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CHAPTER TWENTY TWO

Collateral Innovation: Renewing Theory from Case-Studies

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Introduction

Theories relating to innovation, whether dominant or alternative, are accompanied by discourses. The messages contained in those discourses are promoted by a whole series of different actors who have an interest in peddling them (political leaders, economists, journalists, but also natural scientists, researchers in the social sciences and humanities, management studies, research policy, etc.). Those discourses on innovation are very often positive, if not enchanting (Godin 2015), and have yet to be entirely decoded.

Concerning social researchers, they produce accounts based on studies, at times of ethnographic inspiration, infused with cases monitored over time and focusing on the actors' experience. This experience is captured within the actors' social and material environments (Knorr Cetina 1997). The cases themselves serve as units of analysis while the research is inductive. Knowledge about the phenomenon of innovation thus relies greatly on case studies. It homes in on the understanding, description and analysis of innovation journeys, like the pioneering study of the propagation of hybrid corn in American farming communities (Ryan and Gross 1943). In the aftermath and just to mention the most quoted one, Everett Rogers adopted a systematic approach in order to theorize the spread of innovations (Rogers 1962).

It exists criticisms of case studies, which are focused on their ability to lead to theorization. Such monographic approach can be perceived as inadequate when the subject of theorization is the phenomenon of innovation in our societies. Based on a case, a problem is posed, and even exacerbated, in order to underline its importance and suggest its potential for becoming widespread. Although well documented, the studies are based on particular cases whose value may be seen as idiosyncratic only. While they could make it possible to identify questions, formulate hypotheses, develop a case model, and even outline a theory, their broader validity remains to be proven, according to many scholars. Case studies may not readily provide a framework that could be used to put together, model or develop a stylized representation of something that could be generalized (Gomm, Hammersley and Foster 2000). Their use for such a purpose entails the risk of being trapped inside the "disembodied empiricism" criticized by Charles Wright Mills (1959). To put it differently, the problem posed by case studies, for some scholars, is that these studies could not be considered as strong theoretical contributions in the sense that they not establish a widely-applicable "grand theory", with real-life concepts inserted into the stories recounted, these being only relative reflections of the indigenous accounts.

Nevertheless, case studies tend to reveal regular characteristics specific to a case and a number of mechanisms, rather than acting as a model they are more often of heuristic worth. Whether we are talking about the spread of stereo-photography analyzed by Howard Becker (1982), or the experimental introduction of a new fish-farming method (Callon 1986), the authors do not present a model applicable to other innovations but simply defend the invention of an analytical stance reflecting the complexity and diversity of innovation dynamics. As a result, case studies are valuable to the research effort, when they help to go beyond singularity. That is the reason why this paper tries to better understand how case studies could help to contribute to critical discussion about pre-existing theories. Through the analysis of the

induction of a specific concept, we would question what has been done in the literature with case studies of innovation pretending to propose new concepts.

In order to do so, we will present two case studies, selected for their convergence, and we will show how we used them to forge the concept of "collaterality" and why we have chosen this angle for its theoretical potential as it qualifies in an original way one aspect of the non-linear process of innovation. We have called "collaterality" or "collateral effects" a series of occurrences and ramifications arising from but different from an initial innovation process, and which thereby multiply it. We have suggested that this original process of innovation is taken in unexpected directions that are always related, in some way or another, to the initial directions. In some cases, these initial directions are erased.

Addressing two case studies, i.e. comparing and contrasting them, as suggested by Gomm, Hammersley and Foster (2000), then we have developed a concept as an essential step towards theoretical abstraction. In other words, we have proposed a way to reconcile the case study (based on the actors' accounts) and the theorization of/about innovation. In this way, it was possible to better understand how the cases could have contributed to alternative theoretical development. Comparing and contrasting two cases would be a means of building distance and hence moving towards conceptualization and more wide-spread theorization. The notion of "collaterality" hence fuels this first effort to theorize, which in turn should help to further and even partially challenge innovation theories. In other words, the article outlines a means of overcoming the problem of monographic case studies as productions devoid of theoretical objectives.

Consequently, after having recall three concepts that help to understand the non-linearity of innovation processes and their surprises, like most of the authors do when they propose a new concept, we shall describe two case studies leading to the notion of "collaterality" in order to analyze innovation journeys. The first account focuses on an experiment with emergency telemedicine technology set up between retirement homes and an emergency ambulance centrein the North East of France. The second case outlines a process of exploration and progressive rapprochement between doctors and mechanical engineers. It is set in a hospital centre in the North of France where the aim was to provide new solutions to manage prolapsed organs.

Taking the most salient points from the two case studies, the next section is devoted to a detailed presentation of the concept of "collaterality" and its relevance for reporting on innovation processes.

Finally, we shall conclude this article with some thoughts relating to the contribution of case studies and their resulting conceptualization to the development of innovation theories.

What Concepts help understand the non-linearity of innovation and its surprises?

Since several decades, innovation processes have been described as oscillatory and vortexing. The actor network theory, as early as the late 1980s, initiated this mode of analysis, starting with a critique of the diffusionist and linear model put forward by Everett Rogers (1962) (see Akrich et al. 2002). The point is to indicate that innovation trajectories cannot be analysed through the prism of fate and that there is a risk of reconstructing their logic *a posteriori*. It is then necessary to study innovation processes "in the making". However, concepts were previously proposed to account for the non-linear, surprising and uncertain nature of innovation processes.

With the aim of introducing to the case studies and the emergence of the concept of "collaterality", we will focus on three notions or approaches.

First of all, we would mention an analytic tradition sensitive to unexpected effects, which cannot be anticipated, resulting from a series of entangled actions. We might notably refer to the "unanticipated consequences" of bureaucracy, highlighted by Robert K. Merton (1936). He proposed the following definition: "Rigorously speaking, the consequences of purposive are limited to those elements in the resulting situation which are exclusively the outcome of the action, i.e., those elements which would not have occurred had the situation not taken place" (ibid.). In his functionalist analytical framework, "unanticiped consequences" do not correspond to what was expected and then are "dysfunctional", as reminds us K.E. Sveiby (2017). Following Merton steps, "unanticiped consequences" were also pointed to in the methodological individualism of Raymond Boudon (1982). This author repeatedly qualified the social world by referring to the emerging (or perverse) effects generated by aggregated individual behaviours. It stems from the intentional approaches of the actors involved, hence at times creating surprises but targeting wanted effects. Moreover, Boudon primarily describes the unwanted effects that actors are forced to endure since their only footing is formed of individual choices. On the principle, this way of thinking could help to apprehend non-linear innovation processes which results are not reduced to what was previously expected but could result from the aggregation of individual similar behaviours.

Second, the concept of "function creep" (Winner 1977) could be also useful. It concerns situations in which users do not follow recommendations for use and use an object for something other than what it was designed to be used for or in a different manner from the one prescribed. Users invent new uses or unearth existing uses having escaped attention. The advent of the short message service (SMS), when some English teenagers in the 1990's decided to exhume a forgotten feature on their phone to avoid paying the exorbitant cost of calls, is often taken to illustrate this mechanism.

Finally, it seems important to take into account the concept of "overflow", introduced by Michel Callon (1998). Moving away from the economic concept of "externalities", whether negative or positive, i.e. the effects induced by economic activity (e.g. toxic fumes given off by a factory or the increasing value of the phone regarding the number of its users), Callon prefers to talk about "overflows" to underline the dialectics at work and in which the effort to "frame" (in the Goffmanian sense) becomes obsolete and must be renewed. The overflows are not necessarily perceived as a problem. According to Callon, they are in fact the norm while any framing is always unfinished and incomplete.

The two later concepts are less canonic than the first in the field of social sciences. Nevertheless, they seem relevant to analyse non-linear processes of innovation. Will these concepts be sufficient to analyze the two cases that will follow?

From case studies to the concept of "collaterality"

"Collaterality" as a response to failure: the emergency telemedicine "case"

The first case study is that of experimental work carried out between 2012 and 2014. It involves 10 nursing homes in an urban area with about 100 000 inhabitants in the North East of France and the emergency ambulance service of the regional hospital. The experiment

consisted in testing a telemedicine "case" (term employed by those involved) containing an electrocardiograph, an oximeter (measuring the rate of oxygen in the blood) and a tensiometer. The "case" made it possible to electronically transfer the readings taken by these devices in the different retirement homes to the emergency centre by mail. The defined objective was to prevent very elderly residents from being sent to the emergency ward when this was deemed unnecessary by the emergency doctors. For example, their electrocardiograph plot (ECG) could be taken by the "case" and electronically transferred to the doctors. This would then allow the doctors to decide whether there was a real danger of infarction or not.

The story behind this technical object had followed various twists and turns. Before landing in the retirement homes, the "case" had travelled across other sectors of activity. Containing only an electrocardiograph, it began its life on the ships of the French merchant navy and was used to check for onboard cardiac events. Today, 500 ships are equipped with the case. The company Maciste Technology, which markets the device, was created in 1996 when an engineer suffering from myocardial infarction was struck by the complexity and amount of wires on the ECG systems in hospitals. Once he had recovered, his meeting with a French merchant navy doctor encouraged him to work on simplifying the device and creating a company, which would later be sold.

Several years later, the experimental work studied here stemmed from an encounter between this evolving technical object and professionals in the health and social service sector. Doctor Van Petegen, who was then in charge of the emergency ambulance centre of the regional hospital concerned, was behind the initiative. Having worked as an emergency doctor for 30 years, he was concerned by the increasing number of elderly persons being brought to the emergency ward. He did not feel that they were receiving suitable medical responses to their problems. He therefore began to think about how to slow down this increasing flow of elderly patients and decided that sending out emergency teams to their homes might be avoided in some circumstances. This would help with the shortage of resources (emergency doctors) and equipment (lack of ambulances). During a congress, he learnt about an experiment allowing fire fighters to electronically transfer medical data from their emergency vehicles. He thought that it might be possible to replicate this system within retirement homes. He talked about this idea with Mrs Parinello, the director of two retirement homes in the area. She had also been wondering about how to send her residents less often to the emergency ward as this exposed them to the cold and a long wait, which meant that they often came back to the home in a worse state than when they left. She agreed with Doctor Van Petegen about how it was important to *"remove"* these very elderly persons from the home as infrequently as possible and leave them instead in the warm and cosy environment of the home. An appointment was quickly set up with the start-up Maciste Technology. The company immediately made two devices available to two associative retirement homes in February 2012. In December 2012, an opportunity to benefit from credit from the Regional Health Agency arose making it possible to equip 8 other retirement homes in the sector and buy the first two "cases". A subsidy of 120 000 euros (the case unit cost was 12 000 euros) was thus granted at the end of the year.

In September 2014, a total of 25 ECGs had been electronically transferred to the emergency centre, i.e. an average of 8.3 for the six responding retirement homes. The webcam connected to the "case" took six photos, also electronically transferred to the emergency centre. The number of transmissions was thus quite low given the experimental period duration (over two years) and the number of retirement homes taking part. By way of comparison, roughly 400 calls were made to the centre from retirement homes across the whole area (roughly 60) between April and June 2013. Above all, only the two pilot retirement homes and one other electronically transferred data.

There are many reasons for these limited results, which we shall not go into here (see Gaglio 2018). However, we shall focus on the way in which some actors attempted to quash this upcoming failure, by instilling a vital counter-momentum, and on their efforts to explore other ways to turn the experiment into a success. In fact, the "case" itself was put to one side in order to encourage cooperation between the emergency team and the retirement homes. Here it is important to note that a shared understanding of the clinical and medical state of the residents was required for descriptions given during calls to the centre. Keeping this in mind, and at a time when the technical object was not functional (mid 2012), an informal working group was set up. This included Doctor Van Petegen, the coordinating doctor, and the head nurse of the retirement home directed by Mrs. Parinello, together with the head of the geriatric ward in the sector's hospital. The idea was to prepare a questionnaire to describe the clinical state of residents to be used by the care assistants in the retirement homes. The questionnaire was to provide them with support and act as a guide when they called the emergency team. The document produced reflects work on categorization. It contains items such as *"first observations"* and *"vital signs"*. Different events are then listed (fall, chest problem, dementia, etc.), together with corresponding questions.

The project leaders were proud of this achievement, which was also well received by the financial backers of the experiment during its assessment. This descriptive questionnaire was referred to as the *"Esperanto"* or *"common language"* document to indicate that the ultimate goal was to help the care assistants *"communicate better"* with the emergency centre's doctors by using terms that would be understandable to a doctor, instead of falling back on the usual "well"/"not well" categories. In short, as far as the initiators were concerned, this document promoted the *"professionalization"* of the care assistants and aimed to *"enhance their skills"*. The technical object became relevant, not for itself, and not because it was adapted to emergency situations, but because of the approach that it gave way to, which had nothing to do with using or learning to use the device. This achievement ties in with the desire to set up a more effective[1] form of cooperation, encouraging inter-understanding between the retirement homes and the emergency centre (coordination was based on a call to the centre). Furthermore, this drive for greater cooperation also reflects public discourse about *"opening up"* the health and social service sector.

The project leaders also attempted to stave off failure via the invention of "residential" uses of the device in the retirement homes: a "pre-emergency" use and a "reference" ECG use. We refer to these uses as "residential" as they are linked to a place, or residence, in other words the retirement homes. These uses were designed primarily for the retirement home residents. The actual uses observed in the three homes using the device followed two directions. The first *"pre-emergency"* use was for *"monitoring"* and *"check-up"* purposes, as opposed to use during a *"vital emergency"*. This pre-emergency use is explained in the words of one of the nurses:

> "I believe the first time, I was alone one morning. There was a lady complaining about a pain her chest and a sense of tightness. To be on the safe side, (it was between 8:30 and 9 AM, and I was alone here with my care assistant colleagues), I did an ECG and transferred the reading to the emergency centre. In fact, I did the ECG and transferred it by mail, then I called them immediately after and said, 'I've just sent you a lady's ECG reading', and described the symptoms and explained why I'd done it. And they

[1] This is also reflected in the fact that the care staff of the retirement homes participating in the project visited the emergency center three times.

> answered me straightaway saying 'We're not sure about the results so we need her to come in, we're sending an ambulance.'"

The nurse took an initiative. In fact, she did not apply the applicable protocol for use which involved waiting for a doctor's order to examine the resident using the "case". Indeed, this protocol proved to be an obstruction to the device's appropriation. What was important for the nurse was not to avoid having to send the resident to the emergency ward but to feel reassured about her state of health. The nurse felt she had time to get out and use the case as it was difficult to anticipate how the resident's symptoms and complaints might evolve.

The other residential use of the device consisted in doing an ECG in a normal situation, as opposed to doing one to check a resident's condition in an emergency situation. The idea was to be able to compare the reference reading to an emergency reading. This approach was based on anticipation and the comparison of two ECGs performed at different times. By encouraging this use, the promoters of the project hoped to facilitate use of the device in an emergency situation by providing opportunities for the home staff to practice using it. Doctor Van Petegen was also behind this initiative, which he saw as a means of backing up the project, which had been otherwise floundering. This approach was only systematically adopted in three of the retirement homes, but nevertheless represented over 200 examinations. These homes went even further in this planned use: they performed an ECG on each new resident as part of an overall health check carried out under the authority of the coordinating doctor. The "case" was thus presented to the families of potential residents. This ECG then became part of the resident's medical record and acted as a guarantee of the home's medical professionalism, making the home stand out with respect to other rival homes.

Let us now further explore the result of these attempts to overturn the potential failure of the project. We shall start with the *"common language"* questionnaire designed for use by the care assistants to describe the residents' conditions. As underlined earlier, the "case" promoters believed very much in this questionnaire. However, it became an inert document. The care staff did not spontaneously refer to it. Indeed, it was often left lying on the "case", as if it were a second set of instructions. When interviewed, the care assistants said the document was a challenge to their professionalism, when in fact it had been designed to improve their professionalism. They considered its content as a simple reminder of the questions they were already likely to ask. In other words, they disputed the argument that their *"skills needed enhancing".*

With regard to the "reference" ECGs, these were only applied on a widespread basis in three retirement homes out of ten. The main reason for this lies in a controversy about liability involving the head nurses and coordinating doctors. When invited to perform these exams by Doctor Van Petegen, they voiced reservations that halted the device's widespread use. They argued that if an ECG was performed but not analyzed, the home might be held liable in the event that a resident died from an unidentified condition that could have been identified. In short, they did not feel comfortable about sending these ECGs to an online ether, i.e. the information system database where the exam would be stored. The coordinating doctors also objected to being held liable and, to this, two other aspects need to be taken into account. On the one hand, they considered that interpreting these ECGs entailed additional work, when they only spent one day a week in the retirement home. On the other hand, they pointed out that they did not regularly read and interpret ECG plots, which, according to several emergency doctors met during the study, was an obstacle to developing genuine expertise.

Collaterality as a component of the innovation process

The next case study might be considered among those likely to result in a new form of conceptualization. It did indeed lead to the highlighting of a rarely documented phenomenon as well as a first effort at conceptualization. The concept emerging here may lead to a theoretical development able to challenge existing theories to a small extent.

A) From qualifying a problem to seeking a solution

In the case presented (the detailed case study was published by El Mahlet and Vinck 2019), the story begins with doctors confronted with a health problem, that of prolapsed organs in women. These doctors turned to researchers in mechanical engineering for help qualifying the problem and seeking an innovative solution. Since the nineteenth century, medicine has relied on science and engineering. This has resulted in biomedical engineering and the creation of new medical specialties (radiology, ultra-sound, medical imaging, electro-cardiology, etc.), and the medical device industry. In the case at hand, the problem is an old one and the solution – the use of pessaries to mechanically support the urethra – has been documented since antiquity (Shah et al. 2006).

Confronted with pathological conditions relating to the pelvic system, in particular prolapsus – descent of the genital and rectal organs affecting a high number of women –, a group of researchers, gynaecological doctors and surgeons described the problem as damage to the pelvic tissue, especially the ligaments holding the organs in place, caused by ageing or childbirth. Unable to predict the risk of this happening because of various ill-understood problems, the doctors implemented heavy surgical operations such as the insertion of a surgical mesh sized to hold the organs in place or the replacement of ligaments. However, these treatments were difficult to adapt to individuals and the medical team did not understand why they failed. The project was to design adaptable and customizable prostheses (meshes).

Reporting to a large French university hospital, the team focused its attention on the condition seeking to understand the physiology behind this pelvic descent and eventually decided that the system's behaviour would have to be simulated. They planned to study tissue resistance and, drawing inspiration from scientific literature on the mechanical performance of organs, they designed and performed mechanical testing, but were unable to interpret the results.

B) A detour via mechanical engineering

In the literature they read, the doctors discovered that there was a mechanical engineering laboratory specialized in the study of rubber performance. The lab had forged a reputation as a mechanical protocol centre for these elastomers. Since the subject had not been very fully explored, and the tyre industry depended on it, the lab had developed behaviour prediction models. The doctors contacted the lab to obtain an explanation for their results on pelvic system organs.

The mechanical engineers effectively saw the similarities between these organs and rubber elastomers but believed the doctors' results could not be used since their test conditions were not standardized: the doctors' test pieces were of different sizes. Nevertheless, their discussions backed up the idea of modelling the pelvic system as if it was made up of an elastic polymer material. The mechanical engineers hoped that this would lead to a new polymer theory application. Over the course of the discussions, the doctors came to believe that this mechanical modelling was essential to understand the system dynamics. Their cooperation thus aimed to understand disorders affecting pelvic statics in order to find better treatment techniques, notably via suitable prostheses. The ultimate goal of their project was the design of personalized

prostheses. To achieve this goal, the doctors agreed to take a detour via the design and development of a sensor and a standardized test protocol. The protocol covered tissue sampling (taken from young cadavers, even though dead tissue is different from living tissue), the conditions for dissecting and storing the tissue (freezing), and then performing the traction and compression measurements, taking into account tissue orientation, testing speed (owing to the tissue's visco-elastic behaviour), and the temperature at which the tests were carried out. The tests were to provide reliable data making it possible to develop a static model of the pelvic system and then simulate its mechanical behaviour (rather than physiological or histological). The simulations thus became a source of knowledge to help design the solutions. Different studies were performed jointly leading notably to the numerical simulation of a child being born.

Once the protocol was stabilized the tests performed provided data. The data was then interpreted according to two theories, one relating to the mechanical behaviour of macromolecular polymers with non-linear and viscoelastic behaviour and the other to histological and biochemical aspects. Using the data from the tests and the literature on polymer laws, they built a numerical and 3D geometrical model of the tissue's behaviour. The model was validated by the doctors as being capable of adequately simulating hyper-elastic pathological tissue as well as tissue ageing.

Both the engineers and the doctors used MRI images to identify the parts of the pelvic system and geometrically rebuild each organ making it up. Once the segmentation work had been validated by the doctors, they were able to cut around the organs to define "fixed" areas and "mobile" areas. This made it possible to model the system then analyze it using topological optimization models. Using the functional model, it was then possible to study organ dynamics, without having to refer to their histology. After having studied the movement of the bones, they added the ligaments to the model so that the bladder and uterus movements could be simulated. The end result was that they had produced a functional anatomical model of the pelvic system.

C) The by-products of the innovation process become starting points for new projects

The functional anatomical model of the pelvic system developed by the mechanical engineers as a means of producing knowledge held the doctors' attention. They began to imagine a different use for the model, which had not been anticipated: that of a tool for training doctors. The model could thus enable students to learn how the system worked in an original and interactive way. It could be used both to raise awareness and train doctors. It thus became an educational tool, contributing to the digitalization of medical culture by formalizing medical and mechanical knowledge differently and opening up new routes for learning that did away with the use of cadavers. The next challenge was to transform the scientific culture of doctors while improving their ability to diagnose and prescribe treatments.

At this stage in the collaboration, the engineers and doctors had modelled the pelvic system and improved understanding of the pathologies affecting it, but had not yet come up with personalized treatments for prolapsed organs. The static modelling could be used to link the pressures exerted to organ movements but these pressures would have to be known. Hence a new research problem emerged. This led to the development of a dynamic model of the pelvic system, which resulted in yet another unforeseen innovation in the form of a diagnosis tool. Although the solution initially sought had not been found, several "by-products" had been uncovered along the way: use of the pelvic system models as educational tools (for awareness-raising and training), and use of the dynamic model as a diagnosis tool. These by-products became separate innovative projects. So, from one innovative project a bundle of three

innovative projects emerged, all stemming from the intermediary results of the first process and targeting new end goals.

According to the mechanical engineers, for a mechanical system to be perfectly model led the force and displacement fields had to be determined together with the geometry. As the geometry had been set by the static model, they designed a probe – yet another by-product of the process – to measure the pressures inside the vagina, taking into account the effects of the device on the pelvic system measured, along with the risks of interference with the sensors from the MRI magnetic field and ergonomics. They designed a protocol for pairing the pressure measurements with the displacements observed on the MRI images and developed an electronic and computer system to retrieve and process the signal and data. The invention of this sensor constituted the starting point for a fourth innovative project transferred to industry to create a measurement tool. This allowed other researchers to produce new data about the pelvic system, together with its dynamics and pathologies. The data was published hence contributing to the digitalization and modelling of the human body. An experimental database on tissue was also set up and became an additional resource for research and teaching.

Thus, one of the three by-products of the initial project was able to support research in the biomedical field while the other two influenced the demand for therapeutic solutions. At this point, it must not be forgotten that the initial project itself aimed to produce an offer of treatment solutions.

This account of innovation reminds us that simply inventing a solution is not enough to turn that solution into a widespread innovation. The users (doctors) seized on the intermediary products to meet other needs (e.g. awareness-raising and training of doctors with the development of educational models). These educational spin-off products participated in the innovation process, albeit unintentionally, by creating apparently favourable conditions for the receipt of the therapeutic innovation. In other words, the educational and therapeutic paths followed only seemed to be different since the solution to the patients' problem necessitated the invention of a therapeutic technological offer and the creation of a demand for these products. This demand came from the doctors, who had become aware of the problem, and were capable of understanding the interest of the solution, deciding on the right diagnosis and defining the right treatment strategies. From this point of view, the deflected educational use of the modelling work contributed to the innovation dynamics by acting on demand. The intermediary and spin-off products had an influence on the dynamics by acting on the supply of solutions stemming from the research as well as on demand by raising awareness of this pathology and its solution among the medical public. The various by-products thus fashioned a potential market.

The concept of "collaterality": explanation and relevance

Those two case studies lead us to the concept of "collaterality". This concept, that we have to characterize, is not radically new. It has a back history, a background, starting with the concepts and approaches that we presented briefly in the first part of this paper, which refer to close modes of analysis. Introducing a different term underlies that there is something different within it. But let's return to the former concepts and approach and explain what is different with "collaterality".

For the "unanticiped consequences", while the social world according to Boudon is the result of aggregated individual behaviours in a situation of inter-dependence, our theoretical framework instead suggests an interactional setting up of arrangements leading to some unexpected effects. Furthermore, we also take into account the material aspects of the action,

whereas Boudon concentrates exclusively on the rationality of the actors, whether this is axiological or cognitive. At last, to go back to Merton's conceptualization, "the terminology (i.e. "unanticipated consequences") is laden with negative connotations and it has had no impact on innovation literature" (Sveiby 2017, p. 138), which both (the negative connotation and the lack of impact on innovation literature) constitute a problem, according to us.

Second, although it draws inspiration from the notion of creep function, the notion of collateral effects does not need to be tied to the technical object whose acquisition triggers the innovation process. This is what happened with the telemedicine "case". Its use lead to the drawing up of a questionnaire for care assistants to describe the symptoms of retirement home residents in an emergency situation. The technical object itself was no longer the centre of attention. Conversely, creep functions never lose sight of the original device, made available to a group or a population. The notion of collateral effects is different for another reason since creep functions contribute to the success of an innovation, even if this innovation is different from the one planned. Here, the inventiveness of users comes into play as they struggle against designers and suppliers. Collateral effects do not necessarily result in success. Again, this is illustrated with the telemedicine "case" since the descriptive questionnaire is not adopted on a broad scale, just like the "reference" ECG. As a result, collateral effects should be seen rather as new occurrences, with their own difficulties and their own paths strewn with as many obstacles as that of the initial project; changing the use of something does not necessarily stabilize an innovation. Detours leading to unexpected collateral effects are not necessarily creep functions, but rather explorations of alternative routes for reaching an initial end goal. Whatever emerges from these detours cannot be foreseen, as with the pelvic system treatment case described.

Third, whereas the concept of "overflow" is close to that of "collaterality", we do not think of this last concep in terms of framings with unintentional overflows. The actors may move away from the initial framing (an objective and means), but they do this intentionally, either to explore other possibilities or to find a solution allowing them to return to the initial frame. While collateral effects might be considered as overflows, they concern either "intentional overflows" or unexpected effects produced during intentional and theoretically provisional detours. From a heuristic point of view, the notion of "overflow" has the drawback of losing sight of the direction followed by the actors.

To go further, the presentation of our two case studies stemming from the medical field point to adjacent empirical occurrences: crossings, branch trails and unexpected developments. These moves away from the linear and eschatological vision of innovation processes which was a long time dominant in research, even this has not been the case for several decades. The question to be raised here is whether a new concept is necessary to characterize these peculiar occurrences. After all, hypothetically speaking, the same events could have happened elsewhere in a comparable manner. Our answer to this question is "yes", which is why we propose the concept of "collaterality" or "collateral effects" since the peculiar nature of the phenomenon identified is that the different branches of the original innovation process (with its targets, envisaged solutions, etc.) could not have occurred without the problem underlying the initial project being re-raised (Callon 1986, refers to "re-problematization"). This re-problematization produces effects that exceed the directions and strategy initially set up (attribution of resources, planning, etc.). In this way, the effects are "collateral" in that they follow on from a first displacement and first set of events (intermediary results, meeting of unforeseen obstacles, change of actors, etc.), hence broadening the initial scope. Metaphorically, we have drawn inspiration from the notion of "collateral damage" used in times of war, i.e. the fact that civilians are unintentionally, if not inevitably, affected by attacks although they are not the initial targets.

However, our notion does not take on the negative connotations associated with the term "collateral damage". The meaning we place behind "collateral effects" reflects neither a positive nor a negative judgement. The concept's vocation is to report on a phenomenon and its complexity, rather than to offer a Manichean view of the subject studied.

Examining the history behind the concept of "collateral effects" in the field of innovation has enabled us to characterize it. Let us now explore the notion in relation to the cases studied.

Firstly, with the telemedicine "case", collaterality arises from the solutions to be found faced with the lack of use of the device in emergency situations. Routine use is put in place (the "reference" ECG), along with the standardization (the questionnaire to describe symptoms) of a known interaction between the actors, i.e. the call to the emergency centre from the retirement home. With the pelvic system treatment, collaterality stems from the detour taken to produce an intermediary result allowing the initial objective to be pursued. In both cases, the collateral effects concern the uses and/or resources to be put in place and matched to the initial project taking into account the difficulties encountered in the pursuit of the initial objectives. The collateral effects relate to a series of actions peppered with twists, new hopes and cognitive investments to counter potential failure (case n° 1) or to achieve a first short-term goal (case n° 2). The actors react to things and explore new paths to further a temporarily fruitless project, even if this means changing it, which is something that has been well documented in the literature on innovation. However, what can be seen in the second case is not a response to potential failure (the chopping off of financing in the first case), but to identified difficulties. In the second case, the collateral effects are produced through an iterative process of discovery and progressive learning, resulting in unprecedented collaboration between the doctors and the mechanical engineering researchers. The actors involved in the project discover realities and ideas for solutions that they had not thought about. They take a number of detours to guarantee a solid base for inventing a solution. However, as the project moves forward they also produce models and measuring instruments whose use goes beyond the intermediary steps of the initial innovative project. In the end, the models and knowledge generated prove to be more useful for training future doctors than inventing a treatment solution, at least in the immediate present.

Secondly, the collateral effects take the form of transitional products (the transition being towards a final desired result that remains the same), or by-products of the original innovation process. The focal point for analysis lies in the degree of autonomy gained along the new paths taken in relation to the path initially imagined. This autonomy appears systematically, but varies according to the case. For example, in the first case, the "reference" ECG is designed as a means for the care staff to become more familiar with the use of the "case" so that it can be used in emergency situations, notably at night. The potential for collaterality takes on a life of its own and is transformed into the systematic performance of an ECG upon the arrival of new residents in three of the ten pilot homes. In the second case, the autonomy attained is even greater, leading to the creation of a start-up in the medical and medical implant textile field. The spin-off and intermediary products (e.g. the training of young doctors or modelling of the pelvic system) go so far as to partly replace the initial objective, i.e. predicting prolapsus in women and defining the appropriate treatment. This is why the "by-product" category to qualify the collateral effects is not entirely satisfactory. On the one hand, studying these products is interesting in itself, if not even more stimulating than the initial project. On the other hand, the innovation dynamics results in productions and associated attempts to produce something that take on a life of their own and follow other innovation paths. This is especially apparent in the second case where the branch paths taken contribute to the digitalization of the human body and provide the foundation for new scientific, educational

therapeutic and industrial developments. The actors are swept up in the dynamics of cooperation, which throws up new knowledge in its wake. This new dynamic movement takes over from the initially targeted objective. When it comes to characterizing the concept of "collaterality", we suggest that these detours and associated creations fashion the sociotechnical environment (in other words the "context", Akrich *et al.* 2002), create the need and prepare the demand, in such a way that the environment readies itself to receive the initially planned innovation. Collateral effects provide fertile ground for future successes and initiatives coming under the same generic designation as the initial project, which may still be in its infancy. For example, the "case" project made telemedicine more socialized via the dialogue initiated between the homes and the hospital: at the end of the investigation, several nursing homes had set aside a room in their building for telemedicine, without yet equipping it but in view of providing teleconsultations in dermatology.

Thirdly, the collateral effects of an innovation process generate a series of movements creating new potentialities. These movements may relate to professionality as demonstrated through the innovation project to predict and treat organ prolapsus where the doctors and mechanical engineers broaden their range of skills and, at least partly, redefine their professional identity. Or it may be movement with respect to the initial "problematization", as demonstrated in the telemedicine "case" story where unnecessary costly transport of residents from their nursing homes to the emergency centre is avoided. Indeed, the collaterality of the process notably leads towards the challenge of improving shared understanding between the emergency centre doctors and the home care assistants when they communicate over the phone (using the "Esperanto" questionnaire). This mechanism is well-known in actor-network sociology and is subsumed by the pivotal concept of translation (Callon 1986). Yet, here, there is a nuance since several innovation paths cohabit, and may even overlap, while at the same time being triggered by an originating initiative to which they remain attached to varying degrees. To a certain extent, the first innovation process unfolds and its ramifications are studied. These may lead off in directions quite remote from the original epicentre and create new resources and opportunities.

Concluding thoughts: cases, concepts and discussion about existing theories

The ability of a new concept to challenge innovation theories

Both case studies and their cross examination allowed us to develop a concept, which we pretend to be relatively different from those pre-existing. As other authors could have done, we now need to assess the worth of this notion beyond the two cases in which it is grounded. In other words, how does it contribute to theorization of the innovation phenomenon?

Literature on innovation has for a long time been based on a linear conception of the process. The process is portrayed as sequential, starting with the production of scientific knowledge used to develop, industrialize and sell applications, which are then adopted and used. This top-down model, which assumes a high level of scientific autonomy, as well as a firm separation between science and its application, has been disputed (Edgerton 2004; Godin 2006). This model has also been used to reject many authors who have demonstrated through case studies or statistical surveys that the process is not linear but zigzagging, involving trips back and forth between research, development, industrialization, commercialization and use. Several theoretical developments have thus appeared over the course of time. A first model suggests that the process is pulled by the market, which implies that demand works its way up the chain, from the user to science via market research and design offices, before moving back down in compliance with the basic supply model. A second model places either an individual actor (e.g. a Schumpeterian entrepreneur), or an organized group at the heart of the process. This actor

moves back and forth from upstream to downstream until the right combination is found, the challenge being to pair science and technology with the market. A third model introduces retroactive loops between different links in the chain, either from one link to the next or by skipping intermediary links. Furthermore, the "open innovation" model as opposed to the "closed innovation" model (Chesbrough et al. 2006),consists in seeking ideas to develop differentiating products outside of the R&D department of a large firm and allowing innovation processes of different origins to decant rather than making a quick decision inside the firm about what needs pursuing and what should be abandoned.

Some theorizations nevertheless break up the linearity by highlighting the displacements and transformations of ideas, intentions, demands, projects and knowledge, which in turn introduce branching, slippage, shifts and reorientations. Combined with the previous model, this less linear conception notably results in a swirl pattern conception of the process. This process does not evolve along a single axis and the axis itself can be twisted and even broken as the innovation progresses, thus leading to something very different from what was imagined.

All these models nevertheless share the fact that thinking gravitates around a unique object. However, some authors have shown that innovations combine often different components that synergize with each other (innovation bundles) or are articulated (e.g. architectural innovation or innovation through subtraction). These situations assume that different innovations and innovation axes interfere with each other and that the interactions between the innovation axes must be added to the back and forth movements and retroactive loops specific to each. These developments in the conceptualization of innovation and the modelling of its processes are backed up by case studies and/or feed into new case studies that facilitate reporting on the complexity of the processes.

Our notion of collaterality developed from the case studies presented in this chapter contributes to the conceptualization efforts listed above. It does not fundamentally question the existing theories. Rather, the notion tends to reinforce theories by pinpointing the importance of non-linearity, actors' interactions, displacements and reorientations, and the emergence of unexpected elements, without considering innovation dynamics as a mere coincidence. The notion completes the non-linear theory of innovation processes by underlining the role of surprising results generated by voluntary detours. These lead either towards new innovative projects taking on a life of their own in relation to the initial project, but not necessarily calling it into question, or towards complementary innovations preparing the way for the success of the initially planned innovation by modifying it and/or readying its receiving environment (e.g. by making the demand originate from this environment).

The concept of collaterality also invites us to defend the paradigm of exploration to describe and analyze innovation processes. It encourages us to go beyond a whole series of useful but paralyzing dichotomies: invention and innovation, supply and demand, intermediary results and final result. It allows us to discuss and move beyond the dichotomy between failure and success, and perhaps even the principle of symmetry on which this dichotomy is based (Gaglio 2018). Finally, it invites us to explore all of the productions and transformations, whether expected or unexpected, and the interdependence arising between them. In this respect, the notion also reinforces theories that refuse to portray innovation as focused on a unique object or a unique process and instead combine a variety of elements that overlap and interfere with each other to varying degrees. It allows us to highlight the importance of by-products and intermediary results as well as the paths that take on their own life and create new arrangements

– including in the receiving context – for the initially planned innovation, hence drawing out innovative properties hitherto unimagined.

The concept of collaterality was not conceived with a normative outlook, or with a view to suggesting new best practices, but as a means of characterizing the mechanisms at work in the way innovations are deployed. Nevertheless, the notion does help us to take a step back from the dominant theories and hence allows for a critical approach. The fact that the dominant theories act as a reference for thinking about innovation management policies and methods implies that an alternative theoretical contribution inevitably lends it critical weight with respect to these policies and methods. When an alternative concept is used to promote a political or managerial alternative, it becomes normative and ideological. Furthermore, although the development of this notion did not aim to produce an instrument of criticism, in reality it can be seen as such since it questions the policies and methods in place. It also becomes normative in that it implicitly suggests that other management policies and methods might be conceived. Indeed, such policies and methods might be more in line with the detours, unexpected occurrences, by-products and potentially autonomous sub-projects, or with the intentional exploration and co-building of supply and demand, the inventions and uses, the innovative object and the actors involved, etc. To put it in another words, and unlike the "unanticipated consequences" concept, collaterality is a positive approach insofar as that surprises or detours are not bad news and do not constitute a problem. In a way, it is the logical flow of things and it could lead to new opportunities. The perspective of collaterality is then "positive", analytically speaking, without venerating innovation. The ability of case studies to support alternative conceptual developments

Case studies are regularly proposed in literature. They document processes that have not always been conceptualized, for example with respect to the regulation mechanisms and policies interfering with the dynamics of innovation, or negative externalities and the unequal distribution of the spin-offs from innovations, diversion and bypassing strategies, etc. This wealth of case studies questions existing theorizations and potentially contributes to new conceptualizations. The case studies presented in this chapter also support these efforts to conceptualize and discuss existing theories. They underline a rarely documented phenomenon and outline a concept able to lead to a theoretical development and potentially renew existing theories, at least to a small extent. Such case studies contribute to incremental rather than disruptive theoretical development.

Prior to any conceptual development, case studies first and above all produce accounts. Their narration forms the empirical basis for an analysis taking into account the temporality and complexity of the phenomena studied. As long as they are not overly stylized and, above all, not fashioned by a theoretical framework that would limit their analysis, these accounts provide information making the discussion of existing theories and models possible and paving the way for new concepts. Thus, the account of the second case described in this chapter teaches us that during the innovation process the interesting results produced are sometimes collateral effects. These were unplanned but take on value because they are used by the actors to generate new innovations and/or consolidate the initial project.

This question of case studies and their associated narratives concerns the entire field of STS (Science and Technology Studies), including suggested modelling of the dynamics at work (e.g. credibility cycles, mode 1 and mode 2, S&T regime theory or cycles in the promise economy). Although concepts are sometimes assimilated with theories – this is the case with the triple helix theory (Leydesdorff and Etzkowitz 1996) – theories about innovation seem to be somewhat lacking. On the one hand, ANT (Actor-Network Theory) presents more as a means

of describing innovation dynamics (with the help of methodological principles and conceptual tools) than an explanatory theory (Latour 2005). On the other hand, much research focuses on the production of knowledge and research government modes, scientific and technical discoveries, and the role of users in conception, without even mentioning innovation, whereas this research really concerns techno-scientific transformation dynamics. It exploits existing theoretical developments – such as the absence of a break between science and society or the refusal of technological determinism (Oudshoorn and Pinch 2003) –but does not claim to be theoretical. As the Durkheimian sociologist François Simiand puts it, these researchers expose themselves to critics accusing them of accumulating facts without theory.

Finally, we suggest it would be better to talk about contributing to the theoretical development rather than to the theory of innovation. Firstly, this corresponds to the idea of "middle-range theory" (Merton 1949), in other words the priority given to conceptual, intermediary and situated production, which fits in with the study of innovation processes. Secondly, producing concepts implies contributing to the theoretical effort on innovation not by submitting a new theory but, more marginally, by discussing and extending existing developments. It is a question of being part of a cumulative framework not of starting from scratch and seeking originality at all costs. Thirdly, this paper reminds us (beyond the concept of collaterality itself) that extract from case studies strange or new facts help to conceptualize and then contributes to theoretical discussions.

Bibliography

Akrich, Madeleine, Michel Callon, Bruno Latour and Adrian Monaghan (2002), 'The key success in innovation. Part 1: The Art of Interessment', *International Journal of Innovation Management*, 6 (2), 187-206.

Becker, Howard S. (1982), *Art worlds*, Berkeley: University of California Press.

Boudon, Raymond (1982), *The unintended consequences of social action*, London: Mac Millan Press,

Callon, Michel (1998), 'An essay on Framing and Overflowing: Economic Externalities Revisited by Sociology', in Michel Callon (ed.), *The Laws of The Markets*, Oxford: Blackwell, pp. 244-69.

Callon, Michel (1986), 'Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay', in John Law(ed.), *Power, action and belief: a new sociology of knowledge?,* London: Routledge, pp. 196-223.

Chesbrough, Henry (2006), *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press.

Edgerton, David (2004), "'The linear model' did not exist: Reflections on the history and historiography of science and research in industry in the twentieth century", in Karl Grandin and Nina Wormbs (eds), *The Science–Industry Nexus: History, Policy, Implications*, New York: Watson.

El Maleh, Cédric and Dominique Vinck (2019), 'Innovation collatérale. Lorsque les sous-produits de l'invention préparent la demande en innovations dans le diagnostic et le

traitement du système pelvien', *Technologie et Innovation*, 4 (4), https://doi.org/10.21494/ISTE.OP.2019.0412.

Gaglio, Gérald (2018), *Du neuf avec des vieux ? télémédecine d'urgence et innovation en contexte gériatrique*, Toulouse : Presses Universitaires du Midi, collection « Socio-Logiques ».

Godin, B. (2015), *Innovation Contested: The Idea of Innovation Over the Centuries*, London: Routledge.

Godin, Benoit (2006), 'The linear model of innovation: The historical construction of an analytical framework', *Science Technology & Human Values*, 31 (6), 639–67.

Hamel, Jacques (1998), 'Défense et illustration de la méthode des études de cas en sociologie et en anthropologie. Quelques notes et rappels', *Cahiers internationaux de sociologie*, 104, 121-38.

Hammersley, Martyn, Roger Gomm and Peter Foster (2000), 'Case Study and Theory', in Roger Gomm, Martyn Hammersley and Peter Foster (eds), *Case Study Method. Key Isssues, Key Texts*, London: Sage Publications, pp. 234-58.

Knorr-Cetina, Karine (1997), 'Sociality with Objects: Social relations in Postsocial Knowledge Societies', *Theory, Culture & Society*, 14 (4), 1-30.

Latour, Bruno (2005), *Reassembling the social. An introduction to actor-network theory*, Oxford: Oxford University Press.

Leydesdorff, Loet and Henry Etzkowitz (1996), 'Emergence of a triple helix of university-industry-government relations', *Science and Public Policy*, XXIII, 279-86.

Merton, Robert K. (1936), 'The unanticipated consequences of purposive social action', *American Sociological Review*, 1 (6), 894-904.

Merton, Robert K. (1949), *Social theory and Social Structure*, New York: The Free Press.

Mills, Charles W. (1959), *The social imagination*, Oxford: Oxford University Press.

Outshoorn, Nelly and Trevor Pinch (2003), *How Users Matter: The Co-Construction of Users and Technologies*, Cambridge MA: MIT Press.

Ryan, Brycw and Neal Gross (1943), 'The diffusion of hybrid seed corn in two Iowa communities', *Rural Sociology*, 8 (1), 15-24.

Rogers, Everett (1962) (1st edition), *Diffusion of Innovations*, New York: Free Press.

Shah, Sheetle M., Abdul H. Sultan and Ranee Thakar (2006), 'The history and evolution of pessaries for pelvic organ prolapse', *IntUrogynecol J.*, 17 (2), 170-75. https://doi.org/10.1007/s00192-005-1313-6

Sveiby, Karl-Erik (2017), 'Unattended consequences of innovation', in Benoit Godin and Dominique Vinck (eds), *Critical Studies of Innovation: Alternative Approaches to the Pro-Innovation Bias*, Cheltenham, UK: Edward Elgar, pp. 137-55.

Winner, Langdon (1977), *Autonomous Technology: Technics-out-of-control as a Theme for Political Thought*, Cambridge: MIT Press.