Towards Understanding the Impact of Innovation — An Application of the Need-Driven Ecosystem Theory

Henning Hinderer and Ludwig Martin

***Abstract*—Ecosystems are often used as an analogy taken from nature to explain matters of interdependence and co-existence of players of an industry or of products and services. However, the correlation of those artifacts and the players responsible for their provision with the purpose to fulfill a certain user need needs to emphasized. Through the application of the theory of Need-driven Ecosystems a better understanding of the impact of innovation on those ecosystems as a whole are showcased. Need-driven Ecosystems have two poles, businesses as well as products. Each of these poles is understood as concentric and enabling set of neighboring and intertwined spheres; all with the same aim: to provide an artifact or product catering for the needs of customers. Companies or organizations are set in ever changing environments with various drivers and inhibitors. Successful companies innovate for providing better artifacts to cater for their customers, however ultimately aiming at returns. Based on some examples the use of the Need-driven Ecosystem is showcased. Using this theory, the relationships between company contexts, product features, and the requirement to cater for users can be depicted. The application of this theory assists companies and organizations in two ways. Firstly, it can be used to take stock of current situations in the sense of strategic management and decisions for product development initiatives. Secondly, it can be used as a tool for understanding impacts outside a company's realm on the wider context of the business or products and resulting implications for the company.**

***Index Terms*—Ecosystems design, innovation, interdependence of players and artifacts, impact of innovation.**

I. Introduction

Companies and organizations around the world vie with various products for markets and their customers. Some products appear to be more successful than others in particular markets, and even through normal pricing strategies, not all effects in markets can be explained or managed. However, products with a high level of innovativeness appear on the forefront of any market. Innovative products will become successful if they meet and fulfil the requirements of the targeted customers. For companies, designers or product developers the process of innovating for the development of innovative products in itself is important. Some companies are able to innovate; others appear to lack this ability.

Using positive examples for innovation, drivers for such innovations are to be uncovered. Many studies in this regard exist already [1], [2]. Using some of the respective findings, an alternative categorization of such drivers, hand-in-hand with potential explanations of such drivers of innovation is offered.

Hence, a closer look at the locus and origin of innovations is required. In particular, the contextual influences on innovation or rather the process to innovate needs to be understood. The aim of this contribution is to map drivers of innovation within the context of the Need-driven Ecosystem theory by [3] and hence allow for a discussion on how to understand the impact and promote innovation. In order achieve comprehensible results we apply the steps document, select and evaluate of the design science research cycle [4]. The purpose of these efforts is to help to foster the road towards a better understanding of the impact of *innovation on players and artifacts* within ecosystems and thus economy.

II. Ecosystems

A. Business Ecosystems

Many authors hold that business ecosystems describe the co-existence of players in a certain industry all of which exist in order to fulfil a user requirement [5], [6]. The term is used in analogy to descriptions of nature where plants and creatures live and survive together as species one helping another to be nourished or protected [7], [8]. Regarding mobility car manufacturers, suppliers in the different tiers of the supply chain or suppliers of raw materials can be identified [9]. In a wider sense of the business ecosystem even more players can be identified. Workers and organizations representing them as well as shareholders influence the activities of the system [10]. Governmental and regulatory conditions such as laws, standards, or international conventions set the boundaries within which the respective players may act. Since co-existence of the different players may also require a certain level of competition to assure the eagerness for continuous improvement and thus the ability to survive, industry rivals or even competitive networks should be integrated into a comprehensive view on business ecosystems [11]. Many authors hold that business ecosystems describe the co-existence of players in a certain industry all of which exist in order to fulfil a user requirement [5], [6]. The term is used in analogy to descriptions of nature where plants and creatures live and survive together as species one helping another to be nourished or protected [7], [8]. Regarding mobility car manufacturers, suppliers in the different tiers of the supply chain or suppliers of raw materials can be identified [9]. In a wider sense of the business ecosystem even more players can be identified. Workers and organizations representing them as well as shareholders influence the activities of the system [10].

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Governmental and regulatory conditions such as laws, standards, or international conventions set the boundaries within which the respective players may act. Since co-existence of the different players may also require a certain level of competition to assure the eagerness for continuous improvement and thus the ability to survive, industry rivals or even competitive networks should be integrated into a comprehensive view on business ecosystems [11].

B. Product Ecosystems

On the other hand, product ecosystems are built at first by a group of products or products with a modular architecture that complement each other. Thereby users who want to fulfil a certain need with the product will have a superior experience by using more components of one system than if they had mixed different systems [12]. Again, as an example the mobility industry including cars or other vehicles, mobility services or fuel providers could be used. Another example is the ecosystem Apple Inc. created around its core product the iPhone. Additional devices such as a smart watch, software solutions e.g. iTunes, or digital content like music or the numerous apps downloadable from Apple's app store are designed to give users well-integrated environment. At the same time the system creates a lock-in effect for the customer by raising opportunity costs of a transfer to another system, in the given case e.g. to the Google-Android world, due to incompatibility of devices, software and even content [13]. Such product ecosystems are however shaped by a view towards the customer side only, and how to log these into a closed (eco-)system.

To gain a good understanding of the product ecosystem it is also necessary to integrate not only the core product and services but also the components, e.g. parts of the products. Supporting services in the example above could be the provision of internet connectivity and mobile data or even electric energy. Infrastructure is required in a technical as well as in an organizational sense to allow the product ecosystem to operate properly [14].

C. User Needs at the Center

Both interpretations of ecosystems with a relation to business assume that all activities or their results exist for a business purpose. The value proposition expressing the outcome of any of these efforts has to be recognized and valued by a user who is at the center of all considerations. If the target user does not appreciate the proposed product or service he or she will not become a user and thus not a customer [15]. However, since the reason for existence of such an ecosystem is the joint survival the players by means of their artifacts it is indispensable to have customers willing to pay for the product or service [16]. That means that both the business ecosystem as well as the product ecosystem approach lack the required information from the other perspective.

With regard to mobility the need of the users can be manifold. Mobility may be individual and independent or in groups sharing the same destinations. The user maybe wants to decide to use e.g. a vehicle to move forward from one location to the other at what time ever he or she likes. This indicates that a vehicle should be at disposal any time. The vehicle might be owned by the user or the access could be provided as a sharing service. Automobiles, motorbikes, bicycles or e-scooters could be used for private transport, while trains, trams or airplanes could be used for public transport. The ride might be planned or ad-hoc and it can be provided by taxi or other ride-hailing services.

Other aspects that specify the user need for mobility can be that transportation is supposed to be fast, safe, cost-value beneficial or with the lowest emissions possible. It can be a requirement that the time spend should be enjoyable or productive in terms of giving the user time to some work or communicate with other individuals.

These indicators specifying users' needs for mobility may change over time or according to the given context. Changes can indicate the necessity to provide new solutions for mobility and thereby provoke innovation.

D. A Combined View

Looking at the two interpretations of ecosystems both have one thing in common. They do exist because or in other words are driven by a user need. The user need is in the center of the efforts of each player and is supposed to be addressed by any single artifact. Elsewise the player or the artifact would not be necessary for the ecosystem and could be excluded. This leads to a combined view on need-driven eco-systems including these two dimensions (see Fig. 1) as postulated by [3]. Only by considering the outcome of the activities of any of the players on the business side the idea of the ecosystem and joint survival can be explained. From the product perspective the ecosystem well explains how the individual artifacts work together and mutually help to fulfil a user need. However, without bearing in mind who is responsible to provide for the artifacts only a restricted understanding of the ecosystem's equilibrium can be achieved.

In any case business and product – both have the customer and at least one of his vital or fundamental needs in the center; these needs can be e.g. nutrition, safety, comfort, entertainment or mobility [17], [18]. In any case it can be noted that the given need may only be fulfilled if the products, services, and their components are provided in an appropriate way by the involved players within the predefined boundaries because a lack of customer centricity may result in less success in the market [19].

Combining the two spheres of ecosystems with each other is not entirely new. In the 1920s already, Vygotsky, a Russian psychologist, developed the model of the Activity Theory. This theory combines various factors within societies or organizations to give an understanding of how organizations function.

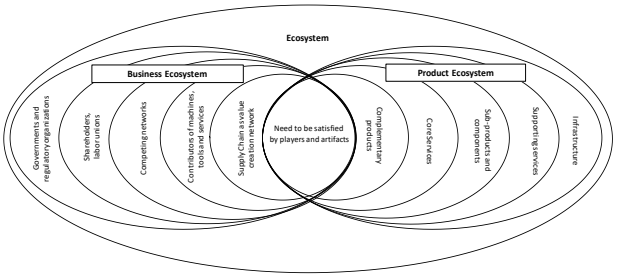

Fig. 1. Need-driven ecosystem (after [3]).

In this theory it is individuals who set rules; this typically based on their experiences and interactions within communities (of practice). The very same communities may already have rules, and thus the creation of new rules, or understanding of processes, is guided by the existing culture and based in an antecedent. The behavior of an individual within a community is thus determined by the existing common rules, but also influences and changes these rules. These rules can have both explicit and also tacit character. The term activity can have many meanings. Activity is understood to be actions (of an individual) and operations (of a community), set in a surrounding wider community. The matrix in which such activity takes place is called the Activity system. Tension within such a matrix through acts of individuals can result in a new understanding and set of rules. [20] offers an extension, and partly an update of this theory. This extension structures the idea of the original Activity Theory into a construct in which human activities are based in hierarchical systems with their focus on objects of activity [21]. For [20] an Activity system comprises various parts, interacting with each other in a constant tension (see Fig. 2).

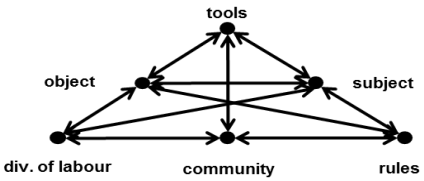

Fig. 2. Activity system (after [20]).

Individuals (subjects) are based in communities with existing rules. These rules govern the use of tools (such as language or physical tools) but also the division of labor (roles within the community). The ultimate results of such activity systems are the objects or in other words artifacts. Objects are the tradable outcomes of community activity. The object thus has two points in which it can be of importance when looking into interactions between role-players. The objects are the common focus points of individuals within an Activity system. The objects are the result of a community's effort. The division of labor, the common rules, the accepted use of tools are embodied in the final object. But the object is more than just the community's own product. It is tradable and is the point in which two or more activity systems might connect with each other. An example set in the construction industry might be the Activity system of a team of architects working on a design, and the Activity system of the assigned structural engineer's team, working on the same design.

This is also reflected in the concept of the Need-driven Ecosystem. While the Activity Theory is a powerful theory to show the interdependencies within communities (of learning), it is difficult to grasp and to deploy in daily management tasks. It largely remains a theoretical construct with little in field application. The Need-driven Ecosystem however focuses the eye of the user more. The various spheres interact and are depended on each other; they feed of and nurture each other – similar to the Activity System, however without the need to understand the full mechanics behind the system. The Need-driven Ecosystem combines Business and Product with the common denominator the user's needs. Moreover, the most important correlation to ecosystems in nature is that the different building blocks depend on each other and could not survive alone.

E. The Mobility Ecosystem – An Example

In the mobility example this may be explained by a person who needs a vehicle if she or he wants to move faster than it could by its own means as a human being. This vehicle has parts and components and needs a road or track to move on it and it is necessary to have conventions for a steadily flowing and safe traffic. Each of these artifacts that provide mobility to the user have to be created or taken care of by one or several role-players such as manufacturers, service providers or even governments. Altogether they provide for the possibility to satisfy the user's need for mobility. An instance of a need-driven ecosystem motivated by the need for mobility is shown in Fig. 3.

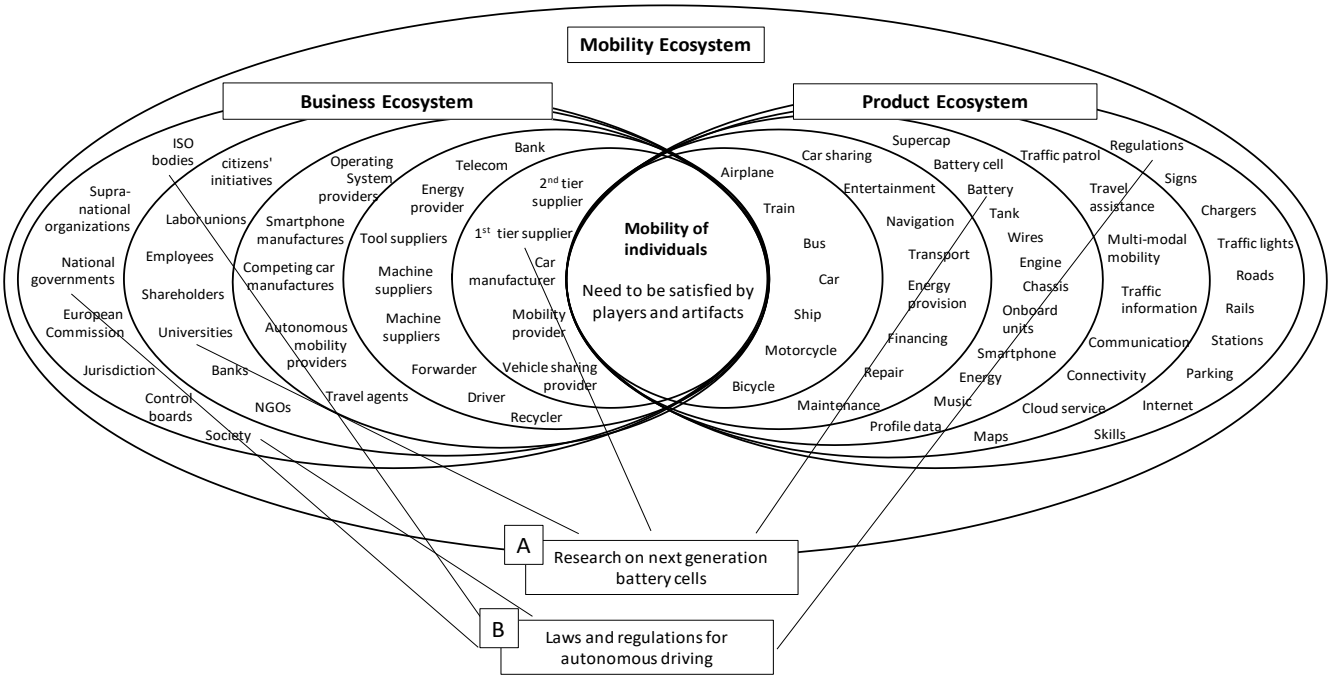

Fig. 3. Mobility Ecosystem and allocation of examples for drivers of innovation (extended after [3]).

III. Drivers of Innovation

Innovation in terms of bringing forward new solutions to a market such as products, services or product-service systems or even other marketable items are created by companies or other existing or new players within such a market [22]. The intention behind is to provide solutions which may be sold and thus to create returns on the investments made that assure growth or at least the future existence of the business; exploitation of market opportunities is core. This expands the view on what inventions stand for which do only aim for novelty but not necessarily for financials success of a business [23]. However, it is indispensable for the payback of an innovation that it meets demand derived from customers' needs.

A major point of origin that can help to explain drivers of innovations are the global sustainable development goals defined by the United Nations. These give guidelines of political decisions indicating areas where substantial public financial means may be available for research or newly developed products [24]; e.g. the goals #9 "Industry, Innovation and infrastructure" and #11 "sustainable cities and communities" encourage law makers, societies as well as standardization bodies to create and provide for regulations even in the field of mobility. As one of the most rapidly evolving field of technology one of the necessary outcomes for future developments and for the implementation of technology in practice are guidelines for autonomous driving (s. detail A in Fig. 3).

Other authors explain the locus of innovation, which can be traced back to megatrends such as digitization, globalization or low carbon economy etc., which are mostly indicated by societal or technological developments [25]. On a more detailed level along the example of the need for mobility trends for innovative artifacts are identified: The major trends that bring forward disruptive innovation are, as previously mentioned, autonomous driving, electrification, diverse mobility, and connectivity [26]. Within this topic the storage of energy especially provided batteries in electric vehicles is an important subject of research which has substantial influence on the future development of vehicles with an electrified powertrain and thus on the possibilities to satisfy the need for mobility (s. detail B in Fig. 3). Other triggers for activities to create novelties can be the need for incremental innovation or curiosity. Companies need to refresh existing product portfolios from time to time and thereby are urged to bring new products or at least updated version to the market. The curiosity of researchers or enthusiasts of certain subjects may also drive inventions. If economic success seems to be expectable individuals my take the opportunity and dare to bring these as innovations to the market.

IV. Analysis of Innovation-User Need Continuum

The two examples have in common that the drivers of innovation trigger activities of one or several players within in the business ecosystem. These activities aim on the creation of new artifacts within the product ecosystem.

Fig. 4 depicts some of the examples in connecting the drivers of innovation, reciprocal activities, resulting artifacts and met user needs. The development of the artifacts, even at times in 2nd or 3rd tier levels of a value chain within a product or business ecosystem, are pulled by user needs. User needs prevail all other push factors for innovation. The constant interaction of user needs and the concentric product as well as business tiers built around them, must be seen as a continuum towards meeting the user needs. A sound understanding and observation of user needs and especially the notable changes can help to presume and detect future developments.

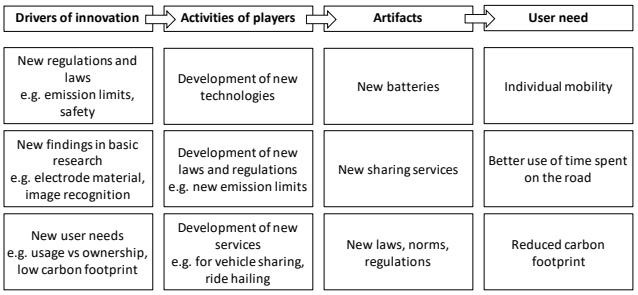

Fig. 4. Connecting drivers of innovation and user need.

Using a Need-driven Ecosystem with "mobility" as the central user need, the artifacts (detail C and D, Fig. 5) can be traced. This allows for an immediate assessment of the impact of such innovations, since neighboring business or product tiers will experience change due to the innovations.

The noticeable change in the propulsion energy from crude oil to electric energy originated from renewable sources will require constant innovation and development e.g. of battery technologies. If the capacity to store energy is increased the reach of the vehicles can be extended. This meets one of the requirements users have derived from their need for flexible individual mobility. However, new battery cells (detail C) will provide new possibilities for new batteries with increased energy densities and thus allow for new degrees of freedom regarding the design of vehicles. New parts for the battery system and its management will become necessary too as well as the demand for the required natural resources will raise. At the same time the demand for fuel tanks for regular cars with combustion engine may drop.

The effects within the product side of the ecosystems will also be noticeable on the business side. Manufacturers as well as suppliers have to adapt their strategies and portfolios. They will need other skill sets from their employees.

This will be of interest for workers unions and even for universities who aim for an education that allows their alumni to find future-proof jobs. In the example the effect will be that an increasing demand for engineers, chemists, and physicists with electro-chemical expertise as well as with knowhow in the design of battery cells will be noticeable.

Along the example of innovative business models for future mobility (detail D) similar interdependencies can be found. In order to satisfy the need for mobility without owning a vehicle, ride sharing or ride services need to be further developed. Mobility providers need to cooperate with vehicle manufacturers as well as software developers.

They need additional financial means from shareholders to setup, advertise and run these services within the legal framework given by the national and local authorities. On the product side of the ecosystem new software applications on mobile devices and within the shared vehicles are necessary.

The communication with providers, other users, vehicles or devices will require an even more reliable infrastructure, enabling fast and permanent connection to the internet with sufficient bandwidth.

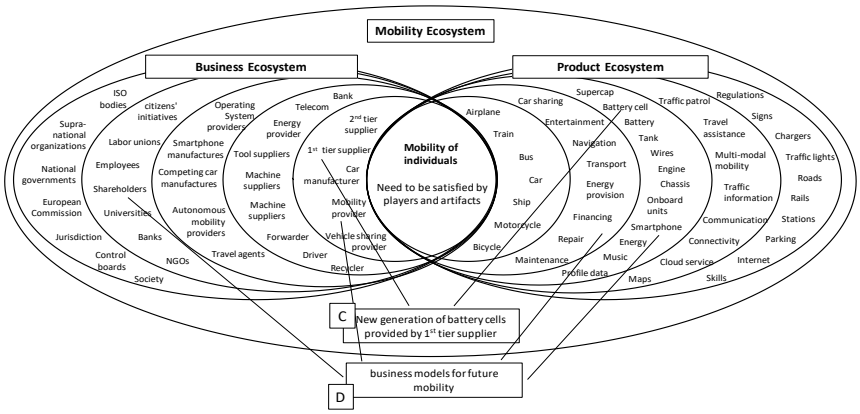

Fig. 5. Allocation of Innovations within the mobility ecosystem (extended excerpt after [3]).

V. Findings and Conclusion

Need-driven Ecosystems expand the view on ecosystems and help to understand forces that drive change, their reach as well as their impact. The application of the concept of a Need-driven Ecosystem can unfold powerful insights into the particular sub-set of an ecosystem. Along the example of the fundamental need for mobility the correlations of players and artifacts with the common aim to fulfil a user's need become transparent. And the impact of innovations become comprehensible. As soon as the focus of the application of the theory is drawn on another need, the elements – players as well as artifacts – on both sides change. However, the scheme behind, which is supposed to help to recognize the patterns, remains convincing. Insights may range from a better understanding of players in the market to a better understanding of the position of one's own product within the value-add chain of an industry.

More over the deployment of the concept of a Need-driven Ecosystem in product development and hence business strategy assessments may add value in two ways. Firstly, efforts in innovation and product development may be more guided considering the context of the particular product as well as of the company innovating and its correlation to other players. This may lead to more focused (product) developments. Secondly, disruptions in markets, may it be through changes in players or products, can be detected and understood earlier and be understood more swiftly in their entirety. This allowing companies to adapt and move onto required innovation processes, reacting to change.

The application of the theory of the Need-driven Ecosystem may offer even more applications. The emerging and important discipline of technology assessment – aiming at forecasting the impact of technologies, may well draw from such approach. The power of the theory is the freedom of choosing the scale at which such assessment may be done as well its universal focus on the ultimate driver for economic activity – the need of customers.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Both authors have conducted this research and developed the approach to explain the impact of innovation along the theory of Need-driven ecosystems co-operatively. Both authors have approved the final version.

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