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Title: Ecoinnovations: a response to the Aquitaine wood *filière* irreversibility?[1]

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Summary:
The present communication aims at discussing the way ecoinnovations impact existing industrial trajectories. In particular, we focus on the question whether or not ecoinnovations may result in a trajectory's bifurcation. Indeed, industries in their current trajectories do develop some irreversibility. We thus question the way ecoinnovations might help overcoming this irreversibility and, from this reflection try to draw some conclusive remarks about policy implications. Our communication relies on a specific case study dealing with the attempt, on the *aegis* of the competitiveness cluster *Xylofutur,* to promote ecoinnovations within the Aquitaine wood *filière*. By putting the wood resource at the very heart of our analysis, our research highlights original features of the wood *filière* dynamics. We will show that this exclusive dependence has caused environmental irreversibility as well as strong spatial irreversibility.

[1] This communication is a derivative work, summarizing and extending some aspects of a paper "Sharing a common resource in a sustainable development context. The case of a wood innovation system", accepted for publication in *Technological Forecasting and Social Change*, april 2010 [1].

Introduction

France, with the *Grenelle de l'Environnement* [2], has recognized recently the accuracy of ecoinnovations. This concept refers to any whose aim, for the actor who implements it, is a "new" action, that is likely to become a process innovation, a product innovation or an organizational innovation, and that is developed in an *explicit or implicit aim* to reduce environmental pollution [3, 4]. These specific innovations seem now to be highly praised, as they are supposed to result in specific positive offsets, in terms of innovation and sustainability. This argument arises after a long period during which the concept did not enjoy any recognition, both from theorists and practitioners. On this topic, Porter and van der Linde [5] had once been pioneers, but their win-win hypothesis, stated in 1995, was most criticized than considered seriously. There is no doubt however that this argument certainly contributed to the society's change on this topic.

It is mainly argued that those innovations create positive externalities in the innovation's emergence and diffusion. Moreover, the diffusion of ecoinnovations seems always socially desirable, because of their contribution to the protection of the environment (except rebound effect); but in private terms they suffer from a lack of incentives and suitability. Hence, the important role of the regulation (in the broad sense) that compensates for the lack of incentives. The essential particularity of the ecoinnovations is that they are specifically sensitive to the regulatory context and to its developments.

The present communication aims at discussing the way ecoinnovations impact existing industrial trajectories. In particular, we focus on the question whether or not ecoinnovations may result in a trajectory's bifurcation. Indeed, industries in their current trajectories do develop some irreversibility. We thus question, though a case study, the way ecoinnovations might help overcoming this irreversibility.

This issue needs that the irreversibility concept be clarified, as it can have multiple meaning [6]. We will start with the statement that it means sensitivity to initial conditions. So, the irreversibility of a technological trajectory or of the trajectory of a territory expresses its sensitivity to their initial conditions. Irreversibility can be defined following three different lines. The first means that sensitivity to initial conditions has no specific impact in terms of performance or efficiency. The second highlights that sensitivity to initial conditions results in a negative impact which remediation cost is prohibitive. Following Williamson [7], the third type, which we consider here, adds to the second version the idea of "remediability". This concept highlights the existence of feasible alternatives devoted to the reduction of the negative impact and implying bifurcation of the existing trajectory. By doing so, Williamson highlights this concept as the most appropriate standard for public policy discussion. The bifurcation of the trajectory (*break out*) involves strategic behaviour of actors.

Our communication relies on a specific case study [8] dealing with the attempt, on the *aegis* of the competitiveness cluster *Xylofutur*, to promote ecoinnovations within the Aquitaine[2] wood *filière*. The French term wood *filière* is used here in the acceptation used in [9]: that is to say an interactive value-chain, from upstream to downstream, between the different sub sectors of forest-based industries including forestry, wood and paper industries. Since 2005, the 'competitiveness cluster' policy has found there grounds of application, with the emergence in

[2] Aquitaine is an administrative region of South-West France.

2005 in the Aquitaine region (South-West of France) of the IPMF (*Industries et Pin Maritime du Futur* [3]*)* cluster. IPMF became involved in the implementation of ecoinnovation projects. Thus the Aquitaine wood *filière* gives a particularly relevant example of the application of the previous issues.

The wood *filière* is a complex subject of studies that requires a systemic approach, in order to understand all its dimensions. A system is a set of elements: actors and institutions, interacting with specific links: market relations, cooperation but also conflict relations. This system consists of an organized set of key products which depends on a set of upstream and downstream industries, and which is also characterized by a common dependence to the woody resource. This systemic framework is relevant because it enables to underline and federate the effects of developing ecoinnovations within a system that is heavily reliant on a common resource.

Thus the wood industry has formed around dependence to the local wood resource (maritime pine), which has induced an environmental irreversibility. This dependence on the resource is coupled with a dependence on a territory, *Landes de Gascogne*, a specific area of Aquitaine region. The Aquitaine forest massif is therefore subject to a spatial irreversibility. This finding of a double dependence results in some irreversibility hampering the development of the Aquitaine wood *filière*. This finding will orient our research question. These ecoinnovation projects represent all the disruptions that impact in various ways on the system and that are likely to affect its boundaries and its performances *via* the dependence of the actors to the common resource. We thus question the way and to what extent those ecoinnovations can cause bifurcations in the *filière*'s existing trajectory.

The data were collected through a specific survey. Our investigation was conducted through 56 semi-directive face-to-face thorough interviews with the main actors of this wood *filière* (companies, research laboratories, intermediation bodies) involved in these projects. We have completed the analysis, by interviewing 10 experts of the *filière*, from regional or national organisms in charge of the financing or the implementation of norms in the wood industries.

Our communication begins with a first section showing the way the Aquitaine wood *filière* is dependant on the wood resource and on the territory. This section analyses the effects of this double dependence on the configuration of the filière's system. The second section shows that ecoinnovations create a disruption on the system. They are intended to result in virtuous positive offsets, highlighted by the interviewed actors. However, they show insufficient to create a *break-out* and a bifurcation of the filière, as the impacts of ecoinnovations are uncertain along different criteria, notably sustainability. Finally from the preceding reflection, we try to draw some conclusive remarks.

1. The Aquitaine wood *filière*, dependent on wood resource and territory

In Aquitaine, the wood *filière* is based on the exploitation of one of the greatest cultivated forest in Europe, a forest that is certified for its environmental management[4]. Despite the fact that this *filière* represents a classical example of an interactive upstream to downstream network of

[3] This denomination meant: Industries and Maritime Pine of the Future. Since 2008, this pole is called *Xylofutur* (for more information, see: www.xylofutur.fr).

[4] The PEFC(Program for the Endorsement of Forest Certification schemes) forest management label is based on criteria defined at interministerial conferences (Helsinki, 1993 ; Lisbonn 1998 and Wien, 2003).

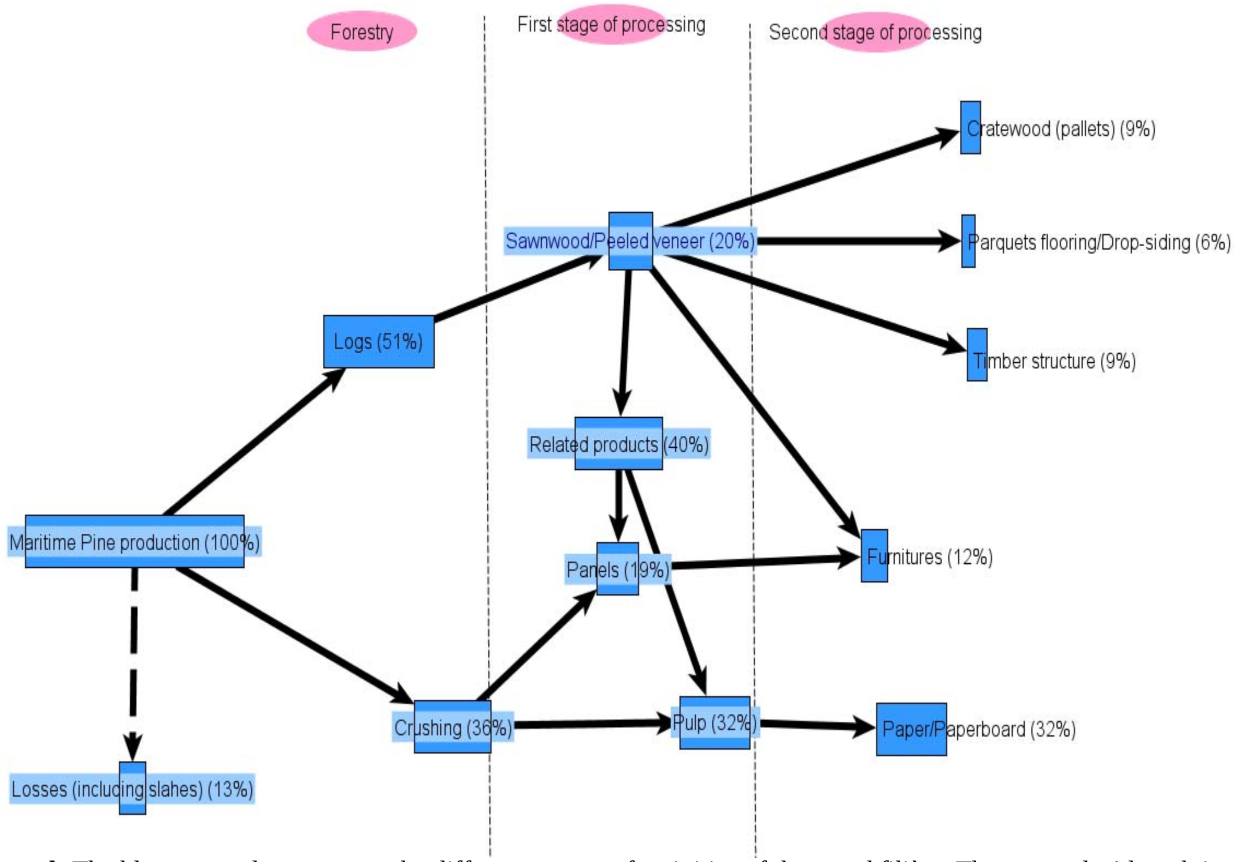
technical and contractual relationships, those relationships are strained by conflicts of interest among segments in a context in which it is difficult to implement concerted strategies.

1.1. The stylized features of the *filière* as a result of an acquired trajectory

1.1.1. A territorialized filière, suffering from segmentation and lacking competitiveness

Aquitaine is the first forest region in France and its forest cover is a lot bigger than the one of the entire France; that is to say 43% for this region. The 2009 storm severely damaged this potential as the figures assess the devastated volumes to a third of the potential of the massif. The industrial local improvement of Aquitaine massif's forest products essentially composed of maritime pine[5] species, enables to maintain 1.7 million ha [11]. Thanks to the economic activities that finance their management, maintenance, and protection, the Aquitaine forests are a major asset for tourism and quality of life in the region. The wood *filière* employment, spread out on the entire territory, represents a major contribution to the economic activity in rural areas.

<u>Graph 1: The wood *filière*</u>



Legend: The blue rectangles represent the different sectors of activities of the *wood filière*. The rectangles' length is proportional to the quantitative use of maritime pine resource (according to the assessments of Pajot [12]). The rectangle named "maritime pine production" corresponds to 100% of the resource, and the pulp industry uses 32% of this local production of maritime pine. The percentages of the used resource are indicated in brackets within the

[5] According to Agreste [10], in 2006 the maritime pine represented 70% of the standing wood volume.

rectangles. The black arrows represent the links (through the resource use) between the different sectors of the industries.

All these characteristics make the resource constrained in terms of geographic extension and production potential. The storm extended those constraints. We will see later how the ecoinnovation projects, impulsed by the actors, are likely to outcome these limits.

The wood *filière* includes a heterogeneous variety of industries and jobs covering the first and the second stages of timber processing, beyond forest and forestry activities. These two segments respectively group together for the first stage of processing: sawmills, panel and pulp industries. For the second stage of processing: frames and joinery works industry, manufacture of wooden containers including pallets, furniture making and stiff paper. In the Aquitaine region, the activities of the first and second stages processing are located on the same territory, which is generally not the case for the French forest massifs. There are strong interactions between the *filière* sub sectors. These interactions occur through the wood working and more particularly through the use of related products stemmed from each of the steps throughout the *filière*.

The wood working represents a much divided activity which contribution to the added value and investment rates remains insufficient. This strongly contrasts with the stiff paper industry, which is dominated by the major groups and is characterized by massive investment rates and very high export rates. Within the wood working industries, the panel industry, which is more capitalistic, is the only one to have high performances. Finally, the furniture sector which is slightly active in Aquitaine and mainly composed of small companies is going through a deep crisis which effects are low investment, export and profitability rates. Until then, the forest-based industries kept a good competitive positioning both in France and in Europe, but at the international level the challenges are becoming more meaningful. It is showed through three medium: markets and technology globalization, competition of new materials and products, and finally the environmental pressure [13].

2.2. A fragile balance around the sharing of the resource

The woody resource is divided into the activities of the first and second stages of wood processing. As seen above, these activities constitute a heterogeneous set with different economic cycles, and that shows a diversity of uses. The wood *filière* is characterized by a strong geographic constraint because the forest resource overrides the location of the first stage of processing. The round wood is a heavy material with a weak added value especially because the maritime pine is a species that is difficult to value. As an indirect result of that, the location of the industries of the second stage of processing depends on this characteristic. The heterogeneousness of the technical and industrial needs has created in the past a lack of partnership culture that handicaps the actors today. Finally, most of the innovations are carried out by means of complementary competences whether the one of the mechanical, electronic or chemical industries.

The shape of the Aquitaine forest system is determined by the interdependence between the renewable forest resource, the different types of actors and their interactions. The resource sharing is done throughout the industries *via* a set of intersectoral links that can be seen through semi-finished products, finished products, residuals, and the activities of recycling or valorization of related products. The initial division of labor between constructional timber and industrial timber conditions the respective places going to the various activities. Generally, it covers the predatory behavior towards the resource of the panel and paper industries which consume a lot of pulpwood and residuals from the constructional timber industries (see graph 1 above).

The Aquitaine region has had until then an abundant resource that offers a potential advantage and its long term development. However, this factorial advantage has to be balanced as soon as the constraints in terms of value enhancement set by the maritime pine species are taken into account. This essence being heterogeneous, there is an organizational solution to the issue of this intrinsic heterogeneousness: there is an industrial destination to each quality of tree, and there is an outlet for each diameter from thinning to clear cutting [14]. As a result, it is difficult to modify the existing balances because the nature of the resource leads to predetermined uses that slow down and have slowed down the emergence of alternatives. In return, any processing that affects an element of the system is likely to affect its whole functioning. It also applies to the issue of actor's input/output: any input is important because it threatens directly the resources and the many outputs (head sawyers) are likely to experience a rebound effect in terms of insufficiency of related products derived from their activity. The different imperfections of the maritime pine (bad straightness, black nodes or pitch pockets) remain a major issue of the first processing. These constraints jeopardize the creation of added value usually expected from constructional timber and have in return an impact on the other industries.

In spite of the growth in forest production[6], the annual growth of the massif's forest production is totally absorbed by the local industry. As a consequence, the panel and paper industries see any new activity as a threat, particularly the ones that use pulpwood. For example, the pellet industry, which emergence could break the contractual equilibrium that has been patiently established. This system periodically generates tensions between the industries of constructional timber and the industries of pulpwood. These tensions appear as soon as there is a potential valorization of related products or deterioration in the wood quality.

2. Ecoinnovations: a partial response to irreversibility

In this context, the perspectives of sustainable development linked to the emergence of ecoinnovations are often put forward by the profession. The IPMF 'competitiveness cluster' enabled to materialize these subjects, especially through ecoinnovation projects.

2.1 EIs: a virtuous circle for the break-out

These ecoinnovation projects are presented on table 1 above. Spurred on by the 'competitiveness cluster', the introduction of new ecoinnovation projects enable to intensify the interactions among the local actors of the system, but also to open this system to other sectors and industries (see graph 2 below built by adding ecoinnovations to graph 1).

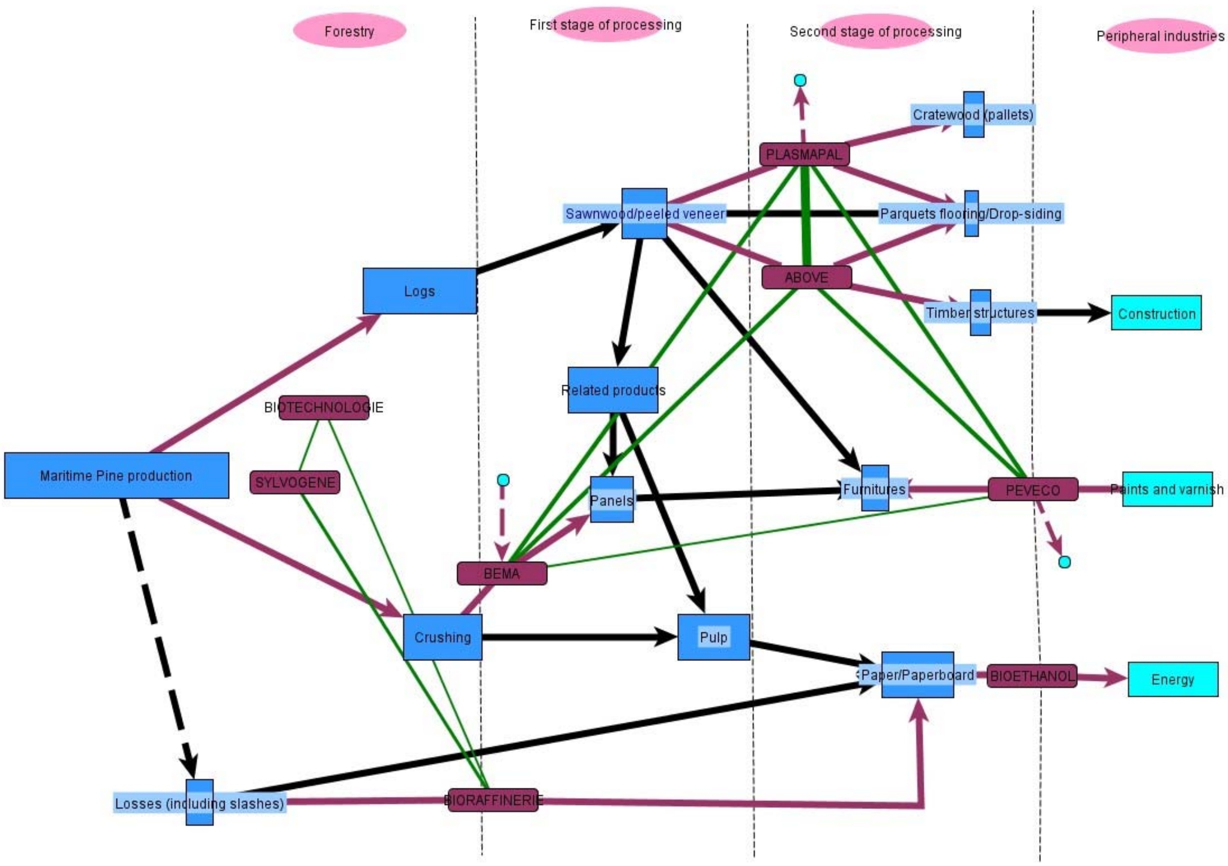
Besides the points of application of these ecoinnovations according to the sequences of the industries, graph 2 underlines the network of ecoinnovations overlapping the sectoral and regional networks.

[6] During the last four decades, the production of the forest has been multiplied by three, thanks to the use of fertilizers and to the genetic improvement of the pines.

Table 1 – Stylized features of the ecoinnovation projects

Project name	Actors : regional and sectoral dimension	Interactions across the projects	Interactions across the resource	Technology
Above	9 organisms : 6 small and medium-sized enterprises, 1 subsidiary of a major group, 1 transfer center, 1 lab, including 8 wood *filière* actors and including 8 Aquitaine region actors	Collaborative project	Strong dependence	Techniques of green wood lengthening by using wet wood gluing
Bema	10 organisms : 4 subsidiaries of major groups, 5 labs, 1 transfer center, including 7 wood *filière* actors and including 8 Aquitaine region actors	Collaborative project, exchange of equipment and staff, testing	Weak dependence (use of other materials)	Manufacture of sizes for biocomposites panels
Bioethanol	4 organisms : 2 subsidiaries of major groups, 2 labs including 2 wood *filière* actors and including 1 Aquitaine region actor and 1 international actor	Collaborative project, equipment provision	Weak dependence	Bioethanol and pulp production techniques: using a paper process for other purposes
Bioraffinerie	4 organisms : 2 subsidiaries of major groups, 1 cooperative, 1 transfer center including 4 wood *filière* actors and including 4 Aquitaine region actors	Collaborative project, pilot project implementation	Very strong dependence	Techniques of forestry and stump extraction, heat engines on fluidized beds(transfer of a Scandinavian technique)
Biotechnologie	3 organisms : 2 labs and 1 transfer center including 3 wood *filière* actors including 1 Aquitaine region actor and partnerships within global research networks	Collaborative project, staff exchange	Loosening of constraints on quantity and quality	Forest biotechnology
Peveco	5 organisms : 4 small and medium-sized enterprises, 1 lab including 3 wood *filière* actors and including 4 Aquitaine region actors	Collaborative project, studies and common testing, certification	No dependence	Manufacture of paint and varnish for wood: improving an existing process
Plasmapal	10 organisms : 5 small and medium-sized enterprises, 4 labs, 1 transfer center - including 5 wood *filière* actors - including 5 Aquitaine region actors	Collaborative project, exchange of equipment and staff	Strong dependence	Processing materials by cold plasma: transfer of another sector
Sylvogene	11 organisms : 5 subsidiaries of major groups, 1 lab, 1 technical center, 4 interface organisms - including 11 wood *filière* actors and including 10 Aquitaine region actors	Collaborative project, studies and common testing	Loosening of constraints on quantity and quality	Techniques of genetic improvement for maritime pine

Graph 2 : The ecoinnovations within the Aquitaine wood filière



Legend: The blue rectangles represent the different sectors of activities of the *wood filière*. The rectangles' length is proportional to the quantitative use of maritime pine resource. The graph of the percentages of the used of resource are indicated in bracket within the rectangles in graph 1.The black arrows represent the links (through the resource use) between the different sectors of the industries. The round purple rectangles represent the eco-innovation projects that we analyzed. The purple arrows represent the links between the different sectors of the chain and the research projects analyzed. The dotted purple arrows (and the light blue rounds) represent the eco-innovation projects analyzed applied to other materials than wood. The green lines represent the common partners between the different projects analyzed. The thickness of the lines is proportional to the number of common partners to 2 projects.

The strong congruency of these networks is partial. Firstly this is due to the fact that the collaborative projects integrate actors that are not involved in the regional network and the timber sector. And secondly, it is due to the fact that these projects are destined for uses that go beyond the *stricto sensu* framework of the forest-based industries. Graph 2 also shows that the ecoinnovation projects allow reinforcing the dynamics of the industries by improving the resource and intensifying the density of the interactions network between the actors and between the sectors of activity.

2.1.1. Ecoinnovations attempting to increase the value of the forest resource

As we can see on graph 2, these projects become integrated into the network of interactions constituted across the resource in the wood *filière*. Graph 2 shows the intensification of links between the different stages of resource processing through the actors. The links among actors will also materialize through the common participation to collaborative projects. However, these collaborative projects can take many different forms. The interactions within collaborative projects will indeed differ by the degree of formalization of exchanges and also by the type of support proposed to the interactions. It can be financial support, sharing of technical artefacts between the actors (for example in the Bema or Plasmapal projects), or exchange of staff, particularly joint supervision of PhD students or post-PhD (for example in the Plasmapal and Biotechnology projects). Finally, although all these collaborative projects integrate actors from public research and companies, some of these projects are rather orientated towards companies and applied research. Whereas other projects coordinated by public research laboratories, will be oriented towards more fundamental aspects.

The objective of all these projects is to increase the value of the woody resource, and therefore improve the dynamics of the *filière*. The objective of some of these projects is then to improve the resource on the upstream level, exceeding the natural constraints of timber while potentially increasing the amounts of available resource. Some downstream projects attempt to associate wood to less ecological materials in order to meet the new demands of the market, or propose more ecological new processing methods. Finally, some of these ecoinnovations aim at proposing new uses of the wood resource.

On the whole, the ecoinnovations add to the existing system and also contributes to its re-composition. As a consequence, the projects configure a multidimensional innovation system that is both territorialized and sectoral and also oriented by the technological and environmental dimensions. Both the implementation of the ‘competitiveness cluster’ and the internal dynamics of the wood *filière*, through the use of the resource, will then lead to an authentic process of coevolution. The development of projects will have an influence on the production of resources. The resource dynamics and the tensions that can exert on this resource will have in return an influence on the configuration and implementation of projects, as well as on the cooperation that can be created between the actors of the filière.

2.1.2. The creation and diffusion of knowledge

These functions occur through the constitution and organization of networks of actors, including the whole set of internal / external ones, or regional / non regional ones. The performances in terms of creation and diffusion of knowledge of the implemented projects do not materialize much in terms of patents. These patents are registered by actors belonging to other industries (chemical industries for example), which does not break with the tendency of the sector’s long period. On the other hand, the projects have or will lead to publications in academic reviews, in various subjects and not only wood science reviews. These are strong characteristics of the wood *filière*, such as the leadership of academic laboratories. However, contrary to what was happening in the past, the industrials – small and medium companies and even the very small companies – are now strongly involved in research projects. According to the actors themselves, working methods are progressing and this indicates an advantage that can be apprehended in terms of organizational learning processes, particularly because the collaborative practice enables to reveal unexpected interactions and becomes a source of unknown knowledge.

2.1.3. An answer to market demand

The concerned ecoinnovations are generally characterized by a dimension of technological rupture and/or strong technological adaptation, which confirms determination logics of *technology push* type determination for some projects which term of completion can vary (from medium to long term) and reinforces the role of academic actors within the system. However, this does not mean that the *demand pull* determinants are absent because the future of the projects and the future of the *filière* depend on the materialization of potential markets in different areas. These markets are identified more or less precisely by the actors, whether they are internal to the firm or external markets. They then concern different sectoral systems of innovation and are related to several territorial scales (region, France, world), knowing that most of the projects generally exceed the regional area, and even the national one (for example the Above, Bema and Bioethanol projects). Targeting international markets is a sign that the *filière* is open but there are compensations in terms of specific obstacles that have to be overcome such as the difficult – due to a lack of habit – that can have some actors to apprehend remote markets or the sensitivity of these markets to the changing variations of fossil energy' s price.

2.1.4. EIs expected to improve environment

The projects' orientations are linked to the diagnostics realized by the wood *filière* on its insufficiencies following pressures from regulatory bodies and the society. The actors present the *filière* as an example of sustainability. Firstly because of the natural sustainability of wood-based products, and secondly because it processes a local raw material into "eco-products" with a minimum transport (80 km in average). The regulatory pressure, with its consequences, is already a source of tensions on the resource. The industrial uses of wood and their negative environmental impact are in contradiction with the sustainable forest management. This implies that a new balance has to be searched and found in order to take into account the industrial need to continue to guaranty the industries' provisions in forest resource at a manageable cost, i.e. a cost that does not handicap the industries' competitiveness. In addition, the widespread use of wood in construction and building that has been defined as a strategic orientation can generate tensions with the panel and paper industries. Besides, the European legislation intervened to encourage the reduction of emissions and polluting residuals linked to the industrial activities (prohibition of preservation treatments of chemical products, VOC or REACH regulations, minimization of the quantity of final waste).

In terms of environmental performances, the collaborative projects have diversified effects. First of all, it is expected that they result in an improvement of the environmental balance: reduction of polluting emissions and fossil energy consumption, control of the economic consequences of climate disasters or fires by replacing the wood with other materials. Then, most of the projects mean at more or less long term an improvement in the use of the resource whether in quantitative terms (the Above project for example) or qualitative terms (most of the projects) or an increase in its production for example the Biotechnologie et Sylvogene projects that contribute indirectly via the improvement of the forest production, to the increase in CO2 stock). Despite their unequal and uncertain impact, it is important to mention that the implementation of these ecoinnovations ensures in principle the general improvement of environment quality in spite of the possibility of rebound effects compensated in more or less important ways (depending on the actors) by the impact of the substitution of the wood to other materials [15].

Secondly, we will underline here the importance of the proactive role of some of the actors of the ecoinnovation projects (particularly the Above, Bema, Plasmapal and Peveco projects) in defining the environmental regulations and standards. Many empirical studies showed the importance of the link between the regulation and the incentives to environmental innovations, in particular its impact on the firms' competitiveness [16-17]. In return, it appears that the involvement in proactive strategies towards the regulation is likely to give to the actors a competitive advantage of first movers to innovate or to adopt the innovations on a lead-market [16]. These advantages were particularly mentioned by the industrials in charge of "rupture" projects (Plasmapal project for example) involved since a long time in French and European institutions that create standards (lobbying).

2.2. A conditional break-out

2.2.1. The limited impact of new knowledge

According to the actors, if the new knowledge represents breakdowns that are sometimes "radical", it does not provoke - for the most part - major endogenous breakdowns towards the dependence to the resource. This is firstly because some projects operate in a logic that is still deeply academic (for example the Sylvogene or Biotechnologie projects), and their practical incidences still remain poorly defined. Secondly, because a lot of projects are a concern of procedures of geographic and/or sectoral transfer of existing processes. However, these transfers do not consist in simple revenues, directly usable because the maritime pine is a very particular species that requires strong adaptation of the specified knowledge for other species. The creation of knowledge can then take the form of a geographic transfer of knowledge; for example the Bioraffinerie project derived from a Scandinavian transfer of technology. Likewise, the Plasmapal project is based on an intersectoral transfer approach by adapting cold plasma techniques to wood processing. In these projects, as well as in most of the projects analyzed, the technology represents a complex approach that requires learning a specific expertise and delicately adapting to the context of utilization. The strong learning dimension also allows building networks of knowledge capitalization which vocation is eventually to exceed the temporal framework of the project. For the future, they lead to ability to build knowledge but also to identify and absorb external technologies [15].

2.2.2. The uncertainty on the demand side

Many of these projects will depend on the industrial demand covered by the media because of its environmental dimension. This implies that materializing the demand is subjected to a prior credible appraisal of the innovation (not done yet) and the compliance to the required standards. The future of the Bema project which targets the panel global market *via* the formulation and development of glues and thermoplastic composites has to take into account the existing environmental standards and their development.

Hence, a market perception that is subjected to a strong variability and uncertainty, that can handicap the progression of the innovation process. It is the same for the Peveco project designed to the national market of wood painting by improving the qualities of the product, but has to adapt its potential market to the environmental standards. It is also the same for the Plasmapal and Above projects. In any event, the appraisal of the future of these projects implies an analysis of the coevolution of the uses, techniques and standards which for now has not been sufficiently implemented. It also implies the following two questions. Firstly the potential clients such as the industrials or the building companies who will use these products as inputs in their production processes have to be informed and trained to use these new products. Secondly, the projects' promoters "who ignore what they ignore" must try to anticipate and analyze the negative external effects present in the new products/processes.

Beyond meeting the market pre-identified demand, these ecoinnovations can also result in keeping the existing jobs and even developing them (for example, the Bioraffinerie project has a direct influence in the chain's activity level, but also as a result, most of the projects). These projects can also contribute to the development of spillovers outside the chain, as these cross functions enable to bet on the development of the *filière's* establishment, despite the uncertainties peculiar to the technical and economic conditions in which this transfers can be implemented. We can mention here the Bema project that allows imagining knowledge transfers towards the sport sector, and the Biotechnologie project for the development of cryopreservation of plant species or the Plasmapal for stone plasma processing.

Materializing these direct and indirect positive effects has to be seen in the perspective of the specificity of these projects, in the viewpoint of the woody resource. Because of the fact that they come within the *filière*, one of the essential particularity of these projects is that the market is not only limited by the demand but by the very supply of this resource. For example, even if it allows a very strong value enhancement of the resource, the market of energy or green chemistry is inevitably limited because it strongly consumes this resource and therefore it potentially has conflicts of utilization with the *filière's* stakeholders. The creation of a new market, normally conceived as having a positive effect on the system in terms of added value and openness, appears as a function which dynamics is linked and therefore constrained (it can be the case for example for the Bioéthanol project) by the appearance of potential conflicts of resource catchment's.

2.2.3. Risks and scientific and environmental uncertainties

Despite their declared objectives, these ecoinnovation projects also generate risks and uncertainties on the system's dynamics. A risk can be defined as "a physical phenomenon, function of a contingency (characterized by its frequency and severity), stakes present in the territory, vulnerability and resilience of the territory" [18]. It differs from uncertainty in the sense that the risk is susceptible of measurement. Assessing the performances of the filière requires taking into account the reduction of some risks but also the scientific, environmental, regulatory and community uncertainties.

A certain number of collaborative projects (Bema, Above, Peveco, Plasmapal) will indeed allow limiting the probability of industrial and environmental risks through the lesser use of chemical products that can possibly generate industrial accidents and fires. Moreover, some projects (particularly the Sylvogene project) will also help to better control climate risks by better anticipating climate disasters like storms or by developing a more resistant resource or developing decision making support tools. Those tools will enable to assess the climate risks while offering solutions that will improve the increase in value of the resource partly destroyed during these accidents (for example the January 2009 storm), and converting them into alternate sources of energy (Bioraffinerie project).

However, most of the studied projects being on a start-up or intermediate development phase, their environmental impact remain uncertain in a scientific point of view. It is for example the case of the Plasmapal project for which the use of nitrogen in the plasma processing technique remains uncertain. The Above, Bema or Peveco projects are also characterized by a strong uncertainty towards the quantities of chemical products incorporated in the glues and paints used to process the wood. Several actors also mentioned the uncertainty remaining towards the long term effect of removing stumps and residues on the soil fertility. These scientific uncertainties come with uncertainties on the degree of acceptance of these projects by the foresters who are though at the heart of the filière dynamics. Many actors of the chain fear that the strong stress on the resource could cause risks of tensions about the use of the resource. These tensions could worsen through the development of major industrial projects that require important uses of the resource, to produce bio energy in particular (Bioethanol project).

The filière is also concerned by the uncertainties on the development of environmental regulations and standards. Indeed, some of the analyzed projects are partly based on an industrial demand determined by the necessity of adapting to environmental standards. And yet for a lot of actors, there is an important risk of seeing these regulations developing in a more restrictive direction, which could prevent some innovation from entering the market.

On the whole, the fact that there are different forms of uncertainties on the possible effects of introducing ecoinnovations into the system will generate a difficulty to measure the global impact of the 'competitiveness cluster' and the new forms of enhancement of the value of the resource that are proposed, if the impact is defined as the result of a set of partial effects difficult to identify. Predicting the environmental impact of the ecoinnovations raises specific difficulties resulting not only from non anticipated interactions between these technologies but also from the incidence of independent factors beyond the projects combined with their results and effects.

Conclusive remarks

Through our case study, we emphasized the necessity of integrating a greater consideration of the natural resources in the filière analysis. This analysis also enables to integrate a better consideration of tensions and scientific and environmental risks that are likely to emerge. Indeed, in the case of the filière, but more generally when it is about other natural resources, we face a scarcity that can result in the extinction of some resources.

In this context, our analysis of the ecoinnovation policy conducted by the cluster show that these projects are to some extent able to loosen the constraint of resource sharing. Notably, because the projects aim to increase the quantity and the quality of the wood resource. Moreover, because these improvements must be accompanied by effects on activity level, the deployment of new business through environmentally friendly intended innovations. Nevertheless, this ecoinnovation virtuous circle is not still carrying a decisive break-out because of many uncertainties accompanying the fate of these projects. Thus, the trajectory of the Aquitaine wood *filière* remains largely subject to uncertainties, as they are technological, economic, social and ecological.

The January 2009 storm provides a perfect illustration of the total imbalance of a system that can occur following an environmental accident, and related to the role of the resource in the system. The implementation of ecoinnovations by the 'competitiveness cluster' aimed at anticipating the imbalances and at reducing the negative impact by increasing the value of the woody resource (including the slashes and waste of the storm). This storm provoked destructions that reached private producers and also public damages. Although this storm provoked many damages to the system, it can also help to open a window of opportunities [19] in order to open the system to other possible paths.

For example, the 'competitiveness cluster' helped the actors of the wood *filière* depart from logic of conflict in the resource sharing and from logic of implicit compromise to more explicit logic of coordination. Therefore in the future, it will be about transforming the unpredictable climate shock into forecasting and future planning in the long term towards a multidimensional management of the forest *via* the construction of a larger order integrating the preservation of the massif against climate changes.

If the necessity of taking into account criteria related to the created knowledge and answers brought to the market demands seems done to a great extent, it is far from being the case of the criteria of sustainable development which, as we have seen it, remain under used and under informed. For this purpose, we suggest a multidimensional approach of post assessment combining four different viewpoints: the technologists'; the ecologists'; the economists' and sociologists'.

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