

Organizing Technological Innovation of Medical Devices Companies:

An Empirical Study of Two Midland Venture Companies

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Abstract

This thesis presents a qualitative study of the role of devices in the technological innovation phenomena of two venture medical equipment companies located in the Midlands, UK. The inquiry takes an empirical and non-foundational approach based on post-ANT and process philosophy. In particular, the thesis employs the theoretical lenses of both ANT and post-ANT concepts, Deleuze's and Guattari's machinic thought and Michel Serres' parasitic philosophy. The data for this thesis comes from a fieldwork study lasting around one year. The methodology is mainly based on interviews and observations of engineers, technicians and managers working in venture companies. The central argument of this thesis shows that the venture organizing process of technological innovation is the product of discursive and non-discursive elements that act in several forms, keeping the venture company working but crucially reorganizing it. The present thesis offers a conceptualization of the device as a parasite-selector that reorganizes the venture company's work activities and brings novelty to their operation. Equally, the mediational power of diagrams - which presents constitutional indifference - participates in the definition and production of the engineers', managers' and technicians' professional identities. The thesis shows how the ideas regarding innovation in use at Med Dialysis and Med Diabetes bring forth the necessity of a life that embraces the uncertainty and ambiguity of the market. As a consequence, engineers and technicians build their professional identities by embracing the uncertainty of the venture company. This thesis names this process 'engineering the engineer'. This is a process that leads to the emergence of a professional identity that this thesis tentatively calls the 'venture engineer'.

Key words: *venture engineer, engineering the engineer, technological innovation, medical devices, non-foundational approaches, post-ANT, professional identity, Serres, Deleuze and Guattari.*

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List of Abbreviations

ANT	Actor-Network Theory
CEO	Chief Executive Officer
CMS	Critical Management Studies
CSTO	Chief Science and Technology Officer
NHS	National Health Service
STS	Science and Technology Studies
SSH	Self-Care Specification Hierarchy
OCDE	Organization for Economic Co-operation and Development
PFI	Profit from Innovation

Chapter I: Organizing Innovation

1. From the Field Notes

It is 21st September, 2011. On this day, I visited Coventry by train. At various times, I used a coach, but this time the experience was completely different. It is inevitable to think about the general user experience and problems such as the inscriptions (Akrich, 1992) within any design in a comparative form - after all, I'm doing research into companies who develop medical technologies for users. The train, the coach and the Med Diabetes Life One (the diabetes medical device of one of the two companies that I'm studying) had been designed by technologists - engineers who have created the world for me and diabetic people (in the case of Med Diabetes Life One). But what kind of world are they creating? How are the economic aspects of their companies affecting these processes? What are the ideas that move these engineers and technicians in defining and designing these new technologies? As the general manager of Med Diabetes told me, during a long interview on 15th September: "We design for the average." But what is the meaning of 'average'? Within the same interview, the manager told me that he wants to create the 'iPad' of insulin pen solutions, pointing towards the immense economic success of Apple devices and - in his view - the incredible adoption of that information technology device.

I'm here at the HTDi technology park, the science university park to which Med Diabetes recently moved and where they now have their offices (a very little 'start-up-like' place). Interestingly, I have to perform the interview while in a car on the way to Birmingham International Airport. The Manager had visitors from Germany - two clients of his parallel project, an engineer design consultancy company. These are 'boys' from a big auto-parts company. Therefore, they play the corporate game. However, I was interested in Med Diabetes, and I didn't know whether these people would accept that I was asking questions about a different business rather than their own interests. In any case, I break the ice by asking questions about their (German) company, pointing to my own experience within the chemical sector - also in a German company! I suppose that sometimes the experience within the corporate sector is not that bad! Nevertheless, they want to talk about the European economic crisis and South America. When the time to ask questions about my project arrives, I discover that, as a novice and being inexperienced, my recorder was running out of battery power! Therefore, I had to use my very bad mobile telephone recorder (in fact, I later discovered that the quality was so poor that I almost lost the entire interview). We are speaking about the Med Dialysis Life One and Med Dialysis in a very detached, 'impersonal' fashion. The general manager tells me that the project has actually been completely stopped, talking about it as if he no longer had any connection with the project. I begin to wonder if this detachment is a necessary condition of doing new business in a highly uncertain environment or whether the

presence of these other clients generates this detachment.

The most interesting part of the interview was the problem of the patent for the Med Dialysis One. Rob explained the difficulties of being competitive in this transitional and "previously non-existent market" for the device. He sees the problem as being located in the pharmaceutical companies - he called them "the big boys" - occupying the range of possible patents to stop further developments. On the other hand, he only foresees solving this with a tacit agreement with those authorities - i.e., the NHS, the Government, regulators, etc. - who are able to create a trend and the possibility of the existence of what he calls "a new market" for diabetic medical devices. Unfortunately, they need £85,000 for the production of a prototype that would allow them to enrol these important actors... And they don't have it. So, they - as a company - decided to raise the money from other businesses (he uses the word 'places'). He is telling me that the government and in particular the NHS are not capable of understanding the enormous utility of this self-care project for both themselves and their users. He never mentioned the potential utility for Med Diabetes, though!

2. The problem and some theoretical considerations

From an actor-network theory (ANT) perspective, the whole of the general manager's story provides a very clear example of what Michel Callon (1986) once termed 'interessement'. We can easily see that getting actors such as the National Health Service (NHS) interested and involved with the Med Diabetes project constitutes successful technological innovation. Following Akrich et al. (2002), innovation can be treated as the craft of forming a strong network of associations between powerful actors (e.g., the NHS), technical objects (e.g., new medical technologies) and a long series of other intermediaries (e.g., the normative environment of the country). But from a different perspective, such as the more traditional 'management of innovation' framework proposed by Teece (1986; 2006), the problem that Med Dialysis confronts is located in the construction of technological assets and complementary assets that lead to the creation of core capabilities. Together, these create a sustainable competitive position within the medical device industry. The ANT and Teece approaches offer attractive points of view of the phenomena. However, both approaches propose very general explanations regarding technological innovation. These explanations run the risk of liquefying the details of the day-to-day practices performed by those creating new medical technology. Both approaches tend to generalize the explanation of technological innovation and neither challenges the foundations of the theory that researchers use to investigate the phenomena (Stengers, 2005).

This thesis, then, wants to look again at the much studied technological innovation problem, considering the foundational aspects of the theories that are normally used to research the related phenomena. It will advance a study according to the nuances that engineers,

technicians and managers live by in their day-to-day activities. The thesis solves a twofold problem. First, it looks to understand technological innovation within the context of two new medical device companies. Secondly, and in parallel, it reflects on the foundation of the theories that I will use to animate the data and the analysis.

In the present study, I seek to put forward a non-foundational account of what comes about when engineers, technicians and managers produce a novelty together: how do they produce and mobilize their figurations of the future as an effect of discursive-material practices enacted in the present (Suchman, 2010: 61)? I want to study technological innovation in a comprehensive manner. To broaden the approach, I study technological novelty as an output, as a performance. Following the performative programme of the economy (Callon, 1998) and the material semiotic analysis of ANT (Law, 1999), the technologies of management are understood as 'socio-technical arrangements', or rather assemblages of heterogeneous disparate groups of entities that could be discursive, material, human and non-human (Latour, 2005). The emphasis of this thesis is placed on technologies of management. Unfortunately, when the word 'technology' appears in any statement, it is quite normal to think about information technology, informatics and several other important 'solutions' within organizations. The focus here is on the 'soft technologies' of management. Technologies like forms of representation - diagrams of time, total cost spreadsheets, amongst others - are enmeshed within the creation of novelty. These are the technical devices that permit the organizing process of any organization (Callon, 2002). These are technologies that can structure or have unexpected effects in relation to technological innovation or, in Callon's (1998b) words, which can 'frame' and 'overflow' the various technological innovation phenomena.

Although these are important technologies, the interesting problem concerns the framing and overflowing effects that management technologies have on workers (Callon, 2002: 214). With Callon, we can see how managerial technology can define and put in place creation and arbitrary acts of domination. Management exerts domination through the access that it has to these technologies. Without these tools, management is simply not possible. We know from Robert Cooper that management technologies open up possibilities for organizing and enable the order/disorder that constitutes an organization (Cooper, 1994). As a consequence, the management process is completely enmeshed within the production of new medical novelties.

It is precisely at the intersection of these non-discursive and material entities that something happens with the person. Callon foresees the problem in his analysis of writing devices as well as its relation with the particularities of those subjects who work. This is an important aspect of the present thesis. After all, this is a thesis about those engineers, technicians and managers who participate in the technological innovation phenomenon. Following the work of ANT theorists, those subjects are part of a heterogeneous network that marks technological

innovation. It is thus important to remember that any analysis needs to consider the nuances of the work itself and management, insofar as people remain an important aspect of the problem. Furthermore, as some post-ANT scholars have opined, without this care, ANT could become a tool to produce the dream “of retrograde managerial work-intensification processes” (Brown, 2011). I agree with Brown that there is an ethical imperative to maintain the status and dignity of the human side of the organization.

However, it is one thing to have consideration of when the individual enters into the phenomena of management and a very different thing to avoid the study of the relations between technical tools and those who use them. In addition, this thesis looks to ask the more general question about whether selves and professions are being shaped or not by relations with certain management technologies? In particular, if Engineer professions are being shaped with the writing devices cited above? If technological innovation is understood as a result - a performance - there is space for conceptions that understand the construction of identity as the result of those relations. Such a programme was embraced by some post-ANT theorists, like Mike Michael in his work *Constructing Identity* (Michael, 1996). However, this work does not directly connect with the problem of the management of technological innovation and presents a particular absence of data-based analysis. This thesis seeks to offer some new avenues and fresh data in discussing identity and - in particular - professional identity in light of relational and constructivist approaches.

This could be critical, considering that management technologies are stabilizing and qualifying the tradability of new services or products by a process called ‘artful integration’ (Callon et al., 2002). In addition, Suchman and Bishop claim that an innovation “is less a question of singular inventions or wholesale transformations than a matter of what we have described... as artful integrations” (2000: 332). An ‘artful integration’ view of technological innovation places the emphasis on the processes of ‘reconfigurations’ and ‘extensions’ within the production of a new medical device. The present thesis will treat technological innovations as artful integrations.

To put it another way, the question animating this thesis is: how do new technological things happen? As Susan Douglas (2010) claims, this seems to be a deceptively simple question. However, the question of what happens in places like Med Diabetes and Med Dialysis when people develop new technological products is not a simple question at all, because the inquiry leads to the revision of a heterogeneous set of entities - of any kind - that participate in the innovation phenomena. As a consequence, the question opens up a whole host of other matters, such as the role of investors, scientists, engineers, business professionals, corporations, government regulators and users. Finally, the question opens up a parallel inquiry as to how do things not happen (Douglas, 2010: 293)? The question of how things do not happen is of importance for this research, since I seek to understand technological innovation in a symmetrical form.

3. The sites of the fieldwork and the approach of the thesis

In order to satisfy non-disclosure agreements, the field sites of the present thesis will be called 'Med Diabetes' and 'Med Dialysis'. These places serve as examples to study the problem of the production of the 'new' (Suchman, 2010: 60). They are centres crossed by several lines of materials, ideas and artefacts. Both are relatively new SMEs- Small and medium enterprises-based in the UK in the West Midlands. Both companies are seeking to produce new methods of healthcare. However, the two companies are at different stages of technological development. At the time of the research, Med Diabetes was at a pre-prototype stage while Med Dialysis was close to launching the 'solution' to the kidney disease dialysis users market. What these sites have in common is the relative novelty of the technologies/products that they are developing and their comparatively brief existence (between three and five years respectively).

In terms of technological innovation, Med Diabetes' work is concerned with developing a new device, 'One Life', a system that combines, in one compact folder, all the equipment that a person with diabetes uses in their day-to-day life. The system looks to enable the more effective management of insulin-dependent diabetes by providing simple-to-use equipment combined with real-time reporting features so as to inform users of the status of their condition on the web. Med Dialysis is in the process of developing 'KidneyCare', a "game-changing" haemodialysis technology that looks for a more robust, efficient and simple device in order to bring patient self-care into dialysis clinics and provide patients with safety and support to undertake self-care dialysis at home. Both are self-care technologies, developed by nascent companies.

The uniqueness of Med Dialysis' technology is based on a disposable cartridge that performs all the critical fluid management functions in a sealed unit. Furthermore, the device is marketed as the solution to reduce the costs of the whole process for the NHS. The innovative aspects of the 'Med Diabetes One' device are based on the integration of a blood glucose monitor that automatically sends information to a smart device that is also connected to the insulin injector. These two streams of information are put together in a web-based interface that allows the user to input other data, such as food intake, and therefore allows the control of the blood glucose levels, insulin dosage, food intake and activity of the diabetes patient in a single place.

In terms of the organization, Med Dialysis is a company that unites a group of highly skilled professionals, who have previously worked on fluidic technology and who have extensive experience in the automotive industry and the medical device sector. They are a strong engineering-based organization (Vinck, 2003) with a terrific track around technology and science knowledge. The company had already received funds from a group of venture capitalists and is ad portas of the launch of their kidney disease medical device. By contrast, Med Diabetes is a newer venture, and while the owners have resisted the use of venture

capital funding at the moment the Med Diabetes One project is at a complete stop. They did not have the money to develop the prototype; therefore, they are looking for new avenues to further advance the technology and its commercialization. These two different field sites allow us to address the question of how new things happen in very different environments.

Finally, these two relatively new organizations both have connections with some important external entities, like the NHS and other hybrid private-public sector organizations. This is the case with Medilink West Midlands (WM Medilink), which is a private organization based on a membership that works for “growth and innovation in the medical and health technology sector” (Medilink UK, 2007) in the West Midlands. WM Medilink is part of a national network of ‘health technology business support organizations’. It looks to aid companies from the early stage of innovation through the whole commercialization process. They also serve as a nexus that seeks to “nurture collaborations between academics, clinicians and industry” (Medilink UK, 2013). Medilink is one of the various intermediary institutions that shape the complex private-public collaborations within the industrial healthcare sector. The complicated relations between these actors bring market logic to the technological development work of Med Diabetes and Med Dialysis.

4. The theoretical approach

In this thesis, I want to research the logic and various mechanisms of the market apparatus that are being adopted within the practices of those organizations developing new medical technology. As a consequence, within this thesis, the inquiry moves towards the management technologies being used by those who are producing new medical devices. As is now well known due to the science and technology studies (STS) tradition, technologies are assemblages of discursive and non-discursive entities. As Law (2002) has demonstrated in his interesting case for UK combat aircraft, the material aspects of technology are entwined with social and political elements of the warfare machine. In addition, as Brown (1997) explains in the case of certain psychological technologies, words have a fundamental material component and are part of a heterogeneous network of material and non-material entities. The focus of this thesis is then the study of material and non-material -discursive and non-discursive- assemblages that are those management technologies being at use in organizations that are developing new technology.

Following Hennion (2003: 131), innovation is understood as a privileged mode that allows a company to produce its reality gradually and collectively, through the use of writing devices, in a continuous process of writing and rewriting, by themselves, their own description. Hennion states that he takes the concept of a company’s ‘self-description’ from the anthropologist Marilyn Strathern (1998: 172), who offers the following definition: “self-description is an instrument which, like [a] compensation procedure, encourages social entities to proliferate...

and such descriptions create units radically distinct from one and other.” That is, when a company writes down its mission and vision, it is multiplying and growing, producing new parts for itself.

Hennion is calling for an innovation studies that puts the focus on proliferation and the self-creation process that occurs when an organization writes and rewrites itself. Such a process happens through the use of ‘writing devices’. The writing process triggers the need for the detailed analysis of presentations and various devices - for example, any type of diagrams. These insights are clearly aligned with the ANT tradition, which considers innovation processes as the results of iterative interactions within an heterogeneous network of ‘actors’ who are within the range of engineers, investors and politicians to end-users and technologies (Akrich et al., 2002).

Indeed, it is with ANT that the problem of the non-discursive emerges within social theory. Although Latour and other seminal actor-network theorists, such as John Law and Michel Callon, talk about technical objects, the central idea of these post-structuralist analytical sensibilities is to study the relations between humans and non-humans and address how these two sets of entities assemble together in actor-networks. Furthermore, Graham Harman argues that Bruno Latour’s philosophy is concerned with ‘objects and relations’ (Harman et al., 2011; Harman, 2009). In Latour and Harman philosophy, an ‘object’ could refer to a technical object but it could equally refer to any kind of artefact, electronic or physical document. Some examples of the objects that are going to be analysed within this thesis are the diagrams of: potential distribution channels, spreadsheets of total cost estimations, new product specification hierarchies and company PowerPoint presentations, among others.

One group of scholars who show interest in the study of this type of object comprises those labelled by Marion Fourcade (2007) as the “performativists” and includes Michel Callon, Fabian Muniesa, Donald Mackenzie and Yuval Millo. These scholars work in the field of economic sociology and the social studies of markets. They follow a line of economic sociology that has theoretical and methodological roots in the work of STS and, in particular, actor-network approaches. Interestingly, this line of economic sociology allows me to shift the focus of the inquiry towards some less visited elements, such as those entities that Michel Callon (2002) calls ‘writing devices’. These are crucial to the data that this thesis offers in relation to the management of technological innovation.

An example of this is presented in the opening field note. Here, Med Diabetes’ CEO requires the mediation (Serres & Latour, 1995) of artefacts, objects and - in particular - diagrams that would allow him to create their ‘Life One’ product. Without those entities, the whole phenomenon of technological innovation is just not possible. Entities like patents are well known within innovation studies, but what about the very same elements that managers use to organize and manage processes for the development of novelty? The main idea is to

study the performative forces that those elements bring to the study of technological novelty management. Those assemblages between managers and elements could be considered as props (Callon, 2008), but for Stengers (2005) they need to be seen as 'existents' that are at the centre of the inquiry.

Following the performativists, technological innovation transcends binary positions - whether social or technological - whereby any valorization of technological novelty needs to be seen as multifarious and never purely located within the economic sphere. This is thus an anti-normative approach to the study of technological innovation. The present thesis is not seeking to find the best means to manage technological innovation in the name of business results. As a consequence, it differs from approaches that conceptualize innovation as a heterarchy or dissonance (Stark, 2009). Indeed, Ann-Christina Lange (2012: 355) has argued that it is problematic to defend the usefulness and beneficial effects of Stark's heterarchy, dissonance and abrasion. Furthermore, these points have been discussed within the STS literature. For example, Jensen (2010) problematizes the idea that any given theory or methodology could be intrinsically more helpful than any other for practitioners.

Furthermore, technological innovation as a concept is not easy to handle. A potential solution is to treat the concept and the phenomena itself as an event. Marian Fraser claims that the concept of an event aids Whitehead in his critique of the bifurcation of nature (Fraser, 2010). Furthermore, Fraser adds that this concept of an event serves Latour and Stengers in their own critique of the "bifurcated relations between subjects and objects... and facts and values" (Fraser, 2010: 58). To understand the concept of an event, some elements of Whitehead's metaphysics needs to be developed. These elements will be presented following the work of various Whitehead commentators within the social sciences.

In attempting to solve the problem of bifurcation, Whitehead defines any 'actual entity' in terms of its relatedness (Stenner, 2008; Stenner & Brown, 2009). Actual entities or 'actual occasions' extend the concept of experience towards all natural processes (Stenner, 2011). It is then possible to hold that "an actual occasion is not a substance or material but an activity of realization" (Stenner, 2008: 99). These realizations trigger the concept of a 'process'. A process is defined as the becoming of actual occasions. Actual occasions are the realization of all potentialities in concrete form.

Stenner adds that in order to become an actual occasion, there must exist a process of 'concrecence'. In this sense, an actual occasion becomes concrete. Furthermore, through the process of concrecence prehended, in other words becomes a new unity. Actuality is a 'cutting off' amid potentiality. To further clarify, Fraser (2010) claims that Whitehead uses the term 'prehension' to express the relatedness of 'actual occasions'. In addition, Stenner (2008) explains that a positive prehension is also called a 'feeling'. This 'feeling' is the operation or movement from the objective towards the subjective. It is the operation that explains the

movement from an objective towards an actual occasion.

Later on, Stenner (2008: 99) explains that an actual occasion is an arrangement of the many that becomes the one. Technically, an actual occasion is the passing from disjunctive diversity towards conjunctive unity. This is a theoretical point that will be of use in Chapter IV, where the model of Deleuze and Guattari is presented to conceptualize the problem of identity. Fraser adds that, for Whitehead, the concept of nature is a positive prehension. Therefore, it is possible to understand why it is that Whitehead understands nature as being “placed in the unity of the event” (Whitehead, 2011: 114). Whitehead’s prehension precedes the bifurcation of nature. As Stenner explains: ‘an actual occasion is thus a pattern grasped into the unity of an event’ (Stenner, 2008: 99). To say that technological innovation is a concept created in an event implies a deployment of the whole of Whitehead’s metaphysical apparatus. Furthermore, it implies that the concept needs to be understood as an actual occasion.

STS scholars sought to demonstrate how organized innovation spaces proliferate and how healthcare and self-care have become more ingrained in business practices. Critical attention has begun to be channelled into engagements with specific innovation practices. Here, social studies of science and technology have contributed to empirical and situated accounts of innovation and business practices (Schillmeier & Domènech, 2010). Concurrently, there is growing interest in the organization of innovation, not as the end-product of research but as a process-based development. Those multiple enactments that emerge within the boundaries between technology and business require careful analysis. The aim is to give a sense of the multiple layers, differential relations and folds that operationalize the relation between technology, science and business practices. In doing so, the thesis explains where and how different modalities of innovation are performed for those engineers and technologists developing medical devices.

An STS approach to technological innovation tries to transcend binary positions - whether social or technological - to avoid the phenomenon of the bifurcation of the nature (Whitehead, 1920). Isabelle Stengers’ cosmopolitical programme allows for the discussion of technological innovation outside the modern separation between nature and the social. It is an approach by which all kind of entities, whether social, technical, material, discursive or non-discursive, need to be considered carefully. The word ‘cosmos’ places at the centre of analysis of those others that are at the side of the humans. At the same time, the word ‘politics’ brings humans to the space where the theatre of technological innovation emerges.

At least theoretically, such an understanding of technological innovation may be given a more powerful and precise conceptualization that will avoid the bifurcation that appears in almost all the actual innovation theorizations. This approach could lead to a careful inquiry, in which Stengers moves the gaze towards those material or non-discursive entities that need to be seen as “existents” (Stengers, 2005). An approach like the one outlined by the cosmopolitical

programme can lead to a decentring of the purely humanist understanding of technological innovation, but at the same time can take care of those persons participating in the process as the designers, engineers and managers of technological innovation.

Regarding the political aspects, a technological innovation research programme that reads from the cosmopolitical needs to consider the importance of large actors, such as the NHS. For example, within the introductory field notes it is possible to see how this entity shapes the entire healthcare system of the UK. In addition, cosmopolitics leads to an understanding of how management tools like those writing devices being used at Med Diabetes and Med Dialysis are able to participate - in a coproduction - in the construction of technological innovation. The venture companies are not simply consuming NHS policies. These companies are actively participating in and producing the boundaries - by the use of some of these devices - of the healthcare system.

The cosmopolitical approach leads to a process- and event-based understanding of technological innovation. Such an approach requires the study of the non-discursive, the discursive and their relations. The scrutiny of the observer needs to be moved towards relations - for example, those general discourses that converge on health in relation to the private and public services of the country. Equally, it also leads the inquiry to those political aspects that inherit Stengers' (2005) demand to slow down the analysis and resist the actual urgencies of 'self-care', and rethink categories as 'good procedures' in the management of the commercialization of new technology.

5. The research questions

From the above discussion, the present thesis poses two general research questions that will lead the whole inquiry:

(1) What forms of prospective technological innovation configurations emerge from the assemblage of engineers, technicians, managers and non-human entities within venture medical healthcare companies?

(2) How, and in what form, is the professional identity of engineers and managers being performed or coproduced by the technological innovation process?

In addition, it asks the specific question:

(3) How are uncertainty and risk performed or enacted in relation to technological innovation in a venture company?

6. The thesis chapters in a nutshell

In brief, this thesis offers three theoretically- and four empirically-oriented chapters as well as a chapter covering the methodology employed and a finally chapter which concludes. Within the theory-oriented chapters, the first (*Chapter II*) covers the foundations of the concept of technological innovation and its relation to the organizing process within nascent companies. This chapter looks to open the 'black box' that is innovation studies and scrutinizes its relation to the literature on organizational studies and strategy. It advances a critical analysis of socio-technical arrangements based on Latour's irreductionist programme. Elements of critical management studies (CMS), STS and - in particular - ANT are complemented with the power of value conceptualizations that are mediated by the lens of process philosophy.

Chapter III offers some insights into how discursive and non-discursive entities, and in particular those that are at the core of management technologies, participate within the ordering process as 'organizing devices'. This chapter looks to link concepts of technology management, assemblages, and actors and networks. Finally, the chapter considers some elements of an object-centred approach to innovation - this will eventually be formalized as a 'dark organization theory' applied to innovation after the data analysis in *Chapter VII*.

Chapter IV is the final theoretically-oriented chapter and concerns itself with the literature that is most useful in analysing professional identity from a materialist perspective. It offers a partial discussion of the CMS literature and the more process-oriented literature in relation to the identity problem. The chapter sets the scene to produce a material- and process-based understanding of professional identity based on the philosophy of Deleuze and Guattari. This chapter offers a concept of professional identity that fits with the previous object-oriented understanding of the phenomena of technological innovation. All in all, the approach theorizes professional identity as a compatible concept with the 'dark organization theory' as applied to innovation.

Chapter V describes the methodology of the study. Within this chapter, I account for the procedures and methods that produce the data and its analysis. The question that leads this chapter is: what does it look and feel like to study the 'coming-into-being' (Daston, 2000) of technological innovations? This is a particularly interesting question, considering that innovations are the result of the efforts of a heterogeneous set of entities, like engineers, managers, technicians, tools, diagrams, discourses and many other entities assembled together. In addition, the chapter will present a discussion of the problem that confronts the researcher who wishes to produce accounts of the world following a non-foundational and performative disposition (Jensen, 2010).

Chapter VI is the first of four chapters that present the empirical analysis of the thesis. Within this chapter, I explain the various phenomena of technological innovation via an analysis

of the publication *Medical & Healthcare: A Guide to Market Access*. The chapter does this by employing a dual narrative. On the one hand, the explanations of the tools and the related literature on management and competitive strategy are analysed within the context of the guide. On the other hand, the narratives based on those actors who work within the companies and the intermediaries of Medilink and the university technology park are articulated. Consequently, the chapter will respond to the question: what kinds of innovation and management tools are enacted within the guide?

Chapter VII is the second empirically-oriented chapter, in which I proceed with the analysis of those ambiguous innovation objects/devices that are being used by managers and engineers. Using some notions from cultural studies of mathematics, the chapter advances the concept of a 'zero object' and - ultimately - of management by ambiguity materialized by ambiguous objects. In particular, the chapter tries to respond to the question as to what forms of prospective people-management technology configurations emerge and whether they are deemed eligible in technological innovation. The chapter elaborates upon the idea of a 'dark organizational theory' as applied to innovation.

Chapter VIII, the third data analysis chapter, offers a discussion about the identity of those engineers/managers, engineers and technicians who work at Med Diabetes and Med Dialysis. The chapter responds to the question: how, and in what form, are engineers and managers enacted within the process of technological innovation? The chapter works through a desire- and process-based analysis of professional identity based on interviews and theoretically-informed discussions of their activities. It demonstrates the process that I label 'engineering identities'. Such a process leads to the conceptualization of 'venture engineers'. Once again, it is through the use of ambiguity that managers steer the venturing process, as shown by the data analysis in the chapter.

Chapter IX is last empirical chapter of the thesis. This chapter expands upon the convergence of the analysis in the previous chapter with the concept of risk. The chapter responds to the question: how are uncertainty and risk enacted within the process of technological innovation? The analysis of risk for the production of technological novelty is offered as an example of what an object-oriented study of innovation is able to offer to the community of people who are interested in technological innovation.

Finally, *Chapter X* draws conclusions and considers preliminary answers to the research questions, as well as some future emerging questions and potential research problems, and the limitations of the thesis analysis and its results. Additionally, the chapter will suggest some potential contributions for practitioners working within venture companies.

Chapter II: Opening the Black Box of Innovation Studies

1. Opening the black box of innovation studies

As Jan Fagerberg explains in the introduction to the Oxford Handbook of Innovation (Fagerberg et al., 2006: 2), scholarly studies of innovation - indexed to ISI Web of Knowledge - have grown at an almost exponential rate from the middle of the 1950s to the middle of the last decade. Fagerberg argues, persuasively, that innovation studies have always been cross-disciplinary, whereby the innovation process itself had been treated as a 'black box'. The aim of this research is thus to open up the black box of the innovation process, particularly within those organizations that manage, perform and organize it. The present study tries to expand the multidisciplinary approach that innovation studies have pursued over the last 40 years. The present study focuses on 'innovation in the making', taking into consideration those individuals, firms, organizations and networks that comprise it (Fagerberg, 2006: 4). As some authors have demonstrated, technological innovation projects actually consist of a myriad of actions, negotiations and micro-decisions in the making (Christiansen & Varnes, 2007). This is the 'black box' that needs to be opened up to show, for example, how some managers in new companies work hard in organizing the heterogeneous set of entities that participate within a given technological innovation project.

Faulkner (2009) has argued convincingly that the study of medical devices in the healthcare sector has been largely ignored in the social sciences. However, STS can be of help in studying organizational issues related to technological innovation because it has a long tradition of researching technological innovation within the medical technology sector (see, for example, Jensen, 2010, on information technology for healthcare). However, and more importantly, STS allows one to confront the most difficult aspects of the black boxing operation, namely to make visible any performativity effects and certain any actual lack of reflexivity within the use of one's theoretical tools. This is the real utility of STS. Some scholars have conceptualized this as a 'non-foundational' approach (Stenner & Brown, 2009). This feature of STS sits within a tradition that offers the possibility to study the phenomena of technological innovation using ideas about processes and multiplicity from non-foundational philosophies, such as those developed by, inter alia, Whitehead, Serres, Deleuze and Stengers (Stenner, 2007).

2. When technological innovation meets management and organization studies

A good place to begin the analysis is to directly confront one of the most influential theoretical accounts that mix up technological innovation with strategic management. This exemplary case of innovation studies was presented 26 years ago, when David Teece published his highly influential article entitled "Profiting from Technological Innovation" (Teece, 1986). Since then, the paper has drawn extensive attention in the literature - it is one of the most cited papers in the field of innovation studies. As Gary Pisano (2006) has pointed out, this is the first paper that combines innovation studies with the strategy literature. Such a convergence opened up possibilities for management and organization studies as well as innovation studies and, more importantly, interdisciplinary work between these two programmes.

Teece's paper is located at the vertex of the management and innovation studies tradition. It opens up the discussion within the literature that studied organizing innovation processes and that which studied the economics of research and development within industry and markets. It is also one of the most relevant papers in terms of its number of citations and in terms of its impact, located in the top fifteen of the most cited works (Fagerberg et al., 2012).

Teece's paper looks to explain why innovative firms failed to obtain economic returns from technological innovation. More precisely, Teece's question is: why is it that a fast second or an even a slow third might outperform the innovator? (Teece, 1986: 285). Teece's framework is based around explaining who the 'victor' of technological innovation is. He looks to answer the question regarding which actor gets the most from the profit pie distribution. Schematically, Teece identifies a group of stakeholders: companies who lead technological innovation ('innovators') and companies who imitate those innovators ('imitators'), as well as other companies that are following the innovator company, the suppliers of the companies and the customers of the companies. For example, a winner would be Apple with its famous use of the technical inventions of rivals to get the most out of the profit pie in a particular market/industry. The fact that Apple did not invent touch technology did not stop them producing a platform by which they received a big part of the pie in the electronic devices market. Apple was a follower of this technological innovation, but they did it better and finally got more of the profit pie.

Within the paper, the use of the concept 'technological innovation' appears in the title and twice more in the body of Teece's paper. Moreover, the word 'innovation' (i.e., its non-adjectival use) appears more than 70 times in the text. Additionally, the word 'innovator' is used 24 times within the paper and is defined as "those firms which are first to commercialize a new product or process in the market" (Teece, 1986: 285). Furthermore, it is possible to infer a certain vagueness from the use of the concept 'innovation'. As a corollary, when the author uses the term 'innovation', he refers to the commercialization of new products or

processes in the market and not necessarily to an innovation based on new technology or technological change.

However, Teece's paper does build on examples about innovations based on technological novelties and change. Indeed, Teece's examples come from a great variety of industries, ranging from mass consumption goods like NutraSweet and RC Cola towards the F20 and the Comet aircrafts, and various personal computer and electronic devices for different markets. Teece classifies the industry actors using a 2x2 matrix that shows the winners and losers along the y axis against the innovator and follower-imitator along the x axis. As Neil Pollock has recently argued (2011), the use of these types of representation tools is active in the world. It is not just a representation of what happens with the innovators and follower-imitators. Or, as Donald Mackenzie has explained, the 2x2 matrix is an engine, "an active force transforming its environment, not a camera passively recording it" (Mackenzie, 2006: 12). The argument is that the matrix works in a performative mode with the reader of this particular mixture of innovation studies and competitive strategy Management and Organization Studies (MOS) theory. Teece is not disclosing a world, he is producing one.

The crucial issue is that what Teece probably needs is a more sophisticated matrix - a matrix "that captures the fluidity and ambiguity of the social world" (Lightfoot, 2008: 371). Only then would it be possible to argue for a more generalized explanation of the technological innovation phenomenon. Such a matrix needs to carefully reflect the assumptions of the theory and the complexities of the classifications performed by the analyst. Perhaps the only clear classification is that which separates the winners and the losers in terms of the share of profit obtained from their strategies. As a consequence, when Teece (1986: 286) develops his framework based on the various building blocks - "appropriability regime, complementary assets, and the dominant design paradigm" - he is using the 2x2 matrix to make the invisible visible and creatively link innovation theory with the literature on the management of strategy. But at the same time, he is producing an "immutable mobile" (cf. Latour, 1986) that can move and be translated within a group of potential readers, such as those who have been reverently referencing the paper since it was first published.

Teece's taxonomy implies a particular view about strategy and technological innovation. As Bowker and Star (1999: 285) put it, classifications and categories are tools that are material and symbolic. Community continually remake and reshape tools. The relations between innovators and followers-imitators need to be observed as entities that are able to change. What needs to be put at the core of the analysis is the interesting question regarding what imitators and innovators actually are. The construction of the matrix needs to look at the history and development of the categories and innovator/imitator identities.

3. Teece's basic building blocks towards profiting from innovation

It was mentioned before that Teece's use of the concept 'technological innovation' is not at entirely definitive and is, in some respects, vague. In fact, too often within the innovation literature there is a lack of specification regarding the concept (Conway & Steward, 2009). Following Brown (1997: 65), technological innovation is an 'actual occasion' that emerged from the machinery whereby a researcher, theoretical elements and any other entity participate in the creation of an event. Concepts perform themselves as ordering devices in time and space. Technological innovation is a concept that makes possible the coherence of the heterogeneous elements of innovation studies, and which calls forth new elements like organizational and strategic management theories to the event, namely Teece's paper. Teece's paper is thus a mixture that creates an assemblage between economic theories of technological innovation and the ideas and theories of management and competitive strategy.

Within this process-based analysis, Teece himself is part of the creation of a mixture between previous studies in technological innovation and directions in competitive strategy and strategic management. Furthermore, a researcher "may be seen as part of various 'machines', each trying to build connections with different practices so as to enable its specific event" (Jensen, 2007: 238). It is then possible to establish that the question about what constitutes technological innovation - that is, a new computer, an automated telling machine or a pharmaceutical - is not a simple matter. Policies, decisions and tactics on strategy, organization, finance, marketing and the location of business are made together with those related to research, design and operations. If we accept that technological innovation is the "successful application of new ideas to products and services," then it follows that this "often requires changes in the organization and strategies that support it" (Dodgson et al., 2008: 2). The consequence is that Teece's model brings a tremendous reductionism to the analysis of the phenomena in question.

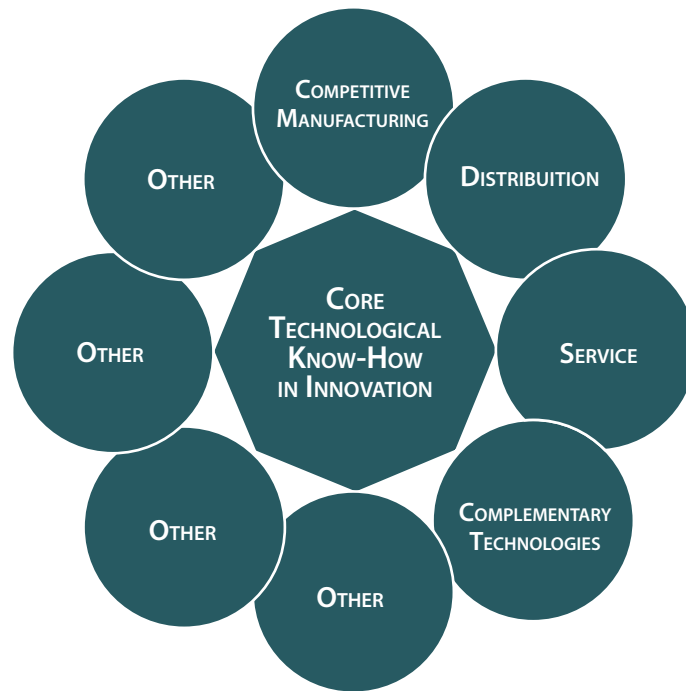
Nevertheless, Teece's framework is a seminal one (Pisano, 2006) for the management of technological innovation. The model was the first to combine technological innovation studies and strategic management. Moreover, in a more recent paper (2006: 1132), Teece explains that his earlier paper made a strong rupture with a particular type of Schumpeterian industrial organization tradition, namely one that is concerned with innovation that uses the market structure as an approximation of market power. Such Schumpeter-based approaches look to build any innovation explanation on market structure. As a consequence, Teece's approach breaks with the traditional industrial organization explanation of technological innovation. The novelty of Teece's approach then allows the author and his readers to trace an alternative theory of innovation. Such an innovation explains 'victory' in the innovation game in terms of three factors: (1) the firm's complementary assets structure, (2) external contracts with providers of other complementary assets, and (3) market entry management.

'Complementary assets' comprise those specialized assets that refer to services, such as marketing, competitive manufacturing and after-sales support. These complementary assets are much more connected with the management skills and strategies of firms. Such assets are a different in kind from those defined as technological assets. 'Technological assets' are instead defined as the technologically-applied knowledge of the particular technological innovation that the company has developed.

It is possible to argue that Teece's approach further expands the analysis of success with technological innovation to areas outside technology, whereby 'technology' is understood as a separated element of the complementary assets (also called 'capabilities'). This is a crucial point within Teece's analysis. As it is possible to see in Figure 1, these complementary assets or capabilities are classified as 'competitive manufacturing', 'distribution', 'service', 'complementary technologies' and several boxes marked 'other'. Teece claims that software could be seen as an example of a complementary technology (Teece, 1986: 288). This is an interesting classification, since one might question how Teece is determining the separation between different types of technologies. For example, how does the author classify the technology related to production, distribution and other organizational activities?

From an STS point of view, the problem of technology is never separated from its non-technological aspects, if indeed there are such things. As the example of Teece shows, software technology is not the only thing inseparable from hardware technology; it is also not possible to separate the social aspects of the hardware design and software design from the hardware and software itself. A beautiful example, of the Xerox photocopier, is given by the feminist STS scholar Lucy Suchman in her famous book *Human-Machine Reconfigurations* (2006). Following the work of Donna Haraway, Lucy Suchman wants to draw our attention to the way in which people make these frames and how they relate to and think about technology. In her example, Suchman asks the question: what is the boundary of a device that washes people's hands? Which part belongs to whom? Technologies take aspects of our activities and practices and materializes them, configuring tools to fit with a certain activity or practice.

Figure 1: Teece's innovation model.



Source: Teece (1986: 289).

Teece's profiting from innovation (PFI) framework "enveloped [a] far wider panoply of factors than had hitherto been addressed in the economic analysis of innovation" (Teece, 2006: 1132). In this sense, Teece's approach reads from approaches such as that created by the Organization for Economic Cooperation and Development (OECD). This organization has defined the concept as follows: "an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2005: 45). However, within the most recent *Guidelines for Collecting and Interpreting Innovation Data* (the so-called 'Oslo Manual'), it was decided to address the question of non-technological innovation (OECD, 2005: 3). This movement away from the first and second edition reflected the change within the innovation literature that Teece's PFI model pushed forward. It is not difficult to see the connection between the "wider panoply of factors" that Teece advocated and broader interests in marketing and organizational innovation.

All in all, both the Oslo Manual and Teece's framework are defined by the measurability of innovation. Furthermore, the manual has a theoretical framework with a broad span that stems from Schumpeter, economic theories based on industrial organization, organizational innovation theories, sociological theories of new technologies' diffusion, evolutionary understandings of innovation, and systemic theories like the famous Lundvall and Nelson frameworks (OECD, 2005: 28-33). The manual also presents some organizational innovation theories (Lam, 2005) and evolutionary approaches (Nelson & Winter, 1982).

Although the complementary assets position is of enormous importance in explaining why some innovators profit, in Teece's view, there is a second basic building block that innovators need to master to get a bigger slice of the profit pie - that is, the 'regime of appropriability'. This regime is constituted by "environmental factors excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation" (Teece, 1986: 287). These are "the nature of the technology, and the efficacy of legal mechanisms of protection" (Teece, 1986: 288). The nature of the technology is the more intriguing of these two factors. Teece's framework exhibits a particular interest in the nature of the knowledge upon which a technology is built. The various knowledge dimensions, which the author defines as tacit and codified or explicit, are important for the regime of appropriability. Additionally, the nature of the technology is closely connected with the product and process embedded in the technological innovation. These two aspects of the 'nature of the technology' are clearly crucial for the regime of appropriability of Teece's framework. Finally, Teece places less stress on the regime of appropriability based on patents and the legal system. He claims that this may have been more important in the past, but now any one can 'invent around' or use reverse engineering. This latter point is striking, considering the importance that companies such as Apple or any other defined as an 'innovator' place on legal aspects, with an incredible increase in patent activity.

Teece's framework breaks with industrial organizational approaches but clearly connects with some evolutionary economics approaches, such as that developed by Nelson and Winter (1982). As a matter of fact, PFI may even have a predecessor in Chapter 7 of these authors' famous book, in which they explore strategies based on imitation and innovation and a connection with appropriability (Pisano, 2006: 1124). Nevertheless, the emphasis on strategy is much more pronounced in Teece's paper. Before Teece's framework, innovation was not considered a crucial factor in the literature on strategic management. Furthermore, Teece's PFI framework leads researchers to formulate a capabilities-based approach to strategy (Pisano & Teece, 1994; Teece, Pisano & Shuen, 1997). This important approach to managing the strategic process was developed within Harvard Business School by Gary Pisano. As Pisano (2006) reflects, the concept of a core capability is the fundamental building block of any company strategy. This concept is a proxy for what Teece calls "core technological know-how on innovation" in his 1986 framework. Strategic management decisions logically emerge from the mixture of particular regimes of appropriability and the core capabilities of a company. For example, if a company confronts tight regimes of appropriability, core capabilities –for example design in the case of Apple that are protected by patents- will lead to victory in the innovation game.

However, not everything is completely explained by the framework of PFI and core capabilities. As can be seen, appropriability regimes are exogenous (i.e., taken as a given) for those companies in their strategizing phase. These regimes are determined by the confluence of

legal forces (e.g., the scope and potency of patent protection) and the nature of the technology itself (e.g., ease of imitability). Therefore, within Teece's framework, strategic work involves selecting the specific complementary assets position based on the appropriability regime that is *always exogenous* to the firm (Pisano, 2006: 1128). This shows a limitation of profit for the innovation framework. Such a limitation is clearly presented in the areas of genomics and open software. Companies such as Merck have liberated knowledge of the human genome sequence to the public, changing the appropriability regime of the industry. Therefore, the regime turned out to be of an *endogenous* character rather than an *exogenous* character. Nevertheless, Mercks also developed strong complementary assets in their distribution and commercialization that have led to the company receiving a huge slice of the innovation profit pie.

What the case of genomics provides an example of is the endogenous character of the appropriability regime. Nevertheless, this is a very counter-intuitive case, where the typical advocate of patents and tight appropriability regimes (i.e., pharmaceutical companies like Merck) opened up the knowledge of the genome, showing that their strategy was not to take for granted the appropriability regime but instead to construct one where the basic knowledge is public and - therefore - incapable of being made use of as a profit-generating machine. In synthesis, PFI does not offer any explanation of the appropriate strategies for the creation of a bigger 'profit pie' or a completely new one.

What the endogenous appropriability regime in the genomics case shows is that technological innovation and a firm's corporate and competitive strategies are far more complicated. As Pisano (2006) explains, within the literature on innovation management, there is a bias towards tighter appropriability regimes based on strong intellectual property rights and a strong legal environment. As was presented in the case of Merck, complementary assets theory shows the flaw in such a bias. Merck had strong complementary assets in drugs development and commercialization; therefore, its incentives were to produce a weak regime in order to block any incumbent that might look to profit from basic genomic knowledge. As a consequence, PFI plus core capability frameworks constitute the perfect mixture to explain those industries in which companies can be innovative in the absence of a 'friendly' patent environment.

The PFI approach feeds current views on the management of strategy. This is why it is so important to refocus the inquiry on this particular approach. In a very creative movement, the PFI plus core capabilities becomes the perfect conceptual machine that links places such as one of the best business schools in the world with the *ex post* case studies of successful innovators (i.e., companies that extract the most rent from technological innovation). The framework informs the normative approach of the OECD and its Oslo Manual. The manual itself shows an understanding of innovation expressed in four ways within companies, namely by the product, process, marketing and organization (OECD, 2005: 34). The literature on

management and innovation creates a powerful assemblage with the OECD manual. There is a continuum between the analysis of the management strategy level and that of the economic aggregate level. Such a black box explains the importance of innovation in the actual industrial policies of almost every country in the world.

4. For a broad understanding of the concept of innovation

Within Teece's framework, the foundations of ideas of technological innovation are never scrutinized. It is therefore interesting to ask the very simple and general question: what is an innovation? Innovation comes from *innovare*, which means to alter, to renew. *Innovare* contains the particle *in* (which could mean *not* or, by a different understanding, into) and *novare* (to renovate or renew), which come from the Latin *novus* (new, fresh, young) (Barnhart, 1988). What is interesting about this etymology is the inside view (i.e., into) that the concept *innovare* inherits from the particle *in*. René Girard (1990) has stressed the importance of the Latin *innovare* and signification as renewal, rejuvenation from the inside, rather than novelty (something much more connected with the external), which the modern sense carries in both English and French. The etymology and history of the category of innovation also include the idea of novelty arising from human creativity (Godin, 2008).

Godin stresses that, over the course of the history of the concept, innovation as novelty has been connected with the "artistic, scientific, technological, organizational, cultural, social or individual" (Godin, 2008: 43). In particular, since the nineteenth century, innovation has come to be defined as 'useful innovation'. In a continuum that begins with imitation and moves towards commercialized innovation, the concept came to be perceived as an instrument of growth, always positive and - at the same time - with a measurable construct that is concerned with firms' innovation, as the Oslo Manual exemplifies (Godin, 2008: 45).

Godin's work uses the 'genealogical' method of Michel Foucault (1984) to show accidents, forces and struggles that came with its original production of the innovation concept and its ulterior 'black boxing' (Latour, 1987). These struggles appear over the course of the long history of the concept. Among the Greeks, the Romans and after the Reformation, the word was broadly used in religious and political practices and with a completely different connotation to that nowadays. This history shows that it was only in the second half of the twentieth century that innovation began to be studied as part of economic tradition and was theorized accordingly (Godin, 2011).

It is clear that, in the case of Teece's PFI framework, innovation is located closer to the idea of 'novelty'. The author particularly stresses the *novare/renovate* component of the genealogy. It is interesting to observe that Teece's classification distinguishing between innovators and follower-imitators are opposites in a continuous line of strategies concerning technological

novelty and change. It is by this classification that Teece exhibits his distance with the Latin *innovare* and *innovatio* and its signification as renewal and rejuvenation from the inside. Although, Teece's analysis tries to show the importance of assets' and capabilities' construction, this is mainly understood as an external realm or else related to the industry and the market. The connection between the technological innovator and the follower-imitator is in opposition, not in a continuum.

The concept 'innovation' inherits the tension between *innovare/innovatio* and *novelty*. This tension is central to the present thesis, because to study what it is that people do when they claim that they are developing new technologies and products in venture companies goes hand in hand with an understanding of the innovation process as a continuum that includes design, creativity and imitation, and which managers, scientists, engineers and technicians perform in their day-to-day activities. There is an evident need to look into the black box of innovation practices, returning to the *innovatio* while at the same time maintaining the broad novelty understanding of innovation practices. The difficulty lies on the issue that the actual innovation concept forgot its *innovare* origin. Perhaps the connection between these two poles is not explained by a clear opposition, and perhaps these strategic behaviours are instead part of a continuum that displays the connections between the practices of people who work in ventures and the so-called 'external users'. Furthermore, this connection needs to be mediated by the possibilities that objects bring to the inner and external worlds of ventures when develop new technology. Novelty is not just commercial; it is also at the core of the practices of engineers. A symmetrical analysis of innovation needs to consider the genealogy of the concept.

Going further back in time, Girard explains how, in Medieval Latin, the word 'innovation' was used to express the opposite of 'dogma', whereby dogma is understood as the incontrovertibly true. Innovation is therefore understood as heresy. Furthermore, in medieval times "orthodoxy is unbroken continuity and, therefore, the absence of innovation" (Girard, 1990: 8). Later on, and gradually, over the nineteenth and the twentieth centuries, the representation of innovation completely changed to become an object of appreciation and a fashionable term (Godin, 2013). Godin adds that almost entirely positive observations about innovation have been made in the texts edited since the second half of the twentieth century onwards. But even during the time of the Reformation, innovation was understood as the restoration of the first Christianity. This is the return to the origin rather than the challenge to dogma conceived of by Catholics (Girard, 1990). As a consequence, in its genealogy the concept of innovation is more properly connected with restoration; novelty needs to be counterbalanced by returning to the origin.

It is clear that something of the dogmatic genealogical power (or at least of the notion of 'restoration' associated with the concept) is still in use in the foundations of Teece's framework.

For example, Teece's idea of wedding novelty and creation with a rationalistic management ethos is often used in management discourse. Nevertheless, as some organizational scholars have established, the very same organizing and managing process may be opposed to novelty (Styhre, 2006). Teece's mixture of technological innovation and strategic management leads us to consider the organizing process of innovation as something 'manageable'. Instead of the unpredictable Schumpeterian idea of 'creative destruction', organizations are treated as sediments of continuously recurring practices.

Although Teece's conceptualization brings forth the problematic relation of novelty and dogma, Godin explains how, during the twentieth century, innovation becomes a more 'capitalistic' concept. Invention, ingenuity, imagination and repetition: all of these concepts which used to be associated with innovation became subsumed under the commercial determination of the modern category of innovation. Furthermore, the actual use of innovation leads to an understanding of creativity and the individual in the service of industrial development and economic growth (Godin, 2008: 46).

As Godin (2008; 2011) and Girard (1990) have argued, the passion for the concept of innovation has become more radical and authors, researchers and society in general have become intolerant of the old fashioned (or tradition) and the power of imitation. Teece's classification of technological innovator versus technological follower-imitator is aligned with this trend. The link between imitation, invention and innovation had been broken for the past 50 years. Additionally, as Girard shows, although business people demonstrate a 'spiritual trust' in innovation, within competitive markets survival is the bottom line. It is competition (from cum and petere - to seek together) what it is at the core of business activities. Furthermore, there is not always the opportunity or the resources to innovate as a solution for competition. This is particularly true when our competitors do something better than us. As a consequence, strategies of imitation are followed and, after a while, imitation generates additional improvements. These improvements were not suggested in the original innovation. Indeed, such improvements can even turn the whole thing around (Girard, 1990: 14), as many Asian companies have been demonstrating since the 1970s. Innovation is also imitation, and probably a repetitive form of imitation that leads to novelty after all. Many people innovate when they think they are imitating. Perhaps Teece's imitators are in fact innovators. Perhaps Teece's categories are less clear cut and more blur.

Teece's framework puts success on the side of profit appropriation. Indeed, what the author seeks to explain is "why innovating firms often fail to obtain significant economic returns from an innovation, while customers, imitators and other industry participants benefit" (Teece, 1986: 285). Teece's analysis stretches the capitalistic understanding of innovation to the limit. He goes further than the market acceptance/diffusion of a new product/technology. He reduces the analysis to the obtainment of profits from technological innovations. As

a consequence, his analysis is not biased by the innovation acceptance/diffusion problem. Instead, the author accepts that a follower-imitator can be more successful than a technological innovator.

In any case, Teece's PFI framework does not provides a fundamental analysis of the novelty versus imitation problem that occupies Girard. Teece treats technological innovation as part of the machine of profit, and does not enter into the problematic relation of imitation and novelty developed by Girard. Although Teece's approach does not accept that innovation is always novelty, instead of an analysis of the complexities that exist between novelty and imitation, he moves the analysis towards a single calculative space. This is the space of profit. What I want to do in this thesis is to perform a study of mere innovation. Such a humble approach to the phenomena needs to seriously consider the limited change that the *in-novare* tradition brings to the concept of innovation. This mimetic model of innovation can lead the present research to a more humble analysis, one that is in the tradition of the modest approach that John Law (1994) has asked for.

Following a humble approach to the technological innovation phenomenon, it is possible to challenge the 'black box' (Fagerberg et al., 2006; Bruno Latour, 1988) that is innovation concept nowadays. Innovation in a modest approach follows a train of thought whereby entities (whether these are subjects or objects) are involved in rhizomatic interactions and where the organizing process is always distributed within a set of connected objects and entities that assemble and produce the novelty together.

5. Opening up the black box of profit for innovation

To open up the black box process of technological innovation, the research needs to refocus on the day-to-day tinkering (Knorr-Cetina & Mulkay, 1983) that brings together different sorts of material and intangible resources (Pickering, 1995). This involves studying what happens in mundane activities, such as the repetitive work of practitioners; it is the path to understanding the *novelty/innovare* or rupture/tradition aspects of the phenomenon. To open the black box means seeing the continuum between tradition and novelty as being the really difficult task for the management of technological innovation. As an example of such a framework, various ANT authors have demonstrated that within a traditional linear understanding of innovation, it is not possible to challenge the choices of the users of the technology. For a symmetrical understanding of innovation, we need to study the adaptation, failures and forces that strive and interact when new technologies are being developed and used (Akrich et al., 2002: 203).

For Teece's approach, innovation is a problem that can be managed by transforming uncertainty into risk by the operations of management. The better the analyst 'reads' the

situation, the more profit the company will receive from technological innovation. None of the aspects related to the everyday are relevant in Teece's approach. For example, his work lacks any user analysis - the word is mentioned just a couple of times in his paper. Although Teece reflects on the organization relations (networks of contracts and integration strategies), his approach is highly idealist and is not at all interested in the relational aspects of the phenomenon of innovation.

Teece's approach presents a complete separation between the phenomena under study and users. By contrast, within the ANT view of innovation, the roles of the user and the analyst are in a reciprocal relationship with the technical objects that they use. Akrich and Latour explain the adaptation of technical objects by users in terms of a dance, whereby inscription, subscription and its opposite - de-inscription - are used to describe the reactions of human (and non-human) actors to "what is prescribed and proscribed to them" and refer, respectively, to the extent to which they underwrite or reject and renegotiate those prescriptions (Akrich & Latour, 1992: 261).

What dominates Teece's PFI approach is the issue of how technological innovation needs to be managed. In contrast, a non-foundational approach would posit some alternative questions. For example, what are the conditions under which we regard an act as being technologically innovative? This question will lead the analysis towards the activities themselves and not just the outputs of the strategies of the organizations. In consequence, the question about foundations will lead to a collecting together of other important aspects of the material and non-material relations extant between the entities and which produce the management of the phenomena of technological innovation.

Additionally, there are questions surrounding the unexpected effects of innovation. Within Teece's analysis, effects are mainly calculable and they are all predictable. As Sveiby (2012) has extensively demonstrated, the undesirable consequences of innovation are indeed a topic in discourses other than innovation, but they are constructed with other terminologies and from other perspectives to innovation research. Undesirable consequences are, to some degree, studied in biology, medicine, environmental studies and sustainable development, etc., and theories are constructed with perspectives from sociology, CMS, STS, etc. Undesirable consequences of innovation exist with all types of innovation. Sveiby's analysis shows how innovation as a category needs to be rethought within management studies.

Additionally, Teece's framework does not study the detailed technical choices made by who that design a product/technology (Akrich et al., 2002). For example, the work of Steve Woolgar is crucial to establishing that the design and production process of a new product/technology entails a development whereby the user is configured in tandem with the technology (Woolgar, 1991). This notion of user configuration by the designer and producer is further developed by some of the literature on STS, which calls for a 'co-configuration'

understanding by which "designers configure users, but designers in turn, are configured by both users and their own organizations" (Mackay, 2000: 757). Important examples, such as policy makers, sellers and the spokespersons of users need to be considered in the final analysis of the user configuration. Additionally, identity co-construction of managers, firms, engineers and technicians needs to be analysed in detail if the analyst approach is to be symmetrical (Summerton, 2004: 488).

As a response to Teece's framework and implicit research programme, this thesis will present a relational approach to the study of innovation based on the analysis of innovation as a result of an event. Such is the traditional historical and philosophical tradition to which ANT rightly belongs (Brown, 2011). The next two sections will thus develop this approach to technological innovation.

6. For a critical constructivist innovation studies approach: adding another layer to the assemblage

At the centre of ANT's ontological approach, subjects are constituted within the interaction with other entities, whether these are subjects or objects. As a consequence, technological innovation and the management of strategy are no longer the same kind of business. Rather than being a fixed entity, the innovator is mediated by objects in a network of entities. As Hamid Ekbil and Bonnie Nardi (2012) comment, within such a process, objects are at the core of the social construction of subjects. The authors call this process 'objectification' (2012: 158). Objectification relates how a particular technology - whether it is a management technology or a new technological product - shapes the way in which the innovator is produced at the interaction. This view is closely connected with the inter-objective perspective (Latour, 1996) and with a more clear emphasis on the dispositional aspects of the technology in relation to subjects.

Adding a new complication to the phenomena of innovation, Hull and Kaghan (2000) have explained how the theme of innovation is now more connected than ever with the problem of organizations. The authors recognize the existence of innovation bias. Such a positive bias can mask underlying inequalities and the unwelcome effects of the innovation phenomena. The authors call for a new line of research to further interrogate the effects of any new technology and the innovation process on those who work and are connected as stakeholders with the organizations that produce these new technologies. The authors call for a cross-fertilization between the traditions of CMS and innovation studies.

Hull and Kaghan recognize that critiques of the pro-innovation bias tend to separate the technical and the social as constituting two different avenues. Furthermore, this separation between the world of the social and the technical persists in some CMS studies. Such a

separation needs to be subjected to the scrutiny of the research process because, as was famously explained Michel Callon and Bruno Latour (1992), from the perspective of STS the classification of what is social and what is technical is a question by itself - it is not something to take for granted. In this sense, it is exactly what Robert Cooper's organization studies programme implies in his search for an alternative to the 'simple location' approach present in organizational theory. Nevertheless, organizations need to be aware of the tendency of simple location-abstractions to represent partiality as wholeness. As Sverre Spoelstra (2005: 108) has clearly demonstrated, for Cooper "entities (and identities) do not have natural locations, and 'things' do not have an essence that keeps them together... Identities, subjects, and organizations are generated, and continuously require regeneration."

This constructivist framework questions the categorization that defines 'technological innovation' and/or 'organizational structure'. This is something that is well known within the STS tradition but which has been less frequently visited in critical studies of management. In fact, approaches like ANT have been accused of a total lack of the potential to intervene critically in terms of the debates on innovation and organization (see, for example, Whittle & Spicer, 2008). Furthermore, these radical epistemological and ontological approaches have been subject to criticism for its managerialism (e.g., Ashmore, 1996). Nevertheless, from Kaghan's (2000) point of view, an 'irreductionist' tradition (Latour, 1988; Harman, 2007) such as that present in Robert Cooper, Michel Callon and Bruno Latour, can enrich the long-term insights of Marx and Schumpeter as to the relationship between science, technology and society.

Kaghan (2000: 345) calls for a "sociologically informed stud[y] of science and technological innovations." The author makes a strong call to embrace an irreductionist approach to the study of innovation that would allow the us to overcome the divisions between 'social' and 'technological', 'material' and 'ideal', and 'nature' and 'society'. In Kaghan's view, Marx sought to solve this problem with his dialectical analysis of capital. Commodities could be considered as actors and the commodification process as 'black boxing'. This is a theoretical movement towards the study of 'research worlds' (Latour, 1998) that are generated from technological inventions in which technological innovation and its management process are fundamental parts. Kaghan adds that the ANT literature has produced useful concepts for understanding such a process, such as the notion of 'action at a distance' (Latour, 1987), which brings the importance of objects to the centre of the social analysis.

For Kaghan (2000), any commodity can be thus redefined as an 'actant' in ANT parlance. Commodities are objects that play an important part in the relations of production and consumption. Humans can also become commodities, as in labour process theory. In parallel, humans can accumulate commodities and capital. Kaghan (2000: 346) explains that Schumpeter and Habermas understood that commodities never emerged 'magically' in the world. New commodities emerge from a long process whereby invention and innovation force

a negotiation and renegotiation among a heterogeneous group of entities within any process of technological change. Within this approach, money is a device that could be considered an intermediary in exchange. An irreductionist approach understands the commodification process by paying attention to moral, economic, technological, natural and social interactions and their particularities (Latour, 1999).

An irreductionist and non-foundational approach seeks to produce a critical reading of the unexpected effects of technological innovation. Such an approach is far from that established by Teece's PFI. There are ontological and critical differences between Teece's approach and the relational one that this thesis wants to explore. For example, in a non-foundational approach, the product exists within a network in which the material and non-material actants participate in its production. A product is thus a relational effect, and at the same time affects the other entities that participate in its network of relations. Although Teece sees the importance of relations and contracts between actors in the value chain, he does not problematize the social and material relations that approaches such as ANT use to understand what constitutes a new technological artefact.

Furthermore, to conceptualize the commodity as an 'actant' allows the research process to follow a radical constructivist ontological approach towards technological innovation that can be read in the Marxian critical tradition (1972). Such a reading would carefully follow Marx's contention that the "evolving means of production will serve as the engine through which the relations of production will be transformed" Kaghan (2005: 2), but would equally employ the ANT programme and its inheritance from process philosophy. Although it is not the aim of this thesis to advance a complete theory that links process thinkers - like Whitehead - with Marx, there has been some philosophical work along these lines. Authors like Anne Fairchild Pomeroy explain in detail how abstractions (like labour) involve an ontological error. She claims that: "Marx's exposition on the exchange of wages for labour highlights the separation between reproduction and production and shows us how it is possible to treat a human being like a commodity for the purpose of exchange" (Pomeroy, 2004: 154). Furthermore, the Marxian labour theory of value explains how it is not possible to deny the relationality of the abstractions made up from dialectical moments of concrete practice. As a consequence, in practice, these categories are in a mixture.

As Pomeroy explains, the fallacy of misplaced concreteness (Whitehead, 1927: 7-8) is to consider a human as a complete, accomplished, settled, actual result of a process act already in the past. This is not completely incorrect, but it is incomplete. Pomeroy (2004: 157) claims that to commit the fallacy is - in a way - to be ruled by those abstractions. The fallacy leads us to think of human beings as being outside of processes. Accordingly, and considering that capitalism's objective is the *valorization of value* (or, to put it a different way, the expansion¹

¹ This expansion is obtained by the exchange of commodities and the wages of labour power, and has the prerequisite of abstraction to calculate the commodity

of *surplus value*), that is performed in the production process when an exchange value is abstracted from its use. It is thus possible to conclude that capitalism is always sustained within this valorization through abstraction –and is an active, living form of this fallacy. In other words, the logic of surplus value fundamentally requires the fallacy of misplaced concreteness.

From here onwards, the study of valorization –or economization, to use the performative terminology of economic sociology (Çalışkan & Callon, 2010) – can be seen as a programme to understand the technological innovation process and how the commodification process is performed and how any given type of entity participates in it. This corresponds – in part at least – with the actual programme of ANT approaches to economic sociology that will be further explained in the next chapter. This is what Teece's framework cannot offer, mainly because the fallacy of misplaced concreteness dominates the use of his framework. To further explain the technological innovation process and its related management processes, within the context of developing medical technology, it is necessary to scrutinize the process whereby labour (or human activity) is entwined with the objects used. If not, we are taking a risk in abstraction that immediately leads the research results towards the fallacy of misplaced concreteness. This is the additional value of ANT.

Obviously, irreductionist approaches can be problematic when the inquiry moves towards the identity of the worker and other humans participating in an organization. As Paul Stenner has explained, this clear move in recent social theory to renounce 'anti-object subjectivism' is a broadly positive move that blurs clear distinctions between the subject and the object, drawing attention to what needs to be understood by the term 'subjectivity' (Stenner, 2008). However, "such positions thus risk a return to a bleak anti-subjectivism" (Stenner, 2008: 92). The author adds that, for Whitehead, the "subject-object relation is the fundamental structure of experience" (Stenner, 2008: 93). The concept of subjectivity cannot be dismissed quickly. The sense of self-identity is still a phenomenon that needs to be studied.

Nonetheless, the radical irreductionist programme solves at least one of the problems that dog approaches like Teece's PFI. For Teece, it is clear that subjectivity and professional identity are not part of the problem. This is because the individualistic economists' *homo economicus* is accepted without any further consideration. Such an approach has been criticized by irreductionist programmes (see, for example, Callon, 1998; 2008). Additionally, such implicit managerialism has been largely criticized by CMS. Finally, Teece's approach is utterly unaware of the performativity phenomenon that exists within economics and related areas of management and competitive strategy. These are theories that do not just explain the world but instead attempt to perform it (Çalışkan & Callon, 2010).

7. For a critical analysis of socio-technical arrangements: opening the technological innovation and management black box once again

Having deconstructed and analysed the concept of technological innovation and its management aspects, it is necessary to set up some specific elements for the analysis of the slippery object of study that is technological innovation. This section looks to take into account the elements that the previous sections bring to the analysis of the organizing process of technical innovation.

First of all, the analysis will not take for granted the goodness of any kind of innovation process. On the contrary, following the symmetrical approach of ANT and considering the etymological origin and history of the category of innovation, it is interesting to investigate the value formation that takes place within the rhizomatic heterogeneous set of entities that produces the technological innovation process of those ventures that develop medical devices. This is a way of avoiding the issue of pre-innovation bias and understanding innovation as a 'whirlwind' model (Callon, 2004) rather than as a linear innovation model. A whirlwind model is one in which the user configuration is present in the creation of technological innovation and, at the same time - as the STS literature has increasingly demonstrated - is a form whereby engineers and technicians become configured by the technological innovation itself.

The configuration of users and engineers is intimately connected with the generation of surplus value. In fact, the valorization of engineering and technological knowledge in the form of labour is one of the core elements that allows capital to generate surplus value. Furthermore, when a commodity is understood as mixture (i.e., a heterogeneous network) between humans and non-humans, the process of innovation can be seen as a mixture between the technological and the social. These are the processes that need to be studied in detail in a constructivist and critical programme of technological innovation.

A critical analysis of socio-technical arrangements needs to shift the question of innovation towards its inner workings (if they do in fact exist). To examine the universalization of novelty and to emphasize the analysis of *innovare* leads us to question the criteria that make possible the innovation category itself as well as to follow a more 'performative metaphysics' (Suchman, 2008). Under a performative approach, the new is an outcome (not a departure or starting point) of assessment. Innovations/new technologies are achievements of discursive and material practices. Additionally, within this constructivist approach, activities of engineers and technicians are a mixture of discursive and material practices that produce the basis of the analysis of this economization process.

Within this process, non-humans need to be considered at the very least as a coordination device for social groups or sets of humans, which configures the socio-technical arrangements

that produce technological innovations. In fact, as Callon (2004) has explained, a new technology can serve as an organizing device. He explains how the collective emerges as a community around the existence of a new technology. This point can be generalized as the existence of inter-objectivity by which humans participate and which organizes their sociality (Latour, 1996).

As Rene Girard (1990) shows, repetition and a mimetic understanding of innovation are important in the practice of business and management within competitive environments. Additionally, Suchman (2008) explains that iteration comprises a model for inventions whereby the new project is based on its predecessors - this is a form of 'mereing' innovation, because it allows those who work on the project to make room for more generative 'future making' activities.. This is a process in which objects are also at the core, coding knowledge in the form of diagrams and making up props for analysis and future creation. In studying innovation, it is not desirable to focus only on particular, successful stories in an ex post fashion. To study innovation according to a symmetrical approach, it is absolutely necessary to accept the risks that the study of those companies who are developing technologies brings into the whole research process.

Furthermore, and following a long STS tradition, Michel Callon (2004) points out that technology shapes new social groups and identities. As was explained previously, identities are in a process of becoming with other entities. Capital requires that researchers, engineers and technicians - and managers in general - abstract and close the process that produces spaces of calculability for the value of labour and the commodification process. It is thus important to understand how identity is shaped by technology - whether or not this identity shaping process is occasioned by technological innovation or else any management technology that participates in the innovation process. As a consequence, technologies of management participate in the heterogeneous set of entities that are part of the technological innovation process and the venture company assemblage.

Finally, a genuinely critical analysis of technological innovation as a socio-technical arrangement needs to be focus on artefacts and objects in general. Objects are institutionalized and serve to coordinate interaction with both internal and external organizational parties (Kaghan & Lounsbury, 2006). Without the analysis of these objects, the commoditization and valorization processes lack materiality and they are not defined in any detail. Without inter-objectivity, economization is not exhausted as a process. A truly symmetrical analysis of the innovation process should bring our attention to the interactions and mixtures of these organizational objects/artefacts that are a fundamental part of the process. These objects can be understood as devices that play a role in the framing and management of ventures' innovative spaces - for example, in those cases where different perspectives need to be synthesized (Clausen & Yoshinaka, 2009).

Chapter III: The Organization as the Location of Innovation

1. Opening up the black box of innovation studies: technological innovation and its relation with organizational phenomena

My interest in the study of organizational activities and innovation activities has its origin in my personal experience organizing a new information technology venture in the 1990s as well as my experience working for a multinational chemical company. Later on, I had the opportunity to perform fieldwork in a Chilean biotechnology venture company. It was during those years that the question as to how people use artefacts in order to organize the production of technological innovation originated. Looking at these experiences retrospectively, I had been participating in the organization of a heterogeneous network of scientists, technologists, users and investors who used these devices to connect their work to the actual or potential existence of commercial and non-commercial transactions for those new technologies.

The question is located within a view about the innovation process that shares many points with a constructionist (viz., social constructivist) view of organizations and the phenomenon of innovation. This is an approach that aims to depict how the meanings, trajectories and outcomes surrounding technologies are created and defended (Pinch & Bijker, 1987). As Hughes (1987: 51) has put it, it is probable that - at least in some way - innovation consists of “messy, complex components that are socially constructed and society shaping.” Therefore, an innovation’s implementation involves multiple negotiations, definitions and/or changes of identity, and the establishment or re-distribution of roles within the organization (Munro, 1995). This takes place within a social context and is inextricably associated with technology, such that ‘socio-technical innovation’ comes to the fore (Harrisson & Laberge, 2002).

A constructionist understanding of innovation phenomena considers the issue of the emergence of the different forms that people use to manage technological innovation and the identities of those who manage the process. In other words, this is a question about ordering and organizing, one that looks to understand the organizing process within those ventures who participate in the emergence of technological novelty. However, raising this question does not necessarily preclude a social constructivist understanding of innovation. Instead, following a “free of adjectives” constructivism (Latour, 2003) opens up a broader question about innovation phenomena. Following ANT (Callon, 1986; Latour 1983; 1992; 1993; Law, 1987) and post-ANT (Gad & Jensen, 2010; Krarup & Blok, 2011; Lee & Brown, 1994; Star, 1991), this thesis seeks to draw new insight into the distributed process that emerges from the interaction between any types of entity participating within the organizing

of the innovation process.

In particular, post-ANT approaches allow this thesis to interpret the organization as an assemblage (an 'agencement', in Deleuze and Guattari's parlance) of material and non-material actors engaged in ordering practices. This is exactly the kind of questioning of order and ordering processes which, within organizational and management studies, was adopted by the second wave of a group of CMS scholars during the 1990s (Brown, 2011: 27). This thesis seeks to revisit the ordering question and apply it to the study of technological innovation. In particular, it has an interest in the questions of how objects are institutionalized and how they serve to coordinate and allow interactions with internal and external organization

As John Law demonstrated in his highly referenced work *Organizing Modernity*, order needs to be understood in terms of 'pools of order' (Law, 1994: 5). There is not just one possible order but rather various orders. Furthermore, order within an organization is a fragile, ephemeral thing, and clearly requires effort to be maintained. Garfinkel (1967) explains how organizations need to 'achieve' their *inertia* (Latour, 2013: 41) within a normal state of change. Any particular moment of order is a complex assemblage of actions that inflects the operation of a given organization. Managers, engineers and technologists are always building this apparent order with the help of tools that allow them to organize. Following Hennion (2003), this comprises the actions of writing and re-writing within organizations and the technological development process. Therefore, with these management technologies, the engineers and technologists of organizations are always seeking to achieve a given order that would allow the organization existence. The existence of the organization and work of technological novelty is entangled in a continuous process. To study the creation of novelty is to study a venture's creation and its ordering process. This is why the study of the *novare* goes all the way down to the study of the organization of rejuvenation from the inside.

Both the ANT and post-ANT literature have stressed the importance of a symmetrical analysis of every kind of entity and the relations that emerge among them. In other words, it is the mediation (Serres & Latour, 1995) of artefacts and objects which allows organizations to produce order. Without such entities, the phenomenon of technological innovation is not possible. All sorts of entities participate in the shaping process of organizations and in the emergence of technological novelty. At the core of ANT-based organization scholars' studies, organizational objects are understood as relational phenomena. More generally, actor-network theorists have pushed for an understanding of objects as the "effect[s] of stable arrays or networks of relations" (Law, 2002: 91). For example, Brigham (2003) explains how a particular data system mounted in fire engines is delegated to reconstructing order. It is the relation between the firemen and the system that constructs a particular order, finally achieved by the assemblage of these two sets of entities. This relational approach calls for a symmetrical analysis of any type of entity whereby, for analytical purposes, subjects and

objects are different in degree rather than different in kind (Latour, 1987)

From the STS of healthcare, Casper Bruun Jensen conceptualizes objects as mediators in the organizational process, “effecting conceptual or practical transformation” within the heterogeneous network to which they belong (Jensen, 2004: ix). From Jensen’s point of view, these objects are part of the instruments and practices that transform the network and then enable the conformation of a future based on the alignment of the various actors and their domains as well as the assemblage of the organizational phenomena. Jensen’s view leads to an object-centred view of organizational phenomena. Such a view is at the core of ANT and post-ANT developments. This is because ANT explains the strength of an actor/actant (whether human or non-human or else a mix of them) in terms of the conformation of its alliances with other actants through a process of translation, whereby “nothing is, by itself, either reducible or irreducible to anything else” (Latour, 1988: 158).

Objects are never isolated in the world - they are always participating in the ‘game of relations’. As Latour comments: “there are only trials of strength, of weakness. Or more simply, there are only trials” (Latour, 1988: 158). ANT presents a relational- and process-based view of the world. In a very similar vein, John Law (2009) presents a conceptualization of ANT whereby “tools, sensibilities, and methods of analysis” (Law, 2009: 141) participate in the enactment of the world.

In any case, and probably because of ANT’s symmetrical analysis of any type of subject/ object rule of method (Latour, 1987), the human part of the equation has been less frequently visited and studied. Despite repeated references to ‘subjectivity’ and - in some forms - to ‘identity’ and ‘agency’ in ANT, professional identity is rarely approached in a satisfying manner in the literature. The phenomenon is studied in only a few cases. At its best, this work is developed in pieces, such as that produced by Mike Michael and Vicky Singleton (1993). Their study shows how ambiguity and ambivalence are important aspects of the actor-network enrolment process. From there, the authors show how multiple identities and ambivalence sustain the network over time. In his *Constructing Identities* (Michael, 1996), Michael dedicates a chapter to the analysis of the phenomenon of identity. The author draws from discourse analysis to demonstrate how a group of scientists constructed their identity by the use of externalization and categorization as discursive devices. This is an analytical line that this thesis wishes to recuperate, though also placing a particular emphasis on those less visited interactional aspects of the discourse.

Within the literature on organizational studies, although the use of ANT is now accepted (Brown, 2011), studies of identity based on the theory are scarce. An interesting counter-example is presented in the work of Harrisson and Laberge (2002). In particular, the authors aim is to demonstrate the construction of the “identity of [those] workers through whom cooperation is constructed but among whom resistance also emerges as the other aspect of

innovation” (2002: 499). Although the work is a study of organizational innovation, the authors offer a theoretical analysis of how ANT can serve in studying adaptation, cooperation, accommodation and conflict during the organizational innovation processes. Building on Callon’s (1986) four stages (‘construction of the problem’, ‘interessement’, ‘enrolment’ and ‘mobilization of allies’), the authors conclude that: “workers were reluctant to support an innovation in which there was no place for an identity based on autonomy, socialization and solidarity” (Harrisson & Laberge, 2002: 515).

However, and as has been demonstrated at length in the literature on organizational studies, “the professional culture in many small, knowledge-intensive companies is characterized by the strong professional identity of the participant individuals” (Boter & Holmquist, 2002: 24) In addition, every person feel that is unique, coherent and unchanging, as the result of forgetting about the “essential multiplicity” (Brown & Middleton, 2005: 68) that produces the set of locations that we dwell in organizations and different contexts. ANT’s conceptualization of identity as a heterogeneous association, in which each entity is associated with its own elements (Singleton & Michael, 1993; Callon, 1980), is interesting as a solution but it does not indicate the emergence of the phenomena of identity.

As a consequence, there is a need for an approach that could open the black box explaining the “gap between our sense of speaking or acting in a self-consistent manner” (Brown & Middleton, 2005: 68). The contention of this thesis is that such an approach can emerge from the use of Deleuze and Guattari’s work in addition to the insights of STS and some organizational literature of CMS. Chapter IV offers further directions to thinking about identity from this particular position.

In any case, the view that people and objects are mutually imbricated in actor-networks had been always clear to the original ‘fathers’ of this approach. It was Michel Callon who noted that ANT can be explained as the combination of two words that are normally “considered as opposites: actor and network” (Callon, 2001: 62). This point brings old discussions within social theory about agency and structure (or micro versus macro approaches) to understanding organizations. As Callon explains, ANT looks to understand how these categories are constructed and provides tools for performing the analysis of category construction. For Callon, ANT understands society - and organizations in particular - as an “ongoing achievement.” In a parallel and self-reflective form, ANT also tries to analyse how social sciences construct society. This is the ‘performativity turn’ that ANT brings to the study of the social sciences. In Callon’s words: “it notes that the social sciences are no more content with just offering an analysis of a supposed society than the natural sciences are content just to describe a supposed nature” (Callon, 2001: 65). Callon has claimed that ANT moves from the study of natural sciences to social sciences and, in particular, to organizational studies.

Following CMS and post-ANT, Alcadipani and Hassard (2010: 419) show that ANT ‘de-

naturalizes' the study of the organizing problem (e.g., of innovation processes), offering the lens of performativity to its study and the necessary "reflexive approach to management and organizational knowledge." Such a de-naturalization is quite close to the 'non-foundational' point of view that Paul Stenner and Steven Brown (2009) have developed within psychology. In this sense, the use of ANT within organization studies could lead to a persistent analysis of the process whereby the founding premises of the field of research are "constructed and reconstructed" (Brown & Stenner, 2009: 4), as well as to how this process reconnects with the phenomena that are under study.

Non-foundational thought has been present since the first innovation analysis conducted by the sociology of the translation studies school (see, for example, a study of electric cars in France (Callon, 1980)) and had its maximum expression in later studies of large and complex technology systems, such as Bruno Latour's *Aramis* (Latour, 1996). Such a non-foundational approach allows for a view into the processes of ordering that is performed by engineers, managers and technicians participating in technological innovation. Such an approach enables *novare* and *innovare* to emerge in the present inquiry. Furthermore, ANT allows the inquiry to advance the question of practices from a materialist point of view, such as: how is that these managers, engineers and technicians perform their work and participate in the creation of technological novelty subject to a closely related connection with various other entities?

Finally, the inquiry into technological innovation and its related organizing phenomena will illuminate debates as to the ontology and politics at the centre of the ANT and post-ANT literature (Hassard et al., 2008; Mclean & Alcadipani, 2008; Alcadipani & Hassard, 2010). As Latour has shown, an external critique is not enough to understand the actual problems of society (Latour, 2004b). Furthermore, as the actual work of Javier Lezaun and Noortje Marres shows, for the device-centred approaches to the study of public participation, it is necessary to move from a post-Foucauldian perspective that treats matter as a tacit, constituting force in the organization of collectives and which is predominantly concerned with the fabrication of political subjects, towards one where objects and devices acquire explicit political capacities and "enact a particular participation as a specific public form" (Marres & Lezaun, 2011: 489).

To open up the organization as a place for technological innovation, in this chapter I will first review certain philosophical elements that may assist as a toolbox for thinking about the problem. Afterwards, and in connection with such tools, I will then review the literature on devices from the point of view of the 'new' economic sociology. Following this, I then move to a more radical object-mediated social understanding. Finally, I return to certain post-ANT literature and management by ambiguity literature, as it is understood by Munro (1995).

2. Apparatus/dispositif and assemblage/agencement

As has already explained, objects in the form of devices - and particularly diagrams - are at the core of the empirical problem of the study. A central theoretical approach to understanding these devices comes from the French pragmatic philosophical thought of the second part of the twentieth century. As Lezaun and Marres (2011) explain, Michel Foucault's conceptualization of objects and subjects is at the core of ANT and post-ANT. This is why this section discusses a critical concept in Foucauldian thought: the concept of *dispositif*. The inheritance that ANT takes from the work of Foucault has been stressed by Bruno Latour in an interview with T. Hugh Crawford. During this interview, Latour explains that the exercise of power demands the use of apparatuses. He then explains that the panoptic analysis of Foucault is an interesting example of an apparatus and that ANT is very much a confirmation of Foucault's tradition (Latour & Crawford, 1993).

Kevin Hetherington and John Law - two important ANT theorists - point out that it is in *Discipline and Punishment* where Michel Foucault sets up the idea of distributed action through a mixed and diverse 'arrangement of materials' (Hetherington & Law, 2000: 127; Law, 1999: 4). This is a central inspiration in the ANT literature. Closely connected with the idea of distributed action in material arrangements is the concept of apparatus - *dispositif* in the original French. Foucault defines '*dispositif*' in a group of his selected interviews and writings as:

"...a thoroughly heterogeneous ensemble consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions - in short, the said as much as the unsaid. Such are the elements of the dispositif. The dispositif itself is the system of relations that can be established between these elements." (Foucault, 1980: 194)

Additionally, the original French word that Foucault used to define apparatus is *réseau*. The concept of *réseau* is closely associated with the idea of a net or ensemble of different things. In fact, translations of the word *réseau* in English include 'network', 'grid', 'net', 'web', 'mesh' and 'connection'. The etymology of the word *réseau* comes from the Latin *rete*, which means 'net' and the adjective *reticulé* ('reticulate' and 'netted' in English) and characterizes objects that have the structure of a net. This brief exploration leads to an understanding of an apparatus as a dynamic array of nodes (things). It is possible to notice the interesting connection of apparatus with the phrase *actor réseau*, which was translated as actor-network (Law, 1999: 5). Latour (1997: 47) claims that the word 'network' in ANT comes from Diderot's usage. For Diderot, the word *réseau* was a useful solution to the Cartesian distinction between matter and spirit. Latour adds that the French *réseau* comes from Diderot's strong ontological use.

As a consequence of this, it is not difficult to see that the idea of an actor-network it is tied to Foucault's *dispositif*.

Foucault points out that any *dispositif* is defined by its connections and the arrangement of associations that can be established between the elements that are a part of it. Foucault understands an apparatus to be a set of heterogeneous elements - "discursive and non-discursive" - that change location and function "widely" in their interplay. Foucault also points out that any given apparatus is a particular historical "formation" that responds to a critical or "urgent" requirement. This dominant strategic mission or function of the *dispositif* is exemplified by the case of the absorption of the floating population of a mercantilist economy. Within this example, Foucault shows how the critical and strategic function moulds the *dispositif*, which "gradually undertook the control or subjection of madness, sexual illness and neurosis" controlling this floating population (Foucault, 1980: 194). As a consequence, the analysis of any *dispositif* brings its history to the analysis of any formation/organization.

Additionally, the concept of *dispositif* is closely related to Foucault's 'regimes of truth' that the thinker defines as "the ensemble of rules according to which the true and the false are separated and specific effects of power attached to the true," whereby a regime turns into the "linked in a circular relation with systems of power which produce and sustain it" (Foucault, 1980: 132-133). This set of rules is particular to a historical period of a given society. Kessler (2006) also points out that the term '*dispositif*' allows Foucault to combine heterogeneous types of elements and analyse their interplay in a particular historical formation that produces arrangements of both power and knowledge. The author stresses that the English translation of the term '*dispositif*' (i.e., apparatus) is closely related to this regulatory emphasis and the unnamed power of the panoptic *dispositif* in Foucault's writings. Foucault's interest lies not just in the heterogeneous items that are a part of the apparatus. The author wants to highlight the contradictions within the *dispositif* that lead to reorganizations and alterations of its sets of heterogeneous elements. That is, the genesis, origin, creation and/or beginnings that the *dispositif* permits in a second movement of its existence with its strategic function. These effects and reorganizations bring unexpected results within the application of any *dispositif*.

To think of technological innovation as a *dispositif* allows one to address the issue of the historical conditions and circular relations that exist between its conceptualization and the power that produces and sustains it. To study the regime of the truth of technological innovation, it is necessary to take account of the material and discursive aspects of the phenomenon. Technological innovation - in short, innovation - is now explained in its historical formation such that, in the words of Godin, it "leads to its capitalistic understanding and usage" (Godin, 2008: 46). The study of management technologies and the objects being used to put those technologies into practice are part of the intricate historical formation that responds to a capitalistic development of technological innovation. These devices are being

used within neoliberal discourses of innovation, technology and entrepreneurial activities that are close to any scientific and technological activity (Lave et al., 2010).

But how is it thus possible to escape from the *dispositif*? In his well-known text *What is a Dispositif?*, Gilles Deleuze (1992: 159) meditates on some of the features of the *dispositif*, defining the concept as follows:

“...a tangle, a multi-linear ensemble. That is composed of different sorts of lines. And these lines do not frame systems that would be homogeneous as such (e.g., the object, the subject, the language). Instead, they follow directions, they trace processes that are always at disequilibrium, sometimes coming close to each other and sometimes getting distant from each other. Each line is broken, is subjected to variations in direction, bifurcating and splitting, subjected...”

Deleuze posits a notion of *dispositif* as a set of interactions between the elements of the arrangement. A *dispositif* it is not just an arrangement of things. There is tension or struggle within it. On the one hand, there are various institutional, physical and administrative mechanisms and knowledge structures that enhance and maintain the exercise of power within the social body. On the other hand, there is a struggle among the elements that makes up the *dispositif* itself. Such a Deleuzian point of view emphasizes its fluidity and openness, which escapes attempts at totalizing control of the *dispositif* but still considers the power and control aspects that are in this kind of array. Some social scientists claim that this notion of *dispositif* is similar to Deleuze and Guattari's ‘agencement’. In particular, the economic sociologists that Fourcade (2007) calls *performativists* have advanced an understanding of agencement from this Deleuzian conceptualization of Foucault's *dispositif*.

Another important philosopher who reflects upon Foucault's concept of apparatus is Giorgio Agamben. He points out that the term ‘*dispositif*’ is a “central technical” term in Foucault's philosophy, but is never fully defined by the author (Agamben, 2009). Agamben explains how the *dispositif* is a heterogeneous ‘set’ that is also “the network or the web established between those elements” and which is also an act of management, of governing an existing state of affairs. He goes on to present a genealogy of the concept, traced from the Greek term *oikonomia* - the administration of the house or of an enterprise. Agamben adds that the Catholic Church would have used the term between the second and the sixth centuries in order to explain the problem of the holy trinity. The Church wanted to assert that God is one but that, at the same time, he manages his home by the use of Christ. This was the way by which the Church answered the questions and resistance those who thought of the holy trinity as a return to paganism. It is from this usage that the word came to be understood as a disposition. In Agamben's view, this is explained by some earlier Latin translations by the

Church Fathers of *oikonomia* into *dispositia* - the divine economy is a *dispositia*.

Such a theological usage could be supported by the origin of the concept in Foucault's work. As is known, Foucault takes the word from his master in philosophy, Jean Hyppolite. Hyppolite wrote on the young Hegel's *Die Positivität der Christlichen Religion*, in which Hegel describes a distinction between natural religion - a direct contact with divinity - and positive religion, made up of prescriptions, discourses and rituals that constrain religious behaviours (Dumez & Jeunemaître, 2010). Additionally, Agamben looks for a generalization of Foucault's concept. According to him, the idea of *dispositif* can point to any kind of object that is able to capture, establish, adjust, form, lead and control human and non-humans (Agamben, 2009). Here, the idea is no longer just about hospitals, discipline, the confession and the panopticon, as Foucault writes. In Agamben's view, a *dispositif* could equally be any writing, literature or other discursive element that can shape the behaviour of some subjects.

Agamben looks for an explanation of Foucault's *dispositif* in the *Archaeology of Knowledge* (Foucault, 1972). In this work, Foucault understood the *dispositif* in terms of 'positivities'. 'Positivities' is a catch-all term for statements, discursive formations or sub-formations (like sciences) or else the set of relations between those formations. From this work, the *dispositif* inherits a strong relation with what is non-natural or free and defined as an obligation. Furthermore, Agamben explains how Foucault is interested in the relations and power games that happen in the positivities (Agamben, 2009: 6). Unlike Hegel, Foucault did not seek to close this dialectic between individuals and history (Legg, 2011). Agamben even advances a definition of '*dispositif*' (he uses the word '*apparatus*') as: "I shall call an apparatus literally anything that has in some way the capacity to capture, orient, determine, intercept, model, control, or secure the gestures, behaviors, opinions, or discourses of living beings" (2009: 14). Such a conceptualization emphasizes its mechanism of entrapment.

For Legg, Deleuze inserts the possibility of the new. The *dispositif* is able to produce subjectivities that can escape and reinsert themselves in a different 'multiplicity'. Deleuze hypothesizes that apparatuses have two different lines: lines of stratification or sedimentation and lines of creativity. Legg adds that "apparatuses are etymologically and genealogically indissociable from regulation and government, but that their very multiplicity necessarily opens spaces of misunderstanding, resistance and flight" (Legg, 2011: 131). These are the spaces that the concept of *agencement* (i.e., *assemblage*) offers. What, then, is a workable definition of this concept?

Assemblage/agencement is a difficult concept. As Phillips (2006) explains, in Deleuze's and Guattari's oeuvre, no philosophical concept ever operates in isolation. On the contrary, the concept '*agencement*' needs to be understood in association with additional concepts (Phillips, 2006: 108). In the case of Deleuze's philosophical work, the word '*agencement*' is related to Spinoza's concept of 'common notion' and the concept of an 'event'. As an example,

Deleuze shows how, for the stoics, the event of a wound brings together the knife and the flesh in concert. Therefore, the event of a wound is not reducible to the tissues or to the knife alone (Phillips, 2006: 109).

Additionally, Phillips claims that the word *agencement* has uses in French such as ‘fitting’ and ‘fixing’ wherever - for example - one talks about the parts of a machine or a body. The word can also be used for the act of fixing an arrangement consecutively, as in the case of the “fixtures and fittings of a building.” On the other hand, the English word ‘assemblage’ does not mean the same as the French *assemblage*. Phillips notes that Deleuze and Guattari rarely use this word in their philosophical writings. This word allocates a collection of things and is also used in a more specific archaeological and artistic dominium - as in the case of collages and a collection of archaeological objects in a fieldwork site.

In his *Assemblage Notes*, Robert Cooper meditates on the difficulties of thinking of movement and follows a line of reasoning that elaborates Whitehead and Benjamin in order to arrive at a concept of assemblage as partial, dispersed, fragile, and tentative. The author also points out that an “assemblage is simultaneously a part of and apart from” (Cooper, 1998: 110). The author continues his explanation of assemblage, delving into the etymology of the concept with the Greek word *sumbolom*. *Sumbolom* means the act of bringing together separate parts. A more recent usage in English belongs to the words ‘symbol’ and ‘simple’, meaning “the joining of the disparate.” Cooper directly connects the concept of assemblage to Deleuze and Guattari’s notion of *agencement*. Furthermore, he emphasizes that *agencement* brings forth two meanings: the notion of ‘arrangement’ and the notion of ‘organization. In this sense, the term ‘agencement’ also captures the notion of agency (Cooper, 1998: 111). Finally, the author explains that the term ‘agencement’ implies that the minimum real unit is always collective and never a unity - it is always a multiplicity.

Organization is a recurring topic in Deleuze’s and Guattari’s writings. Deleuze and Guattari write that an assemblage is any number of “things” or “pieces of things” gathered into a single context. An assemblage can bring about any number of “effects” - whether aesthetic, mechanical, productive, destructive, consumptive or informational, etc. The authors write that:

“in a book, as in all things, there are lines of articulation or segmentarity, strata and territories; but also lines of flight, movements of deterritorialization and destratification. Comparative rates of flow on these lines produce phenomena of relative slowness and viscosity, or, on the contrary, of acceleration and rupture. All this, lines and measurable speeds, constitutes an assemblage” (Deleuze & Guattari, 1987: 3-4).

Organization produces itself by connections that sometimes accelerate and sometimes slow down. This point stresses the collective dimension of those who produce technological innovation. The point also brings forth the articulation and segments that shape the structure of organizations.

In a more general sense, the concept of agencement permits a corollary of Deleuze and Guattari's work and leads to an understanding of subjectivity as a concept that does not reside exclusively in the subject and in language. It is disseminated - to different degrees - in nature, in the cosmos, in machines and in the social, etc. Godchild points out that this aspect of Deleuze and Guattari's work is "not a question of anti-humanism, but a question of whether subjectivity is produced solely by internal faculties of the soul" (Goodchild, 1996: 151). He then argues that, within the work of Deleuze and Guattari, subjectivity is also located in interpersonal relationships, in complex family relations, in social, cultural, environmental and technological machines and assemblages. It is not difficult to see the possibilities of the concept in understanding the process of technological innovation. Technological innovation could be conceptualized as the polyphony of a group of disparate entities co-functioning in constructing technological novelty. The concept of assemblage serves to illuminate further connections between organizational innovation processes.

One theorist who systematically follows Deleuze and Guattari's concept of assemblage is Manuel DeLanda. He claims that the concept of assemblage is useful in solving traditional problems of reductionism within the social ontology of social sciences (DeLanda, 2006b). DeLanda pushes a theory based on assemblage to overcome what he calls 'micro-reductionism', which he relates to microeconomics and micro-sociology, as a second strategy that sees a world of enduring social structures as in the case of classical sociological thought. Finally, there is a third strategy at an intermediate level that he exemplifies with the sociological work of Bourdieu and Giddens. All of these micro-, macro- and meso-level theories may be overcome by the use of Gilles Deleuze's philosophy, he claims.

Following Deleuze's work, he elaborates a social ontology whereby individual people, organizations and cities are "made out of entities at the immediate lower scale, that is, the relations among scales is one of parts to whole" (DeLanda, 2006: 251). Thus, he adds, populations that are an integral part of any level interact in processes from which larger entities emerge "as a kind of statistical result, or as collective unintended consequences of intentional action." Such a new, larger scale entity, "immediately starts acting as a source of limitations and resources for its components." Causality is bottom-up but in parallel, such that the whole constricts and permits the minor-scale parts. A remarkable point in DeLanda's theory is that he does not put 'society as a whole' at the top. Instead, DeLanda positions there another "individual singular" entity.

DeLanda's assemblage theory comes mainly from his analysis of Deleuze's work and

fundamentally from the text *A Thousand Plateaus* (Deleuze & Guattari, 1987). In fact, as Steve Brown (2009) has remarked, DeLanda (2006a: 253) elaborates a definition of Deleuze and Guattari's concept of assemblage. Following Deleuze and Parnet (Deleuze & Parnet, 1987: 55), DeLanda claims that the central idea in Deleuze's concept of assemblage is the exteriority of relations - that is, a "relation may change without the terms changing" (Deleuze & Parnet, 2002: 55). Therefore, "relations are external to their terms" (DeLanda, 2006a: 253). Accordingly, and following *A Thousand Plateaus*, DeLanda arrives at a concise definition of 'assemblage' in terms of a plane. Along one axis, the components of the assemblage may play a range of roles that plot, at one extreme, from the material towards the purely expressive at the opposite extreme. DeLanda adds that "these roles are variable and may occur in mixtures" (DeLanda, 2006b: 12). As a consequence, in this first axis, an element of the assemblage can play a mixture of material and expressive roles. DeLanda characterizes the other axis of the plane in terms of processes that stabilize or destabilize the elements of the assemblage (DeLanda, 2006a: 253), i.e., as closing or opening the assemblage to change.

Destabilizing processes open up a novelty in DeLanda's framework. Additionally, DeLanda remarks that these kinds of processes are what Deleuze and Guattari call 'territorialization' and 'deterritorialization'. Unfortunately, as Brown (2009) explains, the turn to empirical analysis that DeLanda's definition exhibits is not without problems. Brown claims that DeLanda's examples are selective and that they dispossess these elements of social science of the complex nature of their empirical observations. DeLanda falls into the very same difficulties that he found in his analysis of the three different forms of reductionism in social science that he hoped to solve using his assemblage theory.

All in all, the notions of assemblage and apparatus have some interesting connections. Firstly, both concepts are situated along the same line of thought. This is a vector that considers the notion of a unit of analysis as something that is broader than the subject and the object alone. Secondly, the analysis is situated along the connection between the elements that conforms the collective. This is something that might adequately called a 'distributed analysis of the action'. Thirdly, as with the notion of *dispositif*, an assemblage is a dynamic notion, a notion that evolves in the power struggle of its heterogeneous parts. The internal tension within the *dispositif* is not just a Deleuzian idea. It is also present in the work of Foucault himself and some of his interpreters. Finally, even the dominant strategic mission of the *dispositif* is shared with the notion of *agencement*.

Additionally, and especially important for this thesis with its interest in processes of identity formation (from a process point of view), both concepts share the view that subjectivity is not produced exclusively by the inner faculties of the subject. A relational approach such as ANT could clearly benefit from the connection that the concept 'dispositif' (i.e., *le réseau*) has with the notion of an actor-network. As Giorgio Agamben explains, *dispositifs* "must always imply

a process of subjectification. That is to say, they must produce their subject” (Agamben, 2009: 11). Deleuze himself claims that the process of subjectification needs to be studied. Such a process “has little to do with any subject... it’s to do with individuated fields, not persons or identities. It’s what Foucault, elsewhere, calls passion” (Deleuze, 1995: 93). This is a process-based view about identity that this thesis will revisit.

The problems of subjectification and professional identity will be the themes of the next chapter. What follows next is a review of the literature using the concept of agencement (and, as is now clear, *dispositif*) in the field of economic sociology. This part of the literature review offers an ANT approach to understanding economic phenomena. Technological innovation is an economic phenomenon. As a consequence, the interrelation between ANT and economic sociology could serve as an important tool in the study of innovation and technological ventures.

3. The economic-sociological use of assemblage and *dispositif*

It is clear that STS and ANT have displayed a high degree of interest in the innovation process and in the study of what Michel Callon called ‘techno-economic networks’ (1991). Techno-economic networks (TENs) may be defined as the organizational form of those heterogeneous actors (research centres, universities, governmental organizations, users, financial organizations, etc.) who participate in the conception, development, distribution, production or diffusion of goods and services via their various associated market transactions. As Miller and O’Leary (2007: 709) argue, the concept of a TEN offers the opportunity to examine the interactions between science, technology and economics. For example, in the case of the Schumpeterian studies of entrepreneurship, Swedberg (2008: 193) elaborated a possible connection between a more “material” understanding of the notion of techno-economic innovation (as he generically refers to STS and the performativist point of view) and Schumpeter’s economic sociological innovation studies.

Building on the idea of socio-technical agencement and the problem of the economy, Callon (2008) constructed an idea of a *homo economicus* whereby subjectivity is enacted within the *dispositif*. It is possible to see how two different levels of analysis are intertwined. The first one is concerned with the construction of the subjectivity of economic activity while the second one focuses on the level of groups in which this subject belongs (e.g., organizations for profit). Both levels are completely interconnected and they both consider the heterogeneity of the assemblage. In this sense, both the subjectivities of researchers and executives are arranged and organized by the space that this agencement of discursive and non-discursive elements brings into action. Without the ‘props’ that are the diagrams used by the executives of the companies, the whole history could be seen in a very different way. This insight is indeed very old in actor-network approaches. For theorists working in this tradition, actants (i.e., entities

that could be human or non-human) are complex, topological, non-singular entities. These emergent relations are simplified or 'punctualized' (Brown, 2011). As Law (1994) clearly demonstrated in the case of laboratory managers, they are an aggregate of technical, economic and legal relations.

Strictly speaking, Michel Callon writes about the term 'agencement' for the first time in his review of Andrew Barry's *Political Machines*. There, he emphasizes that Barry's use of the term 'socio-technical agencement' is central and very similar to the idea advanced by ANT (Callon, 2004: 121). For Callon, agencement describes a "combination of human beings and technical devices that are caught in a dynamic configuration (the agencement acts)." The term points to the distributed and merged character of the action that emerges from the mix of technology and humans, between the natural and the social. It is interesting that Barry explicitly states that he prefers the notion of arrangements - an assemblage - to the notion of an actor-network because the notion of a network is too closely associated with information technology and instantaneous connections, following a line of reasoning that is shared with Latour (1999).

Responding to Daniel Miller's (Miller, 2002) critique of the performativity economic programme, Michel Callon develops a detailed explanation of the importance of the concept of agencement for a deep understanding of material agency. He cites the well-known work of Hutchins (1995) on distributed agency and a long list of scholars who support the idea that agency is not just in the human being but also in institutions, rules, values and symbolic systems (Callon, 2005: 4). Callon builds upon Deleuze and Guattari (1988), and in particular he emphasizes the notion of agencement as being composed of "human bodies but also of prostheses, tools, equipment, technical devices, algorithms, etc." (Callon, 2005: 4). Callon finally claims that ANT's usage of 'socio-technical agencement' is aligned with this notion of 'agencement' in the tradition of Deleuze and Guattari.

With a slight modification, the concept of 'agencement' is reused by Muniesa et al. (2007). These scholars add an interesting link to Foucault's notion of apparatus, as is presented in the already cited work of Deleuze (1992): *What is a Dispositif?* Interestingly, the link is their point about the subject production process. The authors claim that the subject is not external to the artefact; rather, "subjectivity is enacted in a device" (Muniesa et al., 2007: 2). Here, as was explained earlier, the authors equate the concept of agencement with *dispositif socio-technique* and translate it into the English 'socio-technical device'.

Muniesa et al. (2007: 3) offer a very succinct explanation as to what an economic agencement is. First, the authors describe a general kind of agencement - for example, the agencement of the atomic particles of a nuclear reactor and the agencement of a mathematical formula. Following their line of argument, a more mundane example would be the use of a mobile phone. Here, there is a complex relation between the user of the phone and the mobile phone

itself. An interesting point in this example is that the mobile phone affects the other parts of the human part of the arrangement. In some cases, the artefact can completely change the behaviour of any person who is using it. The example also points to the subjectivity enacted in the mobile phone. For example, there are some cases of countries where the use of mobiles grants a sort of identity to people. But nonetheless, it is a more and less universal example with the telecommunications agencement².

However, Muniesa et al. (2007: 3) go a step further by defining economic agencement as a kind of agencement that “renders things, behaviors and processes economic.” The presentation of the process as ‘rendering’, calls for a specific understanding of this process. Muniesa and his collaborators call this process ‘economization’ and it is defined in a later work by Çalışkan and Callon’s as:

“The processes that constitute the behaviors, organizations, institutions and, more generally, the objects in a particular society which are tentatively and often controversially qualified, by scholars and/or lay people, as ‘economic’. The construction of action (-ization) into the word implies that the economy is an achievement rather than a starting point or a pre-existing reality that can simply be revealed and acted upon.” (Çalışkan & Callon, 2009: 370)

Çalışkan and Callon (2009: 393) demand further study of economization processes. Under their approach, the phenomena of economization could be revealed through empirical studies of the relations between humans and non-humans via the concept of socio-technical agencement. Here, the construction of the market is a socio-technical construction rather than a purely social one. It is necessary to analyse the various material devices that are parts of the mechanism of economic valuation (Çalışkan & Callon, 2009: 384).

Dumez and Jeunemaître point to a 2009 interview of Michel Callon (2009) in which the author claims that devices are at the core of his conception of performativity and ‘performance’. In the words of Dumez and Jeunemaître, devices are the invariant elements of Callon’s approach. In consequence, devices are the necessary condition of the performance/performativity of the economic world. From this view, Callon’s approach is closer to an object-based analysis of social relations, like the one proposed by Serres (1982). Any conceptualization of a device inherits the opportunities of Foucault’s dispositif in addition to Deleuze and Guattari’s notion of agencement.

Additionally, Dumez and Jeunemaître emphasize the importance of Foucault’s concept of dispositif for the performativity of the theory and the reality of the economy. The authors

² There is a group of authors who had been using these ideas in the design of devices and human-computer interaction. For a more theoretical account, the line of work of the Activity Theory (Engeström, 1987) and the literature on distributed knowledge

claim that there is a direct connection between *dispositif* and Foucault's analysis of devices that are hybrids of discourses and non-discourses whereby a "discourse can be the programme of an institution, or, on the contrary, be disconnected from practices and conceal them (the practices being themselves silent, 'muettes'). But it can also be an *a posteriori* interpretation of practices that developed ahead of it" (Dumez & Jeunemaître, 2010: 30). Callon's work, the authors add, proposes the same kind of entanglement between the discursive and the non-discursive.

What is interesting in Dumez and Jeunemaître's critique of Callon is their analysis of what is left behind by the performativity/performance approach to the economy. What the authors claim has disappeared in Callon's work is the devices' dynamic two phase process. In such analysis, Foucault foresees the "urgent need" that the *dispositif* establishes and note that, during the second phase of the *dispositif*'s deployment, new unanticipated functions appear. Those functions lead to strategies that contribute to stabilizing and entrenching the *dispositif* itself. As a corollary, there is two instances in Foucault's device analysis. The first, explains the emergence of the device, and the second explains its stabilization. This last phase could be called the 'strategic phase', whereby continuities and discontinuities are shown. Dumez and Jeunemaître then give an example where the performance/performativity of economics fails to replace the performance of law that is present in a device shaped by engineers' hands. These scholars are making a general call to open up the analysis to - for example - legal-technical devices that could have aspects of economic ideas but which are never exhausted by them.

Performativist sociologists make a distinction between a general economic agencement and a particular market agencement. Muniesa et al. (2007: 3) point out that a market agencement is "one form of economic agencement that is noticeable typically by circulation, pricing and exchange" (Muniesa et al., 2007: 4). This kind of agencement permits the conception, production and circulation of goods and services, but also the valorization process and the contracts and mechanisms of pricing and property transfer. To be more precise, a market agencement generates the possibility of existence for 'calculative spaces' (Callon & Muniesa, 2005). From these calculative spaces, the process permits the abstraction to move around the elements in order to 'perform' a market. Muniesa et al. (2007) came to establish that there is a particular kind of 'agencement' that is a 'market device'. Such an agencement/device consists of "the material and discursive assemblages that intervene in the construction of markets" (Muniesa et al., 2007: 2). There are a huge range of market devices including, e.g., methods for performing analysis, economic and financial models, tools in general, protocols, norms, micro- and macro-indicators, between other objects (Muniesa et al., 2007: 2).

This raises the question of whether such a disparate group of entities ought to be labelled together in this way. As might be noted, such an analysis appears to conflate 'black box'

type devices with 'blank objects' and broader dispositifs. This problem shows that the socio-economic analysis of the performativist literature needs to take some extra 'care' about the concepts being used to animate the analysis of the market and - in general - economic phenomena.

In Michel Callon's view, the device is the crucial factor, whereby they act as individual agents. However, a difficult question is raised: who are the agents pushing and orienting the creation of a given device, and to what purpose? To answer this question, Dumez and Jeunemaître turn again to Foucault. The authors advance a conceptualization by which devices are established at particular moments marked by a sense of urgency and with an intent linked to this urgency. The initial aim can disappear and be replaced by another, as well as by multiple functions that make the device last. But are there other types of mechanisms for creating devices?

What the present thesis aims to do is to offer new insights into the particularities of the devices that people use in organizations in order to perform theories of technological innovation. However, within this thesis, the analysis does not want to give up the strategic view of the dispositif (i.e., a moment of analysis and history) in Foucault. Nevertheless, the analysis wants to place an emphasis on the lines of disruption and the possibility that an assemblage/agencement complements the analysis of a dispositif/device. In this sense, the question about devices is at the core of the present thesis.

In other words, this thesis defines the dispositif as a hybrid, a discursive and non-discursive entity that shapes the behaviour of those who work in organizations elaborating novel technology. Or what Foucault understands as a regimen of truth. At the same time, this thesis is also open to conceptualize technological innovation as an assemblage/agencement or a sympathetic relation between any kind of bodies that are compound with the exertion of love or the hatred between them. These are the relations that permit the novelty within the dispositif/assemblage. Such inquiry demands an empirical approach and not a general, predefined conceptual apparatus.

Any analysis of technological innovation needs to go for the topographical and the topological aspects of the dispositif/agencement. Such an analysis follows a line of thought in research whereby objects are "back in strength in contemporary social theory" (Pels et al., 2002: 1), mainly because of the group of disciplines that are collectively known as STS. This turn to objects is particularly important within the ANT literature. As John Law (2002: 91) has explained, the original ANT approach defines "objects as an effect of stable arrays or networks of relations" (or, more in general for actor-network approaches, objects are relational and contingent performances). Such a relational approximation is based on the concept of translation (Callon, 1986). This emphasizes how a novel event emerges through a combination of heterogeneous actors (e.g., in the case of companies, a group of different professionals) that are organized in a network structure. Therefore, technological innovation can be understood

as the product of the translation of ideas, people, resources, entities and - in general - all those who have different concerns and interests arriving and converging on something common.

A translational understanding of technological innovation and its organizing process mobilizes an object-centred approach to its theorization. This object-centred approach relates to the concepts of *dispositif* and *assemblage*. *Dispositifs* are compounds of objects and subjects; objects are part of the rhizome. Looking at the objects and their relations with subjects, this thesis seeks to open up technological innovation and its management black box by drawing attention towards those entities that have been called ‘devices’ in the performativist literature. An object-oriented analysis calls for a relational analysis of objects in which translation happens in the world of theory/empirics and in the world of objects, humans and their mixtures.

4. Object-mediated social relations: beyond Foucault?

Michel Serres’ approach to translation animates a type of analysis that seeks to understand innovation phenomena as object-mediated social relationship phenomena. Serres argues that objects make human history ‘slow’. From Serres’ point of view, the relations of those working in organizations are delegated in those diagrams/objects (Serres, 1995a). Additionally, in Serres’ account of the society, objects are mediators responsible for the stabilization of organizations -and society in general.

It is Latour’s (1993) well-known analysis of modernity, where it is possible to find a diagnostic of the contradictory practices of purification (i.e., separation between those social and natural aspects). Such an analysis of the modernity follows directly Serres’ translation concept (Brown, 2002). As Harris (2005: 172) has articulated in the context of organizational studies, purification and translation exist in mutual assumption; therefore, the modern ontological view produces the hybrids that the purification precludes. This is exemplified in the operation of science and technology, which produces hybrids by mixing society and nature in increasingly complex assemblages. Nevertheless, the phenomenon is clearly happening in modern institutions as organizations, and in particular in venture companies such as those considered in this thesis.

In an interview of Serres by Bruno Latour, Serres expresses a view “in which the transcendental constitution of the object by the subject would be nourished, as in return, by the symmetrical constitution of the subject by the object... of [this] direct constitutive condition on the basis of the object we have witnesses that are tangible, visible” (Serres & Latour, 1995: 84). Serres is here calling for a more symmetrical analysis of the object and the subject. In particular, the object is the facilitator of the subject; the tangibility of the object permits the subject’s constitution.

An interesting concept that could serve to demonstrate the importance of the object for Serres is the 'quasi-object'. Serres defines the quasi-object as the facilitator of the collective. The author claims that: "this quasi-object is not an object, but it is one nevertheless, since it is not a subject, since it is in the world; it is also a quasi-subject, since it marks or designates a subject who, without it, would not be a Subject" (Serres, 1982: 225). Serres adds that the collective cannot be the sum of individuals; furthermore, the 'I' of the entity and the 'we' of the collective demand understanding as a network of transactions, as it is clear for the quasi-object case, because the '*we*' is less a set of I's than the set of the sets of its transmissions' (Serres, 1982: 228). Technically speaking, the quasi-object is a generator of inter-subjectivity and the we and the I emerge from the exchange or else from quasi-objects.

The human is the connection of relations in the historical becoming of the passing on of the quasi-object - it is a product of this historical and object-centred activity. Within the ordering of society, and in particular of any organization including a venture company, it is the circulation of the quasi-object that allows society to exist (Brown, 2013). Telling the biblical story of Joseph, Serres refers to his multiple identities as a master and as a slave. Joseph is the one that is not recognized for a long time. Brown explains that the circulation of Joseph between identities has a function. The quasi-object that is Joseph produces connections, dreams, Pharaoh, Egyptians and Joseph's family, etc. His capacity of transformation creates his circumstances. Serres comprehends the figure of Joseph as a 'joker' - a blank figure that has no clear identity but who take on several identities and who is crucial for the social order.

Nonetheless, Serres talks about very specific types of quasi-objects. For example, more than people he has an interest in the rugby ball, which acts as a blank domino figure - again, a 'joker' - defining the group of players who are always moving around it. This quasi-object makes the collective (Brown, 2002: 21). Moreover, the quasi-object is a marker of the subject, and inter-subjectivity comes from interaction with the quasi-object (Serres, 1982: 227). Serres claims that: 'we know, through it, how and when we are subjects and when and how we are no longer subjects. 'We': what does that mean? We are precisely the fluctuating moving back and forth of 'I'. The 'I' in the game is the token exchanged. And this passing, this network of passes, these vicariances of subjects weave the collection" (Serres, 1982: 227). As Brown explains, it is the quasi-object that marks the 'I's in this way and there is a movement forwards and backwards from which the subject emerges - this is the quasi-subject. In the example of the rugby ball, to be the 'I' means to have a 'privileged position' (i.e., the one who is in control of the rugby ball) (Brown, 2002: 21) or else be a potential victim (i.e., the one who is not participating in the game).

Brown (2013) explains that the quasi-object is at the centre of the organization of collectivity and individualities. This special object (or kind of objects) is in a parasitic relation with the individuals and the collective. This is the basic relation from which all the others need to be

comprehended. It is also a path towards a solution to the problem of the tension that exists in the dual purification-translation operations of the thoughts that Latour mentions. Brown argues that the logic of identity is flawed when communication is the object of analysis. Indeed, traditional communication is possible only when we define the clear identity of each entity under the communication process. The typical communication model identifies the elements of the communication as being demarcated, e.g., *A* and *B*. The model demands a clear cut definition for each entity. The first problem is that in order to establish the identity of *A*, it is necessary to establish everything that is not-*A*, the set of which includes *B*. At the same time, to define *B*'s identity, it is necessary to define everything that is not-*B*, the set of which includes *A*. This fundamental asymmetry implies that, from the point of view of *A*, the message emanates from a world that is fundamentally defined by its quality of not being *A*. Equivalently, the reverse is true from the point of view of *B*. This generates a relation of incommensurability between *A* and *B* (Brown, 2013). Communication, which is at the base of post-Kantian identity logic, is just not possible.

Following Serres, Brown shows that the solution to the communication problem between *A* and *B* is the emergence of the 'third man'. It is the mediating actor, the intermediary which Serres calls 'the parasite'. Communication requires a channel - a carrier of the flow - but the channel introduces noise. Noise is not an intruder; indeed, the view that noise is not an intruder is an insight from system theory - what is experienced as noise or perturbation at one point within a system becomes information from another perspective within that system (Paulhan, 1991: 40). Noise is part of a system of three elements. When *B* receives *A*'s message, noise is mixed with that message. From *B*'s perspective, the noise is part of the message and it can affect what *B* receives. Serres adds that "noise gives rise to a new system, an order that is more complex than the simple chain" (Serres, 1982: 14). Noise, the parasite, makes the system work. In other words, the perception of difference - of spatial or temporal delay - is what makes communication work. Within the realm of physical systems, the maxim essentially states that insofar as work involves overcoming resistance, if there is no resistance, there is no work; accordingly, friction, loss of energy and noise are a part of what makes a system work: "systems work because they do not work" (Serres, 1982: 79). Moreover, the proposition that 'systems work because they do not work', implies that resistance to the exercise of power paradoxically serves to facilitate the smooth operation of power (Foucault, 1977). However, Serres goes beyond this point - for him, power is part of the game of parasitism (Brown, 2013).

Indeed, in a lengthy meditation on power, Brown puts forward an understanding of the parasite as entangled in property relations, production and value. Brown follows, here, the metaphor of the paralysed man and the blind man. These two men have their problems. The paralysed man "was crawling about on hands and knees" while the blind man "was bumping into a thousand obstacles and... thereby almost broke his neck" (Serres, 1982: 35).

Serres shows that the blind men exchanges power/energy for the paralysed man's information. Information is a rare thing to exchange; there is always energy/production. The parasites shape the way in which production/energy moves (Brown, 2004: 391). Nonetheless, Serres - according to Brown - rejects that these are the pure conditions of the economy. It is property, in the form of the clean (or blank) space from which agricultural production begins. From this initial clean and separation of the land, the parasite comes in. There is simultaneity to the creation of this space and the parasitism that enables the production process. Brown remarks that the making of this blank space shows how agriculture and culture have the same origin. The ground is separate, organized, and then immediately the parasite comes in. Every space is made up based on this operation of separation, of 'cleaning up' (e.g., spaces for education, spaces for production of any type, and so on).

Parasitic relationships comprise the form by which history is constituted. In a broader understanding of the economy, the parasite exerts an 'abuse value' - taking without giving. For Serres, abuse value comes before 'use value' (Brown, 2004: 391). Power is defined by position in the cascade of parasites - the last in the chain is the one who garners the most power. It is here that Serres characterizes the power game as a parasitic game - there is always a later mover who parasitizes the previous operations. Power accrues to those who can jump to the end of the cascade operations of parasitism; power depends upon the technical tools that allow an entity to go further down in the chain and from there acts as a parasite upon the rest.

Such a conceptualization of value could serve as an important tool for the irreductionist radical programme, which looks for an understanding of value. Serres' explanation demonstrates the impossibility of separation between the creation of value and the parasitism of the same - the operation of separation is at the base. Labour is entangled with this operation of separation. From there, it is clear that value is co-created with the parasitic relationship. What Serres is showing here is a way out of the fallacy of misplaced concreteness (Whitehead, 1927: 7-8) that has been placed at the centre of the abstraction process, where the separation between labour and capital is generated and from where it has been demonstrated that capitalism is supported (Pomeroy, 2004: 157). For Serres, the mixture that is capitalism is presented in his awful and tremendous reality. Surplus value always comes after abusive value.

5. Post-ANT, management by ambiguity and technological innovation

A *dispositif/agencement* approach to technological innovation has been developed in the ANT (and previously the TEN) literature. Such an approach inherits much of the ontological and epistemological bases of the *agencement-dispositif* and object-centred approach explained in the earlier sections of this chapter. However, the original ANT approach has been criticized by the so-called 'post-ANT' authors. Scholars such as Susan-Leigh Star (1991) and Nick Lee and Steven Brown (1994) explain how the success of the generalized symmetry

principle carries with it the risk of a totalitarian explanation of everything, thus leaving no space for any 'other'. These explanations risk the colonization of the 'other', whereby this serves as a particularly plastic term indicating all those entities that are made problematic by expansionist projects. Brown recalls this critique about the application of a generalized symmetry principle in organization studies, whereby a flat understanding of humans and technologies precludes an ethical commitment to the human part of the assemblage that we call 'organization'. Indeed, "is the leveling of the difference between the human and the technological not precisely the dream of certain kinds of retrograde managerial and work-intensification processes?" (Brown, 2011: 26).

To be clear, it is not that the dispositif/agencement analysis of heterogeneous entities - objects and persons - or discursive and non-discursive devices is wrong. As Brown and Middleton (2005) explain at length in their study of a neonatal intensive care unit, to study the formalisms of the heterogeneous network of objects and discourses of an organization is one way of avoiding Haraway's (1988: 581) famous 'God trick' of "seeing everything from nowhere." What this criticism brings to the analysis of the theory is the cost that implicit monism brings to the analysis of organizations. In terms of the present inquiry, it is not possible to understand that technological innovation which happens within markets and the economy without some version of social acting at the basis of the explanation (Cameron et al., 2010). Working with the example of financial markets, Cameron et al. have shown how concepts like 'market devices' (although they explain the 'mediation' of human action by devices within financial markets) nevertheless always require some allocation of identities in which human actors resist and can even reverse some changes. This leads to a fundamental question as to the use of performativist economic sociology and actor-network-informed organizational studies of technological innovation practices.

Also critical of the general symmetry ANT programme, Rolland Munro (2012) has discussed in detail the possibilities and limitations of the ANT approach to the study of organizations. What Munro is concerned with in his approach in the study of organizations is to leave behind the generalized symmetry principle that is attached to ANT. Munro builds an ethnomethodological-oriented programme that involves changing the unit of analysis into 'accounts'. These are in neither the subjects nor the objects in organizations (Munro, 1996). Munro's approach resembles the monism of ANT but nonetheless leads to a very different result in the study of the innovation practices and organizational activities of venture companies.

Munro's line of thought comprises a non-humanist approach to the study of the organizations, whereby devices of all types - discursive, non-discursive and others - are tangled up with humans, but also where humans still have discretion based on their 'business' of making visible their explanations and reasons about their own conduct (Munro, 1999: 435). Munro

is looking to return to what he claims are the ethnomethodological roots of ANT. He tries to emphasize the material characteristics of the 'relational extension' that technology and objects offer to his conception of the social. He reads this relational approach from the Melanesian studies of the anthropologist Marilyn Strathern (1991). Latimer and Munro (2009: 318) claim that Strathern offers a conceptualization whereby "relations alter from moment to moment as one set of prosthetic materials is exchanged for another." This is a similar analytical approach to that of Callon (2008) and his prosthetic understanding of *homo economicus*. However, for Callon the prosthetic can be seen as part of the agencement between the person and the device/dispositif. To follow one or the other approach constitutes an empirical problem that is dependent upon the characteristics of the site and the relation between the heterogeneous actors that produce the mixture.

Munro develops a relational approach that has Marilyn Strathern's concepts at its core. Additionally, Strathern's (1996) critique of ANT has made an important addition to the ANT literature. A major point is her acknowledgement of the sort of "fractal logic" presented by ANT theorists. This is a logic that continuously adds new elements to the heterogeneous network (as with the case of the nascent company and the technological innovation organizing process). This critique of ANT has found an echo in Brown and Middleton's (2005) work. Furthermore, these scholars look to offer an empirically- and theoretically-informed approach to solve the network extension problem that the actor-network monism brings to the analysis of organizations.

Building an argument that is based on process philosophy (from Deleuze and Bergson) and using examples from their fieldwork in a highly variable environment (i.e., the intensive neonatal care units of hospitals), Brown and Middleton draw on Strathern's image of the 'hybrid' as the end point of infinite network growth. This interesting point sheds light on Latour and Haraway's conceptualizations, which are mainly based on the study of a heterogeneous mixture (e.g., actor-networks and cyborgs). Strathern demonstrates that what stops the network is the hybrid between science and nature. Brown and Middleton generalize this insight, such that: 'in other words, for Euro-Americans, the demonstration of hybridity in an object or phenomenon comes to act as a stop on the potentially limitless expansion of the network' (Brown & Middleton, 2005: 702).

Furthermore, Brown and Middleton explain the problem of any approach that refuses to make differences in kinds – for example ANT – is based on its implicit monism. ANT conceptualization brings forth the problem of the predictability and calculability of explanations that only deal with differences of degree (Brown & Middleton, 2005: 704). The authors draw on Bergson's example about his observations of the limits of his own body that appear when Bergson chooses images of the material world that are received from the environment; it is precisely here that Brown and Middleton theorize about a version of

hybridity as a 'zone of indetermination' similar to what Lee and Hetherington call 'blank objects' (2000). These blank objects are at the centre of social order creation. Blank objects are fundamental components that permit transformations between already organized sequences (Brown & Middleton, 2005: 706). Following Serres, Brown and Middleton demonstrate that objects add weight to our relationships and permit stability. Brown and Middleton argue that there is a particular kind of object that is 'constitutionally indifferent' (707). The quasi-object - Serres' example is the ball in a rugby game - is an object that it is 'nothing' when it is not implicated in the game. However, although the ball is never played alone, when the ball is in play the players become the object of the ball. This is the kind of object that is interesting for Brown and Middleton - these are objects where indeterminacy is a characteristic of the object itself. It is an approach that clearly exceeds Latour's conceptualization of inter-subjectivity (1996).

However, this is not a return to the concept of a 'boundary object' (Star & Griesemer, 1989). What Brown and Middleton are offering is a quite different theorization. As these authors describe it, a boundary object accrues its power to renders organizations durable across the different communities of practice in which it is naturalized. A boundary object possesses no intrinsic difference within itself; rather, its different characterizations are always constituted relationally within a network (Bowker & Star, 1999). A boundary object merely reflects the existence of many communities of practice, while also becoming a token (Sage et al., 2011).

So what emerges in this text is the notion of a sociality in which the blankness and 'constitutionally indifferent' is a condition of the object. As Brown and Middleton claim, this could lead to a conceptualization of the object whereby "what it is, or rather what it might become, is real without being actually in play at any given time" (Brown & Middleton, 2005: 708). Within this conceptualization, an object contains "all the differences as real potentials", therefore an object that is "several things at once" (Brown and Middleton, 2005: 710). In addition, and aligned with Serres' object centre theory, these are objects that must be thought about as a fundamental part of the social - as objects that define sociality within organizations (Munro, 1995). But at the same time, these objects embed ambiguity where ambiguity "is not the enemy of the order; it is the well-spring of the disciplining potential of the social" (Munro, 1995: 3).

Even in the case of boundary objects (not just indeterminate objects, as in the case of Brown and Middleton). Brown and Middleton demonstrate that if the boundary object supports multiple meanings, the object requires plasticity. Management by ambiguity can be object-centred and there is no need for legitimation or clarity in order to exert domination. To detect management by ambiguity practices, attention once again needs to be refocused on those devices used by managers and which are a part of the mixture that is any management technology and - more importantly - the *dispositif/agencement* that is technological innovation.

In addition, although managers can construe their activity without the ambiguity that devices bring to social relations, they could also choose not to do so. Discretion emerges as a fundamental issue of authority. If the managers change their potential to define ambiguous situations, it is because they want to conserve the situation as it is. As Lee (1999) explains in the case of the ambiguous definition of childhood, the managers of institutions can defer the moment of the resolution of what is defined as a child for their own benefit or interests. In the case of technological innovation, these decisions can be connected (or not) to the uncertainties of potential users, technological acceptance, government policies and norms of quality, among others. In any case, such 'constitutionally indifferent' objects bring opportunities to create the conditions for the exercise of ambiguity. Ambiguity is there to be exerted by the use of the constitutionally indifferent objects in hands of managers.

In any case, ambiguity is an old topic for organization scholars. Research into ambiguity in decision-making and other challenges to the rational model has been conducted over the course of the past 35 years by Jim March et al. (1979) and Joanne Martin and Debra Meyerson (1988). In fact, the Stanford school of organizational studies coined novel terms such as 'high-velocity environment' in the 1980s to capture the turbulence that came together within technology-based economy, where the pace of change in the environment is faster and the uncertainty and ambiguity is high. This is something that brings extra difficulties to management teams when it comes to understanding and tracking relevant technologies, competitors, complementers, products and customers (Eisenhardt, 2010). What these lines of research have in common is the understanding of ambiguity as a phenomenon that is in need of being 'managed' and which refers to the 'external' conditions or the 'context' of the organization under study. In any case, these authors are not addressing the problem of 'management by ambiguity' as is the case in Munro (1995).

In summary, this thesis wants to observe the exercise of managerial discretion in the process of technological innovation. There are situations where managers defer their potential to resolve ambiguity through the exertion of their authority. As an example, Munro (1995) shows how ambiguity is produced when control is exerted. An object-centred approach can further enhance Munro's point about ambiguity, accepting the mediation of the objects that participate in administrative technologies and - more broadly - in technological innovation processes. Objects can explain ambiguity as part of the *dispositif*/assemblage that is a management technology. However, the fundamental component of management by ambiguity is this stubborn social aspect comprises the management technology *dispositif*. Such is the person who has the power to defer their decision or any further movement.

In conclusion, any process-based approach that seeks to complement ANT approaches to technological innovation needs to further review the relations between subjects and objects. In this sense, in a sort of reflexive turn, the next chapter covers important aspects about the

significant literature on identity and - more precisely - on professional identity. This problem has been touched upon by the subject-object mixture that is present in any dispositif/agencement. Nonetheless, identity cannot be placed outside of the innovation problem because, as Brown explains, the subject (i.e., the 'I') emerges within the control of the object. The 'I' is a privileged position - the position of the quasi-subject (Brown, 2002: 21).

Chapter IV: Some Elements to the Study of Professional Identity

1. Introduction

ANT and post-ANT approaches to the management of technological innovation do not go into the problem of the subject in any depth. However, from an ANT perspective, it is possible to at least theoretically grasp the importance of the mediation of these diagrams with those engineers, technicians and managers who work in venture companies. This chapter will offer some elements to build a framework in order to perform an analysis of the identity of those who perform the activities of engineering and managing. These elements will be aligned with the *dispositif/assemblage* conceptualization of technological innovation that this thesis developed in Chapters II and III, which emphasizes the symmetry between actors and their technologies and focuses attention on the translations that occur as knowledge and resources are exchanged in networked interactions.

Professional identity - and identity more broadly - is a complex concept. As Margaret Wetherell (2010: 3) explains, almost all researchers studying identity find that the construct is "slippery, blurred and confusing [in] nature." The blurriness and confusing characteristics of concepts of identity comes from the sheer range of theoretical accounts and the different fields in which it is used. To give an example, the concept is analysed from divergent academic traditions, such as anthropology, social psychology, sociology and management and organization studies (MOS). These are lines of work that have very different epistemological positions, but also a plethora of different ontological bases.

From the ANT point of view, Callon (1998) explains how social network analysis offers a clear explanation of how the economic actor becomes a *homo apertus*, where the subject depends upon the form of the relationships of the network. However, the social network literature has demonstrated that networks are never static inputs, "they [have] evolved in concert with people identity experiments" (Ibarra et al., 2005: 363). This is a claim that empirically supports ANT and post-ANT approaches to the phenomena of technological innovation. Nevertheless, the same authors who use the social network analysis framework claim that these theories are "not well equipped to explain the dynamics of changing, well-entrenched professional identities" (Ibarra et al., 2005: 364).

To understand the relation between the subject and the technological innovation process, the unit of analysis demands a radical change. Any new unit of analysis needs to accept the hybrid comprising the human being in addition to his/her equipment and economic

prostheses (Callon, 1998; 2008). In his own words: "it is not a matter of giving a soul back to a dehumanized agent, nor of rejecting the very idea of his existence. The objective may be to explore the diversity of calculative agencies' forms and distributions, and hence of organized the existence of new ventures and the markets where they belong" (Callon, 1998: 51). In Callon's view, it is not possible to study the subjects of technological innovation while detaching them from their economic prostheses. To study the economization process within innovation, the subjects needs to be researched relationally.

In a closely connected post-ANT line of thought, Kendall and Michael (2001) assert that the term 'identity' is frequently used to denote a sense of 'self', and especially a 'self-reflective' understanding of the self. Following Serres, these authors explain that the literal - mathematical - meaning of the term 'identity' gives an exact equivalence between two entities, statements or symbols. Mathematically, the identity of x is x , but if there is an identity $x = y$ then there must be a transformation within one of the objects in order to accomplish the other, as in the case of $2x + c = y$. Applying this point to management and organizational studies, most of the time the notion of identity is used to link entities that are far from identical. For example, persons of identified as being of type A might be described as being C. Put simply, all As are C. Kendall and Michael remark that A might merely belong to a group of entities that we called C - and probably not exclusively! The authors then explain how such an identification phenomenon leads to an over extension and simplification of any identity. A professional engineer is not an engineer just because he is classified as one within the set of engineers. Moreover, a manager is not a manager just because he has that position in a company. Kendall and Michael are making an argument as to how it is that the term identity simplifies and allows the analyst to resolve the problem of the unity and diversity, fixing the differences of entities rather than studying the differences themselves. In line with Wetherell, the authors see difficulty with the use of the concept and, furthermore, accept the performative power that the notion of identity has.

As explained in the previous chapter, for Serres, the collective or "'we' is not a sum of 'I's', but a novelty produced by legacies, concessions, withdrawals, resignations, of the 'I'. The 'we' is less a set of 'I's' than the set of the sets of its transmissions. It appears brutally in drunkenness and ecstasy, both annihilations of the principle of individuation. This ecstasy is easily produced by the quasi-object whose body is slave or object" (Serres, 1982: 228). It is the quasi-object that defines the subject. But what then is the 'I' in Serres philosophy? The author goes on to say that it is to abandon individuality in the circulation of the quasi-object. The 'I' is then defined within and also abandoned within the 'tissue of relations'. The author adds that within this circulation of the quasi-object appears the subject. The process follows a certain movement, whereby the quasi-object "weaves the 'we'," the collective, and then, when it stops, it triggers the 'I' (Serres, 1982: 225). In Serres' account, the 'I' is not blocked per se. The 'I' is also circulating in - and circulated by - the quasi-object. The quasi-object is

a generator of inter-subjectivity. The 'Us' and the 'I' emerge from the exchange, namely quasi-objects.

Following Callon's analysis and Serres' approach to identity construction, this chapter seeks to advance a framework in which professional identity is constructed through the use of devices, such as the management technologies that are studied in this thesis. These are the diagrams that the engineers of Med Diabetes and Med Dialysis use in their day-to-day innovation activities. These devices offer the opportunity for the performance of technological innovation management activities and professional identity (Bourdieu, 1984).

The chapter is also aligned with STS approaches, where management technology is conceptualized as a heterogeneous network of social, natural and technological actors (Law, 1987). Such is the heterogeneity that engineers and technicians are always trying to organize. This heterogeneous set of entities includes funds, texts and entities of various types. Obviously, this mixture includes the engineer and other professionals as well. Diagrams and engineers shape some of the fundamental parts of the technologies of management that ventures need to use to organize their technological innovation processes.

The aim of this chapter is to review the literature that will assist in seeing how ideas of management and innovation management, shape the emergence of engineers, managers and technicians' professional selfhood. ANT and - more generally - post-structural approaches have demonstrated the rhizomatic production of the engineer's identity (Haraway, 1991; Michael, 2002). The human and the social emerge from the relations of texts, material entities and concepts. Engineers, of course, are biological entities as well as being bundles of beings such as bacteria and many other organisms that coexist symbiotically or parasitically (Haraway, 2007). Finally, devices such as those researched in this thesis participate as prosthetics (Callon, 2008) and complement the economic activity that engineers, technicians and managers engage in at their workplace. To define technological innovation as an assemblage is to think of the importance of those who manage and enact the labour of these processes.

As was explained in Chapter I, Callon (2002) shows how managerial technology can define and place both creation and arbitrary acts of domination. Furthermore, management exerts domination through the access that it has to these technologies. Without these tools, management is simply not possible. We also know, with Robert Cooper, that management technologies open up possibilities for organizing so as to enable the order/disorder that constitutes an organization (Cooper, 1994). These tools can be broadly defined as theories, objects and any other prop that might be used to organize technological innovation activities. Following ANT, these objects are important mediational 'actants' of the technicians, engineers and managers of venture companies (Callon, 1986; Callon, 1991). In a similar vein, cultural activity theory (CAT) has demonstrated that these tools can shape and change the human activity of the engineer (Engeström & Blackler, 2005). From a stricter ANT point of view,

the technical translation - which is the movement from objects to people - is not purely social and/or material. This translation process "is a detour, a folding" (Latour, 1991). It is a process whereby both objects - like theories and diagrams, among others - and the engineer suffer potential transformations.

Obviously, and like any theory, ANT has its limitations in its explanation of identity-related phenomena. Some of these limitations were discussed in Chapter III. In particular, the managerialism of the theory (Star, 1991) and the colonization of the other (Lee & Brown, 1994) lead theorists and scholars to look for new metaphors within the approach. Some of these scholars have also been developing alternative approaches to the images and metaphors that ANT brings to the study of society. For example, Lee and Brown (1994) put forward Deluzian concepts that could lead the analyst to understand assemblages, returning to the rhizomatic foundation of ANT.

Furthermore, from anthropology, Emily Martin (1998), in studying the original interest of ANT - science and society - builds up an approach that draws from the image of the rhizome and the string. Following Deleuze, she understands a rhizome as a system the different projections of which can become concretized as rhizomes or tubercles. She uses this image in order to understand the "kind of discontinuous, fractured and nonlinear relationships between science and the rest of culture" (Martin, 1998: 3). In Martin's stories, there is a site for ambivalence and contingency.

Martin's use of ANT substitutes a collaborative approach for the managerialism of the traditional approach. For her, science is no longer a site of struggle; instead, it is a collaborative activity. In order to construct collaboration instead of competition, Martin uses Haraway's (1994) notion of a cat's cradle. Haraway's conceptualization offers a concerted activity in which complex patterns emerge from the interaction of persons with to others. The cat's cradle is not a metaphor of triumph and betrayal - it is a metaphor that is very close to what is now known as 'open innovation' (Chesbrough, 2003). Furthermore, the cat's cradle is also a metaphor of complexity and emergence. To see science as a collaborative activity is to see a very different assemblage emerging from the working activity of scientists. The cat's cradle metaphor is clearly extendable towards technological innovation. The assemblage/agencement does not need to become a dispositif that reinforces the commercialization of technology. Collaboration can be at the core of the values of human activity.

In a non-foundational approach, relations are situated at the centre, patterns are emergent and the goal is open-ended. As a consequence, an engineer's identity emerges from the process of innovation. However, perhaps this approach too quickly abandons the managerial and entrepreneurial metaphors of ANT (Michael, 2002). As Law (1994) demonstrates, some stories from the field can definitely be very managerialistic, but this does not mean that there is not a multiplicity of different approaches to the organizing processes of science and

technology. Also, this narratives serves as a mode of the deconstruction of the heroism that exists in science, technology and - more broadly - in technical venture creations (Law, 1991).

Pursuing a dispositif understanding of technological innovation leads us to see devices as an important part of technological activities. These are elements that can reshape the rhizome since, as Deleuze and Guattari (1987) explain, each node of the rhizome can affect other entities as well as parts of it. Such a conceptualization is aligned with the post-ANT literature. To enrich Deleuze and Guattari's approach, the present chapter presents concepts of STS and MOS that could serve as elements to shape the toolbox for the analysis of identity. First, elements from co-production and co-configuration are presented. Secondly, the chapter presents some elements from CMS about identity and work. Finally, the concepts of *Anti-Oedipus* (Deleuze & Guattari, 1983) are presented. The general aim of the chapter is to offer new lines of thought in order to study the elusive object that is identity, while nevertheless bearing in mind the object-oriented approach developed in previous chapters. The open question during the course of the chapter is: how is the identity of engineers, managers and technicians shaped and reshaped by the various technologies of management and its related devices?

2. Co-production, co-construction and individuals

Within the broad STS literature, there are various approaches that could be useful in illuminating the complex relationships between devices and the professional identities of those who work in venture technological companies. These theoretical approaches are the co-construction and co-production models of technological development. This particular set of literature has been produced in order to understand the technology-user problem. However, the question as to how technology - and, in particular, management technology - shapes those who produce technological innovation has been only infrequently addressed within the literature.

Although the problem of the user has been at the core of some STS debates (for example, in the wider feminist literature on gender and technology, there are the remarkable examples in the work of Lucy Suchman and Judy Wajcman), there are aspects of the user problem that have been less visited by the STS literature (Oudshoorn & Pinch, 2003; Summerton, 2004). These authors explain that there is a general phenomenon of the co-construction of technologies and users, whereby users' identities are affected, shaped and re-shaped. For example, within ventures, user definitions, technical specifications and quality specifications - to mention a few - are all a part of the co-configuration of technology workers and managers and the users of technological innovations. Managers and engineers are affected in a process that has been called 'configuration work' (Oudshoorn & Pinch, 2003). This is a process that was first defined by Woolgar (1991), where the STS scholar studied users shaped by the

actors of a company that designed and produced new technology (in his case, information technology).

Expanding upon Woolgar's ideas, Summerton claims that there is a lack of inquiry as to the problem of how the practices of technological innovation managers and technology workers configure users while, at the same time, co-configuring their own professional identities. As a consequence, the question that needs to be further researched is: how do managerial practices configure the identities and roles of the managers themselves?

When a manager is working "to interest and persuade" specific users (such as NHS administrators), engineers and managers may build imaginings of themselves and their organizations that symbolize the qualities that some users consider to be of value for themselves. These qualities may include a low-cost policy and more 'flexible' options for the patient, to mention just a few. As Summerton (2004: 488) claims, this projected image is made, characterized and "inscribed onto the technologies according to the managers' visions of themselves and their desired interactions with specific groups of users." Professional identities are thus co-constituted in specific representations to these users. Therefore, the engineers are themselves being engineered by those representations. In this sense, any particular 'driving idea' like self-care gets into the users by use of the technology, and into technology workers because the scripts that they pass through into their designs are part of the assemblage from which the technology workers and managers are configured.

Another important notion that has potential enlightening properties within the discussion is the concept of co-production (Jasanoff, 2004). Jasanoff explains that "co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it." The forms by which technology workers and - in particular - technology managers represent the world leads them to define their own form and to live it. Jasanoff adds that these ideas and the forms in which they are materialized (for example, in a particular management technology or else within the technological innovation produced by the venture company) are constitutive of social life. In fact, "society cannot function without knowledge any more than knowledge can exist without appropriate social supports" (Jasanoff, 2004: 2-3).

Following Jasanoff, it is possible to understand objects (and, in particular, devices) as ordering instruments - instruments that operate by forming a nexus between, for example, the venture company and other institutions, like the NHS. In addition, these objects can serve as a nexus in the co-production of users and the identities of those who are a part of the assemblage that constitutes the persons and dispositifs (as in the case of management technologies and, in particular, the phenomenon of technological innovation and its organizing process). These devices have the potential to redefine identities and put people "back into familiar places" Jasanoff (2004: 39). A working hypothesis of the present study is that the identities of those

workers and managers who are participants in the technological innovation process are shaped by these sorts of devices.

The problem of workers and managers' identities has been reviewed at length by scholars in management and organizational studies. Within the literature on MOS, identity appears profusely in CMS (see Chapter II for a definition of this broad literature). This is why, in the next section, I will review some parts of this broad literature.

3. Identity, from postmodern critical management studies

Workplace discourses are of particular interest to this thesis because medical device ventures are bombarded by governmental-, sector- and market-level discourses as to what to do, and even how to do it. Such a problem has increasingly been the focus in organization studies, especially in those studies looking for a more in-depth understanding of the relation between workplace discourses and the employee's selfhood. Consider, for example, the works of Casey (1995), Kunda (1992) and Knights and Willmott (1989). This critically-oriented literature raises the question: how do these managerial discourses get into narratives of self-identity (Alvesson & Willmott, 2002: 622)? In others words: how are these employess regulated by the process of identification (Knights & Willmott, 1989)?

Alvesson and Deetz (2005) have discussed identity widely. These authors express the view that: "the position on the 'person' follows directly from the conception of discourse. Postmodernism rejects the notion of the autonomous, self-determining individual with a secure unitary identity as the center of the social universe. Even though many other traditions have done so also... postmodernists have pushed this point strongly and in a sophisticated manner" (2005: 86). The scholars situate CMS within the tradition of the Western self-image's deconstruction, where there is no unitary self and where people gain a stable identity by participating in the 'reproduction of domination'. Following the social constructivist Gergen (1991), Alvesson and Deetz explain that persons adhere 'voluntarily' to organizational identities or else make sense of themselves in terms of consumer identities mediated by commercial forces (2005: 87).

Alvesson and Deetz also claim that postmodernist approaches to the study of organizations differ in the forms by which they describe discourses. This could be marked by a continuum from a more textual towards a more extended form. An example would be Foucauldian discourse approaches where materiality is connected with textuality. An interesting example of a Foucauldian discourse is provided by Townley (1993). The author applies a material approach to discourse to human resource knowledge, following an explicit *dispositif* analysis. The author concludes that knowledge production in the management of human resources "operates through rules of classification, ordering, and distribution; definition of activities;

fixing of scales; and rules of procedure, which lead to the emergence of a distinct HRM discourse” (1993: 541). The discourses of human resource management operate in the identities of workers through the mediation of rules, scales and procedures. The problem is not solely located in the texts that ‘shape’ the identity of those who work in organizations.

More recently, Alvesson (2001) has stressed the importance of the analysis of discourses at work in knowledge-intensive companies. Interestingly, he mentions ambiguity as a crucial and definitive aspect of knowledge-intensive companies’ work (see also Alvesson, 2004). Alvesson shows how ambiguity puts pressure on individuals to protect their identities. In addition, ambiguity moves people to non-comfortable zones in which innovative constructions of professional identities are linked with the organizing process of technological innovation. Furthermore, the author has claimed that ambiguity offers possibilities for the use of technology workers’ defensive measures (Alvesson, 2001: 883). A corollary of Alvesson’s work is that ambiguity and voluntary adherence to the venture culture produces interesting effects on the identity production of those who work in new companies.

Robertson and Swan (2003) have noted that in the case of knowledge-intensive companies the expression of individual identity is overwhelmed by the company’s values and discourses. Building on Alvesson’s argument about ambiguity and identity, Robertson and Swan see a connection between organizational ambiguity and identity construction. In fact, they claim that “ambiguity provides opportunities for new constructions of identity, both individual... and organizational but also puts continued pressure on activities that then validate these identities” (Robertson & Swan, 2003: 838). In this sense, ambiguous organizational environments are crucial for control. In addition, these authors demonstrate in the case of a consultancy firm how ambiguity allows individuals to sustain multiple identities as experts and consultants.

This interesting point about control allows these authors to go beyond the subjective/normative of the company. In their example, these authors explain how the identities of ‘scientist’ and ‘technologist’ are decisive to the production of a strong network of ties in the industry’s regional operation and how they create a sort of ‘corporate elite’ (Robertson & Swan, 2003: 852). At the same time, individuals identify themselves with the ‘consultant’ identity, because their client project makes more sense than their own company. These multiple identities perpetuated the ambiguity of the company and their identities.

As was explained in the previous chapter, the difficulties that bring innovation practices and the uncertainties of the company environment are used to enact a particular type of management. Sometimes, the use of ambiguity - and in particular identity ambiguity and multiplicity - is necessary to manage the uncertainties of the innovation process. In knowledge-intensive firms (for example, venture technology companies), these two levels of ambiguity are interconnected. The organizing process based on ambiguity links strongly

with the production of multiple and ambiguous professional identities. It is not easy to see what it is to be an engineer in a venture technology company. A working hypothesis of the present thesis is that it is the use of ‘management by ambiguity’ practices (for example, with the deferral of managers’ decisions or with ambiguous information supported in non-precise instructions and diagrams, like those that define the innovation path of the company) by which identity emerges.

However, such a materialist point of view is not developed in depth within CMS. In fact, Alvesson et al. (2008) claimed that there are three dominant approaches to understanding processes of identification. The first approach is inspired by ‘social identity theory’ (Alvesson et al., 2008: 12), which focuses on people’s tendencies to identify with those social identities which, on a cognitive level, they see themselves as being similar to (Kenny et al., 2011). A second approach they call ‘identity work’ (Alvesson et al., 2008: 12). This is an approach “that takes the native’s point of view” (Alvesson et al., 2008: 16) to explore how individuals more or less consciously build, maintain or protect evolving understandings of themselves through the use of workplace discourses (Sveningsson & Alvesson, 2003). Finally, a third approach is called ‘identity regulation’ (Alvesson et al., 2008: 12). This is a tradition that focuses on how identity is regulated when people understand themselves through managerial workplace discourses (Kenny et al., 2011). All in all, Kenny (2010) identifies a central problem within these three identity theories associated with CMS. The author explains that such understandings of the self and discourses are “empirically, analytically and theoretically separate” (Kenny, 2010: 858).

The separation between individuals and discourse is, at least in part, due to the difficult relation that exists between the discursive and the non-discursive in the underlying social constructionism. However, it is also a result of a lack of a more nuanced relational approach to the co-construction and interconnections between personal, organizational and social levels of analysis. As Kenny has claimed, a nuanced analysis needs to be performed “without falling back into something of a binary, without ‘selves’ at one pole, and powerful discourses at another” (Kenny 2010: 858). In terms of the analysis, there is a need for a more detailed view of how the processes are interconnected and how they shape each other in this ‘dance’ that is the construction of the identity, where co-construction happens, for example, between professional individualities and the organizational aspects of identity. This is in part what Deleuze and Guattari (1983) offer to this ontological problem.

4. For a conceptualization of a desire- and process-based identity

Following Smith (2011), *Anti-Oedipus* can be read as an explicit attempt to rework the fundamental theses of Kant’s *Critique of Practical Reason*. As is well known, the ontological starting point in Deleuze and Guattari *Anti-Oedipus* is that ‘desire produces reality’

(1983: 26). Indeed, Smith claims that the whole of *Anti-Oedipus* is a response to Kant's conceptualization of desire. Smith remarks that, for Kant, desire is a "faculty which by means of its representations is the cause of the actuality of the objects of those representations" (Smith, 2011: 138). Smith then explains that what Deleuze and Guattari want to do is modify Kant's concept of desire. This operation is performed in two stages. In the first stage, the authors establish that if desire is productive - causal - then its product is real. Desire historically determines the socio-political field. In the second stage, Deleuze and Guattari create a new theory of 'Ideas', a purely immanent theory where "desire is constituted by a set of constituting passive syntheses." These are the connective, disjunctive and conjunctive syntheses. Such an immanent theory of ideas is proposed instead of the practical reason that is found in transcendent ideas of God, World and Self within the Kantian cosmivision.

It is in *The Logic of the Senses* where Deleuze explains his immanent theory of ideas. As he explains: "three sorts of synthesis are distinguished: the connective synthesis (and) which bears upon deconstruction of single series; the conjunctive series (if... then), as a method of constructing convergent series; and the disjunctive series (or), which distributes the divergent series: *conexa, conjuncta, disjuncta*' (Deleuze, 1990: 174). This is a formula that produces a relational ontology. With this formula, Deleuze looks to explain a broader theory that conceptualizes the emergence of multiplicities as "the synthesis of differences" (Goodchild, 1996: 39). Deleuze derives this formulation from his broad understanding of difference as an outcome of repetitions (Deleuze, 1994). Therefore, it is from syntheses that Deleuze sees the emergence of a multiplicity (Styhre, 2002). For Shaviri, these syntheses are the modes of production and do not produce reality - they are the "ultimate molecular components of reality" (Shaviri, 2009: 110).

From social psychology, Brown and Lunt (2002: 11) argue that *Anti-Oedipus* is "an attempt to rethink the nature of the relations between the psychological and the social and the nature of differentiation." The authors claim that Deleuze and Guattari are looking to exchange the concept of 'libidinal energy' with 'desiring production'. This is why, in the first part of *Anti-Oedipus*, Deleuze and Guattari develop their theory of 'desiring machines'. For Brown and Lunt, machines are a unit of analysis that overcomes the problem of the individual and the social.

The concept of a machine is a reductive artifice - it is a form that connects the material, the social and the individual. This machinic approach is a materialistic analysis and, as will be seen, is at the same time a performative analysis, since what Deleuze and Guattari ask about concerns not what the machine is but instead what the machine does (2002: 12). Certainly, there is a thread that connects the concept of a desiring machine with the concept of assemblage/agencement developed by the authors in the later *Thousand Plateaus*.

The ontological starting point for Deleuze and Guattari is that "desire produces reality"

(1983: 26). However, Smith (2011: 136) reflects that, at the end of the day, what Deleuze and Guattari understand by the word 'desire' is different from its typical usage. Indeed, desire does not signify a conscious activity of desire (for example, the desire to become a famous engineer or get a stable job). Rather, for Deleuze and Guattari, desires state the unconscious drives. From here onwards, Smith explains that there is an important distinction between desire and interest. This is quite a useful distinction, because for rational choice theory - the author adds - people always act to maximize their own interests. However, for Deleuze and Guattari, interests reside in desire. Desire (i.e., drives and impulses) are "invested in the social formations that makes these interests possible" (Smith, 2011: 137).

Desires open up the space of possibilities that allow interests to move in one direction or another. Desire is not a lack –in the psychoanalytic sense- it is always a positive energy (Carter & Jackson, 2004: 108). Further, Deleuze and Guattari claim that "interest came always after" (1983: 346). Underneath any interests, Deleuze finds "desires, investments of desire that are not to be confused with investments of interest" (Deleuze, 2004: 263). The word 'investment', needs to be understood as something non-spontaneous. In fact, Deleuze and Guattari explain that desire is never "an undifferentiated instinctual energy," and the authors proceed to claim that desire "results from a highly developed, engineered setup rich in interactions" (Deleuze & Guattari, 1987: 215). This is where the synthesis of Deleuze and Guattari's conceptualization becomes useful in understanding broader forms of work activities, like those performed by the workers who develop technologies.

Desire is always assembled in a rich setup of interactions that Deleuze and Guattari call 'machines'. Machines comprise the mode of organization by which desire expresses and expands itself in the social. "Desire," say Deleuze and Guattari (1983: 26), "is a machine and the object of desire is another machine connected to it." Deleuze and Guattari's (1983: 26) favourite example of "desire and its object" as "one and the same thing: the machine, as a machine of a machine" is the breast-feeding mother and her child. A desiring machine is the site of desire production; in fact, desiring machines: "are binary machines, obeying a binary law or set of rules governing associations: one machine is always coupled with another. The productive synthesis, the production of production, is inherently connective in nature: "and . . ." "and then . . ." This is because there is always a flow-producing machine, and another machine connected to it that interrupts or draws off part of this flow (the breast - the mouth)" (Deleuze & Guattari, 1983: 5).

Such a productive machinic relational approach opens up the opportunity to understand technological innovation as a machine connected with to technology workers. These workers are part of a flow-producing machine. This is a process-based view, without distinctions between man and nature. With this process view, Deleuze and Guattari are addressing Whitehead's problem of the bifurcation of nature. Furthermore, the process is not considered

as a goal itself - instead it is a process and “nor must it be confused with an infinite perpetuation of itself” (Deleuze & Guattari, 1983: 5). Furthermore, the productive synthesis is based on the coupling of desiring machines where such machines are at the base of the system. The processes whereby flows are linked together coupled with the extraction of value are what Deleuze and Guattari call ‘connective syntheses’ (Brown & Lunt, 2002: 12). This is what Deleuze and Guattari call the “production of productions, of actions and passions” (Deleuze & Guattari, 1983: 6). The authors also assign to this process the label of ‘schizophrenic production’, such that: “there is no need to distinguish here between producing and its product. We need merely note that the pure ‘thisness’ of the object produced is carried over into a new act of producing” (Deleuze & Guattari, 1983: 7). This is a ‘non-determination’ mode of production.

Later on, Deleuze and Guattari draw a parallel between this ‘non-determination’ of the mode of production and the famous Claude Levi-Strauss concept of *bricolage*, as explained in his book *The Savage Mind* (1966). At the base of desire, it is possible to see the satisfaction that comes with the production of production which is the characteristic of the desiring machine. However, the economy of production (Deleuze & Guattari, 1983: 5-6) is supplemented by an “economy of circulation and distribution.” This is what Deleuze and Guattari understand as the “system of possible permutations between differences that always amount to the same as they shift and slide about” (Deleuze & Guattari, 1983: 12). These are what Deleuze and Guattari call ‘disjunctive syntheses’. This is a formula that takes the form: ‘either... or... or’ (1983: 12). Disjunctive synthesis is also the concept that the authors use to express the machinic process of adding new connections. However, disjunctive syntheses does not just lead to the proliferation of new connections and the reconfiguring of the patterns and material connections of the machines; the disjunction also marks and generates a code that becomes important for the possibility of future connections (Brown & Lunt, 2002: 14).

Furthermore, as Brown and Lunt (2002: 19) explain, Deleuze and Guattari posit the categorization process as a disjunctive synthesis. This is based on a process that builds upon devices that achieve territorialization using semiotic codes in a collective activity with a potential arrangement of different significations. In a bottom-up process, it is thus within the interplay and struggle between the disjunctions and conjunctions that social categories are produced. Connective synthesis needs disjunctive synthesis.

As Shaviri (2009: 113) explains: “the connective synthesis is not in itself enough to define the actual becoming of a world. This is why, alongside the connective synthesis of flows and cuts, there must also be a disjunctive synthesis of routes and permutations.” The disjunction produces the distribution that leads to the emergence of a social category, for example the engineer identity in a venture company. The disjunction also marks - via a recording process - shared codes that will later on participate in the organization process of potential connections

between desiring/production machines (Brown & Lunt, 2002: 14).

There is a special case of desiring machine called a 'social machine'. This is an autopoietic (Maturana & Varela, 1980) machine, because it is able to turn back into itself and, from there, rearrange its own constituent parts: "there are no desiring machines that exist outside the social machines that they form on a large scale; and no social machines without the desiring machines that inhabit them on a small scale" (Deleuze & Guattari, 1983: 340). This kind of machine, the social machine, produces, mobilizes and regulates our subjectivity (Pedersen, 2011). As Deleuze and Guattari explain in their analysis of Richard Lindner's painting "Boy with Machine" (1954), desiring machines are plugged into the social machine. Subjectivity emerges from the plug in process between the desiring machine and the social machine. Subjectivity production is a process that is reshaped by the action of the social machine. Therefore, the connections between productive machines and value extraction are affected by the social machine. Connections and disjunctions are also regulated within the social machine (Brown & Lunt, 2002: 14).

As it is possible to see now, the connective and disjunctive synthesis are still not enough to identify where and how the individual is produced according to Deleuze and Guattari's approach. They claim that "the subject is produced as a mere residuum alongside the desiring-machines... a conjunctive synthesis of consummation in the form of a wonderstruck 'So that's what it was!'" (Deleuze & Guattari, 1983: 17-18). It is thus the conjunctive series (if... then), the one that is called to finish what was initially produced by the interaction between connections and disjunctions. For Shaviri (2009), this self as a conjunctive synthesis is aligned with Whitehead's 'superject' (Whitehead, 1927: 29). The author also claims that Deleuze and Guattari's *Anti-Oedipus* is a revision of Kant's philosophy that consists of references to each of these clusters' Kantian 'Idea', category and relation, back to a corresponding synthesis. The Idea links to conjunctive synthesis, the Idea of the World to connective synthesis, and finally the Idea of God to disjunctive synthesis (Shaviri, 2009: 110).

Furthermore, Brown and Lunt express the view that any given 'social' identity or - in general - social category emerges from the productive process explained earlier: "a social identity, such as 'teacher', 'parent' or 'worker' denotes a place in a certain arrangement of machines rather than an entity" (Brown & Lunt, 2002: 15). People are thus consuming these social identities. Such a method of constructing convergent series and productions of consumptions, of sensual pleasures, of anxieties, of pain, is at the core of the identity construction of technology workers.

As it is now possible to see, Deleuze and Guattari's approach exhibits a completely different self to that presented in Alvesson et al. (2008). An identification process that happens at the level of desire leads to a completely different explanation of identity formation. Such a conceptualization came from the application of a machinic productive process. In the case

of Alvesson's identification process, the author makes an *a priori* distinction between the individual and the organization (and more generally the social context) (Kenny et al., 2011). In the case of Deleuze and Guattari, their theorization does not make such a distinction *a priori*. Following an understanding of where desiring machines couple in connective modes within the production process, as well as where desiring machines and desire in general precede the personal interests of those who work in organizations, it is thus impossible to understand identification separate from the 'infrastructure itself' (Deleuze & Guattari, 1983: 63). Deleuze and Guattari lead us to a production process where people consume identities. This consumption of identities from the social machine is explained by the conjunctive synthesis of consummation.

It is difficult to see how such an ongoing process of identity production and transformation can occur as a process of identity work (Alvesson et al., 2008: 15). As it is well known, 'identity work' is a term that is meant to emphasize the continual and dynamic nature of identities in organizational settings and their capacity to change and adapt to accommodate transformations that take place within or outside the organization. On the contrary, from a product/machinic point of view, the person is always in a network of machines –whether these are people or any other entity; therefore, discourses and other persons (others desiring machines) are tangled with the identity production process. In addition, desire, which is the unconscious but which is also produced from the mix between the connective and disjunctive synthesis (at the level of production itself and recording or distribution)

In terms of identity regulation (Alvesson et al., 2008: 12), Deleuze and Guattari's approach offers novel paths to understanding the regulation process. Once again, it is desire that produces reality and, as a machine, desire needs to connect with other desiring machines. Here, the operation of social machines, which are a sort of apparatus/dispositif that conducts, conduces the production of desire (as in the case of capitalism/socius). These social machines reconfigure the desiring machines, channelling the circulation within the system (Goodchild, 1996). The interesting question to ask is thus: what kind of machinic social process is at stake in a particular identity regulation process? At the same time: what are the desire investments that people perform in order to sustain such a social machine?

Chapter V: Research Study Methodology

1. A performative disposition

This chapter is titled 'methodology' because it deals with the connections between the research question, the thesis's theoretical resources and the concrete actions taken to answer these research questions. It discusses the scientific consequences of taking a symmetrical approach and of understanding any research process as being performative.

Such an approach is connected with debates about the 'end of theory'. As has often been remarked upon, within these debates, method has become the new theory: not in the sense that it has replaced theory, but rather in that it has become its new object across the social sciences and humanities. Methods are now at the centre of the analysis and have become social actors in their own right. Methods are no longer a mere tool but are instead now being seen as objects of investigation in terms of their effects and how they enact or perform realities (Law & Rupert, 2013). These methods need to be understood as knowledge devices that arrange and assemble the research project by certain particular patterns that are simultaneously social and material.

In general, where STS and MOS follow the insights of STS (e.g., Law, 1994; Czarniawska, 2009), they use qualitative methodologies such as ethnography and other discursive analytic methodologies. Accepting and ascribing necessary importance to the performative turn implies a self-reflexive movement towards these qualitative methodologies. As Isabelle Stengers has remarked: "it seems that science exists only when it is able to invent an apparatus that is able to silence rivals, to institute a situation of putting to the rest, where the stake is the power to represent" (Stengers, 2000: 131).

Stenger's call is formulated for the study of what is normally called the 'sciences' and not for the social sciences. Nevertheless, this thesis takes seriously Stenger's point about the power exerted when a rival is silenced. Methodology can be considered to be a dispositive. As a consequence, one needs to be alert to the effects of methods and be always looking for the effects of the technique on the object of analysis.

Additionally, the conceptualization of dispositif brings certain consequences and unexpected situations - resistances that respond to the some aspects of the research process. There are also some power and governmentality issues that deserve revision. These are issues connected with the characteristics of the interview as well as the methodological devices of participant and non-participant observation. In this sense, the methodology that this thesis wants to use demands a symmetrical approach that looks for the relations between the devices that

actors use to organize their socialization and the devices being used by the research process. The actors in the field use devices just as I do. This issue will be addressed by following a performative disposition towards the research project.

Following Casper Bruun Jensen (2010), a performative disposition requires us to take with seriousness all the effects that we have on the object of study. The first part of the notion (i.e., performative) is related to the ANT tradition. As many theorists of this line of thought (among others, Bruno Latour, John Law and Michel Callon) have influentially demonstrated over the past 30 years, research practices *enact* rather than merely *describe* reality. The second part of the notion (i.e., disposition) is understood not as the concepts of a theory or an approach but rather as a tendency or proclivity. The disposition demands one to be prone and awake regarding the performative phenomenon. This disposition has to do with the possibility of performativity. One needs to be open to the phenomenon becoming.

As Strathern (Strathern, 2005: 39) points out, it is clear that at the very same time as we are producing descriptions and writing about the object of study, we are also inventing relations or making new relations. In this sense, a performative disposition reads directly from the sociology of translation tradition. As John Law (1986) mentions in his description of scientists building bridges between scientific and social reality, we can say that this amounts to the invention of relations between micro and macro levels. Or, as he has said later, practices *enact* rather than merely *describe* reality (Law, 2008). Finally, Brown (2010) points out that when at any time we produce a description, we add new elements of complexity to that weave of associations making up the connections between humans and non-humans. This is the mixture that we label the 'research project'. It follows that the work of describing is one of the most prominent ways in which we act. A performative disposition is a motion towards an 'ontological symmetry', whereby epistemology collapses into ontology and 'observing and representing' are no different from 'intervening and constructing'. Jensen's (2010) performative disposition problematizes the very idea that any given theory or methodology could be intrinsically more helpful than any other. This is because it is impossible to avoid intervention from within the description and the analysis of a given problem - there is no such a thing as a clean, detached approach to the study of innovation phenomena.

Adopting a performative disposition implies that the critique needs to involve persistent analysis - on the part of the researcher - of the process whereby the founding premises of her or his own field of research are "*constructed and reconstructed*" and consider how this process is connected with the phenomena under study (Brown & Stenner, 2009: 4). Any time that we animate the data with a theory, we need to reflect as to its foundations and address how such theories allow specific explanations for ourselves. This is an important issue in fields like management, organization studies and innovation studies because these are research fields that are continually looking for the utility or instrumental use of any results or output. If

there is always intervention, the value of the present study is not located on the side of the improvement of the management of technological innovation practices. Instead, the value of the research is located in the analysis of the phenomena and the study of the continuous theory foundation reconstruction and the relation between this reconstruction with the object of study.

Such movement implies the problematization of concepts, theories and methods, which could be used as a shield against what the seeming imperative of making research 'practical' and 'real' (Bal et al., 2004). However, such an issue can be tackled by thinking about concepts and their foundations. For example, as in the case of this thesis, technological innovation needs to be seen within the context of its own genealogy because, as was seen in Chapter II, technological innovation entails a broad range of meanings. Furthermore, the research needs to interrogate the multiple meanings that coexist within the concept of technological innovation.

A performative disposition follows the general analytical approach that considers the mediation of tools and their performativity within the analysis process. It is precisely in relation to this issue that ANT could be of use in the present thesis. ANT uses a definition of mediated action that includes artefacts, diagrams and any other actants involved in the scene where the process of technological innovation is carried out. As Reavey and Brown have shown in the study of memory (Reavey & Brown, 2009) such a concept of mediation inherits the philosophical tradition of Michel Serres (1982; 1995), processes from the line following Alfred North Whitehead (Whitehead, 1927), and the material semiotics of Greimas as interpreted by Latour and John Law (2009).

Indeed, as Serres has shown, our social relations are not stable in the absence of the mediation of objects, as he claims that objects "slow down the time of our revolutions. For an unstable band of baboons, social changes are flaring up every minute. One could characterize their history as unbound, insanely so. "The object, for us, makes our history slow" (Serres, 1995: 87). From Serres' point of view, the social emerges from things and humans enmeshed in networks (Reavey & Brown, 2009). As Steve Brown has explained in his rich work on Serres (see, for example, Brown, 2002), Serres calls this process 'translation'. Human action is created in an inter-objective form (Latour, 1996). It is clear that ANT follows a Serrean approach to mediation, as Latour - one of the founders fathers of ANT - explains: "microbes, neutrinos of DNA are at the same time natural, social and discourse. They are real, human and semiotic entities in the same breath" (Latour, 1996b: 369). This reveals a profound relational conception of the world, which is at the core of the performative disposition.

ANT proposes to go further than the purely textual analysis. The solution to the study of society comes with the extension of the semiotic approach towards all things. Such a semiotic understanding is defined in a precise form in a text of Latour and Madelein Akrich:

"The study of how meaning is built, but the word 'meaning' is taken in its original non-textual and non-linguistic interpretation; how one privileged trajectory is built, out of an indefinite number of possibilities; in that sense, semiotics is the study of order building or path building and may be applied to settings, machines, bodies, and programming language as well as texts... the key aspect of the semiotics of machines is its ability to move from signs to things and back." (Latour and Akrich, 1992: 259)

From the above quote, it is possible to see that ANT's methodological approach goes beyond the world of text and discourse. There is no "gap between text and context" (Latour, 1999b: 374). ANT does not make any a priori distinction between these entities. ANT looks to explain all productions that exist. To assume a gap between text and context implies an unnecessary bifurcation of nature, discourse and the social. For Latour, textuality, sociality and naturality are part of "what is distributed not of what explains the distribution" (Latour, 1999b: 374). ANT follows the analytical approach of a flat ontology and a completely symmetrical approach to the study of technological innovation, where any textually data is never separated from the non-textual data and its context. ANT serves to solve an old problem deriving from social constructionist approaches.

1.1. Discourse and non-discursive phenomena

A performative disposition is operationalized with an analytical approach that looks to understand materiality and texts. However, the data that informs this thesis is mainly a product of interviews and observation method devices. This leaves the analyst with the problem of how to understand the mixture of textual discourses and non-discursive data that inform this thesis. The problem is important, because some of the tools used to analyse the interview as interactions are largely developed by discursive psychology and ethnomethodological-oriented social sciences, where the unit of analysis is mainly based on the transcriptions of the talk interactions of the interviews and less on the observation transcriptions. The problem can be defined more precisely in terms of how to consider the general analysis of the discursive and non-discursive data within the thesis.

As Brown (2001: 176) shows with his example of a multiple chemical sensitivity patient's account, the discourse analysis of the account brings to the fore some important aspects, such as rhetoric, but it does not exhaust the problem because it leaves out an important number of non-discursive aspects, such as the physical space between the interviewer (a doctor) and the somatic aspects of the emotional patient's reaction. Furthermore, this problem has been defined as "tape fetishism" (Ashmore et al., 2004: 354), which is the notion that the analyst considers the record to be a representation of 'what it is', generating a substitution of the event that is the interview. Such a 'fetishism' shows that the analyst can forget about performative

effects and the mediation of the recording process and the subsequent analysis.

Following Foucault's analysis of 'This is not a pipe', Brown demonstrates that, for Foucault, there are complex relations between texts and images. In fact, Foucault claims that Magritte's puzzle shows a "subtle interdependency between the text and the image on the painting" (2001: 178). As Brown and Stenner (2009) convincingly argue, it is the assumption that discourse is the origin, the sense and the place where this sense is produced. This is an assumption that leads to the problem of the bifurcation of nature explored at length by Whitehead. The complex relation between discourse and the image in Magritte's puzzle is based on what Brown calls "mixed ensembles of variable elements" (Brown, 2001:179) or multiplicities. For Foucault, adds Brown, discourse is not concerned with a pre-formed world. Instead it is "an active process of composition" (Brown, 2001:180) where heterogeneous elements like the discursive and the non-discursive are mixed together.

Foucault's idea of discourse is not detached from materiality or, more generally, non-discursive phenomena. Following Brown (2001), there is a need to 'experience' the performance of the painting to understand the truth of the art. This is not something that happens at the level of the representation but rather at the level of the performance. Once again, the concept of performativity is useful in solving the puzzle between the non-discursive and discursive that any account of social phenomena brings to the analyst. To accept experience leads to the analysis of how any kind of entity is part of an assemblage in the sense of Deleuze and Guattari (1983). Whether it is discursive, non-discursive or a mixture of both, the important issue is to grasp the performativity of the assemblage.

Law (2009; 1994) approaches actor-networks as scaled-down versions of Michel Foucault's discourse. In Law's words, there are "modes of ordering" that can be understood as Foucault's 'mini-discourses' - for example, the managerial discourses that exist together with scientific discourses in Law's study of scientific practices in a large scientific laboratory. Following Foucault, these mini-discourses define conditions of possibility and make some ways of ordering webs of relations possible (or not) in organizations. For Law, the managers of the laboratory "are the product of 'multiple decentered discourses' and are studied up rather than down" (Law, 2009: 149). The organizing process is the result of these multiple discursive relations in the laboratory. Stability is the mixture of these mini-discourses. As a consequence, Law's use of Foucault's conception of discourse leads to the observation of the performance of managers.

Materiality and discourse are mixed within performance. As is clear from a reading of the previous theory-oriented chapters, this thesis seeks to push forward an assemblage-based understanding of social phenomena. In order to address the discourse and materiality, Deleuze and Guattari (1987) develop the concept of 'collective assemblages of enunciation'. The concept of collective assemblages of enunciation is complementary of the concept 'machinic

assemblages'. In fact, as Deleuze and Guattari explain (1987: 7): "collective assemblages of enunciation function directly within machinic assemblages." Therefore, in order to understand the power of the former term, it is necessary to first give some details of the latter.

Deleuze and Guattari use the concept of machinic assemblages to refer to *physical* objects - how they interrelate and how they affect and are affected by one another. Their example of the stirrup used in horseback riding is useful on this point. Deleuze and Guattari note that the stirrup instituted a completely new form of war, creating a new connection between warriors and horses, and permitting warriors to exponentially increase the force of their spears at the same time as they ride their horses. Such a technological change triggered the evolution of the spear as a weapon of war. Such an analysis has the sort of analytical force of the concept of a machinic assemblage. The concept of a collective assemblage of enunciation refers to the order of language in a non-representational form. It is in *Anti-Oedipus* (Deleuze & Guattari, 1983) where the authors write about the phenomenon of *glossolalia* in the schizophrenic unconscious. For Deleuze and Guattari, language is located in repetitions that people perform of myths, national histories and general discourses. There is a sort of impersonality to the language that comes from its redundancy. People use language in a repetitive form. People use already existent preceding flows of the language.

Language does not represent but rather performs or enacts 'incorporeal transformations'. An incorporeal transformation is a change in the social position and situation of the bodies but not a transformation of the body itself. There is no doubt that Deleuze and Guattari approach is highly influenced by Austin's (Austin, 1966) 'speech act' tradition. Although the analytical disposition of this thesis is not strictly aligned with the procedures of any methodology of discourse analysis, Austin's approach is at the core of the various 'discursive devices'. The linguistic and material turns are complementary. This is particularly true for the notion of 'implicature', a notion that emerges from the pragmatic linguistic turn developed in the 1950s and 1960s by the work of John Austin and the work of John Searle (Searle, 2000).

Austin developed the concept of the performativity of speech acts and Searle, working on Austin's conceptualization, developed a theory of speech acts. An *implicature* is defined as "the aspect of meaning that a speaker conveys, implies, or suggests without directly expressing" (The American Heritage Dictionary of the English Language, 2004). For example, the utterance 'Can you pass the salt?' is *literally* a demand for information about the person's ability to pass salt; therefore, the understood *implicature* is a request for salt. Additionally, 'implicature' means 'the process by which such a meaning is conveyed, implied, or suggested'. For example, when somebody says 'Some dogs are mammals,' the speaker holds by *implicature* that not all animals that are dogs are mammals.

However, the implicature analysis corresponds with a linguistic analysis. What Deleuze and Guattari are implying goes beyond this. It is a sort of 'material semiotic' (Law, 2008) of

implicatures. Deleuze and Guattari present an interesting example of the verdict of a trial. In such a situation, there is a change in the social position and situation of the bodies but not a transformation of the body of the person itself. The social position and situation is transformed by the verdict 'guilty'. A second example is when people in a terrorist airplane attack become hostages and undergo an incorporeal transformation. This approach is also presented in the later work of Guattari (2011). Under his scheme, the sign is not formed or secured 'personologically' or through a *cogito*; rather, it is produced or achieved by machinic processes (Guattari, 2011). Incorporeal transformations intervene in machinic assemblages, in the order of the body, but do so in a way that is not of the order of cause and effect. This is how the concepts of machinic assemblages and the collective assemblage of enunciations become entangled in a machinic form.

The corporeal and incorporeal entities are imbricated with one another. A collective assemblage of enunciation can never be reduced to a purely physical phenomenon, and vice versa. As Brown explains in his analysis of Foucault's book 'This is not a Pipe', discourse/ incorporeal and non-discursive/corporeal objects mutually inform each other in a variety of forms by the reduction of one to the other. Social constructivism is thus able to critique those incorporeal transformations that collective assemblages of enunciations permit without reducing this phenomenon to the order of the signifier. Crucially, there are transformative possibilities (or novelties) in the mixture of machinic assemblages and the collective assemblage of enunciations. Techniques, objects and enunciations are entities that are participants in the mediations and which are translated in the emergence of new assemblages.

1.2. The problem with the ANT generalized principle of symmetry

A performative disposition is not exactly what the sociology of translation (ANT) scholars have written about the extension of Bloor's symmetry principle (see, for example, Callon, 1986). Indeed, at the core of ANT's empirical analysis there is no distinction in kind. The actor-network theorist sees a complete, flat ontology, in which distinctions between any entities are matters of degree rather than of kind. Indeed, and as in the case of the text and the context of the previous point, ANT - in the words of Latour - tries to avoid the unnecessary bifurcation of nature between the social and nature categories. However, this analytical movement is not performed without difficulty.

Such an analytical impetus to reducing differences in kind to differences in degree (Brown & Middleton, 2005a: 713) brings certain possibilities but also certain costs to the methodology's design. These costs are expressed well by Strathern in her critique of aspects of ANT: "I see in the network of some actor-network theorists a socially expanded hybrid because they have captured a concept with properties of auto-limitlessness; that is, a concept which works indigenously as a metaphor for the endless expansion and intermeshing of phenomena" (cited

in Brown & Middleton, 2005: 702). The problem, as expressed by Strathern, is that there is no end for the hybrid entity in ANT's analysis of social phenomena. The reduction towards differences in degree implies the impossibility of 'cut[ting] the network' of some actor-network approaches. This is an important methodological problem, because if the analyst does not know when to stop, the study enters a never-ending loop whereby the expansion of connections leads to the explanation of everything and nothing.

ANT's reduction of differences in kind towards differences in degree is useful in that it avoids the 'God trick' of seeing boundaries as an *ex ante* category (Haraway, 1988). However, the same analytical approach to studying transformations in degrees (and in particular to the study of the 'procedures or formalisms') to explain the emergence of actor-networks brings with it the same problems as with the study of differences in kind. To demonstrate the point, Brown and Middleton (2005) use the example of John Law's (Law, 2002) TSR2 technology study. It is easy to see that when ANT moves from the study of changes in kind towards changes in degree (for example, from the decision to stop or not to stop the production of RSR2 aircraft towards the study of the engineering formulas), it will not reduce any ambiguity for the analyst or the research project as a whole. That is because no formalism (for example, the formula to calculate the material resistance of wind) contains the principle for its own application. "There is nothing within a calculation of 'wing lift' that informs an engineer when to start applying the formula and, most crucially, when to stop" (Middleton & Brown, 2005: 696). This is the practical problem that Strathern explained so beautifully.

Indeed, this is exactly the same problem that this thesis confronts should it focus on differences in degree instead of kind in studying the stability of any network that shapes the phenomenon of technological innovation. For Strathern, as Brown and Middleton explain, the solution is the existence of the hybrid entity that stops the growing process of the network. However, it is worth asking whether the existence of the assemblage of natural and social aspects draw bring some light on the phenomena of technological innovation at Med Dialysis and Med Diabetes. In is interesting that, for Strathern (1996: 523), the hybrid figure that brings an end to the phenomena of technological innovation is the figure of the patent. Is this the object that cuts the network of technological innovation?

Brown and Middleton (2005) offer a solution that can serve to approach technological innovation in their empirical study of a neonatal intensive care unit (NICU). To solve the problem, the authors embrace the mediation of the body as a "zone of indeterminism" (following Bergson's philosophical thought) whereby perception suffers a kind of selection of "an 'active' and reciprocal process and not the passive recording of stimuli, nor the activation of some prior store of mental representations" (Brown & Middleton, 2005: 703). This image of a 'zone of indeterminism' breaks from the purely monist approach to perception and leads to a consideration of the differences within spatial movements. Brown and Middleton claim

that this is the type of hybrid entity that Strathern identifies with her own example of the patent.

In addition, Brown and Middleton related this hybrid to the ‘constitutionally indifferent’ hybrids or ‘blank objects’ analysed by Hetherington and Lee (2000). The methodological implications of this movement towards ‘constitutionally indifferent’ hybrid objects is important for the present thesis. Furthermore, this type of object can offer possibilities in seeing where it is that the network of the phenomena of technological innovation is cut and how to solve the problem of differences in kind and degree. Such a kind of object produces a sort of interval in the continuity of action in an organization and a space that allows the organization to manage its own boundaries (Brown & Middleton, 2005: 706), mediating between different kinds of actors. These are objects that need to be at the centre of the inquiry.

Following Serres, Brown and Middleton propose ‘objectivity’ as the form to understand the ‘scenography’ in which social phenomena occur. It is, in fact, Serres’ concept of the quasi-object (1982: 225) that Brown and Middleton are following in their study

“...in which the transcendental constitution of the object by the subject would be nourished, as in return, by the symmetrical constitution of the subject by the object... of [this] direct constitutive condition on the basis of the object we have witnesses that are tangible, visible... however far back we go in talkative or silent prehistory, they are still there.” (Serres & Latour, 1995: 84)

However, Brown and Middleton’s analysis does not finish with the quasi-object and the blank objects solution in the analysis of differences in kind and degree. The authors make their most interesting methodological and theoretical contribution when they claim that it is the baby that could be defined as a quasi-object and, furthermore, as being the most blank of the NICU objects. This point has important consequences for an object-centred analysis of technological innovation and its management and leads us to ask difficult questions about hybrids. For example, is it worth the time to ask whether a management practice to develop a new technological innovation is a subject or an object or else a mixture of both? Moreover, is it worth asking what kinds of objects engineers normally use to organize the innovation process?

Brown and Middleton offer a solution to the differences in kind and degree that is somewhat counter-intuitive, whereby “blank or virtual objects allow for forms of ordering which cut between these differences” (Brown & Middleton, 2005: 710). They centre the solution on a specific type of object that is blank (i.e., indeterminate) and they claim that such an object is virtual, ed., “always several things at once. It contains all the differences as real potentials.” The insight is that in order to understand the topology of any social phenomena it is of

interest to consider the empirical problem of how these objects are related with subjects in the field. These are the objects that we need to follow in order to see the limits of the network and its analysis. This is the object-oriented research approach that will lead to an understanding of the connection between the various differences in kind and degree.

In the following section, the discussion about methods turns to practicalities. I argue for a data production approach that is based on a *proximal* method to data gathering/production rather than a *distal* one. These categories refer to the physical positions of all the entities that participate in the research process - in particular, to the distance between any researcher and their object of study.

2. Proximal data production methods

Nicolini (2010) has claimed that the diffusion of innovation and organizational phenomena has typically been studied in line with a *distal* approach (Cooper & Law, 1995). A distal approach follows a rational and predictive rationale and grants to the author the role of legislator. From this point of view, those in the 'business' of the academy become the facilitators of the practitioners, and look to produce improved models to understand innovation and organizational phenomena. Such an approach looks for the reduction of continuous complexity and the generalization of the phenomena's explanation using causal tools. Instead of a distal approach, and following Cooper and Law, Nicolini calls for *proximal* thinking. 'Proximal' means to think about the organizational process and - in particular - the organization of technological innovation "as mediating networks, as circuits of continuous contact and motion - more like assemblages of organizing" (Cooper & Law, 1995: 239).

In my research, I have employed a variety of data production methods in order to construct a proximal reading of technological innovation for medical devices. The data collection included in-depth, open-ended interviews with key informants from Med Dialysis and Med Diabetes, the examination of pertinent organizational documents, and direct observation in the companies themselves. I conducted 24 in-depth interviews of key informants, including: Med Dialysis staff, Med Diabetes staff, and representatives from agencies who participated in the West Midlands healthcare technology industry.

The individuals who were interviewed included managers, engineers and technicians. They were selected based on their participation in the development of technology and the commercialization process at both organizations. Additional contacts were identified using the snowball (or chain sampling) technique, in which the interviewees provided the names of others who could give additional insight into any processes and issues (Caudle, 1994).

The interviews were audio taped and were completed in approximately 60 minutes. At the time of the interviews, I also requested additional interviewee time for follow-up questions

or clarifications, which took on average about 30 minutes, and took place after the interview, normally a week later. Furthermore, both before and after the completion of each interview, I recorded my impressions and observations in field notes, which were subsequently included in the analysis. The interviews were transcribed, and the interviewees were given an opportunity to review their transcripts. I then identified key issues and themes and coded them using Nvivo 9 software for qualitative data analysis.

Documents from both organizations and agencies were obtained throughout the interview process, through e-mail and other visits to the company. I collected and analysed documents relating to a series of procedures and flows of action. In the case of Med Diabetes, the major documents are: PowerPoint presentations regarding Med Diabetes as a company and its product, diagrams that show the 'route to market' of the in-development product, and a conference poster medical device presentation and some web notes from a diabetes medical device interest group.

In the case of Med Dialysis, the documents analysed are: flowcharts of the supply chain design (inbound and outbound), various diagrams (such as the 'Innovation Process', the 'SelfCare Specification Hierarchy' and the 'Risk Radar') and, finally, version four of the company's business plan. I also reviewed some web pages containing opinions and commentaries of NHS programmes on medical devices. An important document that informs Chapter VI of the present thesis is the *Medical and Healthcare: A Guide to Market Access*. This document was provided by Medilink, a hybrid public-private agency that works in the area of the promotion of medical healthcare among private companies, creating links among them and with government initiatives. Other important documents include some publications from a technology park, where Med Diabetes has its operations.

Direct observation at Med Dialysis and Med Diabetes was possible. I was able to attend several Med Dialysis meetings where technicians, engineers and managers discussed and took decisions about the product development process. On two occasions, audio recording was not possible, so I kept written records instead. In any case, I was able to take notes of my impressions and observations within the record and add those impressions to the field notes. All these observations are included in the analysis.

The following sections, I offer some additional (more precise and more specific) accounts of the research methods used in the data gathering/production process.

2.1. Observations

I found it important to follow some of the team members in their daily work precisely because there is a performative aspect within their daily practices. Equally, I was interested in my own performative effects on the research process. All in all, the observation provided background

information that informed this research process, but it is not the primary or fundamental data gathering method. The information compiled through these observations enabled me to gain a more comprehensive visual picture of the team members' working routines. With this, I became more aware of what was left out in my analysis and what was taken in. The times and places of observation are displayed in Table N° 2.

Table 1: Direct observation in the field.

Places	Visits (#)	Hrs.
Med Dialysis	25	72
Med Diabetes (former office)	7	17
Med Diabetes (University Research Park)	12	25
TOTAL	42	114

I made notes of my observations in a personal fieldwork diary. These annotations were mainly kept at the same time as the observations and they were systematized in a closed and encrypted internet-based blog. Next, using Nvivo (version 9.0), I managed to organize these notes into a single format. The observations are used as a secondary data for the present thesis, but they offer the necessary richness and profundity in terms of data for opening up the analysis chapters and themes.

2.2. Conversations and interviews

I adopted an ethnographic interview (Spradley, 1979) approach. Spradley's approach is open, in general, but with the specific aim of obtaining information about the phenomena under study. These are the phenomena of technological innovation from the point of view of those who are producing - or at least co-producing - and managing in venture companies. The research interviews lasted for approximately one hour, and involved nearly all the members of both organizations. In some cases, there was an opportunity for repeat interviewing. I also interviewed a manager from the technology park where Med Diabetes is physically located as well as an officer from Medilink.

2.3. Overview of the interviews

Below is a list of the personnel that I interviewed at Med Diabetes and Med Dialysis and the times taken to interview each them as classified by the venture company in question and other sites/organizations.

Table 2: Interviews.

Organization		Interviews
A) Med Diabetes	Technology manager and owner	1
	General manager and owner	2
	Marketing manager	1
	Internet applications manager	2
B) Med Dialysis Director of science and technology	Commercial manager	2
	General director	2
	Engineer/inventor	1
	Quality manager	1
	Risk manager	2
	Project manager	2
	Engineer mechanic	2
	Fluids technologist	1
	Other technician	1
C) Technology Park	Manager/officer	1
D) Medilink	Manager	1

In terms of method, the interviews differed from the classical qualitative research interview in which it is the informant's 'life world' that is the subject of inquiry. Kvale (1997: 19) writes about the qualitative research interview in that it "has of purpose to gather descriptions in order to interpret the meaning of described phenomena." This is a perspective that considers a rather stable 'life world'. Instead looking at the team members 'life-worlds', I looked for different things during the interviews, which are not necessarily about their personal histories, and mainly focused on perspectives as to the innovation process. For example, although I asked for information about the actors' personal lives at the opening of the interview (especially within the first interview), the idea is to arrive at a discussion of the journey performed by the company in its technology development project. The general tenet of the interview is to allow people to explain how things happen within this process. From there, I proceeded to open up a dialogue whereby the person could refer to their day-to-day practices and - in particular - how they use material elements in their activities (i.e., in terms of activity theory

and mediating tools). In this sense, the interviews were used to explore the innovation process rather than looking for a complete picture of the working life of the staff. The interviews thus focus on themes directly dealing with the technologies' development. As a strategy, the focus on technology allowed me to open up other themes of the work of engineers and technicians.

The methodological question remains: why use interviews in cases where performances and activities are to be the centre of the analysis? Would a focus on observations not be more logical as core material in the analysis? Yes, observations would have been more logical in a performative, symmetrical analysis and an object-centred analysis; however, I would offer several reasons why interviews ultimately take up being central for the data production process. First of all, at the beginning of the fieldwork, I had limited knowledge about the technologies involved and the literature that informed the present thesis. What is it to 'follow an actor' (Latour, 1988) after all? ANT does not offer a clear explanation as to this.

Secondly, since I followed a post-structuralist reading, I accept that meaning making and positioning in interviews are also regarded as performances. Performances in talk deal in this regard with how conversations are interactions (as the entire ethnomethodological literature has shown). Thus, the interviews did not simply confirm the informants' subjective concerns about their efforts to innovate their working practices. The interviews helped me to follow and identify particular ways of doing things. What was performed in the interviews thus did not subscribe to a dichotomous understanding of, on the one hand, staff members' subjective experiences and, on the other hand, innovative 'objective' efforts or a concrete material practice of managing the technological innovation process. The interviews were used as a tool to become attentive to the practices of the engineers and technicians concerned.

Furthermore, paradoxes and multiple views during interviews are not regarded as inconsistencies in the staff members' perspectives. Rather, these multiple views during the interviews are taken as ongoing ontological work. Engineers know that their practices are multiple, complex and always under discussion. Finally, most of the observations simply do not contain references to the innovative efforts or detailed work of the engineers and technicians. There are several reasons for this. Particularly, the amount of time that would be needed to observe such practices is greater than any person could receive in such a place as a venture company. Further, important decisions and activities are never produced in the same place where the company perform its operations. Such a multi-sited study (Marcus, 1995) demands negotiation and a type of fieldwork that is simply not possible considering the political economy of the venture company and its level of activity.

Finally, in order to capture some natural conversations and so as to have some extra data, I participated in a couple of group meetings of the Med Dialysis work team, having access to record some 'natural conversations' at Med Diabetes. Some of this interactive data was also used within the analysis in Chapter IX.

2.4. Artefacts and diagrams

The research draws upon documents, diagrams and drawings. These comprise important data gathered alongside the interviews and observations. Following a performative disposition, diagrams and drawings are more than just representations of the mental images of those developing technology; following a mediational approach, they are tools that mediate the activity of the engineers and managers of venture companies.

This material was always considered to be entangled with those texts elaborated from the transcriptions of the interactive material (i.e., interviews and natural conversations at meetings). The analysis process used the complex mixtures that emerged from the diagrams and enunciations of the participants. Furthermore, I follow those complex dynamics that appear within the *collective assemblages of enunciation* function and *machinic assemblages*. Some of the documents, artefacts, diagrams and drawings that are in used in the present thesis include:

- *Medilink Medical and Healthcare: A guide to Market Access*
- Med Dialysis route to market diagram
- Marketing material of the technology park where Med Diabetes is located
- mHealth Med Diabetes poster (presentation)
- Other PowerPoint Med Diabetes presentations
- Devices for Dignity communication material
- Inbound and outbound supply chain Med Dialysis diagrams
- Med Dialysis V4 business plan
- SC-11 Self-care specification hierarchy
- V-Model
- Risk radar at Med Dialysis
- Innovation technology process at Med Dialysis

The emphasis within the analysis is on the connections between the interactive aspects of the conversations and interviews and the performative aspects of these ‘devices’. I attempted to maintain an open-ended disposition within the data, although through a set of theories that I use to animate the data analysis. As a consequence, I followed the complex relations between the textual and non-textual aspects of the data with the performative aspects of the theories, documents and general objects that intervened in the research.

2.5. Photographs

I took some photographs which, as observations, were used as secondary data to enrich the analysis of the interactive interview-based data. The photographs were used to trigger my memories - this responds to an object-centred research approach in which such photos are more than just a 'precise' representation of my past as experienced during my visits in the field. The photographs were used to evoke places and situations, and to form an experience-based account of the interviews and observations. Non-textual aspects thus enter the analysis in the form of these photographs. Although photographs do not constitute the main data, in some respects they are crucial. This is because they trigger a closer view of the empirical exploration that considers these objects in relation to my performance in the field.

3. Analysis

The data were analysed by first transcribing the field notes and tape-recorded interactions (interviews and observations). The analysis of the transcribed data was exploratory, inductive, and theory building in its approach, which involved the careful reading and rereading of the data, coupled with an iterative process of moving between the data and the existing theoretical literature. However, a difficult question is: where does one start the analysis? This question about order is always an interesting one. From a performative disposition, it is possible to follow Bruno Latour and his call to begin exactly where the network of connections allows one to start. The author tries to give some advice about methodology in his oft-cited work, *Reassembling the Social*: "even when we are in the midst of things, with our eyes and ears on the lookout, we miss most of what has happened" (Latour, 2005: 122). This is because we are always in the middle of the relations in question, whether after something that has already happened or else before something else that is going to happen. Or, to put it another way, this is because the research process is a part of the emergence of the phenomenon under study.

Via a long process of selection and interaction with supervisors, theoretical texts, field materials, trends, conversations with colleagues, my own preferences, etc., I constructed the 'middle'. This selection process was (and is) continuously developing. I began by selecting an explorative approach and formulated interview questions as well as an observation premise when looking for places where I might find the performance of innovation practices in daily work.

Following a particular textual or non-textual machinic entanglement is no easy task. For example, traditional questions about quality need to be rethought. How do we construct reliability in the data analysis? Following Vivian Despret (2004: 124), the focus needs to change. A potential solution is aligned with the observation of the becoming (Despret, 2004: 124). This leads to an event- and process-based understanding of the research project. As a

consequence, the research project needs to be seen as an event composed of discursive and non-discursive entities enmeshed in practice.

3.1. The linguistic and material turn are complementary

In terms of the technical (or detailed) aspects of the analysis, I followed the general guidelines of the textual/discourse analysis approach as understood by the Loughborough School (Antaki et al., 2003; Potter & Wetherell, 1987), especially the line of analysis of scientific practices advocated by Jonathan Potter in his *Representing Reality: Discourse, Rhetoric and Social Construction* (1996) and Michael Ashmore and Steve Brown's non-foundational critique of the analysis of purely textual social constructionist analytical approaches (Ashmore et al., 2004; Brown, 2001; Stenner & Brown, 2009). In short, this is an approach which, although mainly based on the use of texts and what discourse analysts consider to be conceptualized discourse, nonetheless accepts the turn to materiality and the performativity of other kinds of data as well (such as diagrams, draws and photographs, etc.). Furthermore, in looking for a more subtle understanding of discourse, I follow the tradition of Foucault and post-structuralist thought.

I constructed an *ad hoc* analysis path based on the discursive themes that arose from the various interviews and observations. In the first stage, and having the research questions in mind, involved reading the complete transcription and looking for interesting aspects that appeared in the firsthand material's revision. Later on, I systematically read through the conversations and interviews. Now, the task is to look for what have been called 'discursive devices' (Mueller & Whittle, 2011; Whittle et al., 2008). Such an approach considers a list of discursive devices that is built upon the principles of discursive psychology of the Loughborough School. A summary of the devices used in this thesis is presented in Table 3.

The important issue at stake within the analysis is to observe the existence of those devices which, in general, exhibit the performative force of the language (i.e., whether it is rhetoric or else any generative power that the discursive device shows). Crucially, it is not enough to discover the discursive device. To classify the discursive device at use, it is just the first step to perceive the whole text in terms of the research questions. Later on, the researcher needs to scrutinize how does the performative force of the language offer hypothesis about the discourse –verbal and non-verbal- of the actor within the talk interaction or the interview. In any case, these discursive devices do not exhaust the entire set of tools that exist within discursive psychology or linguistics, but they are normally frequently referred to within the literature.

Within the last part of the categorization process, I used these discursive devices as tools to understand the mixtures of other non-textual (discursive) elements. The idea is to examine

the discursive devices employed by managers, engineers and technicians, and produce an analysis of how a variety of discursive devices - such as footing - are employed by actors during the interviews and 'natural' conversations during meetings. For example, and responding to research question two, the notion of a discursive device is crucial in the case of professional identity formation. Discursive devices thus allow the researcher to see how it is that actors construct a set of resources in order to maintain their identities in responding to "an ever-changing kaleidoscope of situations" (Potter & Wetherell, 1987: 156).

The interesting issue analysing the translation process of diagrams and other material devices, theories and enunciations. This is a material semiotic approach whereby, following Deleuze and Guattari, actors' implicatures need to be analysed with their material implications. Additionally, the material semiotic approach looks to perform an analysis of the implicatures (or effects) of the diagrams over the enunciations of the actors. Such analysis looks to understand the performativity of the diagrams and other artefacts plus the analysis of the material effects of enunciations.

Table 3: Some discursive devices used in the analysis.

Discursive Device	Definition	Key Sources
1 Stake attribution	Appealing to the vested interest or stake of another, particularly with regard to discounting or doubting the position of another.	(Potter, 1996) (Wetherell et al., 2001)
2 Stake inoculation	Denying or downplaying the stake or vested interest the speaker has in a situation.	(Potter, 1996)
3 Footing	Positioning ourselves in relation to what we say: the distinction between author, animator and principal. Pronoun selection (e.g., 'we', 'us', 'them') is one way of doing this.	(Goffman, 1979) (Potter, 1996)
4 Externalization ('out-there-ness')	Presenting a description as being independent of the speaker making the construction.	(Potter, 1996)
5 Categorization	The social categories used to describe oneself and others, including what responsibilities, expectations, rights and obligations are involved. Pronoun selection (e.g., 'we', 'us', 'them') is one way of doing this.	(Edwards, 1995)
6 Spontaneity	Presenting oneself as acting in a natural, unplanned manner.	(Goffman, 1974)

Discursive Device	Definition	Key Sources
7 Nominalization	Replacing nouns with verbs, adjectives or adverbs to avoid mentioning those who performed the action, especially to the avoid attribution of blame or responsibility.	<i>(Potter, 1996)</i>
8 Formulation	A statement of what has just happened in an interaction, summarizing what is taken to be already known or agreed.	<i>(Antaki et al., 2007)</i>
9 Authenticity	Describing oneself and one's beliefs as authentic and based on personal conviction, as opposed to simply following orders or acting upon peer pressure, for example.	<i>(Potter, 1996)</i>
10 Concession	Explicit acknowledgement of actual or potential counter-arguments, to appear more balanced, informed and thoughtful.	<i>(Antaki & Wetherell, 1999)</i>
11 Extreme case formulation	Extreme case formulations (ECFs) were identified by using extreme terms such as 'all', 'none', 'most', 'every', 'least', 'absolutely', 'completely', and so forth, whose uses are to defend or justify a description or assessment, especially in case of challenge.	<i>(Pomerantz, 1986)</i> <i>(Edwards, 2000)</i>
12 Bottom line demonstrations	Demonstrations of bottom line realities: reactions that introduce a bottom line, a bedrock of reality that places limits on what may be treated as epistemologically constructed or deconstructable.	<i>(Potter et al., 1994)</i>

(Adapted from: Mueller & Whittle, 2011)

However, the analysis of the actors' reflections is not free of problems. For example, a very practical one is the mediation of the technology at the core of the tape-recorded data. Problems of inaudible talk, capturing nonverbal interaction and limits to access remain (Hammersley & Atkinson, 2007). In addition, participants reflexively orient themselves to the presence of any external actor, including the tape recorder. Such observations indicate the limits of any analytical approach that treats the record as a 'time machine' that allows one to return to the event where the record is created (Ashmore et al., 2004). As Stenner and Brown claim (2009: 151), we must not make the assumption that, at the bottom of the chain of mediations, the original event that was the interview or else the 'natural talk' of the actors is not mediated too. As Serres and the entirety of the ANT literature demonstrate, mediation occurs all the way down. What is needed, in the terms of Stenner and Brown is to consider the communication process as mediation (2009: 153). This is what this methodology tries to construct when establishing that the linguistic and material turns are complementary.

Chapter VI: Medical Device Ventures

1. Introduction

The stories of Med Dialysis and Med Diabetes have a common denominator. Both companies are geographically located in the West Midlands of the UK. There are important issues concerning the Midlands and in particular the West Midlands. The innovation practices of these companies are intimately associated with the Midlands. Indeed, certain actors - like engineers, universities and private-government agencies - are crucial to the medical devices industry, and they are explored in the present chapter. Important intermediaries - like Medilink - will be at the centre of the analysis of the innovation problem.

The question of the relation between such intermediaries and the companies developing new technologies and products has been studied according to the idea of institutional innovation (Etzkowitz & Leydesdorff, 2000). These studies have addressed the importance of the university as a part of a national innovation system. Such a model integrates the different actors - private and public- with the innovation phenomena. Within this literature, Michel Callon (Callon, 1998b) has argued that the innovation model no longer enacts a separation between basic research practices and applied research. In Callon's view, there is a need for a holistic approach to innovation phenomena.

Indeed, nowadays innovation models look like an 'endless transition' - in Callon's terminology - where basic research is closely connected with utilization and a series of intermediaries. This is a phenomenon which -most of the time - is stimulated by governments or hybrid governmental/private entities. This is the world in which Med Dialysis and Med Diabetes are located and develop medical technologies. It is a world where the conceptualization of systemic innovation is accepted for a large number of actors and where the hybridization between the public and private sectors is pervasive in almost all technology sectors. Any linear model of innovation is under threat. We, as researchers, need to look for these new, complicated interactions. These interactions are defined in successive back and forth movements between the public and private actors of the healthcare sector.

In addition, and as it is possible to see over the course of the discussion of the next two chapters, the linear model of innovation is far from the reality for those companies who are actually struggling with the development of medical devices. Callon's 'endless transition' model is exemplified by the analysis of the discourse of the important Association of British Healthcare Industries (ABHI). The ABHI has stated that there are 2,000 SMEs in the medical technology sector. These companies need "assistance plans for business" (ABHI, 2009:6). This is a broad ranging industry (medical devices range from syringes to x-ray machines)

employing around 50,000 people (2009: 3). It is also an industry that is highly dependent on NHS procurement practices (see Chapter VIII for a detailed discussion of the new NHS Commissioner figure). In fact, the ABHI claims that the NHS budget cycle discourages the early adoption of new technologies and, as a consequence, patients are "not benefiting from the latest technologies as soon as possible" (2009: 5). The ABHI has been calling for a profound restructuring of the relationship between the NHS and technology developers in the UK. Furthermore, the ABHI is also calling for a medical devices assessment and a NHS purchasing evaluation process, whereby the use of evidence and the particular characteristics of medical technologies "should include the wider societal benefits" (2009: 5).

However, the ABHI is not the only relevant participant within the 'endless transition innovation model' of the medical devices industry. Private companies like Quotec Ltd. define themselves as "focused on supporting organizations with all aspects of technology strategy and technology management from basic research to the marketplace" (Quotec, 2013). They have been working with the NHS and other local development agencies such as the London Development Agency to offer advice on how best to evaluate markets for novel medical technologies. 'Partnership' is the magical word, through which private, governmental and many hybrid sector actors become entwined. Significantly, what these intermediaries are offering and developing is a particular way of seeing markets, the procurement process (public and private), the regulatory environment and the commercialization (marketing included) of novel technologies. Some of these visions about the market and the industry are put forward by Medilink West Midlands.

Medilink West Midlands (WM Medilink) is a private organization based on membership that works for the "growth and innovation in the medical and health technology sector" (West Midlands Medilink, 2013) in the West Midlands. WM Medilink is part of a national network of "health technology business support organizations" (Medilink UK, 2013). This is an operator which aids companies from the early stage of innovation through the whole commercialization process. They seek to "nurture collaborations between academics, clinicians and industry" (Medilink UK, 2013). Looking at the specific aims of Medilink, an analysis of the document *Medical & Healthcare: A Guide to Market Access* offers a point of departure for the analysis of the organization process of innovation practices in small companies developing technologies. Mimicking the approaches of John Law in his book *Aircraft Stories: Decentering the Object in Technoscience* (Law, 2002) and Annemarie Mol in *The Body Multiple* (Mol, 2003), the present chapter looks to perform an analysis of the document that connects with the multiple realities (or "enactments" in the authors' language) and ways in which this Medilink document become entangled with the innovation and management practices at Med Dialysis and Med Diabetes as a *dispositif*.

As a consequence, the chapter offers a dual narrative. On the one hand, the chapter offers the authors' explanations about the tools and related management and competitive strategy

literature that are introduced within the context of the guide. On the other hand, the chapter offers a narrative based on those actors working within the various companies and the intermediaries comprising Medilink and the university technology park. As a consequence of this twofold narrative, the chapter offers tentative answers to the questions: What kinds of innovation and management tools are enacted within the guide? And: Are the actors in the novel medical device companies using these management/innovation tools?

For the purpose of clarification, the narratives will be divided into two parts. The first part is at the top of each page. This narrative explains the story of the guide and provides an analysis of its tools and its enactment of the market and innovation. The second part is seen in the two columns in the lower parts of the pages. This offers an analysis of the observations and interactive data of this project. With this separation, the author looks to compare the normative discourses that the guide offers to SMEs and the visions produced with the informants in the field.

Figure 1: Medical & Healthcare: A Guide to Market Access(front and back).



The representation of the different aspects of access to the medical and healthcare market by a Rubik's cube itself constitutes an interesting feature of the guide. What is this image trying to do? The Rubik's cube is arguably one of the most famous and routinely used puzzles in the world. It is also a 3D puzzle that offers an incredible amount of possibilities³, with just

3. In fact, considering the permutations, the combinations of a Rubik's cube total 43,252,003, 274,489,856,000. This number emerges from the fact that the original (3×3×3) Rubik's Cube has eight corners and twelve edges. There are 8! (40,320) ways to arrange the corner cubes. Seven can be oriented independently, and the orientation of the eighth depends on the preceding seven, giving 37 (2,187) possibilities. There are 12!/2 (239,500,800) ways to arrange the edges, since an even permutation of the corners implies an even permutation of the edges as well (when arrangements of centres are also permitted, as described below, the rule is that the combined arrangement of corners, edges and centres must be an even permutation). Eleven edges can be flipped independently, with the flip of the twelfth depending on the preceding ones, giving 211 (2,048) possibilities. In formal notation: (See here the detailed procedure: <http://www.gap-system.org/Doc/Examples/rubik.html>).

one that is the final and correct one. Therefore, this image is signalling that in order to receive proper and successful access to the healthcare market, any virtual incumbent in this sector needs to look for a perfect combination of 'movements' of the different 'pieces'. That is, it is necessary to move all relevant pieces in order to arrive at a specific solution to the multivariable puzzle that is entrance to the medical device market. This is a rather mechanistic metaphor, and clearly one that is pervasive throughout the course of the guide. However, is there just one solution for access to the healthcare market? And furthermore, is this 'unique' solution preconfigured or - in the language of the chapter - enacted in only one form?

2. How to sell in the healthcare market

The guide constructs a complete story about globalization, the healthcare market and the potential change from an old automotive-based industry (geographically based in the Midlands, UK) towards a new medical devices industry. This is an old story - a story constructed by a comparison of local labour costs and competitiveness versus Asian industry. From the paragraph below (from the introduction to the guide) it is possible to see the goal of the guide - original equipment manufacturers (OEMs) and companies who used to do business in the automotive industry:

"The automotive sector particularly has seen vast changes in recent years. Faced with massive problems of global oversupply and crippled by spiralling development costs, many of the automotive OEMs - original equipment manufacturers - have either moved their manufacturing plants in the region to less developed economies where labour is cheaper, or sadly, have gone out of business altogether." (Medilink, 2007: 1).

After a short diagnosis of the automotive industry, the document moves quickly towards the medical and healthcare market as a possible place to use all the "experience...within the region" and all those skills that "*still exist*." Most striking - to say the least - is the relationship that the guide establishes between the automotive and healthcare industries. The guide uses a fact-based discourse. This is very similar to what Jonathan Potter calls an "empiricist repertoire" (Potter, 1996:152), which is based on the construction of 'out-there-ness' (1996: 153). The guide establishes that the medical and healthcare market constitutes a possible client of the skills that the automotive industry's expert engineers offer.

The introduction is interesting because the guide 'sells' the conversion between industries. Furthermore, the guide rhetorically converts the whole problem of globalization into an opportunity. As the authors claim: "the very globalization factors adversely affecting the region's traditional industries are helping to open up new and emerging medical markets around the world" (Medilink, 2007: 2).

However, there are many things taken for granted within the guide. For example, why must we consider the medical healthcare industry as being able to 'read' technical skills from the automotive industry? In addition, the classification of lower (automotive) and higher (medical devices) rates of growth is biased; in fact, considering the growth of the actual premium (high quality/high price) automotive market, the analysis used by the guide is completely wrong. Actual growth in the high price/quality automotive industry shows that the question of growth is not a simple matter. All in all, the enactment of the guide does not embrace any kind of alternative scenario or path.

A. Skills transfer?

An implicit understanding of the skills transfer process is more or less shared by those executives working at Med Dialysis. For example, the Chief Technology Officer of Med Dialysis told me that

"...for me to do fluids in another medical device or to go back to fluids around cars, it's just Von Karman's equation" (CTO, Med Dialysis, 04/08/11).

Nevertheless, during the previous interview, the Med dialysis CTO explains that

"once you get really to that very heavily regulated or process-driven thing, then you know the time taken to get up to speed with that will be a lot harder so (.3) you need to get more expert" (CTO, Med Dialysis, 04/08/11).

So, there is an implicit knowledge transfer when it comes to the basic science.

In a second interview, the same kind of answer is offered by the CEO (also an owner) of Med Diabetes. During one of my visits, he refers to the problem of knowledge transfer between automotive and medical device businesses: *"The transfer is relatively simple. Design of a component is the same regardless of sector; however, the rigour and processes in the automotive industry appear to be higher than in the medical sector. This means that when applying this rigour, we end up with a set of business outputs which are scoped correctly and have a high confidence level in their accuracy" (CEO, Med Diabetes, 02/11/2011).*

This apparent contradiction is located at the core of the innovation practices of new organizations. On the one hand, knowledge is treated as a transportable device (expressed as a formula) and, on the other hand, it is treated as being highly sophisticated and idiosyncratic.

The rhetorical construction is presented as a bottom-line argument (Potter et al., 1994) whereby the guide indicates the benefits as being that “the medical and the healthcare sector is growing as people live longer” (Medilink, 2007: Introduction). After the creation of such a space of possibilities, the reader must surrender. In addition, the guide is defined as a “step-by-step [which] guide clearly explains how the medical market is structured and includes advice on how to establish and implement an effective entry strategy, details some of the key support organizations available and [which] offers tips on how to build partnerships” (Innovation Factory, 2012). The guide is a ‘one-stopshop’ approach to innovation for the healthcare marketplace.

It is not clear at all which skills these engineers will be able to transfer from one industry to the other. In fact, the example offers enough information to doubt as to any ready skill transfer between the one industry to the other.

In this sense, there are many questions that the guide does not explore. The market construction and the analysis of skills transferability offer a very particular reading of the problem of technology/industry conversion.

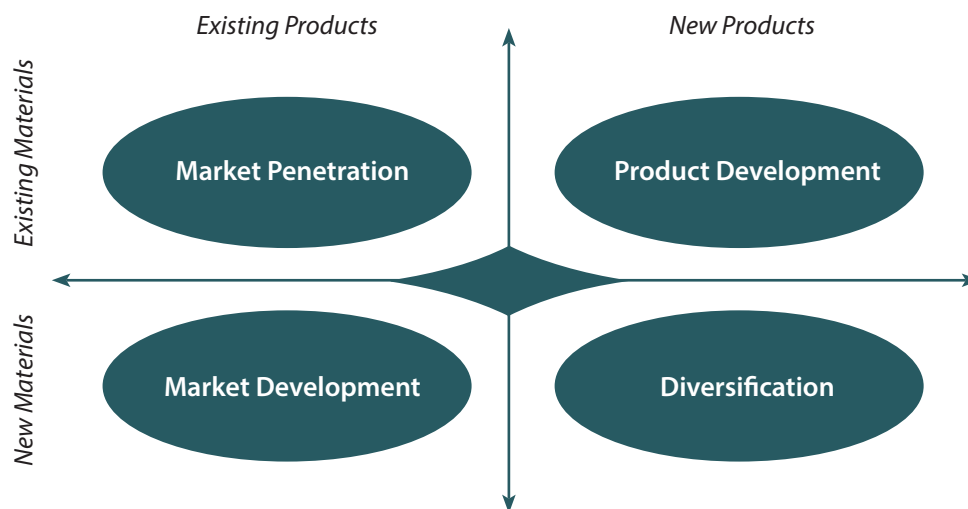
The innovation processes at Med Dialysis and Med Diabetes require the day-to-day questioning of what might be useful from the automotive industry in the development of the medical device business. In particular, Med Diabetes was formed by a group of experts (an industrial designer and IT professionals) who transferred their expertise in automotive design towards the industrial design of medical devices. In the case of Med Dialysis, the professionals come from a more varied range of companies. Therefore, knowledge about medical devices and general healthcare is higher there.

The interesting point is that there is no clarity as to how knowledge transfer will support any particular diversification strategy. Such a strategy demands critical and detailed analysis of the knowledge expressed in the activities of those developing a new technology or product. This point demands hard work. Such manner of work is not once commented upon or even suggested within the guide or its proposal for diversification as the strategy to convert engineers in the Midlands.

3. Diversification- a road map: why diversification, why now?

The second reason that the guide offers for supporting change is based on the diversification strategy (see Figure 2). Indeed, by the use of such exemplary cases as Nokia and Bang and Olufsen, the guide shows the success of such a strategy. In particular, the guide presents the strategy in terms of the triumphs of companies who have successfully reinvented themselves by the use of a diversification strategy. Such rhetoric looks to convince the reader to embrace the change taking place between the automotive and healthcare/medical devices industries.

Figure 2: Ansoff's matrix (as presented in the guide).



B. Business models in Med Dialysis and Med Diabetes

Med Diabetes and Med Dialysis's general innovation strategies follow a particular belief in the goodness of the properties of the products/services. This point goes against the insights of the 'design thinking' (Brown, 2008 ;Martin, 2009) literature. What is clear is that the insights of the product development literature (cases about product development) are in way performative within company discourses.

For example, in a conversation with the CTO of Med Dialysis, the executive explains his strategy as a "razor blade business model." Explaining his view of innovation, the CTO makes direct reference to a strategy based on product development in the specific case of the razor blade model:

CTO: hh and actually there is it's a stream of of thought when you have (.) an object how do you innovate (.) the business model

I: yeah

CTO: So do you (.) change the technology to become what this is is a razor blade business

I: mhm

CTO: a disposable (0.2) or is it a high value single point of sale (.) uh: and item rather than a commodity and a disposable commodity

The interesting question is, then: Why is the guide 'selling' the diversification strategy right at the beginning and before any discussion of the healthcare market and business strategy and planning sections? The guide's targets are those companies participating in the automotive industry. These are companies classified mainly within the range of SMEs. Furthermore, the guide does not spare any space or rhetorical tools in 'selling' the idea of the diversification strategy's benefits. For example, the guide uses a survey of SMEs in the West Midlands to demonstrate how the main reason that companies give (55% of the sample) is to increase profits (Medilink, 2007: Introduction). However, the same survey shows that 45% of the sample expected to reduce their risk. The guide is always externalizing or presenting descriptions as being independent of the authors (Potter, 1996). The diversification strategy is presented as a panacea to the economies of progress.

For the CTO, innovation is a synonym of 'business model change'. More precisely, he enacts the 'razor blade' model (Teece, 2010).

As such, this could be seen as an example of Michel Callon's (1998) definition of the performativity of the economy. This is a semantic type of performativity that conceptualizes economic theory as a resource to construct social reality. However, as Jens Maeße (2013: 25) explains, an actor's *"discourse is furthermore a relationship of 'discontinuity' (Foucault, 1982) between the form of language and its meanings that arise out of the different uses which the formal rules of discourse make possible."* Therefore, performativity always has a spectral aspect in as much as the form of language opens up a field for various meanings. In contrast to the semantic understanding of performativity, for spectral performativity the connecting line between economic theory and the economy is not the meaning of the content but the discursive forms (i.e., as a 'model' or a 'formula', and so forth).

In this sense, the razor blade model enacted by the CTO produces an effect because it is a discursive form.

The razor blade model of performativity could be seen as a type of spectral performativity. The semantic content is not the base of the performativity of the razor blade model.

The concept of spectral performativity is closer to the conceptualization of business models as market devices (Doganova & Eyquem-Renault, 2009). These authors see models as having materiality and as participating actively within the conversations and accounts of those who have the power to reproduce the model through the company (on this point, see also: Mason & Spring, 2011). For Doganova and Eyquem-Renault, models are not simply an abstraction of reality.

There is no single best business model for a particular technology (such as mobile dialysis or a mobile device to treat diabetes). There are, however, business models that produce different effects and enact different strategies.

Moreover, in a clear case of the 'performativity of the economy'(Callon, 1998a) the guide directly quotes:"according to traditional economic theory, firms diversify to exploit economies of scale and scope in order to lower costs of production"(Medilink, 2007: Introduction). This is a bold assertion extracted from books on managerial economics and/or industrial economics. However, the effects of diversification on economies of scale and scope have been subject to the scrutiny of management and organization studies scholars. For example, Palepu (1985) has shown that diversification bears a significant relationship to an increase in profits when the company diversifies in a related business. Thus, a question emerges as to the relatedness of the healthcare and the automotive industries.

Although such a diversification strategy could be related to an increase of certain economies of scope in the case of Nokia, the question remains whether the same strategy is useful for those companies entering the medical devices sector from a different sector, such as the automotive industry. As the literature on this phenomenon has shown, economies of scope (or to increase market power)are not a result of unrelated diversification (Mahoney & Pandian, 1992: 362).

The previous point offers some new light on Perkmann and Spicer's (2010) work on business models. These authors consider business models to be "tools that allow entrepreneurs and managers to imagine and craft organizations adept at drawing value from new technologies" (14). Business models assist managers in creating sense and legitimacy around new ventures. Although the CTO is not the only one using the idea of a business model at Med Dialysis, he is the top executive in charge of the technology and product processes; therefore, his use of the

model could have an important effect on the company's decision-making process.

The performativity of innovation theory is much stronger when it comes from the top of the organization. So, engineers can adhere to different meanings of what constitutes 'innovation' at Med Dialysis and Med Diabetes. It is clear that the power dimension is still an important one for the diffusion of organizational ideas.

It is worth noting that the guide is full of what Bruno Latour (2010) calls 'factishes'. That is, that any entity or concept fabricated by business strategy and management theorists shown in the guide may nevertheless be referred to as 'real', gifted no matter that they are 'fabricated' with an autonomous existence. As Latour explains, the concept 'factish' is a compound of 'fetish' and 'fact'. Both words inherit an ambiguous etymology. The word 'fact' points to external reality and 'fetish' to the "foolish beliefs of a subject" (Latour, 2010: 21). Equally, both words, because of their Latin roots, conceal their respective 'processes of construction' - namely, the process of the construction of the truth of the fact and the process of the construction of the truth of the mind.

The diversification strategy hides the construction of its own category. The public policy that hides away this construction affects those making decisions for change (from the automotive industry to the medical devices industry) in the Midlands of the UK. This thesis argues that 'diversification' appears to be a factish that is 'real' and 'endowed'. It is a factish that conceals its fabrication and has its own autonomous existence.

4. Performing in the medical devices market in the West Midlands of the UK

A central tenet of the guide is to "sell" the opportunities that the medical devices industry offers for those with skills in design, manufacturing and logistics in the Midlands. The enactment of a diversification strategy as the solution for the Midlands SMEs is caught up with the definition of the supply chain that the guide puts forward for the medical devices industry. The health service's value chain is compared with the automotive and aerospace industries (Medilink, 2007: The Healthcare Market). This thus defines a 'space of possibilities' where the SMEs can 'see' the opportunities that the health service offers to them. Furthermore, the guide presents the automotive and aerospace supply chains in the traditional pyramidal form, in which the SMEs are participants as Tier 2 or Tier 3 suppliers (Lambert et al., 1998) of big manufacturers and the final end-service provider (i.e., a car dealer or an airline). Unfortunately, there is no diagram (triangle) of the chain in the case of the health services

C. Med Dialysis's and Med Diabetes' commercialization processes and their relations with the NHS

The NHS is a crucial actor as regards the interviews and observation at Med Dialysis and Med Diabetes. The NHS is all-pervasive, arising whenever the executives of Med Dialysis talk about commercialization and their marketing efforts, but also when they refer to the technological development and future finances of their potential operations. The NHS's norms and public procurement are decisive factors in the success of a new technology/product's commercialization.

The interaction between the interests of the NHS and the interests of the company is a matter of practicality. The enactment of the NHS by the commercial executive of Med Dialysis is an interesting case that informs the relationship with this important actor in the medical devices industry.

Although the commercial aspects of Med Diabetes will be analysed in detail in Chapters VII and VIII of this thesis, some preliminary points need to be mentioned now, namely the particular enactment of the NHS by the commercial manager of the company.

In the guide, the NHS appears as the unique contact point with the final customer. Instead, the guide describes a completely unstructured supply side in the health services. The guide positions the commercial opportunity in this messy and unclear value chain. For the guide, SMEs "can and do manufacture finished products which they supply directly to the NHS or to the distributor" (Medilink, 2007: 2.1. The Healthcare Market).

CM: <i>Commercial manager</i> - I: <i>Interviewer</i>	Translation
CM: la institución el el NHS es una institución que esta eh (0.2) totalmente yo yo diría que es dice está diseñada para eh satisfacerse a si misma (.) eh(0.1)	CM: The NHS as an institution that is, eh; totally, I would say that is designed to satisfy itself...
I: ok	I: Ok.
CM: no para satisfacer las necesidades de los pacientes ha tenido mucho tiempo para: para: navegar y para formarse como una entidad que está diseñada comouna célula para existir	CM: not to satisfy the necessities of the patients. It had too much time to navigate and shape as an entity that is designed to exist as a cell.
I: aha	I: Aha.
CM: el NHS existe para existir no esta (:) internamente la mentalidad que es para servira la comunidad	CM: The NHS exists to exist; there is no internal mentality to serve the community...
I: mmm	I: Mmm.
CM: y eso se ve en todas partes pero la innovación siempre va a chocar contra el muro de la inercia la inercia sobre todo en organizaciones donde eh (0.1) donde no hay un incentivo real por hacer un cambio en instituciones donde dejar el lápiz botado a las cinco porque me pagan hasta las cinco y si no hay liderazgo y leadership em es muy es mucho más fácil no hacer nada	CM:and you can see this everywhere; but the innovation always collides with the wall of inertia, above all the inertia within organizations where, eh, there is no real incentive to change in an institution where I stop the work at five because they pay me until five, and if there is no leadership it is easy to do nothing.

The guide might be considered to be a demonstration in the sense of Ashmore et al. (2005). These authors explain that a demonstration can be understood so as to "render something visible and remarkable" (Ashmore et al., 2005: 78). At the same time, the authors remark that to demonstrate is to re-enact or to make something act one more time. As a consequence, a demonstration is a 're-presentation' of something. However, within this re-presentation, somebody has control over this 'staging' process. This is because of the theatrical aspect of the demonstration. In other words, this representation can be conceptualized as a translation of the object presented into a different set of references (Stengers, 1997; cited in Ashmore et al., 2005: 78). As a consequence, and as a demonstration, the analysis of the guide permits us to go beyond any discussion of its truthfulness and usefulness and to instead study its performative aspects (Doganova & Eyquem-Renault, 2009).

The NHS is presented as a powerful self-organizing entity that is absolutely centred on its own needs and nothing else. This is obviously an extreme case formulation (Pomerantz, 1986; Edwards, 2000) of how the NHS actually works. It is a public fact that the government coalition is changing the way that the NHS is administered by, for example, cutting costs and rearranging the decision-making process throughout the service.

It is interesting that this issue of the satisfaction of his own needs (as presented by the commercial manager) is seen as 'the' big opportunity for the commercial department of Med Dialysis. Accordingly, the language and the metaphors that are used by the commercial manager categorize the NHS as an entity that needs help in challenging its inertia, and this generates a commercial opportunity

Med Dialysis's commercial manager constructs

through its commercial activities. As is further explained in Chapter VII, the methods that the company uses to 'help' the NHS are based on spreadsheets that reveal the hidden costs of the dialysis process. This is an example of what some economic sociologists have called an 'economization process' (Çalışkan & Callon, 2009; 2010); that is, a process that brings the economy to the front of the analysis within any human activity.

The assemblage that is the dialysis service is economized by the use of technologies that serve to enrol the NHS and the new product/services that Med Dialysis is commercializing. Furthermore, these basic accounting techniques are part of the complex mixture that is part of a "calculative infrastructure...that has acquired widespread social legitimacy...not only for corporations but also for public services" (Miller & Power, 2013).

The lack of a clear diagram for the health services enacts an ambiguous value chain for medical device companies. The guide shows the goal but never the path for those who are actually in the automotive and aerospace industries and are considering diversification into the medical devices industry. Ambiguity is being used as a resource to open up a broad (but never clear) range of alternatives for those companies needing to confront the changing industry. The role of ambiguity will be further discussed in Chapters VII and VIII.

Another important aspect of the guide that supports the idea of diversification as the 'saviour' strategy is the use of case studies. In particular, case studies are used to support the performative power of the guide - the cases add to the staging process the power of an out-there-ness (Potter, 1996). Therefore, they configure a scientific type of discourse for the guide.

What is interesting in the Med Dialysis case is that the idea of innovation goes further than the improvement of the dialysis process itself.

To do big business, the medical device company needs to be associated with the government. Furthermore, the venture company needs to be associated with the change management process of the NHS.

The device that Med Dialysis uses to open up commercial opportunities also facilitates opportunities for the organizational change of the NHS and the success of its politics of healthcare. This device can be conceptualized following the academic tradition of governmentality studies (Foucault et al., 1991), where accounting practices are defined as an assembly of heterogeneous elements, like ideas, laws, spreadsheets and standards like those being used by the commercial manager (i.e., a spreadsheet of the hidden costs of the dialysis process).

Considering technological innovation as a dispositif (see Chapter III), this device is aligned with the techno-innovation dispositif defined, among others, by the NHS and broader governmental policies.

As Miller and Power (2013: 24) put it: "there are some obvious beneficiary agents in this development - professional groups and the large consulting firms who are agents of neoliberal reform and corporate governance processes." Everybody is getting something in this relational network of humans and non-humans, from the NHS, companies like Med Dialysis, and a series of other entities participating in the medical devices sector (for example, Medilink).

As a corollary, the important question is: What is the guide producing and enacting with the readers? It is not an issue of whether the guide is presenting a truthful account of the transformation from the automotive and aerospace industries to the medical devices industry.

Another important aspect of the guide that supports the idea of diversification as the 'saviour' strategy is the use of case studies. In particular, case studies are used to support the performative power of the guide - the cases add to the staging process the power of an out-there-ness (Potter, 1996). Therefore, they configure a scientific type of discourse for the guide.

Furthermore, in the case of the medical devices sector, it seems that the link between the entities of the network is stronger. In fact, the point is clear in the next extract from another conversation with Med Dialysis's commercial manager:

CM: Commercial manager - I: Interviewer	Translation
I: hay un link con eso que está pasando de entender un poco más como entidad económica política el NHS lo que pasa con el nuevo gobierno	I: There is a link with what is happening in order to understand the NHS as a political-economy entity that emerges with the new government.
CM: eso es °exactamente° lo que quieren hacer (.) nadie se ha dado cuenta ellos quieren deshacerse de los primary care trust (.) lo vamos a sacar los primary care trust porque ya no se necesitan es mentira claro que esas functions se necesitan pero lo que quieren es romper quemar los puentes y que se arme algo y en vez de usar trescientas personas usen cincuenta porque las funciones tienen que hacerse pero ya el sistema engorda tanto que lo más fácil es simplemente decapitarlo y poner a alguien nuevo porque imagínate empezar a exprimirlo y empezar a echar gente	CM: That is exactly what they want to do. Nobody is aware that they want to get rid of the primary care trusts; we are going to get rid of the primary care trust because we don't need it anymore. This is a lie. Sure these functions are needed but what they want is to break it, to burn the bridges and assemble something new. And instead of using three hundred persons [they] use fifty because the functions need to be done but the system is now so fat that it is easier to decapitate it and put somebody new in...
I: y entonces el costo político de ello sería mucho mayor	I: The political cost will be higher.
CM: mucho mayor porque empezarían la huelgas y que se yo entonces lo que están haciendo yo encuentro que es una movida maestra porque lo que están haciendo es simplemente (0.1) deshacerse de la estructura sacar la tremenda cuenta que tienen y y hacerlo más eficiente.	CM: It is much higher because strikes will come and I don't know then what they are doing; I think this is a master move because what they are doing is simply getting rid of the structure and making it efficient.

The market is then constructed within this re-presentation of the medical devices industry as a sort of opposition to the aerospace and automotive industries. Therefore, an important issue concerns how the guide mediates the presentation of the industry and the market. Michel Callon calls this kind of mediation a 'performance' (2010). This is not purely the semantic performativity of the economic theory or the text/words, but rather the performative effect of the entire socio-technical agencement that the guide belongs to. Such a phenomenon as performance demands the existence of a myriad of other heterogeneous entities. As a consequence, the strategy of diversification rests on this entanglement of relations and concepts. The guide belongs to an assemblage that is based not only on marketing tools but equally on the sector policies and economic policies of the public sector represented by the NHS and the government's public policy on healthcare procurement (particularly in Section: 2.2 Public Sector Procurement).

In such an assemblage, the enactment of the healthcare market and the medical devices industry is a compound formed of the relations of government, the state and the private sector, and the particular set of competitive strategic tools presented in the guide. As a consequence, there is a clear link between the analysis at the level of the tools and the various organizations and industry-level and sector-level economic policies. The proposed strategy of diversification towards the medical devices sector brings forth the whole set of ideas and policies of the economic authorities. The performance is not complete if those actors are not enrolled by the guide. This is an interpretation that pushes an idea of a market and an industry in which the Midlands' SMEs will perform better if they correctly diversify their operations towards the medical devices sector.

Sure these functions are needed but what they want is to break it, to burn the bridges and assemble something new. And instead of using three hundred persons [they] use fifty because the functions need to be done but the system is now so fat that it is easier to decapitate it and put somebody new in...

Within the conversation, the manager uses a series of discursive devices to create the space where Med Dialysis will operate. In particular, his use of footing (Goffman, 1979) - "we are going to get rid of the primary care trust because we don't need it anymore" - is contrasted with his later argument, where the 'real' goal of the NHS is shown.

I: The political cost will be higher

CM: It is much higher because strikes will come and I don't know then what they are doing; I think this is a master move because what they are doing is simply getting rid of the structure and making it efficient.

In the particular case of the NHS and public sector procurement, the guide offers a great deal of information about the procedures, practices and regulations of the purchasing process in which the NHS and its state-owned apparatus are involved. Obviously, the guide is pushing a practical agenda. It is easy to see how the general concern of this section is with how to succeed in making sales to the public sector and - in particular - to the NHS. For example, the guide describes in great detail the centralization of the entities participating in the NHS procurement system. Institutions like PASA - NHS Purchasing and Supply Agency- (www.pasa.nhs.uk) and the NHS supply chain (www.supplychain.nhs.uk) under the NHS Business Services Authority (NHSBSA) as well as the organizational structure of the NHS circa 2007 are summarized in detail and explained. In particular, the guide describes the cost reduction plan of the NHS, whereby the entity has a cost reduction target of one billion pounds in savings.

It is here that he produces two poles: on the one hand, the NHS public account, and on the other, the NHS's basic goal, namely the reduction of NHS fat while minimizing the political costs.

Med Dialysis exists to help with this basic goal. This is an interesting point, because this is seen as the opportunity to eliminate inertia and innovate in tandem with the new NHS policies. As a result, the competitive strategy of Med Dialysis intelligently uses the policies and political ideas of the NHS (and the Health Department) in a way that aligns the company within the general healthcare dispositif to which the NHS belongs. As a corollary, with the help of new services and products from the private sector, the NHS is changing how it does things in the healthcare sector. This is a case of innovation by the assemblage of a dispositif.

The Med Dialysis commercial manager has been trying to enrol the various actors as well as the entire procurement system. He is also offering the opportunity for organizational change in the NHS. Furthermore, with the solution offered by home dialysis and the spreadsheet that shows the hidden costs of the process, Med Dialysis

is not just supporting but also constructing a fundamental aspect of the dispositif that the Health Department is operationalizing within the new NHS. The assemblage that is the healthcare system emerges as a reality with the partners of the NHS. Organization and management studies should view calculative practices as being vital to their field of study rather than something within the sphere of the technical. The technical and what is normally called the 'non-technical' (for example, some aspects of politics) need to be considered together to understand the phenomena of products and services in a technological environment.

An example of the complex relationship that exists between knowledge, purchasing and the creation of a particular market for home dialysis as an economization process is shown by the enrolment that Med Dialysis performed of the document Economic Report—Home Haemodialysis, produced in March, 2010, by the important NHS Centre for Evidence-based Purchasing (NHSCEP).

Finally, the guide describes other relevant actors within the procurement system of the NHS, such as the NHS collaborative procurement hubs, the e-procurement entities and, more importantly, the Primary Care Trust procurement level and the NHSCEP (www.nhscep.useconnect.co.uk). The NHSCEP belongs to PASA and is of particular importance because it is the agency that performs the analysis of new medical devices and which works in close connection with the institutions that run tests and look for improvements from the perspective of regulators and clinical excellence. The guide shows (without a clear mention of it) the interesting outsourcing trend exhibited by the NHS's procurement activities.

This implicit acceptance of any outsourcing strategy demands further analysis. The guide enacts the market, stressing outsourcing as the central mechanism to solve the problems of the NHS. The guide is not just describing a trend - it is also promoting it. To confirm and achieve its health-based economic goals, the state needs the private sector for important tiers of their supply chain management. The guide presents the NHS as any other private company that requires a 'modular' value added chain, where vendors such as Med Dialysis and Med Diabetes are called in to participate. Now, let us look in some extra detail at the outsourcing strategy (or, as it is called in the guide, the 'partnership' strategy)

Med Dialysis uses this report in order to support their strategy. The document compares quality-adjusted life (QALY) and the total cost of annual treatment of home dialysis and hospital dialysis. The NHSCEP promotes home dialysis. The interesting issue is not the calculations or the very strong assumptions that the NHSCEP employed to produce the document (even though these suppositions could be considered problematic by some analysts). Instead, it is the use of the evidence as it appears on the Med Dialysis web page of a publication in the Clinical Kidney Journal that is obviously a referent for those professionals working on kidney diseases and dialysis treatments. It is possible to see the construction of the dispositif and the emergence of the market for home dialysis.

As a corollary of the present section, it is not difficult to see that the construction of the procurement service market is thus completely enmeshed with the characteristics of the supply chain organization in which the NHS is central. This organizing process and its relation with the supply chain and modularity it will achieve form the topic of the next section, which provides stories from the fieldwork sites.

5. Partnerships, networks and outsourcing in the medical device sector

In point 5 of the guide, the concept of partnership emerges as a panacea for the creation of the necessary capabilities and skills in entering the medical devices sector. The guide asks, with its familiar rhetoric: "Did you know, for instance, that one of the world's biggest and most successful electronic games companies is based in the West Midlands region?" (Medilink, 2007: 5. Partnerships & Networks). The guide tries to give a model of extended regional partnership that is based on technology and skill transfer between the actors of the West Midland's region as a toehold for the development of new medical health companies. With this rhetoric, the guide presents the 'local' as something to be discovered.

D. Technology, inbound supply strategy and the organizing process at Med Dialysis

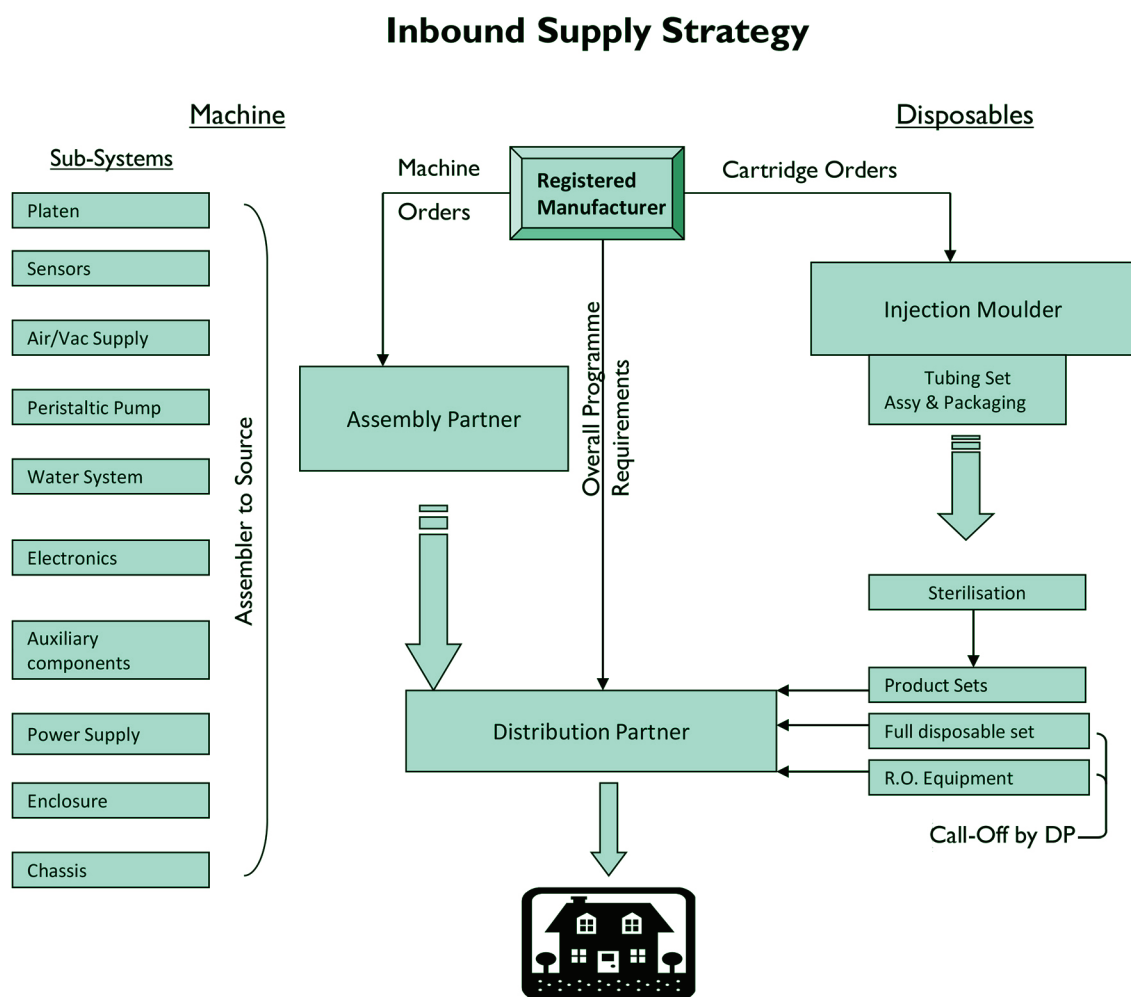
The Med Dialysis CFO pushes forward an idea of innovation in the business model based on the construction of partnership with their vendors. In his words, this needs to be much closer to the one that exists in the automotive industry (as in the case of auto parts vendors). What is interesting about his account is the use of the partnership diagram as a sort of model to explain - and at the same time to support - his discourse. His account is completely tangled with the materiality of the diagram being used.

Med Dialysis has been designed as a company that will work with partnerships in the inbound and the outbound value chains. It exhibits a

tremendous entanglement between the very same technology of the dialysis machine and the design of the value chain (see Figure 3 for an example of the inbound strategy). It is perfectly possible to see the importance of the technological solution in shaping the supply chain and the value chain of the virtual company. In fact, this device (the diagram of the inbound supply strategy) is enacting a particular form of the future. This is a future that is partially organized by the use of the inbound supply strategy diagram.

The guide presents the car industry as the epitome where to look for these capabilities and skills. However, the section looks to further explain the possibilities of partnership (see figure below) as a form of "cooperation in which organizations that work together share with each other the profits or losses of the undertaking in which all have invested" (Medilink, 2007: 5. Partnerships & Networks). The authors present partnership as an alternative to in-house development and buying-in capabilities. Proposing an "agile and flexible" orientation for the first steps of the diversification strategy, the guide positions partnership as a way to avoid the commitments of in-house or buy-in strategies. At this point, the guide becomes very normative as a discourse using bottom-line rhetoric (Potter et al., 1994) regarding knowledge as to what type of strategy is necessary to embrace the diversification of medical devices. In fact, claims such as "often it is unrealistic, inefficient and too costly for SMEs to build up new expertise" (Medilink, 2007: 5. 1.2. Partnerships & Networks) are in line with this rhetoric.

Figure 3: Med Dialysis inbound supply strategy (modularization).



It is always interesting to see what the author is looking for with this type of rhetoric. However, in the case of the guide, it looks as though support for the diversification strategy is supported through the entire guide and without any doubt. The use of discursive devices like bottom-line rhetoric is aligned with the use of dispositifs, such as Ansoff's Matrix (see points 2 and 6 in this chapter). The rhetoric of the partnership is thus supportive of a more general strategy of the document that seeks to convince as to the necessity of change and the acceptance of diversification as the best strategy to create change and gain access into the medical devices industry. Beyond this, although the guide does not support any one kind of partner (e.g., the private sector, SMEs, large companies, universities, research institutes, etc.), the document emphasizes the "knowledge base" partnership. This is defined as a partnership with "public sector research and teaching organizations, including universities and specialist research institutes" (Medilink, 2007: 5.2. The Knowledge Base). The decision is clear in terms of the short coverage given to private sector (i.e., company to company) partnerships in comparison to the significant treatment given to the knowledge-based type of partnership.

In figure 3, it is possible to see that there are two parts in this "inbound value chain." The first is the cartridge (a disposable cartridge) that cleans the blood during the dialysis process, and the second is the mix of machine parts vendors. The diagram clearly shows the division of these two aspects of the technology/product. However, what the diagram does not show at all is the risk involved in the complex connections that emerge between Med Dialysis and all its virtual partners.

In fact, the diagram is a translation of the world and it in fact - in some way - deemphasizes the risk, since it produces an image of solidity about a project that is not at all solid. The diagram needs to sell and enrol those who work in Med Dialysis to align the future in the present. It is, in a sense, a black box (Latour, 1987; 1999).

The inbound strategy diagram offers the possibility of understanding a point about technological development - that is, a development process that is closely connected with aspects that are not at all technical. For example, organizational aspects are at the same time shaped by the technology that the company is developing. They are in a mutually dependent relationship.

The guide insists that SMEs can develop partnerships to build up capabilities in any given area. For example, the guide claims that partners could be hospitals, with a view to developing knowledge of users, or even large companies. Unfortunately, what the guide fails to elaborate in any depth are the economic and power relations within partnership agreements. For example, the relations are asymmetrical wherever partnership emerges between large- and small-sized companies. Why then, does the guide insist on partnership as the solution instead of - for example - in-house development and buy-in strategies? The literature has shown that in order to operationalize the strategy of partnership - particularly with the vendors in the supply chain - management of the companies is very difficult (Boddy et al., 1998). Additionally, partnering in the supply chain management of any firm is based on collaboration. Therefore, in order to produce good results, it is necessary to establish partnership assets. These types of assets could increase the benefits of using a partnering infrastructure to exploit innovative ideas. Unfortunately, such assets are normally outside of the scope of the initial partnership agenda (Maheshwari et al., 2004). It is thus a complex and complicated process of learning from each other that is based on commitment between the parts.

The point is better understood when the concept of modularity is brought to complement the analysis of the supply chain inbound strategy represented within the diagram. This presentation is a "mixture" that presents the technological innovation of the disposable cartridge and its distinctiveness from the machine. Med Dialysis is using modularity (Baldwin & Clark, 2000) to model its supply chain system. Modularity as a solution always deals with complex systems and distinguishes between the interdependence and the independence of the 'modules' which, in this case, comprise the network that is the inbound supply chain of Med Dialysis's new product.

In terms of the CFO's account, the medical devices industry needs to go further than the automotive industry in the use of modularity strategies. This is aligned with some of the

literature which sees modularity as a strategy for supply chain coordination (Ro et al., 2007).

These modules are "structurally independent" but need to work together insofar as "a module is a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units" (Baldwin & Clark, 2000: 63). In the case of Med Dialysis, it is easy to see the difference between, first, the mechanics of the fluid and, secondly, the cartridge. What is less easy to see are the implications that this technological distinction within the organization and in particular on the organizational aspects of the supply chain.

The guide does not mention any of the difficulties of engineering partnership strategies. Such a process demands materiality in the forms of contracts, documentation and quality guides, among other documents. Even with these documents, the creation of assets that can be shared and exploited by two different entities is no easy task. Since the guide is focused on a diversification strategy (defined as the creation of new products for new markets), innovation is one of its probable outputs. Unfortunately, the partnering strategy becomes even more difficult when the desired output is innovation. The difficulties involved in the creation of partnering for the development of new medical devices is something that the guide needs to explain further. Erin Anderson and Sandy Jap explain that partnership and close business relations in general are relatively easier at the beginning of the relationship. Unfortunately, later on in the relationship - with future developments - the creation of a “network of indebtedness” between the partners acts as a wall to generating new connections with external new partners who could bring new opportunities to better satisfy the novel requirements of users and lead to new innovations (Anderson & Jap, 2005)

This modular strategy (modularity in short) of the technology affects the organization because of the complexity of the parts and the distinction between machine and cartridge, which generate distinctions in the management of those virtual partners who actually participate in making the product and technological development. In line with this, some organizational design studies (Sanchez & Mahoney, 1996; Langlois, 2002) have discussed this issue. The modules that Med Dialysis sets up organize its actual and potential activities. The diagram of the inbound supply chain is no less than the representation of the complex network of contracts that organize and control the actual process of development and the future operation of the commercialization of its new product.

In fact, during the conversation with the CFO of Med Dialysis, he used the modularization diagram to support his explanations regarding disruptions as well as to manage any problems that had implications for the supply agreement/contract of any machine part.

A possible hypothesis is that the organization of the group of modules and its related contracts -including quality agreements- it is shaping the technology as a whole. It is the development process what it is shaped by this particular modular disposition.

There is no such a thing as pure technological development separated from organizational development. As a result, the problem is not the modularity of the products' design in organizations. Instead, the mediation of the technology generates additional complications (Latour, 1996). Technology mediation allows for the dual direction of the movement. On the one hand, as Sanchez and Mahoney claim, the organization is shaped by the technology and, on the other, the organization's development process generates a particular type of technology.

What the guide lacks in coverage of the supply chain and the technological development of private company partnering is more than compensated for by its extensive coverage of the potential of the knowledge base as a research sector partner for any SMEs looking for a diversification strategy to move into the medical devices industry. Furthermore, in a self-reflective moment, I should explain that I was myself considered to be a 'partner' of a knowledge base located outside of the West Midlands (Leicester, in the East Midlands, UK) Nevertheless, I recognize that access was granted in the spirit/philosophy of this type of relationship. Since any partnership is based on the reciprocity of the agreement, I tend to think that the present work did not generate a long-term relationship with the fields and companies studied.

A critical point of view of the partnership emerges in a casual conversation between myself and one of Med Diabetes' owners:

I: So, what about this relationship?

O: It's is, hhh, I suppose [it] is the most difficult part of working with an academic organization which is the (.) Of course, intellectual property rights, patents, etc., are based around intellect based on research based around, not so much application, but ideas that what academics in institutions do best; they do ideas they do theories, they do concepts best, not always the end applications for that; and so quite roughly if you enter into a research project with the university, they're going to want to keep hold of what they own, which is the key commodity, which is knowledge.

I: Mhm.

O: am is no point if you [are] looking at this from a business point of view, if your key commodity is knowledge you wouldn't give that way for free (.) There's no point

and it's completely counterproductive at the same time; the struggles we've had with universities previously is with the experience of lots of people with her own universities who use projects such as ours to justify that position within the university.

I: Mhm.

O: So we had [this] with lots of enterprise researchers who had used us as a CV case or a portfolio case for them, which means that they can [go] back to the university financial boards and say 'I don't need to teach, I don't need to get into teaching 'cos look at all this amazing work I'm doing over here' (.) [and] when actually they're personal input into the project had been very minimal. a:m an and that that is something I see quite a lot and it maybe the culture which mainly works this way in Staffordshire, so maybe the culture within Staffordshire I suppose not to all academic institutions but I had heard it from elsewhere as well.

The guidelines that are offered to understand the relationships between universities, research centres and the public sector are very precise. However, the main solutions that the guide offers are located in the management of the project. This is obviously a very mechanistic view of a project of this nature. The guide even offers a list of “common complaints” and various “suggested solutions” in a FAQ. This is not wrong per se, but it looks at the very least biased in terms of the positivity of the examples provided. The contention is that the guide is building a positive discourse. Such a positive formulation “offers a seductive discourse, with much promise. It presents a broad vision of the sunnier side of life, where positiveness can be harnessed for noble individual and organizational ends” (Fineman, 2006: 270). This seduction is a fundamental part of the diversification strategy enacted by the guide.

So, what is interesting about the account of the owner is that the university acts as something like a parasite in the partnership. In particular, with the use of a footing device (Goffman, 1979) the owner claims “I don’t need to teach, I don’t need to get into teaching ‘cos look all this amazing work I’m doing over here.” He is stressing interests that exist on the side of the university. Thus, he is generalizing when he claims that “I see quite a lot” of that particular behaviour with partnerships with a West Midlands university. As a matter of fact, all of the executives were agreed on this point. In one of the conversations with the CEO of the company, it is explained that if he were to use the technological park of a particular university that had facilities for design and usability consultancy, it would simply be because the office rent is quite cheap and because the manager of the centre had asked him personally (as a favour) to suggest a higher percentage in the use of the facilities.

In the view of this young owner, the university is trying to commoditize the results of the research project. So, how is it thus possible to bring them together into a real partnership process? In the view of the owner of Med Diabetes, this is the key commodity of the company; therefore, this is something that he is not willing to cede to the university. Intellectual property rights require hard work, which is why partnering is not an easy task between companies and Universities. What it is important to see is the underlying economy of the partnering. The contract is a complex one. This is particularly the case when the company is not simply a spin-off of the university and wishes to preserve the knowledge that it wants to patent.

As a matter of fact, questions about the foundation of relationships between universities and private companies emerge from the analysis of the guide. For example, what is the economic nature of the partnership and the form of the modularity? How it is possible to build trust between research institutions and companies? What kind of relationships do we need in order to generate technology transfer between universities and companies? The contention of this thesis is that the idea of partnering - particularly those related to research centres and universities - indicates a change in economic organization and the techno-scientific realm. As Rebecca Lave and her colleagues have put it: “the rollback of public funding for universities... the dissolution of the scientific author; the narrowing of research agendas to focus on the needs of commercial actors; an increasing reliance on market take-up to adjudicate intellectual disputes; and the intense fortification of intellectual property in an attempt to commercialize knowledge, impeding the production and dissemination of science” (Lave, Mirowski, & Randalls, 2010: 659).

Lave and her colleagues present some of the questions that emerge if the relations between universities and ventures companies take the form of a modular partnership. Lave et al. (2010) have called this phenomenon “neoliberal science policy.” It is here that management extends its power far beyond the patent system. This is the form by which the economic forces of neoliberalism transform techno-science. Obviously, this is not the only one way of doing things - this type of economization is not necessarily the best type for society. It is an open question as to whether there are alternatives to the present dispositif. Partnerships between the actors who produce public-based research and private SMEs need to be thought through in terms of the economic nature of such agreements.

6. Business strategy and planning as a tool to create the future

The guide presents business strategy and strategic planning as a path to a diversification strategy. Section 3, “Business Strategy and Planning” presents a series of competitive strategy theories and tools. As in the introduction, the first is Ansoff’s Matrix (Ansoff, 1957). These are some of the tools and theories by which managers possessing university degrees - such as MBAs - tend to view the natural form of the conduct of management practice.

E. Michel Porter visits Med Dialysis and Med Diabetes

The next extracts of the conversations with managers will shed some light as to the use of strategy tools at Med Dialysis.

CM: Commercial manager, Med Dialysis.	Translation
CM: eh mapear entonces todo esto lo único que método que podría ser un poco a lo mejor es Porter five forces porque es un poco mas macro un poco mas macro entonces te permite ver que el gobierno te empuja por aquí las las barreras están acá eh la industria hemodiálisis ha mantenido treinta años muy cerrada donde no hay entonces un poco pero para conocer clientes es es muy elevado el Porter	CM: Eh, the only one method to map, then, all of this, that could be a little bit better, is Porter's five forces; because it is a little bit more macro a little bit more macro, and then it allows you to see that the government pushes you to here and the barriers are here; the haemodialysis industry had been maintained [as] closed for thirty years; therefore, Porter is too high and has little to offer.
I: si claro	I: Sure.
CM: no te sirve para el work on the round (.) sirve para la estrategia pero pero el problema de herramientas como esa es que puedes aplicar la herramienta durante seis meses hacer un reporte la gente lo lee y dice (0.1) pero no he aprendido nada nuevo porque esto es obvio	CM: [It] does not work for the work on the ground (.) [It] works for the strategy but the problem [with] these kinds of tools is that you can apply the tool during six months. then do a report, then the people read it and say (0.1) "But I haven't learnt anything new because this is obvious!"
I: aha=	I: Aha.
CM: =mucho mucho del del marketing y de las herramientas tradicionales están diseñadas para yo pienso que que esta para eh business to consumer	CM: Most of the marketing and the traditional tools are design, I think, for, eh, business to consumer.
I: mmmmm	I: Mmm.
CM: no no no no es mucho para business to government o busines to busines	CM: Not for business to government or business to business.
I: aha	I: Aha.
CM: sobre todo cuando hay tanta variabilidad tantas stake holder para el gobierno por la políticas públicas están eh a lo mejor hay herramientas de más alto nivel pero yo no las yo nos las conozco (.) la enfermera no está interesada en el punto de vista comercial o o económico	CM: Above all, when there is so much variety, so many stake holders, for the government, for public policy, maybe there are better tools of a higher level - but I don't really know it (.) The nurse is not interested in the commercial point of view, nor the economic one.
I: claro	I: Sure.
CM: está interesada en su paciente y en su bienestar personal	CM: The nurse is interested in his patient and his personal wellbeing.

Ansoff's Matrix is presented "in order to graphically define diversification as entering new products or services in new markets" (Medilink, 2007: 3. Business Strategy & Planing). Although the analysis began with a call for the analysis of resources (Wernerfelt, 1984; Peteraf, 1993) and core competencies (Prahalad & Hamel, 1990), it quickly falls back into the diversification represented by Ansoff's Matrix. There is nothing inherently wrong about the representation of a strategy in a 2x2 matrix. As an example, Neil Pollock (2011) has recently presented Gartner's "magic quadrant," which is a 2x2 matrix that shows the "positioning [of] technology players within a specific market" and classifies consultancy companies by their ability to execute and the completeness of their vision. What Pollock established is that the magic quadrant is not just the representation of the market; instead, it is an active entity in the world. In the words of Donald Mackenzie (2006: 12), it is an "an active force transforming its environment, not a camera passively recording it."

The argument, then, is that Ansoff's diversification matrix works in a performative form with the guide. Ansoff's matrix can be seen as a "market device" (Muniesa et al., 2007) because it is a tool that makes possible and renders the market for medical products and services. Whenever the diversification strategy leads the virtual incumbent of medical products and services to enter the market and produce a particular offer to a new market with a new product, the device that is the matrix generates movement and renders the operation of actual and potential companies into the creation of new niches and markets for medical products. Furthermore, the matrix has certain 'affordances' (Gibson, 1977). The device shapes the forms by which the virtual incumbent of the medical and healthcare market understands the strategies concerning their palette of products and markets.

I: Aha.

CM: Most of the marketing and the traditional tools are design, I think, for, eh, business to consumer.

I: Mmm.

CM: Not for business to government or business to business.

I: Aha.

CM: Above all, when there is so much variety, so many stake holders, for the government, for public policy, maybe there are better tools of a higher level - but I don't really know it (.) The nurse is not interested in the commercial point of view, nor the economic one.

I: Sure.

CM: The nurse is interested in his patient and his personal wellbeing.

What is not mentioned in the guide is the problem of the resources and capabilities that companies need to mobilize in order to produce movement within the axis of the matrix. A discussion of related and non-related resources and capabilities is needed. The matrix reduces the complexity to its limit. Perhaps a different type of matrix is required, one “that captures the fluidity and ambiguity of the social world” (Lightfoot, 2008: 371). This point has already been discussed in Chapter III in relation to Teece’s classification of innovators and followers. As in the cited chapter, what this problem demands is an acknowledgement of the limitations of any 2x2 framework. The work of the scholar and the practitioner should reflect these limitations and understand the complications that emerge from its use. Equally, as in Teece’s case, Ansoff’s matrix brings complications with its use. Furthermore, it becomes an immutable mobile (Latour, 1987) that can be translated within a group of potential entrants into the industry, such as the potential readers of the guide.

The commercial manager of Med Diabetes is responding here to a question about the tools required to develop his knowledge about clients. It is quite interesting that he is directly pointing to the use of Michael Porter’s five forces. There is no doubt that Porter’s tool is a famous one for all those who have studied for an MBA (which is the case with the commercial manager). Nevertheless, the important issue is the lack of practical benefits that the tool offers to the manager. In his account, the tool appears as a presentation device: “you can apply the tool during six months, then do a report, then the people read it and say (0.1).” But it is nothing more and nothing less than a presentation tool.

The device offers rhetorical power as a demonstration device. Therefore, the interesting question is: what benefit does the tool bring to the manager? Why do people still use it if it does not allow them to learn anything new or else is too “high” in terms of the practice that the manager needs to perform to work with its virtual clients and users? It is here where the performative power of the tool appears at its highest level.

It is a report - this is the kind of report that

needs to be done for investors. Porter’s analysis normally appears in the business plan. As a consequence, Porter’s analysis is part of what some authors have defined a ‘market device’ (Doganova & Eyquem-Renault, 2009).

All in all, Porter’s analysis is part of a dispositif designed to enrol venture capitalists and investors.

The commercial manager claims that the tool “works for the strategy.” He is categorizing strategy (Edwards, 1995). In his account, strategy is something different from his practical work. Indeed, the commercial manager claims that many strategy management tools are designed for business to consumer models and not for business to government or business to business models. An interesting point is the commercial manager’s distinction between those models that are implemented to sell products to the NHS and government entities more generally.

The present thesis is not advocating for the abandonment of the 2x2 matrix in management practice, but does make a call for the analysis of the tool itself and the effects of its use. In particular, the problem associated with the device is strongly connected with its visualization. As Bruno Latour (1986: 13) has claimed: “he who visualizes badly loses the encounter.” The visual inscription mobilizes a great number of events in a single location. However, the entire process of these various event productions is loose and packed into this single point. The matrix becomes an object that can move and be translated within a group of potential incumbents of the market of medical products and services. All in all, it is a problem of representation and the new complications that the device brings to the analyst. On the one hand, it simplifies complex information about markets and products, an action that has a clear effect on the potential decisions of the virtual incumbents of the market. However, on the other hand, it complicates the phenomenon, adding new connections with this mutable mobile object.

Furthermore, the Commercial Manager is enacting a distinction between strategic work and practical work.

What is the commercial manager gained with this distinction? A hypothesis might be that the manager is getting some agency and extra importance. This is because there are no tools to organize the knowledge of Med Dialysis's commercial business issues. This is a form of tacit knowledge and there is no managerial tool to make it explicit. This is obviously a strategy to defend his knowledge/power in the company. The practical things that he does are not supported by tools like Michael Porter's five forces. These are tools to display general issues for other audiences. It is his experience and his methods, which he has developed in practice, that allow him to define clients and perform a commercial strategy.

Strategy is a master concept - this is particularly so in the case of Michael Porter's models. As Carter et al. (2010: 582) observe when they refer to these: “In many important ways he can be characterized as the doyen of mainstream strategic research, through his early work on the

five forces” (Porter, 1980). As Mackenzie (2006) might say, the effects of the five forces do not comprise a ‘camera’ that neutrally describes the industry.

This does not preclude the assertion that the five forces model is of extreme importance for other aspects of his work when, for example, he needs to ‘sell’ the project to investors. In this case, the five forces become an engine. What kind of tool is the commercial manager using? Perhaps something closer to tacit analysis, experience, etc. Porter's ideas are reasonably pervasive in business conversations, but they do not seem to be straightforwardly applicable in the current case. For example, in the case of Med Diabetes and the important telecommunications companies who work in the novel ‘mHealth’ (i.e., mobile healthcare) market, the definitions and boundaries of the actors are not so clear. This makes the use of Michael Porter's ideas - and in particular his five forces framework - difficult.

However, the guide does not stop by offering tools and devices to organize business strategy and planning. After a list of questions that require the reader to get into the “essentials” and “start at the beginning” in relation to market research, the guide moves quickly on to a section about “tools”. At this point in the guide’s presentation, the document presents a very traditional business plan tools set. The SWOT (strengths, weaknesses, opportunities and threats) analysis and the five forces analysis are offered as the basic analysis for the diversification strategy. Everything that is mentioned about the matrix is applicable to these tools.

In the next, short example, one of the minority owners of the company (also a software development engineer) is meditating on the use of certain tools to exert a particular generic strategy in the broad area of the information technology industry and computer hardware.

Interview with a Med Diabetes owner:

I: So what do you think about the use of traditional strategy analysis and its change with the new types of businesses that we can see with the Internet and new technologies?

O: Um, and what they used to do is they used to treat it [with a] very traditional business model; they sold cheap components for expensive prices. Then, what happened is, the world - the crowd - came along and started giving them a bad reputation because, also, every time someone’s Dell computer went wrong they posted about it online, and when you searched for Dell at one point you didn’t get Dell at the top of Google anymore, you got a blog entry called ‘Dell sucks’; and so Dell now lost their own marketing game, because if you search for their own brand name you got more hatred about them

than you get anything to do with their own company; and so what they realized very, very quickly was you have to adapt to be better. You are either cheap and nasty, in which case people stand up and go “Well you know what, I’ve got what I paid for,” or you charge a lot and you are there every second of every day to help them with it; and there’s a range of that, you can go online and discover about it. But the key is to be the best you can be, because then that way people will respect you for it, whereas the traditional business model was stack ‘em high and inexpensive and (laugh), sort of, make as much money out of it.

I: Yeah, I suppose that the idea of Michael Porter is a complete failure. I always suspect that I mean this idea of you could be to differentiate, or you could be a cost leader and have no sense in your example.

O: Sure, the question is not to differentiate with quality or lower your costs. You have to do both.

Sociologically-informed studies of strategy and practices show that, within this literature, there is a body of knowledge that has remained close to its origins in industrial economics. Such literature needs to be revisited in order to observe their performativity and power (Carter et al., 2010). From the perspective of these studies, it is important to discover the power and performativity of the tools presented within the guide. It is easy to see that these tools are looking to enrol the reader and lead her to the particular strategy of diversification. To be more precise, the question is thus about the understanding of the role that Michael Porter's tools play in transforming ideas into strategy. These tools play the power game and are performative in terms of their effect on those who use them. But how can we study this particular dimension of the tool?

The guide presents the device without any major discussion as to how to suspend the conventional wisdom and assumptions of the industry. This is, in fact, the form in which the five forces tool is generally presented in the management practitioner's literature. Nevertheless, the device exerts some interpretative ambiguity by itself. Indeed, it is easy to see that: "Porter's... ideas may or may not be correct and, of course, they are open to empirical and theoretical contestation; however, when his ideas are vested in practice they become performative and a source of their own self-evident truthfulness" (Carter et al., 2010:582). Obviously, the tool's performative dimension needs to be scrutinized in the practices of SMEs' workers and managers who engage in strategic activity. Those practices are virtually organized and delimited -to some extent - in the device marked by the five forces' competitive analysis of the medical devices industry.

This conversation shows the mediation that the internet brings to companies that are trying to follow a pure cost-based approach, forgetting that it is now not so easy to follow a low cost strategy and obtain massive margins from it. What is interesting in this interaction is the immediate recognition of the error of the traditional Porter approach and how the model participate within the conversation, shaping the way that people talk and understand their conversation. Although the tool has been criticized, it is completely pervasive in business conversations and, in this case, within research about business and organizations. The tool is thus performative within the research process too.

It is here that we have to take more carefully the understanding of the results of this research.

Research about venture companies does not have to take for granted the foundations of the theory or model that animates the conversation.

Accordingly, one form of care about the object of study is self-reflection about the foundations that - as researcher - we have when we ask questions and participate in fieldwork.

This is particularly important when we are trying to understand the networks that emerge from the use such devices as Porter's matrices of generic strategies and the five forces. How ought we to "cut the network" of this assemblage of entities that participate in the analysis? (Strathern, 1996).

In more proactive terms, it is possible to go further and interrogate the foundations of Porter's approach by asking the question: what possibilities does the five forces device present to the reader of the guide? This view does not necessarily take for granted the characteristics of the industry or the strategy to follow - the guide is basically taking the diversification option. Nevertheless, a generative approach to strategy needs to challenge the assumptions and think about the limitations that the "industrial economics" analysis inherits. The virtual player of the medical devices sector needs - perhaps - to ask some even more fundamental questions. For example, questions about the blurriness between vendors and clients in the new digital markets in healthcare services, where mobile telephony and smart phones are emerging as the platform to deliver healthcare solutions. But, more importantly, the incumbent does not have to forget that these tools are generative. As Lucy Suchman (2006) has been arguing for over two decades, we keep trying to order the mess with prescriptive devices (for example, separating the industry into typologies, matrixes and predefined strategies), but these are in themselves practices that are mutually constituted by ordering impulses and messy hinterlands.

Chapter VII: A Parasitic Account of Technological Innovation

1. Introduction

As was discussed in Chapter II, the central aim of the present thesis is to open up the black box of innovation studies. The idea - as was specified in Chapters II and III - is to approach the phenomenon in relation to its *innovare/innovatio* aspects. Such an approach follows ANT, whereby innovation is seen as a distributed process that emerges from the interaction between humans and non-humans (Akrich et al., 2002) or what, in a similar vein, John Law (1987) has conceptualized as a "heterogeneous engineering" process. In his study, Law tells the story of Portuguese expansion via the oceans to India. The author uses it to explain how the actor-network both works and does not work. In particular, he explains how an actor-network becomes stable. Law exemplifies the actor-network in the galley. At first, the vessel was low, slim and powered by man, with a large crew. This actor-network was excellent for warfare in the Mediterranean but useless outside it. When new technological advancements were added to the vessel, a new actor-network emerged. Sails replaced man as the primary propulsive force, and the compass and other navigational devices were created. All these heterogeneous elements conform a new actor-network that stabilized and which allowed the Portuguese to dominate commerce along the route to India. From this example, Law elaborates on the importance of artefacts in the network as a whole. He also shows how many elements in the network are difficult to control and may change. If this happens, the network collapses. It is the controlling or taming of these elements that is considered heterogeneous engineering.

The important lesson from Law's story is the importance of studying the relationship between the material and non-material elements of the network and considering how these relations shape a stable arrangement that endures. This is an approach that clearly reads from Foucault's *dispositif*, as was explained in Chapter III of the present thesis. Such a method "looks into the system of relations that can be established between those elements" (Foucault, 1980: 194). It is the system of relations what Foucault defined as the *dispositif*. As a consequence, to follows Foucault, research needs to dig deep into the interrelation of the 'non-human'/'non-discursive' elements with the engineers, technicians and managers of the organizations.

In the last chapter, I looked at discourses and the role of devices in supporting/structuring those discourses. Instead, in this chapter, I will advance further the method by looking at the relations between discursive and non-discursive entities within the *dispositif*. As a consequence,

the analysis of the present chapter will revisit the problem regarding some of the entities that appear to be entwined in people's accounts. Some of these elements are important mediators - such entities enact certain kinds of practices and behaviours. From there, I will return to consider the importance of people and how those who work in organizations are entangled with the phenomenon that we call 'innovation'.

Following this methodological take, this chapter questions the self-evident separation between objects and subjects. This is aligned with a relational point of view of objects. For example, Law (2002: 91) has defined an object as "an effect of stable arrays or networks of relations." To be more precise, the aim of the present chapter is to understand the mediational and relational aspects that these devices perform as regards the work (i.e., innovation activities) in venture companies. In particular, the question that leads the study is: how are these devices entwined with the engineers, technicians and managers who work in Med Dialysis and Med Diabetes? In a nutshell, the specific inquiry of the chapter looks to understand how the mixtures (network-objects in Law's (2002) vocabulary) that are diagrams are part of the activities of those that work in these companies. As a consequence, following this chapter, the reader will have a more precise idea as to the mediation that diagrams bring to the engineering and management activities of the technological innovation process in venture companies.

2. Gaining access, having conversations and some issues about mediation

"I'm sitting in an open space, with a directory meeting table (with an ultra-modern design) and where the walls are full of photographs of loose biological images partially connected with the company's business. The table where I'm sat is long and constructed from three hexagonal tables all placed together. I'm located in front of two executives. One of them is the CEO; the other is the commercial manger, who is also the person who works as the gatekeeper of study, a Chilean Engineer who came to pursue an MBA in the UK and who seven years ago became part of the umbrella company from which this company was spun off. The company is in the medical care business - they are developing technology for haemodialysis. The company is located in a small town very close to the heart of the Midlands"(Med Dialysis Field Notes, Aug. 2010).



As humans, we share the world with many material entities (or artefacts). The participation of these artefacts is essential for any social action (Latour, 1993; Bencherki, 2012). For example, the furniture in this workplace - the meeting table itself - and the partially open and closed spaces of the meeting and the images around those at the meeting. Furthermore, even the notepad that was offered to me (when I discovered that I did not have anything on which to write my field notes) defines the particular materiality in this first encounter. Such artefacts enable the sociality of those in the meeting (Serres, 1995a).

However, the material/space reformulated by the chairs, the table and the pad, is not the only important aspect that I observed during this meeting. It became clear that as much as I needed the pad to organize my notes, the organization's members supported most of their explanations using a flipchart. They were making extensive use of engineering draws to give an account of the company's approach to developing new technology and products. Materiality affects - and is affected by - the representation of engineer ideas by the modalities of the representation. As Vink (2003) nicely puts it in his ethnography of engineers' activities - it is the inspection and analysis of 'graphical representations' that triggers new ideas among engineers and technicians. This is how technicians and engineers work - they tend to use drawings. This is true for the technical- and economic-oriented aspects of their activities. Some examples of these artefacts include the spread sheet of the total user costs of the new technology, the diagram of the logistical model of the business, and the distribution channel strategy, among others.

The engineers of the company use drawings when they present points to me. They also draw diagrams when they respond to my questions. Diagrams produce and qualify the conditions of possibility for communication and connection between the engineers and other actors (Serres, 1995b). From this example, it is possible to comprehend the importance of these artefacts in the shaping of technological innovation.

The characteristics of the heterogeneous entities - including the bodies, diagrams and features of place (Latour, 1993) - that are part of the encounter lead to a stable environment for the meeting. This leads the CEO, the commercial manager and myself to imagine other times and places (Latour, 1997). The materiality that is part of the conversation as an event sets up an agenda for future fieldwork. In other words, the mixture of the furniture, the drawings on the flipchart and the dispositions of the people involved, together leads to a form of trust between those who were at the meeting. In one form or another, this is what happens when engineer managers produce futures in a technological innovation project.

This opening example stresses the point about the importance of those less frequently researched entities - objects. ANT has remarked upon this point since the 1980s (see, for example, Callon, 1980). Some of these theoretical discussions were presented in Chapters II and III of the present thesis. For example, ANT's analytical symmetry principle between

material and human actors is part of a flat ontology, and it is well exemplified by the title - "How to keep the social flat" -in one of the chapters of Latour's (2005) famous book *Reassembling the Social*. However, although the generalized symmetrical analysis offers some new insights into the activities and practices at this new organization, the approach comes with a cost.

The point has been discussed, with some variations and in different contexts, in the post-ANT literature (see Chapter V, point 1.2). As Krarup and Blok have shown, there is a tension in the ANT programme. The authors claim that Latour's "meta-theoretical" promises lead to a form of research blindness in relation to some important aspects of how humans "employ things, effects and symbols beyond their simple, 'empirical' existence" (Krarup & Blok, 2011:42). Following the discussions in Chapter V and in attempting to confront this tension in ANT, this chapter looks to understand how the humans within these organizations are related to the diagrams and symbols used.

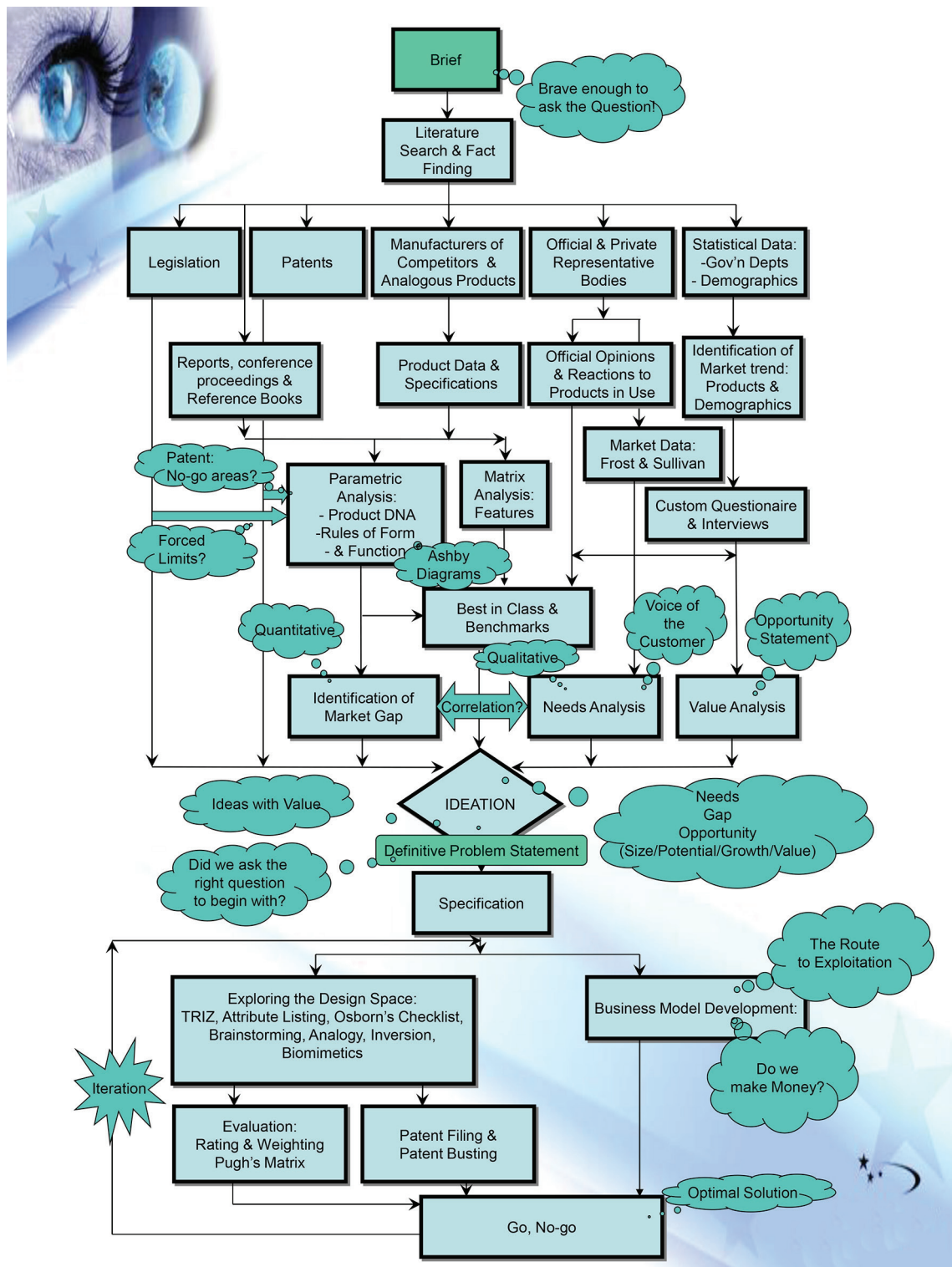
The first example of interactive data comes from an interview to the chief science and technical officer (CSTO) of Med Dialysis. The whole environment of the interview -and more generally of the organization- was conditioned by the urgencies of the preparation for the investors' meeting. The engineers, managers and technicians of the company were almost absorbed by this future board meeting. It is a commonplace that technology sector start-ups always experience a feeling of stress. At Med Dialysis, everybody rushes to prepare presentations and address potential questions for the board meeting. These were the circumstances of the CSTO of Med Dialysis when I had the opportunity to ask him some questions about innovation and how the process is regarded in their novel company.

3. Innovation at Med Dialysis

Example 1: Med Dialysis manager -15/06/2011.

	I: Researcher	R: Med Dialysis CSTO
1	R:	[So] there: a is been about four or five completely different users during the
2		life life cycle of this particular project
3	I:	mhm mhm mhm
4	R:	okay
5	I:	and and do you think that this changed the technology itself I mean the way that
6		you work or design or and and and actually [reduce]
7	R:	[after the] first step
8	I:	aha
9	R:	It's not changed the technology
10	I:	ah okay=
11	R:	=very ah >well< I always tend to think that's why I was trying to find this diagram ((the
12		respondent points to a diagram where the innovation strategy is shown))
13	I:	yeah year
14	R:	>'cose it explains those different avenues< (.) one thing that people don't tend to do
15	I:	mmm
16	R:	in a innovation (.) they focus on the innovation of the technology
17	I:	mmm
18	R:	they never innovate (0.1) the business model or the commercial model (0.9)
19	R:	so=
20	I:	>°very interesting°<
21	R:	I decided >when we've got the technology< what drives the technology >so what's the
22		better mousetrap or whatever it is< rather than >what's the better way of making
23		money<
24		mmm
25	I:	hh and actually there is it's a stream of of thought when you have (.) an object how do
26	R:	you innovate (.) the business model

Figure 1: Innovation strategy.



The interaction displays a conversation with the engineer in charge of the whole scientific and innovation programme at Med Dialysis. It is a general conversation about how innovation is conceptualized in the company. This interactive data comes in tandem with Figure 1.

The diagram in Figure 1 is a flow-chart that explains the path from idea generation to the decision of 'go or no-go' to market with a new technological product -in short, an innovation. There are three important types of elements in the diagram. First, those that appear in light blue boxes. Second, those elements appearing in red clouds. Third, a couple of boxes that appears in a phosphorescent green. In addition, two of the red entities are shaped by forms that are different from the already mentioned clouds. First, there is one with a star-like form (with the term 'iteration' inscribed in it) and one with a double arrow with the term 'correlation?'. Finally, within the light blue elements, there is one that is not a box but is instead a rhombus.

As is well known, a flowchart is a type of diagram that represents an algorithm or a process, showing the steps as boxes of various kinds and their order by connecting them with arrows. This diagrammatic representation illustrates a solution to a given problem. This is what the diagram shows. The start is a different colour (phosphorescent green) and from there onwards the flowchart shows boxes that represent generic processing steps (Breeze Tree Software, 2010). It is interesting to observe the significant number of processes and how few 'conditional decisions' (represented by a rhombus in flowcharts) are included. If the idea generation (or 'ideation') is the only possible conditional decision, this is a very particular decision-making process that looks to produce innovation.

Secondly, it is impossible to know whether the phosphorescent green entities of the flowchart represent the beginning or the end of the process. That is because, in a normal flowchart, the beginning and the end are normally represented by a 'terminator' type of box - this is rounded, or represented as an oval. All in all, the light blue processes in the diagram are significant in number and indicate a coarse, broad range of analysis (qualitative and quantitative) regarding many aspects of the market, competitors and technologies, etc. Conversely, the diagram shows just one conditional decision that is conceptualized as the ideation process.

Another interesting point is the use of red clouds and a couple of other red figures. In general, clouds are not mentioned in the flowchart symbols. However, it is more or less clear that, within this flowchart, the red clouds represent self-reflective instances, or at least questions about resources and the possibilities for the company producing the innovation. This might even be a call to do something, as is the case with the red cloud that makes the call to be 'Brave enough to ask the question'. These are also used to remark upon certain things that could be connected with the various processes - for example in the process 'Identification of the market gap', the related cloud establishes 'quantitative'. This is a call to produce a quantitative analysis of the market gap.

Finally, from a more general point, a cloud chart gives a sort of 'formalized' graphical

representation of a logic sequence; therefore, the charts look to provide people with a common language or else some references as to how to deal with a process (Breeze Tree Software, 2010). What happens with the Med Dialysis flowchart is that it very freely uses this required 'common language'.

Returning to the sequential organization of the data, the attentive observer will immediately recognize the manager's hesitation and pausing (observed from line 11 onwards). This point it is, in fact, striking because, within the interaction, the CSTO is responding to a question about change (line 5). Such a question is something routine in the everyday activities of the manager - it is bread and butter stuff in the development of a new product/technology (regarding change and product development, see, for example: Leonard-Barton, 2007; Brown & Eisenhardt, 1995). As a consequence, it is possible to venture that this artefact is connected with the interactive 'business' being constructed by the CSTO. This artefact could be generating what Steve Woolgar (1996: 725) calls "constitutive reflexivity," namely the existence of close interdependence between the "surface appearances" of documents and/or accounts and the "associated underlying reality." In a nutshell, documents are accounts and "constituent features of the settings they make observable" (Garfinkel, 1967: 8).

A second way of thinking about the 'constitutive reflexivity' is to see this object as a portal to the external world - an external world which brings some important aspects of this 'outside' realm into the conversation. For example, these might be aspects of the underlying relations of the innovation strategy with important aspects such as the NHS and the regulatory environment. Such a link with the outside world is conceptualized by sociologist Mary Holmes (2010) in her study of the emotions and reflexivity. Drawing from Antony Giddens (1990), Holmes explains how people alter their lives as a response to reflecting upon their own circumstances. Such circumstances are there on hand with the diagram of the innovation strategy. Following this second path, the diagram expands the CSTO's conversation and allows him to bring some important parts of the outside world into the interaction.

In this sense, the diagram participates in a complex mixture that gives an account of new patterns of behaviour and ethical norms, political regulations and new knowledge, that emerge in the outside world of the organization (e.g., potential vendors, new medical device regulations, new quality norms, new government healthcare policies, etc.). These are the processes that appear within the 'generic process boxes' of this flowchart. Although it does so in a highly ambiguous form, the diagram offers a multitude of issues that the innovator need to visit, such as such as regulations, quality norms, policies and the potential acceptance of the market of the new product/innovation.

The constitutive reflexivity offered by the diagram to the CSTO acts together with the help of other discursive devices in the manager's discursive construction called 'categorization work' (Edwards, 1995). Between lines 14 and 18, the CSTO offers a categorization of innovation

that is quite interesting. The CSTO claims that there are two groups of innovators. The first group is integrated by those managers who innovate in technology. The second group comprises those managers who innovate in the business model (line 17). On one side, the technological innovation aspects connect with the technology, and on the other side those aspects connect with business. Additionally, those categories constructed by the CSTO are further supported by the expression "they never innovate (0.1) the business model or the commercial model (0.9)" (line 18). This is a clear use of the extreme case formulation discursive device (Pomerantz, 1986).

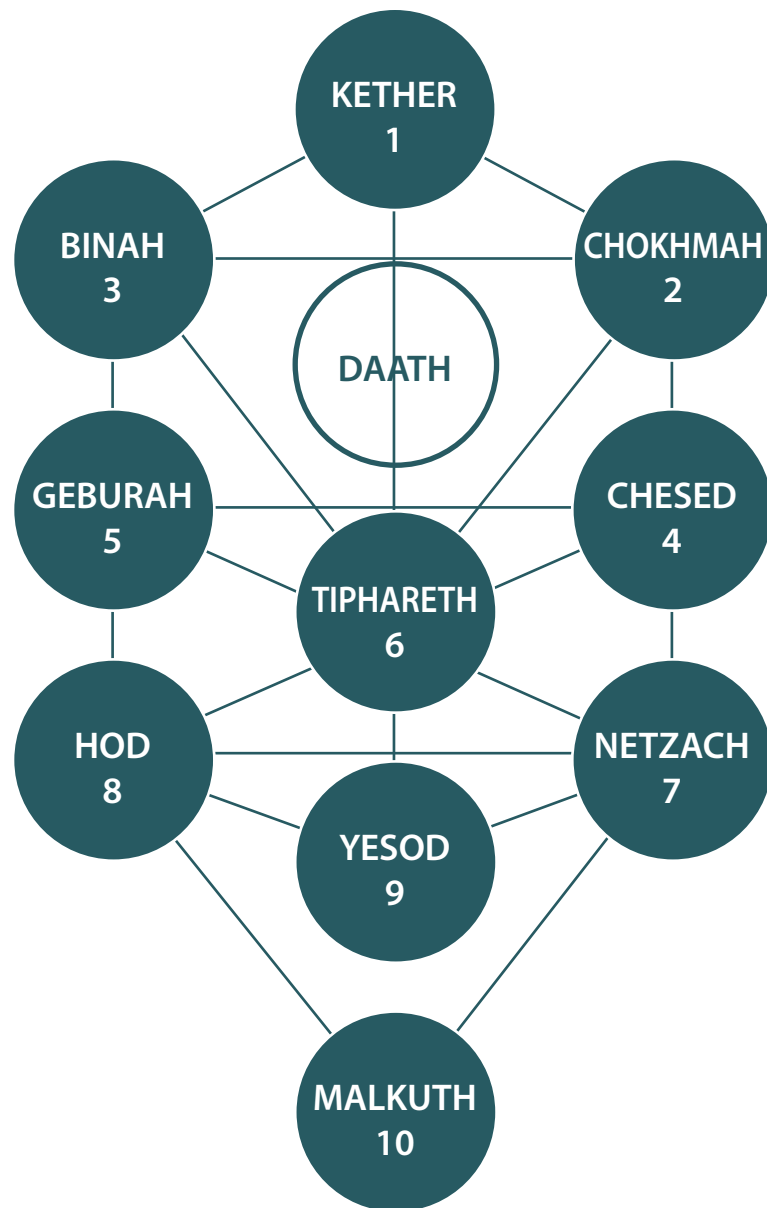
Both discursive devices are supported and mediated by the diagram. Furthermore, it is not too difficult to see that the diagram brings accountability to the CSTO's activity. At the same time, the CSTO's categorization work is an important step in constructing his position as an 'innovator' inasmuch as the phenomenon of innovation requires a movement towards 'strategic reflexivity', whereby activities of innovation respond to changing processes in the market and in society (see: Fuglsang & Sundbo, 2012; Phillips, 1971).

With its free use of generic processes and the supporting self-reflective red clouds, the diagram offers a model closer to that conceptualized by Michel Callon (1998; 2004). Some of the features of this innovation model are presented in Chapter V. The so-called 'whirlwind model' explains the innovation process as one in which basic research practices and applied research are enmeshed. The diagram displays some similitude with the whirlwind model because it shows how different phases (basic science, technological development and user feedback) are mixed up together within the innovation process. However, the CSTO's account uses the diagram as a black boxed entity, where he is concealing its production. Following Mackenzie (2006), the diagram as such has certain performative aspects that are not solely connected with its content.

As a consequence, the performative effects of the diagram demand further analysis. This is a path towards opening up the black box of innovation. For example, following a research working question like how is it that the diagram help with the construction of with the constitutive reflexivity of the CSTO? A possible answer arises when the analysis embraces the cultural studies of the mathematics of Brian Rotman (1987). The author offers an interesting study that leads to an understanding of the diagram as the Kether in the Tree of Life. Indeed, in his discussion of the Kether/Crown, within the context of the Tree of Life (Figure 2), Rotman explains the interesting figure of the Crown as a crucial - necessary - node in the tree.

For Rotman, the Kether is the supreme crown as the origin and the channel - the vehicle through which God's influence flows. The Kether is the creative principle. It is part of life and ambiguously and equally participates in the other-worldly, outside of life as the sign of an originating and immanent God.

Figure 2: The Tree of Life.



Furthermore, the Crown is also - in a topological sense - a window, an aperture or a hole through which divine light enters the world of relative existence from the absolute. As a consequence, if the innovation strategy diagram is thought of as a Kether, the topological metaphor of the window or aperture can be used to explain the existence of something else, something which - in the case of the Tree of Life - is the 'absolute'. The contention of this thesis is that the diagram of Med Dialysis's innovation strategy can be conceptualized as the Kether/Crown within the Tree of Life.

The innovation strategy diagram could be conceptualized as the creative principle. Therefore, the diagram could represent the practical world of the innovation as well as all the other virtual aspects and uncertainties that this phenomenon offers to those who work on it. These are the 'other-worldly' - outside of actual developments. Here, the divine light is the metaphor that explains all those things that are uncertain in our varied and risky futures. Paraphrasing the well-known innovation studies scholar Helga Nowotny, the innovation diagram includes all the uncertainties inherent in the future (Nowotny, 2007: 4). In a topological sense, the diagram is the aperture through which uncertainties pass and are transformed into risk (Luhmann, 2000); therefore, something that is manageable. As a consequence, the diagram is also used to alter the lives of those who reflect upon these circumstances and changes.

The innovation strategy diagram is used to reflect the practice of innovation among the people who work at Med Dialysis. With its particular form of innovation strategy enactment, the diagram opens the entire external world to the CSTO and is a fundamental part of his discourse. In this sense, considering the diagram of the innovation strategy as the Crown leads us to think in a more general sense of objects that are defined as 'blanks' or 'dominoes' by Serres. These are constitutional indifference objects (Brown and Middleton, 2005) and - at the same time - enable these relations to gain an objective reality (Serres, 1995b: 87-88). Additionally, these objects are defined as 'quasi-objects' because it is through them that the collective emerges (Brown, 2002: 21) and from which the phenomenon of inter-subjectivity is possible (Serres, 1982: 227). This is the deeper understanding of the mediation work that the diagram produces in the reflexivity of the CSTO. This quasi-object generates a collectivity and his individuality. The CSTO is not acting alone in the world. He needs this object to be what he represents at Med Dialysis. Equally, the company needs the diagram to produce and stabilize its organization.

As a consequence, Rotman's cultural zero object exhibits the nuances of the performativity of the diagram. The diagram of the innovation strategy brings forth the possibilities of reflexivity by its own performative power. Following Serres, this object is a third - see Chapter III- in the communication that the CSTO establishes with the rest of the world. This is precisely the case in the interactive data. The diagram is the third that mediates the communication of the CSTO, but at the same time the diagram facilitates the management of the uncertainties that exist in the innovation process. As the creative principle, the diagram interconnects the practical activity of innovation with the other-worldly, outside uncertainties. The diagram mediates between these two worlds. Paraphrasing Serres (1982), it is by this mediational process that the diagram causes the human to slow down and develop the conceptualization of technological innovation.

However, the diagram does not need to offer clear cut explanations or paths to solve the problem of technological and product development. Instead, mediating together with

the discursive devices of the CSTO, it is part of the generation of categories that define technological innovation's relevant distinctions. This strategy allows the CSTO to claim, for example: "what drives the technology >so what's the better mousetrap or whatever it is< rather than >what's the better way of making money"(lines 21 to 23). This is a complete economization (see Chapter III) of the technological innovation process. It is the quasi-object that brings the various economic elements (as the quote clearly shows) that are not necessarily at hand into the interactive conversation. The diagram generates economization in an 'immediate' form. The discussion of the economization process will be revisited in Chapter IX.

What remains unanswered is whether this is a unique entity or whether there are other, similar phenomena, whereby diagrams are used by managers to solve their interactive problems. Obviously, the answer to this question requires some additional empirical work. The data for the empirical work comes from the second site of the study, Med Diabetes.

3. Med Diabetes and its ambiguous avenues into the market

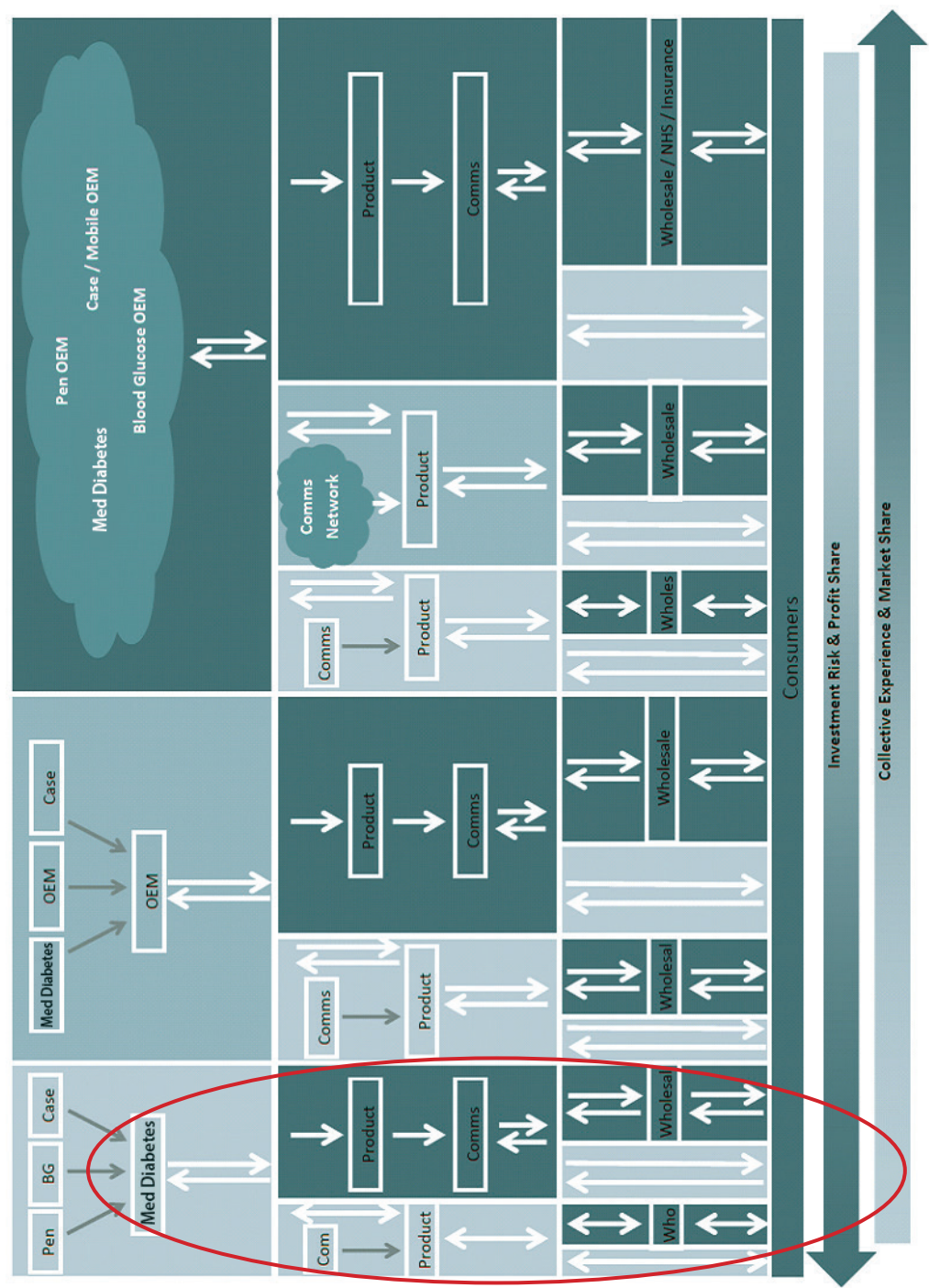
The second example is extracted from an interview with one of Med Diabetes' executives. This venture medical device company develops technologies and a products/services for diabetic users. They are at the pre-prototype stage of their product development. The conceptual product has been presented at various places, and the company was looking for funds to finance a functional prototype and then perform user tests. What is interesting about the 'solution' is the integral character of its design. The venture is still working out a technical innovation (an insulin injector pen) as well as a blood glucose tester apparatus. Within this solution, the pen is wirelessly connected and can send information to an intelligent case/smartphone. The link to the smartphone provides for further connections with information systems associated with a web-based data warehouse, from which users and doctors can track the information online.

The example/sequence is part of an interview with one of the four executives who works on the Med Diabetes project. The interview was performed at her house - this is the place where this company has its commercial and legal direction. The house is also the place where my fieldwork was performed over the course of the end of 2010 and the first three months of 2011. The company is located similarly to Med Dialysis- in a small town in the Midlands, UK.

Example 2: Med Dialysis manager - 15/06/2011.

	I: Researcher	R: Med Dialysis CSTO
1	I:	yeah the the question is a about the
2	R:	the market
3	I:	the market and and even before the market how do you see or how (1) do you
4		imagine or do you conceptualize or visualize which are your clients a
5	R:	ok we we went through a long discussion about this who really are our clients and we have a
6		number of options I think in the end we worked it out to five options in fact if you just hold a
7		moment I'll going get you the diagram and share it
8		(3)
9	I:	Oh excellent thanks you ((the interviewer observe the diagram for a minute))
10	R:	all right if now I have to remind myself how this was
11	I:	yeah take your time
12	R:	we agreed that there is three elements so is the pen the blood glucose monitor and the case
13		and that's 'Med Diabetes' product (shs)
14	I:	yeah
15	R:	so: there was (1) products communications companies or communications and whichever
16		one was the stronger so if on this one and so it it could go to either one and with so there is
17		one two: one (1) to three maybe in the end
18	I:	mhm

Figure 3: Routes to Market



The interactive sequence is connected with the diagram shown in Figure 2. The diagram illustrates the results of the market channel strategy of the four executives of the venture. The lower part of the diagram shows the consumer base (users of the technology plus two arrows from the point of view of the company). The first part displays the level of investment and profit share. This level decreases, going from the right to the left of the figure. The second arrow displays the level of their collective experience and market share. The experience level moves in the opposite direction to the previous one. For example, when the level of investment risk grows, the level of collective experience and market share decreases.

Above these arrows and the client/final user base, the diagram shows different alternatives for distribution associated with different actors in the industry. An important actor is 'comms' - these are the telecommunications companies. Such companies are considered to be partners 'by excellence' because of their significant power in the smartphone user market. To further explain this complex representation, I added Roman numerals to the levels. Level I displays Med Diabetes and the OEM. The manufacturers can produce the case, the pen and the blood glucose meter. Secondly, Level II displays a representation of the different alternatives of commercial relationship combinations between the telecommunications companies and the final product. Finally, Level III shows the potential distribution channels (wholesale, NHS or insurance companies). Secondly, I also add the numbers 1, 2 and 3 to indicate the different integrated alternatives (from production to the final client/user) that the venture company visualizes. As a result, a matrix that displays the potential avenues to the client is produced.

An example is circled in red on Figure 1. In the example (in box I-1) the diagram presents a scenario in which Med Diabetes buys the pen, the glucose meter and the case, to produce its own product. Next, in II-1, Med Diabetes makes a deal with a telecommunications company that could buy the solution adding an smartphone (represent by the darker violet) or received the enhanced solution with the smartphone already. In III-1, the telecommunications company distributes (directly or via wholesalers) the final solution to the consumers/users (darker violet) or else Med Diabetes can take the risk of distributing directly users/customers or use wholesalers. From the point of view of Med Diabetes, I-1, II-1 and III-1 represent the highest level of investment and profit share with the lowest collective experience and market share for the product.

Analogously, the opposite side of the matrix (for example, columns 3-I, 3-II and 3-III) indicates a lower level of investment and profit with a higher level of collective experience and market share for the product. What is fundamentally different in this column is the intensity of the purchasing process from the OEM part-makers. Med Diabetes is operating in the 'cloud', probably in partnership with these manufacturers, and then engaging with different intensities in the commercial relationship with the telecommunication companies and the wholesalers. In any case, very large and complex categories are defined with this diagram: risk, investment, collective experience and market share.

Returning to the interactive sequence, the diagram appears in the conversation when the executive responds to a simple question (between lines 1 and 7). It is clear that the diagram appears at a time of difficulty. In other words, this basic question about clients triggers the need for the diagram. The executive suspends the interview to go upstairs to get a copy of the diagram. The interesting issue at stake is what causes the executive such trouble with the question about their virtual clients'/users' conceptualization? In some respects, the example looks similar to that in the previous section. The diagram here also brings forth a set of different categories and information that delivers 'strategic reflexivity' to the executive. However, this diagram is different because the engineer manager also adds to her explanation that they worked as a team and "went through a long discussion"(line 5) to settle upon these avenues to the market. The diagram is a sort of 'solution' device for past, actual and potential disputes.

Yet, what is more explicit in this second interaction is that the object/diagram appears to be more 'elastic' than the first. In fact, the object appears to be under a continuous reinterpretation. These reinterpretations are based on the use of the diagram itself. For example, the diagram mixes up different levels of distribution involvement (wholesale and direct distribution, shown in level II) in three columns: 1, 2 and 3. This point generates ambivalence in the interpretation. It is not difficult to see that the levels of investment and profit depend very much on commercial distribution and never purely on the investment in the production process (Level I). This is a matrix that is very different to those analysed in Chapter VI. This matrix brings a varied array of interpretations.

Additionally, Level II offers a series of possible agreements between the telecommunications companies and Med Diabetes. All these possible deals have the power to change the investment level, the profit and what the company calls 'collective experience'. It is thus not difficult to see - following Munro (1995) - that the diagram supports(or helps to create) a space of cultural ambiguity. As a consequence, the diagram is an object that allows for the creation of multiple concrete meanings at the same time.

The ambiguity of the diagram and the difficulty that the Manager has in reading are seen between lines 9 and 17. It is here that the remembering process of the manager fails to be facilitated by use of the cited diagram. At line 10, for example, the manager states: "I have to remind myself how this was." This expression shows her struggle to understand the elements that the diagram displays. This is particularly important between lines 15 and 17, where the engineer manager shows a tremendous hesitation about the meaning of the expression 'COMMS' and the product's distribution process. Although this could be understood as a problem with her memory, it is clear that this is not the case because it is the diagrams constitutive lack of clarity that is generating the hesitation and ongoing reinterpretation of the executive.

In consequence, the necessary question that emerges is: how does this diagram mediate the communications process of the manager? After this first question, the analyst can raise further questions as to the possible uses of this diagram as an element of mediation within the entire venture and the group of people who work at Med Diabetes.

An answer to the question about the mediation of the diagram is offered between 1 and 7. Regarding the question about the market, and in particular about her view of the clients, the engineer manager explains that the diagram emerged "through a long discussion about this: who, really, are our clients? And we have a number of options, I think - in the end we worked it out to five options" (lines 5 to 6). The engineer's discourse certainly shows the importance of the diagram as an organizing element of disputes between the venture owners and managers. The 'Routes to Market' diagram is the result of a discussion process. This process is at the centre of the technological innovation at Med Diabetes, which produced a diagram with a constitutive lack of clarity.

Marsh and Jackson (2008) offer an interesting theoretical point that could serve to conceptualize the problem of how it is that the routes to markets diagram is enmeshed with the discourse of the executive. The authors claim that it is the plasticity and ambiguity of the object's characteristics that brings cultural ambiguity to the interaction of the engineer manager. Plastic objects allow for multiple meanings and configure a space of possibilities for the manager's use of cultural ambiguity, as was studied and conceptualized by Rolland Munro (1995). Considering the plasticity of the object demonstrated in the economic analysis of the avenues to market diagram, it is possible to arrive at a solution to the object mediation and generation of cultural ambiguity at Med Diabetes.

However, similar a phenomenon has been studied by ANT theorists. From an ANT point of view, the analyst could understand the mediational character of the diagram as an immutable mobile object (Latour, 1986; see Chapters II and VI for an example). Such an object brings consistency and memory to the social bond (Latour, 1991). An example of such an object is John Law's Portuguese vessel described in the introduction to this chapter, as well as Latour's (1986) example on La Pérouse's map under the contract of Louis XVI. Unfortunately, Latour's conceptualization does not fit the example of the routes to the market diagram. This is because the immutable mobiles are "objects which have the properties of being mobile but also immutable, presentable, readable and combinable with one another" (Latour, 1986: 6). Instead, the routes to market diagram brings flexibility of interpretation. The mediation of the diagram needs a more precise conceptualization than that presented. This is what Brown (2013) has conceptualized based on Serres' philosophy, where objects are at the centre of the general socialization process.

What the data shows (particularly between lines 2 and 7) is that communication depends upon the mediation of the diagram. The diagram mediates when communication is not

working. Equally, the diagram introduces noise to the communication of the manager. This is the noise that redefined the communication between the engineer manager and myself. As Brown (2013: 87-88) explains in his first definition of the parasite: "to one side of ('para') the location of the event ('site') - the medium or being through which communication must pass...Second definition of the parasite - the 'static' that interrupts the transmission of a message." Serres permits a conceptualization where breakdowns of the system are part of it. Serres' approach leads the analysis to the disorganized side of the organization -or, in his words, the "dark side" of the organization- (Serres, 1982:12; cited in Brown, 2013:88).

4.Order and disorder in project planning activity at Med Dialysis

The next field note shows a 'natural' interaction between the CEO and a senior engineer of Med Dialysis. The conversation was observed in between some interviews at the Med Dialysis office.

Example 3: Med Dialysis field notes 24/06/2011.

"The visit finished with one unexpected conversation with the CEO and a development engineer, where I could see some differences in the opinion about the planning of the project work and activities. The CEO claimed that each project is different than every other, so there is no clear approach to organize the future. During the conversation, the senior engineer claimed that although there is a messy system of working at Med Dialysis, there is something constant - a sort of line of doing things that is always underneath the projects. They finally ended with an agreement, using the metaphor of a "learning curve" -in fact they actually drew one- that permits a faster process in future projects, even though those future projects could be very different to the actual dialysis project."

The CEO presents the work in projects as something ambiguous and 'unique', where there is virtually no possible planning process. The conversation shows a tension. This tension exists between the engineer's need for order and planning, and the messy approach of the CEO. My feeling is that, during the conversation, the senior engineer and the CEO were have their discussion as if they were at the same hierarchical level. Later on, the senior engineer informed me that he received formal training (an MBA) and that he "speaks the language" of the business. My feeling is that, within the interaction, the engineer was trying to teach management to the company's CEO.

What it is interesting with the example is the existence of a phenomenon that brings a sort of 'solution' to the executive's dispute. In this sense, it is similar to the example of the routes to market diagram. The solution comes by way of a device. The device is a model - more precisely, a drawing - of the 'learning curve' that is used as a metaphor for the messy planning process that presents an open type of regularity (expressed in the curve itself). The contention is that the learning curve is acting in a similar way to that in the cases in sections two and three, because the model is mediating the communication of the CEO and the senior engineer and allows for the solution of the conflict.

What is thus happening with the learning curve in this example? This question needs the analyst to take the learning curve in terms of its own language - that is, the economy. The learning curve defines that the average time spent per unit produced decreases with the increment of the cumulative volume of production (Cunningham, 1980). What the curve does here is bring a completely different language to the interaction between the CEO and the senior engineer. With Serres, the learning curve translates the world of the economy into the world of the medical devices projects. This is the "process of making connections, of forging a passage between two domains, or simply as establishing communication;" therefore, it is "an act of invention brought about through combination a mixing varied elements" (Brown, 2002: 3-6).

Translation is at the base of the Serrean parasitic understanding of communication. It is also at the core of ANT's principles, as with the notion of generalized symmetry. For example, Michel Callon mentions that "translation involves creating convergences and homologies by relating things that were previously different" (Callon, 1981). Within ANT, translation is the process by which the set of heterogeneous elements is related in a network. In such a process, "the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited" (Callon, 1986: 203). Additionally, translation could be seen, with Latour (1991b), as a delegation - this is the process that describes the reciprocal relationship between the social and the technical. The formula that is expressed in the learning curve is being used to delegate major efforts to minor efforts. In turn, the learning curve delegates behaviour back to the senior engineer and the CEO. The actions of these engineers - and people in general - are bounded by technologies (technologies of the economy in this case).

However, this is a general, loose and ambiguous model for understanding how companies increase their performance within their projects over time. What is it that this company is going to improve with practice? Is it the planning process? What are the particular meanings for Med Dialysis of the variables: average time/labour versus labour productivity, or production costs versus total efficiency? In other words, are they thinking of the learning curve or of the experience curve?⁴ The example of the learning curve shows some of the unexpected outputs of the constitutive ambiguity of the use of some diagrams.

⁴ The first one was developed by the economist Theodore P. Wright in 1936 and the second one by Bruce D. Henderson in the mid-1960s.

There is something about Latour's - and more generally, Callon's - use of Serres' conceptualization of translation that does not follow the previously explained parasitic logic. Following Serres (1982: 35; cited in Brown, 2013: 90), it is possible to see that "the parasite invents something new. Since he does not eat like everyone else, he builds a new logic." What is the parasite's learning curve giving back to the engineers involved in this conversation? Following Brown (2013: 90), the parasite gives something back to the host -this could be seen as the engineer/CEO project management activity as expressed in their conversation. Following Brown, the device (i.e., the parasite) could be giving back information and novelty in exchange for energy -its existence as part of the cascade of parasites. What type of information does this curve give to the engineers? Information about the how to transform the general dispute into a sort of model that closes the traditional problem of the order/disorder in the project's management. Additionally, the parasite also returns novelty in terms of the economic concepts that are now adopted by the engineers, and generates a specific form of technological innovation in their venture. However, the point needs to be further endorsed with some other examples. The next example shows some interactive data from Med Dialysis's project managers.

5. The Med Dialysis project

The next example shows the world of Med Dialysis's project manager. In particular, it shows his account about certain organizational artefacts that used to organize the technology/product development process within the company.

Example 4: Med Dialysis project manager-30/11/2012.

I: Interviewer /PM: Project Manager

- 1 **PM:** right okay I'm I joined this project about two years and three months ago something like that
- 2 **I:** alright okay
- 3 **PM:** so it's pretty mature as a project and there was already in structure and basis of the company when I
- 4 joined
- 5 **I:** okay great excellent excellent and and all this involved in the project area I mean taking care of the the
- 6 the process as you mentioned before of from the beginning to the end alright so then the question
- 7 that is interesting to me is how I mean maybe I can ask you general things I mean about this this very
- 8 same thing how do you see that this things like self-care specification or whatever you call these
- 9 things I mean like technical specifications and this self-care specification hierarchy I mean how this
- 10 things are important and how people use this things to work or make sense of their work if you want

11 **PM:** yeah it's interesting in in many startups companies what you find is that you join a a group of people
12 that are creative and have appetite (.)and have some skills and you want to be able to join and go on
13 a journey and I think what's what's important is to be able to articulate the goals and to anticipate any
14 pitfalls along that route now um there's loads of things that we will discover lots of unknowns in
15 going from A to B to getting uh to our final goal and I think all the tools and all the behaviors that we
16 um should be developing and exhibiting should help us to answer those questions sooner rather than
17 later so everything that we've we've talked about the specification hierarchy and the of course
18 management system

19 **I:** yeah

20 **PM:** the gateway process and the project plan and the self-care specification and the technical specifications
21 etc etc should help us as um milestones on that route

22 **I:** okay

23 **PM:** they are tried and trusted methods or tools of been used in other industries very successfully and all
24 we're doing here is adapting it to our purposes um with a view to making the picture clear because
25 um in our picture is there's a lot of noise lot of lot going on and the more we can um templatize
26 things then the more easily we can understand them and the more easily we can process the work it's
27 very difficult to get away from putting a process in place

28 **I:** Yeah yeah yeah yeah

29 **PM:** and the natural tendencies of any startup group particularly if you've got a bunch of engineers together
30 is to create and come up with idea and produce things

31 **I:** right

32 **PM:** not to um hone it down and sort things and sift and refine and then say oh I can't finish that because the
33 temptation is always to do a better widget whatever it happens to be

34 **I:** okay

35 **PM:** um you know we need to get past that process so you know I found myself tempted by the dark side
36 too

37 **I:** hhhh

38 **PM:** but I know in the companies that I've worked with before and having you know had a major hand in
39 starting up the medical device company and growing it and then getting the product CE marked and
40 FDA approved and then being part of the team the float of the company you know I know what we
41 did right along that way and what we did wrong

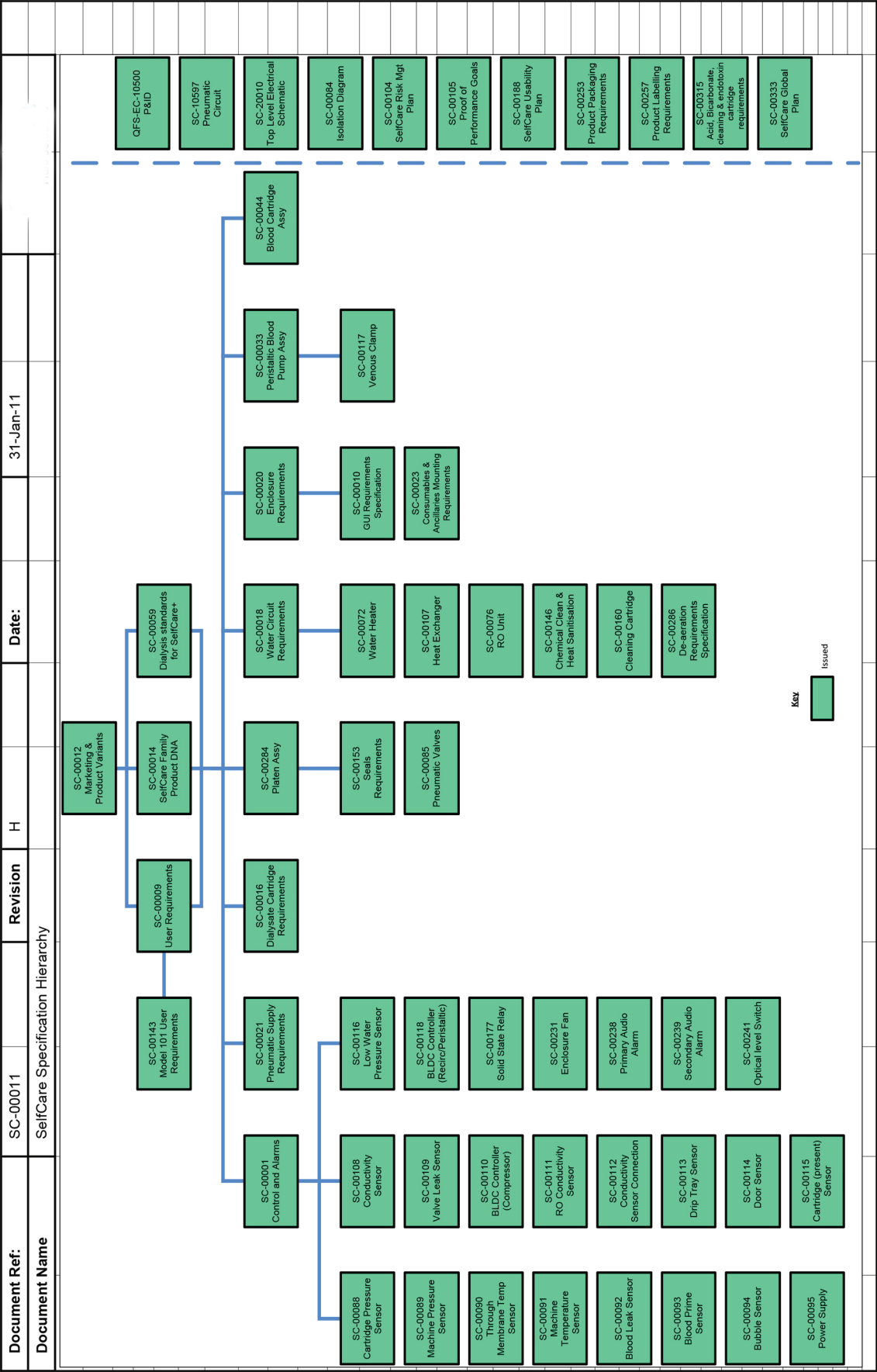
Firstly, the project manager's discourse it is more and less easy to construe as a sort of lineal model that explains innovation development. This is a process in which there is an order. First, there is a design engineer's idea about the new technology; then the idea is conceptualized; and finally, the engineers work together in a sort of messy path to produce the technologically novel product. Secondly, between lines 5 and 11 and after the question regarding the use of the SSH diagram (see Figure 4), the project manager explains and elaborates upon a series of categories about his view on start-up projects and those who work in those environments. This discursive device was shown in the previous section. Such a categorization strategy (Edwards, 1995) is also used within the discourses of the CSTO.

Such categorization is important because it divides the groups of engineers who work at the venture into two poles. On one side, he sees order incarnate in those engineers organizing the venture company. In fact, he classifies (at line 28) these engineers as the ones "putting a process in place." In addition, he sees that this category of engineers as where he belongs: "[I] think what's important is to be able to articulate the goals and to anticipate any pitfalls along that route now, um, there's loads of things that we will discover, lots of unknowns in going from A to B to getting, uh, to our final goal"(lines 13 to 15). Instead, on the other side/pole, there are those engineers who "in many start-up companies what you find is that you join a group of people that are creative and have appetite (.)and have some skills"(between lines 11 and 12).

The poles are further constructed by the use of some extra metaphors. At lines 36 and 37, the project manager makes a reference to his personal history, using the expression: "um, you know we need to get past that process, so you know I found myself tempted by the dark side too." This is an interesting point because, although the project manager clearly expressed earlier that he is part of the group that is "putting a process in place" and "think[s] that what's important is to be able to articulate the goals," he is accepting that the temptation of the "dark side" is always there. Such a self-reflective account shows that the categories are not completely hard or even well-differentiated. There is potential mobility between the categories.

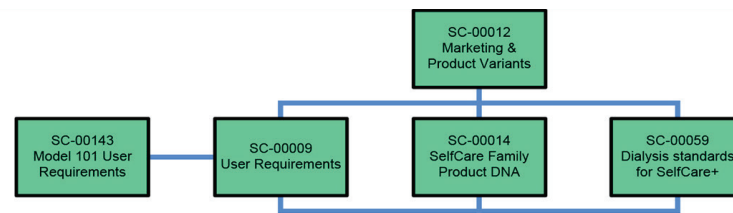
For the project manager, those engineers who work for venture companies and "are creative and have appetite (.)"(line 12) are part of the dark side. This metaphor is quite an interesting and strong one. The project manager is comparing the dark with the disorder. Furthermore, analogously, he is one of those engineers who puts processes into place are on the 'bright side' or the side of order. The question that emerges at this point is: how does the project manager solve the problem of the categorization discursive device that he enacts in his account of the technological innovation phenomenon? The answer to this question emerges again from the use of a third -Serre's third- that makes possible a connection between order and disorder.

Figure 4: Diagram of a self-care specification hierarchy.



The diagram of a self-care specification hierarchy (SSH) is a controlled document. This means that, under the ISO quality norm, the diagram needs to present a serial number and state its revision/version number. It is a summary of a large number of documents that refer to the technical and commercial specifications of the parts, their design and production, and the commercial process -among others- for the technological innovation that the company is developing. For example, in its top part, the SSH (see Figure 4.1) that displays specifications SC-00143 of the Model 101 User Requirements, the SC-00009 User Requirements, the SC-00014 Self-care Family Product DNA and, finally, the SC-00059 Dialysis Standards for SelfCare+.

Figure 4.1: Detail of the self-care specification hierarchy.



From these general documents, the SSH generates in a sort of cascade, including the relations with the complete set of specifications -among others- for the control of alarms in the machine, the water circuit requirements, the enclosure requirements and the peristaltic blood valve. From this 'second level', as in an organizational chart, the SSH 'builds' a model of the technological innovation/new product. What is exciting about this device is that it shows the explosion of the complete set of specifications and produces accountability for those who work in the development process.

The SSH generates a particular kind of mediation. Following Serres, the analysis seeks to show that the SSH operates over the breakdowns of the system and as a nexus between the categories constructed by the project manager. The device, as a parasite, offers information to those who work in the company (in particular, it informs the conversation of the project manager), but it is also a clear case of how Serres understands the problem of order/disorder as part of the same organizing process. It is synchronic that the project manager uses the very same metaphor as Serres when he refers to its disorganized side. This is the 'dark side' (Serres, 1982:12; cited in Brown, 2013:88).

Furthermore, it is possible to see that the SSH adopts a functional role - the people who work at Med Dialysis use the information about the device. In fact, they have the device hanging on the wall, to refer to it in their day-to-day conversations (as I could see during the field work). However, the question is: what kind of service is this device providing? It is clear that the SSH diagram brings the opportunity to organize these unknowns. In a model of innovation like that enacted by the project manager, the SSH reduces the complexity of the broad range of specifications and black boxes it in a single place. Therefore, the diagram helps to organize risk or to better transform uncertainty into risk (Luhmann, 1993) of product development

process. The diagram becomes the object by which those who work at Med Dialysis construct their work activity. The diagram is not just context. As was discussed at length in Chapter V, a material approach that is drawn from ANT do not to consider the "gap between text and context" (Latour, 1999b: 374).

This functional role can be further apprehended according to Michel Callon's (2002) long meditation on management tools. In the author's view, the SSH could bring a dual process of 'complexification' and 'simplification' to organizational practices. It is clear that the SSH brings simplification in confronting the standard complexity of the technological innovation process. This is particularly clear in the case of the dark side at Med Dialysis. This is because the tool brings additional complications due to the new relations and activities that the diagram demands (for example, the work of maintenance/upgrade and follow-up). These diagrams also transport complication to the Med Dialysis managers, engineers and technicians, because the diagrams record, carry and channel interactions through time and space (Bencherki, 2012; Latour, 1996).

However, thinking with Serres, the SSH could be conceptualized in a more precise form. What it is necessary to understand is that the relation of parasitism is always in a cascade. Serres offers Jean de La Fontaine's fable *The City Rat and the Country Rat* as an example of this phenomenon. The story tells how the city rat invites his cousin from countryside to eat some fine food at the home of the tax collector. Everything is fine until the rats hear a loud noise and a disturbance at the door. The city rat runs out of the building and immediately hide from the noise. However, it is too much for the country rat, who is used to living with less fanciful food but in calm (Brown, 2013). From the story, Serres explains that the parasite could also be defined as the "the uninvited guest or 'social' parasite" (Brown, 2013: 89). Furthermore, he demonstrates the cascade effect of the parasitism, showing that the country rat is parasitic upon the city rat while the latter is parasitic upon the tax farmer, who is himself not a producer but instead is a parasite of the fine goods served at the table taken from its producers.

But how is the parasite tolerated? Or, in terms of the present inquiry, why is the SSH accepted by those from whom the device receives its energy in producing and maintaining it? Brown explains how, in Serres' philosophy, this phenomenon is possible because the parasite "does not exhaust the production;" instead, he "parasitizes the reproduction" (2013: 89). The diagrams - SSH, learning curve, routes to market and innovation strategy -do not parasitize the production but rather the reproduction receives energy from those who are entangled in their use. Nevertheless, this allows the parasite to become nearly invisible, except for when they are replaced (as the case of the noise shows with the country rat). Additionally, in making a distinction between information and production, Serres explains how the energy taken by the parasite is given back in the form of information (as the case of the learning curve has shown). To further explain the point about energy/information, Serres tells another fable

about a blind man and a crippled man (already reviewed in Chapter III). The important issue is that these devices are parasites that act in redirecting the flow of production. They move production by the use of information. These parasites are selectors, a point of decision through which new lines emerge redirecting the production fluxes (Brown, 2013). There is a functional role that is sustained in the parasite.

6. How is change managed by the engineers of Med Dialysis?

Example 5: Med Dialysis CSTO-04/08/2012.

I: Interviewer R: CSTO	
1	I: that that's perfect but what happened when for example uh what happened when you discovered
2	that user is not the same that you were working at the beginning and then I mean there is
3	something new in the user how is this affecting the technical specifications for may maybe not
4	too much but the parts and probably some uh (.) design aspect of the [material itself I mean]
5	R: [yeah I mean] the practical aspect of (.)you
6	first of all decide whether it's something you want to accommodate
7	I: okay
8	R: >you could maybe< you first of all then have to rationalize say two of the uh eight people in your
9	survey say they don't like the screen they can't read the lettering first of all you have to validate
10	that they are statistically representative (.) not actually two per cent of the total but actually you
11	know out of the 99 percentile or something and just by chance you got them involved you then
12	sort of legitimize their statements against the others in the survey and if you think it's it's worthy
13	then you have to sort of raise a change note (0.6) to action (.) a design change in the specification
14	I: yeah
15	R: If you are a (0.1) formally that's what you do if it comes late enough in the program if if you do it
16	informally you don't necessarily have to raise a change note it is still very-very flexible you may
17	I: yeah yeah
18	R: >you don't you don't have to do that< you would change the specification
19	I: yeah yeah
20	R: but here at certain points in your model of product development is recurring then (.) uh things at
21	some point are in a design freeze and therefore require a change note for you to unfreeze the
22	design and change the specification so so this is the more flexible or case by case part of the
23	progress (.) that's no that's no difference whether it's ca:rs or fibre optic device or a metal device
24	it is simply engineering stuff.

In this interaction, the CSTO is answering a question about a change in specifications because of a potential change in user needs. Any change of a particular specification triggers management quality requirements. These requirements conjugate organizational aspects with issues of technical development. The question itself emerges from my reflection as to how people manage the constant change that is constitutive of the technological innovation process in an industry where users are highly relevant. Obviously, the introduction of any 'change note' demands a series of management actions. For example, the change note needs to be formally given to the rest of the organization and, in many cases, to the vendors participating in the co-development of the new product.

In answering the question about the change of specifications, the CSTO responds with a typical scientific design based on surveys of users. From lines 10 through to 12, the CSTO builds a scientific account of the form by which the user can be measured and, in particular, of how to "validate that they are statistically representative"(line 10) when it comes to the change in user specification. There is nothing odd about this account. This is particularly easy to understand in the technological/engineering environment, where statistics constitute the day-to-day language. However, the interesting thing is that his account encourages the listener not to treat his story as a product of his expectations but rather as a product of the facts themselves. In terms of the various discursive devices, this is a case of stake inoculation (Potter, 1996: 126). Furthermore, following the sort of vocabulary and distance from the object that the CSTO is constructing in his account, he is enacting an empiricist repertoire (Potter, 1996: 152).

In particular, this repertoire is used to support a very particular example of change. At line 9, the engineer manager claims: "they don't like the screen they can't read the lettering first." There are obvious questions that can arise from this example. It is possible to ask: why is it that the CSTO is using the screen -which is a non-risky type of change - in the context of a medical device that supports the vital care of renal patients? He is definitely managing the risk of change. Why does the CSTO avoid the change? A possible answer appears in lines 12 to 14, where the CSTO's worries are announced. He express the view: "survey, and if you think it's worthy then you have to sort of raise a change note (0.6) to action (.) a design change in the specification." From the CSTO's account, it is possible to infer that a real threat for this engineer manager is that the change becomes institutionalized or - in other words - that it triggers a change note. The construction based on the stake inoculation and empiricist repertoire is being used to manage the risk of an institutional change expressed in the change note.

This point is further supported when he categorizes the change as something "very, very flexible"(line 17),and then at line 18 where the CSTO calls for the management of the change informally: "if you do it informally, you don't necessarily have to raise a change note"(line

17). Then again, at lines 24 and 25: "so this is the more flexible or case by case part of the progress (.)." On the opposite pole, the CSTO (between lines 12 and 16) states: "if you think it's worthy, then you have to sort of raise a change note (0.6) to action (.) a design change in the specification. If you are a (0.1) formally, that's what you do if it comes late enough in the programme." The interesting words relating this opposite pole/category are 'formally' and 'worthy'. To raise the change note will raise a formal institutional change, and should only be done if it is worth it.

These change categories can be related to the categories constructed by the project manager, as in example four, where he gives an account of engineers who organize and engineers who have a creative impulse but who also have an impulse to produce disorganization. These are categories that appear alongside the vast majority of the conversations that I had with the engineers and technicians of Med Diabetes and Med Dialysis. In a broader sense, this is the old, traditional question about bureaucracy in organizations as expressed by Henry Mintzberg (1979) in his famous distinction of the five basic organizational configurations, and particularly with his 'machine bureaucracy' versus 'adhocracy'. On the one hand, it is the machine bureaucracy which works in a highly formalized manner, with many routines and procedures. On the other hand, the adhocracy (or, in a more general sense, post-bureaucracy) typically brings in experts from a variety of areas to form a creative, functional team. This second basic type is also known for its attempts to deal with the innovation problem.

A parasitic understanding of organizations will form a bridge (a relational approach) between the machine bureaucracy and the post-bureaucracy depicted in the accounts of the project manager and the CSTO. This is because the solution is the third -in Serres terms- that exists, intermediating between the bureaucracy and the adhocracy. As Rhodes and Price have claimed, there is a dependency relation between bureaucracy and post-bureaucracy that is based on the parasitism of learning upon bureaucracy (2011). However, the parasites complicate bureaucracy without "exhaust[ing] the production" and instead "parasitizes the reproduction" (Brown, 2013: 89). Therefore, the learning process does not destroy the traditional bureaucracy but instead acts as a switch that moves the bureaucracy towards something new -that is, the novelty effects of the parasite. Furthermore, Rhodes and Price claim that the parasite reinforces the existence of the bureaucracy. They claim, following Serres (1982), that the parasite (alongside its host, the bureaucracy) feeds on the host but enables the system to keep on working. Nevertheless, any parasitic relation "invent(s) something new" (Serres, 1982: 35 in Rhodes and Price, 2011: 256).

However, Rhodes and Price select a very particular parasite: knowledge. This is a category that does not appear in the data set of the present thesis. Instead, the parasite that appears within example five is the change note. A change note can be categorized as information, but to say that it is knowledge is to stretch the analytical possibilities. In Serres' words, it is the

change note appears to be the excluded third that appears in the conversation between the CSTO and myself. It is its functional role and its capacity to differentiate and de-differentiate that explains its performativity. It is its capacity to bring forth some noise in the form of disorganization and organization that needs to be the focus of the inquiry. Recalling the fable of the city rat and the country rat, the noise - as a parasite - disturbed the rats and the system returned to equilibrium. In this case, from the account of the CSTO, it looks like the change note differentiates the fluxes of production (in this case, the production that is the innovation development). The change note invades the post-bureaucratic form of the technological innovation process. This parasite purges some of the flexibility within the process but at the same time (and this is not mentioned by the CSTO) creates something new. It organizes the venture. In this form, the system keeps working (or, in Serres' terms, the system maintains its trajectory but reorganizes its processes). Bureaucracy and post-bureaucracy are mediated by the parasite, which acts as a selector organizing the venture company.

A second - and similar - example regarding the issue of bureaucracy appears in the discussion of the SSH problem (section five, example 4). There, the project manager uses the discursive device of categorization, which understands noise as a metaphor of disorder (or, in other words, the presence of the unclear). He expresses the view that "[what] we're doing here is adapting it to our purposes, um, with a view to making the picture clear because, um, in our picture there's a lot of noise lot of lot going on" (line 25). Additionally, following Brown and Middleton (2006), the SSH produces the non-discursive work of ordering that is performed in the diagram. Such ordering makes possible novel ways of communication and could be considered as a quasi-object Serres' terms.

7. The parasite

As was explained by point 5 (The Med Dialysis project), parasites act in a cascade process. As a consequence, the interesting question within the data set is who or what parasitizes the SSH (or any other quasi-object already presented in this chapter). Following Serres, it is the "man that milks the cow, makes the steer work, makes a roof from the tree" and "they have all decided who the parasite it" (Serres, 1982: 24). Therefore, the question can be reformulate as: who is the parasite of the SSH? A straight forward answer is that the parasites of these organizing devices (the SSH and the change note) are those engineers who are organizing and aligning the goals of those who are the creative, disorganized engineers at the venture company. But then, the question emerges again: who is next in the cascade? The answer to this question is, initially, the venture organization. Following Hugo Letiche (2004), organizations can be seen as quasi-objects too. In other words, the organization is the parasite of the labour of the engineers and the owners are parasites of their organization.

Finally, we have arrived to the last parasite, the one that is "always near to food, close to meat" (Brown, 2013:92). This parasite is whoever enacts the power. As Serres (1982: 26 in Brown, 2013: 94) states: "power depends less on authority than it does upon the invention of technical means to come downstream."Whoever is close to the meat is the one who has the technical means to put him at the end of the cascade. This last echelon of the cascade is "well placed" and "has the right to eat the others." That is why Brown (2013) claims that the last parasite needs to understand space, to know how to move itself and others into the topological spaces that are organizations. These are the strategic aspects of those who own the venture organizations - for example, those who are located on the board of the venture capital companies.

However, perhaps there are more parasites "down the river."Those who work in the banks that lend the money to the venture capitalists, and then the owners of these banks, and so on and so forth...In the non-foundational economy of Serres (Lépinay, 2007), and following the biological definition of the parasite (where the entity is defined as something that infects the host and takes without return something from its host),"abuse value comes before use value"(Serres, 1982: 168). As Brown notes: "before the human even begins to enter into pre-capitalist relations of exchange, we find unequal exchange." Additionally, Mateo Pasquinelli (2011: 672) explains that "Serres...provides in addition a punctual model to understand the relation between [the] material and immaterial, [the] biologic[al] and semiotic, [the] economy and media." As a consequence, Serres' parasitic non-foundational understanding of economic relations explains the complex interconnections between the heterogeneous entities that participate in the assemblage that is technological innovation.

Additionally, Serres notions of interference, parasitism and translation, bestow economic actors with strategic skills and abilities and the capacity to manage the properties of the network. This is because these capacities reflect those which the biological parasite exerts when it enters a host (Lépinay, 2007: 291). These are the important recombinational aspects of the relation. In this point, ANT reads from Serres again. This point suggests a focus on the recombinant properties of the networks rather than their general underlying patterns. The next example (six) shows how parasitism is enacted in the form of the management process in a venture company.

Example 6:

Med Dialysis CSTO-10/08/2012. (Extract 1)

I: Interviewer R: CSTO

- 1 I: but these things um (0.2) I mean my question is uh (0.3) how you connect this user specification
2 with the technical specifications that you are actually sorry just uh a practical question you are
3 in-charge of the engineering here
4 R: yeah
5 I: design engineering andum sort of am: in general
6 R: yes there is a helicopter view for the science and technology yeah yeah science and technology
7 I: mhm
8 R: in a innovation (.) they focus on the innovation of the technology
9 I: mhm
10 R: but mainly all of them never innovate (0.1) the business model or the commercial model (0.9)

Med Dialysis CSTO-04/08/2012. (Extract 2)

I: Interviewer R: CSTO

- 11 I: uh so so that's my I think my question how (0.2) the the the more techno technical work connect
12 with this more commercial or market if you want I I don't want to talk about market but that I
13 mean this uh necessities and users uh possible futures demands uh do you think that actually is
14 uh in the work of the people who designed uh the necessity of think about this future on market
15 or it is a detach thing I mean people who is working with the technology itself (.) needs to think
16 about this when he is doing this work or there is an different level
17 R: it is a different level anyway you are in the business you know
18 ((somebody ask when is that the respondent will finish the interview))
19 I: Just five minutes anyway
20 R: that's fine um yeah I mean (.) it's it helps to have those (0.1) perspective on those ideas
21 I: mhm
22 R: if you are doing what CEO and I do
23 I: mhm
24 R: in the business where you always get that helicopter view
25 I: yeah yeah right
26 R: it's um (.6) what tends to happen with people actually maybe on the on the test space where
27 actually machines they have (.3) smaller ideas not necessarily such big changing ideas or
28 I: okay
29 R: and maybe they are big but they they're related to just that particular development of your time
30 I: okay
31 R: so a little bit of (.1) both because you're always in a sort of helicopter mode you tend to see the
32 bigger picture broader more expensive ideas um that are innovative whereas there may be highly
33 innovative down here and but very very focus targeted

This interactive data set emerges in two different conversations with the second man aboard Med Dialysis. The particular use of the metaphor 'helicopter view' is enacted by the CSTO of the venture company. This metaphor is used in the context of the CSTO's self-reflection. In terms of the next chapter, he enacts the metaphor in his identity work process -see chapter 4 for an explanation of this concept. After the revision of the first extract, it is not clear what the CSTO means by the use of the metaphor. This is because, between lines 6 and 8, the engineer manager expresses the view that: "yes, there is a helicopter view for science and technology; yeah, yeah, science and technology... in an innovation (.) they focus on the innovation of the technology." The meaning of the metaphor could be the view from up above or another traditional metaphor about 'helicopter parenting', which is used to designate the activities of parents who pay extremely close attention to their child's experiences and problems, particularly in educational institutions.

However, after the revision of extract two, the metaphor of a helicopter view appears to suggest a movement up above. In one form or the other, the metaphor suggests movement towards the targets of the venture as a whole. This type of metaphor has been studied by Steve Woolgar (1980) in terms of scientific discoveries. They tend to naturalize or personalize a process in which the person who is announcing the metaphor is also participating. What then, is a helicopter view of science and technology? It is the view that is connected with the business model - the innovation in the business model. This metaphor is connected with the CSTO's categorization of engineers who innovate in the business model and those who do engineering or simply technical things.

Furthermore, in extract two, the manager shows how the helicopter view is shared between both himself and the general manager. Between lines 17 and 24 - or 1 to 7 in the next extract- he expresses a clear cut categorization of different engineers:

Researcher: R and CSTO

- 1 CSTO: it is a different level anyway you are in the business you know
- 2 ((somebody ask when is that the respondent will finish the interview))
- 3 R: Just five minutes anyway
- 4 CSTO: that's fine um yeah I mean (.) it's it helps to have those (0.1) perspective on those ideas
- 5 R: mhm
- 6 CSTO: if you are doing what CEO and I do
- 7 R: mhm
- 8 CSTO: in the business where you always get that helicopter view

The CSTO is categorizing those engineers who are looking to perform innovations under the business model. That is, it is possible to observe a sharp description of this human parasite. This is the parasite of those who perform engineering activities. In other words, it is the parasitic relationship that these managers exert on those who make the production process of technological innovation - what the CSTO understands as traditional engineering matters. This is a position that is close to business (or close to the meat). This is a category of engineers that have the helicopter view.

Furthermore, it is not possible to say that this parasite does not give something back, nor that it is not parasitized by others. In fact, there are other parasites down the river. However, what is clear is that the cited parasite is closer, within the chain of parasitism to the one who takes without giving back. There are those who are closer to the organization, such as the organization owners; in fact, sometimes the venture company owners include the CEOs (and this is the case in Med Diabetes and Med Dialysis).

8. Organizing technological innovation: a parasitic formula

As we could see from the previous examples, no entity (whether it is a manager, a device or anything else) exists independently of other entities. Instead, the entities at Med Dialysis and Med Diabetes exist and are "definable as their relevance to other things in terms of the way other things are relevant to them." Additionally, entities are "constituted by events that [have] occurred in the immediate past and by what will occur in the immediate future" (Stenner & Brown, 2009: 101). This relational and process view of organizational phenomena causes the analyst of social phenomena to observe the mediation between entities. Entities are always in the middle and are mediated by other entities. This is the old principle of ANT that came from Serres' philosophical conceptualization of the parasite.

As was discussed in point 6, the organizational problem presented in the data bears a relation with the mediation of diagrams in the technological innovation process. This problem appears in various data sets in this chapter. First, in the case of the routes to markets diagram, a preliminary answer could be that the tool serves as an 'anti-abstraction' device that 'sucks up' all the generalizations of the teamwork at Med Diabetes. This is because the device serves to reduce the differences between the members and organize any uncertainties of the future. The device thus mediates the collective knowledge of the technological innovation process. Second, in the case of the SSH, the device also mediates the product development process. The device connects those engineers who organize the venture company with those who are creative but who produce a disorganized impulse in the technological innovation process. That is the traditional continuity/difference problem of the organization/work and activities involved in the innovation process.

The problem is that neither the routes to market nor the SSH brings complete order without some novelty that can be conceptualized - following Serres - as the device feedback that leaves both groups of engineers that it feeds upon with some effect in return (Lépinay, 2007). Devices are not there purely to organize those problems of technological innovation practices that are at the same time producing disorder, un-clarity and noise. This is why Serres' claimed that "order and stability emerge like Venus from out of a sea of noise." Following Serres, noise and disorder are no longer a 'problem'. These are not obstacles and are not to be solved in order to arrive at "stable fundamentals" (Stenner & Brown, 2009: 106). This is the big challenge and opportunity that Serres identifies with his idea of non-foundationalism and a parasitic approach to the world. As Stenner and Brown (2009: 103) explain: "for Serres...it is the parasitical relation that functions as the 'atomic form of our relations,' and the principle for the production of change in those relations" (1982:8).

As Serres explains, the mediation of these devices needs to be conceptualized as the excluded third in the communication process. Devices are parasites and are part of the cascade of parasitism that works as a vague, fuzzy space in between those engineers who are participating in the activity of technological innovation. These devices interrupt and intercept, changing the direction of the productive flow. These are spaces of the mixture and confusion (Stenner & Brown, 2009: 104). These devices are the "partially controlled openings between things."

Stenner and Brown (2009) have explained that the notion of homeorhesis is at the core of Serres' parasitical account of the social. Homeorhesis is a composition of the Greek words *homos* meaning 'same' and *rhysis* meaning 'flow' (editors' note in Serres, 1983). Homeorhesis concept was seen by Conrad Hall Waddington as referring to the stability of developmental trajectories (Keller, 2002). Hall explains that in the case of homeorhesis a dynamical system returns to a trajectory (i.e., there are multiple possible states) but not to a particular state as in the much more well-known phenomenon of homeostasis.

From organization studies, Robert Cooper reminds us that organization always comes with disorganization (1994). As Serres, Copper reads from information theory in order to explain that the role of information is to mediate between order and disorder. This is why he states: "while reproducing materially, information at the same time suppress[es] it" (Cooper, 1994: 172). This conceptualization is indeed quite close to that formulated by Serres with his parasitic philosophy. The tensions between the group of creative engineers who disorganize the venture and those in the group of engineers who lead the organization of the venture company are a necessary feature of the phenomenon of homeorhesis. As has been explained by Deleuze and Guattari (1983: 241), "Michel Serres defines in this sense the correlation of the break and the flow...where production is narrowly determined by information." In other words, the parasite injects information into the system and then produces changes in its trajectory - the system's multiple possible states.

As was explained with point 6 and example five of this chapter, there are other authors who have followed this line of thought. For example, Clegg et al. (2004) explain that disorder and noise are not in opposition to order but are rather the precondition of organization. In Serres' words, "systems work because they do not work" (Serres, 1982). Although, as Brown has stated, Serres is not a theorist of organizations (Brown, 2004; 2005) and the author could be seen as 'extracurricular' writer for the social sciences in general and for organizational studies in particular, some novel uses of Serres' philosophy appear in the work of Rhodes et al. (2004) and Rhodes and Price (2011). Although these are interesting studies, extra efforts need to be made to conceptualize knowledge as the parasite of bureaucracy and thus explain the connective synthesis between the phenomena of bureaucracy and post-bureaucracy. Knowledge is an interesting category whenever "knowledge itself arises from the noise of the parasite" (Brown, 2013: 97).

What needs to be developed is a more grounded understanding of the manner in which diagrams and any type of entity participate in the complex assemblage that is technological innovation. This will demonstrate how it is that the process of change is deployed. To follow Serres all the way down, we need to see the fundamental parasitic relationship between each kind of entity, as was demonstrated earlier in this chapter with the relationships between objects and subjects. This means accepting his concept of the quasi-object. The case of Rhodes and Milani could then be understood as a kind of parasitism, whereby the parasite grants the host safety from other new parasites. Following Serres, the organism increments its adaptability but always returns to its trajectory. It is a reorganization that reinforces the system's resistance (Serres, 1982: 193).

Serres' approach to mediation points to consideration of devices as part of an object-mediated relationship at the centre of social relations (Brown et al., 2010). Such an understanding is in line with the ontological take that ANT offers to the study of organizations and the innovation process. As is now clear, it is from Serres that actor-network theorists like Latour and Callon derived their own concept of translation (Brown, 2002). As we can see alongside the examples of this chapter, devices organize practices around venture companies and innovation phenomena.

Following the biblical story, Serres presents the multiple identities of Joseph: "He is a slave, he is a major-domo; he is a prisoner; he is the bailiff of the jailor; the master of his brothers. Joseph is not fixed in his identity... For a long time, he is not recognized, his justice is not known; he is both master and slave"(Serres, 1982: 159; cited in Brown, 2013: 94). It is the circulation of Joseph that produces connections. As Brown explains, it is the transformational possibilities that Joseph brings to the whole network that triggers his conceptualization as a joker. Put another way, the special card that alters the direction of the flow therefore triggers the phenomenon of homeorhesis. This is the power of the blank figure (or dominoes). Jokers

can take on all identities, as the case of the constitutional indifference of the innovation strategy and routes to market diagrams demonstrated. This is why some devices facilitate the creation of the milieu of a variety of forms of human action. The importance of this parasitic understanding is demonstrated when one focus the gaze on the performative effects that these devices have in relation to the socialization process in venture organizations.

As was explained in Chapters III and IV, the central idea in understanding Serres' approach to understanding society is the quasi-object. This chapter has used the concept extensively to conceptualize those devices at work in Med Diabetes and Med Dialysis. The SSH, the innovation strategy and the routes to market diagrams can be perfectly understood as quasi-objects. Alongside of this, Serres explains that the identity of the Engineers the one that is co-created. With this theoretical movement, Serres' parasite becomes a quasi-object and - from its mutation - generates the possibilities of the quasi-subject.

Those engineers producing engineering objects (or simply technical objects) in opposition of those producing innovation in the business model (in the CSTO's account) are also the parasites of other people/processes (for example, parasites of the work of the vendors who are developing technology for the venture company). As a consequence, this parasitic understanding of innovation phenomena leads to a deeper comprehension of it because it provides a means to map the relations of distribution from a material point of view.

Although it is from Serres that actor-network theorists like Latour and Callon derive their own concept of translation, Serres' quasi-objects (like the blank figure or dominoes) are better equipped to conceptualize mediational aspects (for example, the routes to market diagram). Although the immutable mobile of Latour draws on Serres' quasi-object, with "Latour's rendering of the quasi-object the constitutional indifference to heterogeneity that the blank exhibits is lost" (Hetherington & Lee, 2000: 175). As has already been discussed in Chapter III, the blank figure mix ups presence and absence. In this sense, it allows for two forms of different occurrences. The routes to market diagram brings the whole world of the virtual market into the conversation of the other, because its constitutional indifference is open to reinterpretation. Instead, Latour's quasi-objects exhibit an implicit colonialism and functionalism (Lee & Brown, 1994) which when circulates into the organization and leaves behind less space for otherness. If diagrams - and more generally objects - were uniquely immutable mobiles, then the result of the parasitic relation between the quasi-object and the rest of the entities will always lead to new homeostatic equilibriums. Nevertheless, it is not always possible to observe this kind of equilibrium. Sometimes, it is possible to observe homeorhetic equilibrium, whereby an "internally-organized system regulates around moving, rather than fixed-from-the-outside, setpoints" (Margulis, 1990: 866). Certainly, this homeorhetic equilibrium opens up the possibility of a variety of states in maintaining the trajectory of the system, but with a reformulation in the internal entities that are part of the

system. Although the flow of production is the same, the flow can change hands by parasitism and can obviously be reformulated.

That is the value that is added of Serres' theory of quasi-objects over a purely ANT approach to mediation (and more generally to an understanding of organizations and the phenomenon of technological innovation). Serres opens up the possibilities of transformation. Therefore, diagrams/objects and devices generate diverse articulations in the structure of the organization and the technological innovation dispositif. Parasitism and the excluded third allow Serres to generate a position from which identity phenomena can emerge. The parasite or the excluded third, as the case of the diagrams shows, interrupts and canalizes communication at the same time: "we are only together because of the parasite" (Brown, 2013: 96).

The parasite can transform any process -in particular the production flow- in three forms: redirecting it, paralyzing it and catalysing it. This is why it is so important to focus on parasites, whether these are blank objects, zero objects or any type of entity. Such a parasitic understanding of the innovation process triggers a more relational-based approach of identity formation. This will be the object of the next chapter of this thesis.

Chapter VIII: Venture Engineers

Fieldwork observation: 4-08-2011.

"When I finally arrived at Med Dialysis, I received the news that Clive would be busy along with most of the staff. This was because they were preparing for a board meeting. Fortunately for me, I received a ticket that permitted access to the local internet network (using my own laptop!) at Med Dialysis. I began to feel that they were accepting me - in one way or another as a part of this group of people. I struggled for a while to try to connect to the network and use this odd system. Finally, I got connected. This permitted me to work online at the desk that I had been using most of the time. The desk itself belonged to a manager that I called 'the phantom manager', because he was never at the office when I visited Med Dialysis.

From my position I could see that they were indeed working on something 'extra'. They were quite focused on their screens. I now see that they are preparing for the board meeting. This is an important meeting with the investors of the company. Thus, I'm present when the CEO asks the marketing manager to do something extra and urgent for the meeting. The commercial manager argues that he really doesn't have the time to prepare all of the information demanded by the board. But time, says the CEO, must be created to do this! I can see how he is now selling this idea to the group - he is convincing. The manager, engineers and the technician accept it. There are tests to be done, tests that are not easy and which will demand time. The CEO claims: "It is not too difficult - there are always short cuts for the tests." The flux of design and tests can't be stopped. They need to present the results to the Directors Although they still need more than a year to launch the product, they nonetheless need to present results. Nobody, not the CEO nor the engineers nor the managers know exactly what kind of results - but good results, for sure!

I recognize that the development of the product demands time to prepare for the boarding meetings - the people have to have answers in advance and prepare and rethink the work that they have been doing. The lead times obliged, the lead times lead them all! All these engineers work with a single focus. They want to convince the investors that the development had been good, and they want to advance some answers to some potential investor/director's inquiries. They told me that this is the real commercial work nowadays. To convince those who have already invested to maintain their investment and potentially put more money into the company.

I'm looking at this spectacle and at the same time working to negotiate access. It is interesting that being on the inside of the organization doesn't necessary solve the access problem. So, I send an e-mail to the Chief Technology Officer. I explain to him that, if he wants, we can postpone today's

meeting/interview. He then visits me and mentions that we can still have a short meeting. He is very busy preparing for the board meeting, but he makes time for my interview. Now I see how it is that the CEO articulates his work... He is speaking with the operation manager about something for the board meeting. People work standing up - maybe as in a sense of urgency and not to be too reflective. This is the kind of urgency that people live with when preparing a meeting with close deadlines and with the owners. The CTO is working with his people. They are working in the same way. Are they creating their future? At the very least they are creating the future for the next meeting, where - probably - some important decisions about the future will be made, a future that is going to be crucial for all of them."

1. Introduction

The previous chapter presented an object-based theory of organization applied to innovation. Such a theory views the management of new technological innovation as a distributed process. Technological Innovation emerges from the interaction between a heterogeneous set of entities, whereby engineers, technicians and managers participate, but are always entwined with diagrams in a fundamental parasitic relationship between all kinds of entity. This is demonstrated in this chapter regarding the relationships between objects and subjects. As a consequence, the previous chapter established that these diagrams are important mediators and also that social norms are embedded within them.

In an object-based and parasitic approach, the work and creative energy expended by the engineers is parasitized by their managers and the owners of the companies to which they belong. Such a socialization process is mediated by the diagrams studied in the previous chapter. Following an object-based approach to social order leads to an understanding of the identities of those who work in the venture company as a result of the recombination of this parasitic organizational process. In Chapters IV and VII, it was seen that the quasi-object is created alongside the quasi-subject. This is the process that this chapter seeks to elaborate. Parasitism is at the base of the economic system and it is made possible by the mediation and noise that these diagrams bring to venture companies' operations. As a consequence, people and diagrams are entwined in this Serresian worldview.

The diagrams analysed in the previous chapter, particularly those that present constitutional indifference (like the routes to market and innovation strategy diagrams), participate in the definition and production of the engineers', managers' and technicians' professional identities. These parasites are indispensable to the production of technological innovation. These are the third -in Serres terms- that are mediating in the relation of those engineers who simply do engineering and those who reformulate the business model. This is how the parasite provokes interruptions and also excites the system. Echoing the slogan of Deleuze and Guattari in *Anti-Oedipus*, Serres asserts that: "things work because they don't work" and

"we are only together because of the parasite" (Brown, 2013: 96). Parasitism shapes human relations. As a result, and following Brown (2013: 97), the social order is not just a product of contracts or clashes between individuals; social order is also based on mediation, which defines the inter-subjectivity and even the subjectivity of the various engineers, managers and technicians who work at Med Diabetes and Med Dialysis.

This chapter draws on Deleuze and Guattari's process-based approach and particularly their concept of conjunctive synthesis. The idea is to get into the identity production process using the tools developed by Deleuze and Guattari. In a nutshell, the chapter shows how the professional subjectivity of the engineers emerges when they 'plug in' the social machine that is their venture company into society. Following this, the chapter seeks to illuminate how engineers consume social identities as 'venture engineers'.

2. Bricolage and conjunctive synthesis

The first example presents an interview with the CEO. He is one of the partners of Med Diabetes.

Example 1: Med Diabetes CEO - 15/06/2011.

	I: Interviewer	R: Med Diabetes CEO
1		R: so very similar to what we are in Med Diabetes we are medical aghh company but again the
2		market place we are trying to get into is not fully scope and design defined and that's one of the
3		biggest issues in locate and define Mediche>because nobody understands< where to fit within
4		that market place
5	I: all right	
6		R: yeah is is a an injector pen but it is more but what do we need more well because you need to
7		reduce the dependency on professionals and how it is going to support the individual in the
8		monitoring what they are doing and correct it and we are doing a device that will be able to do
9		that but people don't know they want it the medical devi medical companies see what actually
10		mm we don't (.) truly understand that either an and the market and the NHS and the individuals
11		do want it but don't know where I can get it (.) so the thethe space is not defined
12	I: all right	
13		R: ok so we took we'd done lot of learning in the past two years um you know that market entry the
14		market position etcetc is probably one to get there but it >you know< if we are going into the
15		develop market they will be a barrier which is different a barrier would be there a lot of other
16		people that are doing things there and therefore we have to have a different (.) offering than they

17 have to break into the market

18 I: really exactly my question is then how the user is connected it's a little bit more complicated

19 than the case of the user that you are working with because if you are not clear in the I mean this

20 place as you mentioned is not well define because it's changing and it's complex it's not one

21 single place or

22 [one] yes yes one please thanks very much ((accepting the sugar into the coffee served))

23 R: [sugar]

24 I: and how then to work with this idea of user if the user could be in the I dunno if of course a

25 diabetic person but could be more techie or less techie

26 R: yeah

27 I: I mean this sort of things how are you working with this in your actual project or how do you I

28 will use the word imagine this user

29 R: yeah

30 I: in this more messy none a perfect define space of interactions

31 R: you have to go to the highest common denominator and in most cases highest common for this

32 will be non-technical people

33 I: ok

34 R: ok I hope that this is ok it's a Malawian African blend of coffee

35 I: that's sound excellent

36 R: hehehehehehe

37 I: I really love to taste different coffees [so thank you]

38 R: [that's an African one]

39 I: yeah hehehehe

40 R: am that's market and and the people within it there is there is wide non-technical people

41 technical people are definitely or target group because they will see something with our

42 technology provided (.) but if you look at the IPAD for instance my grandson has an iPad ok is

43 four years old but he can used it

The example allows us to see how the manager offers a categorization that is almost a "celebration of the lack of identity" of the company (lines 1 to 10). At these lines, the CEO presents the company as producing a healthcare technology solution for a market that already exists by claiming that Med Diabetes is the only company that understands the potential for the market. To support this rhetoric, at line 3 he uses an ECF (Pomerantz, 1986), "because nobody understands." This is an interesting point, because it constitutes a way of defining his identity as a CEO of a company that can see something that others do not see. Nevertheless,

there is a kind of ambiguity in the definitions of the technology and the market. Potential competitors/industrial players are presented as being incompetent in relation to technological solutions. Nobody really has a clue about the market, nor about the technology.

What strategy is the CEO enacting around his own and the company's identities? A preliminary hypothesis is that the CEO is adopting a particular rhetoric that leads him to reduce the 'risk' of the company being seen as without a reliable or a clear idea or market for their product. This is enacted by his ECF and the characterization of the market as something uncertain for other medical device companies (lines 6 to 11). In particular, the CEO makes quite an interesting claim at lines 10 and 11: "...that either an and the market and the NHS and the individuals do want it, but [I] don't know where I can get it (.) so the space is not defined." This is a categorization of the market and others through the use of a footing device (Potter, 1996): "but [I] don't know where I can get it (.)" makes a distinction whereby users (the market, such as the NHS and private companies) are categorized again as entities that do not understand the solution that Med Diabetes is producing and offering. Furthermore, following the footing device, the CEO builds up an externalization of the market, presenting a description of this particular medical device market as being independent of his own point of view.

The CEO uses these strategies to manage the risks around the company's identity and, as a consequence, his own identity as owner and design engineer of a new technological innovation. This is an identity that exists within an uncertain product development environment. In a twofold movement: the CEO is defining the company's identity by defining its competitors in terms of a lack of knowledge, positioning them in a sort of undefined space for competition. This is striking rhetoric because typically in a competitive strategy an attempt is made to control uncertainty. Nevertheless, the Med Diabetes CEO is defining the company's identity in an uncertain space of possibilities. In this sense, the venture company's identity and the identities of those who work there are constructed around the uncertainty itself. To add a final remark upon his strategy, the CEO then changes the footing, saying: "space is not defined" (line 10). With this announcement, the CEO is implying that there is already a defined space that is not especially closely related to his own view about the market. He is presenting the definition of the market as something external, independent from his own view (Potter, 1996). The construction of this virtual market is the result of the use of these discourse devices.

Furthermore, the CEO defines Med Diabetes' identity using a negative formulation. At lines 13 and 14, the CEO defines the company as having learned how to avoid competition with the existing incumbents in the market: "if we are going in to the develop market, they will be a barrier which is different a barrier would be there a lot of other people that are doing things there and therefore we have to have a different (.), offering [more] than they have to break into the market." This elaborated construction positions the company and

himself as being in a differentiated position. This point echoes the document analysed in Chapter VI (in relation to *Medical and Healthcare: a Guide to Market Access*); the CEO is looking to construct a differentiation strategy within the terms of the Porter (1980) diagram of competitive strategies. What is not at all clear is how Med Diabetes will produce such a differentiation strategy.

Later on, the conversation moves to the problem. At line 29, the CEO states: "you have to go to the highest common denominator and in most cases highest common for this will be non-technical people." These lines show another interesting discursive strategy; in fact, the CEO looks to be building up a level of expertise over the problem of user definition. He is performing a sort of "category entitlement" (Potter & Hepburn, 2008), as the expertise he introduces entitles him to make the subsequent claim. The CEO's expertise is not about his actions as a designer or his medical technology knowledge - instead, he builds his expertise upon his tacit knowledge (Polanyi, 1962). It is tacit because there is no means to systematize or codify it. He is constructing a rhetorical category of a 'non-technical' user. This is a categorization that the all the staff at Med Diabetes use; it is a constant in the discourse of the managers and engineers of Med Diabetes. It is a category that supports their management of the uncertainties of the technological innovation development process.

With the power that his knowledge about tacit knowledge brings, the CEO is constructing a very particular kind of security or insurance as to the future. As usual, he constructs this insurance not in terms of what he and his company know but rather in terms of what others do not know. What is interesting, in this case, is that the CEO does not use his industrial design knowledge regarding the usability for non-technologically-oriented people/users as a rhetorical strategy. In fact, he used a comparison between the medical device that they are developing and the commercially successful Apple product iPad (line 40). Here, the CEO is 'buying' the charm of this product and adding it to his own medical artefact. Considering that the iPad share only some very general similarities with the Med Diabetes One (the insulin injector and glucose meter pen system), the weakness of this comparison is striking.

Another important point is the strategy that the CEO follows to establish an 'out-there-ness' (Latour & Woolgar, 1986) for the medical device itself and the company as a whole. The CEO uses this strategy within the context of the interview. Therefore, he could be following a very similar strategy regarding the context of the industry's development. The CEO is looking to create a reality for this "partially existing object" (Jensen, 2010), Med Diabetes One (i.e., the product). In this sense, the CEO's discursive strategies build up a position of control, or at least a position whereby he can obtain something from the uncertainty of the situation. The CEO's targets are uncertainties about the market, the technology itself and the final acceptance and success of the new product. In this sense, the company's identity formation and his own are entangled with the product's development and the management of the uncertainties of this process.

As a preliminary at least, the phenomena could be conceptualized as a co-configuration of the technology and the identity of the CEO/company as one. In fact, as the STS literature has explained at length, it is the self-images of managers and their desired interactions with specific groups of users that are inscribed within the technology developed (Summerton, 2004). Professional identities are thus co-constituted in specific representations with these users. What is interesting in the example is the CEO's discourse about the management of uncertainty, it is that CEO is using a very sophisticated 'category entitlement' device, supported by the categorization and ECF discursive devices. Such a construction shows how the speech of the manager is entwined with the uncertainties that technological production brings to the organizational process. This type of analysis sheds some light as to how the construction of user categories coproduces the venture's identity and - in tandem - the CEO's professional identity. The CEO's identity construction reads from the broader general user categories -in Deleuze and Guattari vocabulary, a social category- the 'differentiated' company.

This first example offers a plea for the study of the connection between the professional identities of engineers as mediated by the venture's identity (i.e., institutional identity) and the technological innovation process. To accomplish this task, it is now time to move towards the use of the analytical toolset of Deleuze and Guattari's *Anti-Oedipus* (1983). From this, the manager and the organization are machines coupled together in processes of production and consumption. The productive activity of the company (in this case, technology design and development in general) bonds with the productive activity of the technician/engineer in a logical connective synthesis. As a consequence, the production of the identity of the engineer/CEO depends upon the product of the company.

This situation is strikingly similar to that which Deleuze and Guattari describe as the productive aspects of a desiring machine. The authors claim that: "there is no need to distinguish here between producing and its product. We need merely note that the pure 'thinness' of the object produced is carried over into a new act of producing" (Deleuze & Guattari, 1983: 7). The authors then produce a parallel between this 'non determination' of the mode of production and Claude Levi-Strauss's famous concept of *bricolage* in his *The Savage Mind* (1968). Briefly, Levi-Strauss defines bricolage as the practical art of making with what is at hand. Therefore, what occurs with the work of the CEO is a sort of bricolage insofar as he exhibits a close connection between users' definitions and his own work activity. The process of product development connects with its own desire machine.

Furthermore, Deleuze and Guattari offer an in-depth understanding of bricolage as a fundamental part of the identity construction of the CEO. What is interesting to note is that, as a desiring machine, the CEO is in connective and disjunctive syntheses with the production of the venture organization. That is, the CEO's and the venture organization's

production are defined by the use of the particle 'AND' in connective synthesis. At the same time, the CEO and the venture company are in disjunctive synthesis -OR- with other entities, like competitors.

The concept of production includes both potential technology and product development as well as the venture itself (i.e., its self-organizing activity). This is what Deleuze and Guattari call an "assemblage of machines" (1987). The venture company's identity is in machinic -in terms of Deleuze and Guattari- connection with the product that it develops. In addition, the CEO's interactions produce flows that connect with other desiring machines (for example, interactions between Med Diabetes' production and the users defined by the CEO). These interactions produce a virtual market in which those actual and virtual flows, cuts of flows, offerings and potential user demands of Med Dialysis enter into the production process.

More importantly, the CEO's discourse shows how the company and his subjectivity participate in the same production process in a conjunctive series. However, the production process and its connective synthesis do not complete the CEO's subjectivity. The CEO is clearly looking somewhere else to find elements for the construction of his own subjectivity. One of the places from where the CEO could be reading this social category is *Medical and Healthcare: a Guide to Market Access* (analysed in Chapter VI) and the general self-care discourses. The hypothesis of this study is that the CEO is reading this social category - social machine- that is the medical device industry and the actual UK government regulations and general discourses.

The CEO participates in the production of users and the venture company in connective synthesis. However, connective synthesis always comes with disjunctive synthesis. As is clear in this case, the disjunction marks the CEO with the healthcare industry's distinctions. It is exactly there that the CEO's subjectivity is:

"produced as a residuum alongside the machine, as an appendix, or as a spare part adjacent to the machine-passes... This subject itself is not at the centre, which is occupied by the machine, but on the periphery, with no fixed identity, forever decen-tered, defined by the states through which it passes" (Deleuze & Guattari, 1983: 20).

The CEO's subjectivity emerges from these heterogeneous syntheses and the formula: 'if... then'. In the case, the formula could be: IF all these issues/aspects define this industry, with these actors, with the actual development of this technology, etc.... THEN the CEO becomes this particular entity.

Does this process follow the same path when the subject is a professional who is not the owner or within the top management of the organization? The next example considers some aspects of such inquiry.

Example 2: Med Dialysis design engineer - 14/07/2011.

	I: Researcher	R: Design engineer
1	I: right so so anyway he's quite interested in this connection because I don't know I mean you need	
2	these connections with companies all around the world and actually you are not as Ray	
3	I: Ray Roberts	
4	R: yes	
5	I: explained me that the general oper operations possibilities (.) I mean you will always be using	
6	foreigner vendors that are going to supply the parts	
7	R: yes	
8	I: and well different things for the final machine and then even later possibly partnerships to	
9	develop or to produce or to whatever I mean it's always a component things and not one single	
10	site production well even not to various size of different production connecting together so for	
11	me this idea is interesting to explore so that's my question about the partnerships how are you	
12	managing these the possibility of change because the result of this possibility I mean competition	
13	between them and possibly change of specifications i don't know: i mean any change	
14	R: the the only that I have with that is that we need to be prepared with the documentation to be	
15	able to get suppliers which usually needs they need more and more feeding	
16	I: yeah	
17	R: now you can't let the supplier have the same level of responsibility as a our existing supplier for	
18	example (.) and the guys that we have down in Essex to make the cartridges for example they are	
19	doing they are commission to a whole new clean room they're proving that out they're proving	
20	that commission for welding that assembly they're building all of their fixes are they are doing	
21	testing of our components they are doing validation and cleaning and sterilization etcetera and	
22	all of that is stuff that they are taking away from us that we will have very robust specs	
23	specification for once they're finished but we don't have it now	
24	I: okay	
25	R: no not in the same way we won't have it at the same level and that will then feed into the next	
26	level of cost reduction and they're aware of that you know they're aware that this a limited life	
27	the same thing applies to all of the other suppliers	
28	I: right	
29	R: as far as away	
30	I: right	
31	I: now that's up to the COO and the CEO and the project management teams to decide what they	
32	I: want to do and at what point they want to make that changeover (.) and how they want to do it	
33	I: and where they want to go that's not really an engineering decision it's more responsibility ours	
34	I: is just make sure engineering is right and we have a robust machine there are other people	
35	I: around that need to make this decision about when it's tactically useful to go and make that	
36	I: change	

What the design engineer describes in the example is the activity of working with the external providers of the machine's cartridge (for details about this technology, see point 3, Technological innovation and Commercial risk, in Chapter IX). The disposable cartridge is a part of the mobile dialysis machine which cleans up the blood of the patient. The cartridge is one of the core technological innovations of the dialysis solution. It can be disposed of without any need to clean it up, leading the whole process to a higher level of productivity (if the machine is being use in the hospital/clinic) and, crucially, a lower level of maintenance. The cartridge is the result of a co-production process. Med Dialysis produces the technical specifications and the Design engineer defines the vendor as those "guys that we have down in Essex to make the cartridges - for example, they are doing they are commission to a whole new clean room they're proving that out they're proving that commission for welding that assembly they're building all of their fixes are they are doing testing of our components they are doing validation and cleaning and sterilization etcetera and all of that is stuff that they are taking away from us" (lines 18 to 22).

Furthermore, the vendor is crucial to the production process of Med Dialysis. The question opens up the interaction inquiring about the management of change and potential relations between Med Dialysis' and its 'partner' in the cartridge production. It is in answering this question that the Engineer detaches his responsibility for what he calls "the next level" (line 25). What he understands by the next level is an important issue that defines his work at Med Dialysis. With the use of this discursive device, he is categorizing engineering decisions as being at a different 'level'.

What is interesting here is the categorization work (Edwards, 1995) that the design engineer performs. With this, he is implicating that the next level takes charge of cost reductions. The engineer's work is defined - then - as the negation of management work (for example, the work of the CEO, the COO or the project manager). Within this categorization, these are types of activities that could be in charge of the decision management team, but not of those that perform engineering work.

Following a traditional discursive analysis, the engineer constructs his professional identity in the organization and the performance of the engineer's discourse (Potter & Wetherell, 1987: 49). The consequence of the engineer's classification is the clear cut idea of what his work consists of and what the work of others in the company consists of. When the engineer claims (referring to the CEO and the project team) "and how they want to do it and where they want to go that's not really an engineering decision" (in line 32), he is performing a discursive cut in his responsibilities. Therefore, it is these others who manage the risk of the vendor's technical development. These are activities that never form a part of his responsibility because he is someone who does "engineering work." However, is this enough to understand the interaction and the production of his subjectivity?

What needs to be addressed is the problem of changes of technical specifications that I bring to the conversation (at lines 12 and 13). Considering that technical specifications are produced by the design engineer, it could be said that this 'spec' are the Design Engineer(s) very act of production. Such technical specifications are the product of his actions as a design engineer. Vendors use these 'products' as well. In a sense, connective synthesis precisely explains the modular type of production at Med Dialysis (see Chapter VI, section D). At the core of this world are processes and desires. As Deleuze and Guattari (1987: 7) have put it: "any point of a rhizome can be connected to anything other (point), and must be." This is the world in which the design engineer develops "very robust technical specifications" (line 23). With these specifications, the design engineer is seeking to minimize potential change (for example, a change of vendor or a change by the vendor). The technical specifications operate here as another machine that produces a break in the flow of the vendor. For Deleuze and Guattari, the vendor is a machine too. At the same time, the specifications themselves function as a flow or as a part of the vendor machine's productive flow (Deleuze & Guattari, 1983: 38).

However, as the example shows, there are potential changes within the specifications of the product, and as a consequence within the production flow in Med Dialysis. These changes are due to those decisions about change that the design engineer calls "the next level." What could this be in terms of Deleuze and Guattari's toolbox? This could be considered a "disjunctive synthesis" because the phenomenon takes the form of "either...or...or" (Deleuze & Guattari, 1983: 12) Things might occur one way, or they might occur in another way. There is no definite preference. This is the problem that the engineer faces when he responds to the difficult question about change. A disjunctive synthesis involves the interruption of the machinic processes and adds new connections to the network -the rhizome in Deleuze and Guattari's parlance. Nevertheless, such disjunctive syntheses are not just interruptions that lead to the proliferation of new connections and then reconfigure the patterns and material connections of the machines; they also mark and generate a code that becomes significant for future connections (Brown & Lunt, 2002: 14).

What is inscribed in the specifications is the social machine that we call 'modular production' or 'outsourcing'. This is the particular social machine in which the design engineer and the vendor 'plug in' their desiring machines. The disjunctive synthesis produces a code that reconfigures future connections of production - that is, it reconfigures the production process. However, subjectivity production demands another process.

Brown and Lunt (2002) call this process 'fermentation'. It is a process in which conjunctions and disjunctions mould the production process. Once again, as in the case of the CEO of Med Diabetes, the professional identity of this design engineer designates a place in a particular assemblage of machines (persons and other entities) rather than separate or pure entities. The design engineer is shaped by a process whereby "the subject consumes and

consummates each of the states through which it passes, and is born of each of them anew, continuously emerging from them as a part made up of parts" (Deleuze & Guattari, 1983: 41; quoted in Brown & Lunt, 2002: 15).

Furthermore, the design specifications' work is the productive flow constitutes his engineering activity. The specifications also comprise a mediation object between the design engineer's work and the work performed by the vendor/partner in the development of the company. If the specifications change, the flow presents a break (a permutation). This break acts as a disjunctive synthesis between Med Dialysis's productive flow and the vendor's productive flow. The design engineer's subjectivity emerges alongside the social machine that is the venture company and its modular productive rhizome. It is the residual of the productive process; it is the "appendix, or the spare part adjacent to the machine-passes" (Deleuze & Guattari, 1983: 20). This is the conjunctive synthesis process, with the design engineer as the consummation of the modular production as a social category.

The earlier analysis of the emergence of the CEO's and design engineer's subjectivities based on connective, disjunctive and conjunctive syntheses resounds with the idea of actor-networks. As with Deleuze and Guattari, Callon and Law (1997) have claimed that "scientists and engineers are bricoleurs." Elsewhere, Law (1987) has called this process "heterogeneous engineering." This represents a part of the lessons of the last 30 years of the social studies of science and technology. In this sense, the idea that entities do not have fixed boundaries or attributes has received empirical support in actor-network studies (namely, in the research programmes of Bruno Latour, Michel Callon and John Law, among others).

The examples of the CEO and the design engineer show that the human dimension needs to be re-established as a crucial aspect in order to understand innovation phenomena and how actor-network approaches are useful notions to the study of professional identity. All in all, Deleuze and Guattari's toolbox allows the analyst to understand the engineer who, as a result, is consuming and is at the same time consumed by the other entities/machines. In the last example, these other machines were the organization, the vendors and society – the social machine 'par excellence'. These participate in the development of the parts of Med Dialysis's novel product. Such an analysis allows us to return to the idea of a relational development of identity. The CEO and the design engineer are always patchy or sporadic, dependent on other machines.

In this sense, Deleuze and Guattari's conceptualization of conjunctive synthesis becomes a prop for adding a social connection to ANT. The concept shows how social categories are produced and consumed at the same time. Additionally, concepts such as connective and disjunctive synthesis allow us to understand how the work of categorization is not just at the level of enunciation but also at the level of the machinic (or the material level). This is clear in the case of the mediation of technical specifications, which opens up detours/

disjunctions and connections for the production process as a whole. The more changes that exist in the technical specifications, the more ambiguous the design engineer's work is. These ambiguities, as Alvesson (2001; 2004) explains, exert pressure upon and move the engineer into uncomfortable zones from which innovative constructions of identity can emerge. These innovative constructions exhibit resistance to the kind of work that the company moves him to perform.

Those who work under the uncertainty of the technological innovation process confront the problem of ambiguity. Alvesson (2001; 2004) claims that ambiguity pressures individuals to defend the identities they construct and, more importantly, that ambiguity moves people to spaces for the innovative construction of identity at the organizational and professional levels. In short, ambiguity offers an open arena for positive action. Additionally, it also represents a tendency calling for defensive measures (Alvesson, 2001: 883).

Although the engineers can ask for clearer technical specifications in order to manage the change, the managers normally defer the production of clear specifications until the end of the process. Ambiguity is at the core of the engineer's identity coproduction. But at the same time, the conjunctive synthesis shows how the engineer will consummate his subjectivity from the repertoire of possibilities that the social machine offers. He is clearly plugging his desire machine into the social machine of the healthcare industry. Such a social machine is aligned with the venture discourses of actual society and calls for companies to accept increasingly high levels of risk. As a consequence, and cascading down - as in the case of any the parasitic relation - companies shift that risk down to their engineering labour. Such a process is aligned with what Gina Neff has called 'venture labour' (2012). Engineers are mediated by ambiguous tools and accepts higher risk levels.

3. The mediation of diagrams in the identity construction

In point 2, the specifications are the mediational object or the third -see chapter IV for a Serrean explanation of the concept- between Med Dialysis and its vendor. However, this point demands additional analysis. The next example gives a conversation with an executive from Med Diabetes, providing the continuation of the conversation regarding the potential production and distribution channels already analysed in Chapter VII, example three.

Example 3: Med Diabetes manager - 14/07/2011.

	I: Researcher	E: Executive
1	E: so (1) excuse me I can't honestly remember all of this but I think we decided that the best to go	
2	I: mhm	
3	E: would be for us to work with the pen equipment manufacturer and have someone else make the	
4	case	
5	I: mhm	
6	E: and put someone else there for the blood glucose monitor in it ((coughing)) (2) then that would	
7	go through a communication network provider who would sell the whole product and they would	
8	wholesale it so the they could actually doing themselves or they could do it to another wholesaler	
9	I: right right	
10	E: so there were several options and some of them have a greater risk than others some had a better	
11	profit share for us than others ahh and it probably mean that those with the greater risk for us had	
12	a less profit share so we sort of went down to the area that we will have a better market share and	
13	less risk so that's that had we looked at it	
14	I: m:	
15	E: so this aha I'm sorry to say this is not very clear to me now	
16	I: ok maybe is changing	
17	E: it is changing am in as much as (2) ((taking a time to see the diagram)) see with with looks at this	
18	in a lot of different ways for instance Med Diabetes could am we have the legal management of	
19	the product we could sell it through retailer outlets to the final customers or we could be do the	
20	designer in the contracts and the customer management at the end so the customer you wouldn't	
21	get back to the retail outlet they will come to us for am how to use it and if they want to do an	
22	upgrade but we also accept that we could do that through a wholesaler	
23	I: mhm	
24	E: am and that's one of the wholesalers could be like the NHS or we could then going to a joint	
25	venture with overseas companies who would sell am or we could do our own direct sales to	
26	customers am and we will have our own direct backup solutions or am we would have the	
27	mobile am people coming into us and we would buy their stuff and we probably sell it to the	
28	retail outlets as well so can you see it was a very lo:ng discussion about who were the markets	
29	I: mhm	
30	E: we know who the final customers are	
31	I: yeah yeah	
32	E: but how do we sell our product to them so for instance ((coughing)) here ((pointing to the	
33	diagram)) we've talking about am a partner it up with a pen supplier or manufacturer am and	
34	having a financial link to them and licensee to them and they could sell it through retail outlets or	
35	to the wholesalers am and or the retail outlet could sell it into the NHS .hhh	

The situation shows the manager trying to remember the definitional process of the potential production-distribution channels of their product. The routes to market diagram (see Chapter VII, Figure 3) mediates the interaction. The manager struggles throughout to remember. It is the messiness and visual complexity of this diagram that makes it difficult to remember the meaning of each production and commercial distribution scenario.

This is how the diagram is used to enact different points of views about the production-distribution channels. Interestingly, the manager enacts these options and the risk involved with them: "there were several options and some of them have a greater risk than others" (line 10). So, the device produces a space of calculability (see Chapter III). This is how the manager produces a theory of risk in the wild. She claims that some of the options: "have a greater risk than others; some had a better profit share for us than others, ahh, and it probably means that those with the greater risk for us had a lower profit share, so we sort of went down to the area that we will have a better market share and less risk so that's that had we looked at it" (lines 10 to 13). It is striking that the manager express something that clearly contradicts economic and financial theory. She express that if risk is higher therefore profit share decrease. But at the same time, she also recognizes that there is something wrong with this relation, claiming that: "so this, aha, I'm sorry to say this is not very clear to me now" (line 15).

What is the meaning of this manager's hesitation? In Chapter VII, the object was treated as being constitutionally indifferent; therefore, the diagram failed to end the doubts of the manager. Nevertheless, the diagram produces a space of potentially distinct options to end any differences. That is the mediation of the diagram. Furthermore, the account of the manager is, in the end, solid. At line 30, the manager states: "we know who the final customers are." She is categorizing her knowledge in a strikingly similar manner to the CEO from example one. Although she does not remember exactly what the diagram explains, it in fact explains how a group of potential productive agreements and commercial distribution channels operate.

The diagram is mediating and - here - acting with the production of the manager. She is the manager in charge of the commercialization and fundraising for technological development. She produces knowledge about customers and potential investors. In a way, the manager presents the diagram as an external reality; it is a description of what the options are. To this extent, it does not matter that the diagram is the result of their production as a team in Med Diabetes.

The manager is in fact using the diagram as support for her knowledge about the uncertainties of the commercial space of Med Diabetes in development/design product. She defines a specific scenario in which she uses the diagram. The next extract sheds some light on this process: "but how do we sell our product to them so, for instance, ((coughing)) here ((pointing to the diagram)) we've [been] talking about am a partner it up with a pen supplier or manufacturer am and having a financial link to them and licensee to them and they could

sell it through retail outlets or to the wholesalers and the retail outlet could sell it into the NHS .hhh" (lines 32 to 35).

From this extract, the manager is clearly in disjunctive synthesis with the diagram. This is because the diagram is adding new connections with its translation. In other words, the diagram connects the manager with the operator 'OR'. This is because the diagram offers several different production-distribution scenarios. This disjunction comes with the connective synthesis of the productive flows. In the case, the diagram comes with the connective synthesis of its production, which came up with this object and settled the differences between the members of the team at Med Diabetes.

It is now possible to see the manager's identity construction within this machinic process. She uses the spaces of calculability that the diagram produces in connective and in disjunctive synthesis with her knowledge about the final customer. The diagram marks her productive flow for future connections and possibilities. But the question remains, Does the conjunctive synthesis emerges through the mediation of the diagrams? If we follows Deleuze and Guattari, it is impossible to understand identification separately from the "infrastructure itself" (Deleuze & Guattari, 1983: 63). Therefore, the diagram is here offering infrastructure for the manager conjunctive synthesis. However, as we know the conjunction 'reads' from broader social categories. Therefore, the question that remains is still what is the idea of the world that is consummating in the manager's professional identity?

The hypothesis of this thesis is that manager's identity is produced as the consummation of the risk that moves through the diagram and makes a space in the market for the venture. It is only then that her identity emerges as the residual of the machine; it is only then that her identity emerges as the conjugation of the formula: 'If... Then'. Such a formula might take the form of: 'IF the market is defined in this sense using the routes to markets diagram, THEN I'm defined as the manager who knows about the final customer'. As a consequence, her identity as a professional is defined with the new products' creation and with the mediation of the diagram. What is striking in this example is that the manager confronts the ambiguity of the virtual channels of distribution and other complexities of the innovation process through the use of an ambiguous diagram. The uncertainty is managed with further uncertainty.

From an interactional perspective, Goodwin (1987) shows how a discursive strategy that relies on a talk about uncertainty (line 1) can provide the possibility of changing interactions. With her claim, "excuse me I can't honestly remember all of this but I think we decided that the best to go" (lines 1 and 2), it seems that the manager is attempting to create options in the conversation. This shows that her professional identity (resulting from the diagram's mediation) is up for negotiation. This openness needs closure, which is what the diagram brings her in her interaction. It is closing the openness. The object is acting here as a marker of the relationships that had been elaborated. Following the analysis of the previous chapter,

the manager is parasitizing the diagram and receiving information from it, though at the same time she is being marked by the code inscribed in the diagram. This important point leads to the preparation of future connections between the manager's flows of production and - ultimately - affects her identity work.

What is interesting about example three is that the executive is offering various strategies to manage the problem of uncertainty in the company's innovation practice. In fact, at line 34, she claims that "we know who the final customers are." This ECF (Pomerantz, 1986), as with example one, indicates a complex entanglement of the strategies used to manage the discourse and the non-humans intervening in the accounts of the manager. The result of these discursive strategies leads to an understanding that the ambiguity of the diagram serves to produce the identity of the manager.

The idea of innovation in use at both Med Dialysis and Med Diabetes requires an existence that embraces the uncertainty and ambiguity of the market. It is not simply a multiple identity in the sense of 'different positions', as Wicks and Grandy (2007) and Robertson and Swan (2003) have claimed. Instead, people build their professional identity by embracing the uncertainty itself. This comes with the strategic ambiguity (Eisenberg, 1984) that such an artefact as the diagram of the distribution channels brings to the enunciations of these venture companies' professionals. The consummation (or conjunctive synthesis) process clearly involves accepting a higher general risk at the level of society.

It is now possible to understand Bowker's (2010: 127) point of view. The engineers, technicians and - in general - those who work within the high knowledge environment of Med Dialysis and Med Diabetes, all enact multiple identities. The example shows the emergence of their identities within the process conjunctive synthesis of Deleuze and Guattari's toolbox. Additionally, the conjunction shows the production of the collective. This is because the conjunctive synthesis inscribes those particular characteristics' modes of production within it. These particular modes of distribution and exchange are enacted in the diagram.

This is the process that I call 'engineering the engineer'. It is a path whereby the idea of innovation (and its related distribution channels and productive arrangements) acts as a social machine from which engineers, technicians and managers feed their own identities and embrace ambiguity as the solution to the highly uncertain state of the affairs that every innovation project confronts. The next example will offer further insight into the engineering the engineer process.

Example 4: Med Dialysis design engineer - 07/07/2011.

I: Interviewer R: Design engineer	
1	R: and also they want better pipe routing or they want small bore or larger bore pipes
2	I: aha
3	R: or something like that and that isn't relevant to what we're doing
4	I: aha
5	R: what we need to understand is (1) how physically strong are they (.) do they have you know you
6	need to understand physical attributes at all fundamental level are they are they strong enough to
7	carry those boxes of equipment no are they sensitive (0.5) the the is their vision impaired quite
8	frequently what are the problems what are the medical problems will they have what is typical of
9	the mmm set of people that we're going to have on dialysis and to get an understanding of that
10	and from that we have to infer a lot of information to start with
11	I: um-hmm
12	R: because we have an idea of what we want to do over here we have a user group and we have to
13	make those meet now (1) I was talking to some of the guys in the shop floor a while ago and
14	they were saying well nothing ever seems we never even we never seem to know where we're
15	going in this company
16	I: hmm
17	R: I said well actually what we've got to realize is we have a rough idea of how we're able to do
18	something and that thought it is a cloud that moves that will move around the room and what
19	that's doing is we're trying to get that into a stable position where it meets the needs of
20	somebody so that that thought bubble will move or not and because we don't know we'll try not
21	to experiment and we'll hone that and the specifications what we want will get honed in to where
22	we need to be
23	I: hmm
24	R: but at the same time we're honing in the specification of where we want to be
25	I: okay
26	R: so all of the work streams that we have within the company are being handled at the same time
27	so pricing manufacturability customers sorry customer client patient as you will
28	I: yeah
29	R: manufacturing design CA approval etcetera FDA approval
30	I: hmm
31	R: all of those are all of these things are feeding into our specifications

Although the engineers and technicians of Med Dialysis are still at the prototype phase of product development, the production of their professional identities is equally entangled with the underlying productive process. Their professional activities are always on a pendulum,

moving between product development and organizational managerial tasks. Here, at line 3, the design engineer offers a long explanation of customers' and vendors' technical specifications (the SSH and others). In fact, he is reclaiming a sort of technical knowledge of what they "are doing" (line 3). Once again, technical knowledge and the design engineer's identity work are entangled with the production of the specifications and understanding of the "physical attributes [of the product] at a very fundamental level" (line 6). However, the design engineer's claim about his technical knowledge comes with his uncertainty about the future that Med Dialysis, "because we have an idea of what we want to do over here, we have a user group and we have to make those meet now (1) I was talking to some of the guys on the shop floor a while ago, and they were saying well nothing ever seems we never even we never seem to know where we're going in this company" (lines 12 to 15). So how does the engineer solve this problem?

Following a machinic approach to subjectivity production, this must be treated as an empirical question. The problem is the professional identity being organized, whereby the engineer need certainties but works with uncertainties. The example shows that the engineer solves the problem using a metaphor. The professional claims that they work together building over an idea that is like a cloud "that moves that will move around" (line 18). This is, paraphrasing Star and Griesemer (1989) a 'boundary thought' that is current on the shop and design floors of Med Dialysis.

In this case, the idea functions as the stabilization of work activity and - as the analysis will show - it is constitutive of the identity that the design engineer produces about himself and (in one way or another) the whole group working on the design and development of the product. However, it is the process that needs to be understood: how does the engineer plan to "meets the needs of somebody" (line 19)? The engineer offers an interesting answer in explaining the process. He uses the word 'hone', which is an engineering expression. 'To hone' means to sharpen with a whetstone, but also refers to the tool itself (a machine tool) that is used to manufacture precision bores.

The engineer speaks about a 'honing' process. Moreover, he displays a hesitation in his explanation of the process of 'honing' at Med Dialysis. The engineer claims that because they "don't know, we'll try not to experiment" (line 20). He then arrives at the conclusion that the process is twofold. The engineer claims "to experiment and we'll hone that and the specifications what we want will get honed in to where we need to be" (lines 21 and 22). What is interesting about this account is the use of the metaphor of an idea/cloud as specifications (in a general form), and the capacity that this honing process in relation to the specifications of where they want to go.

This research seeks show how this honing process might be conceptualized as a metaphor for the synthesis processes explained within Deleuze and Guattari's framework. First, the

engineer's productive flow is in conjunctive and disjunctive synthesis with other engineers' productive flows. His knowledge and his productive flow are coupled with the "cloud... that moves that will move around" (line 18). The boundary object marks the code in the engineer in disjunctive synthesis. This is how ideas from the managers enter into the process of honing the specifications (the cloud in the metaphor) and are then inscribed in the productive flow of the engineer. Furthermore, the engineer consummates his identity in a process that might be defined as a simple learning process. However, this learning process needs to be understood as the relation that this engineer now has with the various social machines (like his company) through the mediation of the cloud. That cloud moves around inscribing code in the engineers. Additionally, it is possible to see the desire aspects of the process when the engineer claims that: "we want will get honed in to where we need to be" (lines 21 and 22). The engineer is plugging his desire machine into the social machine. Such is the nature of this honing process.

In the world of the design engineers, the network of entities is co-produced. At lines 25 and 26, the engineer states that: "so all of the work streams that we have within the company are being handled at the same time so pricing manufacturability customers sorry customer client patient as you will see." From this account, it is not difficult to see how the honing process that affects the technical specifications affects the engineer; he is offering a holistic understanding of it. Such a reading is one of a social machine, whereby the engineer adapts herself with the required flexibility. The engineer presents a consummation of an identity in which he needs to be flexible enough to be honed by the change involved in the technical specifications and production process.

But how does that honing process appear to the CEO of the new company? In the final example, I present an analysis of a conversation that emerges in between an interview with a design engineer and the CEO (example five).

Med Dialysis's CEO explains (in lines 1 to 15 of example five) how the technical specifications need to become an immutable mobile (Latour, 1990). This is an object that is able to travel towards the different sets of vendors and then produce the various parts of the dialysis machine. Within the example, the CEO presents a distinction between 'two moments' As the modularity requires, engineers maintain a high number of encounters with the vendors' engineers because they are co-producing the parts. Obviously, the interaction decreases when the design is more stable and the part enters into a normal productive phase. As the COO of the company explained, design engineers are in high demand during the innovation part of the project. Afterwards, when the venture company enters a more mature phase, operations demand a different kind of engineer. In their case, the COO claimed that they would need more sales engineers and operations engineers.

Example 5: Med Dialysis design engineer and CEO - 14/07/2011.

I: Researcher R: Design engineer R2: Med Dialysis CEO	
1	R2: and obviously we've discovered a specification for a chair is not just blue and this height ahh:
2	there has to be some subtleties that later on we discovered actually and we've got the right
3	answer but we didn't say it because it didn't talk about how far I could tip them there were things
4	that we keep going back to the spec that we actually have the right product but (0.1) you could
5	buy a different product of that spec if you are not careful (.)
6	R: mhm
7	R2: now at the moment the engineers have a lot of direct contact with the supplier
8	I: right
9	R2: but in the year's time maybe the supplier is in Malaysia or other things so it's not as easy to
10	explain what I really meant it in spec is it
11	I: absolutely
12	R2: and there's a difference between making a drawing and making a part that's fully dimension that
13	the best we want and for engineering purposes the drawing allows you to get working parts in
14	the laboratory
15	I: hmmm
16	R2: but then there's another level for manufacturing (.) because they have full license to do whatever
17	the drawing says
18	I: um-hmm
19	R2: .hhh well (.) we didn't specify that so there's a lot of that ritual that come into the program hasn't
20	it for us
21	R: hmm oh yes
22	R2: as we've moved from very smart creative designers to (.) the detail it must be right it is right and
23	it's a learning curve for us all]
24	R: [it's a honing of this it's the honing of all the systems to to optimize the
25	R2: it's]
26	R: [interplay between all of the requirements in the systems]
27	R2: [it's actually a honing of the people (.) because well it is
28	R: that's just the beating heheh
29	R2: no hehehe we have to get a head around this new world we're operating in that's been the culture
30	change for us]
31	R: [it has very much so very much so from a=
32	R2: =and in working out it will take us three weeks to do this we discovered this actually five or six
33	the quick bit was drawing making and testing it
34	R: yes
35	R2: the hard bit hehehe is making the documentation part

But this is not the only interesting point that we can read from the interaction between the CEO and the design engineer. Echoing example three in Chapter VII, the CEO mentions the 'learning curve' model (lines 22 to 23). Within this interaction, the CEO claims that the movement from the 'detail' design (what is known as the production of detailed specifications for mass production) "is a learning curve for us all" (line 22). The question is: who is learning from this curve? Ultimately, the learning process will be for those who remain within the company. Additionally, the learning process will not be a part of those engineers who will sell their creative engineer design work in a honed technical specification.

Interestingly, and reflecting upon the learning model, the design engineer enunciates the honing process (line 24). Additionally, and in offering a holistic point of view, the CEO interrupts, claiming that the honing process is a kind of assemblage of multiple systems functioning together. However, clarity emerges when the CEO explains that "it's actually a honing of the people" (line 27). This extension of the metaphor used by the engineer makes more explicit the engineering the engineer process. It is now possible to see the full importance of Deleuze and Guattari's explanation in addressing the point of consumption/consummation. Innovation is a social category that enacts two different aspects. On the one hand, there is the creativity related to the design engineers' work. On the other hand, innovation also enacts those Engineers that participates in the production phase.

Innovation is then a social category accepted and used by those working at Med Dialysis. It is a distinction in the modes of production within Med Dialysis. What is important in this distinction is that the engineers consummate their identities as an appendix or adjunct to this social identity. They define themselves by consuming this social category. As a consequence, the conjunctive synthesis that produces the identity of the engineer requires an understanding of the modes of production, the value chain and the relations of power and hierarchies that exist in these new organizations.

Diagrams as technical specifications have a role in and are part of the assemblage that performs the technological innovation and creates the professional subjectivity of those working at Med Diabetes and Med Dialysis. Furthermore, humans and non-humans (as with the cloud of ideas that the design engineer refers to earlier) are part of the 'identity work' and 'punctualization' (Munro, 2011) of the engineer and (more generally) those working at Med Dialysis and in Med Diabetes.

As a consequence, this thesis makes a call to move towards an analysis of identity that sees objects as being at the centre of the socialization process. Therefore, diagrams sometimes act as mediators of the account, whereby "inanimate scraps of paper or silent computer printouts elicit accounts from people" (Munro, 1996). However, diagrams sometimes act as boundary objects that are constitutive of the professional identities of those who work in new companies. This last point is closer to what Latimer and Munro (2009), in following

the work of Marilyn Strathern (1991), call a 'relational extension' of selfhood. In this sense, the present analysis is not trying to "to evacuate human presence altogether from the scene of action" (Munro, 2012: 68). On the contrary, it is trying to look for a place where humans and non-humans and their mixtures can act within the conjunctive synthesis that is the professional engineering identity of those working in venture companies.

In any case, Munro's strategy of moving from the analysis of action towards 'accounts' does not offer a final answer to the problem of technical mediation at Med Dialysis and Med Diabetes. In environments of continuous change - such as the organizations studied here - non-humans seem to be more than mere props of the member's accounts. As some developments within object-oriented philosophy have pointed out, we need to include all types of objects (i.e., human and non-human) within the analysis of social organizations (Bencherki, 2012). There is no 'superhuman' domain within the analysis of professional selfhood. Diagrams are at the core of the phenomena. Furthermore, it is only with the analysis of the mixture that exists between ideas, people and diagrams that the particular kind of design engineer who works in new companies emerges. It is from here that the social category of 'venture engineer' appears, with all its weaknesses and possibilities.

A venture engineer is a social category that exhibits certain similarities to venture labour (Neff, 2012). These are social categories that exist in the social machine constructed by the government and those intermediate agencies which shape actual discourses of entrepreneurship and innovation as solutions for economic problems. The production of a venture engineer as a subject is a result of the conjunctive synthesis that is produced in the connective and disjunctive syntheses of virtual users, meditational artefacts, ideas and any other heterogeneous entities. All of these entities participate in the engineering process that is the conformation of the engineer's identity.

The venture engineer as a subject is produced by a consumption process, whereby governments and their intermediary agencies participate through their machine and enunciation assemblages (see chapter V). These collective assemblages of enunciation create social categories from which engineers 'pick up' their identities. This point is very difficult to observe where the analysis remains at the level of connective and disjunctive synthesis. In other words, it is not possible to see this phenomenon with a plain ANT approach. Instead, understanding the engineering the engineer process and the composition of the venture engineer requires the possibility of the conjunctive production of subjectivity as with Deleuze and Guattari.

The process of becoming a venture engineer resounds strongly with John Krejsler and Dorthe Staunæs's (2013: 1100) actual work on educational organizations. The authors explain that the becoming-human "is a matter of entanglements between technologies, furniture, control regimes, human bodies, sociocultural categories, and so forth." The venture engineer emerges from the cited entanglements in venture companies. Sociocultural categories are

still important for its analysis. Deleuze and Guattari's approach gives us the opportunity of a more subtle analysis of the subject. This is the opportunity that this machinic-, relational- and process-based approach offers in the analysis of technological innovation phenomena. It is now possible to see how parasitic mediation and the conjunctive synthesis process views can be put to use in order to open up the black box of technological innovation. These are complementary approaches. The production of the venture engineer requires material mediation because the engineer is always subject to relations and is always a social category. The 'I' that is the venture engineer (or any kind of engineer) is always the product of the parasitic third that mediates in the communication.

Chapter IX: Venture Engineers and Risk Organizing Devices

Example 1: Observation and notes - 24/06/2011.

I had the opportunity to speak with David. He is one of the inventors who appear on the Med Dialysis patent. He is also a long-time inventor/innovator, who had had a career in the umbrella company from which Med Dialysis was spun off. He has several patents. As he defines himself, he is an engineer-inventor has worked for companies for around 20 years. The innovator makes a point about the personality of the CEO. From his own point of view, the various diagrams are there because he wants to decorate the office with these wall-objects. As I see it, uncertainty, impact, pictorial representations - all of these are a part of the same environment that permits possibilities.

Actually, today I have some extra time - I usually visit the company for three hours between 10 am and 2 pm, a couple of days a week. Today I have the opportunity to hang around the company. I decide to install myself at the same desk that I used while waiting for the interviews. This is the desk of the commercial manager for external markets -mainly Germany. He is rarely located here, in the UK - most of the time he works from Germany and therefore his desk is my natural place of work. Being here, one thing that struck me was the communiqué (on the commercial manager's wall, but visible to the rest of the office) of the Fourth Annual Symposium of Home Dialysis. The Symposium is a very important event in the dialysis community and industry. In fact, the innovator claimed that the commercial manager and he had assisted the First Annual Symposium, at which he claims that acceptance of home dialysis was very limited. There was a lot of debate among the practitioners. But since the third symposium, the debate was over and the acceptance of home dialysis was total!

Another interesting point that it is possible to read from the walls of Med Dialysis is the Quality Policy. I wonder how important it is for the people who actually work at Med Dialysis. Is this policy important for the users/clients, in line with their big self-care banners on the walls? I tend to think that these policies are needed because there are certain regulations to satisfy, but I don't think that these regulations come from the user of the technology; instead they come from the bodies that define what is and what is not risky as regards medical device use. Now, I also think about these Gantt tables, policies and maps as market devices. The map of the NHS is there to locate the commercialization and the policy to permit that commercialization. Med Dialysis needs to think of the future, and there is no way to think of the future without these tools. The market is right here, right now. There is a scientific poster that the commercial people of Med Dialysis have put up

on their wall: "Improving the uptake of home haemodialysis: identifying barriers and best practices towards increasing patient choice" (see Figure 1), tells the others –any other – of the importance of patient choice. It literally tells the others that "Home haemodialysis should be routinely offered as part of a full menu of renal replacement therapy options, including transplantation, peritoneal dialysis and conservative management." This is a poster that could be used to sell the idea of self-care in haemodialysis.

Figure 1: Department of Health document.



Department of Health



Kidney Care

Improving the uptake of home haemodialysis - identifying barriers and best practice towards increasing patient choice

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Introduction

Home haemodialysis should be routinely offered as part of a full menu of renal replacement therapy options, including transplantation, peritoneal dialysis and conservative management¹.

Home haemodialysis (HHD) offers improved quality of life and the opportunity to undertake more frequent or longer dialysis sessions, associated with improved survival, reduced blood pressure, medication, symptom burden, hospitalisations plus freedom from dietary and fluid restrictions².

Despite these benefits, only 2% of the prevalent dialysis population undertake HHD. NICE guidance issued in 2002 stated that HHD was cheaper than hospital HD and should be offered to all suitable patients³, yet numbers continued to fall, as they had done since the 1980s.

Recent figures suggest a reversal in this decline⁴ and an emerging enthusiasm for HHD, recognising that it offers a better quality of treatment, should cost less overall and address issues such as capacity, dialysis away from base and carbon footprint.

Aims

- To identify perceived barriers to successful HHD programmes
- To identify best practice in successful HHD programmes
- To explore current service provision for HHD and costs
- To produce a toolkit and other resources for HHD programmes

Variation in provision and utilisation of Home Haemodialysis

There is widespread variation in HHD rates, not readily explained by geographical or patient characteristics.

Region	% HHD
North East	11.4
North West	10.7
Yorkshire	10.6
East of England	10.5
West Midlands	10.4
London	10.3
East of England	10.2
West Midlands	10.1
Yorkshire	10.0
North East	9.9
North West	9.8
East of England	9.7
West Midlands	9.6
London	9.5
East of England	9.4
West Midlands	9.3
Yorkshire	9.2
North East	9.1
North West	9.0
East of England	8.9
West Midlands	8.8
London	8.7
East of England	8.6
West Midlands	8.5
Yorkshire	8.4
North East	8.3
North West	8.2
East of England	8.1
West Midlands	8.0
London	7.9
East of England	7.8
West Midlands	7.7
Yorkshire	7.6
North East	7.5
North West	7.4
East of England	7.3
West Midlands	7.2
London	7.1
East of England	7.0
West Midlands	6.9
Yorkshire	6.8
North East	6.7
North West	6.6
East of England	6.5
West Midlands	6.4
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West Midlands	6.1
Yorkshire	6.0
North East	5.9
North West	5.8
East of England	5.7
West Midlands	5.6
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East of England	5.4
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Yorkshire	5.2
North East	5.1
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East of England	4.9
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I then began to think that this article and the related poster are enablers (in a general sense), not just because of their content but because they mention the NHS and display the logo of that important public organization. The poster has a clear, large logo of the Kidney Care Unit at the NHS and the Department of Health. After this, the names of the authors (peer acceptance). This is exactly the rhetoric of the papers used by the marketing department. I suppose that this is not to sell to others (perhaps this is also true) but to sell them the idea of self-care haemodialysis!

Later, for the first time, I have a strange feeling of anxiety... What do the people who work here think about the future? They have no security at all in relation to this project. This triggers my own memories of the second half of the nineties, when I tried to set up a company that produced multimedia. Such an economically demanding task brings a lot of personal costs. How does Med Dialysis manage the risk? Although I have no interest in the phenomena of failure and success, the problem of what happens with the people always come back to me. How do they manage the risk of working on a high risk project? And in parallel, how does the company manage the technological risk itself- especially as regards the sensitive issue of dialysis care. For example, an NHS visitor was asking some of the engineers about the possibly catastrophic problem of blood going down into the screen or any other part of the machine. He asks if they can solve this sort of problem/situation. This residual risk can also be extended to water. Then he adds: "It's not anything that you need to do, it's something that you need to think about..." He adds that they need a sort of manual, "in case of". The manual must say something about it in case of these major catastrophic events. He recommended that they speak with somebody in the infection/control department of a hospital in order to understand more about these procedures.

Obviously, the risk that the self-care user needs to undertake is important. But it is also different for other 'institutional users', like doctors, nurses, family care patients, infection/control experts at the hospital and NHS managers. The imbroglio of this self-care technology brings risks at different levels and in different forms...

1. Introduction

The previous chapters present important issues that lead the inquiry towards the problem of risk. For example, the connection between the user's risk under self-care regimes and the personal engineer's risk, expressed in the uncertainty about future work, and finally the methods that these new companies use to manage risk for their operations. Although the kinds of risks associated with users, intermediaries (e.g., NHS) and producers are potentially of a different nature, it is possible to see in this movement a trend or continuity between these two extremes of the risk equation. On the one hand, it is the general acceptance of self-care within the medical practice - and in particular the treatment of diabetes and renal patients. On the other hand, it is the acceptance of riskier projects and especially a riskier professional life for what in this thesis has been called a 'venture engineer'. Both of these movements have in common the blurriness of the boundaries between categories such as 'entrepreneur' and 'labour', and 'patient under care' and 'care giver'. People working within the medical device industry are experiencing – ed., working in projects, facing more risk and a confronting blurrier division between labour and entrepreneurial activities. To become a venture engineer means to accept higher levels of risk in engineering practice. Additionally, to become a venture engineer requires one to look after oneself in the labour market. This situation displays a striking similarity with the relatively novel ethos of self-care that the government and the NHS are pursuing. The present chapter tries to shed some light on the construction of risk in uncertain places, such as medical devices venture companies.

Any venture company developing new technologies encounters a variety of risks. For example, the risk related with the failure of user definitions. This problem of the user has been at the core of many STS debates - for example, in the wide feminist literature on gender and technology and the remarkable examples in the work of Lucy Suchman (2008) and Judy Wajcman (2004). However, there are aspects of the user problem that have been less often visited by the STS literature (Summerton, 2004). For example, in Chapter VIII, this thesis demonstrates that managers' work on user configurations co-configure in tandem their professional identities. Following this point, it is no stretch to hypothesize that any risk management within companies shapes both users and people's professional identities. As a consequence, the study of risk and risk management practices could offer some extra clues into the production of venture engineers' subjectivities.

The chapter draws heavily on the object- and parasitic-oriented analyses of innovation and the toolbox of Deleuze and Guattari presented earlier. These resources trigger a device-oriented analysis of risk. Tentatively, these devices have been called 'risk organizing devices'. In a parallel analytic movement, the chapter will visit the foundations of the concept of risk within the context of organization studies and the STS literature. Furthermore, the idea is to examine an "under-investigated feature of organizations in late modernity" (Gephart et al., 2009: 141).

2. The commercialization of new technology and user risk

The lengthy observation that opens up this chapter is significant in several ways. First of all, it is important for the analysis of risk and the construction of venture care and venture professionals more in general. It shows the importance of what actor network theorists call 'enrolment' (Callon, 1986). The enrolment process affects those who work at the company and those who are either virtual or actual stakeholders of the organization. In the observation, it becomes clear that the scientific posters *Fourth Annual Symposium of Home Dialysis and Improving the uptake of home haemodialysis: identifying barriers and best practices towards increasing patient choice* are there to enrol those working at Med Dialysis as well as those who are virtual participants within the value chain of the new organization. Additionally, the mobilization of scientific institutions like the NHS and its associated kidney research arm requires the production of suitable intermediaries in the form of scientific data and papers. The machinery of science was thus enlisted openly as an instrument of politics and marketing (Law, 1986).

However, it is clear that Med Dialysis wants to establish itself as an "obligatory passage point". Furthermore, as Hardy and her colleagues (2001: 538) remind us: "these strategies help to create convergence by locking actors into the network. The more fixed or stable it appears, the more 'real' and durable it becomes, and the less controversy and ambiguity are evident... The aim, then, is to put [the] relations between actors into 'black boxes' where they become a matter of indifference - scientific 'facts', technical artefacts, modes of thought, habits, forces, objects." Nevertheless, the analysis of innovation from the point of view of enrolment has certain limitations. As is now clear following post-ANT, this analytical approach leads to a Machiavellian managerial understanding of innovation practices and innovation phenomena (see Chapters III and V).

The poster reduces these anxieties about the acceptance of new technology by the expert community. Equally, this is a means to reduce the general organizational anxiety about the future. Gilbert and Mulkay call this discourse an *empiricist repertoire* (Gilbert & Mulkay, 1984). As the authors explain, such a discourse looks for the construction of the 'out-there-ness' (1984: 153) of scientific phenomena. This is fair enough if we are discussing discoveries in terms of the scientific community's epistemology. However, what happens at Med Dialysis is not a purely scientific phenomenon.

Figure 2: Extract from the Department of Health document.



Whilst the data is insufficient to study the 'document in action' (Prior, 2008), some aspects of the document's performativity can be analysed from the physical location of the poster. In this case, the poster is located in the commercial area of the company. It is there to sell certainty by employing a notion of the expert vision about the technology. The Department of Health's logo can be clearly seen. Additionally, the NHS Kidney Care Unit appears in a prominent place in the header of the poster (Figure 2). The links to these important institutions are displayed there. The construction of impersonality, facticity and consensus are all over the document - for example, in the section about home haemodialysis's cost effectiveness, the author uses averages (presumably) and other types of dispersion measures when it comes to the evaluation of the financial benefits of the system (see Figure 3).

Figure 3: Extract from the Department of Health document.

Home Haemodialysis is Cost Effective

Literature examining costs of home haemodialysis consistently demonstrate it is cost effective, corroborated by NICE in 2002 and NHS Kidney Care in 20097.

CEP analysis performed as part of this work demonstrated, with more detailed modelling systems, quality of life and financial benefits for HHD persist. Addressing all true costs is not well described and more work is required.

- HHD £2000 cheaper per year vs. Hospital HD
- Study did not account for capital costs of future in-centre capacity requirements

Building a business case for HHD should address the following

- Cost of future capacity provision (staffing, capital)
- Need to address dialysis away from base capacity, carbon footprint
- Reductions in travel, medications and hospitalisations
- Training, installation and support

The document uses the repertoire of science, but not without controversy. Such controversies are silenced. What this document brings to marketing is a link with those who construct the facts in the document and the network of professionals who form the healthcare practices of home haemodialysis. I am not claiming that there is no opportunity for such a treatment, since what I am doing here is not an analysis of the viability of the technology. However, it is important to point out that the mixture in the document and the marketing activities of the company have certain effects. Those effects affect the organizational participants who read the poster at Med Dialysis. They definitely get a glimpse as to the acceptance of the technology. The wall mounting of the artefact allows the engineers and technicians to look at the links that the poster affords to the organization and - in particular - the out-there-ness that the document brings to the company. Finally, the document also has an effect on those who are virtual customers of the company when they visit the company, thereby enrolling these important actors.

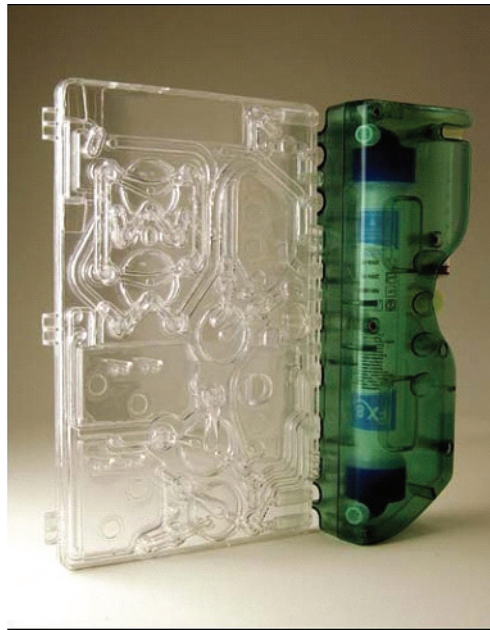
ANT is well known for its capacity to explain - ex post - issues about power and actors' strategies. This is a position of strength if the analyst is studying management and competitive strategy (Steen et al., 2006: 310). However, if a researcher accepts *prima facie* this ANT managerial ethos, then the analysis will discard alternative solutions. There are performativity aspects to the use of ANT. In the field notes, the effects of user definitions and the management of the innovation practices of Med Dialysis gives a preliminary glimpse of the forms that the enrolment and translation take in managing the futures of those who work at Med Dialysis.

The document, in a certain sense, closes off controversies in the inner circle of the company. In ANT parlance, by acknowledging the performative power of the poster as an actant, an analyst may develop a narrative which acknowledges the distributed and complex nature of the innovation practices landscape and does not necessarily ascribe innovations to quasi-heroic entrepreneurial actors (Nicolini, 2010). However, although the explanation of the innovation phenomena and practices that ANT offers is relevant, the approach needs certain qualifications. All in all, the department of health document looks to be closing controversies and, therefore, manages uncertainty and people's feelings about the future.

3. Technological innovation and commercial risk

The next example mixes the operational, commercial, technological and user definitional aspects of Med Dialysis. The following example shows a particular piece of technology. Indeed, this piece is the fundamental technological innovation produced by the company - the haemodialysis disposable cartridge (Figure 4).

Figure 4: Photograph of the cartridge prototype.



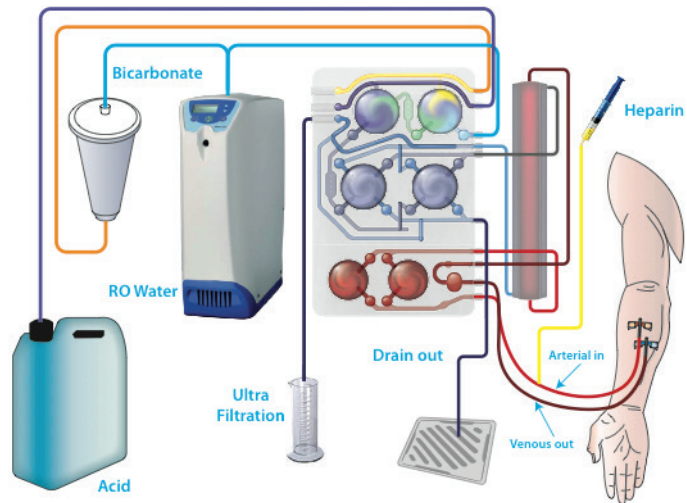
(Source: Business Plan V 4 /2011)

This fascinating piece of engineering forms the basis of the home dialysis innovation and has obtained a patent. The patent is based on the singularity of the mechanics of the fluids that are purified by the system. Economies of time are linked to the use of the cartridge. There is no need to clean up - it is sufficient to simply use it and dispose of it, with all the corresponding time and maintenance savings and potential cost reductions for NHS renal hospital units.

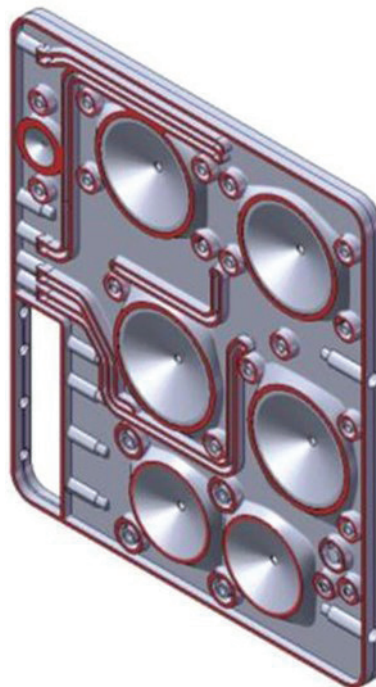
The technology of the cartridge also indicates a complicated solution - aesthetically speaking - since "the uniqueness of the technology is based on the disposable cartridge that performs all the critical fluid management functions in a sealed unit" (Med Dialysis, webpage). The aesthetic complexity of the connections and fluid movements is itself a metaphor of the form by which things happens at Med Dialysis. As was shown in Chapter VI, the company designed an interesting network of relations with actual and virtual vendors (see Figure 3 in Chapter VI). This network comes with Med Dialysis's modularity (Baldwin & Clark, 2000). As a consequence, the operational strategy mirrors the technological development. As was established in Chapter VI, the modular approach produces solutions that deal with complex systems and distinguish between the interdependence and independence of the modules comprising the network of the inbound supply chain of Med Dialysis's new product.

Figure 5: The technology behind Care One.

Section A: The system



Section B: Schema of the cartridge



(Source: web page presentation of the company)

In terms of the cartridge, the technology becomes entwined with the commercial risk and potential success of the entire company. The cartridge is a fundamental element of the business plan. As it is possible to read from example three, the cartridge is positioned as a vital step in beating the competition (lines 3 to 6). The cartridge and the sterile water system are the major technological innovations of Med Dialysis. These are the aspects of differentiation that the venture company is offering to the home dialysis market.

Example 3: Excerpt from the business plan of Med Dialysis.

1	Cartridge. All cartridge functions - including dialyzer, sensors, pump, mixing and
2	flow balance systems - have been designed, developed and tested in the functional
3	breadboard. In tests that included the simulation of haemodialysis by pumping
4	blood through the system, the results show that the performance of the 'Care One'
5	system will meet or exceed those of existing clinic-based dialysis machines such as
6	the Fresenius machine. The data we obtained from such functional tests have been
7	reviewed and validated by external renal specialists.
8	
9	Sterile water system. Med Dialysis has developed a unique sterile water system
10	that can utilise water from a range of sources and is designed to maintain sterility
11	at the required temperature of 85°C while awaiting a patient and generate water at
12	35-39°C for dialysis.

The example shows the importance of the cartridge in the discourse of the business plan. As a technological novelty, this discourse follows an empiricist repertoire. More importantly, it mixes up science and technology with competitive strategy positions through the comparative language used between lines 4 and 6. The text looks to enrol investors who read this excerpt. The use of the word 'unique' in line 9 is an example of an ECF (Edwards, 2000) that triggers the construction of a competitive advantage (Porter, 1980) and enunciation. The document also presents another technological innovation of the sterile water system (lines 9 to 12). Both innovations (the cartridge and the sterile water system) are obviously looking to impact upon the costs of care providers by reducing their operational costs.

How is this technological innovation connected with the user risk enacted by the commercial manager? A short segment of a conversation from one of the weekly operational meetings offers some insight into the importance of the cartridge and its prototype.

Example 4: Med Dialysis commercial manager - 18/10/2011.

	SE: System engineer	PM: Product manager	CM: Commercial manager	DE: Design engineer
1			CM: eh: just a quick question looking at the commercial activities where where so far are we of	
2			having a dialyzing cartridge made by Europlast with all of the specifications that we have today	
3			in a bag (.) are we months away or it is something that we could=	
4		PM: =we are very close		
5		DE: we are not that far away= but sterilization is still a problem		
6		CM: is that 3 weeks (.) is that three °month°		
7		DE: well the problem is the blood and sterilization		
8		CM: ok 'cos I'm thinking on making a sales sales bundle presentation pack		

The example shows the importance of the bundle presentation pack (line 8), what in the general innovation literature is known as a prototype. In this case, it is the prototype of the haemodialysis cartridge. As we can see, the commercial manager follows up the discussion about the new risk management tool with some scepticism. However, in the case of the prototype, he stresses the importance of timing. At line 6, the subtle hesitation and lower volume employed with the word 'month' indicates his emphasis on time rather than technical aspects (the latter of which are emphasized by the design engineer). Then, at line 8, he explicitly connects this issue of time with sales via the bundle presentation pack. It is possible to infer that the pack is an important mediation tool of his activity. Furthermore, the commercial manager is also implying that the pack is of particular importance for the range of commercialization activities.

The commercial manager is enacting an idea that comes directly from the business plan, namely the strategic importance of the cartridge. In this respect, Alex Wilkie (2010) has claimed that the prototype is a materialization of the future. The scholar describes the prototype as a "socio-material technique for performing the future in the present" (Wilkie, 2010: 143). The prototype is thus a crucial part of the strategy that the commercial manager is trying to use in order to reduce the commercial risk. This is his way to produce high impact presentations and then enrol potential customers. The materialization of the future is possible through the mediation of the bundle pack. This is a clear example of the dark organizational theory applied to the technological innovation problem.

In attempting to avoid a mechanical (i.e., Newtonian) understanding of technological change, Wilkie avoids the use of the concept 'trajectory'. This is why he defines the prototype as a vector. A vector allows us to comprehend displacement, and thus movement between points but with a direction. As a consequence, this is precisely the problem of the prototype, as its design indicates the potentiality of the future final product. For example, it shows movement

from A to B. However, this movement has a direction which can change if, for example, the commercial environment changes. The prototype as a vector is engaged in a continual process of becoming and depends upon spatio-temporal circumstances.

The commercial manager wants to organize the user's risk through the use of a prototype. He is using this vector object to manage the future. However, the use of prototypes is not always straightforward. As the case exemplifies, it is not easy to have a physical prototype. The inquiry moves now to an example in which the commercial manager of Med Dialysis confronts the problems of different users, change and risk.

4. User risk and commercial risk

Example 5: Med Dialysis's commercial manager - 02/02/2011.

J: Researcher P: Med Dialysis commercial manager	
1 J: es ese trabajo de de con el	J: This is the work with the patient with the final
2 paciente con el usuario final es un trabajo	user this is a work that it was done erm it is
3 que se hizo erm se hace sistemático o se	systematic or it is done at the beginning its
4 hace al comienzo se hace en la medida	done after you have well obviously with a
5 que ya tienes bueno obviamente con un	prototype this is how how the thing works
6 prototipo como como funciona esa cosa	
7 P: si es por un es por lumpi >le	P: Yes, it is by 'lumpi' ⁵ - that's what I call it when
8 llamo yo< es es cuando llegamos a un	we arrive at an important milestone, when we
9 hito importante cuando lanzamos un	launch a new model or there is an important
10 nuevo modelo o hay un un cambio	change or something at this moment, eh,
11 importante o algo en ese momento eh:	then we group two or three workshops or
12 como que: agrupamos y hacemos dos o	focus groups to test how everything is going
13 tres workshops o focus group para	on at the moment. We just did one the last
14 testear como estamos en ese momento y	week, where [there were] two patients and
15 acabamos de hacer uno la semana	two care-givers; it was a mini workshop. It
16 pasada habían dos pacientes y dos	was not too much; it was not very formal;
17 Cares a hacerlo fue un mini workshop no	but we still have some formal ones and some
18 fue mucho no fue muy formal pero aun	informal ones to see how things go, how we
19 hacemos bien formal y otros más	go.
20 informales para ir viendo cómo cómo	
21 vamos	
22 J: claro claro y ahí trabajan solos	J: Sure, sure, and then are you working by yourself
23 ustedes lo organizan o contratan a otra	or with a contracted external company?
24 empresa	

5 See comments about this expression within the analysis of the interaction

25 P: no lo organizamos nosotros no
 26 vale la pena contratar a alguien
 27 no vale la pena contratar a alguien (.)
 28 no porque es son son pacientes
 29 eh que se han han sido voluntarios ellos
 30 mismos han querido colaborar
 31 J: ah: ellos los han contactado por
 32 ejemplo
 33 P: ellos nos han contactado o a
 34 través de las unidades o a través de la
 35 asociación de pacientes del reino unido
 36 que tenemos una muy buena relación y
 37 normalmente nos so:bran pacientes
 38 dispuestos a a darnos algunos (.)
 39 J: si si claro me imagino ellos son el
 40 driver de motivación para que existan
 41 innovaciones en esta área ya perfecto
 42 eso te lo iba a preguntar sin embargo a
 43 mí me interesa más el intermediario ese
 44 es el que veo que esta menos
 45 estudiado además en general
 46 P: el intermediario que es el que es
 47 el es el que paga el que paga y toma las
 48 decisión=
 49 J: =tu tu crees que que este
 50 intermediario al final igual tienen un
 51 efecto importante en las decisiones que
 52 practicas operativas de que es lo que
 53 necesita el paciente
 54 P: bueno claro
 55 J: en que sentido opera eso
 56 P: e:l: .hhh la unidad renal (.) tiene
 57 por supuesto algo de nuevo es multi
 58 variable entonces tiene mucha historia
 59 tiene ciertos líderes internamente como
 60 en toda institución como en todo
 61 business hay muchas políticas y
 62 problemas políticos internos gente
 63 interna que le gusta un tipo de trabajo
 64 que no le gusta un tipo de trabajo

P: No, these are organized by ourselves - it is not worth the time and money to contract somebody else (.) because these are not the patients, eh, they are volunteers, they decided to collaborate by themselves.

J: So, for example, they have contacted you

P: They have contacted us directly or through other units ((renal units)) or through the patient association of the United Kingdom, which we have a really good relationship with and it is quite normal that we have an overflow of patients willing to give us some (.1)

J: Yes, yes, sure I imagine that they are the motivation driver for the innovation in your field - perfect that it was. I want to ask you, however, what is interesting to me is the intermediary, the one that is less studied

P: The intermediary is the one the one that pay that pay and make[s] decisions.

J: Do you believe that this intermediary has (and in the end has important) effects on the decisions on the operative practices that the patient need[s] to follow in their treatment?

P: Well sure!

J: In which sense is that operating?

P: Eh, the renal unit has, of course, something new - this is something with many variables. Then they have a long history, they have certain internal leaders like any institution (like any business) there are lots of policies and internal political problems inside - people that like a type of work and those that dislike a type of work. Then the renal unit exerts pressure onto the users and then onto the patients about what is going to be the best treatment.

65 entonces la unidad renal ejerce presión
 66 hacia los usuarios hacia los pacientes de
 67 cuál va a ser su mejor tratamiento
 68 J: claro
 69 P: eh (0.1) hay (.) diálisis en la casa
 70 pero usted señora Jones no no es para
 71 Usted eso no no le conviene yo yo su
 72 médico no le aconsejo eso a Usted para
 73 que venga nosotros le hacemos el
 74 tratamiento aca usted no le conviene ah
 75 entonces=
 76 J: =y el médico sigue siendo una
 77 una institución en ese sentido=
 78 P: =entonces eh cero eh eh diálisis
 79 a nadie le n no nos gusta la diálisis en la
 80 casa verdad no no ah ok
 81 J: >ok<
 82 P: entonces hay otros hospitales en
 83 que em: va el paciente eh señora Jones
 84 bueno le podemos entregar su máquina
 85 el martes o el miércoles que día prefiere
 86 (.) pero como que máquina (.) bueno su
 87 máquina de diálisis se va a tratar en la
 88 casa
 89 J: ok (hh)
 90 P: dos cosas distintas no vamos
 91 vamos aprendiendo
 92 iterando o sea
 93 J: pero es interesante eso de que el
 94 el paciente puede querer una cosa que
 95 podría ser mejor pero el intermediario
 96 podría no necesariamente optimizar
 97 para el paciente
 98 P: exacto exacto
 99 J: las cosas no
 100 P: la institución el el NHS es una
 101 institución que esta eh (0.2)
 102 básicamente yo yo diría que es dice está
 103 diseñada para eh satisfacerse a si
 104 misma (.) eh

J: Sure.

P: Eh, There is home dialysis, but for you Mrs Jones this is not for you' (.) That is something that is not convenient for you. I'm your medical practitioner and I do not advise you to; then you have to come here, we will give you the treatment here. This is not convenient for you? Ok then.

J: ...And in this sense, the medical practitioner, it is still an institution?

P: Then, eh, no analysis at all to nobody we don't like the home dialysis no no ah ok

J: Ok

P: Then there are other hospitals that, when the patient visits them, eh, 'Mrs Jones, well we can give you a machine next Tuesday or Thursday, what is the best day for you?' (.) 'But how is that?' (.) 'Well, your dialysis machine, you are going to be treated at home!'

J: Ok (hh).

P: Two completely different things right we are learning iterating I mean

J: But this is interesting - that's about the patient when the patient could want a thing that is better; I mean better than the one that the intermediary could optimize and then better for the patient.

P: Exactly, exactly.

J: the things no

P: The NHS as the institution that it is, I would say it is basically designed to satisfy itself, eh.

105	J: ok (0.1)	J: Ok.
106	P: no para satisfacer las	P: ...Not to satisfy the necessities of the patients;
107	necesidades de los pacientes ha tenido	they have had a lot of time to navigate and to
108	mucho tiempo para: navegar y	form as an entity that is designed as a cell to
109	para formarse como una entidad que	exist as an autonomous cell
110	diseñadacomo una célula autónoma	

Example five shows an interview with the commercial manager. Although this conversation is translated into English, it was conducted in Spanish due to the fact that we shared Chilean nationality. The example shows the general philosophy of Med Dialysis regarding users. Additionally, the example also indicates the complications that emerge between the commercial and design aspects of the new technological development. Design, commercialization and organization are entwined in a mixture that is difficult to resolve. The following analysis will show how risk - particularly user risk - is enacted in the commercial manager's discourse.

The commercial manager hesitates regarding the issue of user risk management (lines 2 and 3). This hesitation is interesting because it indicates a traditional model in the design literature where the analysis of the user is made at the beginning of the innovation process (Callon, 2004). Looking at the commercial manager's hesitation, it is possible to hypothesize that the model that the commercial manager is enacting is a linear understanding rather than a whirlwind model (Callon, 2004: 2) of innovation. Indeed, the manager claims that they perform a kind of analysis by 'lumpi' (line 7). Probably, he uses the word 'lump', which means global or general. That is, the commercial manager performs user tests at the moment that they already have collect a good amount of changes in the specifications. The question that emerges, then, is what kind of global analysis and what kind of change is Med Dialysis waiting for in performing its users study? Or in other words, how does Med Dialysis determine when it will perform the next focus group?

In any case, Med Dialysis uses focus groups (lines 12 to 13). However, this technology comes with a cost. As the STS scholar Javier Lezaun has demonstrated, although focus groups extract knowledge about people, they also produce "opinions that are freely expresse[d] by the subjects, yet structurally incited by the setting" (Lezaun, 2007: 131). In addition, any consumer preference that is mediated by the focus group dispositif is problematic. This is because those who interpret the opinions of the potential users of the medical device need to be professionally trained in order to elicit the focus group's participant's opinions. As a corollary, is still not clear how Med Dialysis manages this user risk.

Within the first 50 lines, the manager makes his points about how Med Dialysis manages final users' needs. However, from line 55 onwards, a different actor emerges within the interaction - this is the intermediary, a crucial class of actors for the whole business. These

are the administrative officers of the NHS (accountants, purchasing officers and managers, etc.). These administrative officers become more relevant in the conversation about risks and how to deal with them. As a consequence, it is during the movement from the final user to the intermediary that the commercial manager engineers the economization process. In this sense, the commercial manager is drawing upon "user risk management" as a risk organizing device.

As Chapter VII shows, intermediaries are important actors in the network who enable the acceptance of medical technology since, within the healthcare system of the UK, the NHS is the major operator. The administrative officers of NHS hospitals are presented as economic actors with crucial decision-making capacities. This is the actor who pays and makes the buying and outsourcing decisions (line 47). Next, from lines 56 to 67, the manager presents an interesting account of the historical-political aspects of renal unit administrators. According to this categorizing work (Edwards, 1995), the renal unit becomes the enforcer of a particular type of treatment (as in the case of haemodialysis).

The description of the renal unit proceeds by describing the NHS renal units as entities that look solely to their own interests. In fact, from lines 69 to 81, the manager uses a footing device (Potter & Hepburn, 2005) by which he expresses with unusual detail the way in which those professionals at the renal unit convince people to accept non-home-based dialysis technology. The manager is building a category whereby the NHS as an institution exists as an "autonomous cell" (lines 116 and 117) with self-interest as its sole motivation.

The commercial manager locates Med Diabetes as a reflection of the NHS's self-interested categorization. Therefore, the company is not "an autonomous cell" but rather a company that requires interaction with others. Additionally, there are other hospitals that belong to this last category (i.e., which are not autonomous cells) (see lines 82 and 88). This categorization work is quite relevant, because it is by the very same categorization that the manager demonstrates his risk management strategy. These last hospitals are those that will probably be more receptive to the mediation of the total cost excel table, presented in Figure 6 of the present chapter. As a consequence, the manager is creating a space of opportunities for Med Dialysis's new product. This space of possibilities for the self-care technology that he is developing allows him to manage the commercial risk of their operations. He is displacing the problem onto the NHS as an intermediary. The important act of the manager is to build up this out-there-ness in order to separate the work of Med Dialysis from those belonging to the external healthcare scenario.

These "future healthcare delivery" (Wilkie, 2010: 195) constructions are crucial in terms of both users and the management of the operative and commercial risk that the commercial manager and the design engineer enact within their discourses. The user's risk management can be seen as a parasitic process whereby those engineers who are downstream in the technical

specifications (like the design engineer) parasitize the productive flow of the commercial area of the company. Furthermore, the commercial area of the company parasitizes the focus group technique in constructing 'consumer preferences', which allows them to generate at least two different categories of virtual intermediaries. As a consequence, the process could be based on the user-centred methodology that is so popular in the management literature and is itself based on 'design thinking' (Brown, 2008; Martin, 2009). This strand of literature promotes the use of design ideas, in which human-centred design becomes the ultimate means of reshaping the entire organization to both facilitate continuous innovation and outperform the competition. However, in Med Dialysis - and in a sort of 'twisted' parasitism of human-centred design and the ideas of design thinking - the user and the user-intermediaries are enacted without involvement (or at least with fewer interests).

Participant involvement is at the core of the design thinking philosophy as a shared future oriented-ness. This view demands a radical reorientation of the company's activities, echoing some concepts such as the democratization of the innovation (Von Hippel, 2005) process and the open innovation literature (Chesbrough, 2003). None of these points are relevant for Med Dialysis. Med Dialysis's practices are probably relevant in ways that are not defined in human-centred design theory (Steen, 2012), but nevertheless they affect the entirety of the finances of Med Dialysis, and especially those who work there developing its technology.

5. The dark organizational theory of innovation and risk

Example six shows the importance of the diagrams (in this case, the total cost of the new dialysis machine diagram). In addition, the example shows other important aspects of commercial risk management that appear in the commercial manager's discourse.

Example 6: Med Dialysis's commercial manager - 05/09/2011.

J: Researcher	P: Med Dialysis's commercial manager
1 P: si la la unidad renal tiene una 2 administración que es como el gerente de 3 compras los contadores ellos eh ellos 4 están relacionados con el trust y ellos en el 5 fondo tienen la autoridad del trust para 6 hacer ciertas cosas pero si el contrato es 7 suficientemente importante el trust tiene 8 que estar detrás para el day to day el el la 9 administración toma todas las decisiones 10 pero para las decisiones de contrato que 11 se yo es el trust es el CFO del trust etc.	P: If the renal unit has an administrative unit (that is, like the purchasing manager and the accountants), then they are closely related to the Trust; and then at the end of the time, [they] have the authority of the Trust to do certain things. But if the contract is important enough, the Trust have to support the decision-making process on a day-to-day basis. The administrative unit takes all the decisions, but when it comes to decisions about contracts, it is the Trust - it is the CFO of the Trust.

12 J: perfecto y en ese mismo punto
 13 había un diagrama que lo he mirado
 14 bastante el de costo unitarios que tu
 15 habías hecho para un poco mostrar que el
 16 costo total de adquisición era distinto no
 17 necesariamente el que el intermediario se
 18 imaginaba
 19 P: la tabla Excel
 20 J: exacto ese diagrama es una tabla Excel
 21 P: si si
 22 J: en qué sentido esta relación de
 23 costo es relevante también para la
 24 definición de usuario es también lo
 25 económico parte de esa definición y como
 26 P: si bueno él es básicamente cuando
 27 ya llega a la administración es es cien por
 28 ciento económica la decisión eh
 29 J: ya
 30 P: o sea no no es cien por ciento
 31 económica la decisión hay un tope
 32 J: aha
 33 P: y pasado ese tope la respuesta es
 34 no (.) uno tiene que operar dentro de ese
 35 tope y el tope está dado por lo que paga el
 36 el gobierno para la diálisis más el top
 37 slicing que es él lo que paga eh: .hhh los
 38 administración del hospital la las
 39 estacionamientos las fuentes la pintura del
 40 edificio
 41 J: ok
 42 P: entonces ese tope (.) si uno opera
 43 dentro de ese tope
 44 J: mhm
 45 (.)
 46 P: la administración tiene eh nop no
 47 puede salirse de ese tope
 48 J: correcto=
 49 P: =excepto muy raras circunstancias
 50 J: ok

J: Perfect! And around this very same point I remember that you showed me a diagram that I had been looking at, and as far as I understood, that shows the unitary costs.

P: The excel table...

J: Exactly. This diagram - that is an excel table.

P: Yes, yes.

J: In which case, this relation of the cost is also relevant for the user definition is it the economic part of your user definition and how...

P: Yes, well it is when - basically - when you arrive at the administration; then it is one hundred percent economic (I mean the decision).

J: Alright.

P: I mean, it is not one hundred percent economic. There is a top.

J: Aha.

P: Over this top, the answer is 'No' and one has to operate within this top, and the top it is given by the amount that the government pays for dialysis plus the top slicing that is what the amount that pay eh: .hhh the hospital administration for the location, the parking zones, fixed costs and maintenance, like wall paint.

J: Ok.

P: Then this top, if one operated within this top.

J: Aha.

(.)

P: The administration has, eh, can't can't get over the top.

J: Correct.

P: ...Except in very exceptional circumstances.

J: Ok.

51 P: entonces la la administración
 52 dentro de ese tope busca lo que value for
 53 money y ahí ese y ahí ese es el el campo
 54 de juego en realidad dentro de ese tope
 55 J: y y que pasa hipotéticamente
 56 cuando hay un cambio de necesidades o
 57 cuando qué se yo como cuando ustedes se
 58 dieron cuenta que su máquina no iba a ser
 59 para disminuir el costo pero si para sacar
 60 los procesos de los hospitales
 61 P: claro
 62 J: hacia otro lado o sea ahí hay un
 63 cambio fundamental en el uso no
 64 P: el el el business case no es una
 65 máquina más barata sino que es
 66 reemplazar el brick and mortar y la mano
 67 de obra dentro de un hospital y todo lo que
 68 significa traer hacia el el hub el servicio
 69 sino que moverlo hacia afuera
 70 J: claro en ese ejemplo hay cambios
 71 que afec bueno que afectan eh toda la
 72 economía del sistema en el caso este del
 73 costo que pasa cuando te pasas eso
 74 significa que hay un efecto también de ese
 75 pasarse hacia la especificación técnica hay
 76 que regular por el otro lado cuando te
 77 pasas del tope
 78 P: bueno nosotros tenemos un
 79 modelo de que nosotros sabemos cuánto
 80 es el tope y nosotros tenemos un modelo
 81 de costos desde build bottom up
 82 J: aha
 83 P: y nosotros nos damos cuenta de
 84 que build botton up con los targets que nos
 85 hemos puesto nos quedamos con un
 86 margen que está dentro de lo que de las
 87 expectativas que tenemos ahora (.) del
 88 punto de vista de riesgo nuestro riesgo es
 89 cuanto quiere el hospital hacerle top slice
 90 ese es nuestro riesgo o sea nosotros

P: Then the administration - within this top - searches for value for money and then this is the playground the reality within this top.

J: ...And what happens, hypothetically, when there is a change in the necessities, or when to tell something when you realized that your machine is not going to diminish the total cost without taking out the processes from the hospitals –outsourcing-

P: Sure.

J: towards other place I mean there is a fundamental change in the use or not

P: the business plan case it is not a cheaper machine instead it is to replace the brick and mortar and the labour within the hospital and all that imply the hospital hub of services and move this outside

J: Sure, in the example there are changes that affect... well, that are affecting the system. In this case, with the cost, this means that there is an effect on the technical specification that needs will lead to regulate by the other side when you over pass the top.

P: Well, we have a model where we know how much the top is, and then we have a cost model that is built from the bottom up.

J: Aha.

P: ...And we have awareness that, to build from the bottom up with the targets that we've set up, we will have a margin that is within our actual expectations. From the point of view of the risk, our risk is when the hospital wants to do a top slice - that is our risk, which is the same as saying that we are here, below cost, without problems; but the problem emerges if the hospital tells us 'No, I don't want to pay this amount.' This is our risk.

91	estamos aquí nosotros estamos bajo el	
92	costo sin problema pero el problema es	
93	que el hospital diga no yo quiero pagar	
94	esto ese es nuestro riesgo	
95	J: aha	J: Aha
96	P: ese es el riesgo que no podemos	P: This is the risk that we can't control.
97	controlar nosotros	
98		

The example shows another conversation with the commercial manager and his views about users, the risks and some of the economic and financial aspects involved in the development of this new technology. The conversation is animated, and based on a diagram/excel table (Figure 6) that the commercial manager uses to present and sell the dialysis machine to various intermediaries (i.e., the NHS's administrative officers).

In the interaction, the engineer addresses a point concerning the importance of the economy for the decisions of NHS administrators. His use of an ECF (Edwards, 2000) at lines 27 and 28, where he claims that the decision regarding a new product/technology is one "hundred percent" economics-based is qualified at lines 30 and 31. There, the commercial manager introduces the category of the 'top' (tope is a Spanish word). The 'top' is the limit - the upper limit that you cannot exceed if you want to sell the new dialysis machine. The account is very precise, and the formula (between lines 34 and 40) calculates the maximum amount that NHS hospitals will pay. This amount is given by the top, which is calculated by the amount that the government pays for dialysis plus the top slicing that the hospital is paying for all the costs involved within the operation of dialysis machines in their facilities. These costs are generally fixed, such as the maintenance of infrastructure, the renting of space, transport services for dialysis patients to the hospital, etc. These are the "occult costs" that can move up the top. At the same time, is equally important that there is a lack of acknowledgement regarding these costs on the part of those working in the administration of the NHS.

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The commercial manager's discourse provides a stark account of the importance of Total cost Excel -the tool- It is the co-production of the economy of the user (in this case, the intermediate user and especially the administrative intermediaries in the NHS's administration and the GP Commissioner -See section 6 for a GP Commissioner detailed explanation. As with old fashioned ANT, the commercial manager is looking to enrol the intermediary (i.e., NHS administrators) through the use of numbers and - in particular - numbers that appear to be non-existent prior to the use of the device that is the total cost excel table. Following Jasanoff (2004), this is an ordering device - i.e., it is an instrument that operates within the nexus between the NHS and Med Dialysis. Equally, the total cost table serves as the nexus in the co-production of the user and marks with a code (i.e., disjunctive synthesis) those who have used it. As a result, disjunctive synthesis affects the manager of Med Dialysis and - crucially - the intermediary user (the NHS). Following the parasitic cascade, the code arrives at the final user (the dialysed patient). The commercial area enacts the economy of the entire network. In addition, the table - as an ordering instrument - organizes the uncertainty and disarray of the phenomena that Med Dialysis confronts, redefining identities and putting people "back into familiar places" Jasanoff (2004: 39).

In addition, the table produces futures by the use of scenarios and discount cash flows (DCF), as well as the valorization of potential scenarios, over five years. This is in line with the work of Liliana Doganova (2011), who considers the DCF to be a market device, which is "the material and discursive assemblages that intervene in the construction of markets" (Muniesa et al., 2007: 2). This table is thus a risk organizing device that has an effect on the construction of markets for new technologies.

What is interesting for the present chapter is the ordering process that this device enacts. As Luhmann (1995: 29) explains, the primary function of a system is the reduction of environmental complexity. However, in the case of an organization (a social system), external risks can be managed only to the extent that they can be internalized by the same organization. So, it is the process of internalization - or more properly the observation of these external risks - which shows how the commercial manager becomes an actor in this risk management process. Secondly, as Brown and Stenner (2009: 167) explain, under Luhmann's communication model, objects like money simplify the complexity of the economic process. Such a simplification of complexity resonates strongly with Latour's (1998) and Serres' (1982) object-centred proposals. In particular, such a complexity simplification echoes Latour's point about the reduction of complexity by objects with a parallel increase in the complication of the relations. Additionally, this point resonates with those deployed in Chapter IV, where organizations were conceptualized as social machines. It is the Anti-Oedipus of Deleuze and Guattari (1972), the book that arrived at an explanation of social systems as an autopoietic machine (Maturana & Varela, 1980).

What is remarkable in the example is that it leads to an understanding of the performance of economic calculation as a network of technical devices. When the commercial manager uses a software program like Excel, he is connected by an invisible strand to the world of software developers located across the planet. They have developed, tested and perfected the spreadsheet tool at different places and at different times (Latour, 1994). It is clear, then, that by the use of the Excel tool, the economic actor activates concepts and logics that have been applied through these particular 'calculative devices' (Kalthoff, 2011).

In terms of risk, the manager makes two distinctions regarding the category (lines 87 to 97). The first is related to the hospital's administrators managing the amount that they wish to put into the equation of their own costs reduction. This cost reduction via outsourcing of their operations it is always within the limit of the 'top' - the upper limit that cannot be exceed if the company want to sell the new dialysis machine. The 'top' it is not controlled by Med Dialysis. However, he also refers to a second risk - the unmanageable risk. This is when the hospital does not recognize the various costs, and so they might decide not to pay. The manager stressed this last point via footing, speaking for the administrators of the hospital. He recognizes that there are some non-manageable uncertainties.

What does the total cost excel table do? The table constructs a very particular way of managing the risk associated with a virtual service/technology. It is a future risk coordinating device. This is because the device is part of intricate future generating practices where risk management (of any type of risk) is an attempt to coordinate uncertainty (De Laat, 2000). These are future coordinating devices that co-produce the intermediary user representing NHS hospital administrators and which participate in the productive activity of those who work at the organization (such as the commercial manager and some of his co-workers and collaborators). In Deleuze and Guattari's terms, the device is in disjunctive synthesis with the manager and his co-workers. This is because the device opens up new connections and shares the codes of the social machine that is the economy. New routes and permutations emerge from the synthesis of those who use it to commercialize and organize risk at Med Dialysis.

However, the production of the user and its risk is not solely based on the use of the total cost table. It is also related to the whole 'business case' that appears in the account of the engineer manager (lines 64 to 68). From this account, it is clear that Med Dialysis is looking to replace various bricks and mortar, labour-intensive NHS operations. It is seeking to replace the hospital's hub of services, moving operations outside of the NHS. In this sense, the code that is transmitted or inscribed in the mediation device brings the social category of outsourcing that the NHS and the Government are enacting for the administration of healthcare in the UK. This is the social machine from which Med Dialysis reads and - finally - consummates its identity. At the same time, this is the social machine from which the various intermediaries and final users consume their identities as well.

The manner in which Med Dialysis is selling itself to investors and important stakeholders of the project (like the NHS) could not be constructed without the use of the device that the manager invokes in this interactive data. Following Çalışkan and Callon (2009; 2010) the Manager economizes healthcare practices within the NHS. In any case, Med Dialysis is simply plugging into the NHS's social machine/policies. In this sense, it is coupling its machine with the social machine that is the state and - in particular - the Department of Health.

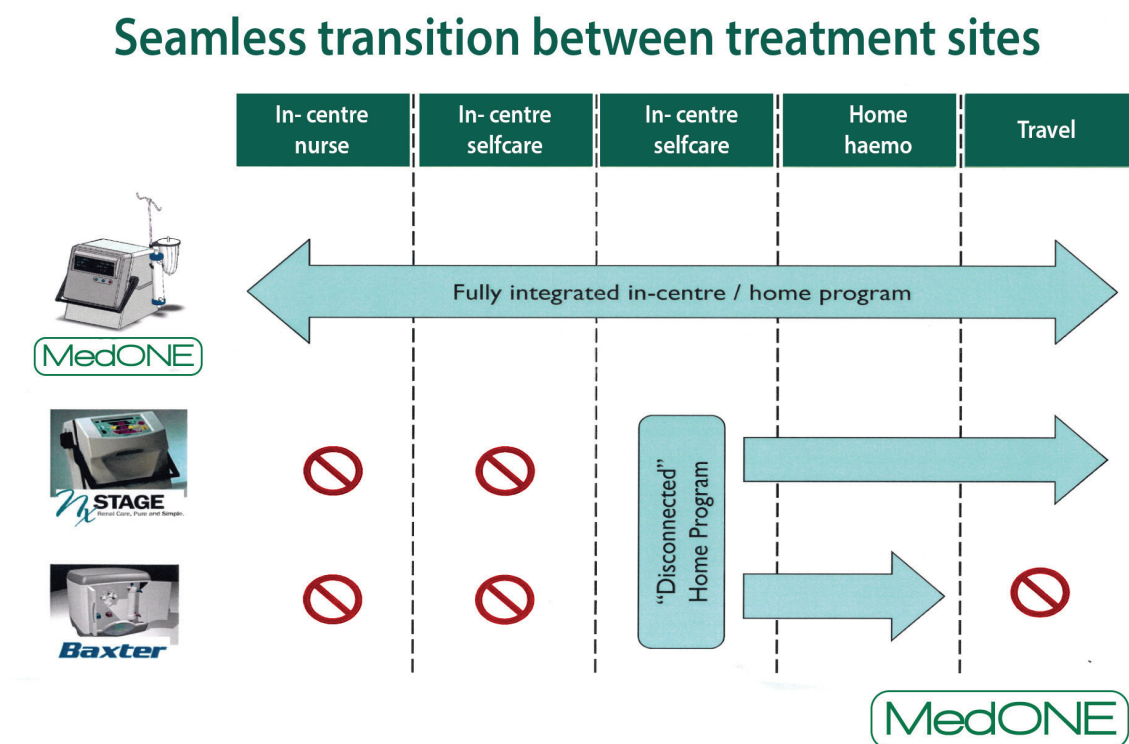
In Callon and Muniesa's (2005) conceptualization, calculations may be either mathematical or non-mathematical. Both mathematical and non-mathematical calculations build up the calculability space for Med Dialysis's technical innovation. In the present case, Figure 3 offers a diagram that is used in tandem with the total cost excel table. In this diagram, the technology appears as a fully integrated process of self-healthcare. The diagram offers a convincing story surrounding a new medical technology that satisfies the entire spectrum of services that the NHS can offer to haemodialysis users. This story is constructed to enrol the intermediary user - the seamless process opens up a very broad space for the use of the technology.

The calculability space produced by objects such as the diagram presented in Figure 7 triggers some interesting effects regarding the commercialization of the new technology. These effects lead to a reconfiguration of the work activity of those participating in the process. Extending the point and following Serres (1982: 225), identity is defined in its circulation alongside the quasi-objects that are these diagrams. Inter-subjectivity emerges between these objects and the manager. The intermediary and the final user also circulate with this object, in the sense that they also participate in the virtual commercial relations that this venture company produces. In consequence, these ordering devices define the calculative space; in terms of flexibility and in terms of the mathematical visualization of the 'occult costs' and DCF, it organizes the co-production of the expert engineers, expert NHS intermediaries and (in the cascade of the parasitic approach) the final user - the renal patient.

As has been remarked upon before, the diagram is in conjunctive synthesis with the engineer and the user - any type. It is then that the code enters, causing a shift in the flow of production of the engineer. The engineer no longer simply produces solutions for dialysis. It produces solutions for dialysis at home, because the outsourcing code becomes inscribed in the specifications of the solution by this disjunctive synthesis. The synthesis produces a permutation (a change of direction) in the engineer's flow of production. This is at the base of the economization process. Thus, the social machine produces the categories from which the user reads his identity as a dialysed patient at home and from which the venture engineer designs and commercializes the new technology. Such an explanation enriches Çalışkan and Callon's economization process with a more detailed analysis of the identity production process, which is not presented in their fundamental work.

From a different perspective, this process is connected with the manner in which manager engineers work "to interest and persuade" specific users (such as NHS administrators). This is because engineer managers can build imaginings of themselves and their organizations that symbolize the qualities that they think users need. These qualities may include a low-cost policy and more flexible options for the patient, among others. As Summerton (2004: 488) claims, this projected image is made, characterized and "inscribed onto the technologies according to the managers' visions of themselves and their desired interactions with specific groups of users." Therefore, the engineers are engineered by those representations. In this sense, the NHS and the state are of particular importance because the inscriptions that they pass through the idea of self-care and cost reduction are visible as a fundamental point from which the engineer is configured as a venture engineer.

Figure 7: Comparison between actual products and the Med Dialysis.



6. The GP Commissioner as the mobile space of calculability to manage risk

Example seven presents some elements in understanding the role of the GP Commissioner - an important NHS intermediary. The manager presents the economization process of the dialysis technology and makes visible the construction of the calculability space. Such is the space from which he is trying to exert his commercial strategies for the new healthcare technology that they are offering to the industry.

Example 7: Med Dialysis's commercial manager - 01/02/2011.

J: Researcher P: Med Dialysis commercial manager	
1 J: Pero entonces como es que los	J: But then what is the purchasing process of
2 commissioner deciden la compra	the commissioners?
3 P: ellos tienen que el business case	P: They have the business case, which has to
4 tiene que cubrir todo y el	cover everything, and the Commissioner
5 commissioner es el que es el bolsillo	represents the final pocket; then, if the
6 final entonces si si el business case	business case shows that this is the most
7 es que el producto es más caro pero	expensive product but the results are
8 los resultados son idénticos (0.2)	identical, nothing changes - we have a
9 no cambia nada nosotros tenemos un	product that produces exactly the same
10 producto que produce exactamente	results but the Commissioner has to analyse
11 los mismos resultados (.) pero el	that this costs the same or less.
12 commissioner tiene que ver que	
13 cuesta lo mismo o	
14 menos	
15 J: ya ya entonces es súper	J: Ok, ok. Then it is super important - the
16 importante el escrito del business	business case presentation that you show
17 case que ustedes le muestran	them...
18 P: nosotros tenemos que mostrarle	P: We have to present to the Commissioner,
19 al al al commissioner que muchas veces	and often they don't know where the
20 no saben los commissioner no saben	real bottleneck is, and then we have to
21 donde aprieta el zapato eh y nosotros	demonstrate, ok, the benefits, that this costs
22 tenemos que demostrarle eh los	less because you will save on taxis, you will
23 beneficios esto cuesta menos porque	save on drugs - that you save on this or that
24 usted se ahorra el taxi se ahorra las	because this paper and all these papers
25 drogas de esto se ahorra lo otro porque	explains that the drugs savings are around
26 este paper y todos estos papers dicen	50% etcetera etcetera etcetera and if you do
27 que las drogas se ahorran un cincuenta	the dialysis at home and this is performed
28 por ciento etcétera etcétera etcétera si	for longer, all these benefits will lead to a
29 usted lo hace en la casa y lo hace por	cost reduction; but we have to go to the
30 más tiempo todos estos beneficios van	Commissioner and convince her about this.

31 a hacer que el costo sea menos pero
 32 nosotros tenemos que ir al
 33 commissioner y y convencerlo de eso
 34 J: y esos papers que tu comentas
 35 son estudios (.) independientes de=
 36 P: =hay una cantidad enorme de
 37 estudios que está saliendo al respecto
 38 de diálisis cotidiana pero son
 39 relativamente recientes
 40 J: ahh
 41 P: le llaman la diálisis cotidiana diálisis
 42 cotidiana es que diálisis (0.2) extendida
 43 más tiempo de diálisis más tiempo de
 44 diálisis porque la diálisis en en hospital
 45 porque porque el dia tiene 24 horas y
 46 hay siete días de la semana es cuatro
 47 horas Lunes miércoles y viernes y otros
 48 pacientes tienen martes jueves y
 49 sábado domingo no se atiende y el shift
 50 empieza a las siete de la mañana y
 51 termina a las siete de la tarde ((and
 52 here P draw a diagram where he shows
 53 the relations between the commissioner
 54 and other actors)) entonces con eso la
 55 diálisis está llena alcanzan tres
 56 pacientes y tú no puedes poner otro
 57 paciente mas entonces ese sistema te
 58 permite cuatro horas de tratamiento
 59 no más y está demostrado ya
 60 científicamente que si tú en vez de
 61 dar cuatro horas de tratamiento das
 62 cinco hay resultados mejores en eh
 63 en muchas pom cosas por ejemplo
 64 en manejo de (.) de fos fos
 65 fosfatos y los los lo remedios para el
 66 fosfato cuestan cuatro mil pounds al año
 67 entonces tú te ahorras el fosfato y ese
 68 es parte del business case que tienes
 69 que ir a ven pero pero es una re es una
 70 conexión tenue porque el tipo que está

J: ...And these papers that you comment about
 - are these independent studies of?

P: There are an enormous number of studies
 that are being produced about everyday
 dialysis, but these are recent.

J: Aha.

P: They call this 'everyday' dialysis. This is a type
 of dialysis that is extended in time. That is
 because the day has 24 hours and there are
 seven days a week. This type of dialysis is four
 hours on Monday, Wednesday and Friday. The
 others patients have dialysis on the Tuesday,
 Thursday and Saturday. Sunday is closed. The
 turn shift begins at 7 am and finishes at 7 pm.

((and here P draws a diagram where he shows
 the relations between the Commissioner and
 other actors))

Thus, the dialysis covers three patients and
 you can't put other patients in it; then this
 system allows you four hours of treatment and
 nothing more, and it had been scientifically
 demonstrated that if instead of giving four
 hours of treatment you give five, the results are
 much better - this is based on various points.
 For example, the management of phosphates
 and drugs for phosphate treatment costs four
 thousand pounds per patient per year.

So you save the phosphate and this is part of
 the business case that you have to go and sell,
 but it is a network - it is a tenuous connexion
 because the guy who is paying the budget
 has silos

71	pagando el el el los budgets tienen silos	
72	(.) las farmacias es otro budget que el	The pharmacies are on a different budget,
73	entonces si tu le dices a tu cliente oye	and if you tell the client look, I'm saving
74	pero me estoy ahorrando dos mil pounds	a thousand pounds with the phosphates
75	en los fosfatos si pero eso no lo pago yo	but I don't pay for the phosphates but the
76	pero el commissioner (.) tiene que ver	commissioner it is involved so you have to tell
77	que decirle a el y a el ((drawing a clear	him ((drawing a clear and bold line between
78	and bold line between the commissioner	the commissioner and operators))
79	and operators)) si lo paga ((knocking	he pays that ((knocking three times over the
80	three times over the table))	table))
81	J: ok	J: Ok.

Almost at the same time as the interview in example seven, an independent healthcare think tank published the document *Transforming our healthcare system: ten priorities for commissioners*. The document shows that commissioners themselves are an interesting case as regards research into the mixture of medical purchasing decisions and the healthcare cost reduction strategy of the Government. Furthermore, the think tank express the view expressing that: “the introduction of GP commissioning consortia who, by 2013, would hold the majority of the NHS budget, more than £60 billion of public money” (Imison et al., 2011). As is presented in the document and in the manager’s discourse, the GP Commissioner performs a central task in relation to the new NHS purchasing function.

The commercial manager needs the Commissioner’s approval of the business case that the company presents. At this stage, the manager is looking to create a form of detachment. He is trying to present a case that works by itself - a self-sustainable case. As Callon and Muniesa (2005) would claim, the commercial manager is creating a single space whereby the economic actor (the Commissioner) can manipulate the cost-benefit operations more simply. This is also clearly aligned with the ten priorities established in Imison et al. (2011). Following the account of the commercial manager at lines 2 to 11, he defines just such a calculability space. However, there is a qualification between lines 15 and 30. It is in the explanation regarding a lack of understanding of costs that the commercial manager emphasizes the importance of devices such as the total cost excel table and other items that need to be considered in the calculations that are black boxed in the GP Commissioner’s analysis.

In the commercial manager’s view, the device serves as a demonstration for those working in the NHS. Moreover, as Callon and Muniesa claim, this space is not simply a mathematical space; it may be based on possibilities built around the knowledge that allows the commercial manager to perform economic operations in terms of cost reductions or efficiency. Using a footing device (lines 21 and 22), the executive stresses the point about the demonstration. It

is precisely here that the executive is able to call for the use of studies and papers that are vivid demonstrations of the potential savings of the new technology. In any case, the strategy of the commercial manager directly encloses this previously non-existent space of calculability, which is now defined and ready to be used.

After the creation of this calculability space - which includes the mathematical and the non-mathematical - the manager and the Commissioner are able to manipulate the entities that participate in the decision. These experts demonstrate the savings that the new technology brings along with Med Dialysis as part of the new space of calculability. In fact, an expression of the associations and materiality of this process would be the diagram that the commercial manager uses to explain the relations between the Commissioner and other actors (i.e., between Med Dialysis and the renal hospital units of the NHS). This is a mediational tool that displays the various connections and all the potential and virtual transactions. This is the object by which the manager shows the movements and associations that this new space of calculation offers.

Another important point about the construction of this calculability space is the temporal dimension. In fact, there is a lengthy explanation of the cost reduction (or at least the relations between both technologies); here, the calculation is the product of the comparison between traditional technology and the new 'everyday dialysis'. This is an economy based on the possibility that this new system offers in optimizing the resources of the Commissioner. The cited economy is again aligned with the 10 priorities of this new super purchaser, which are considered a fundamental part of the "most challenging financial and organizational environment since the introduction of the purchaser/provider split within the NHS in 1991 money" (Imison et al., 2011: 2). What is interesting in the commercial manager's account is the construction of the mixture between the time and scientific resources used to generate the economic agencement (Çalışkan & Callon, 2009) that conforms this new dialysis technology.

Finally, to complete the calculability space of the new product/technology, the manager is helping to create a new kind of entity. Although the figure of the Commissioner is primarily produced by the policies of the Government, it is nevertheless fully supported within the construction that the commercial manager is developing of the actual and future dialysis purchasing process of the NHS. The figure of the GP Commissioner configures or summarizes the mixture between economic cost reductions and best practices in self-care and other aspects of healthcare. In terms of Deleuze and Guattari's framework, this is a social category that emerges from the conjunctive synthesis or consummation of the social machine that constitutes the healthcare industry and the state. In other words, the Commissioner plugs in to the social machine that is the government and its economic and individualistic approach to healthcare.

The GP Commissioner clearly has the power to shape final users through the performativity

of her purchasing decisions. She is an object that allows a particular kind of social process (self-care) and which permits the circulation of the identities of the venture engineers and Med Dialysis itself as a venture company. Furthermore, the case of Med Dialysis allows us to consider the interweaving between the elements of calculation and the elements that come from the science and the policies of healthcare. Such is the complex mixture that builds up a calculative space -with its mathematical and non-mathematical aspects- As a consequence, the GP Commissioner emerges as the product of dual movement that goes up-down from the government and bottom-up from the practices of new medical device companies. That is, the complex assemblage and co-production that is materialized with the changes in healthcare policies and could be conceptualized as an economy of the individualization of care (Basu, 2011). General discourses about the independence of the patient are crystallized in a mobile figure that can freely move around while creating this space of calculability.

7. Operational risk and the venture engineer as a virtual figure

Example 8: Med Dialysis engineer designer - 14/07/2011.

	I: Researcher	R: Engineer designer
1	I:	but what what happen if there is a huge change in the technical specifications because of the users
2		want to change something and do not adopt it
3	R:	yeah that ultimately that's what it means >if you don't< if you don't get anybody that adopts the
4		technology that you developed we're found battling
5	I:	aha
6	R:	battling and everything we do has to be aimed at making sure that doesn't happen but it
7	I:	hmm hmm hmm no I I know I mean just just I mean I suppose that the question is do you think this
8		sort of I mean when you are actually developing things are you visualizing what happens is you have
9		to do a major change in the specifications for a lack of adoption for example
10	R:	sure yeah no certainly we look at different (.) when we say that we've built specifications and the
11		Commercial Manager and his team have been out to try and develop such specifications they have
12		also when we have developed these system then take brought people in see it and take people and
13		take the system out to demonstrate it to you know to get feedback
14	I:	um-hmm
15	R:	because once we've started to develop the product it is very very important to get feedback to say
16		yes you are going along the right lines and the feedback that we've had has been excellent people are
17		very very pleased to see the device that we've developing they're excited and we've got people that
18		are patients that found on the internet that are saying when can we get one when can I can I buy it
19	I:	alright
20	R:	can I distribute this for you this is revolutionary so the feedback we're getting is excellent
21	I:	okay okay
22	R:	so the way that we mitigate that risk is to make sure that that cannot happens

23 I: right

24 R: the CEO is very very good about things like this he he's always said if if we're going to lose if we're
25 going to stop now and lose \$5 million it's better than carrying on and losing \$30 million

26 I: alright

27 R: you know it's it's interesting you've got it is a risk but it becomes as a smaller and smaller risk

28 I: yeah

Confronting the difficult question regarding any change in specifications or a potential failure (and, consequently, a failure to adopt the technology/new product), the design engineer responds using the figure of the commercial manager as the entity on which all the practices concerning users and technical specifications converge. Within the interaction, it is precisely this figure that appears (lines 10 to 13) supporting the coordination of uncertainties. This is not at all odd considering actual management innovation theories. This is because such theories explain the sources of innovation as within being the users (e.g., Von Hippel (2005)).

However, what is interesting about the design engineer's explanation is not that the technical specifications are the mediating artefact in his account. What seems to be crucial is the figure of the commercial manager and his team as the bottom line explanation of the problem (lines 11 and 12). The design engineer deploys a discursive strategy whereby he categorizes and makes a distinction between those who work in the commercial area and those - like him - who receive this information as mediated by the commercial area of the company.

From the design engineer discourse, it is possible to see the performative effect of this categorization and the use of the commercial manager as a virtual figure (Brown & Middleton, 2005: 710). The commercial manager "is several things at once" and "contains all the differences as real potentials." On a more personal note, this is what I saw on every occasion I discussed the problems of innovation, users and the uncertain future with engineers at Med Dialysis. Normally, this was accompanied he with the laconic expression: "you have to see this issue with the commercial manager." However, when I would ask the commercial manager about these various issues, he would normally get stuck and answer with a simple "I don't know too much about this." The interesting issue is that the commercial manager acts as a virtual figure.

Furthermore, in a double movement, the engineer organizes issues of agency regarding the risky situation, which about brings an important change in technical specifications. Next, once the design engineer invokes the categorization, he qualifies his participation in the development process of the new technology. Later on, he builds up a discourse of facts about people who accept the technology (lines 16 to 21) even before the equipment itself is launched. Such a success narrative mimics the now famous triumphant histories of consumer products that people buy even before their launch (for example, the entire line of Apple devices). This emphasis on success as evidenced by the Desire -in Deleuze and Guattari sense-

of others to distribute the machine is an interesting discursive device, which appears in the conversations with Med Diabetes too. As a corollary, the engineer builds up a successful view of the commercialization of the technology to further support his risk management. This is his means of organizing the operational risk of change - it is an organizing activity that is always mediated by the figure of the commercial manager and the potentialities that he brings to the management of risk.

Furthermore, with the use of discursive elements like repetition (line 24), the engineer is minimizing the virtual risks of failure and the consequences for the new company. In the words of the engineer, the CEO is following a linear process for the innovation's development; therefore, he is enacting risk and avoiding uncertainty using the model. Following Luhmann (2000), it is possible to argue that the engineer is participating in the organizational reconstruction of the dangers that exist with their new dialysis self-care machine into risks that can be managed within their existing decision-making process. For Luhmann, risk is a matter of controllable and uncontrollable permutations. This is a reorganization that is mediated by the figure of the commercial manager, his team and the CEO. Uncertainties about the future are transformed under this mediation. The production of the risk is transformed in the connective and disjunctive syntheses between the managers expressed within the discourse of the design engineer.

Although the engineer uses the figures of the CEO and the commercial manager as mediational entities to manage the risk of his activity, when it comes to the CEO I can recall several observations where it was not uncommon to observe a lack of interest in the user and the related risk management process. The next field observation will serve as an example of this phenomenon:

Example 9: Observation and notes - 10/01/2012.

Something that was interesting in my previous conversation with the CEO was the idea of trials and user experience/focus group work. The CEO really does not show too much interest in these sorts of things. He simply mentioned that they invented the machine and now they are experiencing some problems in adapting some features to what people want. He said "Now they want the machine in colours." This is a remarkable issue, whenever the experts from M-Link mentioned the user as crucial success factor in the medical devices industry as a whole. So, if the user is so important (and given the related user tests and its design centred in the potential user needs), how is it possible that companies like Med Dialysis (who have the money to get the feedback) do not consider these elements as important foundations of their innovation practices? I understand this for companies like Med Diabetes, where the budget is limited and where they are using a user definition based on the opinions of practitioners. But I do not understand this for more mature ventures, like Med Dialysis. Seemingly companies talk a lot about usability, user-centred design, co-design and co-production, but they do a little about it and produce this future instead of coproducing it!

It is interesting that the CEO's response is very much aligned with the theory of user-centred design. In this sense, Med Dialysis's and Med Diabetes' engineers are actors who deploy visions of the "future [of] healthcare delivery" (Wilkie, 2010: 195). Perhaps it is time to consider human-centred design from a different perspective. Perhaps it is time to recognize that: "human-centred design can be understood as a political process in which the people involved try to exert influence on the project... As a political process [it] also shows how researchers and designers tend to represent users, for example by creating personas or storylines, and to talk about them and make decisions for them, rather than allowing users to be present and participate directly in discussions and decision-making" (Steen, 2008). This is what can be observed at Med Dialysis in a much more apparent form than at Med Diabetes.

Following Wilkie, the question is: how are the user's technical specifications "performed, managed and contested" and how do these activities generate particular risks for organizing practices? In addition, raising questions about the engineers' user risk categorizations offers an interesting insight that is mediated in the final instance by those who work in the commercial area of the company (i.e., the CEO and the commercial team). There is a process in which the design engineer shifts issues of agency towards the commercial area of the organization. We are now able to ask the question: how does the engineer manage and enact the risk. The probable answer is that he is managing it through the user definitions and market definitions of these other groups in the company. He is 'para-siting' these other practices and ideas. Nevertheless, following this strategy and practice, he is also defining the future. This is the engineer's risk management 'in the wild'. The engineer needs to believe in a stable future in order to work and develop, but he also needs to separate issues of agency. The moment they think about the future, the virtual user and the virtual market, they are in tandem, thereby defining elements that reconfigure their risk practices.

What it is possible to conclude in the case of Med Dialysis is the existence of a parasitic relationship between the commercial area's user definitions and the use of those definitions across the rest of the company. What the commercial area gains (under a Luhmanian approach) is the possibility of transforming uncertainty into risk. Instead, what the other actors of the organization gain with this parasitic strategy is the production of some certainty to proceed with their engineering work; in parallel, they return novelty (as any parasite) such that these engineering areas reinforce the construction of the user performed by the commercial area of the organization. This is a construction that is mediated and remediated by the use of figures by those who work in the commercial area of the company. This is a productive synthesis of calculative tools/devices, such as the total cost excel table and its related diagram, which compares the different competitors of Med Dialysis's technological innovation. Risk is thus an assemblage of entities - whether these entities are material, non-material, human or non-human. This parasitic understanding of risk and risk management is no more than the extension of an object-centred socialization process applied to technological innovation.

Chapter X: Conclusions and Implications of the Study

1. Conclusions

1.1. Opening up the black box of the technological innovation process

When we read about technological innovation ('innovation' for short), one of the defining features at present is its generalized ambivalence regarding experts and expertise. The world seems highly uncertain, unknowable and uncontrollable, which is to say that the business and management tools for predicting and regulating technological innovation do not seem to work as they should. Chapters II and III deploy this phenomenon. Those chapters make a clear case for a non-foundational study of innovation. Such a programme is - in part - taken from ANT, with the important qualifications that post-ANT brings to the study of social phenomena.

The inquiry about the emergence of technological innovation triggers the analysis of those general discourses of technological innovation in the medical industry. In Chapter VI, the analysis of the manual *A guide to market access* showed that there is a strong interrelation between organizational definitions and tools (like modularity) and innovation processes. Chapter VI gives a dual account based on general discourses in *A guide to market access* and on the interactions of those engineers working in venture companies. Within these two discourses, competitive analysis tools (like Porter's five forces and Ansoff's matrix) appear to act as factishes (Latour, 2010: 21). The novel finding of the chapter concerns the existence of relations between those general discourses expressed in the *Guide* and the practices of medical devices venture companies. This complex relationship is, for example, crucial when the Guide enacts the partnership strategy for venture companies. This general discourse is translated into modular operations strategies. Such strategies lead to the economization of any kind of relation between, for example, the universities and the venture companies studied in this thesis. This extra layer of analysis offers new avenues in understanding the phenomenon of "neoliberal science policy" (Lave et al., 2010).

In any case, after the analysis of Chapter VI, the tools offered by the Guide need to be seen as being generative. Technological innovation's disorder will not be organized with those prescriptive devices (for example, by separating the industry into typologies, matrixes and predefined strategies). Furthermore, many of the interactions and observations regarding Med Diabetes and Med Dialysis seem to show that these management techniques are not there to

solve problems; nevertheless, those tools act in different and sometimes unexpected ways. In fact, what occurs is that diagrams - and devices in general - generate diverse articulations in the structures of organizations and the technological innovation dispositif.

In Chapters VII, VIII and IX, the thesis opens up the innovation dispositif and draws attention towards those diagrams that comprise innovation management techniques. Chapter VII describes several diagrams and gives an analysis of those devices in the mixture of the discourses of the engineers, technicians and managers of venture companies. The chapter presents a parasitic understanding of these devices and - in general - of the organizing processes of ventures. Several figures define the nuances of the performativity that these diagrams bring to the innovation processes of organizations. For example, Rotman's (1987) zero object defines the space of possibilities for Med Dialysis's innovation diagram. As is made clear in Chapter VII, the diagram brings forth possibilities for reflexivity by the performative power of the 'innovation model' diagram (see example). The innovation model appears to mediate through the communication that the CSTO establishes with the rest of the world. It is this quasi-object which brings together those economic elements that shape the CSTO's discourses. Additionally, the cases of the 'change note' and the SSH show that these venture devices can be understood as parasite-selectors, which reorganize the venture company's work while at the same time bringing novelty with their mediation. These devices keep the venture company working but also reorganize it. This is the power of the quasi-object as an organizing device.

An innovation technology approach that focuses on quasi-objects (like a blank figure or dominoes) is better equipped to conceptualize those mediational aspects of devices such as those exemplified by the 'the routes to market' diagram (see Chapter VII). The routes to market diagram brings the whole world of the virtual market into the conversation of the other because its constitutional indifference is open to reinterpretation. Instead, Latour's quasi-objects exhibit an implicit colonialism and functionalism which, when it circulates into the organization, leaves behind less space for otherness. If diagrams - and more generally objects - were uniquely immutable mobiles, then the result of the parasitic relation between the quasi-object and the rest of the entities would always lead to new homeostatic equilibriums. As is discussed in Chapters IV and VII of the present thesis, it is not always possible to observe this kind of equilibrium. Sometimes, it is possible to observe a homeorhetic equilibrium, which opens up the possibility of a variety of states in maintaining the trajectory of the system but with a reformulation among the internal entities that are part of the system.

The analysis of Chapters VII and VIII allows us to avoid the fallacy of misplaced concreteness (see Chapter I) that has been placed at the centre of the abstraction process, where the separation between labour and capital is generated and from which it has been demonstrated that capitalism is supported. It also offers a more nuanced relational approach to the co-

construction and interconnections between the personal, organizational and social levels of analysis. Finally, by focusing on these devices the analyst can gain further disclosure into the process whereby the subjectivity of managers, engineers and technicians emerges. From this material and relational approach, the thesis demonstrates how it is that identity phenomena emerge. Looking at the interruptions of devices like the routes to market diagram, it is possible to gain a more grounded approach as to the professional identities of those who work in venture companies. As a consequence, in order to open up technological innovation, the thesis concentrates the analysis on the professional identities of those participants of the process.

1.2. Subjectivity and the engineer's professional identity

Following the long post-ANT tradition (Leigh-Star, 1991; Lee & Brown, 1994), this thesis argues that a purely flat understanding of humans and technologies precludes an ethical commitment to the human part of the assemblage that we call the 'organization'. Indeed, this is particularly problematic as regards innovation and organizations, where it is easy to fall into retrograde managerial and work-intensification processes. This is why, in working out a sensible approach to opening up the black box of technological innovation, this thesis asks a question as to whether or not selves and professionals are shaped by relations with certain management technologies. In particular: are engineering professionals shaped by the writing devices cited above? It is in Chapters VIII and IX that the present thesis offers new avenues and fresh data for the discussion on identity and - in particular - professional identity in light of relational and constructivist approaches such as ANT.

This thesis shows how the routes to market and innovation strategy diagrams participate in the definition and production of the engineers', managers' and technicians' professional identities. Chapter VIII shows the emergence of a specific subject - the 'venture engineer'. This professional identity emerges within a process that this thesis calls 'engineering the engineer'. The identity production process or consummation process produces venture engineers as subjects. This is a process whereby the Government and its intermediary agencies participate through their assemblages of enunciations. These collective assemblages of enunciations create social categories from which the engineers of venture companies consume their identities.

Such a process is almost impossible to visualize with a 'purist' use of ANT's toolbox. Instead, understanding the engineering the engineer process and the composition of the venture engineer requires the expansion of ANT towards such concepts as the conjunctive production of subjectivity of Deleuze and Guattari (see Chapters IV and VIII). Indeed, the present thesis claims that Deleuze and Guattari's toolbox allows the analyst to understand how it is that an engineer consummates his subjectivity from the repertoire of possibilities that the 'social machine' offers. Subjectivities are consummated from social machines, like any organization,

vendors and the society itself - which is the social machine per excellence. This is the central and novel argument of this thesis.

This thesis shows how it is that the engineer plugs his desire machine into the social machine of the healthcare industry. Such a social machine is aligned with the venture discourses of actual society and calls for companies to accept increasingly high levels of risk. As a consequence, and cascading down - as in the case of any parasitic relation - companies shift that risk down to their engineering labour. Engineers are mediated by accepting higher risk levels. In parallel, this thesis shows how the engineers of venture companies try to resist - but finally accept - higher levels of risk. This adds a new layer of complexity to those who offer their labour to venture medical companies.

Additionally, the conjunction process demonstrates the production of the collective. This is because conjunctive synthesis inscribes those particular characteristics' modes of production within it. These particular modes of distribution and exchange are enacted in the diagrams that engineers use to produce their labour. This is the nature of the process that I call 'engineering the engineer'. It is a path whereby the idea of innovation (and its related distribution channels and productive arrangements) acts as a social machine into which engineers, technicians and managers feed their own identities and embrace ambiguity as the solution to the highly uncertain state of the affairs that every innovation project confronts. Such is the corollary of example four in Chapter VIII. In this example, the thesis shows how it is that the SSH and, more generally, the technical specifications change - as in any complex product development process - and act as a 'honing' tool of their professional identities.

Such a honing process shows how the desire machine that is the engineer plugs into the social machine that comprises such social categories as 'outsourcing' and 'modular production', which are distributed into the vendors of the venture company. It is precisely here that social discourses enter into the production of the professional identities of engineers. This collective assemblage of enunciation (see the methodology chapter, after the analysis of the *Guide* in Chapter VI) can be related to neoliberal science and technology policies; it is tangled with the 'machinic assemblages' and dispositif that comprise technological innovation. This honing process is the conjunctive synthesis from which a new kind of professional engineer identity emerges. Such a process is supported by Med Dialysis CEO's expression "it's actually a honing of the people" (line 27, example five, Chapter VIII). This extension of the metaphor used by the engineer makes the engineering the engineer process more explicit. It is then possible to see how social categories - such as 'modularity' and 'self-care', among others - connected with neoliberal policies enact the participants of the technological innovation process.

The engineering the engineer process is also a practice whereby disjunctive synthesis, happens through those artefacts - as the diagram of the distribution channels - that marks, or codes in Deleuze and Guattari terms, these venture companies professionals. After this 'mark', the

engineer becomes an appendix - an adjunct - of the machinic assemblage that is technological innovation. In other words, the venture engineer's subjectivity emerges in synthesis and in a machinistic process whereby diagrams code their production and - at the same time - professionals consume identities from social machines, such as the NHS, the Government and society as a whole.

However, the codes that enter from the disjunctive process are not exclusively from diagrams. In the case of medical device companies, engineering the engineer is also a becoming process, which depends on the coproduction of a 'self-care'-type user. Additionally, venture companies manage the uncertainty that is related to user definitions with the mediation of ordering devices (see Chapter IX) that make possible the realization of the future. An example of such a device would be the prototype of the dialysis machine cartridge. This device participates in the strategy that the Med Dialysis commercial manager produces in order to reduce commercial risks.

In particular, this thesis shows how venture companies try to create healthcare delivery visions. Such visions are enacted to manage user risk. Engineers create personas, talk about them and even make choices in the name of these personas. Furthermore, user risk management appears to be a parasitic process whereby those engineers who are downstream in the technical specifications (like the design engineer) parasitize the productive flow of the commercial area of the company. At the same time, the commercial manager parasitizes the focus groups technique (another device), which produces consumer preferences. Ordering and the future generation of diagrams participate in disjunctive synthesis with engineers, users and intermediaries. This is how codes enter and mark a shift in the flow of the production of the engineer. From then onwards, engineers no longer produce any kind of solution for dialysis - engineers produce solutions for dialysis at home. The SSH inscribes an outsourcing code into the engineers' activities in disjunctive synthesis. In parallel, users read their identities as self-care dialysed patients and the engineers read their identities as venture engineers. The former explanation seeks to offer a new layer of specificity for the economization process thesis (Çalışkan & Callon, 2009; 2010).

Following a line of thought that began with the post-ANT tradition and using the tools of Serres and Deleuze and Guattari, this thesis shows how subjectivity-formation is clearly imbricated with the economization process. As has been remarked upon before, diagrams such as 'routes to market', 'innovation strategy' and the SSH participate in conjunctive (and sometimes in disjunctive) synthesis with engineers' production and users' definitions. This is evident in the case of disjunction when the code marks the engineer, causing a shift in the flow of his production. The engineer no longer simply produces solutions for dialysis. He or she produces solutions for dialysis at home, because the outsourcing code becomes inscribed in the specifications of the solution. The synthesis produces a permutation (a change of direction) in the engineer's flow of production. This is at the base of the economization

process. Çalışkan and Callon's economization process is then able to be enriched with a more detailed analysis of the identity production process.

2. Implications and Limitations

The post-ANT tradition mediated by the use of Serres and Deleuze's and Guattari's tools becomes a sensible approach to opening up the black box of technological innovation. The original contribution to our knowledge that this thesis makes lies in the development of the concept of the 'venture engineer'. This concept is based on a novel development of analytical tools that follows a performative disposition. A performative disposition implies taking seriously the effects of research work. At any time while one engages in research activities, one creates and recreates ways of working with those doing the research. There are no descriptions that do not have an effect on the phenomena under study. The thesis also contributes to the post-ANT literature by adding a new dataset produced by an original approach to the study of organizations based on the tradition of STS.

The novel concept of the 'venture engineer' that emerges from this thesis offers new avenues and a fundamental turn in the study of management processes, organizational dynamics and professional identities. This is a turn which, though it does not forget the tradition of science studies, equally respects the long and extensive experience of organizational studies. It is a renovation from the inside, which offers new forms for studying venture companies and virtually any type of organization that is engaged in technological innovation and the broader problem of technological change.

Another significant finding of this thesis lies in understanding technological innovation as a parasitic process. However, although this thesis offers enough support to an object-centred analysis of technological innovation, the approach requires further empirical work. A parasitic theory of technological innovation demands such extra empirical work. However, the results shown in this thesis are enough to trigger a strong call for a dark organizational approach to the study of technological innovation and its organizational processes.

Another important aspect that this thesis seeks to highlight is the importance of interdisciplinary work. The thesis is itself a clear example of how science studies, economic sociology and organizational studies need to integrate their findings and methodologies. Complex phenomena - such as innovation - demand that we take the difficult but rewarding path of interdisciplinary work in relation to methods and theory. When a problem like innovation is the subject of study of a reductionist approach (for example, purely in terms of its technological or economic aspects), the result will produce a bifurcation of nature (to use Whitehead's (1920) famous expression). In consequence, this thesis embraces and fully supports the interdisciplinary approach that innovation and organizational studies have been

following over the last two decades.

This thesis's approach to technological innovation transcends any binary position, whether social or technological. That is, it seeks to research and discuss technological innovation outside the modern separation of nature and the social. The findings regarding the figure of the venture engineer and the process of engineering the engineer were made possible by considering the participation of different entities, whether these were social, technical, material, discursive or non-discursive. This does, I believe, mark a clear call to apply the cosmopolitical programme (Stengers, 2012) to the study of technological innovation. Such a call would present a huge effort and exceeds the scope of the present thesis.

In any case, this thesis follows an approach that leads to a decentring of a purely humanist understanding of technological innovation, while at the same time it can take care of those people who participate in the process as the designers, engineers and managers of technological innovation. This is clearly a problem which demands that we take care of the political aspects of technological innovation, such as those aspects that are related to 'macro' actors (like the NHS). However, this thesis focuses on the 'micro' aspects of management tools, such as those writing devices that the engineers of Med Diabetes and Med Dialysis use to participate in the co-production of their identities and technological innovation. This is because the venture companies themselves are not simply consumers of NHS policies. An event-based and relational understanding of technological innovation demands the study of both their non-discursive and discursive aspects as well as their relations. Within this analytical movement, I look forward to resisting the actual urgencies of 'self-care' and rethinking foundations of the phenomena of technological innovation.

Embracing the study of technological innovation from a non-foundational approach implies situating one's work within the lineage of studies that, in researching technological innovation, seek to reflect upon the foundations of their own theories and views of the world. Such a non-foundational approach to the phenomena of management and innovation leads to an acceptance of the uncertainty of technological innovation practices and their complexity. Although this thesis is not a source of solutions for innovation management practitioners, nonetheless - and reading between the lines - it provides a strong call to develop a methodical scepticism regarding those tools, theories and 'solutions' employed in managing innovation processes.

After the comprehensive reading of the managers' and engineers' accounts, I can see that repetition is as important as creativity for those managers and engineers in charge of the technological innovation process. Repetition and renovation are as important as novation (see Chapter II for this distinction). At the same time, this thesis offers enough examples to 'build the case' for taking more seriously those material aspects of the technologies of management presently being used within technological innovation processes. Although this

thesis is not an apology for the importance of diagrams, it tries to make a point as to their power and relevancy in the construction of technological innovation.

In other words, this thesis seeks to highlight a point about the need to go further towards the foundations of a theory of the management of innovation. For example, we should ask the question: what are the possibilities that the five forces device presents to your practice? Such a generative approach leads to a challenging of assumptions and reveals the limitations of, for example, industrial economics analysis. Management technologies inherit aspects of disorganization. Technological innovation managers/practitioners as well as researchers need to make more careful consideration of the implications of their tools and management control technologies and the theoretical foundations that they use in their practices.

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