Five
- Objective conditions → Satisfied
- Subjective conditions → Satisfied

Figure 3.8: Iterations of the cluster analysis

The first iteration is carried out taking into account three characteristics all strictly pertaining to the platform context, i.e. platform typology, network architecture and scalability. The consideration of these initial variables lies in the possibility to rely on an established literature and has the aim of first identifying firms taking into account elements which do not directly belong to the new space economy. It is important to highlight that, since the objective of the study is the development of a taxonomy of platform business model in the new space economy, whatever the results arising from this iteration, the clusters cannot be considered as exhaustive since they do not encompass any space related dimension. The first cluster analysis is run by relying on the platform typology, the network architecture and the scalability, and leads to the definition of four clusters which however do not satisfy both all objective and subjective conditions. Indeed, the level of detail is not sufficient and consequently a new dimension must be added in the next iteration, moreover the statistical tests conducted highlight a low homogeneity within the clusters. Therefore, the first iteration does not lead to significative clusters both form a conceptual and statistical point of view.

In the second iteration a new dimension is added in order to start taking into account some elements of the new space economy, and for this reason the cluster analysis is carried out with four variables, i.e. platform typology, network architecture, scalability and competitive domain. Even though an improvement in clusters homogeneity, similar firms still belong to different groups, reducing therefore the heterogeneity among them as highlighted by the silhouette analysis and the inertia. As the previous iteration the objective and subjective ending conditions are not satisfied and an additional dimension must be introduced to obtain meaningful clusters.

In the third iteration, the cluster analysis is carried out by taking into account five dimensions, by adding the space segment, which allows to understand the stage of the space value chain in which the specific company operates. The introduction of this dimension improves both the homogeneity within the clusters and the heterogeneity among them. It is important to highlight that five clusters are obtained, and the statistical tests verify the validity of the clusters from an objective point of view. The significance of the results is also sufficient to satisfy the subjective ending conditions and it is not necessary therefore to add a new dimension in the study and to carry out other iterations. Starting from analysing the Elbow’s graph, which should reflect the optimal number of clusters based on the inertia value, i.e. the sum of intra cluster squared distances, it is possible to see at least two flexing points. The first one is in correspondence of three clusters, however, as highlighted before, even with four clusters the level of homogeneity within groups is too high to consider the analysis explanatory enough. The second flexing point is visible looking at five clusters, with an inertia value of 32.5333. Adding another cluster and moving toward six and seven groups does not add any particular value to the context from a statistical point of view and therefore the optimal number of clusters to consider lies with five.

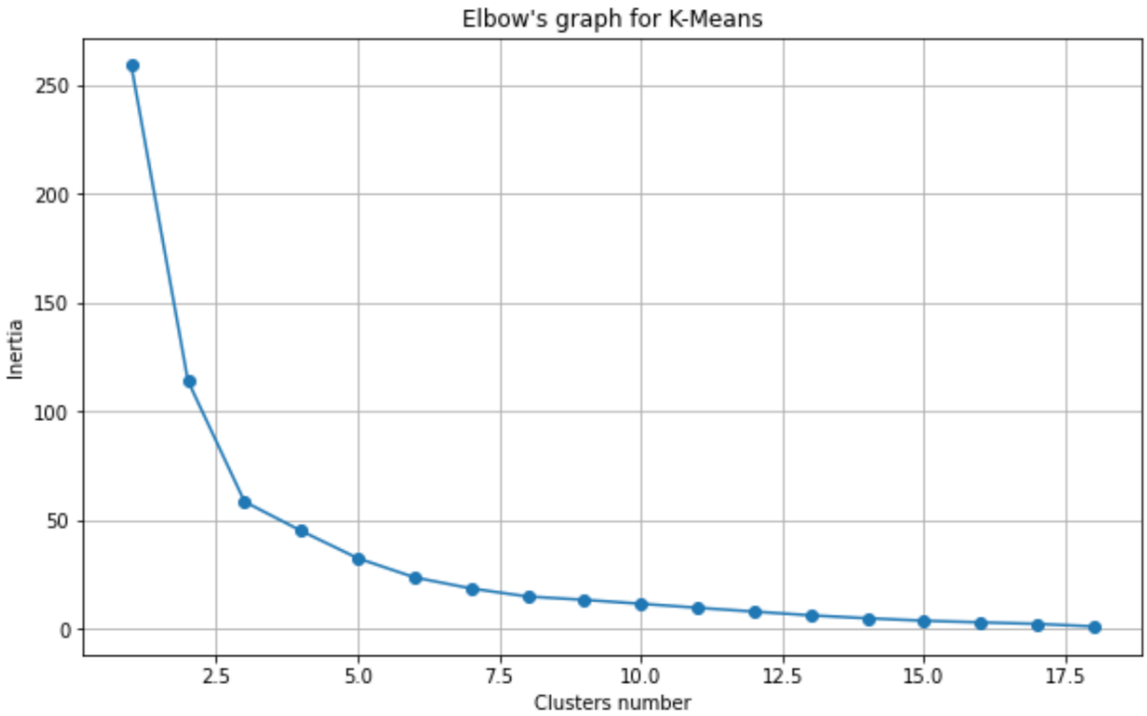

Figure 3.9: Elbow graph of the cluster analysis.

The Silhouette score, ranging between –1 and 1, is settled at 0.7364 and it measures the similarity of an observation with the pertaining cluster with respect to other clusters. Therefore, it gives both a representation of the cohesion within clusters and the separation among them. The higher the score the higher the quality of the cluster analysis. It is important to point out that, concerning this measurement, increasing the number of clusters leads to higher values; therefore, it can be used as an ex-post validation to verify that the optimal number of clusters is sufficiently explanatory.

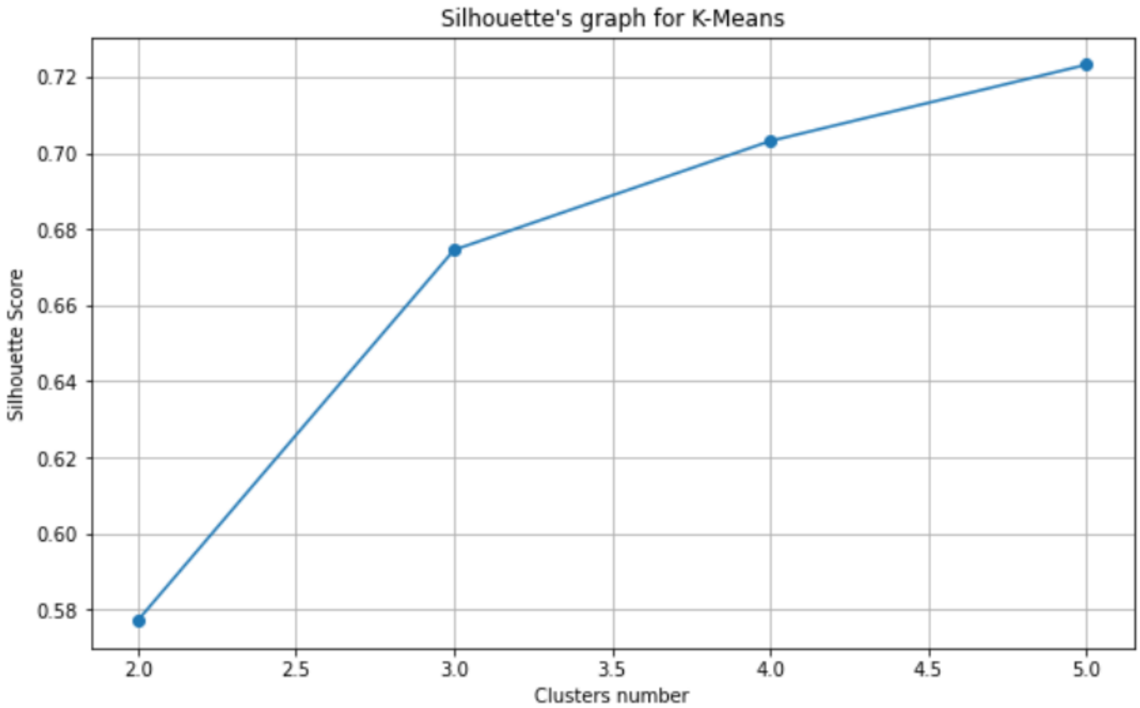

Figure 3.10: Silhouette graph of the cluster analysis.

In order to verify the validity of the results different tools can be exploited and the multivariate analysis of variance (MANOVA) gives the possibility to rely on different indicators. The table below represents the results of some indicators evaluated during the MANOVA with the aim of understanding whether there is a significative heterogeneity among the clusters obtained.

Multivariate linear model

x0	Value	Num DF	Den DF	F Value	Pr > F
Wilks' lambda	0.0955	5.0000	129.0000	244.4572	0.0000
Pillai's trace	0.9045	5.0000	129.0000	244.4572	0.0000
Hotelling-Lawley trace	9.4751	5.0000	129.0000	244.4572	0.0000
Roy's greatest root	9.4751	5.0000	129.0000	244.4572	0.0000

Figure 3.10: MANOVA results

The Wilk's lambda is a test statistic useful to assess group differences in a set of dependent variables and it ranges from 0 to 1. The null hypothesis states that there are not differences among clusters and a value close to 0 allows to reject this assumption. The result of this indicators suggests that there is a sufficient dissimilarity among the groups.

Pillai's Trace measures the proportion of the total variance in the dependent variables that can be attributed to group differences. A larger Pillai's Trace value, which is between 0 and 1, suggests a significant difference, and the result obtained indicates a relevant heterogeneity.

Hotelling-Lawley Trace is a multivariate test statistic that is sensitive to violations of the assumption of homogeneity of variance-covariance matrices. A larger value suggests a significant difference between groups. The result obtained is 9.4751, indicating differentiation among clusters.

Roy's Greatest Root is similar to the Hotelling-Lawley Trace, and also in this indicator, the higher the result, the more the clusters are different among themselves, therefore 9.4751 is a sufficient to verify that they are not overlapped.

The MANOVA is carried out with 5 degrees of freedom and the Fischer test gives a result equal to 244.45 and the p-value for each indicator is lower than 0.05 highlighting the validity of each result.

4 Findings

The cluster analysis identified five clusters which are the most suitable to describe the archetypes of platform business model in the new space economy, consistently with the meta-characteristic of the taxonomy. Relying on the reference sample, the five groups allow each platform to be included in one of them according to its main features. Moreover, taxonomy can help its users to adopt a reference language able to resume a set of a firm's characteristics under a cluster name. The five clusters, (1) "Scientific and technological foundation platforms", (2) "New space economy cloud platforms", (3) "Crowdinvesting platforms for SDGs", (4) "Public-private information platforms", (5) "Space-enabled services marketplace platforms", are labelled according to their attributes and to the existing related literature.

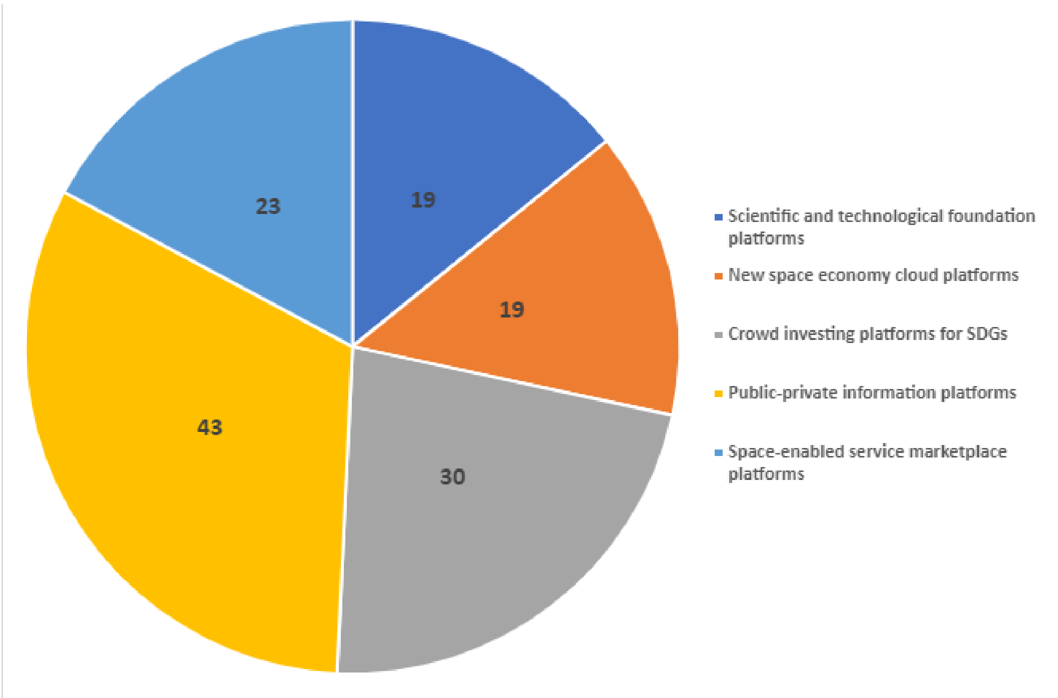

Figure 4.1: Clusters' frequencies.

4.1. Scientific and technological foundation platforms

The "Scientific and technological foundation platforms" cluster includes companies whose business model aims to connect players who provide services related to the development and enablement of the space economy, such as infrastructure, R&D and education services, among which universities and institutional collaborations. Other typologies of users which join such networks are represented by spacecraft and other space infrastructure manufacturing companies. The presence of public entities in these platforms' network is frequent for two main reasons. First, the companies belonging to the ecosystem are often involved in space-related R&D activities, which generate interest for the public sector since innovations can benefit a multitude of firms improving therefore the social welfare. Second, the activities performed by platform actors are necessary for the realization of space missions, carried out by public institutions in the traditional space economy framework. Since all enterprises in this cluster operate in the upstream space segment, the cluster name takes inspiration from this stage of the space value chain defined by the OECD [132] as "the scientific and technological foundations of space programmes, manufacturing and production of space infrastructure". Outside of this cluster there are all platforms which are not involved in R&D activities, education programmes and manufacturing services of space infrastructure.

Table 4.1: Cluster 1 characteristics

Platform typology	Space segment	Network architecture	Competitive domain	Scalability
Complemen-tary innovation	Upstream	Peer-to-peer	Core domain and adjacent markets	Low

The table above resumes the main characteristics of the companies belonging to the cluster. Starting from the platform typology, these firms are involved in complementary innovation markets; indeed, they connect companies which aim to provide innovative technologies and advanced knowledge to the new space economy. In this context some players launch R&D projects and other users decide to join them to realize goods and technologies able to generate value to the whole space value chain. The outputs of the collaborations aim to improve technologies exploited for the propulsion and cooling systems of spacecrafts, telecommunications techniques and the training of the astronauts. One of the most recurrent topics nowadays is represented by the removal of space debris, which are necessary to the protection of space infrastructure and therefore the continuity of space activities. As previously pointed out, these platforms operate in the upstream stage, and they are an example of a peer-to-peer network architecture. In fact, companies which propose innovative projects are frequently involved in initiatives started from other users of the network. The same user can both launch an innovative project and contribute to initiatives started by other actors in the ecosystem, having therefore the possibility to belong to the two sides of the network. Given the cross-industry nature of the new space economy and considering that these companies are located in the first stage of the value chain, their activities involve actors belonging to different markets. A platform which connects actors who search specific technologies and components for a space mission facilitates the collaboration between players which provide the space propulsion, the telecommunication systems and other software necessary to the realization of the activity. Despite the adoption of a platform business model, these firms have a limited level of scalability. Indeed, the specificity of the assets required to carry out the activity and the consequent difficulty to redeploying them prevent these companies from seamlessly adding new value sources to their revenue streams. Furthermore, although being digital platforms, the level of dematerialization is constrained by the physical nature of the activities necessary to run the business. Among the representative companies of this cluster, firm 1 is explanatory of the previous characteristics. Indeed, this business is a spin-off of a university and aims to connect other startups looking for financing from other investors and for support in the development of innovative products and services. Therefore, this platform is able to connect actors from the financial sectors with manufacturing or service companies which operate in several markets. Moreover, except for financiers, companies can both launch projects and be engaged in other initiatives started from other users. The scalability of the company is bounded by the fact that the projects launched by a side of the market are mainly related to R&D activities, which imply the management of complex dynamics between parties and the deployment of a consistent amount of specific resources. Firm 2 is another fitting example of this cluster, since it is a network connecting space infrastructure manufacturing businesses and several actors in other markets which offer and ask for components to develop other products for space missions. Companies can cover the role of supply and demand in this relationship and the level of scalability of the platform is constrained by the specificity of the projects in the ecosystem. Firm 3 belongs to the “Scientific and technological foundation platforms” cluster since it is able to offer a network in which companies of different sectors collaborate to realize space missions. The actors can both ask for some components and services and supply them to other players. The high level of specialization required to carry out the intermediation activity constraints the platform to a low level of scalability.

4.2. New space economy cloud platforms

The "New space economy cloud platforms" cluster encompasses companies whose business model is focused on the collection, elaboration and provision of data from and to different actors, leveraging technologies such as machine learning, cloud computing and artificial intelligence. The definition of the cluster naming is shaped starting from the literature on digitalization and its impact in the industry management domain. In particular, according to Stone et al. (2017) [147] "Industry clouds are defined as cloud-based services that provide broad industry value by aggregating cost reduction, operational benefits, risk mitigation and/or insight creation via pooled information. The two types of industry clouds are: (1) where a company provides cloud-based services to other companies in their industry; and (2) a cloud-based platform through which companies in an industry collaborate towards a common goal, such as improving industry insight and/or capability". Outside of this cluster there are all platforms which do not create a collaborative environment for data collection, processing and distribution, but simply generate revenues by selling them without any further elaboration.

Table 4.2: Cluster 2 characteristics

Platform typology	Space segment	Network architecture	Competitive domain	Scalability
Information	Downstream	Not distributed	Core domain and adjacent markets	High

The table shown above summarizes the main characteristics of the companies belonging to the cluster. Starting from the platform typology, the included firms run their businesses in information markets since their main activity is to provide users with a cloud infrastructure where data are collected, stored and exchanged between parties, generating value from derived activities. The data collected, processed and shared in the platform are the foundation upon which information is built by the demand side of the network. It is important to highlight that, however, the network architecture of the cluster is not distributed since one side of the market, represented by satellite infrastructures' owners, always cover the role of the supply and the other, characterized by companies in the following stage of the value chain, constitutes the demand side. The platforms belonging to this cluster operate in the downstream stage considering that they do not contribute to the creation of spacecrafts and satellites necessary to collect data, but simply manage their aggregation, elaboration and distribution through a digital infrastructure. The actors connected through these networks belong to different industries, since the data exchanged within the platform be useful for environmental purposes and for the processes of companies belonging to the logistic, insurance and maritime sector. Given the nature of data platforms and the almost null marginal costs to sustain while pushing an expansion of the customer base, the scalability level is high. The fixed costs to build the digital infrastructure necessary to run the business are significative, but they represent the only consistent investments sustained by these platforms. The technologies exploited by these platforms, such as the machine learning and the cloud computing need a high quantity of data to perform at their full potential, without however increasing the marginal costs. These features allow therefore these platforms to benefit from a high level of scalability. The representative companies of this cluster shared a very similar business model since they both rely on geospatial public datasets to provide services to other enterprises. Firm 4 is specialized in providing data upon which information is build and delivered through products and services build by the demand side of the network. Considering the adaptability of spatial data and their usefulness, the platforms is able to attract different actors belonging to several markets. Indeed, company 4 involves firms coming from sectors like the environment-related ones and the maritime industry. The flexibility of the platform infrastructure allows the possibility to easily and seamlessly interconnect a wide range of players increasing the ability to scale up by enlarging its business scope and unlocking new sources of value generation. Firm 5 leverages machine learning to create a single cloud where the actors involved upload raw data coming from public satellites in order to obtain insights useful for their decision- making process. As for firm 4, the companies belonging to different industries join the network and facilitate the generation of additional revenue streams. Moreover, the high level of scalability is enhanced by the fact that strongly relying on machine learning, the more the data to process, the higher the benefit the algorithm is able to deliver and consequently, the attractiveness of the platform itself increases. Firm 6 is a representative startup of the "New space economy cloud platforms" cluster and it leverages machine learning to create a single cloud where the actors involved upload raw data coming from public satellites in order to obtain insights useful for their decision- making process. A lot of companies belonging to different industries join the network and facilitate the generation of additional revenue streams. Moreover, the high level of scalability is enhanced by the fact that strongly relying on machine learning, the more the data to process, the higher the benefit the algorithm is able to deliver and consequently, the attractiveness of the platform itself increases.

4.3. Crowdinvesting platforms for SDGs

The companies belonging to the cluster named "Crowdinvesting platforms for SDGs" are all platforms which connect initiators of SDG related projects and investors interested in sustainable activities. According to Horisch and Tenner (2020) [148], "in order to substantially contribute to sustainable development and to finance growth-oriented sustainable ventures, investment-based crowdfunding seems the most relevant approach", and this definition represents the reason of the cluster's denomination. The companies within this group are committed to the achievement of three main sustainable development goals, among the seventeen defined by the United Nation Department of Economics and Social Affairs [149]:

- Goal 2, "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"
- Goal 13, "Take urgent action to combat climate change and its impacts"
- Goal 15, "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"

These firms are mainly involved in financing agricultural projects in developing countries and in the management of forestry in high-risky areas. Investors are mainly individuals; however, some institutions can join the platform network. All platforms which do not provide any financing service, and which are not involved in the development of SDGs related activities are not included in this cluster.

Table 4.3: Cluster 3 characteristics

Platform typology	Space segment	Network architecture	Competitive domain	Scalability
Multisided transaction	Downstream	Not distributed	Core domain	Medium

These platforms run their business in multisided transaction markets considering that several types of users are connected to the network. In fact, the transaction happens between the projects' initiators and the financiers, however other actors are often involved, such as companies which issue carbon certificates and advertisers. It is important to explain that some platforms in the cluster are also able to directly track the carbon emission and provide the related certificates, which can represent a solution to the information asymmetry which the investors can suffer from. Indeed, a third party or the platform itself can confirm the SDG related results that the project can achieve. All these companies operate in the downstream segment since they exploit satellite data, for example to measure carbon emissions directly from space. Since these platforms clearly distinguish the roles of the two sides involved in the transaction, the network architecture is not distributed. Moreover, the demand includes firms looking for financing, while the supply side is represented by individuals which invest in these initiatives. Each firm is specialised in a single market; indeed, some companies are focused only on sustainable agriculture while others exclusively on the forestry management. The scalability level of these platforms could be higher since the marginal costs to manage a transaction are limited; however, some processes, such as the issue of carbon certificates, require a consistent amount of resources to be completed. The firm 7 is a representative observation for this cluster since it is a company which certificates the carbon emissions for sustainable forestry objectives and connect the investors with the actors involved in these projects. The platform is specialized in this specific sector and the tasks required for the certificates do not allow the company to achieve a high degree of scalability. The firm 8 has a similar business model to firm 7, since it is specialized in the environment sustainability, and it fosters SDGs related projects to be financed not only by individuals, but also by insurance and financing companies. Firm 9 is a representative business of "Crowdinvesting platforms for SDGs" cluster taking into account that it is involved in the financing of projects related to agricultural practices in emerging countries favouring the supply of food for local communities. The processes to be implemented in order to manage the right allocation of the collected fundings bound the level of scalability of the platform itself.

4.4. Public-private information platforms

The "Public-private information platforms" cluster comprehends companies which generate value by facilitating activities in different industries, such as the mobility and logistics, through the provision of processed information coming from satellites' data. The definition of the cluster naming refers to the literature on public and private interactions as a mechanism to support social welfare maximization. In this specific context, according to Klievink et al. (2016) [150] public–private platforms are "a governance structure and information infrastructure interconnecting two or more distinct types of affiliated and collaborating actor groups, from both the public and the private sector". Outside of this cluster there are all the platforms which share raw data and do not deal with the distribution of information to the network.

Table 4.4: Cluster 4 characteristics

Platform typology	Space segment	Network architecture	Competitive domain	Scalability
Information	Downstream	Not distributed	Core domain	High

The table above highlights the main attributes of the companies belonging to the fourth cluster. Focusing on the platform typology, these businesses operate in information markets since their main activity is to provide users with a digital infrastructure where information is provided to a side of the network by elaborating data coming from the other one, generating value for the platform ecosystem. The network architecture of the cluster is not distributed since the flow of information moves from the public sector towards the private one; indeed, the former collect data which are exploited by the platform to generate information that is provided to the latter. It is interesting to underline that these platforms focus on single industries at once. The most targeted sectors by cluster 4 platforms are the mobility, the maritime and the tourism. This does not negatively affect their scalability level, considering that, in any case, the value generation process follows the same configuration for each targeted space-derived sector. The provision of information is in fact the core activity for all the companies belonging to this cluster and the replication of the business model in other geographical areas or industries is almost costless from an asset redeployment perspective. This makes cluster 4 startups easily scalable. These firms operate in the downstream stage considering that they only rely on satellite data and are not involved in any manufacturing process through which the leveraged space infrastructures are built. The first representative company of the cluster, i.e. firm 10, is a platform that provides services in the mobility industry. It connects public transportation companies with citizens through a digital interface with the aim to optimize the users flow and provide relevant information which can impact the social welfare. All the information processed are collected via satellites, which, together with a standardized digital infrastructure, allow a fast and costless replication of the business model in other urban areas and sectors. In this case, the public institution covers the role of the supply, providing data through satellites about traffic dynamics and citizens flows, while individuals represent the demand when using the platform looking for information. Firm 11 focuses instead its activities in the maritime logistic sector, and it is specialized in the optimization of port operations. It is evident the similarity of the business model setting with firm 10, suggesting again a high degree of scalability thanks to the possibility of a seamless replication and negligible marginal costs. Being the port a public infrastructure, there is the involvement of the public and private sector, represented by maritime and ship crafts companies, that are turning to the platform to gather useful information about cargo and passengers flows to maximize their respective objectives. Another representative business of the "Public-private information platforms" cluster is Firm 12 taking into account that it is a platform that provides services in the mobility industry. It connects public transportation companies with citizens through a digital interface with the aim to optimize the users flow and provide relevant information which can impact the social welfare. All the information processed are collected via satellites, which, together with a standardized digital infrastructure, allow a fast and costless replication of the business model in other urban areas and sectors. In this case, the public institution covers the role of the supply, providing data through satellites about traffic dynamics and citizens flows, while individuals represent the demand when using the platform looking for information.

4.5. Space-enabled service marketplace platforms

The companies able to match the offer and the demand for services built on satellite data are collected in the "Space-enabled service marketplace platforms" cluster. According to Moreno and Terwiesch (2014) [151], "in online service marketplaces, buyers (firms or individuals) post tasks they would like to procure and sellers bid for them". It is important to highlight that, while the offer side includes both firms and individuals, the supply side is exclusively represented by companies. These marketplaces connect actors who offer and look for services which rely on the outputs of the new space economy, often represented by satellite data. This is the reason of the definition of space-enabled service marketplace platforms. All companies with a similar business model, but which do not act as a marketplace, or which offer financing, data and information are not included in this cluster.

Table 4.5: Cluster 5 characteristics

Platform typology	Space segment	Network architecture	Competitive domain	Scalability
Multisided transaction	Downstream	Not distributed	Core domain and adjacent markets	Medium

The firms in this sample operate in multisided transaction markets, where several actors benefit from the increasing number of the other typologies of users. Indeed, the higher the number of companies which offer the service, the higher the interest of buyers to join the platform. Indeed, the latter have the possibility to choose from different sellers, exploiting the better differentiation and the higher competition. Symmetrically, users which sell services are more willing to join a platform with a high number of actors asking for these goods. These two sides represent the key typologies of users, however also advertisers and other actors, such as online payments companies, are connected to the network. This cluster does not collect any company which is involved in the realization of space infrastructures and therefore these firms are included in the downstream stage of the space value chain. In these platforms, companies selling services are separated from the ones which buy them, and the role between the two typologies of users cannot be exchanged. Consequently, the architecture of this network is not distributed. Moreover, supply and demand represent respectively the input and the output of a value chain segment, not allowing a firm to cover the two roles. The actors connected to the network belong to different markets, indeed a company which offer a service can adapt its offering according to the requests of customers. The reason behind the medium level of scalability is represented by the need to perform complementary activities to verify users' proficiency, since the low marginal costs to connect other users would allow the platform to be highly scalable. Firm 13 is an example of this cluster since the company features are consistent with the ones of this typology of platform. The company is a marketplace for goods related to the construction of buildings, such as IoT and software services. The businesses responsible for the construction of the building can search other companies able to offer the necessary services on the platform. The service can be sold to firms which belong to different markets, and the buyers request can require a high level of expertise to be carried out. The processes necessary to verify the service supplier competence reduce the level of scalability of the platform whose low marginal costs would be a great opportunity for the company to scale up. Firm 14 is a company which connects users able to offer services in the agriculture and forestry, such as the verification of carbon certificates, and firms which compete in these areas. For the sake of clarity, this company is different from firm 7, since the former is a marketplace for services, while the latter focuses on financing activities. The scalability degree is medium since the processes necessary to efficiently connect users involve additional resources, while the low marginal costs to increase the number of users would are able to increase the ability of scaling up of the company. Another representative firm of the "Space-enabled service marketplace platforms" cluster is Firm 15 since it is a marketplace for goods related to the construction of buildings, such as IoT and software services. The businesses responsible for the construction of the building can search other companies able to offer the necessary services on the platform. The service can be sold to firms which belong to different markets, and the buyers request can require a high level of expertise to be carried out. The processes necessary to verify the service supplier competence reduce the level of scalability of the platform whose low marginal costs would be a great opportunity for the company to scale up.

Table 4.6: Clusters' description

Name	References	Included	Excluded
Scientific and technological foundations platforms	"[the upstream activities are the] scientific and technological foundations of space programmes, manufacturing and production of space infrastructure", OECD Handbook on Measuring the Space Economy (2022) [132]	All B2B platforms providing services related to the development of the space economy, such as infrastructure R&D and education services (university/institutional collaborations). It also includes manufacturing services and strartups' accelerators	All platforms which are not involved in research and development, education and spacecraft manufacturing services

New space economy cloud platforms	"Industry clouds are defined as cloud-based services that provide broad industry value by aggregating cost reduction, operational benefits, risk mitigation and/or insight creation via pooled information. The two types of industry clouds are: (1) where a company provides cloud-based services to other companies in their industry; and (2) a cloud-based platform through which companies in an industry collaborate towards a common goal, such as improving industry insight and/or capability", Stone et al. (2017) [147]	All platforms whose business model focuses on the collection of data, their processing and distribution from and to different actors leveraging technologies such as machine learning and cloud computing	All platforms which do not create a collaborative environment for data collection, processing and distribution, but simply generate revenues by selling them

Crowdinvesting platforms for SDG	"In order to substantially contribute to sustainable development and to finance growth-oriented sustainable ventures, investment-based crowdfunding seems the most relevant approach", Horisch and Tenner (2020) [148]	All platforms connecting projects and potential investors in SDGs related activities such as forestry protection, sustainable agriculture and carbon offset	All platforms which do not support any financing activity
Public-private information platforms	"Public–private platform as a governance structure and information infrastructure interconnecting two or more distinct types of affiliated and collaborating actor groups, from both the public and the private sector", Klievink et al. (2016) [150]	All platforms which deal with providing processed information (not raw data) to facilitate an activity, such as mobility and logistics	All platforms which distribute raw data and those that do not deal with the provision of information
Space-enabled service marketplace platforms	"In online service marketplaces, buyers (firms or individuals) post	All platforms that match the offer and the demand for industry specific services, which	All platforms which do not provide a market for services

	tasks they would like to procure and sellers bid for them", Moreno and Terwiesch (2014) [151]	are not linked to data or funding	

The Figure 4.2 is a simplified two-dimensional representation of the clusters according to the platform typology and the competitive domain, which are the two platform features suggested by Cennamo (2023) [25]. Moreover, the colour of each box indicates the level of scalability of the companies belonging to the cluster.

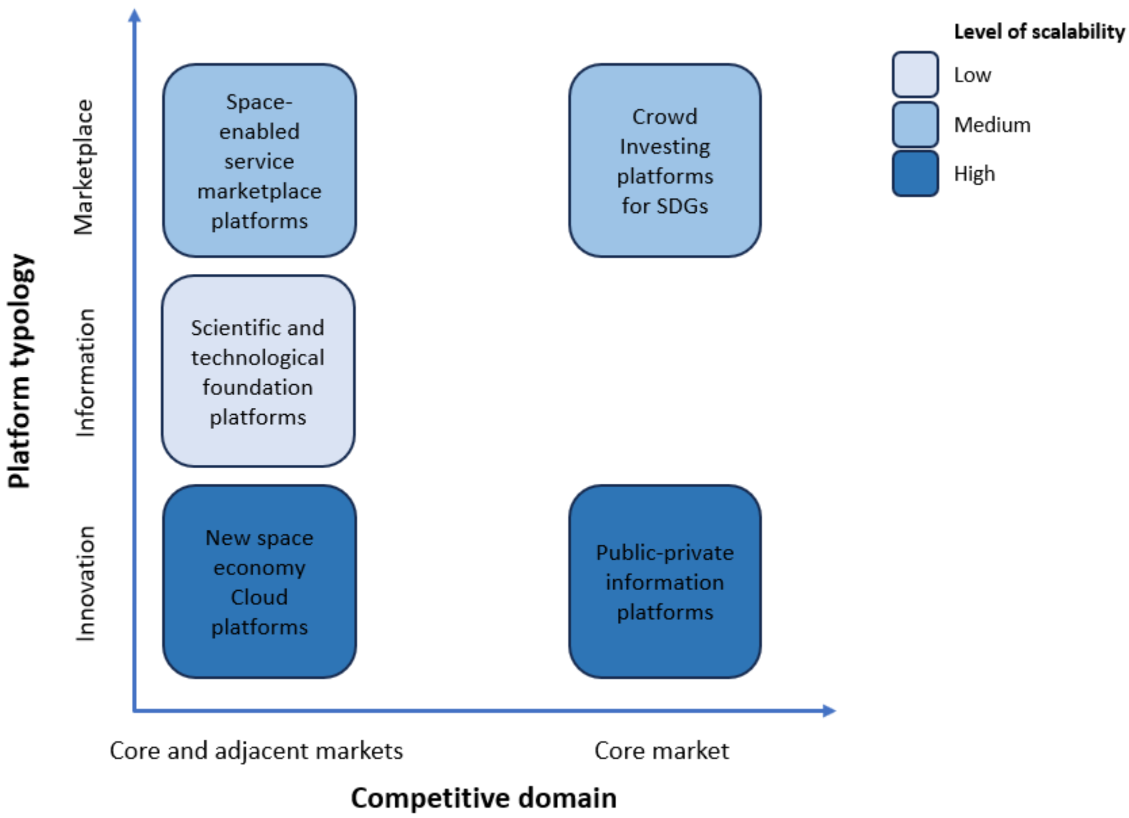

Figure 4.2: Simplified two-dimensional representation of the clusters.

The choice to represent an additional dimension allows to merge established criteria for the categorization of the platforms with a current and highly discussed topic such as the scalability. In this way it is possible to understand whether the new space economy is a favourable environment for companies to exploit the dynamics within and consequently scale up their business.

5 Discussion

The cluster analysis led to the identification of a complete set of variables necessary to define the main archetypes of platform business models in the new space economy: (1) "Scientific and technological foundation platforms", (2) "New space economy cloud platforms", (3) "Crowdinvesting platforms for SDGs", (4) "Public-private information platforms", (5) "Space-enabled services marketplace platforms".

The numerosity of each cluster allows to highlight the high frequency of public-private information platforms, whose firms represent the 32% of the whole sample. Therefore, this result confirms the participation of both public and private sector in the new space economy and the strong existing interaction among them. In particular, the main role of public actors is the participation in the realization of spatial infrastructure and the collection of satellite data, which enable the activities performed in the downstream stage. The platform acts as a bridge between the public and the private sector by converting the raw data provided by the former in available information for the possible streams of derived down-to-earth activities, such as mobility and smart city mobile applications. These platforms can be furtherly divided into the ones which completely rely on public satellites, and the ones that exploit their own space infrastructure to integrate the set of information representing the value proposition of the firm toward the private side of the network. According to its own objective, the user can furtherly elaborate the information to deliver derivative products and services, or simply exploit its meaning without adding any value.

Together with public-private information platforms, new space economy cloud platforms operate in information markets. Companies which compete in this type of sector represent almost the half of all firms in the sample, highlighting the crucial role of space data and their versatility in the value generation process of different markets. It is possible therefore to point out the cross-industry nature of the new space economy, and consequently the possibility for the platforms to enter several value chains. Moreover, new space economy clouds exploit advanced technologies such as machine learning, artificial intelligence and blockchain, whose attractiveness could lead to an increasing number of firms belonging to this platform archetype. The core offering of these companies is not limited to the connection of actors which provide and exploit data but includes also additional services to store and elaborate the amount of raw data available for the users. Thanks to their features, new space economy cloud platforms act as a bridge between the upstream and downstream sectors, by enabling companies in the latter to filter and elaborate the data provided by the former.

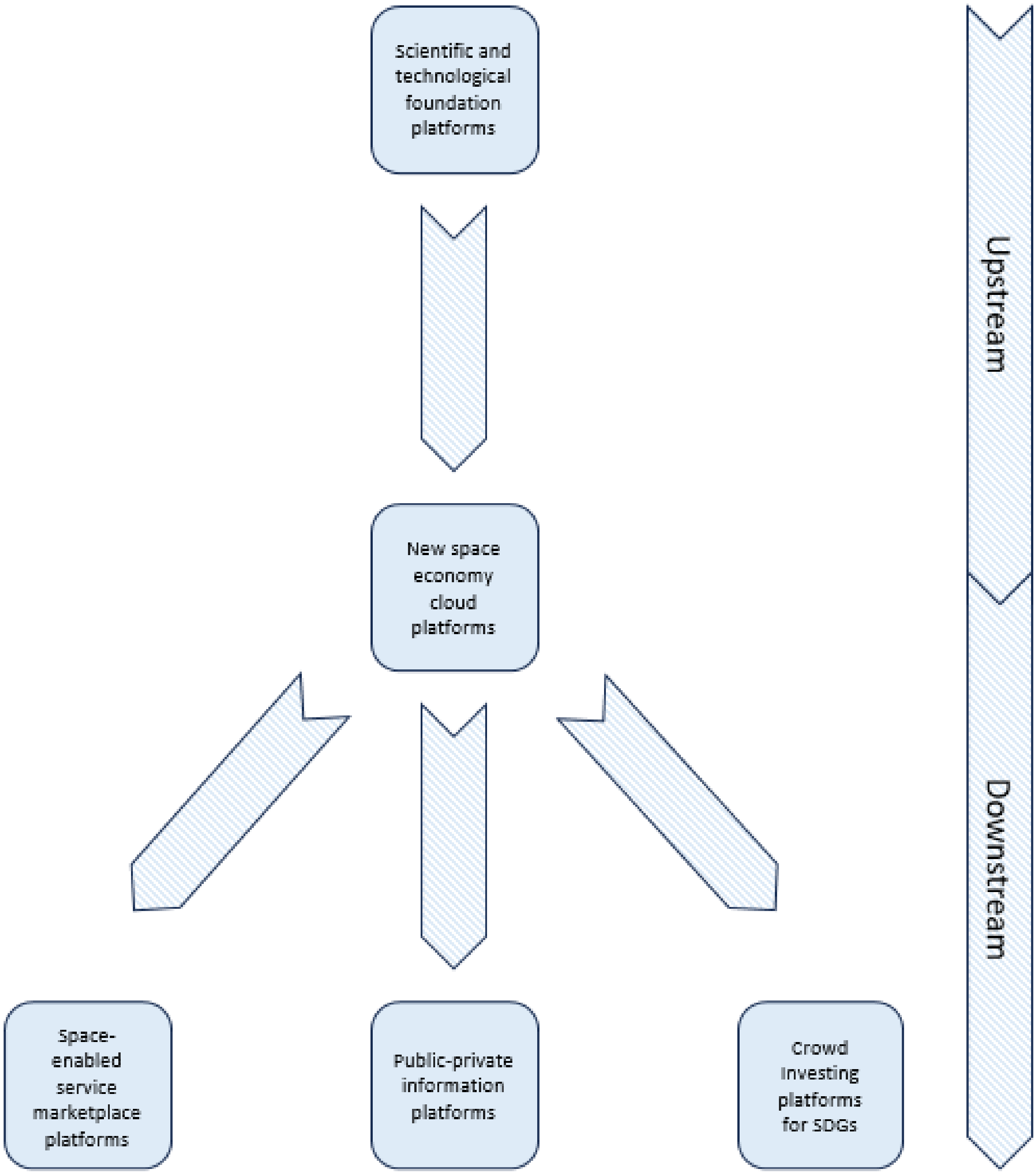

Figure 5.1: Clusters in the space value chain.

The Figure 5.1 represents the position of platforms in the space value chain, taking as reference the one provided by the OECD (2022) [132]. The only platform archetypes belonging to the first stage of the value chain is represented by the "Scientific and technological foundation platforms" cluster since it encompasses all companies that provide the necessary infrastructure from which all the downstream activities are built. Cluster 2, as already pointed out, represents the point of contact between the beginning and the end of the space value chain. The remaining clusters are the only ones able to directly provide value to final customers and therefore the related platform archetypes can be placed in the downstream sector.

In the downstream stage, together with public-private information platforms, it is possible to observe some marketplaces which can be encompassed in the "Space-enabled service marketplace platforms" and the "Crowdinvesting platforms for SDGs" clusters. These firms connect the offer and the demand of the market by enabling the reduction of transaction costs of the parties. The main difference between the two archetypes is represented by the reason of the transaction which is executed on the platform. Indeed, in space-enabled service marketplaces the demand exploits the platform to search the best provider of a specific service within the offer side. On the other hand, the crowdinvesting platforms for SDGs allow the project developers to find financing from other actors which can be both individuals and companies. Another divergent aspect is the range of markets where these clusters companies compete. In fact, cluster 3 platform archetype targets only a specific market which is always related to the concepts of sustainability and social inclusion. Firms in cluster 5 can often target different sectors by including in the network actors which belong to several industries. Both types of marketplaces exploit satellite data to perform their activities, and, in particular, the crowdinvesting platforms for SDGs leverage them to track the achievement of specific sustainable goals or to provide information about the projects to the interested investors.

Moving to the upstream, the "Scientific and technological foundation platforms" cluster encompasses all those companies that allow the existence of all the other platform archetypes in the new space economy since they provide both the theoretical knowledge and the infrastructures necessary to operate in this context. Being the only cluster belonging to the first phase of the value chain and considering that its firms represent less than 20% of the analysed startups, it is possible to point out the lower probability to observe platform business models adopted in the upstream. It can be explained by the fact that the number and variety of actors that can join the network in the downstream is considerably higher than the ones that can be involved at the beginning of the space value chain. This is also due to the high level of specialization required for the manufacturing and technological activities performed by these players. Therefore, the possibility to create strong network externalities and reach the critical mass is limited for the companies running their business in the upstream sector. Cluster 1 firms represent the third platform typology, i.e. innovation platforms. Indeed, the actors involved cooperate to generate value by bringing innovation to the market through the realization of cutting-edge technologies and projects, such as space infrastructures and space missions. It is interesting to highlight that in this stage of the value chain the central firm represents the interface through which users connect, creating an open innovation ecosystem which can foster the value generation process in the new space economy. Moreover, these are the only platforms which include actors whose activities are oriented towards the manufacturing of physical products. Indeed, for all other clusters, the users of the related network provide services and digital applications. In the downstream most of businesses can offer services which are built upon the satellite data and that require a lower amount of investments to start and run an activity than the ones necessary in the upstream. The wider adoption of platform business model in the downstream can be also explained by the fact that individuals can be involved in the ecosystem and therefore the company can rely on a bigger user base.

It is possible to attribute a specific level of scalability to each company belonging to the new space economy whatever their adoption of a platform business model. The firms with the lowest degree of scalability are the ones in the upstream which are specialized in the manufacturing of highly complex products, such as spacecrafts. Indeed, for these companies the additional costs required to start a project are almost constant and significative. These elements prevent the company form easily scaling up, since the amount of resources needed to satisfy the demand increase at a steady rate with the number of projects undertaken by the company itself. The firms in the sample benefit from higher levels of scalability than the previous typologies of enterprises since their platform business model allows them to exploit an increasing user base. Furthermore, their digital infrastructure enables the provision of their offering to new users without sustaining almost any additional costs. It is important to highlight that none of the companies in the sample has a level of scalability comparable to the one of most scalable platforms competing in other markets, such as Amazon. In fact, its business model is able to generate new sources of revenues from both increasing the market penetration and enlarging the set of industries involved. The additional resources deployed to manage a rising number of users is almost null since the costs sustained to build the digital infrastructure necessary to the platform functioning are mainly fixed. Amazon benefits also from processes which can be easily automatized and from users which compete in a wide range of sectors. These aspects allow Amazon to reach one of the largest user bases in the world and therefore to be among the most successful platforms. Companies in the database have a level of scalability which is comprised between the one of manufacturing firms adopting a traditional business model and the one of companies similar to Amazon. The scalability of platforms included in the clusters can be either low, medium or high, according to the satisfaction of the criteria explained in section 3.6.2. Firms with a high level of scalability are included in the "New space economy cloud platforms" and "Public-private information platforms" clusters, in line with the features of their business model. Indeed, they can rely on automatic and entirely digitalised processes which involve actors from different markets. They are not as scalable as Amazon since they are dependent on satellite data which bound these platforms to a narrower user base. "Crowdinvesting plaforms for SDGs" and "Space enabled service marketplace platforms" clusters have a medium level of scalability since, despite the low marginal costs necessary to manage a larger number of transactions, they often need to carry out some processes which require additional resources to match the demand and the offer. The "Scientific and technological foundation platforms" cluster has a low level of scalability since the included businesses cannot automatise their processes at high levels and the marginal costs are not negligible because of the high specialization of the actors involved.

Among the most debated and central topics in the current socioeconomic context, SDGs cover certainly a crucial role. According to the United Nations Department of Economic and Social Affairs, there are 17 SDGs whose objective is to guarantee the economic development paying attention to the sustainable exploitation of Earth resources and the social inclusion. The achievement of these goals and the related targets and indicators cannot be easy to track; however, some SDGs can be measured by exploiting satellites and other infrastructures of the new space economy. Indeed, several companies in the new space economy adopt a model which is oriented toward the achievement of the sustainable economic development and social equality. This aspect is also highlighted by the identification of the "Crowdinvesting platforms for SDGs" cluster. As pointed out in the section 4.3, sustainable development goals number 2, 13 and 15 are the most targeted by companies in this context. Indeed, they are the ones which can exploit satellite data and the digital nature of these platforms in the most efficient way possible. For example, SDGs number 13 and 15 can leverage satellites to track CO2 emissions to depict their geographical concentrations. Moreover, crowdinvesting platforms for SDGs connect sustainable project initiators with individual willing to contribute to the restoring process of terrestrial ecosystem, and with companies competing in other markets which have to offset their carbon emissions. This cluster and therefore the eased process of carbon offset can represent a solution in the short and medium term for the introduction of sustainable technologies, whose development otherwise would have a significative economic impact on the final customer. Indeed, derived products and services prices would increase until these technologies reach their maturity. Companies can therefore reduce their carbon footprint by joining these platforms, without increasing the economic effort of the customer. The digitalization of the platforms enables individuals and companies belonging to a certain geographical area to invest in a project which takes place in a different country.

Taking a company perspective, it is possible to highlight the new space economy related industries targeted by firms and their geographical distribution.

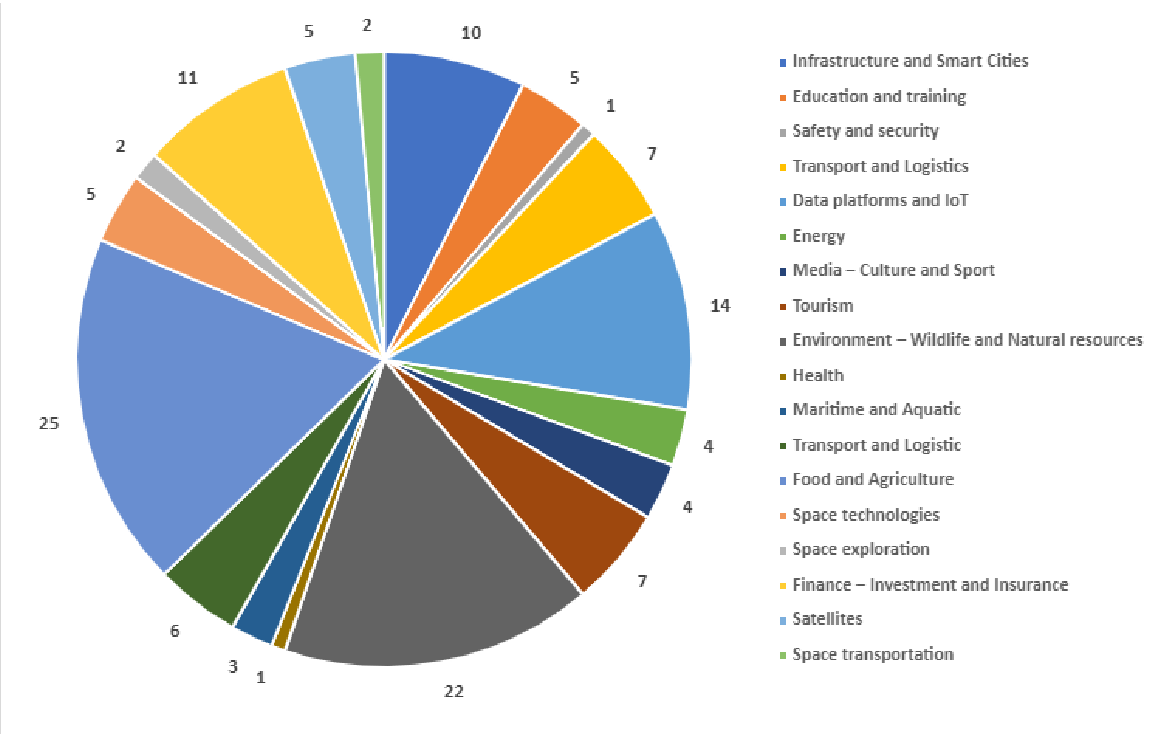

Figure 5.2: Distribution of platforms by the industry of application.

Following the definitions provided by OECD (2022) [132] and analysed in chapter 3, from a sector perspective the startups of the final sample can be categorized according to the targeted industry of their main activity. It is possible to see from the graph above that largest percentage of the enterprises operating in the new space economy focuses their business in the "Food and agriculture" sector and the "Environment - wildlife and natural resources" industry, highlighting again the sensitivity to sustainability related topics. Another relevant segment is the "Data platforms and IOT" underlying the evidence of digital technologies breakthrough in the space industry. A crucial role is also covered by "Finance - investment and insurance" and "Infrastructure and smart cities" markets that are mainly encompassed respectively by clusters 3 and 4. Future streams of the literature could focus on and deepen the possible correlation between the industries in which platforms run their activities and the characteristics of each dimension taken into account and prospective additional variables.

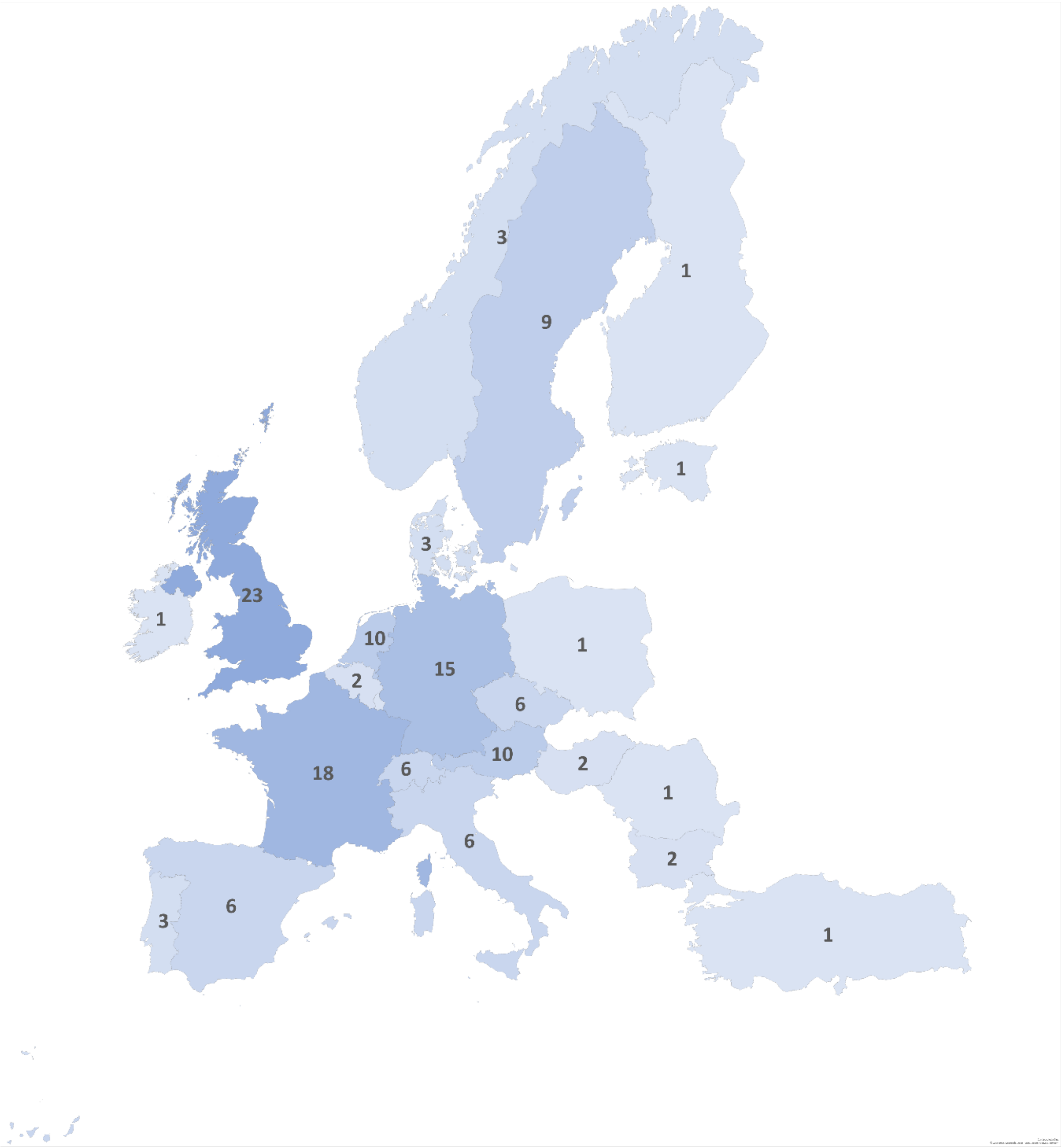

Figure 5.3: Distribution of platforms by country.

From a geographical point of view, the platforms operating in the new space economy are most likely to place their headquarters in the United Kingdom, aided by the fact that is easier for startups to collect the necessary investments to start their activities. Other relevant countries are France and Germany, in which enterprises find a favourable environment to develop their business ideas. For the sake of a better graphical representation, Russia is not included in the Figure 5.3, even though three startups have their headquarters settled in the country. For 102 of the 134 platforms in the final sample, it is possible to clearly state which is their geographical coverage. Enterprises with a national scope amount to 37, equal to the 36% of the disclosed 102 companies. The covering of a limited area can be explained by the fact that the user base of these platforms is either at the beginning of its expansion or the ability of the platforms to scale up is restricted. Only 10 out of the 102 firms, involve users from Europe, deciding not to enlarge their businesses to a global extent even though they would have the capability to widen their geographical scope without constraints. Companies which decide and manage successfully to achieve a global coverage amount to 55, representing the majority of the subset. This allows these enterprises to exploit the platform business model flexibility at its full potential.

Since the available data are limited because of the difficulty in gathering related insights from public and private databases, the cluster analysis is performed only considering the platforms whose headquarters are located in Europe. This can lead to the possible exclusion of certain platforms whose features could give rise to the identification of additional clusters which are not encompassed in the current research. Indeed, the new space economy in the United States is more developed and the related market size is largest than the European context.

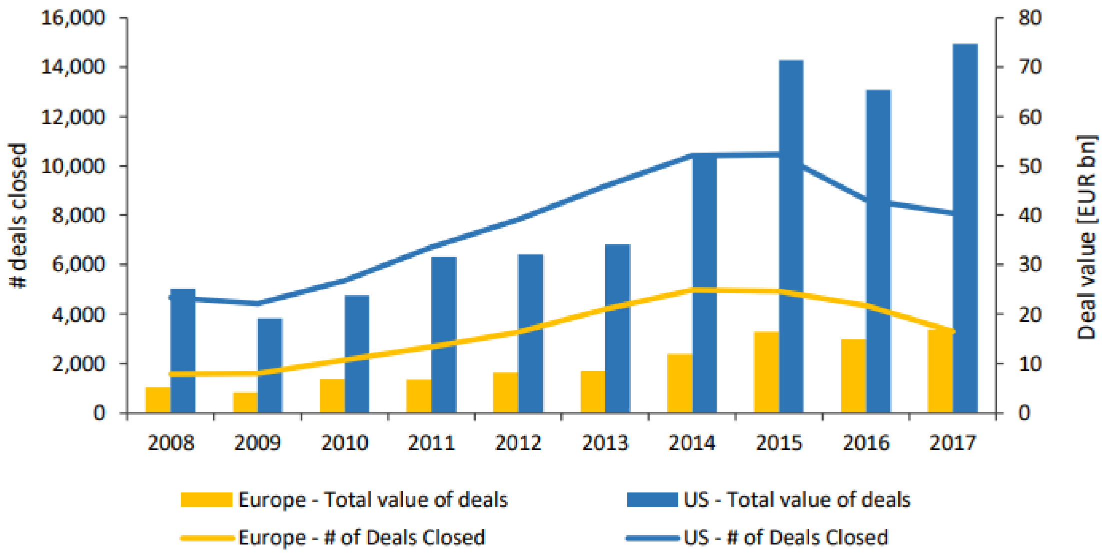

Figure 5.4: Venture Capital activity in the US and the Europe per year, European Investment Bank (2019) [128].

These difference in investments favour the higher number of startups in the US than in Europe, therefore it could be interesting to observe whether these could have an impact also on the typologies of platforms competing in the new space economy.

6 Conclusion

This study aims to understand how an established business model as platforms find an application in the emerging context of new space economy. The development of the taxonomy has the objective to address the literature gap represented by the point of contact between these two streams of the literature.

The value of this research lies in three main contributions: first, the definition of a common terminology which can facilitate the adoption of a common language among practitioners; second, the identification of five main archetypes of platforms in the new space economy; third, the investigation of scalability levels of platforms within the space domain considering their typology and the range of markets in which they compete.

Starting from this consideration and the possibility to categorize space platforms in homogeneous groups according to their features, the future streams of the literature have the opportunity to verify the existence of additional clusters with respect to the ones identified in this research. Moreover, studies that focus their analysis on the European context can take these platform archetypes as a reference to generate additional insights to the specific topic. Taxonomy users can group platforms with similar features under a single name and subsequently deepen other characteristics for each of the identified groups, according to the objective of the research and the attributes of the cluster itself. Indeed, focusing on the "Space-enabled service marketplace platforms" cluster, the correlation between the successfulness of the platforms and the revenue model implemented and consequently the choice of a proportional or fixed fee could be an interesting topic to analyse. Moreover, the developed taxonomy can be useful also to investors and regulators. Indeed, the former can benefit from an easier identification of similar companies in carrying out benchmarking activities, while the latter can exploit clusters features to set a global common standard for all startups and established companies which operate in the space market. The limitation of this study is represented by the difficulty in retrieving information about platforms in the new space economy bounding the analysis to the European context. Among the possible solutions, the extension of the study to the US based platforms allows to encompass a larger set of companies belonging to a more important market.

7 Bibliografia

[1] R. C. Nickerson, U. Varshney and J. Nuntermann, “A method for taxonomy development and its application in information systems,” *European Journal of Information Systems,* vol. 22, pp. 336-359, 2013.

[2] M. L. Katz and C. Shapiro, “Network Externalities, Competition, and Compatibility,” *American Economic Review,* vol. 75, pp. 424-440, 1985.

[3] J. Yang and E. S. Mai, “Experiential goods with network externalities effects: An empirical study of online rating system,” *Journal of Business Research,* vol. 63, pp. 1050-1057, 2010.

[4] K. Lin and H. Lu, “Why people use social networking sites: An empirical study integrating network externalities and motivation theory,” *Computers in Human Behavior,* vol. 27, pp. 1152-1161, 2011.

[5] D. P. McIntyre, A. Srinivasan and A. Chintakananda, “The persistence of platforms: The role of network, platform, and complementor attributes,” *Long Range Planning,* vol. 54, p. 101987, 2021.

[6] D. P. McIntyre, A. Srinivasan and A. Chintakananda, “Networks, platforms, and strategy: Emerging views and next steps,” *Strategic Management Journal,* vol. 38, pp. 141-160, 2017.

[7] K. J. Boudreau and . B. Jeppesen, “Unpaid crowd complementors: The platform network effect mirage,” *Strategic Management Journal,* vol. 36, pp. 1761-1777, 2015.

[8] D.B. Yoffie and M. Kwak, “With friends like these: The art of managing complementors,” *Harvard Business Review,* vol. 84, pp. 88-98, 157, 2006.

[9] D. Jugend, C. J. C. Jabbour, J. A. A. Scaliza, R. S. Rocha, J. A. G. Junior, H. Latan and M. H. Salgado, “Relationships among open innovation, innovative

performance, government support and firm size: Comparing Brazilian firms embracing different levels of radicalism in innovation," *Thecnovation*, vol. 75, pp. 54-65, 2018.

[10] A. Coggan, S. M. Whitten and J. Bennett, "Influences of transaction costs in environmental policy," *Ecological Economics,* vol. 9, pp. 1777-1784, 2010.

[11] S. Sanderson and M. Uzumeri, "A framework for model and product family competition," *Research Policy,* vol. 4, pp. 583-687, 1995.

[12] M. Muffatto and M. Roveda, "Product architecture and platforms: a conceptual framework," *International Journal of Technology Management* , vol. 24, pp. 1-16, 2002.

[13] C. Y. Baldwin and C. J. Woodard, "The architecture of platforms: a unified view," *Harvard Business School: Finance Unit Working Paper Series,* pp. No. 09-034, 2008.

[14] X. Xu, V. Venkatesh, K. Y. Tam and S. Hong, "Model of Migration and Use of Platforms: Role of Hierarchy, Current Generation, and Complementarities in Consumer Settings," *Management Science Journal,* vol. 56, pp. 1304-1323, 2010.

[15] M. Ceccagnoli, C. Forman, P. Huang and D. J. Wu, "Cocreation of value in a platfrom ecosystem: the case of enterprise software," *Journal of Management Information Systems,* vol. 36, pp. 263-290, 2012.

[16] A. Gawer and M. A. Cusumano, "Industry Platforms and Ecosystem Innovation," *Journal Product Innovation Management* , vol. 1, pp. 990-1029, 2014.

[17] A.Tiwana, B.-. Konsynski and A. A. Bush, "Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics," *Information Systems Research,* vol. 21, pp. 675-687, 2010.

[18] P. Spagnoletti, A. Resca and G. Lee, "A design theory for digital platforms supporting online communities: a multiple case study," *Journal of Information Technology,* vol. 30, pp. 364-380, 2015.

[19] B. Tan, S. L. Pan, X. Lu and L. Huang, “The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com,” *Journal of the Association for Infromation Systems,* vol. 16, pp. 248-280, 2015.

[20] T. Kretschemer, A. Leiponen, M. Schilling and G. Vasudeva, “Platform Ecosystems as meta-organizations: Implications for platforms strategies,” *Strategic Management Journal,* vol. 48, pp. 405-424, 2020.

[21] C. Cennamo and J. Santalo, “Platform competition: Strategic trade-offs in platform markets,” *Strategic Management Journal,* vol. 34, pp. 1331-1350, 2013.

[22] M. Pagani, “Digital Business Strategy and Value Creation: Framing the Dynamic Cycle of Control Points,” *MIS Quarterly: Management Information Systems,* vol. 37, pp. 617-632, 2013.

[23] A. Hagiu and J. Wright, “Multi-sided platforms,” *International Journal of Industrial Organization,* vol. 43, pp. 162-174, 2015.

[24] L. Chen, T. W. Tong, S. Tang and N. Han, “Governance and Design of Digital Platforms: A Review and Future Research Directions on a Meta-Organization,” *Journal of Management,* vol. 48, pp. 147-184, 2022.

[25] C. Cennamo, “Competing in digital markets: a platform-based perspective,” *Academy of Management Perspectives,* vol. 35, 2023.

[26] S. Wheelwright and K. Clark, “Creating project plans to focus product development,” *Harvard Business Review,* vol. 70, pp. 70-82, 1992.

[27] A. Gawer, M. Cusumano and D. Yoffie, “The Platform Organization,” in *Designing Modern Organizations*, 2020, p. Chapter 5.

[28] M. Armstrong, “Competition in two-sided markets,” *RAND Journal of Economics,* vol. 37, pp. 668-691, 2006.

[29] J. Rochet and J. Tirole, “Platform Competition in two-sided markets,” *Journal of the European Economic association,* vol. 1, pp. 990-1029, 2003.

[30] M. Rysman, "The Economics of Two-Sided Markets," *Journal of Economic Perspectives,* vol. 23, pp. 125-143, 2009.

[31] A. Gawer, «Bridging differing perspectives on technological platforms: Toward an integrative framework,» *Research Policy,* vol. 43, pp. 1239-1249, 2014.

[32] A. P. L. M. H. Meyer, The power of product platform, 1997.

[33] C. Y. Baldwin and K. B. Clark, "Design Rules: The power of modularity," *The Academy of Management Review,* vol. 26, pp. 130-133, 2000.

[34] C. Y. Baldwin, "Where do transactions come from? Modularity, transactions, and the boundaries of firms ," *Industrial and Corporate Change,* vol. 17, pp. 155-195, 2008.

[35] D. Parnas, "On the Criteria To Be Used in Decomposing Systems into Modules," *Communications of the ACM,* vol. 15, pp. 1053-1058, 1972.

[36] R. N. Langlois, "Modularity in technology and organization," *Journal of Economic Behavior and Organization,* vol. 49, pp. 19-37, 2002.

[37] A. K. R. Garud, "Technological and organizational designs for realizing economies of substitution," *Strategic Management Journal,* vol. 16, pp. 93-109, 1995.

[38] J. E. Souto, "Business model innovation and business concept innovation as the context of incremental innovation and radical innovation," *Tourism Management,* vol. 51, pp. 142-155, 2015.

[39] V. Krishnan and S. Gupta, "Appropriateness and Impact of Platform-Based Product Development," *Management Science,* vol. 47, pp. 52-68, 2001.

[40] D. J. Teece, "Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy," *Research Policy,* vol. 15, pp. 285-305, 1986.

[41] A. Gawer and M. A. Cusumano, "How Companies Become Platform Leaders," *MIT Sloan management review,* pp. 68-75, 2008.

[42] J. West and M. Mace, "Browsing as the killer app: Explaining the rapid success of Apple's iPhone," *Telecommunication Policy,* vol. 34, pp. 270-286, 2009.

[43] A. Ghazawneh and O. Henfridsson, "Balancing platform control and external contribution in third-party development: the boundary resources model," *Information Systems Journal,* vol. 23, pp. 173-192, 2013.

[44] N. Economides and C. Himmelberg, "Critical Mass and Network Size with Application to the US FAX Market," *NYU Stern School of Business,* pp. EC-95-11, 1995.

[45] F. Zhu and Q. Liu, "Competing with complementors: An empirical look at Amazon.com," *Strategic Management Journal,* vol. 39, pp. 2618-2642, 2018.

[46] J. Rochet and . Tirole, "Two-sided markets: a progress report," *The RAND Journal of Economics,* vol. 37, pp. 645-667, 2006.

[47] D. S. Evans, A. Hagiu and R. Schmalensee, Invisible Engines: How Software Platforms Drive Innovation and Transform Industries, 2008.

[48] D. S. Evans, "The Antitrust Economics of Multi-Sided Platform Markets," *Yale Journal on Regulation,* vol. 20, pp. 325-381, 2003.

[49] D. S. Evans, "Some Empirical Aspects of Multi-sided Platform Industries," *Review of Network Economics,* vol. 2, pp. 191-209, 2003.

[50] S. G. Medema, "The Coase Theorem at Sixty," *Journal of Economic Literature,* vol. 58, pp. 1045-1128, 2020.

[51] G. G. Parker and M. W. V. Alstyne, "Two-Sided Network Effects: A Theory of Information Product Design," *Management Science,* vol. 51, pp. 1494-1504, 2005.

[52] S. Vandermerwe and J. Rada, "Servitization of business: Adding value by adding services," *European Management Journal,* vol. 6, pp. 314-324, 1988.

[53] A. Gawer, Platforms, markets and innovation, 2009.

[54] T. K. Koh and M. Fichman, "Multihoming Users' Preferences for Two-Sided Exchange Networks," *MIS Quarterly: Management Information Systems,* vol. 38, pp. 977-996, 2014.

[55] G. Ye, R. L. Priem and A. A. Alshwer, "Achieving Demand-Side Synergy from Strategic Diversification: How Combining Mundane Assets Can Leverage Consumer Utilities," *Organization Science,* vol. 23, pp. 207-224, 2012.

[56] T. Eisenmann, G. Parker and M. V. alstyne, "Platform envelopment," *Strategic Management Journal,* vol. 32, pp. 1270-1285, 2011.

[57] J. L. Zittrain, "The generative internet," *Harvard Law Review,* vol. 119, pp. 1974-2040, 2006.

[58] A. Gawer, "Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces," *Long Range Planning,* vol. 54, p. 102045, 2021.

[59] E. Autio, S. Nambisan, L. D. W. Thomas and M. Wright, "Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems," *Strategic Entrepreneurship Journal,* vol. 12, pp. 72-95, 2018.

[60] J. Cenamor, D. R. Sjödin and V. Parida, "Adopting a platform approach in servitization: Leveraging the value of digitalization," *International Journal of Production Economics,* vol. 192, pp. 54-65, 2017.

[61] S. C. Srivastava and G. Shainesh, "Bridging the Service Divide Through Digitally Enabled Service Innovations," *MIS Quarterly: Management Information Systems,* vol. 39, pp. 245-268, 2015.

[62] F. Vendrell-Herrero, . F. Bustinza, G. Parry and N. Georgantzis, "Servitization, digitization and supply chain interdependency," *Industrial Marketing Management,* vol. 60, pp. 69-81, 2017.

[63] R. Rajala, S. A. Brax, A. Virtanen and A. Salonen, "The next phase in servitization: transforming integrated solutions into modular solutions," *International Journal of Operations and Production Management,* vol. 39, pp. 630-657, 2019.

[64] R. Rabetino, W. Harmsen, M. Kohtamäki and J. Sihvonen, "Structuring servitization-related research," *International Journal of Operations and Production Management,* vol. 38, pp. 350-371, 2018.

[65] M. Kohtamäki, V. Paridac, P. Oghazi, H. Gebauer and T. Baines, "Digital servitization business models in ecosystems: A theory of the firm," *Journal of Business Research,* vol. 104, pp. 380-392, 2019.

[66] M. Hasselblatt, T. Huikkola, M. Kohtamäki and D. Nickell, "Modeling manufacturer's capabilities for the Internet of Things," *Journal of Business & Industrial Marketing,* vol. 33, pp. 822-836, 2018.

[67] D. Sjödin, V. Parida, M. Jovanovic and I. Visnjic, "Value Creation and Value Capture Alignment in Business Model Innovation: A Process View on Outcome-Based Business Models," *Journal of Product Innovation Management,* vol. 37, pp. 158-183, 2020.

[68] H. Gebauer, E. Fleisch and T. Friedli, "Overcoming the Service Paradox in Manufacturing Companies," *European Management Journal,* vol. 23, pp. 14-26, 2005.

[69] T. J. Marion, M. H. Meyer and G. Barczak, "The Influence of Digital Design and IT on Modular ProductArchitecture," *Journal of Product Innovation Management,* vol. 32, pp. 98-110, 2014.

[70] V. Eloranta and T. Turunen, "Platforms in service-driven manufacturing: Leveraging complexity by connecting, sharing, and integrating," *Industrial Marketing Management,* vol. 55, pp. 178-186, 2016.

[71] S. Pekkarinen and P. Ulkuniemi, "Modularity in developing business services by platform approach," *The International Journal of Logistics Management,* vol. 19, pp. 84-103, 2008.

[72] L. D. W. Thomas, E. Autio and D. M. Gann, "Architectural Leverage: Putting Platforms in Context," *Academy of Management Perspectives,* vol. 28, pp. 198-219, 2014.

[73] C. Meyer and A. Schwager, "Understanding Customer Experience," *Harvard Business Review,* vol. 85, pp. 116-126, 2007.

[74] A. Bask, M. Lipponen, M. Rajahonka and M. Tinnila, "The concept of modularity: diffusion from manufacturing to service production," *Journal of Manufacturing Technology Management,* vol. 21, pp. 355-375, 2010.

[75] D. Opresnik and M. Taisch, "The value of Big Data in servitization," *International Journal of Production Economics,* vol. 165, pp. 174-184, 2015.

[76] Y. Chen, I. Visnjic, V. Parida and Z. Zhang, "On the road to digital servitization – The (dis)continuous interplay," *International Journal of Operations & Production Management,* vol. 41, pp. 694-722, 2021.

[77] C. M. Christensen, D. Wang and D. V. Bever, "Consulting on the cusp of disruption," *Harvard Business Review,* vol. 91, pp. 106-114, 2013.

[78] C. Kowalkowski, L. Witell and A. Gustafsson, "Any way goes: Identifying value constellations for service infusion in SMEs," *Industrial Marketing Management,* vol. 42, pp. 18-30, 2013.

[79] K. Kapoor, A. Z. Bigdeli, Y. K. Dwivedi, A. Schroeder, A. Beltagui and T. Baines, "A socio-technical view of platform ecosystems: Systematic review and research agenda," *Journal of Business Research,* vol. 128, pp. 94-108, 2021.

[80] H. Perks, C. Kowalkowski, L. Witell and A. Gustafsson, "Network orchestration for value platform development," *Industrial Marketing Management,* vol. 67, pp. 106-121, 2017.

[81] Y. Qiu, A. Gopal and I. Hann, "Logic Pluralism in Mobile Platform Ecosystems: A Study of Indie App Developers on the iOS App Store," *Information Systems Research,* vol. 28, pp. 225-249, 2017.

[82] A. Gawer, "Digital platforms and ecosystems: remarks on the dominant organizational forms of the digital age," *Innovation: Organization and Management,* vol. 24, pp. 110-124, 2022.

[83] S. Nambisan, F. A. Zahra and Y. Luo, "Global platforms and ecosystems: Implications for international business theories," *Journal of internation business studies,* vol. 50, pp. 1464-1486, 2019.

[84] D. McIntyre, A. Srinivasan, A. Afuah, A. Gawer and T. Kretschmer, "Multi-sided platforms as a new organizational forms," *Academy of Management Perspectives,* vol. 35, pp. 586-583, 2021.

[85] C. E. Helfata and R. S. Raubitschek, "Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems," *Research Policy,* vol. 47, pp. 1391-1399, 2018.

[86] M. Jovanovic, D. Sjodin and V. Parida, "Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms," *Technovation,* vol. 118, p. 102218, 2022.

[87] K. J. Boudreau and A. Hagiu, "Platform rules: Multi-sided platforms as regulators," *Platforms, Markets and Innovation,* pp. 163-191, 2008.

[88] K. J. Boudreau, "Open Platform Strategies and Innovation: Granting Access vs. Devolving Control," *Management Science,* vol. 56, pp. 1849-1872, 2010.

[89] G. G. Parker and M. W. V. Alstyne, "Platform Startegy Survey," *The Palgrave Encyclopedia of Strategic Management,* 2014.

[90] C. Shapiro and H. R. Varian, Information rules: a strategic guide to the network economy, 1999.

[91] J. West, "How open is open enough? Melding proprietary and open source platform strategies," *Research Policy,* vol. 32, pp. 1259-1285, 2003.

[92] J. Crémer, Y. d. Montjoye and H. Schweitzer, Competition policy for the digital era, 2019.

[93] T. Teh, “Platform governance,” *American Economic Journal: Microeconomics,* vol. 14, pp. 213-254, 2022.

[94] S. O'Mahony and R. Karp, “From proprietary to collective governance: How do platform participation strategies evolve?,” *Strategic Management Journal,* vol. 43, pp. 530-562, 2020.

[95] B. Caillaud and B. Jullien, “Chicken & Egg: Competition among Intermediation Service Providers,” *The RAND Journal of Economics,* vol. 34, pp. 309-328, 2003.

[96] J. Rietveld and M. Schilling, “Platform Competition: A Systematic and Interdisciplinary Review of the Literature,” *Journal of Management,* vol. 47, pp. 1528-1563, 2021.

[97] W. B. Arthur, “Competing Technologies, Increasing Returns, and Lock-In by Historical Events,” *Economic Journal,* vol. 99, pp. 116-131, 1989.

[98] P. A. David, “Clio and the Economics of QWERTY,” *American Economic Review,* vol. 75, pp. 332-337, 1985.

[99] M. A. Schilling, “Technological lockout: An integrative model of the economic and strategic factors driving technology success and failure,” *Academy of Management Review,* vol. 23, pp. 267-284, 1998.

[100] F. F. Suarez, “Battles for technological dominance: an integrative framework,” *Research Policy,* vol. 33, pp. 271-286, 2004.

[101] A. Tiwana, “Evolutionary Competition in Platform Ecosystems,” *Information System Research,* vol. 26, pp. 266-281, 2015.

[102] R. L. Priem, “A Consumer Perspective on Value Creation,” *Academy of Management Review,* vol. 32, pp. 219-235, 2007.

[103] J. M. Utterback and W. J. Abernathy, “A dynamic model of process and product innovation,” *Omega,* vol. 3, pp. 639-656, 1975.

[104] J. J. Zhang, Y. Lichtenstein and J. Gander, “Designing Scalable Digital Business Models,” *Advances in Strategic Management,* vol. 33, 2015.

[105] A. Chandler, “The enduring logic of industrial success,” *Harvard Business Review,* 1990.

[106] M. P. Feldman and I. Lendel, “Under the Lens:The Geography of OpticalScience as an Emerging Industry,” *Economic Geography,* vol. 86, pp. 147-171, 2010.

[107] A. N. Tanner, “Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions,” *Economic Geography,* vol. 90, pp. 403-427, 2014.

[108] C. Binz and B. Truffer, “Global Innovation Systems—A conceptual framework for innovation dynamics in transnational contexts,” *Research Policy,* vol. 46, pp. 1284-1298, 2017.

[109] M. Trippl, S. Baumgartinger-Seiringer, A. Frangenheim, A. Isaksen and . O. Rypestøl, “Unravelling green regional industrial path development: Regional preconditions, asset modification and agency,” *Geoforum,* vol. 111, pp. 189-197, 2020.

[110] R. Phaal, E. O'Sullivan, M. Routley, S. Ford and D. Probert, “A framework for mapping industrial emergence,” *Technological Forecasting and Social Change,* vol. 78, pp. 217-230, 2011.

[111] P. Forbes and A. Kirsch, “The study of emerging industries: Recognizing and responding to some central problems,” *Journal of Business Venturing,* vol. 26, pp. 589-602, 2011.

[112] R. Gustafsson, M. J. ̈. ̈. ̈ainen, M. Maula and J. Uotila, “Emergence of Industries: A Reviewand Future Directions,” *International Journal of Management Reviews,* vol. 18, pp. 28-50, 2016.

[113] M. Porter, Competitive Strategy: Techniques for Analyzing Industries and Competitors, 1980.

[114] R. Garud and P. Karnoe, Path Dependence and Creation, 2001.

[115] S. Baumgartinger-Seiringer, J. Miörner and M. Trippl, "Towards a stage model of regional industrial path transformation," *Industry and Innovation,* vol. 28, pp. 160-181, 2021.

[116] J. Miörner and M. Trippl, "Embracing the future: path transformation and system reconfiguration for self-driving cars in West Sweden," *European Planning Studies,* vol. 27, pp. 2144-2162, 2019.

[117] K. Frenken, F. V. Oort and T. Verburg, "Related Variety, Unrelated Variety and Regional Economic Growth," *Regional Studies,* vol. 41, pp. 685-697, 2007.

[118] H. Gong, C. Binz, R. Hassink and M. Trippl, "Emerging industries: institutions, legitimacy and system-levelagency," *Regional Studies,* vol. 56, p. 523–535, 2022.

[119] J. J. Yun, D. Won, K. Park, E. Jeong and X. Zhao, "The role of a business model in market growth: The difference between the converted industry and the emerging industry," *Technological Forecasting and Social Change,* vol. 146, pp. 534-562, 2019.

[120] S. Lubik, S. Lim, K. Platts and P. Minshall, "Market-pull and technology-push in manufacturing start-ups in emerging industries," *Journal of Manufacturing Technology Management,* vol. 24, pp. 10-27, 2012.

[121] R. H. Hayes and S. C. Wheelwright, Restoring Our Competitive Edge: Competing Through Manufacturing, 1984.

[122] E. Maine and E. Garnsey, "Commercializing generic technology: The case of advanced materials ventures," *Research Policy,* vol. 35, pp. 375-393, 2006.

[123] B. Lin and Z. Jiang, "Estimates of energy subsidies in China and impact of energy subsidy reform," *Energy Economics,* vol. 33, pp. 273-283, 2011.

[124] D. Mowery and . Rosenberg, "The influence of market demand upon innovation: a critical review of some recent empirical studies," *Research Policy,* vol. 8, pp. 102-153, 1979.

[125] S. Hoeffler, D. Ariely and P. West, "Path dependent preferences: The role of early experience and biased search in preference development," *Organizational Behavior and Human Decision Processes,* vol. 101, pp. 215-229, 2006.

[126] K. Y. Bjerkan, T. E. Nørbech and M. E. Nordtømme, "Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway," *Transportation Research, Part D: Transport and Environment,* vol. 43, pp. 169-180, 2016.

[127] X. Sun, X. Liu, Y. Wang and F. Yuan, "The effects of public subsidies on emerging industry: An agent-based model of the electric vehicle industry," *Technological Forecasting and Social Change,* vol. 140, pp. 281-295, 2019.

[128] European Investment Bank, The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures, 2019.

[129] Euroconsult, Space Economy Report, 2022.

[130] Space Foundation, [Online]. Available: https://www.spacefoundation.org/.

[131] R. M. Parrella, G. Spirito, C. Cirina and M. C. Falvella, "The New Space Economy and New Business Models," *New Space,* vol. 10, pp. 291-297, 2022.

[132] OECD, OECD Handbook on Measuring the Space Economy, 2022.

[133] ITU, [Online]. Available: https://www.itu.int/en/mediacentre/backgrounders/Pages/High-altitude-platform-systems.aspx#:~:text=ITU%20Radio%20Regulations%20(RR)%20define,point%20relative%20to%20the%20Earth..

[134] J. O. Wooten and C. S. Tang, "Operations in space: exploring a new industry," *Decision Sciences,* vol. 49, pp. 999-1023, 2018.

[135] B. McKelvey, H. Tanriverdi and Y. Yoo, "Call for papers: MISQ special issue on complexity and information systems research in the emerging digital world," *MIS Quarterly,* vol. 39, pp. 995-996, 2015.

[136] Y. Lei, Y. Guo, X. Li and Z. Jing, "Space economy: a new frontier of information systems, analytics and digital commerce," *Industrial Management & Data Systems,* vol. 123, pp. 616-629, 2022.

[137] R. O. Briggs, J. F. N. Jr and J. S. Giboney, "Guest editors' introduction: on the contributions of applied science/engineering research to information systems," *Journal of Management Information Systems,* vol. 32, pp. 3-9, 2015.

[138] Y. Vakulenko, D. Hellström and K. Hjort, "What's in the parcel locker? Exploring customer value in e-commerce last mile delivery," *Journal of Business Research,* vol. 88, pp. 421-427, 2018.

[139] ITU, [Online]. Available: https://www.itu.int/en/ITU-T/studygroups/com17/Pages/cybersecurity.aspx.

[140] OECD, OECD Handbook on Measuring the Space Economy, 2012.

[141] OECD, The Space Economy at a Glance 2014, 2014.

[142] D. J. Ketchen and C. L. Shook, "The Application of Cluster Analysis in Strategic Management Research: An Analysis and Critique," *Strategic Management Journal,* vol. 17, pp. 441-458, 1996.

[143] L. Stanberry, R. Nandy e D. Cordes, «Cluster Analysis of fMRI Data Using Dendrograms Sharpening,» *Human Brain Mapping,* vol. 20, pp. 185- 258, 2003.

[144] A. Et-taleby, M. Boussetta and M. Benslimane, "Faults Detection for Photovoltaic Field Based on K-Means, Elbow and Average Silhouette Techniques through the Segmentation of a Thermal Image," *International Journal of Photoenergy,* 2020.

[145] R. Schollmeier, "A Definition of Peer-to-Peer Networking for the Classification of Peer-to-Peer Architectures and Applications," in *First International Conference on Peer-to-Peer Computing*, 2001.

[146] S. Varga, M. Cholakova, J. Jansen, T. J. Mom and G. J. Kok, "From platform growth to platform scaling: The role of decision rules and network effects over time," *Journal of Business Venturing,* vol. 38, 2023.

[147] M. Stone, E. Aravopoulou, G. Gerardi, E. Todeva, L. Weinzierl, P. Laughlin and R. Stott, "How platforms are transforming customer information management," *The Bottom Line,* vol. 30, pp. 216-235, 2017.

[148] J. Hörisch and I. Tenner, "How environmental and social orientations influence the funding success of investment-based crowdfunding: The mediating role of the number of funders and the average funding amount," *Technologocal Forecasting and Social Change,* vol. 161, 2020.

[149] United Nation Department of Economics and Social Affairs, [Online]. Available: https://sdgs.un.org/goals.

[150] B. Klievnik, N. Bharosa and Y. Tan, "The collaborative realization of public values and business goals: Governance and infrastructure of public–private information platforms," *Government Information Quarterly,* vol. 33, pp. 67-79, 2016.

[151] A. Moreno and C. Terwiesch, "Doing Business with Strangers: Reputation in Online Service Marketplaces," *Information System Research,* vol. 25, pp. 865-886, 2014.

8 List of Figures

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