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Testing, Contesting and Legitimizing Technology Diffusion in Regulated Environments

Stéphane Guérard and Ann Langley

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University of Zurich, Plattenstrasse 14, CH-8053 Zurich,
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Contact Details

Stéphane Guérard

University of Zurich

Department of Business Administration

Universitätstrasse 84, CH-8006 Zurich, Switzerland

stephane.guerard@uzh.ch

Tel.: +41 44 634 37 55

Fax.: +41 44 634 37 49

Ann Langley

HEC Montréal

3000, chemin de la Côte-Ste-Catherine

Montréal, H3T 2A7, Canada

Ann.langley@hec.ca

Tel: 514-340-7748

Fax: 514-340-5635

TESTING, CONTESTING AND LEGITIMIZING TECHNOLOGY DIFFUSION IN REGULATED ENVIRONMENTS[1]

ABSTRACT

Based on a longitudinal case study approach, this paper shows that the legitimation processes of technology diffusion in regulated environments is subjected to distinct power struggles manifested in different framing contests when several competing technological frames are crafted, are contradictory and attempt at capturing the same resources. We show that technology framing contests increase ambiguity which may in turn spark the need to rely on technology testing in order to bring a resolution of the debate, to lower ambiguity and to provide legitimacy to the purpose and benefits of a technology. Furthermore, we show that when framing contests over diffusion cannot be resolved through legitimated means, institution testing may come into play. This is likely to occur when the cultural-cognitive legitimacy of a technology has acquired sufficient force to trump regulatory legitimacy.

KEYWORDS

Institutional testing, framing contest, legitimacy, technology, Boltanski and Thévenot.

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INTRODUCTION

We know that technologies can attain a taken-for-granted status (Suchman, 1995) and be accepted uncritically (Leblebici, Salancik, Copay, & King, 1991), but how does their diffusion become legitimate within particular organizational fields, particularly those that are highly regulated? As many authors have indicated, technology adoption and substitution is not simply a market process in which autonomous buyers evaluate alternate offerings and select those they prefer, but also an institutionally embedded process in which legitimacy plays a key role, and where multiple values or logics intersect. For example, Maguire (2004) shows how the penetration and substitution of the insecticide DDT was shaped by four different kinds of discourses: a commercial discourse surrounding a product as an efficient solution to a problem, a scientific discourse oriented around knowledge about the product and its effects, a public opinion discourse concerning how the product should be judged, and a policy discourse around the rules and regulations that should apply to it. As these various discourses evolved, the legitimacy of the product shifted dramatically along with patterns of diffusion. Similarly, in their history of the construction of value in the biotechnology sector, Kaplan and Murray (2010) note how industry participants had to simultaneously embed their new firms in different domains of value ranging from technical concerns (will the technology work?), appropriability concerns (legal rights of ownership), market concerns (will people buy the technology?) and ethical concerns (e.g., about safety).

In this paper, we consider the processes by which the diffusion of a new technology, the PET scanner, was legitimated as it developed within one institutional field of consumption: the Quebec health care system. An institutional field of consumption is a community of organizations sharing a common meaning system and consuming or intending to consume similar goods and services. In contrast to much of the literature on the interaction between institutions and technology that focuses on *producers* of technology (Hargadon & Douglas,

2001; Munir & Phillips, 2005), we focus principally on the dynamics between *users* and *institutional* actors (Kaplan & Tripsas, 2008). We trace the pattern of diffusion of a technology that was initially seen as experimental, but that acquired over time increasing legitimacy to become widely diffused despite its high cost and despite governmental efforts to control it. Although a large body of research has examined patterns of technology diffusion in general (Greenhalgh, Robert, Bate, Macfarlane, & Kyriakidou, 2005; Rogers, 2003; Valente & Rogers, 1995), little work has focused on the processes by which diffusion comes to be legitimated in a regulated field.

Studying how users get involved in legitimating technology diffusion is important for several reasons. First, the legitimacy of technology diffusion is often an important issue when it comes to technology bearing high risks or costs for society. For example, the distribution and locations of nuclear plants in Germany (Flegel, 2010) or charcoal-based electricity plants in China is often prone to negotiation between potential users, producers and authorities. Another example comes from the diesel filter for diesel cars in Germany where users were asking for diesel cars having a certain size to be equipped with a filter (Guérard, Gustafsson, & Bode, 2011). Because the diffusion of these technologies are likely to entail significant risks and costs for the society, they are often regulated by authorities and promoters of these technology have to legitimize the way these technologies should be used and be diffused. Second, the literature has a clear tendency to look at the legitimacy of the technology itself (Deephouse & Suchman, 2008) and has neglected to investigate how diffusion can also be prone to legitimacy processes. Instead of understanding diffusion as a proxy for legitimacy, we concur with Colyvas and Jonsson (2011) on the need to see diffusion and legitimacy as two distinct concepts where diffusion patterns need to be legitimated.

The study of diffusion in *regulated contexts* also has some interesting specificities. Regulated contexts place would-be adopters in the position of needing to *justify* technology diffusion to

a key audience (the regulator). This suggests an emphasis on discursive processes, and leads us to consider the relevance of a "framing" perspective (Benford & Snow, 2000; Dowell, Swaminathan, & Wade, 2002; Kaplan, 2008) in which actors articulate and promote their conceptions of technology in terms of its purpose, the benefits it may or may not deliver, and how it should or should not be used. Although the idea of the "technology frame" developed by Orlikowski and Gash (1994) was originally presented as a purely socio-cognitive concept (see also Garud & Rappa, 1994) drawing on the idea that different groups would develop different meanings for technology based on their histories and contexts, in the social movements literature (Benford & Snow, 2000; Snow, Rochford, Worden, & Benford, 1986), the notion of "frame" has a more strategic and political connotation. In a study of technology framing within strategy making in a single firm, Kaplan (2008) bridges socio-cognitive and political conceptions by viewing frames as both cognitively embedded, but also to some degree, consciously manipulated. She shows both how individuals attempt to bolster the legitimacy of their own frames and undermine those of others (in "framing contests"), and also how they are willing to adjust frames to achieve resonance with others ("frame alignment") in order to establish a dominant frame that enables them to pursue their interests. A framing perspective thus seems very relevant to the issues examined here.

Although researchers have investigated the conditions under which institutional entrepreneurs legitimate technology (Hargadon & Douglas, 2001; Munir & Phillips, 2005) and how organizations develop and manipulate technological frames (Kaplan, 2008; Kaplan & Tripsas, 2008; Orlikowski & Gash, 1994), the question of how the legitimacy of technology diffusion emerges in relation to patterns of framing has not been empirically explored. This paper contributes to an understanding of how the diffusion of technology is legitimated by combining insights from framing perspectives with notions from conventionalist and institutional theories. In particular, we show how attempts to promote diffusion of the

technology lead to power struggles which manifest in "framing contests" (Kaplan, 2008), which give rise to ambiguity that tends to slow diffusion. We show how this also stimulates the use of evaluation routines (Garud & Rappa, 1994) or "tests" (Boltanski & Thévenot, 2006; Constant, 1987) that ultimately lead to reductions in ambiguity and offer a route towards legitimation. In our study, we find that "tests" may be of two different kinds: associated with the technology itself, what we call *technology testing*, or with the rules that govern its diffusion, what we call *institutional testing*. Also, this study connects constructs that are not explicitly linked in the literature, in particular framing contests (Benford & Snow, 2000; Kaplan, 2008), testing (Boltanski & Thévenot, 2006; Kaplan & Murray, 2010) and legitimacy (Suchman, 1995).

We begin the paper by reviewing the framing, the institutional and the conventionalist perspectives on legitimacy in technology diffusion, identifying the key theoretical elements that will be mobilized within our study, before presenting the empirical context and methods. We then describe the findings and consider how they contribute to better understanding the process of legitimation of technology diffusion in general within regulated contexts.

THEORETICAL BACKGROUND

The Framing Perspective

As originally defined, frames are *schemata of interpretation* (Goffman, 1974) or socio-cognitive structures that orient people in the way they make sense of the world, events, organizations or artifacts. Frames are powerful guiding structures that influence people's behavior (Berger & Luckman, 1967; Kahneman & Tversky, 2000) and are shared by members of a field through the development of common beliefs, knowledge, meaning and norms (Porac, Ventresca, & Mishina, 2005). To our knowledge, Orlikowski and Gash (1994) were the first to apply this concept to the interpretation of technology. They define a *technological frame* as "the core set of assumptions, expectations, and knowledge of technology collectively

held by a group or community" (p. 199). By studying the adoption of Notes technology in one organization, they found that due to differences in their assumptions and expectations, knowledge users and technologists developed different technological frames to interpret technology.

This socio-cognitive conception was complemented by authors adopting a social movements perspective who take a more political stance on framing as they define it as the strategic and political attempt to change influence cognitive structures (McAdam, McCarthy, & Zald, 1996; Snow et al., 1986). When several actors act strategically and politically in order to elaborate and push for technological frames that are aligned with their interests (Barley & Tolbert, 1997; Hargrave & Van de Ven, 2006; Pinch & Bijker, 1987), this may give rise to framing contests i.e. a battle over the meaning of an artefact. While most authors adopted either a socio-cognitive or a political perspective on frames, Kaplan (2008) bridges both approaches by conceptualizing technological frames as both institutionally embedded, but also as strategically and intentionally manipulated. She shows how people attempt to undermine the frames of others while promoting their own frames and how frame alignment increases resonance with recipients of technological frames.

Most previous studies have looked at the technological frames and framing contests elaborated by technology *producers* and have documented how these processes may lead to dominance (Kaplan & Tripsas, 2008) or development of a standard (Garud, Jain, & Kumaraswamy, 2002) in a given technological field. In contrast, our study focuses on technology *users* in a regulated environment. A perspective on how potential users strategically elaborate technological frames and engage in framing contests in order to influence the legitimacy of technology diffusion still needs to be explored. One key process that we suggest is implicated in achieving legitimacy in technology diffusion is "testing", a notion grounded in the conventionalist literature.

Borrowing from the Conventionalist and the Institutional Perspectives

Conventionalist theory (Boltanski & Thévenot, 2006) has an interest in understanding how disputes or framing contests can be resolved through testing. For Boltanski and Thévenot (2006), technological artifacts and people are ordered on a scale of value, called *state of worth*. People or artifacts which are more aligned or resonate more with the higher common principle would be considered as being more worthy. However, the state of worth can be questioned or challenged when an injustice or disharmony arises and engenders a dispute. In this situation, a test can be performed to establish or not the legitimacy or state or worth of a technology or an individual as it can provide a proof. The performance of technological artifacts or people undergoing the test is likely to re-order their state of worth. Should they fail the test, their state of worth would be re-ordered to a lower position, while a success would either maintain or enhance their position.

Such a test must be consistent with the higher common principle, closely related to what institutionalists label institutional logics (Thornton & Ocasio, 2008), and be perceived as a relevant proof of the materialization of this principle. Therefore, "a test of worth cannot be reduced to a theoretical debate. It engages persons, in their bodily existence, in a world of things that serve as evidence, and in the absence of which the dispute does not have the material means for resolution" (Boltanski & Thévenot, 2006: 131).

Some authors have suggested that testing is important (Garud & Rappa, 1994; Kaplan & Murray, 2010) in legitimizing technology. Because the benefits and risks associated with an emerging technology are unknown, actors draw on evaluation routines to define what the technology is (Constant, 1987; Garud & Rappa, 1994). Garud and Rappa (1994) are among the few scholars who explicitly attempt to understand how evaluation routines developed by researchers may provide legitimacy if the technology performs according to their expectations and beliefs. This concept is close to the notion of test as the technology is assessed according

to a shared point of reference and which materializes in measurement tools to assess the performance of an artefact. In the same vein, Kaplan and Murray (2010) found that to influence the evolution of the field of biotechnology, entrepreneurs developed evidence and developed tests that fit their evidence. While the work of Constant (1987) and Garud and Rappa (1994) explicitly relate testing to the measurement of the performance of an artefact, the work of Boltanski and Thévenot (2006) extends the notion of testing to other intangible objects such as norms, culture or social order. All these authors consider that testing is a key social phenomenon which legitimizes or delegitimizes the position of technological artefacts or actors in a given field, depending on their performance during a test.

Finally, we borrow the concept of legitimacy from the institutional perspective. Building on Suchman's (1995: 574) classical definition of legitimacy, the legitimacy of technology diffusion can be defined as the "generalized perception or assumption" that the way a technology intends to be or is actually diffused is "desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions". Legitimacy can take different forms. Based on his three classical institutional pillars, Scott (2008) proposes three types. Regulative legitimacy is conferred to actors who comply with the law or who shape the law to make them appear in conformance with it. Normative or moral legitimacy is related to the conformity to professional norms or standards, and cultural-cognitive legitimacy refers to entities that attain a taken-for-granted status and are uncritically accepted. As long as there is an alignment between an entity and one of these types of legitimacy, an entity may be deemed legitimate. Typologies of legitimacy have been mobilized in several studies and have mainly addressed the strategies organizations use in order to gain legitimacy (Deephouse & Suchman, 2008; Suchman, 1995; Vaara, Kleymann, & Seristö, 2004), to understand the motivations of organizations to adopt innovations (Kennedy & Fiss, 2009; Tolbert & Zucker, 1983) or to justify new organizational or industrial arrangements (Erkama & Vaara, 2010;

Vaara et al., 2004; Vaara, Tienari, & Laurila, 2006). However, there is a fairly limited number of studies mobilizing the neo-institutional lens which explicitly looked at how organizations struggle to legitimize artifacts or technology (Aldrich, 1999), and even less on legitimizing technology diffusion.

Overall, the studies from these perspectives highlight different dimensions of the legitimation of technology. The framing perspective insists on the socio-cognitive and political aspects of meaning creation related to technology, the conventionalist perspective is sensitive to the question of testing to put an end to disagreements or disputes in social life and the institutional perspective has extensively conceptualized legitimacy. We show in this paper how a combination of these perspectives can help illuminate the process of legitimation of technology diffusion.

RESEARCH CONTEXT AND METHODOLOGY

Research Context

The PET scanner is a particularly interesting technology to study technology framing activity and framing contests because it is complex, expensive, and was initially at least, quite controversial, as the purpose of the technology was not clear. However, the high quality of the images which the scanner could produce created excitement in the medical community while engaging health care regulators in efforts to limit its diffusion in health care systems due to its high costs (acquisition costs of 2 million USD and annual running costs of 1.5 million USD). Nowadays, the PET scanner is a complex imaging technology for diagnosing cancer, cardiac and neurological diseases. Currently, experts claim that about one PET scanner per million of population is sufficient for clinical and research purposes (Cleemput, Camberlin, Van den Bruel, & Ramaekers, 2008).

Highly regulated environments are particularly interesting to study the legitimation processes of technology diffusion because users must legitimate to their audience, in this case the

regulator, where and why the technology should be diffused. Thus, this case was valuable to study because it was likely to unravel processes which could be difficult to observe in other contexts. The highly regulated institutional field which we selected for studying the diffusion of the PET scanner is the Quebec[2] health care system which is publicly run and highly centralized. This field constitutes a field of consumption because the case is characterized with hospitals and private clinics which attempt to convince the Government of providing funding for the diffusion of the PET scanner and of influencing the way the PET scanner should be diffused. The Ministry of Health funds the system from tax revenues and negotiates global budgets with hospitals. It is particularly regulated when it comes to expensive technologies such as the PET scanner as the Ministry of Health must authorize hospitals to acquire the technology. A Health Technology Assessment Agency makes recommendations concerning which technologies should be reimbursed by the State.

The diffusion of the PET scanner in this institutional field of consumption occurred in three regions labeled A, B and C. It involved four independent teaching hospitals[3] (TH) that we named THA1, THA2, THB, and THC; two of them are part of the same region. Other hospitals like the general hospital GHC of region C were involved in the legitimation process of the diffusion of the PET scanner. Overall, 11 scanners were adopted before 2008.

Data Collection and Data Analysis

The research involved a retrospective case study design with embedded units of analysis (Yin, 2003), where the legitimation process prior to and during adoption of the first PET scanners

[2] One of the biggest provinces of Canada.

[3] At the time of the study, the teaching hospitals were not part of a network like it is now the case.

was studied. A case study research approach is suitable for at least two reasons. Firstly, it allows for theory elaboration (Lee, Mitchell, & Sablynski, 1999) by showing how existing unconnected variables in the literature are related in certain situations which the case study describes. Second, the case study approach enables us to capture in detail how processes unfold over time (Langley, 1999).

Data on the legitimation process of technology diffusion were collected from two sources: interviews and documents. First, organizations having adopted the PET scanner during the study and those who engaged in battles to obtain it (sometimes unsuccessfully) were interviewed. Overall, 42 semi-structured interviews were carried out at all levels: national, regional and at sites which intended to obtain a PET scanner. Of these interviews, 33 lasted between 40 to 110 minutes, and 9 between 20 to 40 minutes. Respondents were selected according to their centrality in the process. To perform these interviews an interview guide was crafted to capture the characteristics of the diffusion of the PET scanner in this institutional field. Interviews began by asking the respondents to tell the story of the adoption process of the PET scanner in which they were involved. They were then asked to explain what the technology meant to them, what were the arguments in favor and against the technology, and what legitimation strategies were mobilized by all actors involved in the diffusion and adoption of this technology across the province of Quebec.

Second, internal and external documents were collected and analyzed to establish process chronologies, to examine written technological frames, to identify major field frames inherent to the system, and for triangulation purposes with other sources of data (Eisenhardt, 1989; Miles & Huberman, 1994; Patton, 2002). Overall, 87 documents including extensive reports produced by hospitals and the government as well as press released were collected for analysis.

To break down the complexity of the data into manageable pieces and to allow meanings and specific mechanisms to emerge (Langley, 1999), we elaborated a detailed narrative through iterations between data collection and data analysis (Eisenhardt, 1989). The narrative was reviewed by two informants to check validity. These narratives showed that there were intense struggles over the meaning of the technology and its diffusion.

We then examined in more detail the discourses actors put forward to describe and justify the value of the technology and the way in which it should be adopted, in other words, their framing of it. These discourses could be grouped into three main dimensions which are: 1) the *purpose* of the technology i.e. *what* is the technology for; 2) the *benefits* of the technology *i.e. why* adopt the technology; and 3) *how* the technology should be diffused at the regional, national levels and local levels, i.e. how it should be diffused and who should adopt it. Table 1 shows how we coded our material according to these dimensions.

The coded dimensions correspond closely to the dimensions of *technological frames* documented by Gash and Orlikowski (1994) as well as to other authors' representations of framing discourse (Benford & Snow, 2000; Creed, Scully, & Austin, 2002; Kaplan, 2008; Markowitz, 2007; McAdam et al., 1996). We evaluated the reliability of our coding by asking a trained research assistant to recode a sample of 27 relevant segments (14% of our sample), into the major themes technological frames. We obtained inter-rater agreements of 87%. The main arguments used by each party involved in the struggles over the diffusion of the PET scanner in the Quebec health care system are displayed in the text by using matrix displays (Miles & Huberman, 1994). The use of matrix displays facilitated a comparative analysis between sites.

TABLE 1:
DIMENSIONS OF TECHNOLOGICAL FRAMES (195 SEGMENTS)

***What is the purpose of the technology*? (39 data segments)**
Frames about the purpose of the technology focused around two elements:

a) *Clinical tool*: uses of technology for oncology, cardiology or neurology.
b) *Research or clinical tool*: whether the technology is a research tool or a clinical tool

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***Why* was this technology adopted i.e. what are the benefits/risks? (40 data segments)**
Frames supporting the adoption took many different forms, classified into 4 categories:

a) *Effectiveness*: discussion of the superiority of the technology for health outcomes.
b) *Epidemiological need*: discussion of numbers of patients needing the technology
c) *Good value for money*: positive arguments about efficiency and cost-benefit ratio
d) *Standard technology*: statements that the necessity of the technology is now taken for granted

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***How to* diffuse the technology or *who* should adopt the technology? (116 data segments)**
Technological Frames around the diffusion of the technology contained two conflicting perspectives supported by a rationale of quality and a rational of access.

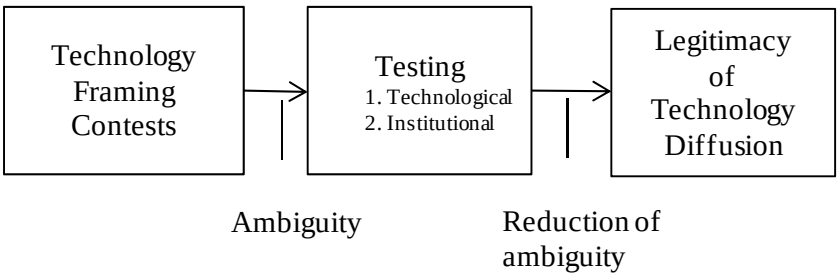
a) *Concentration:* arguments for restricting the diffusion of the technology to fewer centers to (i) enable use of most advanced technology; (ii) ensure adequate expertise in key centers; or (iii) to restrict diffusion and use (and cost). The first two rationales are associated with a frame of quality and the second to a frame of efficiency.
b) *Dispersion:* arguments for widening the diffusion of the technology to more centers to ensure availability in the regions for people all around Quebec to have access.
c) *Equity of access:* The technology should be adopted here to ensure fair geographic proximity and access for professionals.
d) *Good value for money:* The technology should be adopted here because it will be cheapest this way, we can make better use of it, low investment is required, etc. This corresponds to a frame of efficiency.
e) Local epidemiological need: The technology should be adopted here because of the needs of the local population. This is related to a frame of access.
f) Mission aligned with the technology: The technology should be adopted here because we have the appropriate expertise, capacity, infrastructure, network, and mission alignment (associated with a variety of frames depending on the purpose and benefits of the technology).

FINDINGS

This section describes the theoretical model that emerged from our data and that is displayed in Figure 1. As will be described in the following, our findings suggest that testing is a key concept explaining how framing contests may be resolved and how they may lead to the

legitimacy of technology diffusion. We now present the case narrative and analysis building up to the model.

FIGURE 1:
LEGITIMACY OF THE TECHNOLOGY DIFFUSION: A THEORETICAL MODEL



The Case Study

The case study is constituted of two phases. In the first phase, we see technology framing contests that essentially raise questions about the value of the technology itself – leading to the first form of testing i.e. technology testing. In the second phase, technology framing contests are more related to the way the technology should be diffused. This leads to a second form a testing i.e. institution testing.

Phase 1: Technology Framing Contests over the Purpose and the Benefits of the Technology

Region B. The adoption of the first PET scanner that would eventually perform clinical applications occurred at teaching hospital THB and resulted from the entrepreneurship of a nuclear doctor who relentlessly fought to persuade the Quebec Ministry of Health to invest in the creation of a research center, which would include a PET scanner and a cyclotron for research applications in oncology. While in 1995 the main purpose of the PET scanner was still to perform research, the first clinical application of PET scanner procedures were financed through research funds and through a special budget supplied by the teaching hospital in 1998. The first use of the PET scanner in a clinical setting aroused consternation among nuclear doctors around the province, especially from those practicing in major teaching hospitals in the bigger regions A and C, and it prompted those hospitals to press for a

PET scanner for themselves. No one actually understood why a PET scanner was installed in a relatively small and remote area. Irrationality and political games were invoked to explain this unexpected situation. In addition to this, the decision of the US Centers for Medicare and Medicaid Services to authorize the reimbursement of the PET scanner for lung cancer as well as the wide and fast diffusion of this technology in USA contributed to build up pressure on the Ministry of Health to diffuse this technology on a wider scale. In July 2001, the remote teaching hospital THB surprisingly acquired a second PET scanner, officially for research purposes. Meanwhile, although hospitals in the region A were surprised, most of them were caught in political tensions due to the merger of teaching hospitals. Hence, many technology initiatives were dropped temporarily in favour of other important issues related to these mergers.

Region C. While the acquisition of the PET scanner by the teaching hospital THB encountered no competition or resistance, either locally or nationally, competition in region C between the general hospital GHC, a specialized hospital in cardiology and in lung cancer, and THC, the most important teaching hospital in the area, seriously impeded any attempt at adoption. As early as 1988, both hospitals were already striving to persuade the Ministry of Health to acquire a PET scanner for clinical purposes as well as for research, but the technology was not sufficiently mature from a clinical point of view to convince the authority and for hospitals to continue struggling for this cause.

In 1995, cumulating scientific evidence for the use of the PET scanner in lung cancer revived the interest of both hospitals in obtaining this technology, and in 1997-1998 each hospital submitted a report to the Health Services Regional Agency. In 2001, both hospitals sent an up-dated version of these reports to the same agency:

> *"Medical literature reported awesome clinical results when using PET scans for, among others, lung cancer. This was the first kind of cancer where their efficacy was documented. (…) This produced a renewed interest for PET scans around 1994-1995. It*

became known, in oncology circles, that using the procedure could yield significant information on lung cancer diagnosis. This led us to produce a brand new report on this topic in 1997."

These reports developed different technological frames on the purpose of the technology and on its benefits. In addition, they explained how the technology should be locally implemented. However, the meanings they attempted to impose on the technology were different. In this case, both hospitals were in competition and developed technological frames in such a way that their own sites would be perceived by the authorities to be most appropriate for a PET scanner.

Specifically, because of its dual mission in cardiology and in lung cancer, hospital GHC declared itself to be the best centre to receive a PET scanner. It contended that its supra-regional mission combined with the fact that it performed the highest number of cardiac surgical operations justified obtaining a PET scanner. Since the evidence on the potential in the case of lung cancer was indisputable, hospital GHC also emphasized the fact that they were performing the highest number of surgeries in pulmonary cancer. On the other hand, teaching hospital THC argued that oncology was the main application of PET scanner. Given that more than half of the clinical activities in oncology in the region C were performed at THC, it argued that it should be the first centre to adopt a PET scanner. Also, since the cyclotron was essential to the production of radiopharmaceuticals, its location also became an issue.

Because the half-life of the radiopharmaceutical used in cardiology is approximately 2 minutes, hospital GHC argued that the cyclotron should be close to their building. Emphasizing its mission in research and in evaluating new technology, THC argued that the cyclotron should be in their organization. These self-interested arguments and destructive battles did not accelerate the diffusion of the technology given that the government was trapped, not knowing who should obtain the technology. Moreover, important financial

constraints such as a high deficit did not allow the government to provide both hospitals with this technology:

> *"Confronted with this tug-of-war, how did the Managers of the Health Services Regional Agency react? They took no decisions. They did nothing. They did not know what to do. And don't forget that, for them, cost is the most important consideration. They did not mind investing nothing, especially in a context where hospitals are still in deficit."*

Hence, confronted with these struggles, the Ministry of Health had no choice but to avoid announcing an investment that might turn out to be in its disfavour: "Even in 'C' region, there were debates between THC and the GHC. They told us: 'Settle your own problems. The minister won't get the news out, only to be fired upon by one of the two hospitals.'" Table 2 summarizes the technological frames mobilized by actors at this point.

Given that the regulator is the only actor who can actually authorize and provide the funding for such an expensive acquisition, it was really reluctant to allow one of these hospitals to obtain the PET scanner. Two reasons motivated the regulator not to move forward. First, facing divergent and self-interested technological frames about the purpose and the benefits of the PET scanner which were based on different bodies of the scientific literature, the regulator did not know how to handle this ambiguity: *"Faced with these battles, what do the government administrators do? They don't make a decision. They don't really know."* Second, the extraordinary cost of the PET scanner was a powerful impediment to the legitimacy of this technology.

TABLE 2:
TECHNOLOGICAL FRAMES DEVELOPED BY HOSPITAL THC AND GHC IN QUEBEC

Technological Frames	Hospital THC	Hospital GHC
Purposes	**PET as a research tool** **PET as a clinical tool for oncology** "Clinical indications for the PET technology are by order of importance, oncology (over 18 pathologies for which indications are recognized), neurology (2 indications), and cardiology (1 indication)." [This argument is supported in the report by one article containing a systematic review of evidence supporting PET for oncology.] "The PET scanner is a functional imaging modality with a huge potential, as it has generated a voluminous literature. It has three main applications which are: oncology, for the majority of recognized applications; and neurology and cardiology which have fewer applications. In oncology, the PET scanner is effective for the diagnostic, the staging, the assessment of treatment effectiveness and the re-staging; it's a crucial modality for frequent and deadly diseases."	**PET as a clinical tool for cardiology and lung cancer** "The two areas where clinical use and potential are best developed and recognized are precisely for heart disease and lung cancer." [This argument is supported in the report by reference to 51 studies, 42 of which provide evidence for cardiac applications]. "Lung cancer is the most important and the best documented indication for the PET scanner in oncology. The lung cancer constitutes by itself at least 50% of the total number of PET scanners in oncology."
Benefits	**PET has several clinical advantages** "Early evaluation of the effectiveness of anticancer therapeutic interventions" "The PET scanner can significantly reduce useless surgeries and services." "In oncology, the PET has a major role to play as it allows to better orient the chemotherapy; what no other conventional imaging modality [CT scans or MRI] can do." "A routine assess using PET scans may avoid around 20,000 non-indicated laparotomies and 4,400 resections on patients with a weak prognostic."	**PET scanner is effective** "Several studies confirmed the high diagnostic performance of the PET scanner for the detection of heart disease." "The PET scanner has emerged as an important diagnostic tool in the treatment of lung cancer." "The PET scanner is a powerful diagnostic instrument in cardiology and has an important potential for clinical and research applications. Despite its high costs, which is in part due to the necessity to have a cyclotron on the spot to produce short life isotopes, the great diagnostic precision of this technique and the exclusive character of the diagnostic information collected can make the technique cost-effective for some applications such as the identification of the myocardial viability and the early identification of coronary disease." "The main objective of a new technology in the diagnostic of a lung nodule mainly consists in reducing the number of invasive interventions (biopsy, thoracotomies) for benign lesions. The current evidence suggest that the PET scanner is a sensitive exam to detect malignant lesions."

Who should adopt in the region?	**Those whose missions and activities are aligned with the technology** “The assessment of technologies is part of the mission of a teaching hospital [like ours], that’s why new technologies, no matter which one, must be implemented there in priority. Teaching hospitals only, and in particular ours, have such a wide variety of medical and professional expertises to appropriately assess a new technology such as the PET scanner. "The strong points of the hospital were that it was a large hospital treating more than half of the clinical activity in oncology in the region." "THC wanted the machine because they are a centre for excellence and technology evaluation. They wanted to do research with that." **Those with appropriate competence to run a cyclotron** “The THC hospital offers a special and functional environment to install a regional unit of the production and detection of positrons: the circular accelerator (cyclotron) would work under the supervision of the most important team in biophysics in hospital settings in Quebec. This team has a unique expertise on linear accelerators with a direct application on patients and an expertise to work with the cyclotron.” "At THC, there was already a physician team. We had hired two nuclear doctors who were trained or in training with fellowships of a least a year." "We already had a solid physician team to make the cyclotron work, and to take care of it."	**Those whose missions and activities are aligned with the technology** "GHC is a designated university institute in cardiology and pneumology where the highest number of heart surgeries are undertaken each year." “The GHC hospital, designated university institute of cardiology and pneumology, is the centre with the highest number of major cardiac surgeries per year in Quebec; and with the clinical expansion foreseen from January 2002, it will become the biggest centre in Canada. The GHC hospital is also the site where the highest number of surgery of the lung cancer in Canada. The clinical importance of this double mission in cardiology and in pneumology is naturally extended in terms of research and teaching activities and, as a results, make the GHC hospital a unique site in Quebec and in Canada” "We have the largest group of pneumology specialists in Canada." **Those who need the cyclotron close to their installation** "Our argument at GHC was that we needed the cyclotron in cardiology given the short half-lives of radiopharmaceuticals in this speciality" "By having it on our site, it could still be used by Hospital THC who work more in oncology"

Analysis. Somewhat paradoxically, these technological frames on the purpose and benefits of the technology which were both based on science and on the authorization to be reimbursed in USA did not contribute to helping the PET scanner gain legitimacy for all actors involved in the debate. At this point, cardiologists considered that the PET scanner was a legitimate technology to be used in cardiology and oncologists deemed the technology to be legitimated to treat cancer, but there was no consensus within the medical community in Quebec. The regulator who was more sensitive to cost-effectiveness issues did not perceive the PET scanner as a legitimate tool either given ambiguity which was raised from the struggles over meaning between both hospitals. In other words, competition expressed via struggles over meaning – the only legitimate means of acquiring the technology in the Quebec health care system – placed the regulator in a quandary and initially at least inhibited the legitimate diffusion of the PET scanner.

Technology Testing

Altogether, quarrels in region C, the first clinical use of the technology in the province of Quebec, the authorization to reimburse the PET scanner procedure by the Centers for Medicare and Medicaid Services in USA, and the emerging evidence in the scientific literature praising the clinical benefits of the PET scanner stimulated both the president of a Quebec Association of Nuclear Medicine and a Patients' Association for Cancer to ask the Ministry of Health to produce a report on the cost-effectiveness of this technology. This request was addressed to the Health Technology Assessment Agency in September 2000.

While the legitimization of the PET scanner as a clinical tool in this organizational field was strongly enhanced with its first clinical use and with the authorization for reimbursement by the Centers for Medicare and Medicaid Services in the USA, the publication of the Health Technology Assessment Agency (HTAA) report in October 2001 confirmed the evidence-

based legitimacy of the PET scanner in this organizational field as an indispensable diagnostic tool for specific conditions.

The clinical conclusions of this report were unequivocal and claimed that at least 15,000 examinations were required annually. Although the report does not proclaim any dominant application (cardiology, oncology, neurology), it definitively supports its legitimacy, a legitimacy which is related to the efficiency and effectiveness of the technology as a diagnostic tool. Indeed, from that moment, the legitimacy (derived from evidence) of this technology was associated with an intensification of hospitals asking to have a PET scanner, especially in the region A: "After the HTAA report, the first impact and the most visible one is that we received rapidly many applications [to acquire the PET scanner] from many [hospitals] that were all referring to this report."

Besides legitimating the technology in this institutional field of consumption, the HTAA report suggested how the PET scanner should be disseminated in the province of Quebec. The following quotations from interviews support our contention that from then on the technology was perceived as legitimate from a clinical point of view. Indeed, all the respondents point to a technological frame around the benefits of the technology that would eventually lead to it being taken for granted as an essential medical tool:

> *"It's like asking whether you need an operating room in a hospital. (…) It's an indispensable and necessary tool."*
>
> - Nuclear doctor

> *"It's inevitable; it's a question of the quality of medicine. Some will even say that it is bad medical practice not to use it in diagnosis."*
>
> - President of a Medical Association

> *"After the Health Technology Assessment Agency report, the first and most visible impact is that we rapidly received many requests from the hospitals that were all referring to this report."*
>
> - Biomedical engineer

Analysis. The framing of technology in region C could not resolve issues surrounding the legitimacy of the technology alone as two groups of medical professionals were contradicting each other. The only way to build the legitimacy of the purpose and benefits of the technology was to rely on an independent organization, the Health Technology Assessment Agency, which would conduct an evaluation of the technology. Because this organization has the reputation to be reliable and professional and is the only formal agency in the province having this mission, its evaluation provided legitimacy to the PET scanner at least in terms of its purpose and benefits. Indeed, the report did confirm that the technology was useful for several applications and that a certain number of exams were required every year. The assessment of the technology constitutes a form of testing (Boltanski and Thévenot, 2006) as the technology "passes through" a legitimate evaluation routine, in this case scientific evaluation, to judge the appropriateness of a technology. We refer to this evaluation routine as technology testing and will deepen the analysis in the discussion section.

Phase 2: Technology Framing Contest over the Diffusion of the Technology

However, content of the report suggested a new dimension of technology which was not clearly disputed before. Indeed, the report paved the way for further struggles over the meaning of the technology in terms of the principles on which the technology should be diffused in the health care system. This led to further framing contests and another round of testing but of a different form as we shall see.

While the report clearly established the legitimacy of the technology itself, the recommendations of the report suggesting that the PET scanner technology should be *"progressively deployed in collaboration with teaching hospitals and university institutes"* and *"through research activities"* raised several concerns among nuclear doctors. The recommendations were perceived by the Quebec Association of Nuclear Medicine as a signal that the PET scanner technology was going to be diffused to teaching hospitals only, given

their mission in research, and that the report was suggesting that more cyclotrons (an expensive machine mainly used in research) should be bought to produce FDG. This was perceived to be favouring research at the expense of clinical applications:

> *"[Some of] the Report's […] conclusions were appalling, because several actors in this report had private interests. […]. I said : 'We're trapped', because these two centers [THA1 and THA2] wanted major investments to become great training, teaching and research centers. But all we wanted was to develop a clinical tool […] to detect sickness and take the best possible clinical decisions for a patient to avoid removing half his face if he had tongue cancer."*

Reacting to this report, the Quebec Association of Nuclear Medicine created a *special committee* rallying nuclear doctors in remote hospitals in order to negotiate directly with the Government in power. By primarily defining the PET scanner as a clinical device and not a research tool, the aim of this special committee was to counteract the recommendations favouring teaching hospitals, and to democratize access to this high-end medical technology by proposing that 12 major centres in oncology should obtain a PET scanner, but at once and not progressively. This was technically possible since by the year 2002 the FDG was being supplied by American private companies so a nearby cyclotron was no longer necessary.

By December 2002, after intense negotiations and after teaching hospital THA2 announced its intention to buy a PET scanner with or without the consent of the government, the Ministry of Health agreed to invest $23 millions USD to buy 12 PET scanners and to diffuse them all over the province. This agreement brought a short period of truce up to the election of April 2003 which witnessed the change of the party in power and the nomination of a new director of hospitals at the Quebec Ministry of Health. This marked a radical shift in the informal agreement to diffuse the technology widely.

Moreover, from the beginning of 2003, the debate over how the technology should be diffused took a new turn with the availability of the relatively new and more effective architecture (Henderson & Clark, 1990) of the PET-CT scanner. Because the CT scanner

provides quasi instantaneous anatomical images while the PET scanner provides unrivalled functional images, the combination of both increased the precision of the diagnosis. With the emergence of this alternative, two types of architecture were available on the market: *PET-CT scanners* and *standalone PET scanners*.

Experts estimated that the clinical added-value of the PET-CT scanner over the standalone PET scanner was for approximately 15% of cases, mainly in the Oto-Rhino-Laryngology speciality. In addition, the PET-CT scanner allowed a hospital to perform 12 cases per day instead of 8 with a standalone PET scanner. This was due to the fact that the addition of the CT scanner reduced the time required to scan a patient. Besides allowing more patients to be diagnosed per day per machine, acquiring a PET-CT scanner would allow teaching hospitals to participate in international research protocols. Indeed, the PET-CT scanner was becoming a standard in research for OECD countries: “Even at the University UB, they were excluded from over 30 multi-centers protocols. As a result, they are becoming regional, and cannot longer have any impact in terms of research.”

The parallel development of this new architecture with the publication of the Health Technology Assessment Agency report combined with the election of the new government turned the dynamic surrounding the diffusion of the technology into a confrontation between two clans: the *Pro-stand-alone-PET* clan which favored the diffusion of 12 PET scanners against the *Pro-PET-CT* coalition which wanted the technology to diffuse progressively from teaching hospitals to other hospitals.

The following quotations illustrate in a revealing manner the heated debate which was taking place. The proponents of those who framed the PET scanner a clinical tool were in favour of diffusing the technology to make it accessible to the whole population were arguing that: "Better give everyone a good Chrysler than giving a Ferrari to 3 or 4 people, that's what we wanted at the Association."

The frames of the proponents arguing that the PET scanner should be further developed by research were emphasizing the important of the quality of the diagnostic produced by doctors. According to them, quality should be the primary principle along which the PET scanner should be allocated were using the following metaphor:

> *« They'll say, « I am a Cessna pilot, I can also pilot a 747." People will say that, but it makes no sense! (..) They'll say: "It's not complicated – I'll put it on automatic pilot." OK, but is that the function of a 747 pilot? So you'll place your life in the hands of someone who doesn't have the expertise necessary to make complex and major adjustments that a technology like that requires."*

Table 4 provides further examples of quotations framing the way the technology should be diffused in this health care system, and summarizes the technological frames mobilized by each clan in this struggle. To make sure that the PET scanner would be widely available, the Quebec Association of Nuclear Medicine invested in different lobbying actions to persuade the government of the necessity of diffusing the PET scanner to as many places as possible for people to have access to this technology.

TABLE 4:
FRAMING CONTESTS FOLLOWING THE HEALTH TECHNOLOGY ASSESSMENT REPORT IN QUEBEC

Technological Frames	Stand-alone PET	PET-CT
Purpose	**PET as a proven clinical tool needed by all regardless of location** “First, we said that this technology was mature… It was not a research tool. I did my internship at [name of the hospital] and there was not even 1% of the exam which were for research purposes. It was with real patients, with real cancers. So, number one, it is a device which is for clinical purposes. They should not come to bother us with their research projects to say that they are doing research. This is complete bullshit.” « The application of this tool is essentially in oncology – more than 90%. There is a little bit in cardiology and in neurology and a bit of research. But the main application is 90% in oncology. So, it a clinical tool which should be used for patients with cancer.”	**PET-CT as a high-performing proven clinical tool which needs to be further developed through research** "The study of [HTAA] confirms that the PET scanner is clinically useful for several applications in oncology, neurology and cardiology. In oncology, the PET scanner is known for some specific applications when it comes to lung cancer, colorectal cancer, melanoma, head cancer, neck cancer, and lymphoma. Depending on the cancer type, the PET scanner contributes to look for metastasis et therapeutic follow-up. In neurology, the PET scanner shows a good effectiveness for some applications such as epilepsy and cerebral tumors. In cardiology, the usefulness of the PET scanner is known for some applications like the myocardial perfusion and myocardial viability. Finally, the PET scanner has an interesting potential in other applications in these domains.
Benefits	**PET scan for all to avoid child from suffering** "Chemotherapy is hard as a treatment. That's why with the PET scanner, we can evaluate whether local radiotherapy or chemotherapy would be better and protect the child from suffering. [...] Just think if you have a 12 year-old child who needs radiotherapy and you have to send them to the big city. It's torture." **Lower travel costs with greater equity and access** "Oncology is permanent. You have your cancer, you come back, you are re-evaluated. There's a lot of travelling. So the PET will allow the regionalization of care, keeping resources, people, and avoiding excessive travel costs." “The Association favours the dedicated PET cameras that are twice as cheap [than PET-CT], but everyone would get one." “[With PET] we can save $15,000-$20,000 for people we operate on unnecessarily."	**Better quality diagnoses per case** "A PET scanner will locate the tumor… in the body but not in a specific way. It will say: it is there. But with the CT, we can take a tomographic image which will locate the tumor in the tissue so we can see exactly where it is." **Lower cost per examination with higher quality** "An ordinary PET scanner can do about six or seven patients per day. With the PET-CT, we can go up to 12 so we can double the volume and [lower the cost per examination]. " “So, typically, if you look today at a typical hospital they take may be 15-20 minutes to do the attenuation correction a piece [with a standalone PET scanner] versus 30 seconds [with a PET-CT]. […] [Moreover], The FDG cost per patient is significantly less." **Inevitability of PET-CT** "[In the conference] basically nobody was speaking of Stand-alone PET. Nobody. [...] I can’t think of a single institution that has actively gone to tender for Stand-alone PET."

Diffusion	**PET for all, coherence with prior distribution of oncology centres** "With the government, we proposed that the 15,000 exams that were necessary per year in oncology, that the 12 first pieces of equipment be installed in the regional centres for oncology " “We told ourselves: “what about if we tried to offer the techniques along axes of radio-oncology?” This has the advantage to be binary. Whether you are a center in radiotherapy or not. There is no need for further arguments and it eliminates lots of fights between centers which wanted it. This argument could terminate the debate. Moreover, it had the virtue to follow axes that the government had already taken in the past.”	**Competence has to be developed first before allowing adoption** “We buy a Formula 1. We want to have a driver, but we train him in 15 days, and we send him with the other F1 drivers, and he has no team around him, etc. You know what you need to have a F1? You need more than one mechanic. You need a formidable team. And then, you say that are going to buy 12 Formula 1 and that you will train for in 15 days. And you will tell me that you want to compete at the F1 level, well, you must be kidding!” “A progressive deployment is even more advisable considering that a PET center demands specialized material and human resources to function properly. At the present time, available human resources trained specifically for PET are insufficient in Quebec. They could not sustain this planned deployment. Training of specialized personnel should be a top priority.” (HTAA report)

Nonetheless, at that time, the PET-CT which was as twice expensive as the standalone PET scanner tended to be privileged by the government due to the international trend on the PET-CT over the standalone PET scanner. However, this tendency was not enough for the government to announce that a decision had been made. Indeed, the Ministry of Health needed to get the support of the Pro-stand-alone-PET coalition which was still promoting a wider diffusion.

Analysis. Again, these framing contests were not helpful in enabling the regulator to make decisions as to how the technology should be disseminated. The opposing frames have strong cultural-cognitive resonance in the context of the Quebec health care system i.e. equity of access and quality of care. However, they lead to completely opposite conclusions as to what is the legitimate way to allocate the technology across the health care system. The arguments mobilized within the framing contests did not have sufficient resonance or legitimacy to resolve the conflict alone. This led to another form of testing… in which it was not so much the legitimacy of the technology itself that was tested, but rather the legitimacy of the very rules underlying its diffusion.

Institution Testing

The First Deviant Adoption. The confrontation between the Quebec Association of Nuclear Medicine and teaching hospitals that followed the publication of the HTAA report as to how to diffuse the PET scanner was not a good omen for a quick diffusion of this technology. This combined with repeated informal and unanswered requests from hospitals to obtain a PET scanner and the fast diffusion of this technology in the USA induced disillusionment and cynicism in many nuclear doctors with regard to the possibility of obtaining a PET scanner: "The deployment of PET scanners, I've been hearing about that for four years, and another announcement arrives every 15th of the month. It's the classic running gag. I've stopped believing in that."

Since it was the most advanced detecting technology for cancer, doctors and administrators of THA1 understood the strategic importance of the PET scanner and its alignment with their mission. However, being aware that no budget announcement for the deployment of the PET scanner would be made in the short term, Doctor Z, a nuclear doctor working at THA1, asked the private foundation of the hospital to buy a PET scanner.

The stratagem consisted of renting the technology to THA1 for a symbolic sum. This allowed the teaching hospital indirectly to buy and have access to the technology, thereby evading the law which compels hospitals to have the consent of the government before acquiring a PET scanner or expensive technology. Because people in the Foundation were surprised at the deficiency of the Quebec health care system in the number of PET scanners, members of the board were easily persuaded by Doctor Z that financing this technology made sense. This was reinforced by the fact that THB had a PET scanner, while THA1 had none: “Members of the foundation were surprised. They wondered: ‘How come region A has no PET scanner and region B has one?’ And when everybody says ‘It doesn’t make any sense!’ the legitimacy is there, with no questions asked.”

As a result, by January 2003, THA1 acquired a PET scanner without asking for the authorization and even without informing the Ministry of Health. When the story came out in the lay press in the same month, the official version stated that the machine was financed by research funds and used for research purposes. Interestingly, the media were already announcing that privately selling services was an option if the teaching hospital were to lack financial resources for operating the machine. Because THA1 could publicly legitimate this acquisition by invoking the fact that the machine was for diagnosing a widespread deadly and highly publicized condition (cancer), it was unlikely that the Ministry of Health would denounce it:

> *"Put yourself in the shoes of the Minister who comes to tell us: "Whoah! You are going to get the machine out of there and you are not going to use it." That's a risky business. If that went to the media, we would have several very sensible and logical explanations to give to the people. The government would look pretty silly. (…) Especially as there are so many cancer cases… [the government wouldn't want to hear us] tell patients, "Well – we're ready to offer you a useful service, but the Minister has decided that you can't have it" Politically, you have to be careful."*

After this adoption, doctors from various hospitals called THA1 for information on how this strategic move was carried out: "Five or six doctors called me to know how I had done it. How I dealt with the board of directors, the general management staff, and the Foundation, to do it, and make it official. They really wanted to know how I had pulled that off."

Given that access to health care is a public service in Quebec, doctors cannot, by law, receive private payment for health care services which are insured by the universal coverage. Despite this rule, THA1 had to find a way to finance the running costs of its PET scanner. The solution found was to offer PET scanner services at nights and on week-ends on a private basis to private clinics that were willing to pay 2500$. This would give patients or organizations access to a PET scanner within three to four days instead of two to six months, which corresponds to the normal public waiting time. With the surplus generated from this activity, THA1 was able to fund its public activity, and also to charge the Quebec Health Insurance Agency for each act publicly performed.

Fifteen months after the acquisition of the PET scanner, the maneuver which consisted of prioritizing private before public patients was reported in the media and provoked a swift reaction from deputies at the legislature and from the Minister of Health who asked THA1 to stop selling public services to the private sector: "Political actions were taken. After all, we are part of a Health System that is socialist. People said: 'It's not fair that a public hospital with public funding is used for activities tied to the private sector." This situation had to be handled rapidly by the government because the health insurance law forbids organizations from the public health care network to be financed through private activities. Moreover, the

situation was critical to the point that publicly paid staffs were employed to run the PET scanner to generate private revenue. To enable THA1 to stop financing its operation through private funds the Minister of Health announced that an operational budget of 1250 cases for 2004-2005 would be allocated to them.

Analysis. The struggle between teaching hospital THA1 and the Ministry of Health is the expression of, on the one hand, hospitals' interests in adopting such a prestigious and expensive technology and, on the other, the cost-containment imperative of the government. Because hospitals need the authorization from the government to acquire this technology, the government can use its regulatory power to hinder any adoption by delaying the announcement of a dissemination plan. However, wide diffusion in the USA, the confirmation of the effectiveness of the technology by the HTAA report, the special status of cancer, which is often synonymous to a sentence of death, and patient needs, all contributed to building the cultural-cognitive legitimacy of this technology and a strong pressure to adopt. Further, given its mission in cancer and in technology assessment, THA1 had an important incentive to acquire this technology. This cultural-cognitive legitimacy of the technology and the interest of THA1 to adopt advanced technology are two powerful incentives to acquire a PET scanner. The legitimacy of the technology was such that it outweighed the legitimacy of the regulation which was impeding such adoption. This adoption against the will of the government is a form of what we call *institution testing*, which we define as an action against regulatory constraints.

While institution testing was a strategic move to pre-empt the adoption of the PET scanner, other actions in this case can also be considered deviant. For example, the private funding of the daily public operation of the PET scanner is questionable as regard to the law. The problem stems from the situation where patients willing to pay were jumping the waiting list, something the public and the government could not tolerate because it goes against equity of

access. Another problem was that publicly paid human resources were used for diagnosing private patients. Overall, it is because this technology is aligned with the mission of the organization and also because legitimacy of the technology is greater than the legitimacy of the regulation that institution testing was possible.

Interestingly, this behaviour was successful for at least two reasons. While institution testing pre-empted the adoption of this technology, it also allowed THA1 to obtain a budget. Indeed, when the story of privately funded operations at THA1 came out in the lay press, the government reacted to calm the tension by providing an operational budget. In this case, the government was literally trapped because it could not hinder access to a cancer diagnosing device nor could it sanction a deviant behaviour which was generating inequity in the system as other hospitals did not have this technology. Furthermore, the success of this first episode of institution testing paved the way for further breaches.

A Second Deviant Adoption. The director of the Nuclear Medicine Department at teaching hospital THA2 had already had the idea to acquire a PET scanner with or without the consent of the government. In 2002, with the support of a public personality, he opened a private foundation with the purpose of funding a PET-CT scanner. After the acquisition of THA1, THA2 met with the private foundation of the hospital to finance part of a PET-CT scanner. The new foundation created by the public personality together with the traditional foundation of THA2 gathered the amount of money required to acquire a PET-CT scanner. Before proceeding with this acquisition, THA2 informed the Health Services Regional Agency, the interlocutor of the Ministry of Health, that they were inviting companies to tender for a PET scanner. Promptly the Health Services Regional Agency sent a letter to THA2 urging them to stop this acquisition process:

> *"We told the Health Services Regional Agency that we were offering tenders to acquire the equipment. The Agency sent us a letter telling us that we could not do that. There were laws at the Ministry level, and they sent us a copy of those laws. They said that only*

> *the Minister had the right to decide new programs. We could not invest money in this project, and so on."*

Although THA2 did not obtain the authorization to acquire this technology, the adjunct director of the hospital decided to move forward with the project. This choice was strategic for THA2 as the PET-CT scanner was aligned with its mission and was also a good way to compete against general hospital GHA in oncology:

> *"It is part of our mission. If we want to provide the best care available for cancer patients, we must acquire this equipment. […] There is also this competition between General Hospital GHA and teaching hospital THA2. They both want to dominate the oncology program in region A."*

The letter from the Health Services Regional Agency was insufficient to stop the movement given that adopting the technology was of little risk for THA2 because, as one interviewee stated, if the technology had to diffuse, it had to diffuse in a teaching hospital: "Granted, we went against the rules, but it was a calculated risk. If a machine was to be deployed in the province, it had to be in a teaching hospital first, as there were already two machines at teaching hospital THB."

Once the hospital infrastructure for the PET scanner was under construction, THA2 asked the government for an operational budget, but once again this was a dead letter. To finance its operation, THA2 drew on its global budget thereby increasing its deficit. Because generating deficit in hospitals was and is still prohibited by the law, this behaviour is rather unexpected. While THA2 started operating its PET-CT scanner by May 17th 2004, its budget constraint limited the number of patients to undergo examinations to 2 patients / day instead of 12 patients / day. This precaution was taken to avoid ending up with a huge operational deficit if the Ministry of Health would not provide an operational budget.

Analysis. Again, in this episode institution testing was possible because the legitimacy of the technology was greater than the legitimacy of the regulation, and also because the technology

was aligned with the mission of THA2. This confirmed that institution testing, a deviant adoption in this case, was a relatively low risk behaviour given the mission of the teaching hospital in oncology and in technology assessment. Furthermore, THA2 had indications that THA1 would get away with purchasing their PET scanner without trouble. Finally, institution testing spread to this hospital for competitive reasons also. Indeed, for THA2 to remain a reference in oncology, acquiring a PET scanner was necessary. THA2 was deviant not only in acquiring the technology, but also in the way it financed its operation. Because the government did not allow an operational budget, this hospital drew on its global budget to finance its operation despite the risk of deepening its deficit, an offence in the eye of the law since 2002 in Quebec.

A Third Deviant Adoption. In 2003, general hospital GHA was approached by a citizen who wished to present the hospital with a major donation for the acquisition of a PET-CT scanner, provided that the hospital agreed to buy from a specific private company and within a certain timeframe. After having been informed about this unique opportunity, the Health Services Regional Agency, under the authority of the Ministry of Health, considered that other organizations in the region A would qualify for a PET scanner before this general hospital. Under the threat of losing the donation, the general hospital GHA informed the Health Services Regional Agency that it was inviting companies to tender for a PET-CT scanner despite the opposition of the Ministry of Health. Since the Health Services Regional Agency of region A did not want to be held responsible for the general hospital GHA to have lost this donation, the Ministry of Health did not respond to this letter:

> *"No one wants to be the person who will explain to the media that a benefactor cancelled his pledge because we waited too long, and we could not buy the equipment. The Health Services Regional Agency's civil servant understood this perfectly. He was stuck between a rock and a hard place. So he let us proceed with the invitation to tender, even if it did not suit him at all."*

Although funds were immediately available to acquire a PET-CT scanner, the general hospital GHA finally decided to wait for the authorization of the Ministry of Health. After a few months, the government came up with a plan of dissemination (see next section) of the PET scanner technology in Quebec and since the general hospital GHA was in this plan, the government authorized this hospital to acquire a PET scanner. However, the authorization was not accompanied by the necessary operational budget. Applying the same strategy as teaching hospital THA2, general hospital GHA financed its operations through its global budget thereby incurring the risk of increasing its deficit. Nonetheless, since the risk of not being reimbursed was quite low, the general hospital GHA started examining patients in October 2004, before receiving its operational budget, but using a cautious approach and not spending too much on this technology. The government committed itself to pay an operational budget to GHA by August 5th, 2005 to cover its costs since the beginning of its operation:

> *"At the General Hospital GHA, a generous benefactor has promised to pay the total sum for the acquisition of a PET scanner, but the government has given no hint it was willing to pay for the annual operating costs of this equipment. The hospital has been waiting for a year and a half…"*
>
> - Local newspaper, January 6th, 2005

Analysis. The desire of general hospital GHA to take advantage of the donation inspired it to acquire a PET scanner despite opposition from the Ministry of Health. Hence, institution testing is still an issue in this case, although a milder case. The main difference with the two previous cases is that general hospital GHA waited for government approval before really acquiring it. While it still somehow forced the hand of the government to be on the dissemination plan, the status of this general hospital, which is not as prestigious as a teaching hospital, and its mission, which is not so centred on evaluating technology, may explain its more conservative behaviour as regards to the adoption of this technology.

Although the donation was an important factor for adoption, competition between hospitals to become or to remain a local reference in oncology is clearly the motor that brought the

general hospital GHA to acquire a PET-CT scanner. Because general hospital GHA called teaching hospital THA1 to know how the latter managed to obtain this technology, mimetic isomorphism might be driving not the acquisition per se, but the process of acquiring a medical technology. Furthermore, because general hospital GHA does not have the budget to run its machine, like THA1, it drew on its global budget to do so. Hence, starting the adoption process before having the authorization of the Ministry of Health was a good strategy to pre-empt the adoption of this technology. Most probably, without deviant action, general hospital GHA would have had a PET scanner, but at a later time; and it might not have been the more sophisticated PET-CT scanner.

Concluding the case study. To avoid the chaotic diffusion of PET scanners, the government of Quebec had a strong incentive to develop a dissemination plan: "So, I guess government decision takers thought they better take charge of this matter and manage it, or else, it would manage itself by itself." The Quebec Association of Nuclear Medicine and the Ministry of Health finally reached an agreement as to how to disseminate the PET scanners and a plan was created giving priority to those who already had a PET scanner, i.e. those who were defending a quality-based diffusion approach. According to the dissemination plan of June 2005, the PET scanner technology would be disseminated in three phases with an emphasis on providing PET-CT scanners to teaching hospitals first or hospitals on the way to acquiring one. Thus, adopting a PET scanner without the consent of the government was a good strategy. As one interviewee remarks: "The consequence for GHA in adopting a PET scanner earlier is that they accelerated their case [at the Ministry of Health]. Maybe they would have received their authorization later."

DISCUSSION

Like new industries, new technologies face the liability of newness (Aldrich & Fiol, 1994). They have to become legitimate with different groups in order to diffuse and be used.

However, contrary to what is assumed in the literature, regulated environment may involve that not only the technology itself needs to be legitimated, but also its diffusion. Indeed, our case study shows that there are two distinct processes which provide legitimacy to technology diffusion: one involving technology testing and the other institution testing. For the case analyzed, the first legitimation process was specific to the purpose and the benefits of the technology and involved *technology testing* and the second one concerned its diffusion and was characterized by *institution testing*.

Legitimation Processes of Technology Diffusion

The first legitimation process was characterized by framing contests which took place between two hospitals in one region where each one attempted to influence the regulator by defining the technology according to its own mission and interest (whether as a tool to be used in cardiology and lung cancer or as device to be used in oncology). The second legitimation process was related to the diffusion of the technology. In the case, the framing contests over the diffusion of the technology involved contradictory arguments. Teaching hospitals were in favor of creating competence centers with the latest technology and general hospitals dispersed across the province of Quebec preferred to have the less expensive version of the technology to be regionalized and accessible from different points in the province. Thus, in regulated environments, the legitimation processes of technology diffusion involve not only the demonstration of the benefits of the technology as is often assumed in the literature, but it is also related to who should have the technology or how it should be diffused. Each of these processes is subjected to distinct power struggles manifested in different framing contests when several competing technological frames are crafted, are contradictory and attempt at capturing the same resources.

Technology Testing

The process leading to the legitimacy of the purpose and the benefits of the technology is characterized by a high level of ambiguity which was the result of technology framing contests. It is the reliance on *technology testing* that is the evaluation of the technology through a legitimate procedure which terminated one framing contest and granted legitimacy to the purpose and benefits of the technology. In our case, the technology framing contests over the technology (cardiology versus oncology) increased the ambiguity surrounding the purpose and the benefits of the technology and led the Quebec Nuclear Medical Association to ask for an evaluation of the technology. Because this evaluation was held by an independent governmental assessment agency, which has the mission to assess medical technologies, the report it produced had the effect of providing legitimacy to the purpose and benefits of the technology and in our case put an end to framing contests on this dimension at least. Paradoxically, it stopped the framing contests not because it proclaimed a 'winner' of the contest, but because it recognized the multiple purpose and benefits of the technology; it's not that the technology is for cardiac or oncology applications, it is both. It is the legitimacy of the independent governmental assessment agency in this health care system which granted legitimacy to the technology through some sort of spillover effects (Kostova & Zaheer, 1999) from the legitimacy of the procedure it uses (i.e. science) to the legitimacy of the technology. Taken together, these results lead to the following proposition:

> *Proposition 1: In regulated environments, technology framing contests increase ambiguity which may in turn spark the need to rely on technology testing in order to bring a resolution of the debate, to lower ambiguity and to provide legitimacy to the purpose and benefits of a technology.*

Legitimate procedures such as scientific evaluation may provide normative legitimacy if the results of it reflects a positive assessment. While Suchman (1995: 580) argues that adopting "accepted techniques or procedures" may confer legitimacy to organization, our case provide

evidence that legitimate evaluation procedures based on an institution such as science can provide legitimacy to an artifact. Technology testing involves legitimate procedures which may provide cognitive-cultural legitimacy to a technology if the evaluation is positive. The legitimacy of the procedure seems to produce legitimacy spillover (Kostova & Zaheer, 1999) from the procedure itself to the technology because there is a cultural consensus on the method used to assess the artifact.

The literature which conceptualizes the development of technology from the perspective of the developers and the manufacturers use the term evaluation routines to take into account the practices which test technologies (Garud & Rappa, 1994). Evaluation routines use equipment to produce facts or evidence which serve to assess the technology (Latour, 1987) and it is a normative activity which is often part of a 'tradition of technological testability' (Constant, 1987). While developers externalize their beliefs through their personal evaluation routines, our cases suggest that users and regulators may also rely on assessment not to evaluate its potential to be further developed, but to check to what extend a technology fits cultural requirements and expectations. Our data confirm the imminent role of technology testing in legitimating the purpose and benefits of technology, and may also confer legitimacy to how the technology should be diffused as long as this issue is not contested. In other words, when a test is conducted and the results are positive because they fit cultural expectations, it confers legitimacy to the technology. Consequently, it can be expected that this technology will be more extensively used as it will be considered as valuable in a given field (Boltanski & Thévenot, 2006). Boltanski and Thévenot (2006) would argue that when the result of a test is positive i.e. successful, a technology has increased its "state of worth" i.e. its value or legitimacy in a given World.

Institution Testing

This legitimacy which was derived from the Health Technology Assessment Agency report gave rise to another round of framing contests where the way the technology should be implemented in the system was at stake. With the regulator not making decision and with a technology which is legitimated by formal technology testing, it opened the door for organizations with sufficient political clout and financial resources to adopt the technology preemptively without government consent, what we call *institution testing*. This occurred when facing apparently irresolvable framing contests, actors relied on *institution testing* that is a strategic behavior which terminates framing contests when the cultural-cognitive legitimacy of a technology is stronger than regulatory legitimacy. In our case, the framing contests related to the way the technology should be implemented in the health care system i.e. highly dispersed versus concentrated throughout the province of Quebec generated a lot of tension and ambiguity which led the regulator to postpone any decision related to the adoption of the PET scanner. This generated frustration among doctors and hospitals and they began adopting the PET scanner despite the law which forbade this type of behavior. Because hospitals adopted without the consent of the regulator, the latter had to elaborate a plan which stated which hospitals should have a PET scanner. Interestingly, those who used institution testing, i.e. tested the regulator, were included in the plan thereby legitimizing the forced implementation of the technology by hospitals. This suggests that *institution testing* was a behavior which not only pre-empted the diffusion of the technology, but which also established the legitimacy of the diffusion of the technology, terminated the related framing contests and lowered ambiguity. These results suggest the following:

> *Proposition 2: When framing contests over diffusion cannot be resolved through legitimated means, institution testing may come into play. It is a strategic behaviour available to the most powerful actors in a given field which may resolve framing contest by pre-empting the diffusion of a technology in highly regulated environments. This is likely to occur when the cultural-cognitive legitimacy of a technology have acquired sufficient force to trump regulatory legitimacy.*

In their model of institutional change, Greenwood et al. (2002) theorizes that the legitimacy of an innovation would evolve from moral and/or pragmatic legitimacy to cognitive legitimacy which corresponds to the institutionalization of an innovation. While this study argues that there seems to have been a sequence related to the way legitimacy unfolds in time, little research examines how different legitimacies influence each other or may clash.

What constitutes an institutional test in our study is the challenge made to the regulator by the hospitals which affected the decision of disseminating this technology with prudence, while the hospitals wanted it rapidly. Boltanski and Thévenot (2005) would argue that when actors perceive that there is an injustice between the "state of worth" and the current positions occupied by technological artifacts or people in a given field, a test can be mobilized or used to evaluate if there is an injustice in the current situation. The test in that case involves different principles such as imperative of cost control by the government and the efficiency of diffusing the PET scanner. It is because of the incompatibility of these two principles that the regulator was tested, i.e. challenged, by adopting the technology without its consent. The result of this challenge suggests that the test favored the challenger of the status quo.

Contrary to the concept of institutional entrepreneurship (Maguire, Hardy, & Lawrence, 2004), institutional work (Lawrence & Suddaby, 2006) or institutional contradiction (Seo & Creed, 2002) which assumes that agents are purposeful and conscious agents which deliberately attempt to push for non-isomorphic institutional change, little work has documented unintended institutional change. Actors in our case studies were interested in obtaining and legitimizing the PET scanner, not changing institutions. However, institution testing led to the adjustment of rules to accommodate those who behaved against the will of the regulator. This conferred to the technology the legitimacy over the way it should be diffused. In a sense, this is remarkably similar to the story of the Little Prince where the king commands to the sun to rise every morning. In the same manner, our case studies document how the regulators

followed those who pushed for opening up the path to technology diffusion because the technology had sufficient legitimacy to outweigh the law.

CONCLUSION

In this paper we have shown that the legitimation processes of technology diffusion in regulated environments is subjected to distinct power struggles manifested in different framing contests when several competing technological frames are crafted, are contradictory and attempt at capturing the same resources. We show that technology framing contests increase ambiguity which may in turn spark the need to rely on technology testing in order to bring a resolution of the debate, to lower ambiguity and to provide legitimacy to the purpose and benefits of a technology. Furthermore, we show that when framing contests over diffusion cannot be resolved through legitimated means, institution testing may come into play. This is a strategic behaviour available to the most powerful actors in a given field which may resolve framing contests by pre-empting the diffusion of a technology against regulatory constraints. This is likely to occur when the cultural-cognitive legitimacy of a technology has acquired sufficient force to trump regulatory legitimacy. Finally, building on evidence from our research, we develop a processual model which links framing contests, testing and the legitimacy of technology diffusion.

Note that our model applies specifically to situations where organizations are competing to influence the meaning and the diffusion process of an artifact when there are scarce resources and when institutions impede the legitimation process. The adoption of high technology within regulated health care systems is a particularly likely context for such phenomena. However, they may also occur for other products and in a broader institutional framework. For example, in the case of dextran sulphate to fight aids, there was a framing contest in the lay and medical press where some doctors claimed that the compound was ineffective while others believed in was effective. Here, pharmaceutical companies engaged in technology

testing to produce evidence. At the institutional level, the gay community was involved in institution testing when they illegally imported the drug from outside the USA (Maguire, 2002) despite prohibition from the Californian authorities. Like in the case of the PET scanner, the ambiguity was related to the effectiveness of the drug.

Another example is the case of the genetically modified rice in Ireland. While the European Union has explicit legislation which states that genetically modified product must pass an authorization procedure before being commercialized, genetically modified rice was found in the European market without receiving such authorization. While OGM-free NGOs and rice producers were framing this product as potentially dangerous, the producers of the rice were framing it as risk-free (Food_Standards_Agency, 2006). The legalization of marijuana in USA for medical use is also a case where many recreational users were illegally consuming it despite the lack of evidence about the long term effect of the drug. Research has finally found that this drug was effective for relieving patients having cancer. Other new technologies such as medical devices, drugs, genetically modified food, pesticides, nanotechnologies, or biological technology such as cloning may be subjected to the same legitimation processes. This suggests that adopting technology despite institutional pressure may contribution not only to legitimize a given technology, but also its diffusion.

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