

Title: Path dependent path breaking – tracing innovative entrepreneurial behavior through C-K method

Abstract

Breaking with the path-dependency associated with innovations and innovating firms is normally seen as something challenging but also giving rise to entrepreneurial opportunities. However, we have little understanding of how entrepreneurial behavior breaks new innovative paths. This paper explores path-dependencies and path breaking in technology ventures by their entrepreneurs, using a methodology for innovative design – the C-K method. The method among other things adds to our understanding of how a changed direction of a venture is based on deliberate and designed actions. Many of the studied ventures were found to change directions in unforeseen ways. Yet, when doing so, this path breaking was based upon generated knowledge rather than on “new discoveries”. These observations increase our understanding of how predictive and effectual entrepreneurial logics can be combined. The findings also indicate that technology entrepreneurs especially in early stages might be well suited to mindfully deviate from established paths.

Keywords: *path-dependency, path breaking, C-K method, entrepreneurial decision making, effectuation*

INTRODUCTION

This paper explores entrepreneurial behavior and decision making in early-stage technology ventures through the lenses of the C-K (Concept – Knowledge) method. The C-K method depicts developments of an innovation in a Concept space and a Knowledge space. Up to this point, the method has primarily been applied on innovations and R&D in corporations. The ventures explored through the method in this study are spin-offs from R&D at corporations or universities to which entrepreneurs attending a master level entrepreneurship education have been appointed. This setting has been investigated due to its high survival rate of technology ventures which partly was assumed to be caused by an ability of the ventures to do innovative adaptations. The paper adds to our understanding of the entrepreneurial decision making resulting in path-breaking.

The theory of path dependency is used broadly in economics and sociology to explain that history often matters and that we in many situations such as when innovating do not have the strategic choice that we like to think we have. Path dependency in terms of having shared frameworks and operational routines might not only be a problem, they also help many innovating firms to be more efficient and thus more competitive in the way it develops new products and services. Path dependency is thus often related incremental innovation and its reliance on established and measurable criteria (Christensen, 1997). Path dependency also explains why more disruptive and radical innovation often is more challenging. Through Schumpeter, entrepreneurial behaviour is strongly linked to more disruptive – path-breaking – innovation (Schumpeter, 1934). However,

entrepreneurs are also affected by history and there is little understanding of how and why actual path-breaking occurs (Garud & Karnoe, 2001).

Entrepreneurial behavior can be seen as the combination of actions, carried out by the entrepreneur, which continue to adjust and define an opportunity and position it as acceptable to the market (Alvarez & Barney, 2007; Williams Middleton, 2010). Entrepreneurial behavior is observed as enacted decisions of an emerging venture. In innovative terms, this behavior can represent the mindful deviation from the path dependency mapped out for a particular opportunity. Understanding the logic utilized to make the decision to break from one path to another may give us insight into how innovative opportunities are pursued.

Research has outlined two main logics guiding entrepreneurial decision making – causal logic and effectual logic (Dew, Read, Sarasvathy, & Wiltbank, 2009; Sarasvathy, 2001). Causal (or predictive) logic emphasizes the use of assumed existing information or knowledge, upon which key decisions are made, in order to realize a pre-determined outcome. Effectual logic is a logic of controlling known and ‘at hand’ means in order to create multiple possible effects and unanticipated ends. Both logics can be used towards a generalized goal or aspiration – the difference lies in the choices made towards that goal or aspiration (Sarasvathy, 2001), and whether the transformation of the idea is more explorative or exploitative (Politis, 2005).

Using a C-K method to investigate developmental paths of technology ventures, we shed more light upon the use of both logics and how they inform decisions to break path dependency of original opportunities. Hence, the purpose of this paper is to investigate selected technology ventures through the C-K method in order to add more understanding to innovation theory around path dependency and the logics of decisions guiding entrepreneurial behavior. The subsequent sections are structured as follows. Theory section will outline our understanding of innovations and path dependency as well as logics used for entrepreneurial decision making. The C-K method is also presented. The method section describes the context of the study. The findings section describes the entrepreneurial decisions and resulting paths of four selected ventures. Finally the discussion relates the empirical evidence to our understandings of path dependency and decisions guiding entrepreneurial behavior.

THEORY

Path dependency is a concept used in situations when the actions of the present are influenced by the paths followed to get there (Leonard-Barton, 1995). The origins of path dependency can be traced to David (1985) and his analysis of the persistence of the QWERTY keyboard – having remained the same since the 19th century. Path-dependence lead to ‘technological trajectories’ or ‘technical regimes’, defined as a set of rules for how to produce, use and regulate specific technologies (Le Masson, Weil, & Hatchuel, 2010).

Path-dependency is related to firms and their behaviors as well as to innovation, technologies and whole industries. Within firms path-dependency has been located to three different domains within the firm in the 'technology-as-hardware' domain, in the 'knowledge base' and in routines (Coombs & Hull, 1998). However, often the concept is seen within a larger context of a "technological paradigm" that define the needs that are meant to be fulfilled, the scientific principles utilized for the task, and/or the material technology to be used (Dosi, 1988). Being in the forefront of a technological trajectory within technological paradigm can be a source of competitive advantage. However, path-dependency often also implies that there are large difficulties for actors within a technological paradigm to break with it and create new paths. This presents an opportunity for introduction of entrepreneurial decision making. Entrepreneurs can be seen as knowledgeable agents with capacity to reflect and act in ways other than those prescribed by existing social rules and taken-for-granted technological trajectories (Garud & Karnoe, 2001). Entrepreneurs could thus be seen as path-breakers, although that does not mean that they can exercise unbound strategic choice making. Rather, entrepreneurs are embedded in structures they jointly create and from which they mindfully depart (Garud & Karnoe, 2001).

Entrepreneurial behavior

Entrepreneurial behavior can be defined as behavior of individuals engaging in a process of creating new ventures, where the process includes units of actions which can be observed by others (Williams Middleton, 2010). Large scale studies on entrepreneurial emergence have resulted in identifying activities key to venture creation (see for example, Gartner, Carter, &

Reynolds, 2004). These have been organized into four main categories of behaviors (Liao & Welsch, 2008) – planning activities, establishing legitimacy, resource combination, and market behavior. This behavior is learned through experimental and experiential engagement in the process (Deakins & Freel, 1998), utilizing interpretation and feedback from surrounding factors as part of the decision to act in one particular way or another (Anderson, 2000). Behavior learned through engagement and experience of having achieved entrepreneurial success is the basis of effectuation (Kruecken, 2003).

Sarasvathy argues that entrepreneurs incorporate a special logic to their decision making, termed effectual logic, enabling creation of new and unanticipated effects from known means (Kruecken, 2003; Sarasvathy, 2001). It is not a logic of ‘anything goes’, intuition, passion, and fearlessness in the face of risk; but rather a process of logical reasoning. Effectual reasoning is viable when the ‘problem space’ consists of uncertainty (the impossibility to calculate the probability for future consequences), goal ambiguity (preferences are not given or prioritized), and isotropy (lack of clarity about which elements of the environment to pay attention to) (Kruecken, 2003, p 70). Use of effectual logic is argued as viable in uncertain or ambiguous environments, as it allows for decision making based on that information which is controlled by the individual (the entrepreneur’s available ‘means’ – such as personal capabilities and accessible resources, including human and social capital), in order to explore or create options, instead of being limited to acting only towards a pre-determined outcome (Dew et al., 2009). Hence, effectuation suggests that new venture creation is largely driven by the relationships the entrepreneur has with

her stakeholders, and the ability to manage and utilize the stakeholders to develop contingencies that the new venture can leverage into profitable opportunities (Kruecken, 2003, p 239).

C-K theory

The C-K (Concept Knowledge) theory (Elmquist & Segrestin, 2007; Hatchuel & Weil, 2009; Kazakçi & Tsoukias, 2005; Le Masson et al., 2010) is a design theory based on the distinction of two different expandable spaces: the space of Concepts and the space of Knowledge. Knowledge is defined by assertions that we already know (or we know that this is not yet known). We can say if it is true or false. On the contrary, the space of concepts regroups propositions that do not already exist but that can be formulated due to the knowledge assertions.

For example, if we are working on bicycles, “bikes usually have two wheels” would be an assertion in the K space and “a smart bike” would be a concept (since we do not know yet what a smart bike can be).

The design process is modeled as the co-expansion of the two spaces. The available knowledge will enable formulation of the initial concept (C0). In the C space, this initial concept is split in different sub-concepts (some following the “common view” of the objects and others breaking one usual attribute of the object). These alternative concepts will lead the designer to explore new knowledge basis and to acquire new knowledge (through experimentations, enquiries, tests, models, etc.). This new knowledge enables the refinement of the concepts and/or the abandoning of certain concepts. This iterative process progressively leads to the identification of the knowledge that is needed to proceed and can thus be used to guide the learning process.

This iterative expansion of the two spaces is illustrated in Figure 1.

Insert Figure 1 about here

Based on existing knowledge (K0), an initial concept (C0) is developed. Transitions to the K-space are necessary in order to find new knowledge (K1), which in turn may reframe the concepts into alternative concepts (C1, C2 . . .). The design reasoning stops when a concept is fully specified by a succession of attributes and accepted as true in K (there is a ‘conjunction’). This presentation of the theoretical C-K framework, although simplified, illustrates the core of design reasoning, i.e., to work on the combined expansions of concepts and knowledge.

This C-K theory is usually used during the design process in order to explore the field and propose new concepts and a new knowledge base for observation and analysis. In this paper, the C-K method will be used to analyze our case study of path dependency and path breaking of emerging entrepreneurial projects that were incubated at the Encubator.

C-K theory applied to the entrepreneurial process

If we look at the entrepreneurial process through the C-K theory, the concept space is the space of the opportunities, of the visions, whereas the knowledge space is the space of the resources (scientific knowledge, business studies, market studies), of the constraints (‘my product has to

respect this and that constraint’) and of the evaluation criteria (‘a good product should answer to these needs’, ‘...be sold at this price’, etc.).

An opportunity, which is usually defined as a coupled technology/market that presents value and should lead to a successful business, is an idea that is very ‘down in the tree’. High concepts in the tree are less defined and more open; low concepts in the tree are the ones that are the most well defined, and that are about to be realized and to become knowledge.

In this design framework, a focusing entrepreneur who tends to further define the product in order to concretize the initial idea would be illustrated or defined by a tree with one, very long, branch. The entrepreneur does not explore multiple paths, but tends to specify the product by giving it attributes; the entrepreneur is more exploiting an opportunity. On the contrary, an opportunistic entrepreneur, who jumps from one conceptualization to another would be described as someone who explores the tree in its width, jumping first from a concept to another which is quite close to the first one (because it is recognized that entrepreneurs have few resources, so they have to explore opportunities that are quite similar to their first idea), and so on; the entrepreneur is exploring an opportunity (or opportunities).

Insert Figure 2 about here

METHOD

We will first describe the contextual background from which the ventures studied emerged. We will then present how data on the selected ventures was collected and analyzed.

Contextual background

In the mid-1990's, individuals at Chalmers University of technology recognized the need for stimulating entrepreneurial activity and bridging the gap between inventors with ideas and the marketplace. This resulted in starting Chalmers School of Entrepreneurship in 1997: a combined masters-level education and incubator (named the Encubator). Students not only learn about the venture creation process; they learn through it (Lundqvist & Williams-Middleton, 2008). At the beginning of the second year, student teams are matched with an idea to form a project (potential future venture). The ideas are recruited or accepted from university or corporate R&D, or from independent inventors. During the incubation year, the students are in charge of the development of the project, with the ambition to incorporate, should the project illustrate viability at the end of the educational period. This often leads students to engage, to be part of the project, and, as much as possible, contribute their thoughts and reflections to the development of the project towards a venture. The pedagogic approach supporting their actions includes assignments, meetings with the board of the projects, interactive coaching with the teachers and advisors, among others, which enable active learning and reflection-in-action through a venture-creation approach (Ollila & Williams-Middleton, 2011).

The success of the approach has resulted in an 80% success and survival rate of the ventures

incorporated (data from 1997-2009) (Berggren et al., 2010). Some of the incorporated ventures have been independently identified as top success stories for venture start-ups in Sweden. Beyond the high-growth economic performance criteria of some of the highlighted success stories, the ventures stemming from the Chalmers School of Entrepreneurship can in general also be identified as particularly technology-based, innovative and disruptive, in comparison to the majority of ventures developed through incubators and/or educational programs in Sweden.

This structure of entrepreneurial education and incubation differs from the traditional ways of teaching and enhancing entrepreneurship:

- The ideas are proposed by idea providers (who can be experts, researchers, inventors, small or big companies) and not by the entrepreneurs. The first consequence of this is that new actors are brought and decide to work on an idea that was initially not their own. This suggests a potential form of detachment from the idea. The different stakeholders are very free to operate with the idea and can easily transform it or switch to a connected idea that seems more valuable or more feasible. This detachment might be a critical aspect enabling path breaking and disruption.
- A significant amount of coaching is provided to the students. Not only are the students coached by their teachers, as is common in educational environments, but they are also coached by the Encubator's business advisors, by alumni mentors, and by additional external resources the students themselves attract to the projects. The emphasis on coaching forces or empowers the student to reflect upon their actions and associated consequences, in order to

help develop and articulate motivation for the choices made. We suggest that reflection may play a key role in the logic the entrepreneurs utilize to explore new ideas and different paths. When faced with a decision, they are often required to, or chose to, look at the alternatives in order to explain their reasoning (to themselves and their key stakeholders) for why they have decided upon a particular path. This often includes cycles of analysis as steps are taken in order to determine if their choice is relevant or not. The reflection process pushes them to consider alternatives, adapt decision, and enhance the potential of their initial idea.

This structural organization of the incubation process and the entrepreneurial education is not common (Lackeus & Williams Middleton, 2011). The result of the approach seems not only provide the individuals with the role of entrepreneur in charge of bringing an idea to the market, but also as innovators that help shape the innovation. This is observed through the mechanism of finding, exploring and developing the potential of the ideas proposed in previous sections of the paper.

Data collection and analysis

C-K theory is used to generate understandings of the mechanisms that lead entrepreneurs to explore, create and chose new paths that were not the initial one of the project. We want to understand how they are not only problem solvers but also rule breakers creating and considering new disruptive paths.

To reach this purpose, we analyzed four projects from the Encubator (some of them were incubated at the very beginning of the program (1997) and some are much more recent and just leaving the incubator). This study was made through interviews of the entrepreneurs, coaches and idea providers in order to form short case descriptions (Yin, 1989). These interviews let us understand better the journey of the projects and analyze how they have or intend to transform their project into a successful start-up. The cases including the C-K maps are based on different evidence: the business report written by the students at the end of the incubation year, but also different reports written during the years, and the slides of the presentations that they have made during this incubation year. These documents give a more objective view of the journey of the project. Then, we used some evidence coming from these “historical” documents to confront it to the view that the entrepreneurs can have about their project. Finally, the progress reports of the Encubator were used to follow the projects and their journey once they had left the Encubator.

All this information was used to analyze the design process ongoing during the projects. Thus, the journey of the different projects was translated into C-K, in order to highlight the exploration process and the different steps the entrepreneurs used to shape the innovation.

FINDINGS

The journeys of the projects are illustrated in the associated C-K map figures (see figures 3 through 6). They identify a transformation of the initial idea. In some cases, we observe entrepreneurs as individuals that are either very focused and in charge of the concretization of

one disruptive idea; in other cases we see them as opportunistic, shifting from one conceptualization to another until they settle upon the configuration of factors that allow them to achieve success. The comparison of the first exposition of the ideas by the idea providers and the products and services offered by the different start-ups shows that the idea has evolved significantly from the beginning. Two profiles of cases are presented as follows.

The initial idea is ‘pre-determined’

In most of the cases that have been studied, the initial idea proposed to the students consists in a technology associated with a specified application.

The Insplorion case. This case concerns using plasmons to analyze specific chemical reactions. The idea provider, a well-know researcher from Chalmers proposed this technology and explained that his aim was to use it as a device allowing NO_x reduction. The first job done by the entrepreneurs was to develop the initial idea of NO_x reduction. They thus inscribed themselves in the whole ecosystem of the NO_x emission reductions and had considered two different alternatives: the first one was to develop sensors for cars in order to optimize the combustion while avoiding NO_x production, and the second one was to develop research tools. After different analysis (freedom to operate, market analysis, intellectual asset analysis), they decided to develop the research tool in order to put it on the market and earn money as soon as possible, and to develop a partnership with car manufacturers in order to learn more about car sensors and to propose a product in a long-term perspective.

While developing the research tool for NO_x reduction, they had a lot of interactions with their idea provider and with other researchers of his network. Through this knowledge acquisition, they finally understood that the value of their technology is that it enables people to follow catalysis reactions, step by step, even under extreme physical and chemical conditions. Thus they finally decided to work on this new concept of “real time catalysis study”.

Insert Figure 3 about here

If we look at the background of the idea providers, he already had a lot of knowledge about catalysis and its studies under extreme conditions, but the idea he proposed to the Encubator was much more focused. Thus, by developing the initial idea of NO_x reduction (in a way that could be described by causation, because they knew which goal they wanted to achieve), the entrepreneurs explored new knowledge basis and understood that their project was included in a higher concept (“Studying catalysis in extreme conditions”). This high concept in C space enabled them, not only to understand better the value of their technology, but also to structure the exploration of different niches, such as the NO_x reduction sensor and the research tool for catalysis.

In this case, we can say that the entrepreneurs have designed new paths and thus increased the overall potential of their venture. The path creation relied on the new knowledge basis and on the new people that the entrepreneurs (and the other stakeholders) brought to the project.

The Cereduce case. In the Cereduce project, the idea providers had developed a technology to create yeast that produces very little alcohol during the fermentation process. Thus, they proposed their technology to the Encubator, packaging it as a technology that would be used in the wine industry. Actually it has been demonstrated that if alcohol production could be reduced during the fermentation process, wines could be tastier without increasing its alcohol rate.

The entrepreneurs decided to develop this idea and to overcome the different development problems in order to bring this yeast to the market. By analyzing the different locations they could have in the value chain, they considered three options: 1) Sell the yeast to yeast suppliers in order to give them an additional competitive edge; 2) Create a new position in the value chain and directly target wineries; 3) Utilize the modified yeast to deliver superior products to end consumers.

In order to evaluate the potential, the feasibility and the attractiveness of these different alternatives, they contacted yeast providers and studied the different activities/customers of this actor. This showed them that yeast providers were not only present in the wine industry, but also in many other industries, such as the enzyme industry or the chemical industry.

Understanding that the value of the knowledge they had was expandable to much more areas than the wine industry, they finally decided to be an actor in alcohol reduction. This concept, which is now their leading concept, inscribes them in a disruptive path. Actually, most of the existing modified yeasts aim at increasing the alcohol production during the fermentation

process. This rule breaking in the common view of modified yeasts will enable them to expand and create new concepts and bring new values to the fermentation industries.

Insert Figure 4 about here

The Ecoera case. The initial aim of Ecoera was to mix biomass and environmentally friendly additives to form a renewable pellet fuel for heat production. In this case the eventual concept ended up being radically different than the initial. A whole platform for reducing carbon dioxide in the atmosphere while increasing crop yield and generating bioenergy was created (see Figure 5).

Insert Figure 5 about here

The initial idea is a platform technology

The other profile that was observed is characterized by the idea-providers proposing their technology to the entrepreneurs, showing them that the technology has a lot of potential applications and that they will have to choose the most valuable one.

The Pharmsurgics case. The idea provider to Pharmsurgics, a researcher on TNF inhibitors, accidentally discovered their healing properties and acquired a patent from another

research group (working on lactoferrin-derived peptides), thinking that the combination of the two technologies could provide good results for healing improvement. Actually, after a few experiments and studies, it was confirmed that the technology he had developed through the combination of two research results, was very valuable in terms of healing improvement. Thus, he decided to propose this idea to the Encubator, hoping that it would lead to an interesting product development.

To the entrepreneurial students, the idea provider explained that the knowledge could be used for two main applications: reducing infections and reducing post surgery adhesion (adhesion is a biological phenomena observed after surgeries: some parts of the tissues that should remain separate, are attached during the healing process). Thus, at the beginning of the project, the students had to analyze the value of these two potential applications, and to compare the feasibility of these alternatives. As many technologies were under development to reduce infection in healing processes, they decided to focus on the other application path: preventing post-surgery adhesion. This exploration of the anti-adhesion application led them to acquire new knowledge about the technology, but also about the healing process and the different mechanisms that could be considered to reduce adhesion. This enabled them to develop lactoferrin-derived peptides that prevent the apparition of post-surgery adhesion. They have made the choice to target flexor tendon hand surgery because in this case, adhesion is very disabling (thus this case is the most valuable application of adhesion prevention), but relatively minor product modifications will enable the development of treatments covering a broad range of surgical procedures.

Insert Figure 6 about here

In this case, we can observe that the initial idea was mainly located in the knowledge space, with many possible concepts associated. The entrepreneurs began by choosing one promising application and bringing it to the market, overcoming the different stages to develop a pharmaceutical product. However, the company kept the other application path (anti fungus), as an explorative path (they did not aim at developing products in short terms perspective but kept the exploration in order to be aware of the new technologies and maybe to propose innovation in this field). This higher concept “improving wound healing” and their innovative behavior leads them to be the key actor of a new company involving three start-ups dealing with dermatology, wound healing and anti-infection.

DISCUSSION

Out of these case studies, we can observe that we have two main patterns. The first one begins with knowledge basis and a specified concept (C0). While they are developing the initial idea (path dependency to the concept given by the idea-provider) in a causative way, the entrepreneurs gather new knowledge that enables them to re-consider their project in a wider scope, and to define a higher disruptive concept (C-1). This retro design opens new paths (C0b), often more valuable than the initial one. In this pattern, the entrepreneurs begin with a causal logic, and with

the new knowledge basis that they have activated, they understand better the initial idea and the way it had been packaged by the idea provider. This understanding enables them to mindfully deviate: they open new paths and then have both an effective behavior (considering different possibilities and keeping the exploration for all the paths) and a causative behavior (focusing and developing one specific concept).

In the second case, the entrepreneur begins with a platform technology: a technology (K0) that could have many different applications (C1a, C1b, C1c). The exploitation and the development of these different paths leads the entrepreneurs to acquire new knowledge and precise the concepts, but also to progressively discover what is the main concept that is ahead these different paths. This higher concept (C0) structure the different niches and gives robustness to the overall project. In this second pattern, the entrepreneurs act both in causal and effectual ways, since they have a goal to achieve and focus on the application they have chosen, but they keep all the paths opened and redefine the concepts as the project is living, with a “learning as you go” process.

Insert Figure 7 about here

Analyzing the different profiles

The two profiles described above are mainly driven by the initial idea proposed to the entrepreneurs. A first reaction could thus be to select the best profile (according to success but

also educational criteria), and then to set-up a strategy in order to choose the type of ideas that lead to this profile. However, it appears that both profiles present interesting outputs and challenges for the students and one profile does not appear to be superior to the other.

The first profile (a too focused initial concept) presents the advantage of showing from the beginning an “easy” path to develop. Then the entrepreneurs can begin the development and probably earn some money out of this first development, before redefining the main concept that they work on and enhancing the potential of the initial idea. However, the risk is that the entrepreneurs never see that the first idea was too focused and that its potential could be increased thanks’ to a retro-conception effort. In this case, they would not create new paths but be traditional entrepreneurs that bring an idea to the market without reshaping and transforming it.

The second profile (a “platform” idea with a lot of potential applications) will force the entrepreneurs to look at the potential of the different alternatives from the beginning. Thus, by letting them the choice of the path, the idea-provider makes them compare the value of the different possibilities. However, the risk here is that the entrepreneurs do not want to close paths and then never develop any specific path, so never reach the market with a concrete product.

In the first case, the students will tend to focus: they clearly see the application they want to reach and then, they do not see the utility of exploring new alternatives. Then, the coaches and the teachers will balance this tendency to focus by asking them to contact new actors, to look for alternatives and to try to value this other paths. On the contrary, in the second case, the

entrepreneurial students, as they see many valuable applications, will tend to keep all the possibilities, without aiming at choosing one. Thus the coaches' role is to force them to choose one specific path to explore and to develop (even if they should keep a lighter exploration on all the different paths).

The study of the different cases and the two profiles that emerge out of it show that the Chalmers School of Entrepreneurship have managed to set up a reasoning balance between exploration and focus, thanks' to an organizational balance between students and coaches. This makes the educated entrepreneurs being not only developers, but also innovators that reshape the idea and enhance its potential.

This work on the potential provides robustness and originality to the projects:

In the cases studied, the generative power of the work done by the entrepreneurs has not only led to a better resulting product, but it has also increased the robustness and the originality of the projects. The development of one initial idea or the exploitation of the initial knowledge leads the entrepreneurs to learn, to explore new knowledge basis and to expand their network. It also leads them to precision the product and to look at different possible alternatives for this initial idea. In the C tree, this is illustrated by a descent in the concept: by defining the attributes of the future product, the entrepreneur concretizes the initial idea and makes choices that will enable it to reach the market. This behavior corresponds to the focus of the problem-solving entrepreneur:

he begins by an idea and has to solve different problems in order to maximize the value that will come out of this idea.

We show in the cases, that entrepreneurs use this development process to learn and to acquire new contacts, new knowledge basis. This enables them to consider their initial idea in a wider scope and to inscribe their project in a higher concept, which is very often a disruptive concept.

This definition of the higher concept is a long process that needs time, work, knowledge and interaction with other actors. But it is this higher concept that increases the potential of the initial idea. This concept enables them to open new paths and consider new disruptive concepts. It structures the different niches that the venture will explore. Thus, this disruptive and rule breaking concept gives robustness and originality to the project.

By generating different paths and by acquiring knowledge during the exploration, the entrepreneurs have built a robust system: the variety of possible applications of the initial technology enables a switch from one concept to another. Then, if, for any reason, the development of one concept is no longer possible, they are able to use the knowledge and the network they have built to develop another application. By considering different alternatives, the entrepreneurs have increased their network and are always able to connect their concept to new knowledge basis. This leads them to envisage novel and disruptive paths. It seems the entrepreneurs not only begin with a disruptive idea (most often based on high-tech technologies) but they also bring originality to this idea through the exploration process.

The high potential comes from the rule breaking and the multiple niches that are generated

In all the projects that have been studied one or several paths, inherited from the proposition of the idea provider, have been developed. Through this exploitation and development of the initial idea, new knowledge and new actors have been involved to the project, opening or showing new opportunities, new paths to explore. Besides, this has opened the scope in which the venture is inscribed, placing the venture as an actor and a designer of a high potential disruptive concept. This high concept is very often rule breaking, in the sense that it does not follow the common tendencies. It helps the company structure its exploration of different niches, thus bringing originality and robustness to the company.

The student entrepreneurs seem to be highly capable in provoking path creations. As new actors in their idea field, they put energy to understand the environment and to understand their initial idea in a wider scope. This behavior develops knowledge about the genealogy and connected ecosystems of their idea, which then allows them to mindfully deviate from the initial concept to new paths that bring originality and robustness to their ventures.

CONCLUSIONS

The purpose of this paper has been to investigate selected technology ventures through the C-K method in order to add to our understanding of path dependency and decisions guiding entrepreneurial behavior. The key finding is that the studied ventures all deviated from an

initially perceived trajectory for an opportunity, breaking with a path in a mindful way (Garud & Karnoe, 2001). New opportunities were thus not discovered by chance but as a consequence of new knowledge gained by actions. Such path-breaking can be seen as a combination of predictive and effectual logics but with an emphasis on the latter.

Established R&D settings in firms and research laboratories have been found to have difficulties breaking with path dependency resulting in innovation that often is more incremental than radical or disruptive. The current study, while focusing on individual level entrepreneurial behavior, provides indications for how path breaking actually can occur. It also suggests that perhaps technology ventures, where the lead entrepreneur does not have a lot of invested interest into the original idea, might be more suited for exploring unforeseen opportunities of a more or less radical nature. The student entrepreneurs seem capable of acting upon an innovation in way that differentiates from them from the inventors. Furthermore, the application of the C-K-method into the analysis of early-stage entrepreneurship allows us to see how path-breaking occurs during a process of venture emergence. Of the four projects there were two main profiles of path-breaking, one expanding an initially relatively specified concept, and one starting in a more generic ideas and then exploring multiple and often unforeseen concepts before making a decision.

This study has been explorative and based upon a limited amount of cases in one specific context. Further research should investigate the generality of our indicative findings. Furthermore, several questions are raised, which require further investigation and consideration: Is the lack of

experience of student entrepreneurs into specified knowledge areas actually a key factor for path breaking to be enabled? How and when do effectual and causal logics interact and make sense for making decisions as an opportunity is developed? What is the importance of this type of path-breaking occurring in new ventures – rather than in more established structures?

Figure 1. A Generic Representation of the C-K Theory (Source. Based on Hatchuel, Le Masson & Weil, 2004)

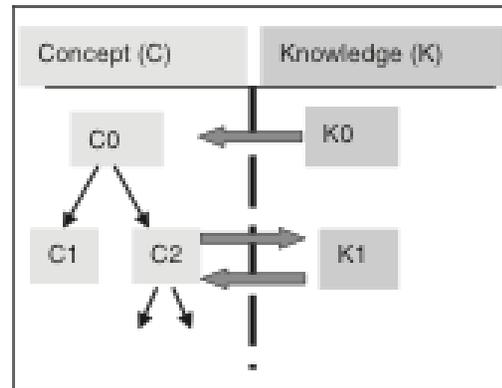


Figure 2.

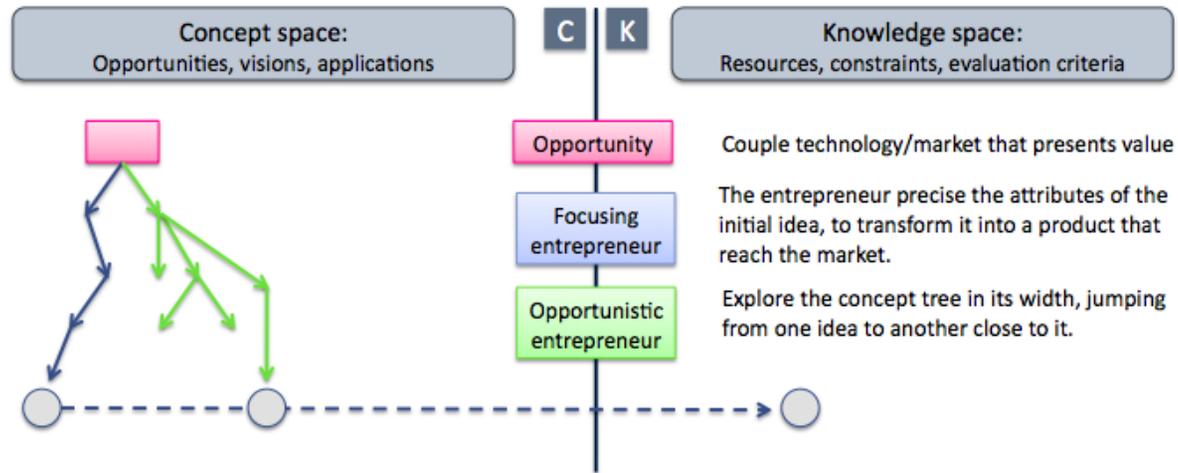


Figure 3. C-K applied to Insplorion

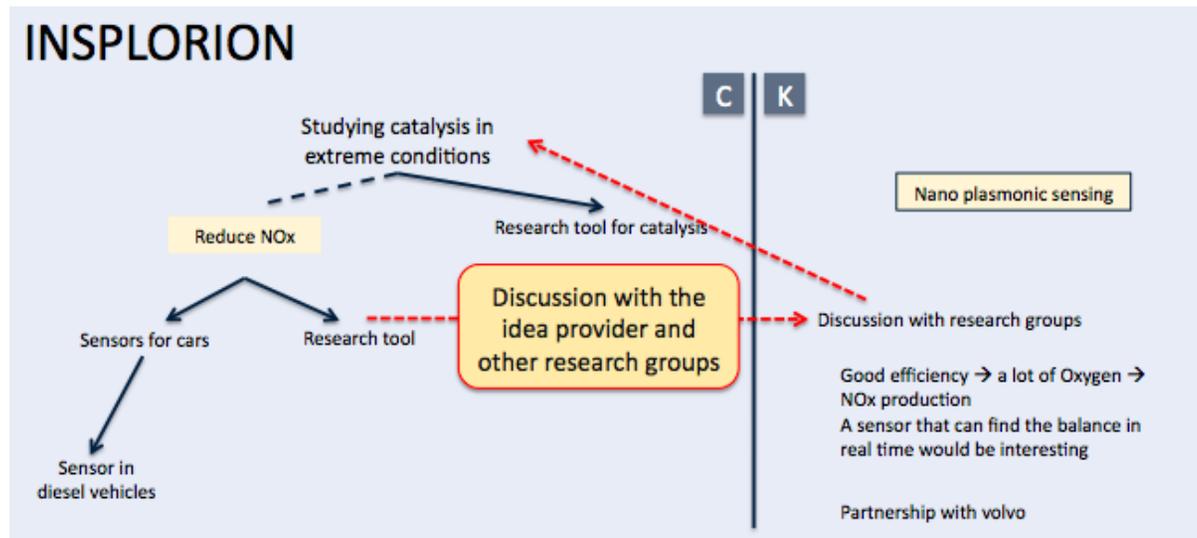


Figure 4. C-K applied to Cereduce

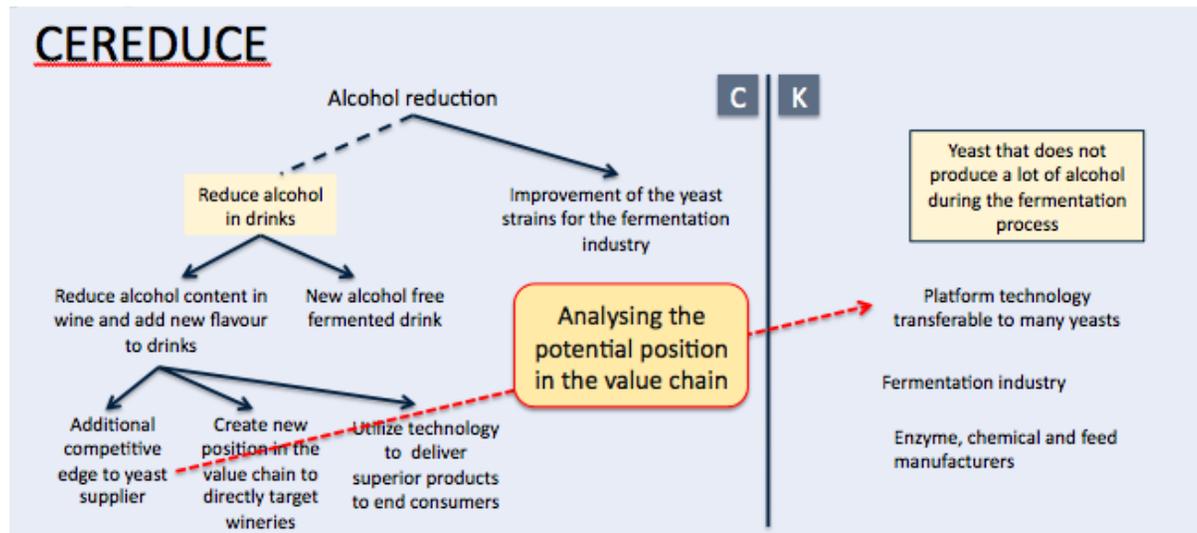


Figure 5. C-K applied to Ecoera

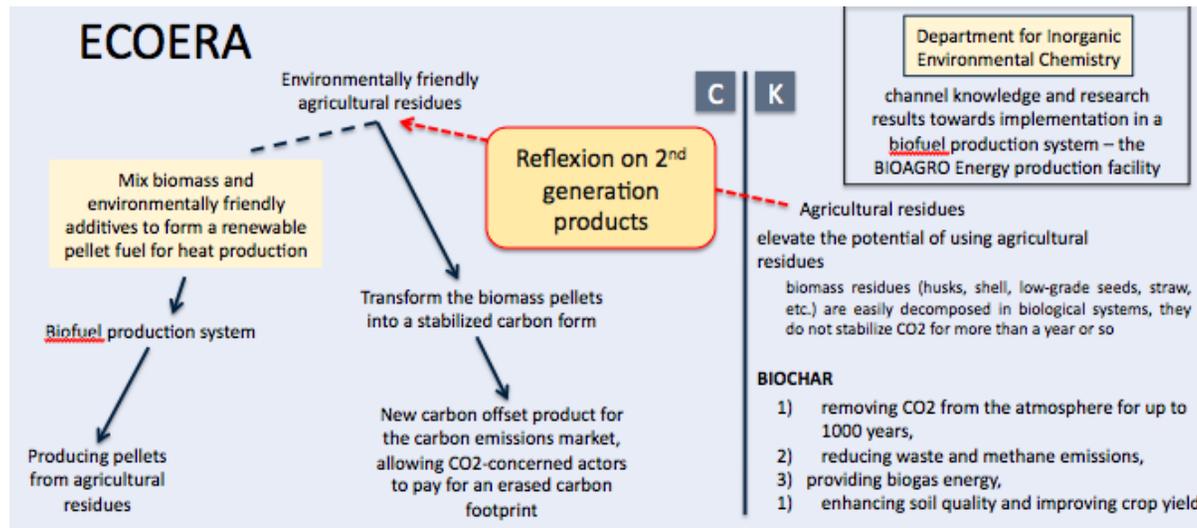


Figure 6. C-K applied to Pharmsurgics

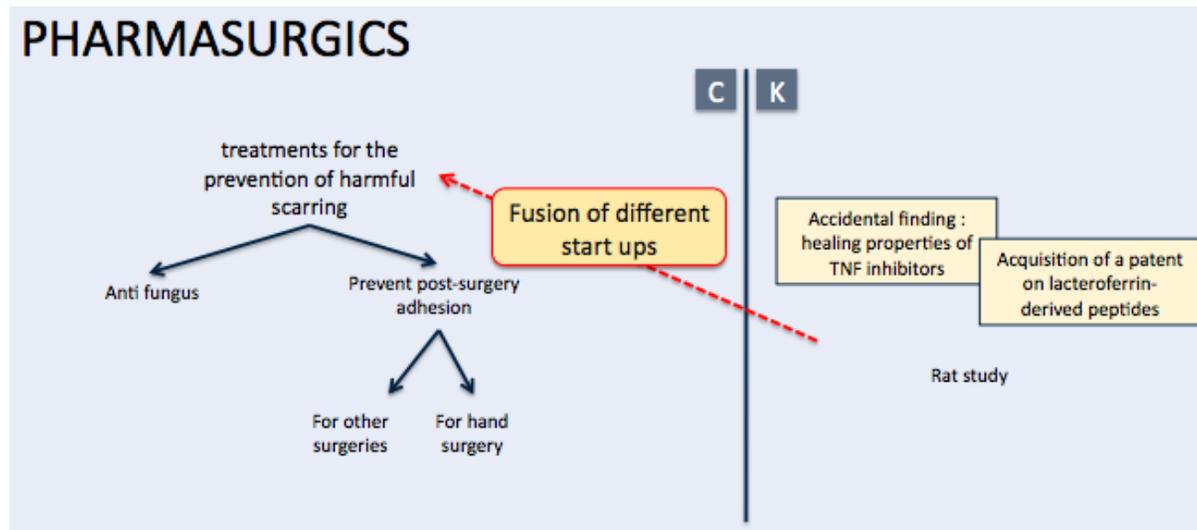
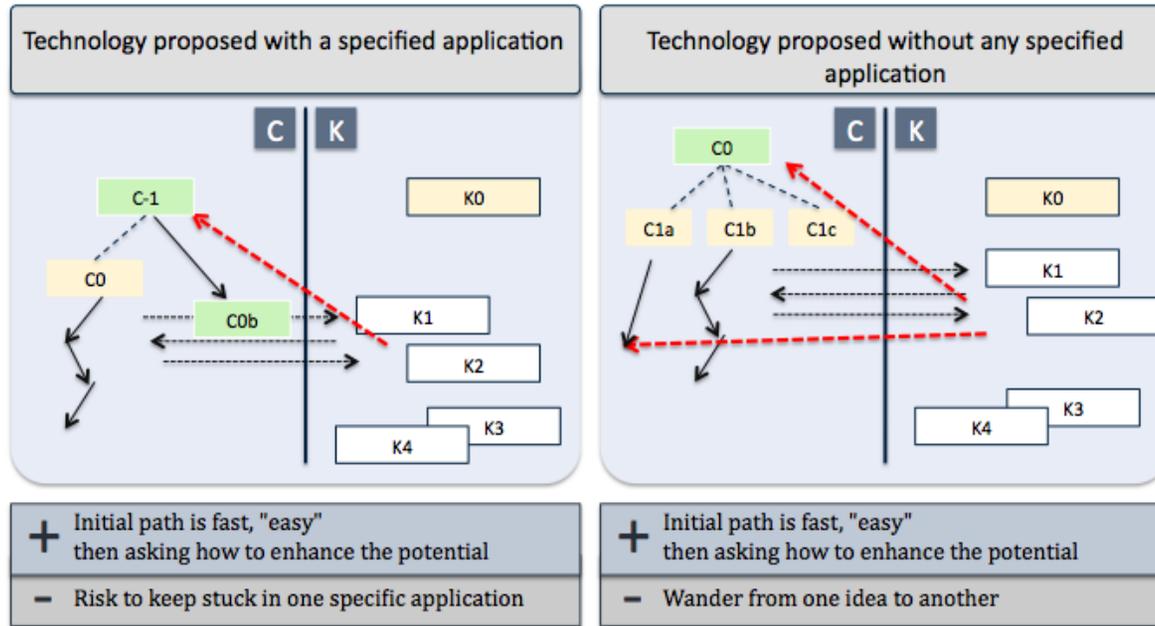


Figure 7. Two patterns of path development presented through C-K theory



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