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Organizational Forms and Agri-Environmental Practices: The Case of Brazilian Dairy Farms

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Abstract: Understanding the relationship between the organizational characteristics of a farm and its environmental performance is essential to support the agro-ecological transition of farms. This is even more important as very few studies on the subject have been undertaken and as there is a growing diversity of organizational forms of farms that differ from the traditional family model. This paper proposes a comprehensively integrated approach of dairy farms in Brazil. A case study of six archetypes of farms with contrasted organizational characteristics is developed to explore the relations between, on the one hand, farms' organizational structure and governance, and on the other hand, the adoption of agri-environmental practices. Results show that the adoption of agri-environmental practices varies across the wide range of farm's organizational forms—from the family to the industrial models. Farms with limited internal resources depend more specifically on external sectoral or territorial resources to implement environmental practices. If the environment is conducive to the creation of incentives and coordination mechanisms underlying learning processes, farms will adopt agri-environmental practices, regardless of they are organized. The creation of local cooperatives, farmer's networks and universities extension programs can strengthen farmers' absorption, adaptation and transformation capacities and boost the adoption of environmental practices. Finally, considering farms as heterogeneous organizational forms in terms of human capital, resources, market, and informational access is essential to accelerate the agroecological transition.

Keywords: farm; organization; governance; adoption; agroecology; practices; regulation; Brazil

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1. Introduction

Understanding the interconnections between agricultural activities and ecosystems is essential to build sustainable agriculture. Various authors represent these complex interactions by describing the services, both positive and negative, that agriculture provides, as well as those from which it benefits [1,2]. Indeed, agriculture benefits from services generated by ecosystems (climate regulation, pollination, soil conservation, etc.) can itself contribute to the provisioning of ecosystems services (maintenance of biodiversity, carbon storage, water purification, etc.) through agri-environmental practices employed in the farms.

This dual interaction exists at the farm level and for a given production. It raises the question of understanding the relations between the farms' organization and the choice of agri-environmental practices that can at the same time reduce negative externalities and increase positive externalities. However, there are very few studies on this issue, while the diversity of organizational models of farm (peasant farms, family farms, entrepreneurial farms, family business farms, etc.) has been well documented and discussed in the scientific literature [3,4]. The majority of existing studies tend to look at only two archetypes of

farms, the large agro-industrial farms, and the traditional small family farms, recognizing that the latter is more efficient in achieving sustainability objectives [3,4]. A few others are mainly interested in the relation between farm's organizations and environmental choices [5,6], but they are mainly applied to European farming systems. The issue has not yet been addressed for the newly emerged farm forms, such as the entrepreneurial farms or family business farms, and in contexts other than Europe. Do the latter perform better or worse than the traditional family farms in terms of the adoption of environmental practices? What are the organizational factors, if any, that drive the farmer's adoption of environmental practices?

This article develops a qualitative analysis of the relations between a farm's organizational forms and its agri-environmental practices. A farm's organizational form is defined by the farm's structural characteristics (size, family and employed labor force, capital structure, etc.) and its governance system. Our main hypothesis is that these internal factors, as well as the farm's external environment, do influence the adoption of environmental practices. We provide empirical evidences based on the case study of different archetypes of dairy farms in Brazil. First, dairy farms are known to generate both negative and positive externalities. Second, Brazil appears to be particularly suitable for studying such an issue. In addition to being the fourth biggest milk producer in the world, Brazil has a regulatory environment that recognizes the existence of different farm's forms of organization (Law number 11,326, 24 July 2006 established the criteria for the definition of family farming related do the size of the farm, the labor force used and the percentage of family income coming from the farming activity), ranging from the peasant forms to the large agro-industrial ones. Brazilian environmental law (Law number 12,651, 25 May 2012, known as the "Forest Code" established the rules about rivers' margins preservation with native vegetation on the width of the riverbed. The law also established the protection of 20% to 80% of farmland with native vegetation according to biome and allows exceptions to family farms) also gives special attention to family farms. Another interesting fact is that the number of family farms reduced by 9.5% between 2006 and 2017 while milk production increased by 62 percent in the same period [7]. These facts make relevant the question of the environmental impact of farm's organizational forms, on the one hand, and that of the efficiency of the measures implemented in Brazil to support the adoption of agri-environmental schemes by family farms, on the other hand. Several studies focusing on the study of Brazilian farm's organizational forms [8,9] but they usually do not consider the relation between farm's organizational forms and the adoption of agri-environmental practices [10]. Our study is based on six semi-directive face-to-face interviews with farm owners and a visit to their farms conducted in the states of Paraná and São Paulo, the 2nd and 6th largest milk producing states respectively [7].

The objective of this paper is to add to the existing literature by focusing on the process of adoption of agri-environmental practices, based on an in-depth and integrated approach to the farm's organizational forms. First, we examine the influence of farm's internal factors specific to each organizational form. Second, we study the influence of farm's regulatory, sectoral, spatial, and market environments in the adoption. This paper uses concepts from the economics of innovation [11] and concepts of evolutionary economics to build up the analytical framework. The first allows us to better understand the factors influencing the adoption. The last helps to go deeper into the learning processes associated with the adoption of agri-environmental practices on farms [12,13]. We believe that these results can provide a better understanding about how different farming organizational forms can influence the agri-environmental practices adopted by farmers. Besides that, the results can support private and public strategies to generate environmental policies that fit better the diversity of farming models in the Brazilian context.

2. Theoretical Framework

The emergence of new farm models different from the traditional family farm leads us, firstly, to consider the farm as a company similar to any other, which supports the

joint production of marketed goods and non-marketed environmental goods/bad, and secondly, to study the farmer's adoption of environmental practices through the lens of an organizational innovation process undergone by its company. Our main hypothesis is that thanks to their internal characteristics, some farming organizational forms are more favorable to environmental innovation than other is. However, any organization operates in a given socio-economic environment. As such, external factors do also influence the farm's capacity to innovate. The theoretical framework developed to address these hypotheses is detailed below.

2.1. Environmental Externalities and Farm's Agri-Environmental Practices

The concept of externality has been widely used in the study of environmental problems [1,2,14,15]. An environmental externality is defined as the effects that some agents cause on the wellbeing of others and can be generated as "joint products" of the production of a good or service [1]. Indeed, given those complex interdependencies between agricultural socio-technical and environmental systems exist, we can consider that the production of marketable agricultural goods cannot be considered independently of the production of (non-marketable) environmental externalities [14]. Studies therefore converge on the fact that agricultural practices constitute satisfactory proxies to analyze the environmental externalities produced by farms [15]. These externalities are either unintended positive (carbon storage) or negative (air pollution) [2].

Dairy farms in particular are known to yield environmental externalities, both positive and negative, depending on the breeding practices. The preservation of native vegetation on farmland for grazing (especially in areas adjacent to rivers or water bodies) produces positive externalities in terms of biodiversity preservation, maintenance of water stocks, support to water quality, animal well-being, etc. [2,3,16]. Another example is the use of appropriate animal waste management to reducing microbiological and chemical pollution [17,18]. Animal effluents and used water storage and treatment facilities, especially when placed far from watercourses, can be built to minimize farms' negative externalities into the water, air as well biodiversity [6,17,18]. Feeding animals with a balanced diet is also related to the reduction of negative environmental externalities. More generally, less input intensive farming systems (i.e., that use no synthetic fertilizers and chemicals), in which permanent grasslands are grazed throughout the year, can produce less negative environmental externalities and can contribute to the production of positive environmental externalities [1,2,6,16,19]. Assessing a farm's agri-environmental practices helps indeed to better understand the environmental externalities produced through a specific farm socio-technical system.

2.2. What Organizational Factors Drive Farm's Adoption of Environmentally Friendly Practices?

The innovation economy approach proposes to study the environmental innovation process by analyzing not only the incentive and regulatory mechanisms but also the organizational characteristics of the adopter and its specific technical and sectoral systems [11]. Evolutionary approaches consider meanwhile the processes of interaction and co-evolution between the factors composing a company, and between the company and its environment [20]. Based on these two sets of theoretical literature, we propose the following framework for analyzing the determinants of farm's agri-environmental practices for different farm's organizational forms (Figure 1). Inspired by the framework developed by [6], we distinguish in particular two sets of variables: the internal factors related to farm's organizational forms (Section 2.2.1) and those related to the coordination between the organization and external actors, and more specifically those related to market, regulatory, sectoral, or spatial dimensions (Section 2.2.2).

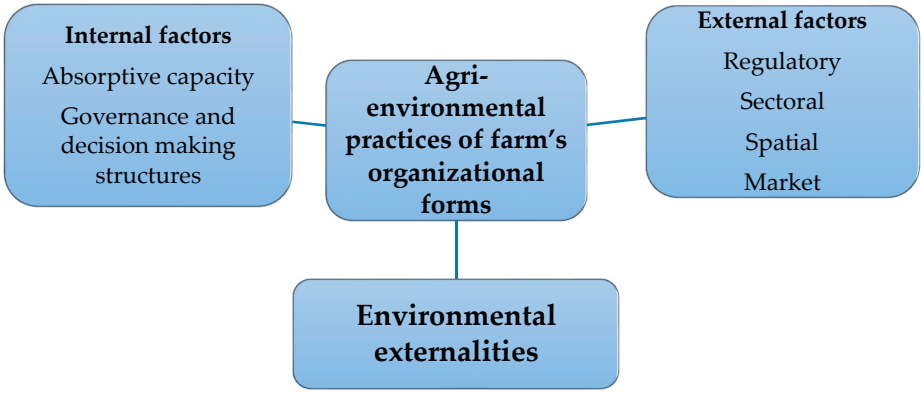

Figure 1. Framework to study the relations between farm's organizational forms and agri-environmental practices.

Reference [11] developed a framework proposed to study the environmental innovation in the industrial sector. Inspired by the latter, we intend to analyze the role of farm's absorptive capacity, governance, and decision-making structure, on the learning processes associated with the adoption of agri-environmental practices. We also study the sectoral, spatial, and market factors [21,22] related to the farms' adoption of agri-environmental practices learning processes. This theoretical framework allows us to analyze the interactions, over time, between the farm's internal and external factors in the consideration of environmental externalities by the different farm's form of organization.

2.2.1. The Internal Factors: The Role of Farm's Organizational Forms

As shown by several studies [5,6,9,12,13,23,24], some forms of organization are better able to manage certain types of environmental externalities involving different assets. They pointed out, in particular, the effect of the organization's absorptive capacity, of the manager's characteristics, and the farm's governance structure, on the adoption of agricultural practices.

The farm's absorptive capacity is related to its ability to assimilate and apply new practices [13,24]. It refers to the set of organizational strategies, routines, and processes through which a firm or system acquires, assimilates, transforms, and exploits knowledge [20,24]. This capacity is identified by factors such as investment capacity, training, quality and diversity of human and managerial skills, and the experience gained within organizations along their learning trajectories [20,24]. Thus, learning is not only a technological issue but also an organizational one. This refers to the notion of techno-organizational learning, which refers to the inseparable and progressive construction of technological and organizational capabilities of a firm in the innovation process [20]. The learning trajectories associated with an adoption process enable the creation of an organizational memory [12,20] that is often associated with the firm's dynamic capacity to adapt to a changing environment [13].

In terms of the manager's characteristics on the adoption behavior, studies stress the effect of the following ones: level of education, believes and representations [5,25], sense of belonging to a community [25,26], reliability on his advisors [26], and perceptions related with the transmission issue of the farm [27]. Literature also highlighted purely mimetic or epidemic behaviors in practices adoption behavior [6]. The role of the governance structures seems to be less explored and the few studies that have been conducted tend to oppose the traditional family structures to the so-called industrial structures on the adoption of environmental practices [3,6,12].

In fact, the literature recognizes the coexistence of different farm's governance structures: family farms with emerging forms that deviate from the traditional family farming structure [3,28]. The traditional family structure refers to a productive entity in which all assets (land, capital, labor) are under family ownership, in which agricultural production and family life are intertwined, and which is characterized by a high rate of intergener-

ational succession and transfer of agricultural know-how [3,4,12]. Farm structures that deviate from the family structure are characterized by a partial to total separation of ownership and asset management rights, by the development of wage employment, and by non-farmers capital investors. This phenomenon results in a high variety of farms' organizational forms described in the literature, such as: corporate-style farms [29], "factory-style corporate farms" [28] (p. 175), family business farms [4], partnership farms [28] (p. 172), entrepreneurial farms [30] or family and peasant farms [3,4,12].

2.2.2. The External Factors: The Role of Farm's Environment

The external factors are associated with mechanisms of interaction and the co-evolution of the organization with its environment [20,31]. The effect of regulation on agents' behaviors is the most discussed dimension in the standard literature in environmental economics. Trust relations and reputation as well market pull effect are also identified as key external factors in the establishment of incentive and coordination mechanisms in the process of adoption of environmental practices [11].

Concerning regulation, the empirical literature highlights the role of the mechanisms of regulatory compliance (voluntary or mandatory) and the anticipation of future regulations in the adoption of environmental practices [20,24]. The degree of stringency of the regulation, the level of implementation, and the effectiveness of the associated control mechanisms [32,33] as well as the legitimacy ascribed to the regulation [25] are also important factors of adoption. The effects of the regulatory environment on farmers' adoption of agricultural production practices were studied in European countries [32], in the United States [33], and particularly Brazil [34]. In the latter case, studies show that the combination of public control policies and incentive mechanisms for encouraging farmers to adopt environmental practices has significantly contributed to reducing impacts.

The demand for products with eco-friendly attributes is constantly increasing. Yet, it is difficult to identify eco-friendly attributes ex-ante or even ex-post [23]. Private actors seeking to respond to this demand generally do so as part of a strategic initiative to develop a brand image [22] and/or to maintain their reputation [35]. They must therefore implement incentive and coordination mechanisms for reducing uncertainty about the characteristics of their products and information asymmetry between producers and consumers [22,36]. This requires specific investments in implementing standardized processes and practices (specifications, etc.), in developing a technical mastery of all production stages, and in setting up a traceability system [21]. It is to ensure a return on these specific investments that economic actors resort to vertical integration and/or arrangements with partners based on various coordination (contracts, hierarchy, and reputation) and incentive (financial and non-financial) mechanisms [21]. Production contracts between farmers and upstream actors are the instruments traditionally used to facilitate the creation of incentive mechanisms for the adoption of low-input production practices.

The adoption of environmental practices can also be the result of a deliberative process combined with knowledge sharing between the actors of a collective [26]. Indeed, collective learning processes can encourage farmers to re-examine their shared knowledge, values, and beliefs and, in turn, convince them of the legitimacy of adopting alternative agricultural practices [26]. Finally, the participation of farmers in arrangements facilitating investments for the reduction of negative environmental externalities depends on its specific environment.

3. Materials and Methods

3.1. Criteria for Identifying the Multiple Case Studies of Dairy Farms Organizational Forms

We selected the multiple case studies representing a diversity of farm's organizational forms, which we shall present below without any prior hypothesis as to their environmental profile in terms of agri-environmental practices. Four main criteria were used to identify a diversity of farm's organizational forms studied [29]: (i) the methods of governance and operational management of the farm; (ii) the characteristics and management of the

workforce; (iii) the farm's capacity for innovation and, (iv) the degree of integration of the farm in the local area, supply chains, and markets. Regarding governance, some farms pursue goals that have nothing to do with family heritage (land is seen as a production tool rather than a family asset, priority is given to short-term profitability, etc.) [3,4,29]. Some types of farms also differ from the traditional family model by the involvement of several decision-makers, by capital that may belong to investors from outside the family, and by the division of the farm into operational and decision-making units [28–30]. Regarding labor management, non-family farms may also differ from family ones. They are predominantly managed by wage-earning, generally skilled workers to whom responsibilities can be delegated [28–30].

Thus, governance and labor management are key dimensions for characterizing the different forms of organization and were central in our choice of the farms to study. These dimensions enabled us to define the main organizational profiles to be studied, ranging from the family farm forms [3,4] to more business-like forms [28–30]. Among the hybrid forms highlighted in the literature are the "family business model" [4], the "family entrepreneurial model" [7,30], or the "factory-style" industrial model [28] (p. 175). "Family farms", according to the Law number 11,326, are the most important form and represent about 80% of Brazilian dairy farms in 2006 [7]. The diversity of farm's organizational forms cannot be clearly identified in the Brazilian agricultural census [7]. However, the figures show that only 3% of farms produce more than 200 L of milk per day and it represents 35% of the milk produced in Brazil [7].

Contact with local organizations (cooperatives, universities, and farmer unions) was useful to get access to the interviewed farmers. They provided us a list of farms potentially considering a diversity of farm's organizational forms following the four main criteria established before. Then, we randomly contacted farmers and ask if they were interested in participating in the study and able to welcome us on their farms. The selected farm's organizational forms are consistent with the literature presented in Section 2.2.1. Again, we do not pretend to do a representative study of all the forms of organization presenting in the Brazilian dairy sector. We aim to illustrate contrasted farms organizational forms existing in the literature to explore the relations between, on the one hand, farms' organizational structure and governance, and on the other hand, the adoption of agri-environmental practices.

3.2. The Survey of the Selected Sample of Farms

Our methodological approach was based on a series of semi-structured interviews with dairy farm owners and a visit to their farms. We conducted the interviews in 2016 in the states of São Paulo and Paraná (Figure 2), the 6th and 2nd largest milk producing states respectively [7]. Farm visits are useful when studying sensitive topics such as environmental issues. It allow us to cross farmers' declarations and researcher's on-site observations. This also helps to draw-up the links between practices and the environmental externalities observed generated on-site.

The interview guide was structured around three key sections corresponding to the three main points presented in our theoretical framework:

1. The first section enabled us to identify the forms of organization characterizing traditional family farms, on the one hand, and other types of farms, on the other. We also identify the internal factors relative to the farms' governance structures, the socio-economic characteristics, and how it can influence the adoption of farm's agri-environmental practices.
2. The second section collects information about farm's agri-environmental practices to assess the degree of environmental externalities potentially produced by the system. It is organized around three criteria:
    (i) Farmer's compliance to the Law of May (2012) in terms of the protection of native vegetation in farmland. We used the statements made by our interviewees to assess four levels of positive externalities potentially produced: very high, if they go beyond the law; high, if they fully implemented the protection;

medium, if they partially implemented the protection; low, if they have not implemented the protection.

(ii) Production practices used (tillage method, fertilization methods, crop rotation, pesticide use, permanent grasslands are and grazing system, etc.). Based on these practices we analyze farm's input intensity and grazing systems to define the negative externalities potentially produced in three levels: high, input intensive system and no grazing; medium, semi-intensive use of inputs and permanent grassland areas where animals can graze; low, low use of inputs (use of agroecological practices: no pesticides, no synthetic fertilizers, no tillage, etc) and grazing all the year.

(iii) Animal waste management system (treatment, storage, and spreading of effluents) and distance from watercourses we can define the potential negative externalities of farms in three levels: high, no waste management system and close to watercourses; medium, partially implemented waste management system and are closed to watercourses; low, fully implemented waste management system and far from watercourses

3. The third section identifies the farm's external factors. We collect information to analyze the influence of the commercial factors on farms' agri-environmental profile, to characterize the regulatory and market environment (production standards) of the farm as well as the innovation networks in which they are involved.

Figure 2. Map of Brazil and states where data was collected.

For each section, we asked the owner to describe not only the current state of their farm organization and the agri-environmental practices used but also the main stages and the processes of changes, when relevant. In other words, this historical analysis informed us about the manager's perception regarding the various topics discussed and helped us to better characterize the mechanisms that influence the adoption of practices by farmers. Farmer's interviews and farms visits took from 3 to 5 h. During the farm visits, observations are made of the farmer's practices, and crosschecking are done with the farmer's declaration. When it is possible, discussions are conducted with people present on the farm other than the farmer interviewed. This helps to evaluate the relative validity

and reliability of the interviews' content [37]. All the interviews were transcribed in full being translated from Portuguese into English. Selected verbatim excerpts were then used for the analysis and illustration of the farmer's discourse.

4. Results

4.1. Farm's Organizational Forms and Its Internal Characteristics

The dairy farms studied represent different forms of organization. The first farm (EA1) is a family farm (it meets the criteria established by the Brazilian law of 2006), while the other five farms differ in various degrees from this model. Farm EA1 is in the State of São Paulo. It has family governance. Indeed, the capital belongs to the family and the farm management has been centralized in the hands of the family (father and son) for three generations. The land property, as well as farming skills, are passed on from father to son. In terms of management, farming activities and family life are closely intertwined. Production for self-consumption is a family tradition. The interviewee's discourse also shows that he is guided by an objective of long-term profitability, and by a desire to pass on land and farming legacy through the next generations. The family derives almost all income from farming. The farm is characterized by low internal absorptive capacity, due mainly to its small size (20 milking cows) and low investment capacity; furthermore, the education level of its owners is low. Its capacity for innovation is highly dependent on external resources (advice, financing, etc.).

The second farm (EA2) is in the State of Paraná. This farm is characterized by what can be called an entrepreneurial governance style. It means that the family owns only a small portion of the farmland. The farm entrepreneur leases the land, the herd, and the farm infrastructure from his neighbor. The latter delegates the operational and financial management of his farm, as well as the decision-making power to the farm entrepreneur. Two employees work on the farm, one full-time and one part-time. Part of the production activities (maize and silage production) is outsourced to an agricultural contracting company. The farm entrepreneur, who recently graduated from a veterinary school, derives 100% of his income from managing the farm. The entrepreneur considers the activity profitable but wishes to stop it once his contract with his neighbor expires showing a short-term profitability strategy. This farm has a low absorptive capacity due to its owner's lack of experience and managerial skills (25 years-old), its low investment capacity, and small size (30 milking cows). Its capacity for innovation is highly dependent on external resources.

The third farm (EA3) is also located in Paraná. The farm governance is qualified as a "family business form", with an owner who does not work on the farm and delegates the work to an employee but has all the decision-making power. The farm accounts for only 2% of his income. He is a lawyer, and the farm is one of the properties in his investment portfolio. The owner wants to keep the farm in the family because he feels a strong attachment to the land and to dairy farming. He has two intertwined objectives: to keep the farm for leisure and personal enjoyment on the one hand, and on the other hand, to possibly pass it on to one of his daughters, who recently graduated from a veterinary school. Three employees work on the farm, one of whom supervises the other two. Only the maize harvesting and silage production operations are outsourced to another company. The farm has a limited absorptive capacity. However, despite its relatively small size (38 milking cows) and its owner's lack of farming skills and experience, the farm has a high investment capacity. Its capacity for innovation is also highly dependent on external resources.

The fourth farm (EA4) is also in Paraná State. In terms of governance, it is what we call a family partnership farm. Two brothers co-own and co-manage the family farm. One of them is a veterinarian and was the director of a multinational company in the meat industry. The other is an occupational safety consultant. They have off-farm activities, but the farm now accounts for most of their income. Decision-making is more decentralized than on the first three farms. The two brothers make strategic decisions jointly. The latter seldom perform farming tasks and delegate all the operational management to an employee. Thus, there is one manager, who supervises six other employees. The sowing and harvesting

activities are outsourced. The owners' focus is on ensuring the short-term profitability of the farm, but they are also concerned about the succession. This issue is a matter of concern for the brothers, as none of their children seems to be interested in farming. The farm has a high absorptive capacity due to its large size (190 milking cows), to the owners' 30 years of experience, and considerable investment capacity. Its capacity for innovation is partly dependent on external resources.

The fifth farm (EA5) is also located in the State of Paraná. Its governance is close to an industrial or corporate farm style. Six shareholders (two from the family and four from outside the family) manage the farm. Several decision-making bodies exist and are structured hierarchically. The Board of Directors makes strategic decisions. One of the shareholders is the administrative and financial director and another is the director of production operations. In addition to being shareholders, they are also employees. Finally, there are three waged managers supervising 16 workers. All the activities related to food production and the construction of facilities are outsourced. The primary objective is financial profitability and milk production on the farm started recently (less than 5 years prior to the survey). This farm has a high absorptive capacity, due for the most part to its large size (730 milking cows), the high investment capacity, and because the shareholders have complementary skills (one animal scientist, one veterinarian specialized in reproduction, two agronomist-farmers, and dairy cow breeders, one corporate administrator, and dairy cow breeder). Their capacity for innovation depends very little on external resources.

The last farm (EA6) is in the State of São Paulo. This farm is an agribusiness corporation whose capital stock is owned exclusively by one family and its governance is that of a family-owned industrial corporation, with a board of directors composed of four family shareholders and chaired by the father. The farm has been in the family for three generations. Two of the family members work on the farm. The first is an agricultural engineer and oversees the operational management of the production and processing activities. The second is a business school graduate and acts as a financial and commercial director. The operation employs 230 wageworkers, including 12 team managers, in charge of the different stages of production, processing, and marketing of the farm's products. They outsource very few of their activities. The governance is guided by a financial as well patrimonial rationale, with a focus on profit maximization through intensification and the creation of benefit on the products. This farm has a high absorptive capacity thanks to its large size (1600 milking cows), a significant investment capacity, the diversified and competent human capital (continuous employee training), and the skills acquired through experience in managing large-scale farming operations for several generations. Their adoption of the practices depends very little on external resources.

4.2. The External Environment of the Dairy Farms

Regarding the regulatory environment, all farms' managers reported that they comply with the 2012 Brazilian law for the protection of areas covered with indigenous vegetation on farm holdings (Native Vegetation Protection Law). However, all the interviewees testify that although environmental protection is considered a major issue, the State has disengaged itself entirely from the provision of support to farming communities in their transition to compliance with regulations and has withdrawn from its role of enforcing regulations. All interviewees express a feeling of unfairness, a sense that the law is unclear and that the State does not support farmers.

Thus, for EA1, the technical support provided by a local university has been key in bringing the farm into compliance with regulatory requirements. "A professor came with students to help us with this new regulation and they even planted trees". The farm manager also expressed a sense of injustice and feel that the State is illegitimate in its application of environmental regulations. "Instead of punishing the big ones, they are going to punish the small farms of 10 to 20 hectares ... There's a big farm in the area that doesn't comply with environmental regulations and they have never been punished". The farm managers of EA2 and EA3 reported that they are aware of the importance of

compliance but that the State has not adopted any compliance monitoring measure. The managers of EA2 consider that the lack of information and clarity in the laws as well as the lack of state support are major obstacles to regulatory compliance.

In EA6, our respondent concurs with this assessment "the law is not very clear and the obligation for farmers to implement conservation measures or not depends very much on the demands of the controlling officer". The managers in EA 4, 5, and 6 reports that they have had no problems in bringing their operations into compliance and that there is increasingly stringent monitoring of farms' compliance with environmental regulations in their region. The owner of EA4 underlines the key role played by the cooperative through knowledge sharing into the compliance process: "The cooperative has organized collective training sessions, provided technical support to its members to facilitate their transition to compliance with environmental standards".

Regarding milk production, due to the lack of environmental regulations governing the treatment, storage, and spreading of animal waste, some farmers are not necessarily aware that poor waste management can result in severe environmental externalities (e.g., water contamination, loss of biodiversity, etc.). Consequently, perceptions, motivations, and behaviours associated with the impacts of animal effluents vary from farmer to farmer. Due to the small volume of effluent produced on his farm, the owner of EA1 does not perceive animal waste as a major source of pollution. For the owners of EA2 and EA3, this source of pollution is not perceived as a problem either. The owners of EA4, EA5, and EA6 are more aware of the environmental impact of animal waste. According to the owner of EA4 "In a region like ours, which has a large concentration of dairy farms, with many animals confined in stalls, animal effluents is becoming a concern . . . ". As for the owner of EA6, he believes that "with the big amount of effluents produced in the farm, I can't flush it all down the river like people used to do in the old days".

We observed that the managers of EA4, EA5, and EA6 have been more proactive in anticipating future regulations but that there is also some dissatisfaction them regarding the lack of support they receive in the process towards compliance, as well as the lack of compensation for complying with the requirements. According to the owner of EA4, "regulations similar to those imposed in the swine production industry will soon apply to the dairy sector". For the owner of EA6, "environmental laws are constantly changing, and the tendency is to pay more attention to the issue of dairy effluents". Despite the cost incurred by the producer, he also states that he is vigilant and stays ahead of future regulatory changes: "In our production planning, we had already considered the question of the environmental impact and kept the recycling of effluents in mind. We have only minor adjustments. For us, compliance has not required any major structural changes".

Spatial, sectoral, and market environments of the farms are different and have an important impact on farming practices. EA1 produces raw milk (normative instruction number 62, 29 December 2011, defines production, packaging and processing criteria that allow milk to be classified into 2 categories: cooled raw milk and type A milk. Chilled raw milk concerns all volumes that cannot be qualified as type A milk. Type A milk must meet specifications with requirements for more stringent microbiological and sanitary processes and parameters. This milk costs more and is intended for consumers with greater purchasing power) and sells it through different channels and market segments (with low to high-value-added). Most of the milk is collected and processed by a small local cooperative (100 members) founded with strong involvement of the local University and which the farmer has been a member since its creation. There are no written contracts, but there is a strong sense of belonging among the members and of satisfaction with the cooperative: "The cooperative has played a central role in changing the lives of small milk producers in this region and we have always learned by working together . . . prices at the cooperative are more advantageous and stable . . . we no longer pay for the collection . . . The farmers are paid for quality and farmers are aware of the importance of producing quality milk". Some of the milk is processed into cheese that is sold at the local producers' markets. The farmer perceives this marketing channel as 'ideal'.

EA2 and EA3 produce raw milk, all of which is then sold to a private processing business. The dairy products manufactured by this business are intended for a "low-end, low added value" market that extends beyond the State of Paraná. There are no written contracts. As the EA2 farmer explains: "I can stop delivering milk overnight without getting any penalty". This can lead to disputes. The farmer adds: "They didn't pay me for 3 months in a row, their cheque bounced. I changed buyers". Processing companies set the prices, on par with the prices of the competition, but with the possibility of negotiating them. Traceability and quality standards are low or even non-existent and the farmer. The farmer reports: "they say they pay for quality but in practice, they only pay for the volume of milk we deliver to the factory . . . So, there is no point in investing money and effort in improving quality". This form of opportunistic behaviour is an obstacle to risk pooling and makes it difficult to share the costs incurred in implementing quality standards.

Farms EA4 and EA5 have a contract (with an exclusivity clause) to deliver milk, to the local cooperative. If a farmer wishes to stop supplying the cooperative, he is required to give the latter at least 6 months' notice. This cooperative is larger than that mentioned above. It processes part of the milk under its own brand, supplies the national market, and more specifically the country's main consumer centres (São Paulo, Rio de Janeiro, etc.). The cooperative operates in a high value-added segment of the dairy market. The cooperative, in partnership with an international dairy company, put in place mechanisms of price incentives and technical support to encourage farmers to adopt environmentally sustainable farming practices. These mechanisms reduce uncertainties related to quality and the practices employed by farmers. They add value and help the cooperative develop a reputation for its products and brand.

EA6 farm produces type A milk, most of which is processed on-site and marketed under its own brand. "We started producing type A milk thanks to a joint venture with a well-known domestic brand. After ten years of operating as a joint venture, we had a good knowledge of this market and so we decided to start producing under our own brand". The regulations to produce this type of milk require, among other things, full traceability of the production process. The milk produced on the farm is also certified Kosher (milk produced, conserved, and processed according to dietary criteria established by the Torah). Among the products of this farm: "Type A dairy products are high-quality-differential products. They have a distinct freshness. Our customers are diverse, but most have a strong purchasing power. Direct producer-to-consumer delivery is a fast-developing marketing channel". Other processing companies also buy farm's raw milk. The strategy of producing this type of milk and selling it under their own brand requires creating a brand image and provide quality guaranties to the consumer. Provide these guaranties to build up a brand image requires the adoption of production practices complying with standards related to the welfare of workers and animals, and environmentally sustainable practices.

4.3. The Agri-Environmental Practices and the Environmental Externalities of the Dairy Farms

The degree of environmental externalities potentially produced by a farm is the result of dairy farm's agri-environmental practices. It can vary from low to very high and is assessed by three main criteria (see Section 3.2): the compliance with environmental laws related to the preservation of areas with native vegetation cover, production practices used (input intensity and grazing systems), and animal waste management (treatment, storage and spreading effluents). These practices combined allow us to define the farm's agri-environmental profile (Table 1).

Table 1. Agri-environmental profile of practices and farm's organizational forms.

	EA1 Family	EA2 Entrepreneurial	EA3 Family Business	EA4 Family Partnership	EA5 Corporate Farm	EA6 Agro-Industrial
Degree of positive externalities potentially produced associated with the farmers' protection of areas with native vegetation *	Very high, thanks to the preservation of areas with native vegetation, in full compliance with the law, and beyond.	Medium, thanks to the partial preservation of areas with native vegetation, within the limits defined by the law; drainage of the ponds for irrigation	Medium, thanks to the partial preservation of areas with native vegetation, within the limits defined by the law	Very high, thanks to the preservation of areas with native vegetation, in full compliance with the law	High, thanks to the preservation of areas with native vegetation, within the limits defined by the law	High, thanks to the reservation of areas with native vegetation, within the limits defined by the law
Degree of negative externalities potentially produced by farming practices (level of inputs and permanent grassland)	Low, due to the set of agroecological practices **	Medium, due to large acreage in permanent grassland and semi-intensive use of inputs; conventional practices	Medium due to large acreage in permanent grassland. Semi-intensive use of inputs, and use of conventional practices	Medium due to percentage of the land is in permanent grassland; But high input systems, and use of conventional practices	High, due to intensive input systems, Conventional practices	High, due to intensive input systems, Conventional practices
Degree of negative externalities potentially produced by livestock waste management	Low, due to sufficient distance between milking facilities and watercourses. Animal waste used in the family gardens	Medium, due to partially implemented waste storage facilities and proximity to watercourses	Medium, due to partially implemented waste storage facilities are proximity to watercourses	Low, due to waste storage and treatment facilities (compost barn)	Low, due to waste storage and treatment facilities (methanation)	Low due to very well managed: waste storage and treatment facilities, regular monitoring of the quality of surface and underground water
Agri-environmental profile	Agroecological with low potential externalities	Semi-intensive with medium potential externalities	Semi-intensive with medium potential externalities	(Semi)intensive with medium to low potential externalities	Intensive with low to high potential externalities	Intensive with low to high potential externalities

* Brazilian Environmental Preservation Law. Farmers are required to maintain large areas of native vegetation under protection, to maintain biodiversity. Farmers are also required to take measures to protect water sources, riverbanks, ponds, etc. In the regions studied, farmers must keep approximately 30% of their surface area with native vegetation under protection. ** Direct seeding, without using any synthetic fertilizers nor pesticides, rotational crops, year-round pasture, no silage corn production, use of grass-legume mixtures, rational rotational grazing on small plots.

Regarding the preservation of areas with native vegetation cover, the representatives of all the farms declare that they have complied with the regulations and have partially or fully protected vegetation close to riverbanks, following the criteria established by law. The owners of EA1 and EA4 report: "We have taken all the necessary measures—and more—to comply with environmental protection laws". The owners of EA2 and EA3 admit that they have not taken all the protection measures stipulated by the law. According to the owner of EA2 "In the past, the animals use to have free access to the river. Now, the areas along the riverbanks, with native vegetation cover are all protected from the livestock". The owner of EA3 reported that he had already initiated the compliance process: "a large part of the areas to be protected have already been brought up to environmental standards. The rest will be done soon". The owners of EA5 and EA6 claim that they protected the areas with native vegetation cover according to the criteria stipulated by the law. Finally, the degree of positive externalities potentially produced due to the farmers' protection of areas with native vegetation is considered as very high in the EA1 and EA4, high in the EA5 and EA6, and medium in the EA2 and EA3.

In terms of production practices, EA1 stands out from the other farms. It has adopted agroecological practices: direct seeding, no pesticides or synthetic fertilisers are used, use of grass-leguminous in the grassland, use of different species of grass, use of hardier livestock, absence of grain concentrates and corn silage in the ration, rotational grazing on 70 parcels throughout the year and no irrigation. All these practices, combined with the fact that the farm produces a low volume of milk (around 10 L/milking cow/day), lower the risk of producing negative externalities on this farm. It is also interesting to note that the extensive farming method used is suitable on a farm in which little family labour is available. "We tried, but it didn't work . . . My cousin does it, but his wife does the milking and operates a tractor too, my son's wife does not do that".

EA2, EA3, and EA4 produce corn silage and buy feed (mainly concentrates) but have a larger acreage in permanent pasture grazed by the animals. They use synthetic fertilisers, and pesticides. They use dairy cattle specialized breeds, but the cows' milk productivity per day varies between the three farms 28 L for EA4, 22 for EA2, and 18 for EA3. Therefore, farm EA4 has a slightly more intensive system than the others do. The three farms have in common genetic improvement, artificial insemination, and direct seeding practices as well as the absence of irrigation. EA2, EA3, EA4 use conventional practices and use much more inputs than EA1. Because of these practices and productivity figures, the level of environmental externalities potentially produced by farms' practices is considered as medium. This leads us to classify their production methods as semi-intensive.

EA5 outsources all food production activities. One of the farm's shareholders produces part of the feed (corn silage and grass). The latter uses conventional practices (he does, however, use direct seeding and crop rotation), including input-intensive techniques (synthetic fertilisation, pesticides, etc.). EA6 uses irrigation and conventional, input-intensive production practices (but he also uses direct seeding and crop rotation). Most of the farm's acreage is used for corn silage production, the other part being used for grass production. Part of the feed is outsourced. On both farms, animals have no access to pastures. The farmers use specialized dairy breeds with very high production potential and apply genetical improvement techniques. The daily milk output per lactating cow is approximately 40 L. Because of these intensive practices and the use of inputs, the degree of environmental externalities potentially produced by both these farms is high.

The negative externalities potentially caused by waste management vary from farm to farm. EA1 has no animal waste management system, but its potential generation of negative externalities is very low due to the production practices it uses (year-round grazing and exclusively grass-based feeding), low level of productivity, and the distance of the milking facilities from watercourses. In EA2, EA3, and EA4, the lactating animals are fed in feeding facilities but also have access to grazing paddocks throughout the year, although there is no rotational grazing. EA2 and EA3 are equipped with a rather inadequate milking and waste management facilities located close to watercourses. Because of this partial

management of animal wastes, the risk of externalities potentially produced by the farms is classified as medium. EA4 manages livestock waste by collecting it into settling ponds and composting it in a compost barn (a method of treating excreta by composting excreta under confined or semi-confined animals in a building; agricultural by-products are added to the soil such as: rice husks, coffee straw, sawdust, etc.), which helps to reduce externalities. EA5 and EA6 generate a large quantity of animal waste. However, the farms have efficient waste management systems. EA5 uses methanation as a waste treatment solution and in EA6 the solid effluents are composted while the liquid waste is used for spreading. EA6 regularly monitors the quality of surface and underground water within the farm's boundaries. Because of these reasons, we consider the degree of negative externalities potentially produced by livestock waste management in EA4, EA5, and EA6 as low.

5. Discussion

5.1. Organizational Forms and Agri-Environmental Practices

On the one hand, we have observed the influence of internal factors structural characteristics, governance, and absorptive capacity. On the other hand, we have observed the influence of factors external to farms such as the regulatory, sectoral, spatial, and market environment. We also identified incentive or learning mechanisms playing in the adoption processes.

The results relative to the traditional family farm (EA1) show first that the form of organization and governance influence the farmer's consideration of environmental externalities. In accordance with [13,24], we show that farmer's choices of production methods are intrinsically linked to a strategy of adaptation to the capacities, skills, and preferences of the family as the on the farm available workforce. In line with these studies, our results also show that the farm's trajectory of adoption of agri-environmental practices is intrinsically linked to family-oriented objectives, including that of the transfer to future generations of farming traditions, knowledge, and lifestyle. Regarding external factors, the results show that with the low absorptive capacity (low levels of education and skills and low investment capacity) the sectoral and spatial factors play a major role in the adoption. The interaction with the university (for more than 20 years) has contributed to the farmer's learning and adopting agri-environmental practices. The university provided the technical and operational support necessary to bring the farm up to environmental regulations. Thus, the role of educational and research institutions is important for the definition of environmental actions in the analyzed production systems. In this sense, public policy should give more attention to regions where there is a lack of research and extension agencies. In these regions, the role of industry or collective forms of production can be an important alternative. The main role of the Universities and NGO's in the adoption of agroecological practices in Brazilian family farms is also showed in other study [9]. The reinforcement of informative networks is a key point on the development of family farm's resilience [13]. The market environment of the farm seems to have very little influence on the adoption of practices.

About the entrepreneurial farm (EA2) and the family farm business (EA3), the results first show that internal factors associated with the form of organization such as low/medium absorptive capacity (the managers' low level of experience, a lack of diversity among low skilled employees) have a limiting effect on the adoption. We also showed that limited awareness of the impacts of the practices employed on the farm is an obstacle to the adoption of agri-environmental practices [38]. The fact that the farmers (EA2) see land as "a production tool" and prioritizes short-term profitability can also explain the negative effect on the adoption of greener practices. Other authors [5] also identified this kind of environmental attitude associated with a "yield optimizer" farm governance profile. Because of the complexity of EA3's short and long-term strategies, the links between the governance of the farm and environmental strategies are less clear for this farm. The absence of incentives associated with the lack of standards compliance monitoring has a negative impact on adoption and is a major barrier to the application of Brazilian Forest

Code [16,34]. Sectoral and market characteristics also make it difficult to set up contractual and incentive arrangements for sharing the value-added, which could contribute to the adoption of agri-environmental practices. The interviewees explain that overly opportunistic behavior, combined with the absence of quality standards and compensation payments, makes difficult for relations of trust between the farmers and processing companies of the region to develop. These problems of coordination to put in place quality standards are mentioned in many studies [22,35]. The difficulty to precisely measure the agricultural environmental externalities make it harder to set up incentive arrangements for environmental practices adoption along agro-food value chains [23]. Especially in the case of livestock effluents, the lack of specific legislation, perception of its impacts, and high cost of waste treatment facilities are the main obstacles to the adoption of best waste management practices. The policy should pay more attention to dairy farms effluent pollution, mainly in the case of the intensification of agriculture practices happening in Brazil now. More than regulation, it seems important to designing incentives to the adoption of low-cost dairy waste management solutions.

In the case of the family partnership farm (EA4), we first find that the farm's high absorptive capacity (the managers' high level of training and experience and their investment capacity) is an important factor promoting adoption. Manager's awareness of the environmental impacts also drives the adoption of the farm's practices [38]. Our results corroborate other studies [26] showing that collective arrangements have a significant and positive effect on the adoption of environmental practices. In fact, by contributing to the construction of a common reputation and the development of common values between the members, the cooperative has played a key role. It facilitates the dissemination of knowledge, the distribution of value added in their production, the pooling of specific resources, learning, as well as the implementation of bonuses for the adoption of agri-environmental practices. Selling milk in a high value-added market, with standards governing quality and production practices, is a factor contributing to the reduction of environmental externalities.

Internal factors appear to be the main drivers of adoption agri-environmental practices by the corporate farm (EA5). Its large absorptive capacity (large size, high investment capacity, highly qualified human resources, and diversified skills) contributes to the establishment of coordination mechanisms in the organization that facilitate the adoption of the practices. In addition to these factors, the farmers' ability to anticipate possible stricter regulations also influences adoption. Moreover, the farm's participation in a cooperative network and the fact that it operates in a high value-added market with standards governing quality and production practices seem to be factors contributing to the adoption.

The adoption of agri-environmental practice by the industrial farm (EA6) seems to be linked to a brand image strategy. Indeed, to produce dairy products for the high value-added market in which it operates, and to be able to sell under its own brand, the farm must use the incentive and coordination mechanisms associated with the construction of an environmentally friendly" image. For this purpose, it relies on highly structured internal coordination mechanisms based on knowledge acquisition (continuous employee training). This explains the farm's high absorptive and innovation capacity (investment capacity, high level of organizational experience, highly qualified human resources, diversified skills), which positively influences the adoption of agri-environmental practices. The organizational memory developed over a three-generation long process of learning the ins and outs of industrial farming also seems to explain the implementation of agri-environmental practices, as part of a strategy of anticipation of stricter environmental regulations

5.2. What Explains Farm's Adoption of Agri-Environmental Practices? A Synthesis of the Main Sights

First, the results illustrate the internal factors associated with the farms' organizational choices and help to better understanding the adoption of agri-environmental practices. In line with the literature, the study shows that structural [6,9] and governance factors [3,5,9,12,13], the managers' perception [9,25,38], and the organization's absorptive capacity [9,13,24] influence farmer's choices in terms of environmental practices.

About governance, we observe that in the case of the family farm, the organization of production and family life are closely intertwined, which has an impact on the farmer's adoption of agri-environmental practices. We show that the involvement of the family members in farm activities is related to the practices used [27]. In fact, the availability, skills and wishes of the family labor force are important drivers of agri-environmental practices choices [27]. These corroborate the studies stressing that the adoption of practices on farms is closely related to family dynamics and changes in family preferences [4,13,21]. Our results show that technical learning processes are inseparable from organizational learning processes. The influence of the land ownership status and the farmer's objective to pass on the farm to future generations on the reduction of environmental externalities seems less clear. As for farmers' perception of the impacts of practices on the environment, behaviors vary. The limited awareness by some farm managers seems to be a major obstacle to the reduction of externalities. Some studies also highlight farmers' perceptions of environmental risk is the most important determinant of the adoption of good practices [39].

In line with the literature, we observe that the internal incentive and coordination mechanisms, as well as the organizational memory of organizations, are important determinants of adoption [9,12,13]. Indeed, we show that it is thanks to their significant investment and managerial capacities, the quality, and diversity of their human resources, and their organizational memory that these organizations can adopt agri-environmental practices.

Secondly, the results illustrate the role of external factors in the adoption process. They show that organizations with low absorptive capacity and limited internal resources rely strongly on their regulatory, spatial, and market environment to be able to implement environmental practices. Indeed, if the environment is not conducive to the creation of incentive and coordination mechanisms nor the implementation of learning processes, farms will not adopt agri-environmental practices. We find that environmental regulations must be accompanied by incentive and support policies to push the implementation of those practices in dairy farms.

In situations where the State is deficient in this respect, regulations can be fully respected only if they are accompanied by incentive mechanisms and mimetic or learning processes arising from the farm's interaction with its spatial and market environments [6,22,26]. In fact, our results show that local cooperative networks and interactions with the university play key roles in the process of adoption of agri-environmental practices by farmers. These networks allow for the emergence and development of collective learning and knowledge-sharing processes [26]. Indeed, factors such as trust, reputation, and the sharing of common values achieved through these networks all have positive effects on the adoption of agri-environmental practices [22].

The study shows that in parallel, operating in a high value-added market also gives rise to market price-based incentive mechanisms and mechanisms associated with brand image (reputation) building strategies [21,22,35]. The study shows that anticipating stricter environmental regulations is a factor that influences the choice of practices. Nevertheless, similar to other studies show, the implementation of stricter regulations and standards generates controversy concerning the cost-benefit impact of such regulations, whether in economic or social terms [16,34,40]. Indeed, our results also reveal that the adoption of quality standards, especially environmental standards, can benefit some actors while excluding others. Furthermore, as showed in the literature [39], our case studies illustrate that the spatial heterogeneity of human capital and resources makes compliance with quality and environmental standards particularly difficult in Brazil.

6. Conclusions

This article has aimed to contribute to existing knowledge on the processes of adoption of agri-environmental practices by conducting a more in-depth study of the internal organization factors and those related to farms' external environment. We contribute to make an empirical progress in the analysis of the links between models of agricultural organizations of choice of practices. For this purpose, we conducted case studies that has

helped us to highlight the decision-making processes, incentive, coordination mechanisms, and learning processes on which the environmental profile of farms is based. We have used innovation and organizational economics approaches and evolutionary economics concepts to better understand the decision-making and learning processes associated with farms' adoption of agri-environmental practices.

About the internal factors, the study has highlighted the role in the adoption of agri-environmental practices of farms' structural and governance characteristics, absorptive capacity, and managers' perceptions. In the case of operations with high absorptive capacity, the farms' investment capacity, the quality, and diversity of their human resource, their organizational experience, and learning seem to play a key role in the implementation of agri-environmental practices. At the same time, we find that organizations with limited internal resources depend more specifically on external sectoral or territorial resources to be able to implement environmental practices. We have highlighted the important role of local cooperative networks and the partnership with the University in the adoption of agri-environmental practices, particularly for farms with lower absorptive capacity. Indeed, the implementation of arrangements for encouraging farmers to adopt agri-environmental practices involves the pooling of technical, informational, and financial resources as well as values related to trust and reputation. More generally, a manager's perception of the environmental externalities generated by productive practices is also a factor in the adoption of practices. The links between environmental profiles, land ownership status and farmer's succession issues seem more complex and call for further exploration.

Regarding the role of regulatory factors, the study highlights that more than setup environmental regulations, it seems important to designing incentives to push farms to preserve native vegetation and adopt waste management measures. Policy, market, and sectoral environment should provide these incentives and support mechanisms. Operating in a high value-added market also gives rise to price-based and reputation (brand image building) incentives promoting the adoption of environmental practices. The study also shows that anticipating stricter regulations is also a factor that influences the choice of practices.

This study has also provided theoretical and methodological insights. First, it seems important to use a multifactorial approach (internal structure, governance, and external environment) to understand a farm's environmental profile. It seems useful and relevant to apply the analytical framework generally used when studying eco-innovations in the industrial sector to the study of farms. Moreover, in the context of the case studies, the semi-directive interviews combined with visits and observations in the fields and on the farms enabled us to collect original, detailed, and reliable information. This approach has enabled us, not only to highlight the complex relationship between the form of organization and farm's environmental externalities by exploring the decision-making and learning processes associated with the adoption of practices. However, it is important to stress that the results of this study should be generalized with caution. Conducting interviews with a larger sample of farms would allow for a wider generalization of the results.

Finally, to promoting the adoption of better agri-environmental practices, policies should better consider farms as heterogeneous organizational forms. This heterogeneity can be related to factors composing farm's structure and governance but also to the sectoral, spatial, and market environments. Considering the constraints and needs of these different organizational forms to strengthening the farm's absorption, adaptation, and transformation capacities seems to be good insights to accelerate the agroecological transition.

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