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Innovation through Withdrawal Contribution to a Sociology of Detachment⁽¹⁾

ABSTRACT

To develop the understanding of innovation processes conceptualized in terms of association through “sociology of translation” studies (cf. actor-network theory), this article analyses innovation processes in terms of dissociation and detachment mechanisms, examining innovation through—withdrawal;—that is, innovation based on reducing or withdrawing use of a practice—“subtracting,” “detaching”—a given artefact. Specifically, it focuses on the shift to farming techniques that have eliminated ploughing, bringing to light four major mechanisms constitutive of dissociation: centrifugal association; making entities and associations visible; making other entities and associations invisible; bringing together or “associating” new entities. The study helps refine our understanding of the detachment processes at work in innovation, shedding light in this particular case on transfers between public research institutes, industrial companies, farmers and citizens seeking to develop new farm production models.

Research by sociologists into technological innovation in recent decades has tended to place great emphasis on the processes by which new technological artefacts have suddenly appeared, then following their diffusion have become integrated, and to the sociotechnical changes that are associated with them. Synthetic studies have been obliged to take account of the different approaches to these processes (Flichy 1995), especially by emphasising their contrasting positions in relation to whether they have a distinct grasp or not of the technological and social dimensions of these innovations. Hence, for example, diffusion theories developed in concert with the development of consumer society and based on the appropriation of new artefacts by the domestic and productive sectors have produced a model for the analysis of the diffusion of innovations that highlights two quite distinct entities. On the one hand these are technological artefacts with properties defined and

(1) An early version of this article was discussed at the conference of the Association Française de Sociologie in Grenoble (5-8 July 2011). The authors would like to thank Ronan Le Velly, Rémy Barbier, Pascal Béguin and Nathalie Jas for their advice and comments, as well as the comments by the *RFS* reviewers. This research was helped by a grant from the Agence Nationale de la Recherche as part of Programme SYSTERRA, ANR-08-STRA-10, and the funding support of ADEME and Département Sciences pour l'Action et le Développement (SAD) of INRA.

specified by their inventors, and a social milieu on the other hand, that is made up of persons connected within a network of influence (Rogers 1962), adopting the innovation more or less rapidly as it exists. The social history of technology (Hughes 1983), constructivist sociology of technology (Pinch and Bijker 1984) and actor-network theory (Callon 1986) have each in their own way torn down the boundaries between the technological and social components of innovation. Thus humans and non-humans have become the entities taken into account in relation to each other in understanding innovation processes. This approach suggests that the dynamics at work operate through the association between heterogeneous entities within sociotechnical networks (Latour 1989), innovation thus being the “mechanisms of reciprocal adjustment of the technological object and its environment” (Akrich [1987] 2006). Research carried out in this field has thus covered a wide variety of innovations so as to identify the variety of these registers of association and transformation (Law and Hassard 1999), carefully analysing the mechanisms of participation, the movements and reconstructions of the associated entities, in relation to the introduction of a new object or new practice. They have also helped to question the distinctions between technologist-innovators and users (Von Hippel 1976; Akrich 1998), and thus fed into the critique of the latter on their “trickle-down” reading of the innovation process.

Despite, however, their respective contributions and differences, these approaches to the innovation process share one initial postulate. Innovation is structured around the introduction of a new element, an artefact, a way of operating, a service, and its success is dependent on the number of adopters and the significance of the entities (resources, skills, etc.) which are articulated with it (Akrich, Callon and Latour 1988). The innovation certainly cannot be reduced just to the new element introduced, but it is structured around it; from this point it becomes the formative element of the innovation. However, two observations urge us to question this premise centred on the “addition”: not all innovations correspond to the addition of an element and the reconfiguration of associated elements. The proposed contribution of this paper is precisely to shed light on innovations that are not structured in that way. In contrast, we propose to describe these as “innovations by withdrawal” and make the hypothesis that they correspond to a family of sociotechnical phenomena it is useful to consider in order to posit a new problem of innovation, and to contribute more widely to studies of the mechanisms of detachment.

A new problem of innovation

Two observations have invited us to define this recurrent problematic for the sociological study of innovation processes and this contribution to a sociology of detachment.

Thinking on the basis of the “less than” or the “without”

The first observation is an empirical one: many contemporary innovations are marked by being organized around the withdrawal of artefacts, their abolition or more moderate use of them. The majority of innovations of course is linked to the introduction of a novelty and includes its corollary that of the disappearance and withdrawal of a practice or of an object “replaced” by this novelty. However where for instance in product innovation (Schumpeter [1911] 1983), we see the withdrawal of certain elements, such withdrawal is not specifically structuring. Although the take-off of hybrid maize and digital photography is based on their substitution for, respectively, traditional varieties and silver photography, it is not usually defined in this way. However, in the innovations we discuss here the structuring element is precisely the withdrawal of sociotechnical network elements, although various other elements are introduced, removed or transformed.

Such innovations by withdrawal are often described by their proponents as a response to the harmful effects of consumer society, to threats to the environment and human well-being produced by scientific and technological advances. Thus the car-free city, pesticide-free agriculture, supermarket check-outs free of plastic bags and food without colouring or preservative are all mobilising myths (Hatchuel 1998) stimulating innovation processes aimed at “sustainable” development and the well-being of people. Moreover it is sometimes human entities that are concerned in the process of withdrawal, as for example the intermediaries in the food-chain in the context of development of “short” supply chains, of “direct” sales, with the aim of bringing into closer contact entities that were not directly associated, such as agricultural producers and consumers.⁽²⁾ Thus an essential feature of these innovations by withdrawal is the fact they are associated with the development of a rhetoric of “better” by “less of,” and calling for the “shortening,” “reduction,” “downsizing” or even “elimination” of the presence of certain entities, being designed to detach actors, their practices and modes of organization from the latter.

Studying dissociations and detachments

The second observation that has led us to set out this problem about withdrawal is of a theoretical nature. Innovations by withdrawal, rather than being a new category of innovation that is ontologically different to those already known,⁽³⁾ instead represent an interesting way into a questioning of how

(2) On this innovation, Dubuisson-Quellier and Le Velly (2008) highlight in detail the hybridizations which develop in the field and distinguish between the image of the long market with intermediaries and that of a direct relationship between producers and consumers.

(3) Product innovation vs. process innovation (Schumpeter [1911] 1983), but also organisational innovation, incremental innovation vs. disruptive innovation (Christensen 1997), regular innovation vs. architectural innovation (Abernathy and Clark 1985), etc.

sociologists have treated innovation processes. Whether they try to grasp the processes by which innovations emerge, and changes are diffused, these approaches are focused on processes accompanying the addition of something and the creation of new ties to this thing, as if attachment was necessarily a trait characteristic and structuring of innovation. Empirical surveys have then been used to study and describe diffusion, adoption, as well as the winning over, mobilisation and enrolment of new entities. A number of writers also refer to detachment: Schumpeter's concept of creative destruction for example, or the need to dismantle associations pre-existing the introduction of the innovation, described in Callon's work. The latter thus writes "A interests B by cutting or weakening all the links between B and the invisible (or at times quite visible) group of other entities C, D, E, etc. who may want to link themselves to B" (1986: 205), and that "the interressement helps corner the entities to be enrolled. In addition, it attempts to interrupt all potential competing associations and to construct a system of alliances" (*ibid.*: 206). However it is clear that sociologists of innovation and translation have hardly studied these mechanisms of dissociation and detachment,⁽⁴⁾ being more interested in translations seen more as the construction of new associations than as the breaking of existing ties, whilst from the standpoint of this sociology the two processes go hand in hand. Other streams of research, dealing in particular with de-institutionalisation processes (Maguire and Hardy 2009), and of various social phenomena such as bereavement or disposal of objects (Hetherington 2004), have however tried to characterize the nature of the mechanisms of withdrawal and detachment between humans and their environment. The rites of passage or, in another context the efforts at de-legitimation have thus been described as processes favouring detachment and the work of distancing and reconstruction deployed by actors in this environment. These writers, and Hetherington in particular, emphasize the temporal dimension of these processes, often punctuated by intermediate steps during which an irreversible change is constructed.

These innovations founded on withdrawal thus invite sociologists of innovation to consider, or even reconsider, the importance of these dissociations and detachments in the processes they study and to commit themselves to the field of work that contributes to a "sociology of detachment." For this, we suggest the design and implementation of a new symmetry principle for the study of innovation, which would thus aim to study the associations and dissociations, attachments and detachments taking place in a similar manner. This principle has already been proclaimed by the sociology of translation but rarely practiced; and the case of innovation through withdrawal confronts us so firmly with the importance of the work of detachment that it cannot any longer be treated in the negative. The hypothesis that follows from this position would be that what makes the strength of an innovation is as much the

(4) The concept of "*attachement*" developed by Callon (1999) defines the construction of a universe of singularity around an entity.

sturdiness and the amount of sustainably broken ties, as the quantity and strength of the ties that link entities in an innovative project.

We propose to put this approach and hypothesis to the test in the context of change in agricultural practices. In agriculture, some actors attempt to direct farmers' practices towards reduced use of pesticides, fertilisers and other synthetic inputs thought to present risks to the environment and human health. In this particular context there have been developments in France since the end of the 1990s of new agricultural practices characterised by the fact that they *no longer* use ploughing (or tillage) and on which we have conducted research since 2004, that forms the basis of the results presented in this article.

The terrain: development of no-tillage farming techniques in France

What are known in France as *techniques without ploughing* (*TSL–Technique sans Labour*), or *no-tillage* have experienced rapid growth in France and now account for about one-third of the areas cultivated for cereals and oilseed (Chapelle-Barry 2008). They have most frequently been developed on large farms, by farmers who were initially seeking technical solutions to reduce their costs of production and labour time. Ploughing,⁽⁵⁾ which agronomists consider as fulfilling some essential agronomic functions (physical destruction of weeds, improvement in soil structure) is amongst the most expensive crop operations in monetary terms (fuel, equipment) and time. No-tillage involves a wide range of technical practices, usually seen as falling into one or other of two large “families” (Labreuche *et al.*, 2007): *Techniques Culturelles Simplifiées* (TCS) [simplified cultivation techniques] and *le semis direct* (SD) [direct-seeding.] The former consists of replacing ploughing by superficial soil tillage, without turning the soil horizons like a plough would do. The second consists of not preparing the soil, even superficially, and only carrying out sowing by implanting (or seeding, “drilling”) the crop seed directly into the earth, as its name implies. The direct-seeding technique was perfected in the 1970s on the American continent, in the USA and then Brazil through collaborations between farmers, agents of state agricultural development services, and private agricultural equipment firms (Coughenour 2003; Ekboir 2003). The stakes were not only economic but ecological. In these countries intensive crop farming had created serious problems of soil erosion,⁽⁶⁾ that the authorities had tried to limit by promoting crop-raising practices to farmers that reduced soil exposure to inclement weather conditions. The maintenance of permanent vegetation cover over the soil was also encouraged to reinforce this protection. In America as well as in France,

(5) Operation of ploughing or tilling the soil, turning the soil horizons using disc ploughs or ploughshares.

(6) On the analysis of the crisis set off by the aeolian soil erosion of farmland in the USA, the *dust bowl*, see Masutti (2004).

farmers nowadays also maintain this cover by keeping the residue of the last crop (straw, for instance) or by sowing so-called “cover crops” which are not usually harvested and whose main function is to manage soil fertility. This is why the no-tillage techniques are often described by their proponents as “conservation agriculture” for land.⁽⁷⁾

Supplanting natural entities with technical objects

Even though the initial motivations of French farmers were mainly economic, and the state of degradation of their land was not at all comparable with that of their American counterparts, the idea of conservation farming and its environmental issues began to appear towards the end the 1990's at the same time as the technology for direct-seeding with cover crops. This joint appearance of new practical and discursive styles was not by chance. It was closely tied to the initial study tours that were being made at that time by groups of French farmers to the USA, Brazil, and Argentina, and to the first attempts at using direct-seeding in France. In particular a trip to Brazil in 1998 made by a group of farmers from the centre of France played a determinant role in this process. The group in question comprised cereal growers from Touraine all with large farms of whom the majority had been members of a Club des 100 quintaux [Club of 100 quintals growers].⁽⁸⁾ These farmers, aggressive in their search for innovations and new techniques to optimise their systems of production, went to meet an agronomist of the French-supported Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in Brazil, Lucien Ségué, who worked with local agronomic researchers on the development of direct-seeding systems. The promoter of and guide for the trip was Claude Bourguignon, a scientist who had been a soil microbiologist at the Institut National de la Recherche Agronomique (INRA), and the founder of an independent soil analysis laboratory that specialised in alerting French farmers to the importance of soil biological activity. The two men knew each other and shared a particular view of what the relationship should be between agronomic science and the farming profession—that of a science which ought to be at the service of and attentive to farmers, to help them to innovate, but also to inspire them to make their own innovations. They contrasted this model with that of a restricted science, cut off from the agricultural word and from citizens, that they criticized by

(7) As a measure of the growth of no-tillage in France, the organizations aiming to promote themselves and conservation agriculture have expanded significantly since the early 2000s. Thus, the association BASE (Bretagne, Agriculture, Sol et Environnement) [Brittany, Agriculture, Soil and Environment] consisted of 750 members in 2011 (as against six at its creation in 1999), in an area which has progres-

sively expanded (sixteen departments, with 40,000 ha cultivated).

(8) Agricultural development groups formed at the start of the 1960s under the impetus of the Chambres d'Agriculture, with a central objective: to achieve as quickly as possible by the development or adoption of technological innovations in particular of wheat yields of at least one hundred quintals per hectare.

putting forward their own concept of research. Séguy argued for a local agronomy (*agronomie de terrain*), carried out for and with farmers, and based on experiments conducted with them and not in experimental laboratories. Bourguignon referred to his personal development, citing his resignation from INRA in the 1980s which had been prompted by his disagreement with the agricultural development model promoted by the *Institute*, which he considered to be inimical to farmers and to the conservation of natural resources.

Currently accepted thinking in agronomic research (Labreuche *et al.* 2007), and which Bourguignon argues for in relation to farmers, is simple. The absence of ploughing and even more of any working of the soil increases the biodiversity and biological activity of the soil (lombrics, microfauna and microflora, microscopic fungi) and fulfils the functions hitherto performed by ploughing. Earth worms thus can multiply more easily in an unploughed soil, dig more tunnels to mix the soil horizons and thus improve the porosity and the structure of the soil. Moreover no-tillage aids the development of micro-organisms and more rapidly transforms the residues of vegetation into nutritive elements for the plants and the development of natural predatory species of some crop pests on the surface of the soil, such as carabids which eat slugs. The withdrawal of ploughing is based on a simple principle, as affirmed by its proponents⁽⁹⁾—to withdraw or reduce the use of technical objects whose functions will be “spontaneously” replaced by natural entities and thus maintain the high level of crop yields and conserve the environment at the same time. This withdrawal structures a set of causal chains, and is a necessary stage in order that nature can return to its own ways. If the innovation process involves “adding more nature” its structuring works by the withdrawal of ploughing, and it is hence this that sets off a whole series of dissociations and the construction of new associations.

The technical objects facilitating no-tillage

The idea of maintaining high yields is important to a better understanding and description of the discourses and practices associated with no-tillage. The actors own rhetoric stresses the need to use natural processes and to give up technical procedures such as ploughing but without completely abandoning all recourse to technical objects. The proof of this lies in the fact that direct-drilling seeding carried out without any ploughing has not been possible in industrialised modern agriculture⁽¹⁰⁾ without the development of two essential technical innovations by private agricultural supply firms. The

(9) This principle is also at the core of the concept of “ecological intensification” put forward by the deputy director of the Agence Nationale de la Recherche in France (Griffon 2006). This is to design an agriculture that is both able to “feed the world” while conserving and using ecological processes.

(10) Direct-seeding and the use of cover crops are practiced in the traditional manual way in the agricultural food systems of the southern hemisphere (Africa, Central America).

first is the direct-seeding drill that makes it possible to sow crops without working the soil and through a cover-crop. Developed in the USA and Brazil by agricultural equipment manufacturers, these tractor-drawn machines have made it possible to sow seed-crops with minimal and very localised disturbance of the soil. The second is related to the development of weedkillers (herbicides) by agrochemical firms in the 1960s that help to get around the avoidance of ploughing, one of whose functions is, of course, the mechanical destruction of weeds. Thus the practice of direct-seeding is still based even today on spraying herbicides whose active component is a chemical such as glyphosate,⁽¹¹⁾ before the sowing and to clean the field of cover plants. The agrochemical firms and the makers of direct-seeding equipment are thus actors who have a significant investment in the promotion and development of no-tillage, as much in France as they have been in the countries of the American continent (Hall 1998).

Although the proponents of this innovation ascribe a central role to nature and its entities, the introduction of new technological objects is equally indispensable for its putting into practice. The proponents of other alternative practices such as biological agriculture, who advocate the withdrawal of pesticides,⁽¹²⁾ differentiate themselves from conservation agriculture because they see it as less ecological and too close to the agrochemical firms.⁽¹³⁾ But the supporters of direct-seeding believe that it is more ecological to use herbicides and not to plough than the reverse. Moreover those actors concerned with no-tillage, whether supporters or those interested in it, see this innovation as in particular being about getting rid of a technological practice and its weapon of choice (the plough) as well as its effect on natural entities such as the soil, rather than as recourse to new drills and herbicides. The names of the organisations set up to promote no-tillage and contacts between its practitioners since the end of the 1990s refer only to the abandonment of ploughing and its environmental impact on the soil. Although they are often sponsored by agrochemical firms these organisations are called Bretagne, Agriculture,

(11) Glyphosate, now used in the public industrial domain was invented at the beginning of the 1970s by the American company Monsanto and marketed as *Roundup*. It is now the best-selling herbicide in the world. Its sales rose sharply in the years 1990-2000 with the development by Monsanto of crops genetically modified to withstand spraying with glyphosate (soyabeans, cotton). Thus, the development of direct-seeding drilling in countries such as Argentina was closely related in the late 1990s to the "dissemination" among farmers of technical package of direct-seeding drills+ glyphosate+GM soybean (Goulet and Hernández 2011).

(12) Note that organic agriculture has since its foundation at the beginning of last century, defended the reduction of tillage, stressing the

importance of the biological equilibrium of soil. Although no-till is widely used in its practices, direct seeding, where dependent on a herbicide, is absent from it.

(13) In response to the creation in 2008 of the Institute for Sustainable Agriculture (IAD), an organization promoting direct drilling supported by companies like Monsanto and Syngenta, the network of Centres d'Initiatives pour Valoriser l'Agriculture et le Milieu Rural (CIVAM) [Centres of Initiatives to Promote Agriculture and the Rural Environment] and WWF-France issued a press release calling for "citizen vigilance about the hijacking of the use of [the term] *sustainable agriculture* by agrochemical firms," challenging the "takeover in favour of the interests of industrial groups" of this meaning of the term.

Sol et Environnement (BASE) [Brittany, Farming, Soil and Environment,] Non-Labour et Semis Direct (NLSO) [No-Tillage and Direct Seeding,] Fondation Nationale pour une Agriculture de Conservation des Sols (FNACS) [National Foundation for Soil-Conservation Agriculture,] and even Association pour la Promotion d'une Agriculture Durable (APAD) [Association for the Promotion of Sustainable Agriculture] and Institut de l'Agriculture Durable (IAD) [Institute of Sustainable Agriculture.]

The development of no-tillage opens up the possibility of analysing some detachment processes that lie at the core of withdrawal innovation, and to anticipate some key points. Although these innovations refer to *less of or without*, they are nonetheless based on the presence of new entities, technological or natural, and on the actors who are associated with them (seed-drill and herbicide manufacturers, spokespersons for micro-organisms in the soil). These entities even play a vital role in the process of withdrawal; placed between the entities to be dissociated, they aid in the breaking of existing ties and in detachment. We need to probe the processes through which this breakdown works, the fitting together of the different entities and the way in which some come to the actors. The dissociation processes are not limited just to the breakdown of a relationship between two entities, for instance the farmer and the plough. Other entities intervene, particularly agents and ex-agents from the agricultural research bodies, but also the drills, seeds, soil, herbicides, earthworms and micro-organisms and many others that observation of the sociotechnical chains will reveal.

Survey method

There were a number of sources that we used for the description and analysis of these processes. This was based initially on a discourse analysis of the discourse of the "expert" proponents of no-tillage (members of CIRAD, a microbiologist who had been employed by INRA, representatives of firms) during lectures, day-courses for farmers⁽¹⁴⁾ and as part of written documents (reports, books). We also analysed the content of a range of documentary sources produced by the promotional collectivities of no-tillage and by the agricultural supply firms, (advertising, technical and sales documents, Internet sites). Lastly our findings were based on thirty semi-structured interviews carried out in metropolitan France with the following actors: independent experts and consultants, agronomists and soil scientists working in

(14) We analyze in particular the contents of four conferences and training courses provided by our two experts. For Bourguignon, lectures on 1 September 2000 at Loudeac (22) at the Technical Seminar organized for the twentieth anniversary of the Groupement d'Achats de Loudeac [Loudeac Purchasing Group] (taken from VHS recording), and February 24, 2003 during the one-day course "Soil Conservation Agriculture and its Challenges" organized by the FNACS at Parmain (95). For Séguy, lectures in August 2003 at *Lycée Agricole* [Farm School] of Montargis (45), organized around the products of direct drill maker Semeato, and August 31, 2005 at the 7th National Festival *Non-Labour et Semis Direct* [No-tillage and direct-seeding] Reignac-sur-Indre (37).

agricultural research bodies, technical and sales staff of the agricultural supply firms concerned, and with farmers using these practices, and associations promoting no-till farming. We also carried out ethnographic observation of farm work (particularly direct-seeding) amongst the latter in two French regions with contrasting soil conditions in order to better understand the ways in which these practices and the discourses around them were reconstructed in relation to the abandonment of ploughing and to the emblematic tool that made it possible, the plough.

Mechanisms and processes of innovation by withdrawal

In order to account for the construction of relations (which he called “translations”) between heterogeneous entities, Callon (1986) defined four processes—problematisation, “*interessement*,” enrolment and mobilisation of allies through a spokesperson. Although he noted that innovation, when seen as the construction of sociotechnical networks, involved the making of new ties as much as dissolving others, his conceptualisation was more concerned with understanding how new ties were made. He stressed that the creation of a new translation occurred through the detachment of an entity from its usual ties to veer it off course, to make it participate with and tie it to other entities. The mechanism involves placing oneself on the line taken by an actor either so as to prevent him from making a tie as he would have done without this interference by the innovator, or by convincing him of the unfeasibility of the expected tie without a detour via the innovator. Whilst Callon and the neo-institutionalists generally document well the creation of new and desirable associations (for example to stress the superiority of an innovation or institutional change), they often only evoke or affirm, without demonstrating specifically at an empirical level, that the same problematisations (as noted in Callon’s work) or rhetorical strategies (particularly as shown in that of Suddaby and Greenwood 2005) help to de-legitimise the prior institutions and undo the previous associations.

As we will see this type of mechanism is also found in our survey. The proponents of no-tillage position themselves on the problematic ties between farmer and environmental protection, between farmer and the quest for economic savings, and propose to make a detour via no-tillage, which involves abandoning ploughing. On this point however, little is said, as if the dissociation between farmers and ploughing was easy to achieve, or at the very least more obvious than the creation of a new translation. Yet the tie which links the farmer to ploughing is a sturdy one; ploughing is in fact a practice that is still deeply embedded in the occupational norms of farmers and in the recommendations of prescriptive organisations (Chambres d’Agriculture [public-sector farming organisation, present throughout France], and agricultural cooperatives). Anthropologists have shown that this inscription of

ploughing and the plough in agricultural practices and agrarian societies is an ancient one, and that it is shared by many civilisations and regions throughout the world (Brunhes, Delamarre and Haudricourt [1955] 1986). It is thus legitimate to describe ploughing as an institution in the sense of a durable set of norms, values and meanings simultaneously externalized from individuals but internalised by them (Berger and Luckmann [1967] 1996), of a resonance of beliefs and conventions, supported in whole or in part by legal framework and by standardised operating procedures (March and Olsen 1989). The institution of ploughing thus forms a normative framework that regulates practices and a shared cultural repertoire (Powell and DiMaggio 1991; Scott and Meyer 1994) that defines the meaning of practices and within which individuals make their choices. Actors thus inherit socially constructed relationships which function like objective rules, like commitments, norms of thought and action (Meyer and Rowan 1977), and modes of action that become an integral part of their reality and ensure a form of cultural persistence (Zucker 1977). This institution of ploughing can be interpreted from the perspective of individuals and singular groups as a set of attachments to practices, forms of thought, beliefs, and obligations. The dissolution of the tie which links farmers to the plough is thus not something obvious. It supposes a contestation of the established (Lourau 1970) and dynamics of de-institutionalization (Maguire and Hardy 2009), which this article aims to explore.

We will show that four types of mechanisms are involved in this detachment between farmers, ploughing and the plough: the centrifugal association, the reinforcement of existing ties, the association of new entities and the making invisible of certain associations.

Associating in order to dissociate: the centrifugal association

Paradoxically, the primary mechanism of detachment and dissociation involves the construction of new associations between the withdrawn entities (ploughing and plough) and other entities to which the farmer is not tied, or is unwilling to be tied any longer. Proponents of no-tillage negatively charged ploughing, by associating it with threats, social or biophysical processes, objects or symbolic registers that were devalued and devaluing for farmers. By using knowledge from a range of sources (results reported by farmers, scientific research, and often from unspecified sources) their work involves problematizing the practice of ploughing to place it at the intersection of a number of risks and to show that its withdrawal will help to avoid them. This rhetorical strategy by actors helps in particular to weaken the legitimacy of prior norms and beliefs (Subbady and Greenwood 2005) which had woven the links between practices and arguments around ploughing.

Economic risk

To begin with the lectures and writings of experts and firms' representatives endeavoured to link the practice of ploughing to an economic threat for French farmers. Using statistics and comparative tables as support, they claimed that its withdrawal would allow the latter to continue in the future to be present in an international market that would be increasingly competitive, whilst the prospects for public subsidies paid as part of the EU Common Agricultural Policy appeared uncertain. They argued that ploughing is too costly an operation, whose continuation was opposed to that of the French farmer. What better proof could there be than that put forward by the soil microbiologist when he described to farmers the meteoric rise in agricultural markets of the "champions" of direct-seeding, Brazil and Argentina, whilst they received no public subsidy at all? He emphasised the need to follow the example of these farmers who were both precursors and competitors:

"They have systems that are much cheaper than yours [...] you need to go out with only 35 litres of fuel [...] and this can be done."

Using this example from the other side of the world these experts linked ploughing with the risk of seeing French farming and farmers disappear in the long term, victims of economic competition from other farmers who had already understood they had to dissociate themselves from the practice of ploughing.

Environmental risk

Just as much as they stressed the economic decline of French agriculture, however, the proponents of no-tillage also associated ploughing with an ecological decline whose effects could already be felt, according to them. With slides to support them they showed soil erosion and ravining and using figures whose scale showed the extent of the predicted catastrophe, experts denounced the damaging effects of this practice for soil conditions in France and the world more generally.⁽¹⁵⁾ One of them put it like this in a lecture:

"There is an ecological dimension, and not just in France. I would say it is global. [...] Soil erosion is an extremely serious problem. In 6,000 years of agriculture we have created two billion hectares of desert, one billion of which was in the twentieth century. [...] Every year ten million hectares disappear from agricultural use. Erosion due to the intensification of agriculture increased by an average of about one tonne per hectare per year. Every year you lose another tonne. Thus France in the 1980s lost twenty tonnes of soil, in the 1990s thirty tonnes, at present we will soon exceed forty tonnes."

(15) One can draw a parallel with another dynamic of withdrawal, namely that driven by public health policies to encourage people not to smoke: the placing on cigarette packs of pictures of diseased organs borrows from the same process to make the consumer see the perils to which he is exposed through his practice and his use of the object to be "withdrawn."

Farmers in the audience were also being directly associated with the ongoing disaster, being addressed in the second person plural as “intensive” farmers of the twentieth century. While ploughing in the popular imagination is traditionally associated with seeding and fertility (Brunhes, Delamarre and Haudricourt [1955] 1986), it is associated to the lexical field of death, and destruction. Farmers thus say:

“Ploughing kills it [the soil] but you only see it afterwards.”
“It harms the land.”

Experts are also trying to associate, rather than overlap, economic and environmental dangers. In other words, to reduce erosion, is also to save money, as highlighted by the microbiologist:

“Currently you lose thirty tons of soil per hectare per year. If you take an average price of 20,000 francs per hectare, you lose roughly about 150 francs per hectare in soil capital. That really is not included in the farm accounts.”

Seguy and Bourguignon are involved in quantifying the effects of ploughing, and especially the impact of ploughing on the soil and incomes of French farms. Indeed they have published research (Séguy, Bouzinac and Quillet *et al.* 2003), highlighting positive effects that are much greater than those measured by the French Ministry of the Environment and INRA, and contributed actively to the development of controversies around the subject (Goulet 2008). But these experts go beyond the fact of referring to the figures, to effects that are observable *a priori* by farmers in their fields or their accounts. They also touch on dimensions of identity, on the frustrations and suffering felt by farmers in the image they have of themselves and their profession. In effect they associate ploughing with the spectre of the farmer-polluter, a figure denigrated by French society in the 1990s following pollution scandals of agricultural origin, such as nitrates in water. These scandals and the media coverage they received have in fact greatly harmed the occupational identities of the farmers, as has been shown by rural sociologists (Lémery 2003). The imposition of environmental standards and public recognition of the principle of multifunctionality were perceived as a social stigma (Laurent and Rémy 2004; Miéville-Ott 2000). Therefore, faced with the representatives of one of the groups in the profession most affected by these crises, namely grain farmers, experts have advocated the abandonment of ploughing as a way out of this plight. It is thus a matter of making ploughing something “undesirable” and making no-tillage “desirable,” particularly by emphasizing the symbolic benefits that farmers will reap from this. During a lecture an expert stressed that:

“You will pollute less, and therefore consumers will be quite happy with this change in farming practices.”

The discourse of no-tillage practitioners thus borrows from the repertoire of environmentalism, placing the soil at the heart of a civic world (Boltanski and Thévenot 2006) and a new definition of the farming profession that

breaks with the productivist and intensive one that symbolizes the systematic recourse to technical objects such as the plough. As a Breton farmer said:

"I work to keep my land in good heart, I work to feed humanity, and to protect the environment."

The risk of failing to act

Finally, the destroyers of ploughing associate this practice with a rural world and a farming profession that would be marked by a failure to act (*immobilisme*), confinement within tradition and other forms of resistance that hinder moving forward and innovation. The pioneer farmers of no-tillage take as evidence of this the fact that giving up ploughing has made them deviants in their socio-occupational environment, that comprises in their view advocates of ploughing firmly attached to retrograde technical standards. Some of them stress that:

"They won't accept that you can do this sort of job. [...] Out of ten who plough, there are two who understand what you are doing."

"They treat us as if we were no longer farmers."

By making ploughing a symbol of a backward and conservative French farming, they make no-tillage into an agriculture of the future, already being practiced in Brazil, the birthplace of direct-seeding; thus the soil microbiologist declared in a lecture that:

"From the moment when countries develop them you cannot stay outside this green revolution, you cannot stay in your little corner and continue to practice an outdated form of farming, while there are people who have a twenty five years start over you [...] the techniques I have told you about are already being carried out on 16 million hectares in the world."

Thus the proponents of no-tillage extend the list of entities negatively associated with ploughing, including those agricultural research and development bodies they also deem too unwilling to act and conservative. As we have said, these latter have made little contribution to the introduction of no-tillage in France. The defenders of no-tillage thus associate ploughing with a research and development system that is a prisoner, like those farmers who plough, of a standard and a tradition, and that is in particular disconnected from the real needs of innovative farmers, shut up in its laboratories and experimental stations, and thus cut off from experience in the field. On its internet site the FNACS thus claims to be:

"Born from questions posed by a handful of farmers who were not satisfied by all the answers given by 'official' bodies, ITCF,⁽¹⁶⁾ Chambre d'Agriculture, and who were particularly concerned by the ignorance of these organisations about how farming soils work *in situ*."

(16) Institut Technique des Céréales et des Fourrages [Technical Institute for Cereals and Forage Crops, funded and run by farmers] (now Arvalis).

So it is what they see as a failed techno-scientific system that the proponents of no-tillage associate with the practice of ploughing. The soil microbiologist (Bourguignon) who had previously worked for INRA, joked about it and located himself between farmers and the agricultural research organisations:

“I’m a soil microbiologist. My background is a bit special, because I was at the ‘Agro de Paris’ (Institut National Agronomique Paris-Grignon), and at that time the third year speciality was ‘soil microbiology.’ It’s a course that was stopped in 1986. So it’s great, I haven’t had any competitors who have come on the market for fourteen years.”

He associates INRA with a failure to act and a conspiracy, putting himself on the side of the interests both of farmers and the land.

Thus in a documentary film released in 2005, he says:⁽¹⁷⁾

“We left INRA, we started up on our own account. Because when we started to show that the soils biologically die, we were asked to keep quiet. We left the Institute and we started up on our own account, because it was felt that our duty as scientists was still to alert the agricultural world that the path that was chosen was not good. [...] There can’t be sustainable agriculture unless it is on living soil.”

Finally, it was the failure to act by those selling agricultural machinery that is associated by the proponents of no-tillage with ploughing—these actors were resistant, so they say, to no-tillage because it would mean their sales of ploughs, other machinery for working the land and tractors would be reduced. Ploughing and agricultural machinery more widely are associated with the commercial interests of the agricultural equipment industry, which would limit the capacity of farmers to innovate, and help to impoverish them.

The construction of a passage point to avoid

The work of detachment thus involves the aggregation of a multitude of allies around the entity aiming to make it increasingly intolerable in the eyes of the actors concerned. In this work of detachment the proponents of no-tillage interpose themselves at the centre of old attachments, by associating ploughing with all of the threats facing farmers and society: they make it into a *passage point to avoid* (PPA) for actors if they want to survive, thus weakening the structural tie which connected them up to the present. The term centrifugal associations is used to describe how they tie the PPA to entities placed at the periphery of the network, because they are negatively charged, freeing up at the centre of the latter a place that was hitherto part of the structure. During the course of this stage the experts effect a re-framing, a significant re-translation that aids detachment: this involves showing farmers that what they are really attached to is not ploughing, but high yields, productivity and competitiveness, and good management of nature and their soil. Thus on one hand proponents sketch out a sociotechnical network that involves ploughing, the plough, the backward-looking farmers who plough, a static France,

(17) *Alerte à Babylone*, by Jean Druon. Culture Production, 95 minutes, 2005.

its agricultural research and development bodies, those who sell ploughs, and degraded soil. On the other hand they form a new assembly in which ploughing has been detached by associating direct-seeding, inventive and autonomous non-ploughing farmers, an innovative France, Brazil, a science that is close to innovative farmers and citizens, and especially soil filled with earthworms and other living beings. The PPA is not a negative definition of the obligatory passage point (OPP) proposed in Callon's sociology of translation (1986). The *OPP* was defined structurally as a node articulating several networks that were otherwise not connected. Instead, the passage point to avoid (PPA) particularly stresses the existence of other possible passages, and is either another alternative passage point, or a multiplicity of paths in a highly meshed network. In the present case the PPA is a structural node of the sociotechnical network, in a central position, which is made to disappear and whose particularity is that in no event should the other entities be tied to it.

Strengthening links by making pre-existing entities visible

The second mechanism at work in the process of detachment is one that renders visible certain entities that were hitherto dumb or invisible, in order to reinforce the ties that associate them with actors. In the field of no-tillage, two major types of entities are thus made visible: soils and the other living beings that inhabit them, whose activity is related with the functions performed previously by ploughing,⁽¹⁸⁾ and farmers' knowledge, rendered essential by their ability to meet the practical contingencies induced by the detachment of ploughing. The mechanism strengthening associations works largely by rhetoric, and by practices demonstrative of biotechnical processes, such as the impact of withdrawal on the proliferation of worms for example.

Making soils and their biological activity visible

An essential job for experts, the pioneer farmers of no-tillage and the agents of private firms is to highlight the importance of the soil and its biological activity for the success of no-till. They thus make the soil move from being a simple "support," as these actors commonly say, to that of being an agent in its own right of an agriculture that is productive and respects the environment. In their lectures and training-days, experts and other actors act as spokespersons for these entities, mobilizing the power of statistics and graphs to show for example, increased numbers of earthworms in unploughed soil, or through images of micro-organisms photographed under a microscope and projected on a screen. They explain the role of these beings in soil aeration, and the degradation of organic matter, and suggest to farmers what will

(18) Thiébaud (1994) points out that in the mid-1990s soil was—unlike water or air—an element of which there was low awareness in environmental politics.

happen in their fields if they stop ploughing. Thus the soil microbiologist remarks that:

“It will once more allow the epigeal fauna to reorganize [...] you will force the animals to replenish their galleries at the top and you’ll see that your capping will disappear, the water will again be able to get into your field, you are giving back to your soil porosity, and you will see again your roots of wheat will be able to go down more quickly.”

They brandish the figures whose scale is only the equal of an all-powerful nature, to make the farmers aware of the undreamed riches that until then had lain beneath their feet:

“Did you know that in a gram of earth there are from 800 meters to 1 kilometer of mycelium?”⁽¹⁹⁾

“Soils contain 80% of the living biomass on the Earth; earthworms alone are heavier than all other animals combined; a good soil in good heart is two tonnes of microbes to the hectare; microbes have a biochemical activity 350 times greater than ours.”

They deliver, specifically, what was up until now invisible because too small or underground. They always include, within training-days, observation of in-situ soil pits, and trenches dug in the field to observe the deep soil layers. Earthworms, their burrows, plant roots that de-compact the soil, so far unsuspected, are then revealed to the eyes of novices. A battery of tools is mobilized for this practice of observation and to equip the experts: spades, which can be used to dig holes, and knives worn at the belt, and used to clear the roots or clods. When farmers encounter these soil profiles it can be a moment of bifurcation in the detachment of ploughing, as a woman farmer remarked:

“It clicked for me. It was obvious [...] and I had not been able to see it before. He might well have told me ‘your plants, they work the soil instead of you having to do it’... I said ‘Well, that’s great, things are going well.’ And over there [...] It’s like suddenly believing in God, I just hadn’t seen it before...”

Sometimes even the microscope is called into action by the experts, to show farmers the infinitely small. In the documentary film referred to earlier, the soil microbiologist invites a farmer to inspect the soil in the middle of one of his fields, putting a clod of earth under the lens of a microscope. He asks him:

“Have you seen? No? You’ll see that it’s awesome! Look at it!...”

The experts stress the importance of soil organisms, notably through their ability to solve concrete problems that are or will be facing farmers abandoning ploughing. Thus the example of invasions of slugs, which are encouraged by the higher surface humidity of unploughed earth, is frequently mentioned in order to stress in counterpart the positive impact of no-tillage on carabid populations, a beetle that is a natural predator of the slug. Similarly, soil compaction and subsidence are discussed in order to emphasize the transitory nature of these problems because of the rapid growth of the earthworm. This soil fauna, highlighted as an essential aid for the no-tillage farmer, also

(19) Vegetative part of soil fungi capable of facilitating the degradation of organic material or to increase the efficiency of the absorption of water and nutrient by plants.

becomes central to the specific iconography of no-tillage collectives. The logos of organisations such as FNACS, NLSD or the specialist magazine *TCS* use images of earthworms equipped with spades digging up the earth and wearing university graduates' hats. Biodiversity of the soil surface is also represented through game animals, since maintaining permanent cover promotes breeding areas in fields.⁽²⁰⁾ Usually visualised as the image of a nature to be conserved, and protected by binding measures, they are presented here as replacements for the plough, focused on production and effective action. Thus the microbiologist tells farmers that:

"If the fauna and microfauna are working instead of you, you will be economizing on fertiliser, they'll be sorting it out, and also they'll be working for nothing, every day of the week—and they never go on strike."

A farmer also states:

"Biodiversity is an environmental thing, but one that works for us."

From being an unknown entity confined underground or invisible to the naked eye, soil life becomes a support for production and the visiting card of no-tillage for its practitioners. Why not then experiment with giving up ploughing, when all the components for its success are already there, all together and under the feet of the farmer? As one of them says:

"My soil which was dead has been brought back to life, and erosion is over [...] I've even learned that there were bacteria that were there in nature, which are now present in my soil."

Whilst until now ploughing was an obligatory passage point towards production, the proponents of no-tillage have shown that in the end it is only a possible one amongst others, that farmers can sustainably give up. Through these disassociations and ways of making things visible, they have re-drawn the map of sociotechnical arrangements: they attempt to make previously discrete entities (earthworms) hold a position of structural equivalence (White 1992) to ploughing and as solidly tied as this was to the success of harvests and of farmers. Yet the experts are clear on one point: these new allies will only be effective over the long term if there is no re-attachment to ploughing, if the broken ties are not re-made. They stress that any return to ploughing, even if occasional, would mean the loss of the benefits that have been acquired in terms of biological activity and sending both farmers and their soil back to zero. A choice has to be made between these two passage points, ploughing or earthworms, because they will not be able to co-exist.

Making farmers' knowledge visible

Both defenders and practitioners of no-tillage stress that nature does work unaided: the farmer is there to manage it, understand it and thus better direct

(20) By the end of the 1990s representatives of local hunting organisations and of the state body regulating hunting (Office National de la Chasse et de la Faune Sauvage) appear to have quite rapidly become involved within BASE in Brittany.

it. No-tillage will thus not be possible unless the farmer confronts the unknown, and the unpredictable and mobilises and develops the skills and knowledge that the proponents of no-tillage try to make visible. Their work is carried out by a distancing of a research and development process considered static and resistant to innovation, and by the demand for a break with a model of innovation that would have reduced the farmer to the passive role of “adopter.” This time the farmer is placed at the forefront of innovative actors who are holders of knowledge, as the soil microbiologist argues by referring to direct-seeding in a publication: “For the first time in the history of agronomy, farmers are ahead of agronomists, and it is from this base that the agriculture of the future will emerge.” (Bourguignon 2002: 9).

Thus both proponents and practitioners of no-tillage contest the model where the farmer is only an underling: they criticize “push-button” systems, the “prescriptions” that they have been given by prescribing technicians and advisors. The abandonment of ploughing has a political dimension for them,⁽²¹⁾ it is “taking back power for the farmer,” where he “is once more master of his farm, and really takes up his role as decision-maker.” They underline the capacity of farmers to innovate, to produce a knowledge which, like that about soil organisms was already available but unrecognized. The president of the BASE association stresses that:

“Innovation comes from the farmers. It always came from farmers, but before now we didn’t know that.”

and adds:

“They’ve sold us so many solutions... the solutions are in people’s heads.”

But over and above an assertion of their identity in response to the malaise described by rural sociologists, this emphasis on the renewed role of the farmer is based on a pragmatic justification for the changes brought about by the abandonment of ploughing in the conduct of action. Indeed, beyond the loss of landmarks and routines guiding their action, the withdrawal of a practice that artificialises natural environments such as ploughing helps to open up the expression of the specific features of these milieux, and thus require increased localization in the knowledge of the operator. The figure of the farmer as decision-maker then becomes central—based on his ability to observe, to draw conclusions and to create a situated system of reference. The “ready-made solutions” that have been criticized are replaced by the unexpected, the unusual and creativity, as highlighted by a direct-seeding practitioner:

“Everyone needs to build their own system.”

Making visible entities that were hitherto present but unobtrusive is essential to detachment mechanisms, that are close complements of the first stage that involves making the entity to be withdrawn a passage point to avoid. The

(21) On the political dimension of the innovation concerned, either for farmers with this assertion of identity, or for agro-industrial firms and the instrumentalisation of the environmental aspects of no-tillage, see Goulet (2010).

withdrawal of ploughing, its disappearance from the sociotechnical network, leaves the field free for those entities made visible, and to the reinforcement of the associations that tie actors together. In other words detachment involves the identification of new, alternative passage points, even of a new obligatory passage point. In return, it is the making visible of these entities and their presence, their ability to express the action they describe, that makes it possible to create lasting dissociations and avoid a return to ploughing and the plough.⁽²²⁾ For practitioners, making them visible lays down a base for a new operating scheme for action, secured within demonstration of concrete examples, evidence from farmers and of scientific work demonstrating their operability. The operating scheme also appeals to the imagination, conjuring up an image of an all-powerful nature and a capable farmer, master of his milieu. Making farmers' knowledge more visible, beyond that of the objects of nature, thus helps to give farmers the feeling of at least a subjective controllability over the new system.

But where our own case study is concerned a point still remains to be clarified in understanding the mechanisms of detachment. If, as we mentioned, the dynamics of dissociation have been inadequately scrutinized until now, this does not mean that we can ignore the remaining associative mechanisms beyond those of the centrifugal association. Withdrawal of an artefact (the plough) can as we have stressed be accompanied by the introduction of new artefacts (drills, herbicides), and it is therefore important to highlight the ways in which withdrawal and reduction, dissociation and association, detachment and new attachments all cohabit.

Association of new entities

In parallel with making other entities visible, the introduction of drills and herbicides have made a dissociation between ploughing and farmers a possibility without compromising crop yields. Without them no-tillage would not exist, let alone direct-seeding, for otherwise it would be at risk of seeing the field overgrown by weeds and being unable to sow through the covering vegetation. The agricultural equipment and agrochemical firms associated with these entities have thus been very active in making their products into essential objects through various processes. And, beyond these "original" objects and their firms, others have gradually joined the no-tillage network—fertilizer companies promoting the mineral fertility of soil, preparations with which to sow soil fungi, pesticide sprayers, low-pressure tyres limiting the impact of tractors on soil structure, etc. Events such as the "Festival Annuel NLSD" [Annual Festival of no-tillage and Direct-Seeding,] and the advertising pages of the specialist journal *TCS* thus bring to light the cohort of

(22) In the case of detachment vis-à-vis objects or loved ones, Hetherington (2004) highlights, rather than attachment to new objects, the creation of rituals of irreversibility (substitutes, alternatives for and sublimations of the entity which is being detached).

entities with an interest in no-tillage that their spokespersons seek to associate with farmers. Some firms have become especially prominent, particularly through the associations they have built with the experts who are proponents of no-tillage. Thus the Brazilian manufacturer of direct-seeding equipment Semeato came into the French market in the 1990s because of its close relationship with Séguy, the agronomist working for CIRAD in Brazil. While the latter considered the marque to be the “Mercedes of direct-seeding drills” he became, as a result of his experiments, a central actor in the annual trips to Brazil that the firm organised for its French customers. Similarly the firm invited him to France to give lectures, as in much the same way various businesses associated themselves with Bourguignon by inviting him to help their customers.

It is also through the marketing and advertising route that firms try to interest farmers by combining various rhetorical themes in their slogans. For instance one Argentinian manufacturer of seed-drills addressed French farmers by using economic and ecological themes in its advertising—“economise and avoid global warming”.⁽²³⁾ Seed-drill and sprayer manufacturers play on the productivity and performance of their products, striking a sensitive chord with their customers on large cereal farms. One German manufacturer prides itself in an advertisement for having sown “98 hectares in 24 hours with a 3 meter drill,” while a firm making sprayers highlights for its part, the “world ground spraying record: 102.57 hectares in 1 hr 14 mins 14 seconds.” Finally, most of these firms also focus on the advice they are able to provide to farmers, on an expanded after-sales service that will compensate for the lack of expertise of the classical actors in agricultural development about no-tillage. Monsanto emphasises, for example, in the publicity leaflet for *Roundup* that it published in the first issue of the journal *TCS* in 1999, the help and technical advice that it intends to supply to farmers.

Thus the proponents of no-tillage, and especially agricultural supply firms, try to build and reinforce associations between practitioners and a variety of technical artefacts. They develop discourses, services associated with objects aiming to place the latter in the common practice of practitioners and socio-technical networks of no-tillage. These promotional operations of new objects involve making their common practice an inevitable consequence of the process of withdrawal, together with soil fauna and farmers knowledge that are made visible.

Making some entities and relations invisible

All of the ingredients are now there to make the detachment of ploughing effective. Actors are convinced *a priori* that continuing to plough would be

(23) Reference is made here to the reduced consumption of fuel and thus of greenhouse gas emissions, as well as carbon sequestration in soils that will in due course allow direct-drilling associated with permanent living soil cover.

against their interests but also that the conditions are now ripe so that crop-farming without ploughing will “work.” Study of the relational chains and discourses reveals, however, that a fourth mechanism comes into the detachment process. The originality of the detachment process within the heart of innovation by subtraction occurs through, as we have mentioned, the construction of the PPA and the organisation of the network around a structural node which owes its status not to the fact that the other entities are tied, but rather to the fact that they in particular are *not* tied. This fourth mechanism consists of making undesirable entities and associations invisible, such as for example those between herbicides and pollution, or between firms and the commercial exploitation of farmers. It helps to maintain the coherence and meaning that actors construct around withdrawal. Some entities such as those mentioned above (seed-drills, herbicides, firms), are indeed categories of actors or objects that had been convened centrally at the centrifugal mechanism of association. Actors then try to dissociate themselves from them, to put at a distance techniques and salesmen because of the damage they cause to the environment and the rural world. Ploughing, the plough and the people no-tillage farmers call “scrap-metal dealers,” then become seen as spokesmen for the categories to be avoided. How then to be associated with these entities without chaos and contradiction ensuing, without having to reverse, and by maintaining the established dissociations at least on a rhetorical or symbolic level? Maintenance of this balance proceeds through a process of rendering invisible these entities and associations by the different actors mobilized around no-tillage. Firstly, farmers minimise their importance in their practice and in the factors helping no-tillage succeed on their farm. The seed-drill is thus considered to be just one part of the action which cannot in any case be playing an essential role. As one farmer stressed:

“What’s important is not the machine or the make. Doesn’t matter if it’s blue, red, or green, it’s what you do with it that counts.”

What counts from now on is the practice and the experience of the farmer, his creativity and his ability to diagnose what is going on in his own fields. The seed-drill, as the bearer of a script that would align the practices of farmers on knowledge from outside, may hinder the process of making more visible the development of the farmer’s own knowledge. As for herbicides, farmers stress their own efforts in optimising their use (precision spraying, more sophisticated choices of application conditions) and state that they use them no more than when they were ploughing and less nowadays than their neighbours who continue to plough. It is better to keep well away from the risks that these technical objects may produce for the environment, health, or the image of farmers in society. Although within the same class of objects as those of the PPA, these indispensable objects which are so important for the process are rendered invisible in favour of other natural entities more in tune with the way in which actors wish to define no-tillage and their profession, for themselves as for others.

Those firms that design and produce these objects take part in the work of rendering things invisible on both a practical and a discursive level, by trying

to give themselves a low-profile in the eyes of both farmers as the general public. We should recall the fact that they are part of a category of actors associated with a failure to change, who could prevent farmers from advancing and innovating. Yet they, and the technical objects that they design, nonetheless manage to play a role alongside farmers in the detachment that is at the core of innovation through withdrawal. How then can they at one and the same time be both criticized and in a close relationship with the actors practicing and advocating withdrawal? The strategy used by the Brazilian firm Semeato is instructive for analysing this phenomenon. Today the firm is very clearly positioned at the leading edge of no-tillage, which is direct-seeding. It highlights the minimal and very localized impact that the seed-drill has on the soil when sowing, causing just a slight disturbance making it almost invisible against the marks it makes on the earth. The firm also attaches central importance to the experience of its customers, promoting trips, horizontal exchanges between peers and other links through making them feel part of a community, during its one-day meetings. The work of organising these “communities of practice” (Wenger 1998) is part of the passing-on of essential support to practitioners involved in no-tillage innovation, as additional subjective controllability of the system initiated with the process of making soil entities and knowledge more visible. This time this controllability has to be made more effective: the firm provides cognitive resources and helps in their circulation to define new benchmarks and support for action. The company also chooses a specific mode of penetration into and presence in the market for seed-drills. It is not represented by conventional farm equipment dealers but by a few farmers who are themselves practitioners of direct-seeding and licensed users of the marque. Between these farmer-salesmen and their peer-customers, the market relationship is thus diluted in a relationship of cooperation and advice where the immaterial and the ideal take precedence over the material and the market (Goulet 2011). The firm, through its farmer-salespeople, is working alongside the farmers in a common struggle against the same threats, for the same achievements. Whether this be at the level of the impact of direct-seeding on the soil or the relationship with farmers, the seed-drill and the firm are thus rendered invisible, allowing free rein to entities such as the soil or farmers’ knowledge.

The mode of action of agrochemical companies is also based on this principle. This is first of all to work on making the impact of their herbicides on the soil invisible, like that of the seed-drill manufacturer, and in order to do this to be involved in the production of discourse and knowledge to establish their safety. Thus, but sometimes with only limited success, the American firm Monsanto has tried to demonstrate the harmlessness of glyphosate on the soil, the environment and human health.⁽²⁴⁾ In another context the Swiss firm

(24) There has been great controversy in France and other countries over the safety of glyphosate and its derivatives for groundwater quality and human health. In France, the Cour de Cassation [High Court] in Lyon found Monsanto guilty in October 2009 of false advertising which stated that *Roundup* is “biodegradable” and “left the soil clean.”

Syngenta developed devices for producing and disseminating knowledge demonstrating the positive impact of no-tillage on soil fauna populations.⁽²⁵⁾ In its advertising strategy the American firm is also working, as we saw in the previous section, to highlight the knowledge and advice that it proposes to provide to farmers, instead of and in place of herbicide as such. It also tries to make itself more unobtrusive by both financially and logistically supporting organisations that promote no-tillage, and helping to build up around them the image of a movement started and led by innovative farmers. Thus an environmental expert employed by the firm to aid in the development of no-tillage in France was, until 2011, Secretary of the regional association BASE, of the national association APAD and the European conservation agriculture federation (ECAAF). One of his roles was to help in the promotion of this innovation in many public, political and scientific events, in every case as the representative of these organisations rather than as an employee of the firm. When talking to the researcher, however, he emphasized his individual commitment and the “intellectual approach” which guided this action in support of farmers. Through this self-embedding strategy (Dibiaggio and Ferrary 2003), of making its herbicides as well as itself seem invisible, the firm strives to build an image around no-tillage of a rising and ecological innovation, associating natural objects and practical knowledge of farmers. Through this work, agricultural supply firms produce a discourse and a strategy in which they define themselves as detached actors, alongside other actors in the innovation process.⁽²⁶⁾ Indeed the network is an association of no-tillage, non-backward and non-polluting farmers, experts and scientists who are not isolated in their laboratories or agricultural research stations, and the staff of non-polluting and non-market firms, of non-degraded soils, all mobilised around no-tillage farming.

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The contribution of this research lies in the analysis that it generates of dissociation mechanisms at the core of the innovation process, and its contribution to the wider field of sociological research dealing with processes of detachment. It leads us to confirm the hypothesis put forward in the introduction, that the power of an innovation is based as much on the sturdiness and quantity of ties that are broken as on those which are woven by the actors. It thus invites us to postulate the importance of a third principle of symmetry

(25) The film *Perdreaux et quintaux* [Partridges and Quintals,] financed and produced by this agrochemical firm, was awarded the first prize in the category « Agriculture-Environnement et Biodiversité » in the AgriCinéma festival in 2007 of the Salon de l'Agriculture de Paris.

(26) In this regard, several authors in France

(Goulet 2010) and in the Americas (Hall 1998), have emphasized the public relations strategy deployed by agrochemical companies around no-tillage farming to help “green” their image, at a time when they suffered from a negative perception among the public about the impact of their activities on the environment.

which is based on the analysis of sociotechnical innovations: that equal attention is given to successes and failures, to humans and nonhumans, but also to associations and dissociations. Thus, rather than being the identification of a new category of innovation that is ontologically different from those already identified and studied by sociologists, the concept of innovation by withdrawal and the examination of the dynamics that it involves, contributes (in the light of the no-tillage case-study) to an enrichment of the approach developed by sociotechnical analysis and the sociology of translation. Indeed the case of innovation by withdrawal highlights the more general importance of mechanisms of dissociation and detachment, against the better-known ones of association, intersement, enrolment and mobilisation. We have shown that detachment is first of all the outcome of interposition, produced by those undertaking the innovation at the core of existing associations that tie the entities to be withdrawn to the actors. By a centrifugal process of association and retranslation of the fundamental interests of these actors, these entities shall be made undesirable and become passage points to be avoided (stage 1). They structure the process in an original way so that the new arrangement is built around their distancing, from their desired withdrawal and their absence. Their importance lies in this organised disappearance, in this ousting.

This is reinforced and perpetuated by the reinforcement or the construction of pre-existing or new associations. Hence the making visible of entities and their properties, the consolidation of their ties with actors (stage 2) but also the introduction and association of new entities next to them (stage 3) creates alternative passage points for the withdrawn entities. But these associations, as well as the dissociations are made more or less visible by actors, in the context of practice or that of discourse. Some associations (stage 4) are displayed openly, others are kept more unobtrusive so that they will not compromise the dissociations that are undertaken. This work is carried out as much from a practical point of view, in order to ensure the operability of the new system for actors, as from a discursive and subjective point of view, by recording the changes made in the identities of actors and the debates that concern them. The demonstration of these mechanisms for making (in)visible thus shows that all of these points are not necessarily associated in exactly the same way within sociotechnical networks. According to their involvements⁽²⁷⁾ or trajectories, actors will give more or less to see some entities or associations rather than others. It becomes necessary to look further than the mechanistic logic of association and dissociation, to the meaning given by actors to innovation and to the question—a political one as we have seen—of detachment.

(27) The notion of the “involvements” [*enjeux*] within the meaning of what is important for an actor, makes it possible to dispense with the analysis of other sociotechnical networks to which the actor is attached. These involvements, however, can also be analysed as sociotechnical networks rendered inconspicuous by the actors, and yet, which concern them just as much. It is not necessary to leave the analytical framework proposed by ANT to switch to other approaches (e.g., systems and strategic analysis or neo-institutional analysis).

This position calls for attention to the trajectories of actors and to the collectives with which they identify, though not in contradiction to the principles of actor-network theory, despite the criticisms levelled at it on this point (Whittle and Spicer 2008). It means treating innovation and detachment not only from the point of view of these entrepreneurs and their capacity to manoeuvre (Mangematin 1993), but also that of the whole set of actors associated with the process, their practices, their strategies and the meanings they ascribe to events and words. It helps to show, in the case study chosen, that the withdrawal of an artefact becomes structural in the process because the actors themselves (experts, farmers, firms) make it a central element, according to the problematisations effected successively by one or other of the actors, and the strategic issues or identity they carry. The momentum of the innovative process relies on two relational chains (one linked to soil erosion and concern for their conservation, the other in search of cost-savings) brought into convergence within the rhetoric of a few actors advocating a return to nature in the soil and in farm work. This innovation process through “more nature in the soil” is translated by the actors into an innovation through “withdrawal of ploughing and the plough.” The equivalence between “more nature” and “withdrawal of ploughing” rapidly leads into a structuring of the problem around the second term of equivalence in the discourse of actors and the practices they introduce, which then becomes the focal point of all rhetorical and sociotechnical reconstructions.

Finally, this research is a contribution to the debate around the sociology of detachment. We have shown that innovation through withdrawal operates through mechanisms of association, of making visible and invisible, in which human actors are trying to describe themselves and to describe the recessed entities with which they interact. Through these associations and distancing processes, by the definition of each point in the sociotechnical network in terms of what it is not, and thus the performative construction of an “opposite” double, actors construct detachment by producing and relying on discursive, cognitive and material resources. Even if they do not mention the question of detachment as such, research on the prohibition of routinised and institutionalised practices has contributed to the study of this mechanism. Thus Maguire and Hardy (2009) have shown in relation to the prohibition of DDT insecticide in the 1960s that the activity of militant environmentalists involved de-legitimizing the substance on the three bases that until then had supported its use: a cognitive basis (produce and disseminate knowledge demonstrating it is harmful), a normative basis (de-legitimise its use at a moral and symbolic level), and a regulatory basis (mobilize decision-makers to enact laws that ban the product). If the centrifugal process of association that we have analysed overlaps to a large extent with this process of de-institutionalisation, we have shown however that with no-tillage withdrawal is not covered by this operation: detachment is also a process of construction of new associations and of making visible alternatives to make it possible to circumvent the passage point to avoid. This dimension has been anticipated in research by sociologists and anthropologists on bereavement, and the series of

ritual acts that are part of the detachment from the deceased and from objects (Hetherington 2004). Following a person's death, the "work" of bereavement involves a reorganisation of the relationship of those bereaved within their social and material environment, in which particular objects that belonged to the dead person or which represent them may take on increased importance (Caradec 2001). Actors also try to relate to immaterial entities (soul, spirit), based on belief, and with which they attempt to build a relationship because in some way they prolong the deceased persons' presence (Piette 2005). In other contexts such as the fight against the addiction and withdrawal of drug addicts, sociologists of drug use have shown that detachment involves attachment to other substances, which are substitutes for the earlier ones (Gomart 1999). The case of no-tillage farming sheds light on the importance, issues and especially the procedures that make absence less strong, either to make it bearable, or to avoid the reversibility of the process (a return to ploughing and everything that is positively associated with it).

Due to its similarities with the observations and analyses produced across a range of fields and objects of study, the research on which this article is based makes it possible to anticipate that the sociology of innovation will have the ability to contribute a sociology of detachment to the field. Conversely, in relation to the social and political slogans emphasizing the need to design innovations that contribute to "sustainable" development, and even reduce the risks associated with scientific and technological innovation, the prospects of a thorough analysis of the conditions of detachment also opens up new questions for the sociological analysis of innovation.

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