Title: Exploring effectuation in early-stage ventures using the C-K design theory

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Abstract

We have little understanding of why and how entrepreneurs sometimes continue to innovate within their ventures. The discovery perspective within entrepreneurship assumes a relatively linear and casual logic, once an initial business or product opportunity is identified. However, recent entrepreneurial decision making theory around effectuation emphasizes a logic of design as a means for determining future action. To date this logic has not been studied through innovation design theory lenses. The purpose of this article is therefore to explore how nascent technology ventures continue to behave entrepreneurially post conceptualization. The C-K (Concept-Knowledge) design theory is used to illustrate series of enacted decisions in four technology venture cases. The cases show how the ventures change direction based on deliberate and designed actions, resulting not only in more innovative opportunities but also allowing the ventures to become more robust and thus adaptable to change. The article adds insight to how effectuation is carried out as a logic of design.

Keywords: *entrepreneurial behavior, decision making, innovation, C-K design theory, effectuation*

INTRODUCTION

This article explores entrepreneurial decision making in early-stage technology ventures through the lenses of the C-K (Concept – Knowledge) design theory. The C-K theory 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. In this study, the ventures explored are spin-offs from R&D at universities and corporations to which 'surrogate entrepreneurs' have been appointed, in part to inject (new) entrepreneurial behavior. The article contributes to our understanding of entrepreneurial behavior and the impact on continued innovative development by adding insight into effectuation.

Entrepreneurship can be seen as a process of emergence (Gartner et al. 1992) contingent upon entrepreneurial behavior, which can be described as a series of enacted decisions leading to the emergence of an organization (Williams Middleton 2010; Gartner et al. 2010), and is identified as an individual-level phenomenon (Bird and Schjoedt 2009). However, the relationship between individual behavior and organizational emergence is complex and not well understood (Cogliser et al. 2007) as decisions are often not easily observed, and are often considered to be rationalized in hindsight (Davidsson 2006; Cassar and Craig 2009).

Two main perspectives in the field of entrepreneurship exist which premise the relationship between the individual, the opportunity, and the emergence of an organization. The first describes entrepreneurship as a process of discovery (Shane 2003; Shane and Venkataraman 2000), in which some individuals (in comparison to others) are capable of 'discovering' an existent and definitive opportunity, and then proceed to take decisions based on estimation of risk that allow for the exploitation of the opportunity. The second describes entrepreneurship as a process of creation (Casson 1982; Gartner 1985), in which an individual explores hypotheses on an initial idea, and through learning creates an opportunity. The first perspective can be seen to build upon a causal logic for making decisions because it assumes that the entrepreneur bears risk, while the second is more consistent with an effectual logic for decision making, because it assumes that the entrepreneur bears uncertainty (Sarasvathy 2001).

In studying experienced and expert entrepreneurs, Sarasvathy and her colleagues (Sarasvathy 2001; Read and Sarasvathy 2005; Sarasvathy 2008; Read et al. 2003) found that these individuals make decisions based upon a 'logic of design', which she calls effectuation, rather than a 'logic of choice', identified as causation (Sarasvathy and Dew 2005). Both logics can be used for determining how to act for the future, but while causal logic has been well studied and is often applied within existing corporations, effectual logic is seen as viable for making decisions in uncertain conditions and is not well

understood (Dew and Sarasvathy 2002). Understanding the effectual logic utilized to make and enact decisions within a process of emergence has the potential to give us insight into how entrepreneurial behavior can remain innovative beyond a point of discovery or conception.

Recognizing entrepreneurship as dependent upon entrepreneurial behavior, and building upon a perspective of entrepreneurial behavior as driven by a 'logic of design', we explore how C-K design theory can be used as a lens to illustrate the developmental paths of early-stage technology ventures. The article is structured as follows. The theory section will outline our understanding of logics used for entrepreneurial decision making. C-K theory is presented as a design methodology that allows for interaction between existent knowledge and designable concepts, in order to develop potential new knowledge. The method section describes the way in which intend to apply C-K theory to the entrepreneurial process, and then goes on to present the context of the study as well as the selection and data collection of the empirical cases. Our findings illustrate the progression of entrepreneurial decisions and resulting paths of the four cases selected. Finally, the discussion relates the empirical evidence to our understandings of the logic and decisions guiding entrepreneurial behavior, and the impact on continued innovation within early-stage technology ventures.`

THEORY

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 (see extensive discussion of causation and human decision making in: Sarasvathy 2001; Eisenhardt and Zbaracki 1992; Mackie 1965). The decision maker uses a 'logic of choice', guessing about the unknown future consequences of acting upon information that is understood to give predictable outcomes. Effectual logic (Sarasvathy 2008, 2001) is a logic of controlling known and 'at hand' means in order to create multiple possible effects and unanticipated ends. The decision maker uses a 'logic of design' in order to guess about unknown future preferences, with the intention being that to the extent you can design the future, you can control it (Wiltbank et al. 2006).

In the field of entrepreneurship, effectuation draws from a creation theory perspective, which is also the perspective taken in this article. Creation theory is anchored on three main assumptions. The first assumption is that an opportunity is subjective. The second assumption is that individuals (entrepreneurs) create the opportunities (as opposed to recognizing them). The third assumption is that when going

through the process, these individuals bear uncertainty. Uncertainty means that not only are the probabilities of outcomes unknown, but the outcomes themselves are not known or knowable. The entrepreneurs, believing in an opportunity, test it with potential customers or in the marketplace, getting feedback or reacting to responses, and then progressing to the next testing phase until the opportunity is successful in the marketplace (Alvarez and Barney 2007).

Effectuation

Effectuation can be used to describe the decision making processes enacted in order to "take a set of means as given and focus on selecting between possible effects that can be created with that set of means" (Sarasvathy 2001). It 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). Effectuation builds upon effectual logic, or a 'logic of design' (Sarasvathy and Dew 2005), argued to be viable for making decisions within environments containing the following elements: 1) Knightian uncertainty – the impossibility of calculating possibilities for future consequences, 2) Goal ambiguity – lack of assumed or structured preferences, and 3) Isotropy – the inability to determine upon which elements of an environment one should focus attention (Sarasvathy 2008, p. 70). Sarasvathy argues that use of effectual logic enables entrepreneurs to create new and unanticipated effects from known means (Sarasvathy 2001; Kruecken 2003). It is important to emphasize that effectual logic does not equate to 'anything goes' reasoning based solely on intuition, passion, and fearlessness in the face of risk; it is positioned as a process of logical reasoning, and can be seen as an alternative or even complementary approach to causal logic (Sarasvathy 2008).

Effectuation recognizes that individuals that behave entrepreneurially have learned to enact decisions that are not solely premised on an outlying goal, but rather on the means available to them and within their control. The theory of effectuation has been developed in part based on empirical research exploring the decision making processes of experienced or expert entrepreneurs (Dew et al. 2008; Sarasvathy and Dew 2005; Wiltbank et al. 2009; Read et al. 2009), but is also recognized as still in an immature state, requiring more empirical studies of early-stage entrepreneurial emergence, in order to avoid hindsight and success bias common to research in entrepreneurship (Davidsson 2006; Gartner et al. 2010).

C-K theory

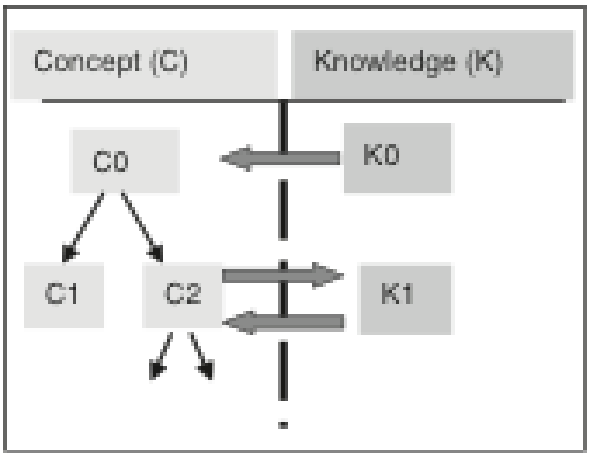
The C-K theory (Le Masson et al. 2010; Armand Hatchuel and Weil 2009; Elmquist and Segrestin 2007; Kazakçi and Tsoukias 2005) is a design theory based on the distinction of two different expandable spaces: the space of Concepts (hereto called C space) and the space of Knowledge (hereto called K space). Knowledge is defined by assertions that we already know (or that we know are 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. Based on existing knowledge (K0), an initial concept (C0) is developed. The available knowledge enables 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 attribute of the object). These alternative concepts will lead the designer to explore new knowledge bases and acquire new knowledge (through experimentations, enquiries, tests, models, etc.). The new knowledge enables the refinement of concepts and/or the abandoning of certain concepts. 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 space (there is a 'conjunction'). This iterative process progressively leads to the identification of knowledge that is needed to proceed and can thus be used to guide the learning process. The iterative expansion of the C and K spaces is illustrated in Figure 1.

This presentation of C-K theory, although simplified, illustrates the core of design reasoning, i.e., to work on the combined expansions of concepts and knowledge (A. Hatchuel and Weil 2003). C-K theory has mainly been used within a design process in order to explore the field and propose new concepts and a new knowledge base for observation and analysis. It is a design theory for knowing the unknown and in this respect resonates well with effectual logic. In this article, the C-K method will be used to analyze case studies of early-stage technology ventures during incubation (i.e. in a process of emerging) in order to trace enacted decision making.

Figure 1. A Generic Representation of the C-K Theory



(Source. Based on Hatchuel, Le Masson & Weil, 2004)

METHOD

In order to investigate how individuals are making decisions in early-stage technology ventures, we need to first explain our understanding of how to apply C-K design theory to the entrepreneurial process, so that it can be utilized methodologically. Following this, we will describe the contextual background from which the venture case studies emerged. This is followed by a presentation of case selection reasoning, and then data collection and analysis.

C-K theory applied to the entrepreneurial process

If we look at the entrepreneurial process through the C-K theory, the C space is the space of the opportunities (visions), whereas the K space is the space of the resources (scientific knowledge, business studies, market studies), the constraints ('my product has to respect this and that constraint') and the evaluation criteria ('a good product should answer to these needs', '…be sold at this price', etc.). In the C-K design framework, the decision making path of an entrepreneur defining the product as a means to make concrete the initial idea would be illustrated by a relatively linear progression in the C space. This entrepreneur does not explore multiple decision paths or make iterations between different C and K trajectories, but instead specifies the product by giving it attributes; the entrepreneur is seen to be exploiting an opportunity that is based on one initial idea. On the contrary, the decision making path of an entrepreneur who is continually redefining (creating) the opportunity, would be illustrated by multiple

iterations between the C and K spaces. The expansion would start first from an initial concept to another which is quite close, recognizing that entrepreneurs often operate under bricolage (Baker 2007), and thus may be constrained to explore opportunities that are quite proximal to their initial idea, and then proceed through cycles. In this case, the entrepreneur is seen to be exploring an opportunity (or opportunities), stemming from an initial idea, but complemented not only by additional concepts but also introduction of additional knowledge. We will present decision path development through C-K design theory in the form of C-K maps, as a way to illustrate the iteration (or lack of) between the knowledge and concepts described in the cases.

Contextual background

The cases presented in the article all stem from the same environment – an integrated education and incubation/technology transfer program at Chalmers University of Technology, described as a School of Entrepreneurship. The School builds upon a venture creation approach (Ollila and Williams-Middleton 2011), allowing students to not only learn *about* the venture creation process by employing traditional educational methods, but also to learn through engagement in an emerging venture process, recognized as valuable for imparting knowledge *for* the practice of entrepreneurship (Mwasalwiba 2010). Student teams are matched with an idea to form a project (potential future venture). The ideas are recruited or accepted from university or corporate research and development, or from independent inventors. As part of the design of the School, students engage in venture creation and contribute their knowledge and ideas towards developing the project into a venture, with the option to incorporate should the project illustrate commercial viability. 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). We chose to select cases from this environment because it allowed for access to early-stage technology ventures that were in a process of organizational emergence. The educational component of the environment also facilitated access to 'in process' documentation, as part of the design of the School includes delivery and presentation of the on-going project at various points in time. The incubation component of the environment facilitates a continued access to the team behind the project even after it has completed tenure at the School and also been incorporated into a venture, as the incubator maintains an equity relationship to the venture.

Data collection and analysis

A qualitative case study method is applied. Case studies investigate phenomenon within real-life context, when boundaries between phenomenon and context are blurred, and multiple sources of data is utilized (Yin 1994). We selected four projects/teams that continued to be developed from the School environment, either in a project form, or that were incorporated post education: one project from the class of 2004, one project from the class of 2006 and two projects from the class of 2009. These cases were selected due to having illustrative design-based decisions, possible to trace through expanded C and K spaces, and through the interaction between the two spaces. All the selected ventures have attracted a variety of financing (grants, soft loans and/or equity). However, as regards the extent they have generated revenue from sales, they are can still be considered early-stage having little more than occasional trial sales to date.

In-person interviews with the student entrepreneurs, coaches and idea providers were conducted in order to form short case descriptions (Yin 1994) of each project turn venture. These interviews let us understand better the journey of the projects to venture status and analyze the intended and enacted decision path of the individuals as they transformed their project into a successful start-up. In order to balance the potential hindsight bias from interviews, evidence was also gathered through documentation and archival material. Documentation data included business reports written by the student teams not only at the end of the School period, but also interim drafts written during the School period. In addition to this, we also looked at business slide presentations made at different times during the School period. These documents include real-time aspects difficult to capture through ex post interviews around the journey of the project. In addition to internal project documentation, annual reports from the incubator/TTO were used to follow the projects once they had left the School. Data was triangulated (Flick 2006) where possible in order to determine replicable information and falsify inconsistent information in an attempt to minimize the subjectivity of the data presented.

The collected data was used to analyze the design process ongoing during the project development both during the incubation period, and after the project left the incubator/educational environment. C-K theory is applied methodologically to illustrate the decision making process used by the students acting as surrogate entrepreneurs to explore viable business options from the initially disclosed idea of the project. The journey of the different projects was mapped in both the C-space and K-space, in order to highlight the exploration process and the different decision steps the student entrepreneurs used to shape the opportunity into a viable venture.

FINDINGS

Using C-K theory, the journeys of the project cases are illustrated through mapping the decisions of the student entrepreneurs, presented in Figures (see Figures 2 through 5). The figures demonstrate a transformation of the initial idea. In some cases, we can observe that the decisions of the entrepreneurs focused on attributing the initially disclosed opportunity; in other cases we can observe that the decisions made included iterations between the C and K spaces, until settling upon the configuration of factors determined to be the viable business opportunity. In these cases the comparison of the first exposition of the ideas by the idea providers and the resulting value proposition, packaged into products and services by the different student entrepreneurs and their ventures illustrates a significant evolution of the initial idea.

Decision making of cases mapped in C and K space

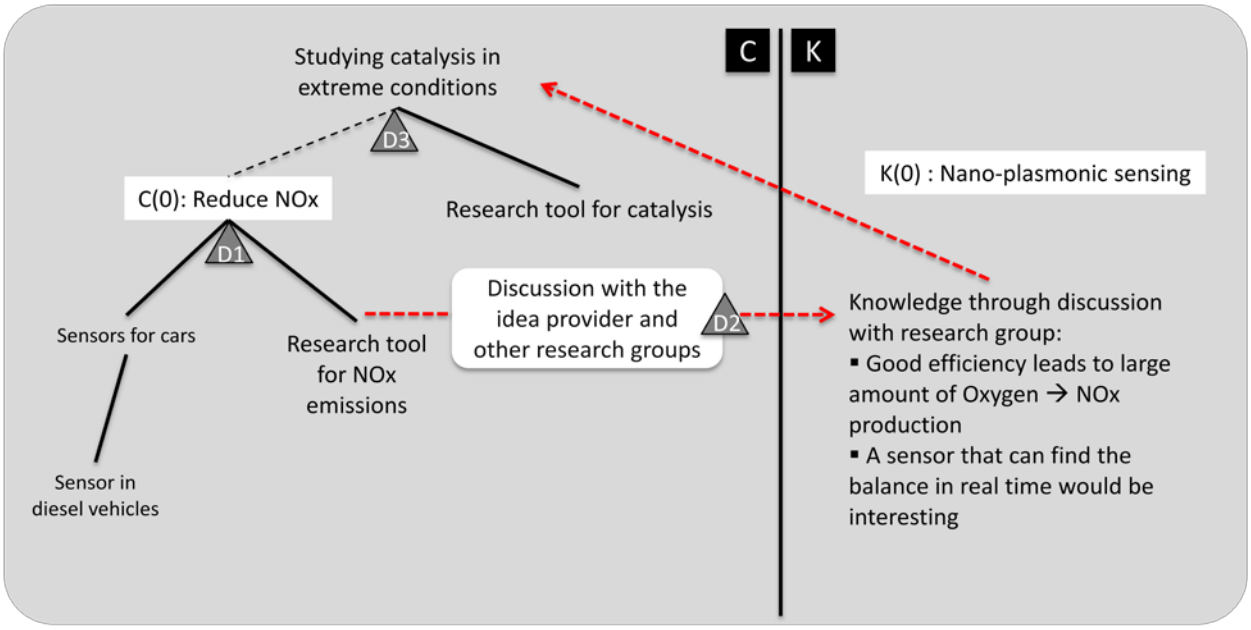
In each of the cases studied, the initial idea disclosed consists of a technology associated with a specified application. We provide a description of the initial idea provided by the researcher or company to the student team and associated stakeholders and then describe the decisions taken to exploit or explore the opportunity, building from the data collected through methods explained in the previous section. The actual name of the projects/ventures has been changed to provide anonminity.

The NOx Redux case. The idea provider, a researcher from the department of applied physics at Chalmers University of Technology proposed a nano-plasmonic sensing technology to analyze specific chemical reactions. The researcher's proposition was that the technology could be used as a device for NOx reduction in engines. The student entrepreneurs adopted the NOx reduction as the initial concept to develop. They explored existent knowledge regarding NOx emission reductions and decided upon two alternatives to investigate further: the first was to develop sensors for cars in order to optimize the combustion while avoiding NOx production; the second was to develop research tools. The conducted market and intellectual asset analysis, and addressed freedom to operate, and then decided to develop the research tool alternative. The decision was based on ability belief in early entry to market and the need to earn money as soon as possible. In addition, developing a research tool for NOx emission could facilitate building partnerships with car manufacturers. This was considered advantageous as it would allow the entrepreneurs to learn more about car sensors.

While developing the research tool for NOx reduction, the student entrepreneurs 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". The idea provider had background knowledge and access to additional knowledge about catalysis and its studies under extreme conditions, but the idea he proposed to the School was much more focused. By developing the idea of NOx reduction not initially disclosed by the idea provider, the student entrepreneurs explored a new knowledge basis and understood that the project could be repositioned relative to a different concept that was not dependent upon the disclosed idea, but rather superceded it. The new concept position in C space enabled them, not only to better understand value of their technology, but to also act upon this understanding in order to structure the exploration towards different niches, such as a NOx reduction sensor and a research tool for catalysis. The student entrepreneurs designed new opportunities building upon new knowledge bases through additional human resources that they (and their other stakeholders) brought to the project.

Figure 2. C-K theory applied to the NOx Redux case



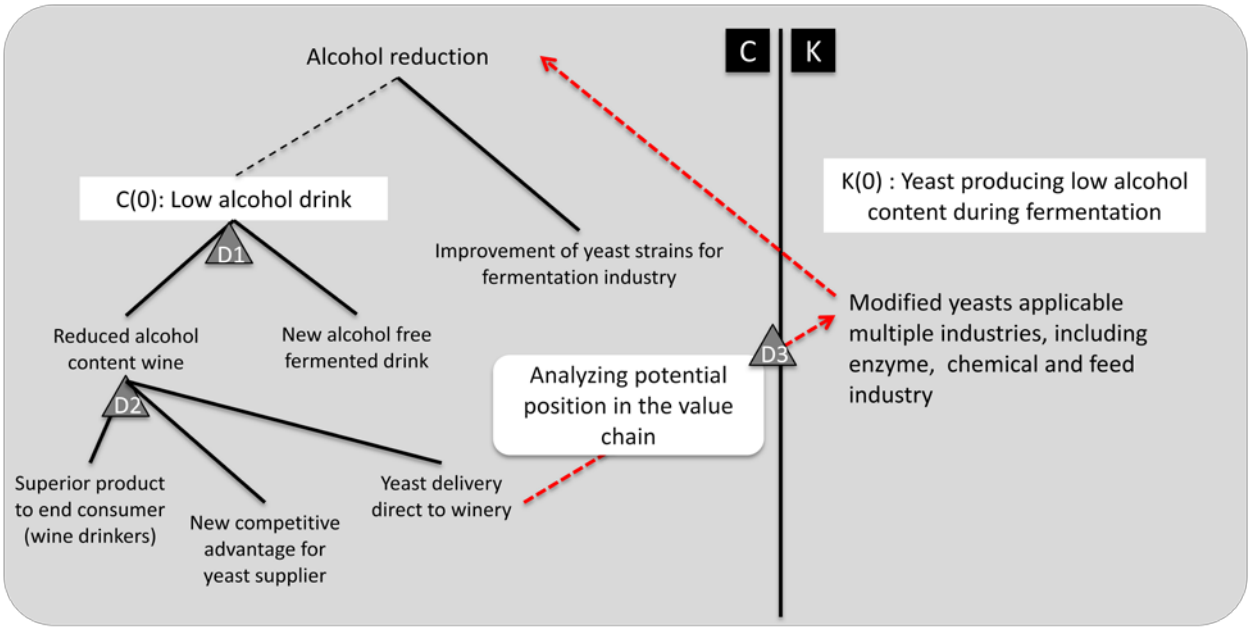
The Lo-Alco Yeast case. The idea providers presented a developed a technology for yeast that produces very little alcohol during the fermentation process. They proposed their technology as valuable in the wine industry based on demonstrations that shown that if alcohol production could be reduced during the fermentation process, the taste of the wine could be enhanced without increasing the alcohol

rate. The student entrepreneurs decided to develop the proposed idea. The main challenge was to overcome the different development issues in order to bring the yeast to the market. The student entrepreneurs analyzed different possible positions they could have in the value chain. They could: 1) sell the yeast to yeast suppliers in order to give the yeast suppliers a new competitive edge; 2) target wineries directly; 3) create their own products using the modified yeast to deliver to end consumers.

In order to evaluate the potential of the positional options in the value chain, including the feasibility and market attractiveness, they contacted yeast providers and studied their product portfolio and customer profiles. Through this study, the student entrepreneurs realized that yeast providers were not only active in the wine industry, but that their products translated into other industries as well, such as the enzyme industry or the chemical industry.

Recognizing that the yeast technology could be applied to different positions in the value chain, but was also expandable to industries outside wine production, the student entrepreneurs decided to change the focus of the yeast technology towards alcohol reduction in general. This became their new leading concept, and gave them a unique position as most of the existing modified yeasts aimed at increasing the alcohol production during the fermentation process; not reducing it. Introducing modified yeasts that reduce alcohol brings new knowledge to the market.

Figure 3. C-K theory applied to the Lo-Alco Yeast case

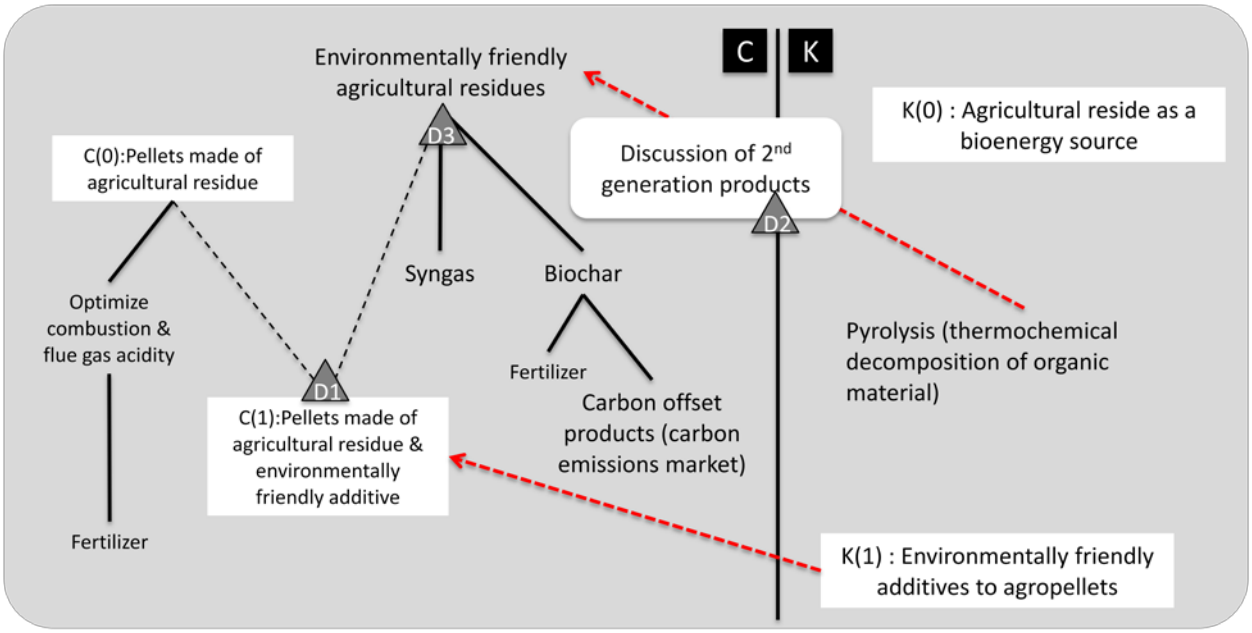


The Eco-Pell case. The initial concept of producing pellets from agricultural residues came from an EU project called BIOAGRO involving several Swedish companies in the agro sector. BIOAGRO aimed at creating a prime pellet fuel from agricultural residues – such as husks, shells and straw from crop and seed production. Pellet fuel based upon agricultural residues was a novel concept and the venture Eco-Pell was formed to exploit this new path. Pellets were traditionally made from sawdust – a raw material of declining supply and increasing demand. The concept was essentially to put together the optimal formula for a biomass fuel pellets that among other things, optimize the combustion performance and flue gas acidity and also make the ash returnable to the field as a fertilizer.

One of the first decisions in the Eco-Pell venture was to link up additional research and development capacity, through hiring a person to work with the specific agropellet formulas together with researchers at the department of Inorganic Environmental Chemistry at Chalmers University of Technology. They analyzed and determined the power of certain additives for the agropellet fuels. This development contributed to the building of an agropellet production facility in southern Sweden, through the BIOAGRO project. As Eco-Pell continued to work on the agropellet opportunity, one of the Eco-Pell stakeholders initiated a discussion about biochar carbon sequestration (removal of CO_2 from the atmosphere). This opportunity was initially questioned in regards to the opportunity that was being developed, but after further discussion, was considered as a new concept that superceded the existing opportunity that only considered the agropellets. Biochar is produced by processing biomass through a pyrolysis (thermochemical decomposition) step, generating not only the biological charcoal, but also syngas. The syngas is a valuable and energy-rich gas comparable to biogas. It has a range of uses: it can be used for heat or biofuel production.

The new Eco-Pell platform transforms the biomass pellets into the stabilized carbon form called biochar. This biochar can then be retained in agricultural soils and provide for a fourfold benefit: (1) removing CO_2 from the atmosphere for up to 1000 years, (2) reducing waste and methane emissions, (3) providing biogas energy, (4) enhancing soil quality and improving crop yield. Linked to the platform, Eco-Pell developed a new carbon offset product for the carbon emissions market, allowing CO_2-concerned actors to pay for an erased carbon footprint. Eco-Pell today is the first company in the world that has created sales with this new type of CO_2 reduction technology – stabilizing biomass carbon into biochar while also generating renewable syngas (a form of biogas) as well as soil enhancement. In this case the eventual concept ended up being quite different from the initial concept due to multiple iterations between the C and K space.

Figure 4. C-K theory applied to the Eco-Pell case



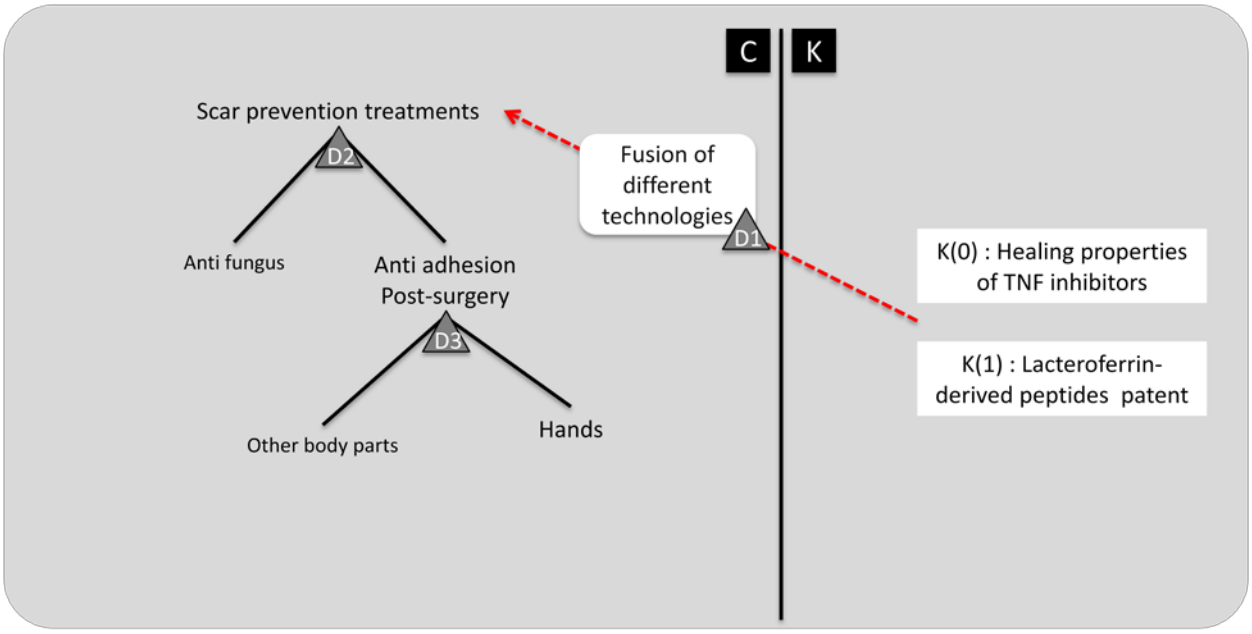
The Wound-Heal case. The idea provider to Wound-Heal, a researcher on TNF inhibitors, discovered special healing properties. Acquiring a patent from another research group working with lactoferrin-derived peptides, the idea provider hypothesized that combining the two technologies could provide improved healing results. 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.

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.

Figure 5. C-K theory applied to the Wound-Heal case



DISCUSSION

To better understand effectuation's logic of design (as opposed to causation's logic of choice), four cases have been described using C-K design theory. These cases resided illustrative design-based decisions, possible to trace through expanded C and K spaces, and through the interaction between the two

spaces. The discussion will first center on any reinforcing effects that C-K theory has on effectuation. Next, insights from the current study that add to an understanding of effectuation are discussed. Finally, aspects of effectuation not addressed by C-K theory are identified.

The cases, when seen through a C-K theory lens, reinforce aspects of our understanding of effectuation. Effectuation is about addressing uncertainty through a logic of design perspective, in which entrepreneurs build upon the means they have at hand. This core understanding resonates very well with the fundament of C-K theory, offering design thinking based upon expansion of a concept space and a knowledge space as driven by interaction between the two spaces. The four cases display how expansions in either of the two spaces allow the entrepreneur to effectuate, which in turn drives the acquisition of new knowledge in the K-space, and vice versa. While these effects are unanticipated from start, they are, in hindsight, possible to trace and appreciate as consequential. Application of C-K theory thus confirms the main assumption of effectuation, namely that entrepreneurship is not solely about intuition, passion, and fearlessness in the face of risk. Rather it is a process of logical reasoning. For example, the large and seemingly unrelated conceptual leap between the new agro-pellets and the carbon-capture platform in the case of Eco-Pell can be understood as operating within expanding C and K spaces, rather than as chance interaction of two "independent" discoveries.

One of the cases – Wound-Heal – could be seen as having applied a more casual logic. The entrepreneurs of Wound-Heal basically expanded in the C space towards increased specificity regarding which wound healing situation upon which to apply the basic invention. However, from the point when Wound-Heal was acquired, the venture can be described from a more effectuating point of view: the venture residing knowledge about higher level concepts was able to appreciate being part of a much wider setting. The other two cases – NOx Redux and Lo-Alco Yeast – both display decisions that resonate well with effectuation: expanding C and K spaces while exploring concepts on higher levels than initially anticipated.

C-K theory also adds new insights to effectuation. Previous theorizing around effectuation has not in any deeper sense substantiated the view that effectuation is based in 'logic of design'. The C-K design theory, which has not previously been applied to early-stage venturing, offers such substantiation in relatively simple terms. Essentially, applying C-K theory to an entrepreneurial context illustrates that effectuation could have much to do with the dynamics between expanding C and K spaces, and not only with expanding knowledge or generating new concepts in separation. With the expansion of C and K spaces also comes an increased resourcefulness of the entrepreneur – having more ends around which to

effectuate in increasingly different ways. Thus, the cases and the C-K theory do shed new light on how opportunities can be continuously designed (rather than once and for all 'discovered'). The effectual logic displayed through the C-K mapping helps rationalize effectuation not only as perhaps the only available response to extreme uncertainty but also as a way of generating more innovative opportunities while increasing the robustness of the venture through having more options.

Nevertheless, the application of C-K theory to the cases also disregards central aspects around effectuation. While effectuation emphasizes a relational and human side, C-K theory focuses on objectified knowledge and concepts, in the sense that it does not stipulate from where (or whom) knowledge and concepts are founded or taken. Effectuation emphasizes the relationships the entrepreneur has with her stakeholders and how entrepreneurs manage and utilize the stakeholders to develop contingencies; the 'who you know' (Sarasvathy and Dew 2005). C-K theory does not include such aspects specifically. However, this does not imply that C-K theory could not be used consciously by entrepreneurs and their stakeholders while interrelating. In fact, the cases do give implicit recognition of expanded C and K spaces stemming from the entrepreneurs relating to new (or old) stakeholders. The extent to which C-K theory is compatible with the more behavior- and human- centric perspective of effectuation thus remains to be explored, for instance through the use of C-K theory proactively and not only in hindsight, as in the cases presented here.

CONCLUSIONS

This article has applied C-K theory to selected early-stage ventures in order to increase our understanding around effectuation and ventures remaining innovative beyond a point of conception. Four different cases have been described as expansions into a conceptual as well as knowledge space while emphasizing the dynamics between the two spaces. It can be concluded that C-K theory helps clarify the nature of effectuation in early-stage ventures. C-K theory offers a substantiation of the claim that effectuation builds upon a 'logic of design' rather than a 'logic of choice'. Essentially, C-K theory illustrates decisions made while ventures expand concept and knowledge spaces. The cases show how the ventures change direction based on deliberate and designed actions, resulting not only in more innovative opportunities but also allowing the ventures to become more robust and thus adaptable to change.

Although C-K theory misses out on the relational and behavioral side of effectuation, it still holds promise to be useful for entrepreneurs and others partaking in early-stage venturing. Whether or not C-K theory can become a practical tool for entrepreneurs wanting to effectuate and innovate, remains to be

investigated. The current study applied C-K theory ex post, albeit with careful consideration of historical evidence. It is also important to note that the current design has selected cases being more illustrative around effectuation, and thus in no way is indicative around how common or relevant effectuation is in entrepreneurship in general. Given the studied ventures are early stage in regards to how much revenue they generate, there is reason also to further investigate how later-stage ventures having substantial sales, can continue to innovate through effectuation.

A practical implication from this study is that C-K theory should not only be able to help entrepreneurs be more innovative, but also potentially help venture stakeholders to better appreciate the decisions made under high uncertainty, and perhaps avoid framing decisions in only a causal and predictive logic. Through the use of C-K theory, effectuation might become easier to legitimize, making the actual behavior of many entrepreneurs (rather than as a rationalized and by appearance more causal and predictive behavior) easier to communicate. We shed more light upon the logics used for decision making and how they can impact the continued development of initially disclosed opportunities. We suggest that developing further understanding of the effectual logic used in emergent stages of organizations can help to maintain the 'entrepreneurial' behavior as the organization matures. All these implications of course require further investigation in order to be further substantiated.

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