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Ecosystem creation under high uncertainty – a longitudinal analysis of the alignment process

Nuria MORATAL, Anne-Lorpene VERNAY, Carine SEBI

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Abstract:

Sustainability-oriented innovation increasingly materializes through business ecosystem. To create value, business ecosystems rely on complementary inputs made by interconnected, yet independent actors. Ecosystem research has highlighted the role of the central actor (aka keystone) to coordinate the different interdependent actors. It also discusses tensions that the keystone has to deal with in order to reach alignment. Research often focuses on business ecosystems that are based on digital platforms. These ecosystems are characterised by a high flexibility and adaptive capacity. Little research looked at business ecosystems that are based on technological infrastructure that are asset-heavy and prone to technological lock-in. This article proposes to analyse how alignment is reached and maintained in ecosystems that require the development of an asset-heavy technological infrastructure. We inquiry into which are the tensions inherent to asset-heavy ecosystems and how these tensions are tackled. We do that by conducting a longitudinal analysis of a business ecosystem aiming to deploy an infrastructure of green hydrogen refuelling stations in the Auvergne-Rhône-Alpes region, France. Analysis is based on 34 interviews conducted over an 18 month period. The paper contributes to the growing literature on business ecosystems. Results show that reaching and maintaining alignment requires being able to cope with three tensions and discuss eight strategies that the keystone mobilised to do so. We associate each of these tensions to different key moments of ecosystem formation.

Introduction

Firms increasingly form business ecosystems to develop complex value propositions (Jacobides et al., 2018). To create value, ecosystems rely on complementary inputs made by interconnected, yet independent actors with different levels of (technological) distance from the end consumer (Adner, 2006; Jacobides et al., 2018). Ecosystem research has highlighted the central role of ecosystem leader aka keystone in coordinating the different interdependent actors (Adner, 2017). It also shows that the keystone has to deal with a number of tensions as it needs to reconcile individual and collective interests (Wareham et al., 2014). Research also discussed the challenge faced by keystone actors when the ecosystem they aim to develop emerges under situation of high uncertainty. Scholars argue that the keystone can design a blueprint of how the ecosystem should look like: which is the value proposition, which is the set of skills, and which activities are needed to achieve the value proposition. This blueprint will reduce the perceived uncertainty and contribute to actors' alignment (Iansiti & Levien, 2004). Moreover, the keystone can also develop dynamic control points in order to cope with internal and external event that reinforce or dissolve the blueprint (Dattée et al., 2018).

Research on business ecosystem often focuses on digital platforms (Jacobides et al., 2018) that are by definition flexible and adaptive. However, sustainability-oriented innovation also increasingly materialize through business ecosystems (Oskam et al., 2021). Sustainability-oriented innovation, especially when they build on new technological infrastructure require a lot of physical assets which are very expensive to develop and prone to technological lock-in (Liebowitz & Margolis, 1995). This makes these ecosystems even more challenging to develop. In this article, we want to understand how the keystone of an asset-intensive business ecosystem that emerges under a situation of high uncertainty manages to reach and maintain alignment between ecosystem actors. More specifically, we want to identify strategies that the keystone can use in order to cope with tensions that are inherent to business ecosystem and specific to ecosystems that are based on asset-intensive technological infrastructure.

To answer this research question, we analyse the emergence and development of a business ecosystem aiming to deploy an infrastructure of green hydrogen refuelling stations in the Auvergne-Rhône-Alpes region in France. This case study is exemplary in that it depends on the cooperation of multiple public and private actors to succeed and because it emerges in a context of high level of uncertainty as it tackles a completely new market. We conduct a longitudinal analysis over an 18 month period and conducted a total of 34 interviews with both the keystone (which is a public private joint venture bringing together industrial firms, banks and a local authorities) and the other ecosystem members.

This article contributes to the growing literature on business ecosystems by analysing in detail how alignment can be reached in an asset-intensive ecosystem that emerges under high levels of uncertainties. It presents four tensions that keystone actors have to cope with and discusses eight strategies that the keystone mobilizes in order to cope with these tensions.

Interdependency and need for coordination in business ecosystems

Borrowed from biology, the term ecosystem refers to a group of interacting actors, generally firms, which depend on each other's activities (Jacobides et al., 2018). Various definitions of ecosystem exist. In this paper we build on Adner (2017) who describes ecosystem as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017). Alignment structure refers to reaching mutual agreement among the members regarding the value proposition that the ecosystem materializes, the ecosystem governance and value appropriation (Adner, 2017; Williamson & De Meyer, 2012). Ecosystems appear when no single actor has the necessary assets, expertise and skills to offer a product or a service for the end-user and the market structure does not allow for enough coordination for the joint value proposition to materialize (Jacobides et al., 2018). This typically occurs with products or services that have a high level of novelty and for which the components are not standard and therefore are not offered through a traditional supplier market. Firms need to coordinate their efforts to make their different components compatible and offer an aggregated value proposition. Jacobides et al. (2018) highlight that an important characteristic of ecosystems is modularity. A modular architecture consists of having a number of modules that are separated by "thin crossing points" (Baldwin, 2008), meaning distinct parts of the production process for the different components. Because this distinction often comes with different types of technological skills required, components of a modular architecture tend to be produced by different organizations, which is one of the reasons why ecosystems appear. Organizations in an ecosystem have a high degree of autonomy concerning the design of their modules but are also interdependent and need to coordinate and agree on an overarching architecture design parameters. The keystone of the ecosystem usually sets this overarching architecture and does coordination efforts to ensure interoperability of the different modules (Jacobides et al., 2018).

Ecosystem literature has historically focused on defining what ecosystems are and on explaining under which circumstances ecosystems appear, but recent literature has opened the question of how does the keystone of an ecosystem reach alignment of actors, as the materialization of the value proposition depends on it (Jacobides et al., 2018). Because there is a variety of actors with different interests, the coordination of their actions towards a common goal is crucial but also complex and recent ecosystem literature focuses on this issue (Dhanaraj & Parkhe, 2006; Kapoor & Lee, 2013; Wareham et al., 2014).

Some authors explain that organisations need to individually find the right balance for the tension existing between cooperation and competition. Hannah & Eisenhardt (2018) also show the importance of coordination by highlighting that a keystone needs to reach the right balance between cooperation and competition in the ecosystem with different advantages and disadvantages to different levels of cooperation and coordination. Wareham et al (2014) go further and explain that the complexity of ecosystem coordination comes from the fact that the keystone needs to address several tensions between partners and describe a typology of tensions that typically appear in ecosystems, namely standard-variety, control-autonomy and collective-individual objectives. Oskam et al. (2020) discuss three tensions that have to be managed in business ecosystem with sustainability goals: value creation and value capture; mutual value versus individual value and gaining value versus losing value. Overall, literature identifies relevant tensions and explains that the keystone needs to set up rules of interaction that facilitate this coordination (Adner, 2017). Although insightful, these papers, explaining the role of rules to solve tension and coordinate actors and the role of coordination itself, do not explain how does the keystone convince these organisations to integrate the ecosystem in first place, especially when this ecosystem depends on the development of an asset-intensive technological infrastructure.

Traditionally, literature has explained that there is usually an ecosystem central firm or a “keystone” that defines clearly the ecosystem blueprint, or in other words, the value proposition that the ecosystem will offer to the market and the network of activities needed to achieve it (Adner, 2017; Eisenmann, 2008). The blueprint is supposed to offer a convincing framework, to reduce uncertainty and to convince the potential actors of the ecosystem to participate in it. Dattée et al., (2018) show, however, that in situations of high uncertainty, ecosystems require actors to commit resources without having a clear vision of what the value proposition will look like. Besides, in asset-intensive ecosystems, materializing the value proposition depends on high level of investments which increases the perception of risk of potential ecosystem actors. Dattée et al., (2018) show that to reach a clear blueprint, the keystone of an ecosystem needs to first align actors, meaning convincing them to accept to participate in the ecosystem. Then, the interactions between all the ecosystem members will allow for a blueprint to emerge. Nevertheless, how this alignment is reached in this situation of high uncertainty and resources demands remains again unexplained. Situations of high uncertainty are, yet, growing, due to the need of organisations to offer innovative sustainable solutions which often consist in completely new products or services.

Coping with ecosystem tensions

Previous literature highlighted that tensions are inherent to business ecosystem and the literature highlights various types of tensions depending on the characteristics of the business ecosystem studied (Oskam et al., 2021; Wareham et al., 2014). In this paper, we argue that four tensions are particularly relevant for business ecosystem that are based on asset-intensive technological infrastructure.

To begin with, keystone actors for instance need to cope with the fact that value is created interdependently at the level of the ecosystem but that value will be appropriated at the level of individual organisations. Tension can emerge because there is a need to balance mutual benefits and individual interests (Boudreau, 2011). Keystone actor need to find the right incentives to stimulate ecosystem members to invest in complementary innovations while making sure they can preserve their own organisational interests (Wareham et al., 2014). This is even more challenging when ecosystem emerge under high uncertainties and individual uncertainties become collective uncertainties, as the ones that influence one of the partners will influence the others as well (Li and Garnsey, 2013; Vasconcelos Gomes et al., 2018).

Second, for the value proposition to materialise, creating enough value is a necessary condition for the business ecosystem (Santos, 2012). At the same time, to be and remain attractive for ecosystem actors, business ecosystem also have to be able to capture enough value in return (Chesbrough & Appleyard, 2007). Keystone actors have to find the right balance between value creation activities and value capture activities. This can create tension especially because contributing to value creation does not necessarily imply being able to capture value in return (Oskam et al., 2021).

Third, another tension can emerge if business ecosystem actors have different perception of what is valued, who creates value and how the value captured by the ecosystem should be distributed between ecosystem actors (Tsujiimoto et al., 2018). This tension relates to whether ecosystem actors agree about what is a fair distribution of value between each other. It is important for the keystone to find the right incentives to make sure that value is fairly distributed between ecosystem actors in order to make sure actors continue to create value in the long term (Lepak et al., 2007).

Fourth, we argue that in business ecosystem that involve the development of an asset-heavy infrastructure, one additional tension can emerge. Technological systems are known to be prone to path dependency and lock-in (Liebowitz & Margolis, 1995). Reasons for this are twofold. One the one hand, they involve important capital expenditures and long return on investments. This means that once investments are made in the technological system, it is very costly to change course. Moreover, technological system are designed to fulfil certain technical specifications and changing these specifications can be very costly as well. We argue that this tendency for lock-in and path dependency

will induce a fourth tension which is the need for the keystone to balance between making progress in order for the ecosystem to be and remain attractive while not deciding too quickly in order to minimize the risk to develop a technological infrastructure that is sub-optimal.

Methods and data

We follow a qualitative and inductive approach (Edmondson & Mcmanus, 2007) with the aim of building theory (Eisenhardt & Graebner, 2007). More specifically, we rely on the analysis of one embedded case study with qualitative data coming from semi-structured interviews. Our empirical analysis draws on the case Zero Emissions Valley (ZEV). It consists in the deployment, in the French region Auvergne Rhône-Alpes (AURA, East of France), of a fleet of fuel cell electric vehicles and the necessary refuelling infrastructure and hydrogen production infrastructure for fuel cell users to be able to use their vehicles across that region using only green hydrogen. It represents the largest infrastructural project for hydrogen mobility in France.

We consider this case as suitable to answer our research question because we believe it is particularly revelatory due to its exemplary characteristics. First, the emergence and development of the ecosystem depends on the cooperation of multiple public actors (regional authorities and cities) and private actors (large industrial firms and banks, SMEs and start-ups) to succeed. Second, it emerges in a context of high level of uncertainty as it tackles a completely new market. From a technological point of view, the ecosystem depends on industrialisation of technological prototypes with multiple uncertainties regarding costs and performance. The market for the product is also quite uncertain and keystone will have to identify which end-uses to prioritize. Moreover, to succeed the ecosystem will have to secure the simultaneous development of infrastructure and usages. Finally, this case study is also interesting because it concerns firms attempting to offer an alternative to polluting transportation and therefore face one of the major societal challenges today, which is energy transition. Energy transition requires the development of new services and products, which, like hydrogen mobility, ask for pooling complementary assets together. Many sectors are following this path today or will have to follow it in the coming years. Finally, low-carbon hydrogen (including green hydrogen) is now part of energy transition strategies of many countries and constitutes an important element of the EU Green Deal. The hydrogen mobility is an emerging sector and therefore its study is particularly relevant.

Case overview and history

The premises of ZEV started in 2016 when Engie - major French energy supplier (former national incumbent gas actor) diversifying its portfolio towards new energy services like hydrogen - joined Michelin - major international key mobility actor that sees hydrogen has a major leverage for its future as vehicle material provider - in Symbio's capital to accelerate hydrogen mobility solution. Symbio is a fuel cell pioneer and inventor of the first range extender for hybrid vehicles (electricity-hydrogen). A couple of years later, when Symbio faced financial difficulties, both Engie and Michelin decided to launch a project consisting on the deployment of an infrastructure of refuelling stations for hydrogen vehicles which would be accompanied by a program of public subsidies for hydrogen vehicles. The existence of the infrastructure and the subsidies would reduce the barriers that potential hydrogen car users face when deciding whether to buy (or not) a hydrogen car. To do so they needed to work together with public authorities and they chose the regional level as the most appropriated one and the AURA region in France as the more suitable for the development of this project. After convincing the regional authorities to endorse and adhere to the project, they applied for some European funding which they won, and they started the implementation of the project.

Engie, Michelin and the AURA region built a Joint Venture (JV), called Hymulsion, which would be the formal responsible for the deployment of the infrastructure. Two financial institutions joined the JV (Credit Agricole, a private bank, and Banque des territoires, a public financial institution). Hymulsion counts, therefore, on three private firms (*Engie, Michelin, Crédit Agricole* a French national private bank) and two public entities (namely the Administrative *AURA region* and the national public Bank the *Banque des Territoire*) and it was formalized in 2019. Hymulsion ensures and coordinates simultaneously the deployment of hydrogen production (with electrolyzers using exclusively renewable energy) as well as storage and distribution infrastructures. The regional authorities are in charge of attributing the subsidies for car purchase. While Engie and Michelin acted as keystones in the very early phases of development of the ecosystem, it is Hymulsion that took over that role since its creation.

Additionally to Hymulsion and its shareholders, the ecosystem counts on a network of cooperating actors with a variety of functions. These actors include start-ups in charge of the construction of hydrogen stations and electrolysis infrastructures (Ataway, McPhy and HRS), local authorities of towns who will host the stations (Chambery, Grenoble, Clermont Ferrand, Lyon or Moûtiers among others) and car sellers (local Jean Lain and Renault dealers for each city). Symbio was involved in the ecosystem at its beginnings, but they left it due to a change in its business model (shift from car constructor to component manufacturer). A consulting company (Enerka) and a competitiveness cluster (Tenerdis) were also involved at the beginning of the ecosystem construction. Car constructors (Renault, Toyota

Hyundai) are also involved in the ecosystem although they have a rather passive role and are waiting for further developments to get more involved.

The French national recovering plan announced in September 2020 will dedicate 7.2 billion € to the hydrogen sector over 10 years. This fund is already having an impact on the investment decisions of all actors and in the ecosystem we study. We thus expect ZEV to evolve towards larger set of applications (heavy trucks, or industry) implying bigger infrastructures, with potentially new welcoming actors. As a result, the bunch of surrounding actors is not definitive and may evolve according opportunities offered to ZEV.

The resulting code structure is shown in the following table.

Table 1: code structure

First order codes	Second order themes	Aggregate dimension
<ul style="list-style-type: none"> • Highlighting the potential of the technology to contribute to larger societal objectives (fight climate change) • Presenting the project as a stepping stone in the development of a new sector 	Embedding	Coping with tensions between individual and collective interest
<ul style="list-style-type: none"> • Emphasising the aspects of the ecosystem that can contribute to actors' organisational interest • Making the overall vision compatible with organisational cultures of actors 	Framing	
<ul style="list-style-type: none"> • Reciprocity as a way to accept committing resources • I commit resources if other commit resources as well 	Ensuring reciprocity	Coping with tensions between gaining and losing value
<ul style="list-style-type: none"> • Changing the distribution of role when an actor fails to fulfil its role • Redesigning technological infrastructure when technologies do not have the expected performance 	Reconfiguring	
<ul style="list-style-type: none"> • Gatekeeping by defining specific selection criteria • Defining prerequisite that trigger allocation of resources • Adapting the vision when the overall environment requires it (market response, political response, etc) • Prioritising capabilities and assets needed by the ecosystem and identifying actors that have them 	Rationalising	Coping with tensions between creating and capturing value
<ul style="list-style-type: none"> • Integrate process or values that key actors consider as fundamental by entering actors 	Assimilating	
<ul style="list-style-type: none"> • Select sub-optimal locations • Making compromises when needed (to convince new actors to enter the ecosystem and present actors to stay in it) 	Compromising	Coping with tensions between making progress and
<ul style="list-style-type: none"> • Actors accept to commit resources when they see the ecosystem reach intermediary milestones 	compartmentalising	

<ul style="list-style-type: none"> Actors accept to commit resources when they see a clear middle-term objective in the form of an intermediary goal 		avoiding sub-optimal lock-in
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The code structure shows four main tensions that the ecosystem keystone needs to address in order to achieve alignment.

Findings

The literature shows that to reach alignment, the keystone needs to secure agreement about the value proposition that the ecosystem aims to materialize, the ecosystem governance and value appropriation between ecosystem actors. Moreover, to maintain alignment, the ecosystem needs to create momentum and to be able to adapt as the environment changes. Each of these needs creates tensions. In the following section, we discuss the strategies used by the keystone to cope with these tensions while seeking to reach and maintain alignment.

Coping with tensions between individual and collective interest in order to agree on the ecosystem value proposition

A characteristic of innovation ecosystems is that value creation takes place at the ecosystem level while each actor will seek to capture value at the level of individual organization. The keystone has to reconcile the collective interest to jointly create value and the individual interest to capture value. We observed two strategies that the keystone adopts in order to cope with this tension: **embedding** the ecosystem into a larger objective that actors can adhere to and **framing** the ecosystem vision according to the interests of each actor.

Embedding

Embedding the ecosystem vision into larger objectives relates to linking the value proposition of the ecosystem to a bigger purpose than the ecosystem itself. Because of high uncertainty, actors cannot anticipate whether the ecosystem can appropriate value and if so how much. Interviews revealed that participation cannot depend solely on short-term profits that actors can expect by participating in the ecosystem. To cope with this, we observed that the keystone makes a lot of effort to embed the ecosystem within a larger aspiration. For instance, when trying to align actors, we observed that the keystone presented participation in the ecosystem as a means to enter a growing sector or to contribute to solving a major societal challenge. When presenting the project, the keystone often started describing the vision that ZEV builds on. The keystone insisted not only on the potential of the project by itself, but also on the potential of the hydrogen technology. Hydrogen mobility was presented in a very optimistic way, as a very promising solution that could overcome the problems of

mobility using fossil fuels (pollution) and the problems of electric battery mobility (the waiting time for recharging batteries, capacities of batteries to allow mobility over long distances). Participating in this project would thus mean being part of a market that would have an important role to play in the future.

We observed that ecosystem actors shared similar expectations about the potential of hydrogen. For instance, one of the shareholders explained: *"Our group is convinced that the battery alone will not be enough and that hydrogen is an essential complementary solution"*. Similarly, the representative from one of the banks explained: *"we follow developments on hydrogen and we believe in it more than others. So we think that this is a sector that will develop, particularly in terms of mobility"*. By embedding the ecosystem in much broader societal changes, ecosystem actors are able to justify their collective ambition. Interestingly, embedding the project in a larger sectoral dynamic is not something the keystone did alone. Other more peripheral actors did that as well. Explaining his role, one of the car dealer for instance stated *"we are playing our role which is to evangelize the hydrogen automotive product a little by putting vehicles into service through our rental agencies"*.

Framing

Besides embedding the ecosystem in broader societal changes, the keystone also needs to make sure that ecosystem actors (core or peripheral ones) are convinced that participating in the ecosystem is a way for them to fulfil some of their own organisational interest. We observed that the keystone tried to do that by translating the overarching objectives of the ecosystem as something meaningful for potential ecosystem actors. For each actor, the keystone would frame the project differently. For instance, explaining the beginning of the project, a representative of one of the keystones stated: *"I digest the New Year's greetings speech from the president of the region for 2017 and I ask myself the question: in that speech what are the political elements that stand out? Air quality and job creation"*. These became the two core elements that the keystone used to convince the Region to integrate the ecosystem. To local government, the keystone focused on the providing solutions to fulfil their own local objectives. For instance, some cities decided to introduce 'zero emission zones' where only low emission vehicles will be able to drive through. The keystone presented participating in the ecosystem as a means for the city to propose alternative to owners of polluting vehicles. To banks, the keystone focused on the innovation potential of the ecosystem, the potential of hydrogen as a generalized mobility solution in the future and the level of investments that would be needed when the sector grows. The Bank framed the vision as follows: *"It is in the interest of the territory, with all that this will bring in terms of job creation, and potential investments around ZEV"*. To energy-intensive industries, they offer the possibility to implement concrete actions related to their carbon neutral strategy such as deploying and refilling on site a fleet of professional hydrogen vehicles.

Coping with tensions between gaining and losing value in order to agree on the ecosystem governance

Participating in the ecosystem entails agreeing about the way roles and responsibilities are allocated in the ecosystem. This allocation will determine the level of resources that actors have to commit to the ecosystem and it is crucial that actors are confident that risks and rewards are adequately shared between ecosystem actors. The ZEV ecosystem also has the characteristic that it is asset intensive. For the value proposition of the ecosystem to materialize, many resources are required (eg. financial resources to finance the stations and the vehicles and land to build the refuelling stations). This, combined with the uncertain return on investment, makes participating to the ecosystem a risky endeavour. Moreover, the ecosystem builds on technologies that are not yet mature and addresses a market for which consumer demands and their willingness to adopt the technology are not clear. This increases the risks that some ecosystem actors may not be able to fulfil the role assigned to them.

To deal with these issues, we observed that the keystone adopted two strategies: **ensuring reciprocity** to convince ecosystem actors that risks are shared equitably and **reconfiguring** when actors failed to fulfil the tasks assigned to them.

Ensuring reciprocity

We observed that ensuring reciprocity has been a very important strategy used by the keystone to convince actors to allocate resources to the ecosystem. Actors had to be persuaded that if they allocated resources, others would do that as well. For instance, when building the first stations, the keystone was confronted to a delay as it took longer than expected to formally create the joint-venture. The two industrial partners could have decided to build the first stations jointly. However, they found it easier to split the responsibilities and decided that each of them would be responsible for building one station instead. *“We will each build a station in advance of phase: Engie in Chambéry and Michelin in Grenoble, a service station and Hymplusion will buy it after”*. Similarly, the keystone itself is a joint venture and shareholders agreed that they would each commit certain amount of resources to facilitate the functioning of the joint venture. This is illustrated by the following quote from the director of Hymplusion: *“each shareholder commits to put in a certain amount of full time equivalent to facilitate the operation of the company and the deployment.”*

Ensuring reciprocity is also something that proved important for more peripheral ecosystem actors as well. Empirical observation for instance point that some car dealers were reluctant to enter the ecosystem because they found it more difficult to sell hydrogen cars than gasoline, diesel or even electric battery cars, notably because they know less about the technology. To align them, the keystone had to show that they would also commit resources to support the commercialisation of

hydrogen cars. This is illustrated by the following quote from a representative from Hymulsion explaining how he addressed car dealers: *“we are the ones who will bring you knowledge and skills and know-how around hydrogen. So, be present and let's build animations together to attract the buyers with different possible animations. [...] We will work together and I will find the right contacts for you in the field.”*

Reconfiguring

We observed various instances where some actors were not able to fulfil the role that had been assigned to them. For instance, the keystone realised that it was difficult for some cities to gather the letter of intentions necessary for the stations to be built. As expressed by an interviewee from one of the participating cities: *“you have to have the soul of a salesman and I am not a salesman. Hymulsion often talks about a pioneering spirit, but it's hard to convince. It's hard to carry this message you see.”* To overcome this difficulty, the keystone reconfigured the allocation of role and internalised the commercialising activities. This is illustrated in the following quote. *“Finally, the region has revised its strategy by providing the company which manages the entire project in its technical part, more precisely the [keystone] Hymulsion, with a sales representative.”*

Similarly, the keystone also faced a situation where one actor tried to hide the difficulties they faced to industrialise their fuel cells production facility. This was an important role in the ecosystem as the availability of hydrogen vehicles depended on this. After many inquiries, the keystone finds out: *“They told us “Yes, we have a problem. The vehicles are not on time.” And the question is when and can we have a date? And we don't have the date of when”.* To deal with this issue, the keystone proposed reconfiguring the value proposition of the ecosystem to include heavier vehicles.

Finally, when working on the call for tender to identify companies that would build the refuelling stations, the keystone discovered that equipment manufacturers were not able to deliver the technology at the price that the keystone expected it could obtain. This results in a reconfiguration of the design of the stations and instead of building an electrolyser (to produce hydrogen) in each station, they would construct a few large electrolysers and distribute hydrogen to the different stations. This is illustrated by the following quote: *“we realized that we were being promised things that were unattainable in terms of operating costs. And so it just wasn't possible. We understood that we had to massify the production units”.*

Coping with tensions between creating value and capturing value in order to agree about value appropriation

Innovation ecosystems also have to balance between the need to create value so that the value proposition can materialise and the need to secure value capture so that the ecosystem can be viable over time. To deal with this, we observed two strategies that were adopted by the keystone: **rationalising** in order to minimize risk and **assimilating** values or processes demanded by an entering actor in order to ensure they capture value.

Rationalising

As explained previously the ecosystem emerges under a situation of high uncertainty. Participating in the ecosystem comes with important financial risks, especially for the keystone and the ecosystem core members. We have observed that to align actors, a lot of effort was put in place to rationalise how resources are used in order to minimise risks as much as possible. This means, putting in place a set of criteria to identify the actors that can best complement the ecosystem and agreeing on criteria that trigger the allocation of ecosystem resources.

First, an important factor has been to align in priorities actors that had complementary assets and capabilities. For example, at the very onset of the project, the two project initiators, Michelin and Engie, needed to find the support of regional public authorities. Engie proposed to focus on the Auvergne-Rhône-Alpes (AURA) Region because it has a strong industrial energy heritage and hosts many French hydrogen actors that could provide complementary assets to the ecosystem.

Second, to rationalise resources, the keystone plays an important role of gatekeeping by establishing criteria for the identification and selection of actors that have the capabilities to contribute to the ecosystem. For instance, in the case we study, the keystone needs to partner with local authorities that will host the stations and coordinate the different actors at a local level. They looked for cities where the local authorities were likely to be favourable to contribute to the development of the ecosystem and as explained by an interviewee cities are chosen when *“there is a willingness, a political commitment which is manifest and well presented”*. Similarly, in order to identify pioneers that could potentially buy hydrogen vehicles, the keystone asked the cities to look in their archives for companies and institutions that had already participated in initiatives for cleaner cars. The project leader in the city of Grenoble explains: *“I will identify in our archives of companies, companies that have large fleets and that are already sensitive to sustainability issues through other public programs”*

Finally, another important element to convince actors to commit resources to the ecosystem has been to design and agree upon prerequisites that would trigger the allocation of resources. Coming back to

the example of cities that host the refuelling stations, showing political commitment is not sufficient. The keystone included two additional criteria that have to be met before a station is built: the existence 50 letters signed by local actors that commit to purchase a hydrogen vehicle and an economic criteria consisting on the expected consumption of hydrogen of the local fleets associated with one station. As explained by one interviewee: *“50 vehicles does not mean anything because if 50 vehicles traveling 5,000 km / year versus 50 vehicles traveling 250,000 km, we will not have the same turnover at the station”*. Agreeing upon these economic criteria has played an important role in aligning the banks that demanded to reduce the risk that refuelling station would be built without users present to buy hydrogen and therefore pay for the station.

Assimilating

We also observed that to align some actors, the keystone sometimes had to accept to assimilate the procedure or important values actors brought forward in order to preserve their own organisational interest. For instance, as the keystone presented the shared vision to actors that could join the ecosystem, we observed that some actors accepted to endorse the vision but put forward conditions, asked for some adjustments. For instance, for the Region it was important that the infrastructure would be considered as a public service meaning that it would be developed throughout the region. This meant that the keystone had to accept that some stations might not be economically interesting as far as they served to connect well the region. The region explains it in the following way: *“That is to say that there are places where we will decide to put a station so that it makes a network, but that means that some stations will not be profitable. We do not create 20 profitable stations”*.

Coping with tensions between making achievements and avoiding becoming locked-in a sub-optimal situation in order to create momentum

As aforementioned, the ecosystem of ZEV is asset intensive. Similar to other technical systems, it is prone to lock-in and path dependency. When technical assets are constructed, they meet certain specifications and changing these specifications is difficult. For instance, when a station is built to refill lightweight vehicle, it is very costly to adapt the station in order to refill heavier vehicles such as buses. This also explains why the keystone made so much effort to rationalise investments. At the same time, it is also necessary to ensure that the ecosystem creates and maintains internal momentum. This momentum allows maintaining alignment and aligning new actors as the ecosystem develops. To keep momentum going, the empirical data suggests that the keystone performed two activities: **compromising** and **compartmentalising**.

Compromising:

We observed a few instances where things did not go as planned, forcing the keystone to make some compromises in order to still be able to make progress. For instance, after attributing the call for tender to companies that would build the refuelling infrastructure, the keystone faced the issue that there were not enough commitment letters signed to officially initiate the construction process. The keystone had to find a compromise and start building some stations nevertheless. Hympulsion General director (the keystone) explained it in the following way: *“the shareholders would say: “Well, the vehicles are not there, what are we doing to find a solution?” Some said “Hympulsion can wait, we do not build the stations. Too bad, it does not matter, we lose a year and the vehicles will come”. Well, the operational problem is that we ordered the stations and that if the actors of the sector do not have the orders now, there are a certain number who will not be able to survive. So the choice we want to make is: we do some stations, we find other hydrogen purchasers”.*

Compartmentalise

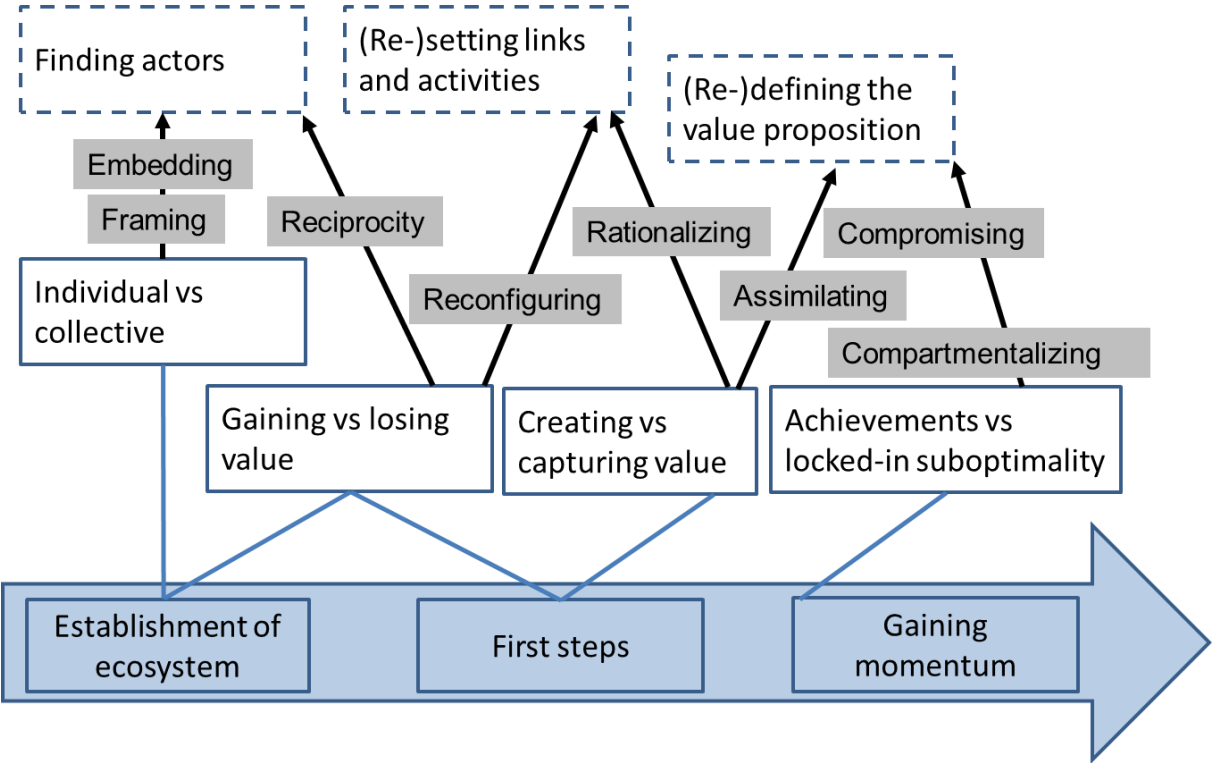
We also observed that being able to create and keep momentum was sometimes difficult because core ecosystem actors had conflicting timeframes. For instance, at the onset of the project, the keystone had managed to pool together actors that were interested in developing an ecosystem for hydrogen mobility, including regional and municipal authorities. However, the keystone also observed that while the industrial actors felt the urge to act fast the Region did not share this time constraints. A representative from Engie explains *“we feel that there is a listening, a “why not”, but we measure that there are two different time scales. We are in an emergency but politics are more in the long term”.* The keystone resolve this by identifying a European call for projects that help subsidize alternative diesel infrastructure. This would bring additional funds to the project and motivation to the Region to act faster. *“I immediately understand that this has an extremely precious benefit because it allows the two time scales to coincide. That is, there is a definite milestone. [The European call for projects] allows everyone to get into project mode. Basically, the next question asked of stakeholders is not whether they are interested in working on hydrogen topics. But the question becomes: here it is, Engie and Michelin aim to respond to this call for European projects which must be submitted on July 14 in Brussels. Do the regional council, the metropolises of Clermont, Lyon, Saint-Étienne, Grenoble want to support this initiative or not?”.*

Similarly, when launching the call for tender to identify the firms that would build the stations, the keystone had to design a tender that provided enough flexibility. The keystone for instance knew how much hydrogen they would need to produce in total but not how many electrolyzers they would need. The tender was set-up in such a way that the consortium that won the bid could start constructing the some component of the stations while living some flexibility to adapt the specificities of each station

to a later stage. This is illustrated by the following quote: “the program is of 1,600 kilos per day of hydrogen production distributed on the entire network. This will be done either in four or three electrolyzers and maybe two, it is in progress at the moment”.

Wrap-up and model proposition

The following models explains the tensions that we find as well as the stages of the ecosystem formation and aspects of the governance that they relate to.



Discussion and conclusion

This paper parts from the observation that ecosystem literature highlights the importance of alignment without addressing what makes alignment possible, especially in ecosystems that are asset-intensive and emerge under high uncertainty. The paper presents eight strategies that the keystone uses in order to cope with prevailing tensions and be able to create and maintain alignment over time as the ecosystem emerges and grows.

Based on our analysis we can make a few observations. First, the analysis show that to reach agreement about the value proposition the ecosystem would materialize, the keystone embedded the ecosystem in something large than the ecosystem itself - participating in the ecosystem will offer them an early presence in a growing market. We observed that actors that were aligned in the ecosystem all speak as one single voice. The keystone managed to create a shared vision and narrative about the

raison d'être of the ecosystem. Moreover, this shared vision also acted as a boundary object: each of the actors was able to use it in order to justify their participation in the ecosystem.

Moreover, literature often assumes that the biggest alignment challenge of an ecosystem keystone is to ensure that members' strategy to capture value is not damaging the ability of others to capture value as well. How are ecosystem members persuaded in first place to enter the ecosystem is, to the best of our knowledge, not yet addressed. Literature often assumes that there is competition to enter an ecosystem and that this competition regulates who can be part of the ecosystem. We believe, however, that under high levels of uncertainty, there is not a lot of competition to participate in the ecosystem and this is precisely what we observe in the case we study. Despite many potential members showing interest in the ecosystem, it was laborious for the ecosystem keystone to convince them to be part of it.

The ecosystem keystone also needs to make members of the ecosystem commit resources to it. Literature has traditionally explained that this is made possible by offering a precise blueprint of the roles in the ecosystem and the relationships between those roles. Literature assumes that for the keystone identifying capabilities and linking them to roles is a rather natural process, as well as the process of making members understand which is their position and role. Under high uncertainty this is, however, not the case. The keystone cannot decide alone which role needs to be fulfilled and choose an actor depending on its capabilities. As explained before there is not a high competition to enter the market and actors need to agree on their positions and roles. Our results illustrate that the keystone made a lot of effort to persuade actors to enter the ecosystem. Results show efforts made by the keystone to minimize risks for ecosystem actors – by rationalising what would trigger the allocation of resources by the ecosystem and by ensuring trust between ecosystem actors by ensuing reciprocity.

Finally, the analysis also shows that creating and keeping momentum is extremely challenging and that the keystone had to negotiate compromises and design the emergence and development of the ecosystem in a sequence of very small intermediary steps. We also observe that the ecosystem gains flexibility not through modularity as is often mentioned in the literature but by anticipating changes and leveraging flexibility that can be provided by complementors.

While this version of the article is mostly based on interviews conducted during the first round of interviews, the next step will be to analyse the second round of interviews. This will be especially useful in better understanding how internal momentum is built and how the various activities are redefined as the keystone identifies what blocks the development of the ecosystem are tries to respond to that.

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