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Formal rules and its role in centralised-diffusion systems: A study of small-scale producers of oil palm in Colombia

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Abstract

This paper explores the different pathways of technology diffusion and the resulting impacts on technology adoption that can emerge following a strategy to incorporate vulnerable communities of small-scale producers into traditionally top-down governance agribusiness systems. Building on the Contract Farming Arrangements (CFA) literature, we suggest that despite high levels of top-down control and the mono systems of diffusion that these practices imply, diffusion forms can vary considerably according to the motivations that drive different types of producers and the variances in local governance. We
summarise these diffusion forms as a *diffusion pathway of governance dictated by dominant change agent control* and a *diffusion pathway of governance dictated by change agent control and user participation*. An important contribution of the paper is to highlight the critical role of formal rules in defining the types of governance for the creation of these different pathways. However, additional factors associated with the participation of smallholders such as attachment to land, engagement in collective action and long-term sustainability visions also introduce variations in these pathways and define the results of technology adoption. The study focuses on the Colombian oil palm sector; a key agribusiness sector targeted by policy makers with a strategy to integrate small-scale farmers into the agribusiness value chain as a means to relieve poverty and reduce levels of rural violence associated with conflicts over land and production of illicit crops.

**Key words:** formal rules, technology diffusion, technology adoption, agri-food, small-scale producers.
1. Introduction

In agri-food markets, debates around technology diffusion and technology adoption have important implications for farmers and the agency these have in decision-making within the innovation-development process. In developing countries in particular, there has traditionally been a high dependency on the technical assistance of so-called “technical experts” for the diffusion and adoption of agricultural practices. These so-called experts are often processors and agro-industrial firms, and their support generally exists under centralised-diffusion models.

According to the ‘centralised-diffusion systems’ approach, these technical experts exert considerable control over the research, diffusion and adoption of technology (Rogers, 2010). Diffusion of agricultural innovations is commonly characterised as highly linear, with little consideration for possible variations (Ryan and Gross, 1943; Röling, 2004; Spielman et al., 2008; Knickel et al., 2009; Kuijpers and Swinnen, 2016). And yet, this depiction of the diffusion process does not reflect reality and indeed paints a simplistic caricature of rural diffusion processes. We therefore introduce the idea of “pathways of diffusion” to discuss how small producer agency in centralised systems can produce variations in types of diffusion practices which can have a significant influence on long-term sustainable practices within centralised-diffusion systems.
One understudied, yet critical factor that is specific to agricultural contexts and can influence the formation of diffusion pathways in centralised models is *formal rules*. By the term formal rules, we refer to the local agreements that define technical responsibilities for crop management, and the selection criteria by which producers of an agricultural cluster are chosen. More importantly, these formal rules also underpin social values and mutual commitments. We focus on two key elements that help us to understand the variations in rules and therefore the differences in the resulting pathways. The first element of this discussion is related to governance typologies, which are defined here as the different levels of control in decision-making processes for crop management and the distribution of technical responsibilities amongst members of a cluster. The second element relates to the types of technology users that are selected through formal rules.

For the purposes of framing the discussion, the contract farming arrangement (CFA) literature provides useful insights into the types of governance, and therefore types of formal rules in agri-food clusters. Specifically, the works of Kirsten and Sartorius (2002) and Barrett et al. (2012) discuss CFAs in terms of the technical responsibilities of smallholders and leading agro-industrial firms, the leading roles in decision-making and the criteria for the selection of producers. The paper develops a framework where a typology of formal rules lays out three diffusion pathways within centralised systems, the governance of which are dictated by CFAs of high, partial or low change agent control. Each scenario favours different relationships of the technology transfer from agro-industrial firms to producers and is associated with responses in terms of levels of technology adoption.
The specific context of the discussion is an empirical analysis of three oil palm clusters in the north-east of Colombia. Although Colombia produces just 2% (1,275,000 tons) of the world palm oil, compared to Malaysia and Indonesia, which together produce 85.3% (53,197,000 tons) (figures for 2015, Fedepalma, 2019), oil palm in this country is an emblematic case for the study of CFAs for several reasons. Firstly, it is the biggest producer of palm oil Latin America and following similar smallholder\(^1\) schemes for oil palm production in Southeast Asia (Beekmans et al., 2014), the Colombian government adopted a strategy for the implementation of ‘alliances’, in which incentives are created for smallholders to improve their livelihood opportunities by growing oil palm. In Colombia’s case, these programmes were particularly important because it is hoped that this can act as a substitute to the growing of illicit crops. As a result, the number of plantations owned by small-scale producers in these alliances grew from 2,307 in 1997 to 4,396 in 2011 and reached 32% (301,000 tons) of production\(^2\). This expansion in principle also benefits the agro-industrial companies that can increase the installed capacity of their mills without growing land ownership, whilst making adjustments in the way they diffuse technologies and practices and support the implementation of these techniques. Thus, in this new industry framework, smallholders become strategic allies rather than just raw material producers. Although important for the oil palm sector, the alliance strategy has been strongly questioned since high and medium levels of displacement were found in some areas that contained alliances.

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\(^1\) This study uses the definition of smallholders as farmers controlling 50 hectares or less of cultivated area (Rspo.org, 2017) that also have difficulty in accessing technical and economic resources.

\(^2\) Authors’ calculations based on Fedepalma (2019).
In other regions, funding was not extended to new smallholder producers, unless they became part of an alliance\(^3\) (Potter, 2020). As we shall argue, the incorporation of small-sized farms therefore marks an opportunity for the agroindustry to experiment with different forms of technology diffusion and adoption, as well as positively impact poor farmer livelihoods. The experience of the palm oil has implications for other sectors where similar schemes can be considered.

The central questions that this paper raises therefore are: how can different types of formal rules lead to different pathways of technology diffusion? how does technology adoption vary with the different pathways of diffusion and how do these variations impact the adoption of long-term and short-term practices separately? Our proposition is that the manner in which poor smallholders are integrated into agri-food sectors through formal rules can be vital for improving their socioeconomic conditions in the short and long-term. Similarly, the manner of their integration can help to define more socially sustainable pathways of diffusion based on new forms of crop husbandry for the industry. These important issues should be considered by policy-makers.

In this paper we focus on preventive practices and shock practices to deal with the plant disease epidemic of oil palm Bud Rot (BR), which represents one of the most pernicious threats to the Colombian oil palm industry. For the study of formal rules we employed

\(^3\) It is important to note that most of these alliances were controlled by rural elites in Colombia (Potter, 2020)
qualitative methods, these were also used to analyse the responsibilities and roles of actors as well as emergent technical relationships. For technology adoption, quantitative measures were used. We considered a comparative technique for cross-case analysis to find patterns of diffusion and draw conclusions. Finally, the results show that, not only are formal rules a critical factor in the creation of pathways of technology diffusion, but a study of different formal rules can also provide new insights about the process of innovation-diffusion and adoption in the context of agro-food farming.

The next three sections describe the conceptual framework for this study, followed by sections on methodology and data. Section 6 presents results whilst Section 7 discusses findings and draws conclusions.

2. Challenging the linear perceptions of the centralised-diffusion model in agriculture

Within the context of agriculture, technology-diffusion processes are understood to be the delivery of services, equipment and inputs as well as the transfer of practices, knowledge and information regarding crop management. In the literature on diffusion of agricultural innovations, the predominant theoretical approaches have evolved from being highly centralised to more decentralised or systemic models (Klerkx et al., 2012). The centralised models relate to models in which technical experts generate innovations that are distributed by change agents, to opinion leaders, and from them to technology users.
(Rogers, 2010). In this case, the technology users are agricultural producers (Ryan and Gross, 1943). While change agents are actors in charge of linking R&D systems with user systems such as agricultural extension agents and scientific institutions, opinion leaders are actors that are able to influence other individuals’ attitudes and behaviours. By contrast with centralised models, the ‘decentralised models’ have wide sharing of power and control between technical experts and technology users (Rogers, 2010).

Agri-food sectors of developing countries are usually characterised by adopting centralised-diffusion models. One of the main reasons for this is because there are demand–led value chains where those with closest access to consumers and markets have greater power to define certifications, standards and distribution of incomes. Furthermore, in these sectors, smallholders often have limited access to productive assets, limited access to production technologies and institutional constraints to credit and insurance (Barrett, 2010; Key and Runsten, 1999; McCarthy, 2010; Minh et al., 2011; Bitzer and Bijman, 2014). By contrast, much of the agency in terms of technical capacity is concentrated in change agents who are alleged to have the technical and economic capacity to support the innovation process of smallholders.

However, a significant body of thinking, under the umbrella of decentralised systems, provides extensive critiques to the centralised models. Debates mainly revolve around the crucial role of local knowledge, needs and values of farmers as well as the contribution of other stakeholders in the diffusion and adoption of technologies, which are not considered
by centralised models (Röling, 2004; Spielman et al., 2008; Knickel et al., 2009; Gilles et al., 2013; Garb and Friedlander, 2014). Another critique of centralised models is that they do not grasp the complexity of the relationships between farmers and extension agents, which goes further than a one-way hierarchical relationship (Leeuwis, 2004). Other studies commonly argue that these models do not consider the particularities of every context, nor do they further expand the impacts of technology adoption and agricultural research (Garb and Friedlander, 2014; Wigboldus et al., 2016).

When comparing the way that the studies on agricultural innovation characterise both centralised and decentralised models of diffusion, it is possible to notice that several authors tend to approach this as a binary choice between top-down and bottom-up approaches, leaving out what actually happens in reality, which has elements of both. Some authors in this literature, such as Rogers (2010), Schut et al. (2014), and Díaz-José et al. (2016), recognise that a combination of characteristics from these diffusion models can be used in a way that is not mutually exclusive. However, the study of these ‘grey areas’ could considerably enlighten our understanding of how technology is diffused successfully, especially to small-scale producers. We elaborate on this view and discuss multiple scenarios with different results in terms of technology adoption that may emerge within a dominant centralised-diffusion model due to variations in local arrangements.

Within the agricultural innovation literature, there is an important body of work discussing the critical drivers of technology adoption that also affect technology diffusion. Some of
these drivers are producers’ characteristics (e.g. education, age and income), attributes of innovations, and institutional settings (Wejnert, 2002; Pannell et al., 2006; Mills et al., 2017). In this paper we will focus on one less explored aspect that influences governance relations in diffusion, which is the contractual setting. Important evidence indicates that top-down mechanisms often take place in a planned way in agri-food sectors. There are studies in the literature on agricultural innovation referencing the impact of government institutions (e.g. policies and extension services) on technology adoption (Wejnert, 2002; Kassie et al., 2015). However, there is a lacuna in studies that specifically analyse the effect of local agreements on adoption and particularly on technology diffusion.

Some studies in Eastern Cape, South Africa, indicate that formal rules and technical agreements with processors are the principle means to transfer expertise and ensure the alignment of emerging farmers’ products with the requirements of global demand (Bitzer and Bijman, 2014). However, in this paper we argue that the significance of these rules goes beyond formal contractual relations and determination of transaction costs. In fact, formal rules and agreements, underpins mutual expectations and values of trust and friendship. Variations in these agreements, re-interpreted here as formal rules, therefore need to be considered more carefully within the theory of innovation diffusion. This is particularly true for the centralised models, since different agreements could lead to variations in outcomes of technology diffusion.
3. Unpacking the concept of the formal rules within centralised-diffusion models

In the context of agri-food where market relationships are at the core, formal rules are necessary to reduce uncertainty between individuals’ market interactions. These agreements are considered here in terms of ‘institutions of governance’ by which Williamson (2000) suggests there is a contract between parties through private transactions. Here, the concept of contracting is used in an alternative way. It is argued that these arrangements initially emerge in a scenario of market relationships where smallholders and agro-industrial firms have overlapping economic interests. However, both parties commit to each other under rules of expectation and trust regarding technology transfer. Therefore, these arrangements do not only cover transaction costs but a contested relationship whose interpretation of parties’ commitments differ from Williamson's (2000) principles.

We interpret formal rules in this paper from a micro perspective rather than a macro perspective of governmental regulations. This is a fairly new approach since contributors to theories of innovation diffusion (Rogers, 2010; Valente, 1995; Wejnert, 2002) and perspectives of agricultural innovation (Lee, 2005; Monge et al., 2008; Spielman et al., 2008; Knickel et al., 2009) do not mention formal rules for the characterisation of diffusion processes.
We suggest, by contrast that formal rules can take the form of contract farming arrangements (CFAs) that regulate the technology transfer between agro-industrial firms and smallholders. CFAs are agreements between agricultural producers and buyers in which farmers ensure the supply of products and firms guarantee the purchase of farmers’ product. In these schemes, buyers typically facilitate the access to inputs, technical support, information, technology, managerial skills, and other resources needed by smallholders (Key and Runsten, 1999; Barrett et al., 2012). As such, CFAs can influence the extent to which innovations are delivered and adopted by smallholders. Various studies in African, Latin American and Asian countries show that contract farming systems have provided technologies to participants in the agri-food production (Kirsten and Sartorius, 2002; McCarthy, 2010; Barrett et al., 2012; Abebe et al., 2013).

Therefore, it is possible to say from the CFA literature that, within contexts of commodity production, the arrangements or formal rules negotiated between farmers and agro-industrial firms can have variations, and assign specific responsibilities to different types of smallholders. However, governance and characteristics of the selected smallholders can influence how rules are defined and implemented in the process of technology diffusion and how they can lead to pathways of diffusion.

3.1. Types of governance
The power relationships linking smallholders and agro-industrial companies in CFAs can be understood from a global value chain (GVC) perspective, which can provide the elements for characterising and introducing variations in formal rules. Within the domain of GVC studies, there is a well-established governance typology that entails particular power relationships, roles and responsibilities regarding transfer and implementation of crop practices. Schmitz and Humphrey (2000) and Gereffi et al. (2005) propose three typologies within the GVC literature—*market governance, network governance, hierarchy or vertical integration*—that reflect variations of power relationships resulting from different levels of complexity, ability of codification and supplier capabilities. The more difficult it is to codify the required standards and the more complex the product and process specifications are, the more central coordination is needed.

Following from Gereffi et al. (2005) and Poulton et al. (2010), types of governance refer to the variations in levels of participation and control of agro-industrial firms and smallholders in decision-making processes related to technology transfer and crop management. These governance typologies are regulated by CFAs that honour commitments amongst actors. Consistent with the GVC governance typologies, Key and Runsten (1999) and Kirsten and Sartorius (2002) identify three types of CFAs: *marketing contract of sell-purchase, partial agro-industrial control and full agro-industrial control*. Although buyer companies are not always essential in productive schemes of developing countries, for example when farmer associations source essential services to smallholders (Valkila et al., 2010; Vicol et al., 2018), the provision of technical resources has traditionally occurred under vertical coordination.
exerted, wholly or partially, by buyer firms (McCarthy, 2010; Poulton et al., 2010; Abebe et al., 2013).

The type of governance gives actors a degree of control over technology-diffusion processes and assigns roles and technical responsibilities regarding crop management decisions, provision of resources and technology adoption. We can summarise these typologies in the following way:

**Table 1. Types of CFAs**

<table>
<thead>
<tr>
<th>Type of governance</th>
<th>Roles of parties and responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low agro-industrial control</td>
<td>Agro-industrial firms have minimum involvement in supply of inputs, technical services and technologies, credits, etc.</td>
</tr>
<tr>
<td></td>
<td>Small-scale producers have full autonomy regarding their production management; they sell their production to agro-industrial firms</td>
</tr>
<tr>
<td>Partial agro-industrial control</td>
<td>Agro-industrial firms partially supply inputs, technical services and technologies, credits, etc.</td>
</tr>
<tr>
<td></td>
<td>Small-scale producers participate in their production management; they sell their production to agro-industrial firms</td>
</tr>
<tr>
<td>Full/high agro-industrial control</td>
<td>Agro-industrial firms fully supply inputs, technical services and technologies, credits, etc., and fully control crop management of producers.</td>
</tr>
<tr>
<td></td>
<td>Small-scale producers sell their production to agro-industrial firms</td>
</tr>
</tbody>
</table>

Source: own elaboration adapted from Key and Runsten (1999) and Kirsten and Sartorius (2002)
3.2. Selection of technology users

Formal rules also establish criteria for selecting technology users. Within the CFA literature, one of these selection criteria is based on the socio-economic characteristics of smallholders. Within the literature of agricultural innovation-diffusion, users’ socio-economic characteristics can indicate the potential capacity of smallholders to: access resources, services and technical support; and adopt new technological practices (Feder et al., 1985; Pannell et al., 2006; Marenya and Barrett, 2007; Kassie et al., 2015; Mills et al., 2017). Hence, poor smallholders may require more economic and technical support than better-off producers.

Another selection criterion that distinguishes smallholders of different CFAs refers to whether or not producers prefer to participate within an agreement in a collective or individual way. Associations and cooperatives are mechanisms used by smallholders to negotiate CFA conditions, participate in the decision-making process and cost-effectively deliver or share inputs and services. Furthermore, farmer organisations contribute to easing the flow of information and technologies (Sartorius and Kirsten, 2007). By undertaking different responsibilities, farmer organisations may be able to introduce variations in the agreements.

Together with the three types of governance, both the socio-economic characteristics and the types of participation of the selected smallholders are critical factors in shaping formal
rules and therefore, pathways of diffusion. The outcome of this process is reflected in the levels of technology adoption.

4. Technology adoption within pathways of centralised-diffusion

It was indicated in table 1 that at least three types of governance can influence diffusion relationships. Based on the characteristics of each type, it is possible to draw insights into the levels of adoption that may result from these relationships. For low agro-industrial control, we assume that unless a central actor (e.g. farmer associations) intervenes in the provision of resources, or producers have high levels of technical competence, there may not be any guarantee that technical resources will become accessible to smallholders. It is likely that the poor access to resources in this scenario diminishes the likelihood of technology adoption. For example, McCarthy (2010) shows that independent oil palm farmers in Indonesia found it difficult to sustain their agribusiness due to the necessary large economic investment.

In the case of partial control, where an agro-industrial company and producers participate in a contract farming agreement, smallholders may gain high levels of technical support from the firm but also from other potential actors. Unlike the above scenario, the significant access to technical support may entail an increase in adoption levels. Finally, by having high agro-industrial control, smallholders may have a guaranteed supply of inputs and assistance, which in turn may favour the levels of adoption. Despite these possible high
levels, smallholders in this scenario are highly dependent on the leading change agent for the technology diffusion.

It can be noticed that the previous pathways of diffusion do not consider attributes of agricultural technologies for adoption. These attributes are important because different technologies may receive different support during the process of diffusion. One of these attributes is the ‘immediacy of rewards’ or the time in which farmers will receive, or expect to receive, the net benefits of adopting a technology (Rogers, 2010). According to Rogers (2010), practices that people adopt now but whose desired rewards are distant in time have a particularly slow rate of adoption. Immediacy of rewards is not commonly discussed in the studies on diffusion of agricultural innovation.

Based on the immediacy of rewards, we categorised the types of agricultural innovations as short-term practices and long-term practices. The first group of practices refer to agricultural technologies that are implemented after a stress or shock occurs and whose results are expected in the short term. The second group of practices refer to technologies that are intended to guarantee the long-term development, growth and yield of agricultural crops. The final results of these practices are not usually seen immediately. This category groups the following practices: water management, fertiliser use, soil management and prevention practices of pest and disease management. Particular attention should be given to this category, since failure in implementing preventive practices may reduce the
agricultural sustainability of the crop, i.e. the ability of a system to continue and to maintain its productivity in spite of major perturbations (Conway, 1985).

Our framework aims to explore the impacts of three diffusion pathways –defined according to the governance typologies— on both short-term and long-term practices within agri-food developing clusters (Figure 1).

**Figure 1: Framework of analysis for centralised-diffusion systems in agri-food**
5. Methodology and Data

5.1. Oil palm nuclei and the management of the But Rot disease (BR) in Colombia

In the Colombian oil palm sector, the *nucleus* is the basic configuration of a geographical cluster. Nuclei are made by *anchor companies* and growers in nearby areas that sell their produce to these firms. Anchor companies are in charge of purchasing, and sometimes processing, the oil palm fruit and usually centralise the technical decisions of the nucleus. Colombia has 69 nuclei, in which agro-industrial companies mostly support producers through CFAs, whilst others re-create an organisational condition to provide technical services (Fedepalma, 2019; Sanz et al., 2018).

In the last two decades, Bud Rot disease (BR) has caused one of the worst plant disease epidemics in the Colombian oil palm sector. Between 2010 and 2014, BR affected 28% (37,400 hectares) of the 134,000 hectares cultivated for oil palm in north-east Colombia, resulting in economic losses of around US$129 million and in deep socio-economic crises (MADR, ICA and Fedepalma, 2015). The Colombian agro-industry companies often follow official protocols for the BR management that are developed by the Colombian Oil Palm Research Centre (Cenipalma) (Arias et al., 2014; Martinez et al., 2018). With assistance from Cenipalma, we grouped these protocols according to their immediacy of reward attributes:
- Preventive practices (long-term practices): 1) cultivation of leguminous plants, 2) frond analysis, 3) soil analysis, and 4) maintenance of drain channels.
- Shock practices (short-term practices): 1) BR monitoring (number of diseased trees), 2) BR surgery (removal of tissues infected with BR), 3) eradication of diseased trees, and 4) application of additional fertilisers to diseased trees.

The adoption of shock practices can help to control the spread of BR in the short-term. Preventive practices are especially important because they can strengthen the health status of oil palm trees, reduce the risk of future infection, and contribute to the agricultural sustainability of the agribusiness (Martinez et al., 2018). Throughout the oil palm epidemics of BR in Colombia, the government was focused on adopting reactive measures, for example, the provision of financial assistance to affected producers and the creation of an institutional framework that forced the adoption of shock practices.

5.2. Data and methods

To progress the study of formal rules and the evaluation of technology adoption, we considered the comparative case study approach to be the most appropriate data collection and analysis method (Stake, 2005). This allowed us to find emergent patterns of data in different diffusion processes. The selection of case studies relied on theoretical, rather than random, sampling. The theoretical sampling allowed us to sharpen generalisability from different cases and raise theoretical level by studying the emergent patterns of data
(Eisenhardt, 1989; Stake, 2013) regarding technology diffusion processes. We purposefully focused our efforts on selecting cases that would provide examples of each conceptual category of governance; namely low, high and partial agro-industrial control. Researchers from Cenipalma and regional actors helped to identify the selected cases from the north-east region of Colombia, where the last epidemic of BR took place.

The oil palm nuclei A, B and C provided an opportunity to study centralised-diffusion processes corresponding to low control, partial control and high control of the crop management by anchor companies A, B and C, respectively. The cases also shared regional and stress circumstances which allowed us to control environmental variations. We guaranteed that centralised diffusion of technologies was taking place through CFAs in these cases. Through technical relationships, anchor companies A, B and C transferred the official BR protocols as well as services and resources to smallholders for the BR management.

The main units of analysis are the nuclei for production (including all their smallholders), the formal rules and the levels of technology adoption. Small-scale producers in this study controlled 50 hectares or less of cultivated area according with the definition of smallholder (Rspo.org, 2017). We agree with Fernandez-Stark et al. (2012) that the definition of small-scale producer has various connotations that go beyond landholding scale and include producers with poor access to public services and markets. This study uses size and the
difficult access to technical and economic resources as the defining element for small-scale producers. Table 2 characterises the producers in the case studies.

Table 2: Characteristics of small-scale producers in nuclei A, B and C

<table>
<thead>
<tr>
<th></th>
<th>Nucleus A</th>
<th>Nucleus B</th>
<th>Nucleus C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean landholding size (No. Hectares)</strong></td>
<td>26</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td><strong>Income source</strong></td>
<td>Only oil palm: 0%  People with livestock: 26%  Staple crops: 25%  Non-farming activities: 23%  NI: 20%</td>
<td>Only oil palm: 24%  People with livestock: 43%  Non-farming activities: 21%  NI: 12%</td>
<td>Only oil palm: 26%  People with livestock and/or rice: 29%  Staple crops: 23%  Non-farming activities: 23%</td>
</tr>
<tr>
<td><strong>Participation income</strong></td>
<td>High dependence on oil palm: 43%  Low dependence on oil palm: 46%</td>
<td>High dependence on oil palm: 46%  Low dependence on oil palm: 46%</td>
<td>High dependence on oil palm: 77%  Low dependence on oil palm: 10%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td>Primary: 32%  Secondary: 34%  University: 34%  Technical career: 0%</td>
<td>Primary: 48%  Secondary: 19%  University: 24%  Technical career: 9%</td>
<td>Primary: 85%  Secondary: 10%  University: 1%  Technical career: 3%</td>
</tr>
</tbody>
</table>

1: based on producers’ perceptions
This study employed primary sources of information that were gathered from semi-structured interviews and surveys in the period of March to July 2015. We ensured the reliability of the data and the analysis by using quantitative and qualitative methods. We surveyed all producers of each nucleus (35 from nucleus A, 33 from nucleus B and 65 from nucleus C) and interviewed 25 participants in their work place. All questionnaires and interviews were conducted in person. Quantitative data was also cross-checked during interviews with other actors.

The surveys helped to collect information about socio-economic conditions, levels of technology adoption and reasons for adoption. Adoption levels were measured in terms of the total number of users for each BR-related practice at a single point in time, 2015. The semi-structured interviews helped to characterise the formal rules related to the technology-diffusion process of BR-related practices. Interviewees included participants involved in the process of technology diffusion, such as small-scale growers and technical assistants, as well as researchers and officers of farmer organisations and Cenipalma. This group of actors helped us to obtain a range of responses and to triangulate the information provided by all respondents, thereby enhancing the validity of the research. Three key informants were interviewed at the beginning and at the end of data collection and analysis.
in order to provide feedback about the results. We analysed the collected information under the categories and sub-categories of table 3 and compared the evidence with the framework of centralised diffusion (Figure 1).

Table 3: Taxonomy for qualitative analysis

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sub-categories</th>
<th>Information assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal rules</td>
<td>Governance: Roles and commitments for technology transfer</td>
<td>Leadership in technology transfer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participation in decision-making processes for planning and implementation of practices in crop and BR management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provision of inputs, equipment, financial support and technical assistance (monitoring, training, knowledge transfer) for adoption of crop and BR management</td>
</tr>
<tr>
<td></td>
<td>Type of technology users</td>
<td>Responsibilities in technical implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selection criteria of smallholders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collective or individualistic action</td>
</tr>
<tr>
<td>Technology adoption</td>
<td>Levels of technology adoption</td>
<td>Total number of users and non-users of shock and preventive practices.</td>
</tr>
</tbody>
</table>

Source: Own elaboration consistent with the studies of Barrett et al. (2012) and Díaz-José et al. (2016).
6. Formal rules for technology diffusion and impact on adoption in the

Colombian oil palm agribusiness

This section depicts the formal rules of the selected nuclei and their resulting levels of adoption.

6.1. Case A of semi-autonomous small-scale producers

6.1.1. Formal rules

The CFA in this nucleus was mainly based on a market contract for fruit commercialisation (or low agro-industrial control), in which smallholders assumed most technical responsibilities and Anchor Company A had minimum involvement in crop management. The anchor company provided the seedling plants, facilitated the purchase of fertilisers to some producers and provided technical assistance. Smallholders were highly autonomous in decision-making processes and economically independent from the anchor company.

There was, however, an exception in which company A played a more leading role. Anchor company A transferred, verified and, in specific cases, directly implemented the strategy for adoption of shock practices, particularly, BR monitoring (number of diseased trees) and BR surgeries (removal of tissues infected with BR). This showed that the company prioritised
the adoption of shock practices rather than preventive practices and gave high autonomy to smallholders to implement preventive practices.

Regarding their selection criteria, Anchor Company A preferentially selected better-off producers, who were not fully dependent on the oil palm business as their only income source. This selection was intended to reduce Anchor Company A’s responsibilities and transaction costs for the provision of services. As a result of the criteria, most producers of nucleus A were characterised as having a business profile and were expected to be economically independent from the anchor company. The data indicated that 66% of producers had economic capacity to employ crop managers, while 34% led the management themselves. The data also revealed that most producers had completed primary education and 34% had a university degree (Table 2).

The high socio-economic conditions may have affected the tendency of producers in nucleus A to adopt short- rather than long-term practices. The business profile, high autonomy and detachment from their land suggest that these growers used the cultivation as a profitable investment rather than a sustainable livelihood. This can be explained by the fact that several producers usually lived in urban areas or employed crop managers. One could also propose that since these producers might tend to expect immediate profits, they put greater attention and financial effort on adopting shock practices, which favour this type of benefit, than on preventive practices. This is a different way of understanding the importance of socio-economic characteristics for the diffusion process to which the studies
of innovation diffusion, adoption and CFAs indicated. This literature suggested that higher economic capacity would be associated with greater adoption of technologies (Feder et al., 1985; Pannell et al., 2006; Rogers, 2010; Mills et al., 2017).

6.1.2. Technology adoption

The results of the formal rules in nucleus A indicated that the adoption of shock practices (93%) far exceeded the adoption of preventive practices (54%). The major percentage of non-users was registered on the cultivation of leguminous plants and maintenance of drain channels. By contrast, practices with major support, such as BR monitoring and BR surgery, were adopted by 100% and 92% of smallholders, respectively (Figure 2).

Figure 2: Levels of technology adoption in nucleus A, 2015

Source: Own elaboration from survey data
The higher adoption of shock practices can be explained by the major support to these techniques, compared to the assistance for preventive practices, that Anchor Company A provided to smallholders. The company regularly verified the implementation of BR monitoring and BR surgeries. Values of trust and friendship also made the relationship between these Anchor Company A and smallholders go beyond technical and contractual interactions and were fundamental to achieving the effective diffusion of shock practices. The importance of trust-based relationships between contracting parties in agribusiness, was also highlighted by Fafchamps and Minten (2002).

An additional factor that may also explain these differences is the nature of selected smallholders and therefore their low interest in adopting practices long-term practices. Figure 3 shows that more than 50% of surveyed producers affirmed not being interested in performing soil and frond analyses because their adoption did not seem as urgent as the adoption of shock practices. It is likely that the business profiles of smallholders in this nucleus made them more responsive in tackling issues that could impact their immediate benefits. In fact, the choice to plant grass for cattle between oil palms, which is considered by experts of Cenipalma as a harmful practice for oil palm cultivation, instead of cultivating leguminous plants, clearly evidenced the preference of smallholders for cattle breeding. One interviewed producer asserted:
“I make profits almost every day from cattle breeding by selling milk or, in few months, by selling the calves. So better to take advantage of the grass growing around”

The level of low-interest reveals the key importance of users’ attitudes in the decision process, which is not new to the theory of innovation diffusion and literature of adoption. Pannell et al. (2006) and Rogers (2010) highlight the importance of farmers’ willingness as a key aspect of adoption.

Figure 3: Reasons for non-adoption of preventive practices in nucleus A

Source: Own elaboration from survey data

6.2. Case B of dominant control of an agro-industrial firm

6.2.1. Formal rules
Unlike nucleus A, the anchor company in nucleus B dominated decision-making processes related to smallholders’ crop management (high agro-industrial control). Amongst its responsibilities, Anchor Company B had to: shoulder the initial investment costs; provide agro-chemicals, equipment and assistance; monitor practices; define technical guidelines; and harvest and transport the fruit. Furthermore, the company assumed the direct implementation of disease and pest-related practices in the smallholders’ plantations.

Surprisingly, under this set of rules, smallholders could choose to participate in the adoption of some practices. The implementation of shock practices and preventive practices, that required high levels of expertise (e.g. frond and soil analyses), were assumed by Anchor Company B. Nevertheless, the adoption of other preventive practices (e.g. cultivation of leguminous and maintenance of drainage channels) and non-BR-related practices (e.g. fertilisation and management of weeds) were implemented at the discretion of smallholders.

We suggest that the producers’ decision regarding their participation in implementation of practices was driven by their specific socio-economic nature. This nature was determined by the Anchor Company’s selection of producers. The selection criteria were based on searching for landowners with suitable land and road access infrastructure. As a result of these few requirements, the population in nucleus B was highly heterogeneous in regard to socio-economic conditions.
The data indicated that almost half the population was highly dependent on the income from the oil palm production. Regarding educational levels, 48% of the population only attended primary school and 24% had a university degree. A large proportion of smallholders (60%) implemented agricultural practices and managed their own plantations whilst about one third of the population either hired private management or left this management entirely to Anchor Company B. This was a common arrangement for smallholders living in main cities.

From collected information, we identified two groups of smallholders: rural producers who were highly dependent on the oil palm crop and lived in rural areas; and better off-producers with a business profile, who did not manage their own plantations and lived in urban areas. Compared to the latter, rural farmers were more attached to their land and appeared to consider the oil palm crop as their main livelihood and not just a profitable investment. Therefore, it was of greater interest to these producers to enhance agricultural sustainability of the crop rather than focusing on immediate benefits. This could explain why these producers were often involved in the implementation of agricultural practices, contrary to better-off producers.

6.2.2. Technology adoption

The diffusion process in nucleus B resulted in a high percentage of users adopting shock practices (91%), particularly 100% and 97% of producers implementing BR monitoring and
BR surgery, respectively. Contrary to this, there was a low adoption level of preventive practices (46%) characterised by the lower implementation of soil analysis (38%), frond analysis (22%), and cultivation of leguminous plants (43%) (Figure 4).

![Figure 4: Levels of technology adoption in nucleus B, 2015](image)

Source: Own elaboration from survey data

These outcomes reflected the intensive support on the adoption of shock practices that Anchor Company B provided to smallholders due to the company’s business-based and immediate priorities. The marked vertical relationship of diffusion and the different types of producers in nucleus B caused problematic relationships between the participants of the CFA. However, producers in this nucleus relied on the company’s experience and allowed them to be involved in the adoption of shock practices.
One of the main reasons for the low adoption levels of preventive practices was the fact that Anchor Company B did not give priority to these practices and failed to comply with its obligations in the implementation of soil and frond analyses (See ‘Other actor in charge’, figure 5). This was despite the company’s well-known expertise and economic capacity. It suggests that other factors beyond economic capability and technical competence explain adoption of preventive practices by anchor firms. It also highlights the drawbacks of highly dependent system, especially if these practices are not among the agent’s priorities.

Figure 5: Reasons for non-adoption of preventive practices in nucleus B

Source: Own elaboration from survey data

Although Anchor Company B took control of BR management, the nature of users was still found to be highly relevant in understanding the tendencies of producers in the implementation of non-BR-related practices. Technical assistants reported that smallholders being involved in the adoption of these practices, as was the case with rural farmers, exhibited the best productivity levels.
6.3. Case C of small-scale producers capitalising collective action

6.3.1. Formal rules

The CFA in nucleus C was characterised by the partial agro-industrial control and the participation of various actors in the smallholders’ crop management. As part of the CFA, Anchor Company C was in charge of: providing seedlings and assistance; leading the technology transfer; and buying the farmers’ produce. Producers of this cluster were organised in a farmer association responsible for: negotiating fair trading conditions with Anchor Company C; complementing technical services; and facilitating the access to associative credits and government subsidies. The social organisation, Fundepalma, provided supplementary support to smallholders.

During the epidemic, actors shared technical responsibilities in a complementary way. Anchor Company C strongly supported the BR management and was in charge of transferring technologies and verifying the appropriate adoption of practices. This company assumed the adoption of preventive practices that required high levels of expertise such as soil and frond analyses. For their part, the association hired a team of workers in charge of implementing BR monitoring (number of diseased trees) and BR surgeries (removal of tissues infected with BR). As for smallholders, they were in charge of: reinforcing the adoption of BR monitoring and BR surgeries; undertaking cultivation of leguminous plants and maintenance of drain channels, fertilisation of diseased trees and eradication; and
implementing other non-BR-related practices. Finally, Fundepalma provided additional verification of shock practices.

The CFA of nucleus C assigned responsibilities to participants based mainly on the nature of producers, which explained the involvement of producers in crop management. The smallholders in this nucleus were characterised by being rural farmers in unfavourable economic conditions that sought to improve their living circumstances through the oil palm cultivation. Compared to nuclei A and B, producers in this nucleus owned 10 hectares less of oil palm crop on average and were highly dependent on oil palm production as their main livelihood, as well as other agricultural activities (see table 2). These farmers led the management themselves and most of the time worked on their plantations with their families. Although the majority of smallholders had low levels of education, producers had an average of 30 years’ experience in agriculture.

The nature of producers in this nucleus suggests that they were committed to their land and farming livelihoods. We can conclude that these producers were therefore interested in adopting preventive practices and other non-BR-related practices. The smallholders’ attachment to land can be also explained from their high involvement in crop management, and the fact that they all lived in a small town near to their plantations. This did not mean that these producers neglected the adoption of short-term practices completely; in fact, some smallholders reinforced the implementation of shock practices performed by their association.
6.3.2. **Technology adoption**

Whilst BR-related practices had high levels of adoption in nucleus C, long-term practices were slightly lower than short-term techniques. We found that, of the 96% of smallholders that adopted shock practices, 100% of them implemented BR monitoring and BR surgery. Of the 83% that adopted preventative practices, 100% of them implemented soil and frond analysis. This highlighted a significant contrast with cultivating leguminous plants, which was only adopted by 41% (figure 6).

![Figure 6: Levels of technology adoption in nucleus C, 2015](image)

*Source: Own elaboration from survey data*

We suggest that the high levels of adoption of shock practices resulted from the complementary work and support of Anchor Company C, the farmer association, smallholders and Fundepalma. An important part of the technical support was the
significant influence that Anchor Company C exerted on the decision-making processes and the smallholders’ willingness to accept the involvement of central actors in BR management. This was the result of the high reliance of smallholders on the expertise of the anchor company, and values of friendship embedded in the CFA that had been cultivated during the historical interactions amongst its participants.

The high implementation levels of preventive practices can be explained by the interests of both smallholders and Anchor Company C in adopting soil and frond analyses. It is argued that smallholders hired the services for soil and frond analyses from the anchor company, and that this company implemented these practices on the basis of the existing formal rules. Anchor Company C was also driven by their interest in improving the long-term agricultural sustainability of producers and social conditions. Interviewed smallholders pointed out that the company advised them about technical as well as organisational, legal and social issues, even though these last three functions were not included in the contract.

Lower levels of long-term practices were explained mainly by the low socio-economic conditions of users and preference for diversification of livelihood strategies over the adoption of long-term practices. For example, smallholders argued that the major reason for not cultivating leguminous plants was their preference of growing grass for cattle breeding (Figure 7).
7. Discussion and Conclusions

The discussion in this paper has been driven by an important debate concerning the prospect for the development of different pathways of technology diffusion through the incorporation of smallholder producers into agribusiness production in developmental contexts. The focus was on the application of different practices in three oil palm clusters by means of the development of different formal rules, which are a key issue within the area of the Contract Farming Arrangements literature. The three case studies find three types of formal rules adopted in oil palm clusters, which resulted in two pathways of technology diffusion. The first pathway, exemplified by nuclei A and B, we refer to as the diffusion pathway of governance dictated by dominant change agent control. In this scenario, leading change agents select producers, provide technical assistance and
implement key practices. A second pathway, exemplified by nucleus C, we refer to as the diffusion pathway of governance dictated by change agent control and user participation. Here, a leading change agent defines and closely monitors agricultural practices but shares decisions for the selection of participants and implementation of practices with producers.

Our findings are significant because, whilst all nuclei followed the Colombian National Oil Palm Centre-led adoption of a set of uniform practices (shock practices), the low adoption of preventive practices in nuclei A and B could threaten the long-term sustainability of crops, as suggested by Munévar and Acosta (2002). Clearly the “official” strategy in Colombia—based uniquely on short-term responses to the disease— is not the only avenue open to the sector and underlines broader debates around the fact that there needs to be greater recognition of diverse practices when confronting disease in the oil palm and broader agri-food sectors.

This in-depth study teased out that three different factors underpinned the different adoption levels of preventive practices in those contrasting trajectories: differences in distribution of technical responsibilities and leading roles (associated with governance), the priorities of leading change agents and the nature of users (associated with selection criteria). The formal rules within nuclei A and B were based on a narrow structure of governance; meaning functions and responsibilities for management of practices related to BR disease were narrowly defined and, in these cases, mostly attending shock practices. This resulted in low implementation levels of preventive practices. Conversely, higher levels
of adoption of these practices were found in cluster C which had distributed technical responsibilities amongst several actors, higher involvement of users in adoption, and participants with a long-term vision of the smallholder agribusiness.

The above suggests that a broad governance structure of CFAs and shared functions may enable smallholders to access a wider range of support for technology adoption. This is useful, especially when technical expertise is required or when the adoption of practices has high levels of complexity. In addition, we can argue that if the decisions of agro-industrial companies are driven primarily by a business-based approach, they are likely to be motivated by short-term priorities, rather than a long-term sustainability perspective and in turn, mainly support short-term practices. The third point, the types of users, provides a key explanation for how the different pathways emerged. On the one hand, there was a set of economically wealthier producers with short-term perspectives and little interest in supporting practices that did not lead to short term profits. On the other hand, there was a set of smallholders with high dependence on oil palm for their income that had developed a more long-term perspective. These producers had a lower socio-income level and were clearly more involved in implementing long-term practices and plantation management than better-off producers. Thus, the study has helped to flesh out the central argument posed at the beginning of the paper: differences in formal rules can play an important role in distributing technical responsibilities amongst participants of agreements and in creating multiple pathways of centralised diffusion, the roles of which have not been fully explored in the diffusion literature.
The broader contribution of the study lies in two areas. Firstly, that the nature of users and the motivation of change agents can help explain adoption of short-term and long-term practices. Much literature on diffusion of agricultural practices has tended to relegate analysis of small-scale producers to studies of socio-economic conditions and their economic capacity to adopt technologies (Wejnert, 2002; Bandiera and Rasul, 2006; Maertens and Barrett, 2013). Nevertheless, other factors such as the degree of attachment to agricultural production, long/short term vision, and engagement in collective action would seem equally relevant. Preferences and attitudes towards long-term or immediate profitability were also key drivers of adoption. Adding to these attributes, we consider that the models under which change agents make decisions—short-term business-based or long-term sustainability approaches—and their interests regarding the integration of smallholders into agribusiness can be determinant in this context. These findings complement with other work such as Pannell et al. (2006), Rogers (2010), Mills et al. (2017) regarding the impact of attitudes on farmers’ willingness to adopt innovations and change agents’ motivations to technically support producers.

Secondly, whilst it is clear that the strategy of smallholder incorporation in the oil palm outlined in this paper alone is not likely to fundamentally change the deep-seated problems of unequal access to land and social marginalisation that has defined small-scale farming in countries such as Colombia, there are some practices that can begin to challenge this situation and from which insights can be gained. The capitalisation of collective action
through the formation of smallholder organisations in which farmers could offer alternative approaches for confronting the Bud Rot disease; for instance introducing soil analysis and frond analysis, emphasizes the benefits that formalisation of processes can have. Nevertheless, additional technical and financial support coming from official agencies, NGOs and other sectoral actors are mostly needed in rural areas to guarantee the survival of these collective organisations.

Given the sampling method, the current study presents some limitations. The profiled nuclei represented a purposive sample of centralised-diffusion processes. Therefore, care has to be taken when making inferences in other specific circumstances of centralised systems to which it applies, for example, global value chains and adoption of contract farming agreements for cash crops (Ramirez et al., 2018; Meemken and Bellemare, 2020) as well as large environmental perturbations (Hongmei, 2016). Careful analysis of the emergence of clear pathways suggest certain patterns that enabled us to produce some generalisations within the innovation-diffusion theory. Although further studies in this area can enrich our understanding of pathway development in agribusiness settings.

The practitioner implications of the study are clear: Improved partnerships between agro-industrial firms and smallholders are necessary and attention needs to be paid to different types of formal rules, the selection of farmers and their motivations, and also the particular interests of change agents. In the case where smallholders participate in technology adoption, some principles taken from bottom-up approaches that are sensitive to farmer
characteristics in the design of practices and/or support collective action strategies would be recommended. In the Colombian context, the introduction of these improved partnerships by government programmes and agri-food sectors may help with the implementation of an integrated package of agricultural practices as well as the long-term agricultural sustainability of farmers’ crops.

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