THE REGIONAL INTEGRATION OF BIORAFFINERIES IN FRANCE: AN APPROACH BY THE TERRITORIAL INNOVATION MODELS

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Abstract

A biorefinery integrated into its territory embodies the development of a business cluster, insofar as it reaches a minimum threshold on the geographical scale, while crossing progressive stages of regional development. From the point of view of the regional economy, there are several stages of spatial development and location of economic activities. The interest of this article lies in its objective to understand, from the point of view of regional economy, why the development of biorefineries follows the trajectory of economic activity clusters. To go further, we believe that through our example, the biorefinery can be considered as a new model of territorial innovation[1] both by its spatial development process, and by the territorial integration that prevails within these complexes, in an approach of economic sustainability. In a second step, we try to highlight the mechanisms at work as well as the determinants that allow the biorefinery to be territorially integrated.

Keywords: territorially integrated biorefinery, cluster, industrial symbiosis, top-down and bottom-up approach, sustainability
JEL Classification : Q57, R11, R12

1. Introduction

The objective of this paper is to evaluate the regional integration of the biorefinery in France, seen as a cluster of economic activities. As a very broad economic concept, integration in our case means the ability to encompass and combine different actors of the value chain in a logic of geographical proximity (Colletis et al., 1999). This logic of regional or territorial integration can thus be applied to biorefineries insofar as the concept of these new modes of biomass valorization is similar to business clusters. We used interchangeably the terms of regional and territorial integration. Thus, the concept of territorially integrated biorefinery is used here in order to express the integration of a biorefinery to a certain geographic space while the concept of regional integration of a biorefinery is used mostly to show a broader territory of development or within a network of already-in-place biorefineries. According to the definition of the IAR cluster[2], "a biorefinery" is an industrial complex, located on the same site, which transforms agricultural and forest biomass into a variety of bio-sourced products (food and feed, chemicals, biomolecules and agro-materials) and bioenergy (bioethanol, electricity and heat) as part of the sustainable development strategy.

Our problematic is based on understanding the regional integration of the biorefinery as a cluster of economic activities. Concerning the academic use of the concept of cluster we explain that the term cluster popularized by Michael E. Porter (Porter, 1990) is the more

[1] See Moulaert and Sekia (2003) on territorial innovation models.

[2] The IAR cluster (Industries et Agro-Ressources) is a competitiveness cluster that brings together large and small companies, research organizations and educational institutions working together in a given region to develop synergies and cooperation efforts around a common theme (www.competitivite.gouv.fr). It was launched in 2005. Following the call for applications to label competitiveness clusters for a new four-year phase (2019-2022), the IAR cluster has just obtained its label from the French government as a competitiveness cluster dedicated to the bioeconomy.

appropriate in our analysis, on a theoretical basis, to explain the territorial/regional integration of the biorefineries. The biorefinery is more reminiscent of a territorial structure that resembles a Porter-like cluster[3] than the organization of a French competitiveness cluster[4]. Moreover, as we will see further in our analysis, in a case of particular biorefinery, a "competitiveness cluster" is rather complementary to the development of the biorefineries.

Understanding the development and expansion of a cluster of innovative economic activities, its territorial anchoring and the local actors' games, which are part of its environment, represent one of the most important characteristics in order to explain the territorial/regional development of the biorefineries as a new model of territorial innovation (Moulaert and Sekia, 2003).

2. Literature review

The analysis of the cluster concept is one of the most appropriate theoretical concepts to show the relationship between biorefinery and regional development: "the definition of biorefinery allows us to see it as a concept, a manufacturing unit, a process, a plant and even as a cluster of manufacturing units" (IAE Bionergy Task 42, 2019). The integration of the biorefinery into an industrial cluster is gradual and depends on several spatial and socioeconomic determinants. As described by Spitzer (1997), it all starts with "a business community cooperating together and with local actors efficiently sharing information, materials, water, energy, infrastructure, and natural habitat, with the goal of quality economic and environmental gains and an equitable increase in human resources for the industry and the local community". Integration of a biorefinery manifests itself in different ways: industrial process integration, infrastructure integration, supply and product integration, value chain integration and environmental policy integration (Stuart and El-Halwagi, 2013). Moreover, from the perspective of geographic economics, one can even speak of a territorial/regional integration of the biorefinery, which then becomes a territorial biorefinery (Ceapraz et al., 2016).

Cluster biorefineries are estimated to be more competitive due to the integration of different plants on the same site even though they belong to different value chains (Girio et al., 2017). On the one hand, the integration of a biorefinery in an industrial cluster contains

[3] A cluster is defined as "a geographic concentration of interconnected actors consisting of firms and institutional organizations" (Porter, 1990).

[4] A "competitiveness cluster" specific to the French territory, is different and complementary to a cluster and, represents a combination, in a given geographical area, of companies, training centers and public or private research units engaged in a synergy around common projects of an innovative nature. This partnership is organized around a market and a technological and scientific field that is attached to it, and must seek a critical mass to achieve competitiveness and international visibility. The competitiveness clusters were created in 2004 as a grouping of companies, higher education institutions and public or private research organizations within the same territory in order to work in synergy to implement economic development projects for innovation.

advantages from an energy perspective (Hackl and Harvey, 2010). On the other hand, it is also beneficial from an economic point of view insofar as it contributes to the optimization of energy and material production processes through the joint application of different technological processes on various plant resources (Laurent et al., 2011). This transition of the biorefinery to a form of cluster also has the consequence of reconfiguring the "business model" since we are witnessing, initially, "a technology park or industrial park, then an industrial-type technology park dedicated to the biorefinery and finally a biorefinery-type cluster" (Vincze and Terras, 2016). According to Baas and Boons (2004), Boons and Berends (2001), there are several stages that show the scale of territorial governance of this kind of cluster (biorefinery type). The first stage is known as 'regional efficiency' and represents a 'bottom-up' approach that consists of coordination between different local actors to share risk and improve economic utility; the second stage called 'regional learning' seeks to establish a common base of knowledge exchange in general, and in sustainability (*in situ*) in particular, by mobilizing trust; the third stage that takes the form of a sustainable/sustainable industrial district, already provided with a good geographical and spatial basis, aims at common goals in sustainability.

On the basis of this work, an analysis through the prism of integrated biorefineries is proposed in *Table 1*. In this perspective, five main characteristics have been retained: (*i*) the territorial innovation model, (*ii*) the innovation dynamics and knowledge flows, (*iii*) the regional development, (*iv*) the relational dynamics between actors, and (*v*) the relationship with the environment.

Table 1. Comparison of innovation characteristics between two territorial innovation models (cluster and biorefinery)

Characteristics of innovation in territorial innovation models - cluster and territorial biorefinery	Model	
	Cluster	Biorefinery
Territorial innovation model	Cluster: "...a spatial concentration of thematically linked firms and other organizations (universities, research laboratories, public support agencies, and others) that are connected on the basis of business-related commonalities, complementarities and	Territorial biorefinery: a territorially integrated biorefinery is often compared to a cluster because of the integration of the different plants on the same site even though they belong to different value chains. Thus, from the point of view of geographical economy, we can even speak

	derive economic benefits from this" (Fromhold-Eisebit and Eisebit, 2004, Martin and Sunley, 2003, Steiner, 1998)	of a gradient of integration, that is from a territorial integration to a regional integration of a biorefinery
Innovation dynamics and knowledge	Capacity of the actors to implement innovation within a system of shared values; sharing of values between cluster members; trust and reciprocity	Knowledge, development, and dissemination of academic research on dominant biorefinery technologies; low entrepreneurial experimentation; influence on research direction; low resource mobilization; successful market formation for biofuels; global legitimacy (Bauer et al., 2017)
Regional development	Territorial approach based on spatial solidarity and flexibility of clusters; this flexibility is an element of this innovation	In the case of the biorefinery we talk about several stages of regional integration: (according to Baas and Boons, 2004, Boons and Berends, 2001): 'regional efficiency', 'regional learning' and 'sustainable/sustainable industrial district'
The relationship between actors: territorial governance and the role of institutions, proximity, industrial symbiosis*	The network is a mode of social regulation and a source of discipline. It allows for the coexistence of cooperation and competition; institutions are "agents" and allow for social regulation, fostering innovation and development; governance is either local (bottom-up) or regional (top-down). There are several types of proximity with different levels of impact on the performance or innovation of the cluster's companies on a regional scale. Unlike industrial ecology, cluster studies have not examined the potential of industrial symbiosis or eco-	Clustered companies tend to be integrated into inter-firm relationships in the same or related sectors in order to facilitate joint actions; 'top-down' approach in new generation biorefineries; 'bottom-up' approach in existing biorefineries or in the expansion of old ones; geographical proximity, institutional proximity (linked to the existence of a 'territorial project') and organizational proximity (multiple and multi-level interactions between local actors in an eco-systemic logic of industrial and territorial ecology) (Ceapraz et al., 2016); in connection with the concept of

	industrial parks resulting from collective actions in local agglomerations	industrial ecology, industrial symbiosis is an innovative way to increase resource productivity and is one of the approaches to achieve a circular economy; among the actors who operate an integrated biorefinery we can note industrial actors, private research organizations, farmers' cooperatives
The relationship with the sustainability (the environment)	Relationship with the environment imposes constraints and new ideas: being able to react to changes in the environment and limited spatial view of the environment; industrial cluster literature tends to capture a relatively early stage of environmental upgrading especially in mature industrial clusters (Yoon, S., Nadvi, K., 2018)	Relationships with the environment indicate a very high stage of sustainability especially in connection with industrial symbiosis (Yoon, S., Nadvi, K., 2018)

Source: based on Moulaert and Sekia (2003), Teräs and Mikkola (2019), Yoon and Nadvi (2018) and work by the authors

* "Industrial symbiosis is the association between industrial facilities or companies in which the waste or by-products of one industrial facility become raw materials for another. Industrial symbiosis can be described as a collaboration between several different entities, often geographically close, i.e. companies and factories co-located in clusters or industrial parks exchanging resources (materials, energy, water, by-products) that can be used as substitutes for products or raw materials, which would otherwise be imported from elsewhere or treated as waste. Industrial symbiosis can also involve the joint provision of utilities and services between network actors" (Teräs and Mikkola, 2019).

3. Method

A literature review is proposed to highlight the link between the development of the biorefinery and the territory, by comparing the theoretical framework of clusters with the real development of biorefineries. Thus the corpus of regional economics on clusters is useful in explaining the progressive path of territorial integration of the biorefinery from a grouping of local companies to a cluster of economic activities. A deductive approach of research associated with a scientific investigation of the territorial innovation models is crucial for our analysis as long as the development of the biorefinery is based on locally anchored resources and actors. Certain innovation characteristics are described as relevant in showing, within a regional framework, the progressive territorial/regional integration of several biorefineries.

In a first approach, the comparison of the characteristics of innovation proposed by Moulaert and Sekia (2003), which consists in explaining why such a localized departure of actors in the cluster finally leads us to a new spatial structure of the territorialized biorefinery type, seems to us to converge towards the territorial/regional configuration of biorefineries.

In a second approach, we will highlight the different levels of territorial/regional integration of French biorefineries by comparing the case of Pomacle-Bazancourt to other two cases of biorefineries evolving within different territories. Indeed, biorefineries integrate differently in their host territory and their mobilization of territorial capital takes place in a singular way (Rakotovao et al., 2018). Several steps of this territorial integration within a region are described by Rakotovao et al. (2018). Moreover, this territorial integration or anchoring can also be referred as "a set of reciprocal links that unite an economic activity (actor, company, sector, etc.) with a territory" (Frayssignies, 2005) or even as "the contextualization of economic and organizational activities at the heart of social arrangements and processes" (Boons and Howard-Greenville, 2009).

Different methodologies can be considered when we refer to the territorial/regional integration of the biorefineries.

First, a spatial scale of integration is not punctual but progressive ((Rakotovao et al., 2018). From the first generation of biorefineries to the last generation there are constant differences in scale and territorial anchoring. Therefore, the territorial environment of the biorefinery will evolve through its internal and external environment (Rakotovao et al., 2018).

Secondly, different criteria or determinants issued from the literature on territorial innovation models are used in order to unveil the differences between Pomacle-Banzancourt and other "less integrated" biorefineries. By "less integrated" we mean that the five characteristics describe before will partially be fulfilled by these biorefineries. Thus, the case of Pomacle-Bazancourt biorefinery is used as a benchmark of an "ideal territorial/regional integration" is order to show the differences with other territorial biorefineries.

3.1. The cluster and the biorefinery: two interrelated territorial models

The literature framework showed us several differences between the concept of cluster and the development of the biorefinery. A description of comparisons between the innovation characteristics of these two models is developed here.

3.1.1. The territorial innovation models

The biorefinery aligns with a particular category of clusters with similar or different characteristics from a classical cluster. As described in this analysis by the territorial innovation model approach, the biorefinery can undergo different spatial scales of development from a particular territory to a more regional scope.

Several types of clusters coexist (VertigoLab, 2019): on the one hand, horizontal integration clusters characterized by the concentration of companies grouped together in the same sector of activity and vertical integration clusters referring to the geographic concentration of companies that are part of the value chain of a product (with privileged links between customers and suppliers). In the case of the biorefinery that follows a territorial development oriented rather cluster, we speak then of a territorial biorefinery. This is a territorially integrated biorefinery, whose organization resembles a cluster due to the integration of different companies/plants on the same site, even though they belong to different value chains.

3.1.2. Innovation dynamics and knowledge flow

While in the case of the cluster, one speaks of several characteristics like a reciprocal sharing, a mutual exchange of values, and a climate of trust and reciprocity, in the case of the biorefinery, one evokes features like a flow of knowledge, a development or a diffusion of academic research on the dominant biorefinery technologies. On the other hand, entrepreneurial experimentation is rather rare due to high costs and grandfathering. The orientation on research direction indicates national policies that have focused on biofuels, and thus have put biorefineries in the direction of fuel production technologies. In addition, resource mobilization remains difficult given the lack of capacity and strategies for feedstock mobilization. While market formation is successful especially for biofuels due to quotas, other products are still struggling to establish a niche market. Finally, the legitimacy of integrated biorefineries is global (Bauer et al., 2017).

3.1.3. Regional development

In the case of the cluster, we speak of a territorial approach based on spatial solidarity and flexibility, flexibility being an element of territorial innovation. According to Baas and Boons (2004), Boons and Berends (2001), in the case of the biorefinery we outline several stages of regional integration as follows: the 'regional efficiency', the 'regional learning' and the 'sustainable industrial district'.

3.1.4. Relational dynamics between actors

This fourth characteristic encompasses territorial governance and the role of institutions, proximity and industrial symbiosis. In the case of the cluster, the network is a mode of social regulation and a source of discipline with a coexistence of cooperation and competition.

Governance in the cluster can be ‘top-down’ or ‘bottom-up’. In the first case, institutions have an important role as ‘agents’ and enable social regulation, promoting innovation and development. In addition, ‘top-down’ approaches have the role of implementing cluster policies at the regional level. The second type of approach, ‘bottom-up’, is considered to be the prerogative of local industrialists who, through their local collective action, are at the origin of the emergence of the cluster (and thus avoiding as much as possible the spheres of political influence) (Fromhold-Eisebith et al., 2004).

Unlike industrial ecology, cluster studies have not examined the potential of industrial symbiosis or eco-industrial parks resulting from collective actions in local agglomerations. In the case of biorefineries, clustered firms tend to be integrated into inter-firm relationships in the same or related sectors to facilitate joint actions. Regarding the governance, both 'bottom-up' and 'top-down' concepts can be applied to biorefineries, whether in the case of a new site or an old pre-existing industrial site (FMFACP, 2012). However, the ‘bottom-up’ approach is usually implemented in existing or expanding biorefineries. The 'top-down' approach, on the other hand, is more related to “newly designed, highly integrated systems designed to utilize various biomass fractions” (FMFACP, 2012). Some attributes of the spatial/geographic scale of biorefinery development should be mentioned here: regional heritage in industrial and agricultural know-how, links to the local community and local actors, and global position as a major player in global value chains (Kristensen et al., 2019). There are several types of proximities with different levels of impact on the performance or innovation of cluster firms on a regional scale. Thus, in terms of proximity, the territorial biorefinery is illustrated by the geographical proximity, the institutional proximity (linked to the existence of a 'territorial project') and the organizational proximity (multiple and multi-level interactions between local actors in an eco-systemic logic of industrial and territorial ecology" (Ceapraz et al., 2016). In connection with the concept of industrial ecology, industrial symbiosis is an innovative way to increase resource productivity and is one of the approaches to achieve a circular economy and green growth in order to secure supplies and the necessary diversification of resources. Moreover, mutual trust and shared ideologies between actors are among the key determinants of a symbiotic model. Thus, among the actors that make an integrated biorefinery work and be

sustainable, we can note the industrial actors, the private research organizations and the farmers' cooperatives.

3.1.5. Relationship with the sustainable environment

In the case of the cluster, the relationship with the environment imposes constraints and new ideas, i.e. being able to react to changes in the environment. On the other hand, we encounter a limited spatial view of the environment and the literature on industrial clusters tends to capture a relatively early stage of environmental upgrading, especially in mature industrial clusters (Yoon, S., Nadvi, K., 2018). For the biorefinery we talk about relationships with the environment that indicate a very high stage of sustainability especially in the relation to the industrial symbiosis (Yoon, S., Nadvi, K., 2018).

4. Results

Our analysis of the territorial integration of biorefineries is depicted using the theoretical framework of territorial innovation models issued from the works of Moulaert and Sekia (2003). We have tried to trace the development path of a biorefinery in relation to its territory, using these models of territorial innovation.

First, a comparison of the characteristics of territorial innovation (from the works of Moulaert and Sekia, 2003) between the concept of cluster and the biorefinery showed us similarities of territorial development that suggest that the biorefinery can be framed in the category of models of territorial innovation with very particular attributes.

According to the first criterion, i.e. the conceptual similarity between the cluster and the biorefinery, gave the biorefineries the advantage to weave coordination relationships with various stakeholders of the territory (agricultural cooperatives, farmers, institutional actors, universities, training centers, complementary industries, research units, etc.) that are more or less integrated on the same geographical site, and even belong to different value chains. Moreover, a biorefinery can take different forms of integration, that is a gradual integration that depends on various factors. In this way, a cluster is limited and its development is punctual.

According to the second criterion, the dynamics of innovation concern the diffusion of innovation, especially on the dominant technologies of biorefineries in the field of biofuels. Their mono-product legitimacy (biofuels) is global, but there are still other products or co-products that can be developed in the future. Low entrepreneurial experimentation and mobilization of resources is still lagging and depends again on the spatial scale of the biorefinery.

The territorial/regional development of the biorefinery that reflects its level of integration depends on several factors and we can cite the diversity of social, economic, technological and also political resources. Different scales of regional integration such as ‘the regional efficiency’, ‘the regional learning’ and ‘the sustainable industrial district’ have been already experimented by our case studies.

One of the most important characteristics, the collective dynamics of biorefinery actors is characterized by several key competing determinants. In this direction of the collective dynamics of actors, several major axes have been identified (Rocher, 2006): *a)* 'top-down' or 'bottom-up' action or coordination instruments: on which modes of action (regulatory, economic, social, legal, etc.) are the decisions taken based? The answer here is either a 'top-down' governance typical for new biorefineries, or a 'bottom-up' governance more suitable for biorefineries already in place; *b)* the actors: which actors are visible from the point of view of changing behavior and positions with regard to the management of biorefineries and what are their collective dynamics? The answer here is a diversity of actors like industrial actors, private research organizations, farmers' cooperatives. Certain biorefineries are prone to the industrial symbiosis, which involves relationships of trust and mutual exchange between actors in order to pursue productivity increase and resource diversification in a circular economy framework. *c)* the territory and the proximity: which territory should be considered for the proper management of biorefineries? The answer here is a diversification of proximities, either geographical proximity, institutional or even organizational proximity.

And last but not the least, their link with the environment implies a very high scale of sustainability.

5. Case studies

5.1. The ‘ideal’ territorially integrated biorefinery: the case of Bazancourt-Pomacle

French agro-industrial research, mainly based at the Bazancourt-Pomacle biorefinery, is intended to generate economic development from the territory's agricultural resources, favorable to the environment, in connection with the world-class competitiveness cluster "Industries & Agro-Resources" (IAR) supported by the Grand Est and Hauts-de-France regions.

The Pomacle-Bazancourt site is an example of an integrated biorefinery and is considered one of the most successful biorefineries in terms of territorial transition, which is based on the process of industrial symbiosis as the result of a 'technological roadmap' (Debref, 2012). According to Dubois and Kristensen (2019), an important feature of the Pomacle Bazancourt biorefinery model is represented by the strong functional links between agricultural

development, technical and organizational innovations and industrial applications. The rural proximity and the positioning as a cluster allow to merge two essential determinants of partnerships and links between industrial and rural actors: the supply of biomass and the development of the biorefinery towards the size of a cluster (or the territorial integration of the biorefinery in a cluster or economic activity park).

Its particularity compared to other biorefinery models, is the integration of an open innovation ecosystem, supported by regional agricultural cooperatives with the progressive association of processing plants. The territorial anchoring through the establishment and expansion of the site has benefited from investments from agricultural cooperatives and the support of local actors. These institutional and functional links at the territorial level allow the biorefinery to ensure a constant local supply of biomass, to enable the development of a diversified innovation system as well as the voluntary involvement of regional political actors (Kristensen et al., 2019).

Another feature that concerns the interplay of local actors is represented by the concept of industrial symbiosis. Industrial symbiosis refers to synergies that take place between actors located at the biorefinery site (Schieb et al., 2016). Chertow (2000) defined industrial symbiosis as “the involvement of several different industries in a collective approach that includes the exchange of materials, energy, water, and by-products to increase competitive advantage”.

In a second step, the innovation platform BRI (“Bioraffinerie Recherches & Innovations”) was commissioned as part of this agro-industrial cluster and is considered "the first open innovation platform validated by the State as part of the competitiveness cluster policy in 2009" (MAA, 2016).

5.2. Comparison between several biorefineries: Pomacle-Bazancourt, Tereos Marckolsheim and Roquette Lestrem

To highlight the different levels of integration of biorefineries with their production territory, we will refer to other two French cases, the Tereos Marckolsheim biorefinery and the Roquette Lestrem biorefinery in comparison with the Pomacle-Bazancourt biorefinery. This comparaison shows us to what extent there is still progress to be made concerning the territorial anchorage of these biorefineries and their more or less regional integration (*see Table 2*).

Table 2. Levels of integration of territorial biorefineries seen through the prism of three French cases

Integration factor	Pomacle-Bazancourt	Tereos Marckolsheim	Roquette Lestrem
Territorial innovation model	• Highly integrated biorefinery: feedstock integration, technology integration, product integration (Moncada et al, 2014) • 8 biomass valorization plants: - Cristal Union (sugar, alcohol) - Chamtor (wheat-based ingredients) - Cristanol (bioethanol) - Vivescia (cereal-based products) - Air liquide (CO2 collection) - Soliance (molecules for cosmetic purposes) - Whetoleo (detergents) - Biodemo (2G pilot) - Futurol (2G pilot)	• Medium integrated biorefinery: product integration • 2 biomass valorization plants : - Tereos (cereal-based products) - Jungbunzlauer (bio-based chemical ingredients)	• Non-integrated biorefinery (single site)
	• Creation of a shared research center between beet and cereal growers (Agro-industry Research and Development or ARD)	• Membership in the bi-regional competitiveness cluster "Industries and Agro-resources", known as IAR, whose purpose is to	• Membership in the bi-regional competitiveness cluster "Industries and Agro-resources", known as IAR, whose purpose is to

Innovation dynamics and knowledge	• Development in situ of fundamental research activities (European Center for Biotechnology and Bioeconomy or CEBB) • Creation of a partnership innovation platform whose objective is to support the spin-off of the biorefinery concept (Bioraffineries Recherche et Innovation or BRI) • Membership in the bi-regional competitiveness cluster "Industries and Agro-resources", known as IAR, whose purpose is to support manufacturers in the bio-economy sector	support manufacturers in the bio-economy sector	support manufacturers in the bio-economy sector. • Membership of the regional cluster "Nutrition, Health and Longevity". • Founding member of the Regional Institute of Agro-sourced materials in the Hauts-de-France or IFMAS
Regional development	Multiple geographic scales	Multiple geographic scales	Individual geographic scale
The relationship between actors:	• 'Top-down' approach: support for innovation by local and territorial authorities (Thénot and Katir, 2017) • Strong geographic and organizational proximity between biorefinery plants and with	• 'Bottom-up' approach: the intervention of local and territorial authorities is done independently of innovation strategies within biorefineries. Indeed, these are not considered as innovation platforms but as a classic economic activity	• 'Bottom-up' approach: the intervention of local and territorial authorities is done independently of innovation strategies within biorefineries • Indeed, these are not considered as innovation platforms but as a

territorial governance and the role of institutions, proximity, industrial symbiosis	innovation platforms • Development of synergies between production plants, favoring exchanges of flows and materials in an industrial and territorial ecology dynamic	• Geographical and organizational proximity limited to certain actors in the value chain: implementation of a supply system favoring local agricultural suppliers, partnership with an industrial client for the supply of intermediate products • Institutional proximity in development: territorial project for supplying municipal canteens • No industrial symbiosis	classic economic activity • Undeveloped geographical proximity with the actors of the territory • Weak institutional and organizational proximity with the territorial actors. • No industrial symbiosis

Source: based on authors' work

5. Conclusions

Several conclusions can be formulated since the territorial/regional integration of biorefineries firstly address some stylized facts about the relation between the concept of cluster and the development of the biorefineries. The framework of territorial innovation models serves as a basis us to analyze the degree and diversity of territorial resources that allow the biorefineries to integrate more or less at territorial or regional level. The territorial/regional integration of the biorefineries is depending largely on the type of territorial resources in place. As already mentioned in our analysis the concept of territorially integrated biorefinery was used here in order to express the integration of a biorefinery to a particular geographic space while the concept of regional integration of a biorefinery is used mostly to show a broader territory of development or within a network of already-in-place biorefineries. Thus, different scales of integration have been formulated and several case studies of Pomacle-Bazancourt, Tereos Marckolsheim and Roquette Lestrem biorafineries confirm this assertion.

The Pomacle-Bazancourt biorefinery is a territorialized or territorially integrated biorefinery and is considered a new model of territorial innovation both in terms of its characteristics as a cluster of economic activities and its territorial governance, which resembles

that of a cluster, but with different determinants. The Tereos Marckolsheim biorefinery has a lower level of integration by forging links with local actors, but these are limited to the level of actors in the value chain. Finally, the Roquette Lestrem biorefinery is a non-integrated biorefinery and the links with local actors are not very well developed. In fact, the major determinant here is spatial. Geographic proximity is referred to as a key factor for collaborations and synergistic opportunities that define industrial symbiosis (Chertow, 2000). According to Torre (2018), the proximities approach has rarely made the connection to the field of territorial development. Yet there are similarities between the two approaches concerning local production, spatial relations and also the integration of social and institutional issues (Torre, 2018, Colletis and Pecqueur, 1993). As it will be specified later in our work, the introduction of the proximities approach in our analysis of biorefinery will finally lead us to conclude that the different types of proximities represent a key element of the regional integration of biorefineries and implicitly of their territorial development.

The definition of industrial symbiosis described by Chertow (2004) allows us to mention that, compared to petrochemical refineries, the development of biorefineries is exclusively regional, especially from the point of view of sustainability. Upstream and downstream synergies, as in the case of biomass flows (upstream) and shared knowledge platforms (downstream), contribute to the competitiveness of the cluster. First of all, there is a need for geographical proximity and integration of the local biomass share. In this sense, the biorefinery will follow the path of regional development by commissioning several types of local supply.

Further analysis should focus on how the territorial/regional biorefineries can improve their governance and its mechanisms by involving private and public stakeholders in the territorial acceptance of the biorefineries. This issue could be a major concern in the upstream (biomass) and downstream (bio-products) value chain, especially for the political, economic and social issues at stake. All these different facets should require the implementation of new frameworks of territorial organization through the principle of proximity and cooperation. This work will provide further reflection on the elements favoring new territorial governance structures of the actors and their spatial coordination (local authorities, private actors, farmers, civil society).

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