COCOA SECTOR IN CÔTE D'IVOIRE: ARE PUBLIC-PRIVATE PARTNERSHIPS (PPP) HELPFUL?*

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Abstract

The aim of this paper is to understand how an agricultural PPP project namely Vision For Change (V4C) works by focusing on its productivity side. This paper shows that the program significantly increases the yield by 81.98 kilograms per hectare, the income by 37.9% and the price by 46.58 XOF (0.071 euros) per kg. One factor of success is the novel approach used to provide high yield and swollen-shoot tolerant technology. Second, the available technologies that meet the demand of the producers is mainly due to background investigations, training activities through innovation platforms and external support provided by the extension agents (cocoa village centers operators). Third, the PPP platform has been a useful tool to coordinate the interventions as well as generating learning among stakeholders and thereby reducing the search and new discovery costs. The agreements among institutions of the platform lead to economies of scales and help to make new technologies affordable to the producers. In addition, policy coordination at macro level with public sector and a wide range of private companies with variety of interest help managing the tension between coordination and capture.

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1. Introduction

Cocoa sector is the backbone of the Ivorian economy. It contributes to 40% of the export revenue and about 800,000 farmers make their living directly from cocoa production. Most of these domestic producers own small-size farms, estimated to vary between 1.5 and 5 hectares. Collectively, these smallholders represent more than 80% of the country's total production per year. Surprisingly, these smallholders are generally poor, without formal education, credit-constrained, disorganized and scattered across the country. Faced with these challenges, these farmers are often not well equipped to cope with climate shocks, declining soil fertility, unproductive orchards, and the spread of cocoa diseases. Moreover, recent public and private investment efforts to curb these issues have generated poor outcomes, due in part to the continuous lowering of cocoa price, the government inability to guarantee an acceptable cocoa pricing structure, the poor organization of cooperatives, the lack of supervision and technical assistance to producers, and the lack of stabilization[1] mechanism. As a result, younger generations of farmers shift to alternative crops (rubber tree, palm tree) thought to provide a continuous stream of income, threatening the sustainability of cocoa production. The marketability of cocoa products has been reduced since the liberalization of the sector.

Yet, the global demand for cocoa products remains high and recent forecast[2] suggests that cocoa demand will continue to grow significantly over the next decade. In this context, overcoming the sustainability challenge of the cocoa industry is essential to maintain and optimize cocoa production and the country's position of the world's leading producer of cocoa.

In addition to the increasing demand of cocoa products, another important issue is meeting the satisfaction of the consumers who are increasingly demanding in terms of the (physical, chemical, ethical, social and environmental) quality of market products. The complexity of the problem characterized by a combination of productivity and social issues requires a synergy of actions from both the public and private stakeholders to mobilize technical expertise (extension, research, etc.) and financial resources to promote a sustainable cocoa economy.

To face some of these challenges, Mars Inc. initiated a cocoa sustainability program[3] called *Vision For Change* (V4C) in the Nawa Region (Côte d'Ivoire) in November 2010. The basic idea is to overcome the issues of market uncertainty and production volatility by boosting productivity and empowering local communities. Specific interventions to increase productivity include the provision of improved planting material and fertilizer, as well as training in good agricultural practices. As for community empowerment, the program aims at improving in a sustainable way the environment in which cocoa farming communities reside. This includes women empowerment, investment in social infrastructures and child labor mitigation efforts. This paper is interested in understanding the productivity effects the V4C Project.

V4C is a PPP project aligned with the Ivorian Government's 2QC (*Quantité-Qualité-Croissance*) program, which seeks to rehabilitate 40 percent of the country's cocoa orchards and increase yields to 1.5 tons per hectare by 2023. The 2QC program - initiated in 2009 - aims at improving the productivity or the *Quantity*, the *Quality* and the revenues that will induce *Growth*. To develop and implement, in a

[1] Although a stabilization system has been existed in Cote d'Ivoire, McIntire and Varangis (1999) highlighted some weakness in its functioning. The system ensured a fixed price to the producers but this price was far from profitable because being largely below the price of the international market over the period 1983-1997. An Ivorian producer pays more than necessary and the surplus generated is used to finance the government budget instead of improving the welfare of the producer. The stabilization system was dismantled in 1999.

[2] It is expected supply deficit up to 2025 (see ICCO 2012 Conference)

[3] Other multinational firms including Mondelez International, Nestlé and others have also initiated several cocoa sustainability programs.

participatory manner, interventions that are in line with the 2QC program, a public-private partnership platform (PPPP) was set up in May 21st, 2012. The platform aims to improve the effectiveness of the public and private stakeholders' interventions through (i) dialogue between public and private stakeholders, (ii) promotion of the coordination of interventions, and (iii) monitoring and evaluation of the interventions. This strategic coordination between the public and private sectors is needed both to assist in the design of appropriate public actions and to provide effective feedback on their implementation (Page and Tarp, 2017).

Following the creation of the PPPP, the 2QC has been updated to consider new challenges facing by the cocoa sector, new solutions to address these issues and to take into account the private sector concerns. As mentioned by Stiglitz (2017), *markets by themselves may not lead to either a good allocation of resources among sectors or the appropriate choice of techniques*. That is why the PPPP has been a useful tool to build a comprehensive policy for the cocoa sector. Firstly, these collective efforts (PPP platform) address the coordination issues between public and private sector interventions to have a harmonized program through consultations. Indeed, the PPPP helped to reconcile the positions of the private and public stakeholders and to harmonize the interventions especially regarding central issues related to cocoa farming (e.g., productivity, swollen shoot disease). Such collaboration generates a *learning society* (Stiglitz, 2017) because no agent has a panoramic view of the sector or knowledge of the distortions the public sector is supposed to correct (Kuznetsov and Sabel, 2011). Secondly, the capability of the private sector to innovate and those of the public sector to provide complementary public inputs for private sector research (Kuznetsov and Sabel, 2011) help to foster investment in research designed to address the low productivity problem. The private sector has invested in research and development by renovating laboratories. But, the researcher salaries and inputs for research are jointly provided by the public sector and the private sector. The cost of research is therefore supported by both parties. This approach has the advantage of making research funds available (coordinated actions of several entities) that allow to start new and or to pursue existing research activities since duration is the key ingredient for research to mature and succeed. Moreover, it allows the practice of the evaluation (by imposing a follow-up of the activities) in order to improve the policy implementation. And, it allows mitigating knowledge spillovers that might prevent the private sector to invest otherwise. Parties that commit to research funding are aware of the potential risks inherent in the activity because results may be inconclusive.

The link between the objectives of the V4C project and the 2QC makes the project *relevant* for the country. V4C is a PPP project financed by Mars Inc. and managed by ICRAF (World Agroforestry Centre) even though, some of the activities are co-financed with other donors. Mars provides US$50 million to support the project over a ten-year period. Nevertheless, for the governance purpose as well as the implementation, ICRAF worked closely with public and private agencies. For instance, in March 2010, Mars Inc. signed a Memorandum of Understanding (MoU) with the Government of Côte d'Ivoire, in which both entities agreed to work together on productivity projects for farmers. In addition, V4C's activities belong to the working agenda of the thematic groups of the PPP platform which are the main instruments of the PPPP (see section 3).

This paper is interested in understanding the productivity effects of Mars Inc. PPP project (V4C) and the mechanisms that can explain the outcomes of such program. More specifically, the aim of this paper is to figure out how the V4C project works by focusing on its productivity side. The paper attempt to answer the following specific questions: (i) Does the V4C project translates into higher cocoa yields and increase in income? How does it work? And (iii) what policy lessons can be learned from the V4C project? Are they scalable?

This paper argues that while funded and managed by the private sector, V4C project is a collaborative effort between the public and private sectors in which each sector contributes to the activities needed to accomplish a shared objective. Moreover, the activities are part of the working agenda of (i) input supply

and productivity improvement, and (ii) fight against swollen shoot thematic groups. In addition, this paper shows that the V4C project develops new technologies that are available (accessible) and used (adopted) by producers. The mostly requested services are pesticides (68%), fertilizers (54%), grafting (33%) and replanting (29%). The innovation platforms of the project accelerate the adoption of the technologies. The interventions increase the yield by 81.98 kilograms per hectare, the income by 37.9% and the price by 46.58 XOF (0.071 euros) per kg. We also show that the Cocoa Village Center (CVC) operator (extension arm of the project) business is sustainable since the net profit per month is 221 253 XOF (337.3 euros).

One factor of success of the project is the novel approach uses to provide high yield and swollen-shoot tolerant technology. Second, the available technologies meet the demand of the producers mainly due to background investigations at the beginning of the project, training activities though *innovation platforms* - Cocoa Development Centers (CDCs) or Farmers Field Schools (FFFs) - and external support provides by the CVC operators. Third, the PPP platform has been a useful tool to coordinate the interventions as well as generating learning among agents and thereby reducing the search and new discovery costs. The agreements among institutions of the platform lead to economies of scales and help to make new technologies affordable to the producers.

The main lesson is that PPP in agriculture, especially in cocoa sector can be a very interesting tool to reach the 2QC goal and avoid the shift to other crops and ensure the sustainability of the cocoa industry by improving yield and farmer's income. Policy coordination at macro level with public sector and a wide range of private companies with variety of interest help to foster the embeddedness.

The results also suggest that the project can be scaled up. The creation of the PPP platform and its functioning - via Plenary Assembly and Working Groups - are a solid ground for scaling up. Orchard Rehabilitation Pilot Project (ORPP) and the activities of CVCs that are right now beyond cocoa farming (with the support of other donors) are two scaling up examples of the V4C project.

In what follows, section 2 presents a summary of the literature and section 3 highlights the connection between V4C project, 2QC program and the PPP platform. Section 4 is devoted to the presentation of the interventions. Section 5 shows the theory of change and section 6 presents data and summary statistics. The results of the program are presented in section 7.

2. Related literature

There is a growing empirical literature that supports the long-lasting idea that agricultural productivity is essential for structural transformation (e.g., Foster and Rosenzweig 2004, Nunn and Qian 2011, Bustos et al. 2016)[4]. It has been demonstrated, for example, that agricultural productivity can stimulate growth and employment in manufacturing through its positive effects on income and aggregate demand (Murphy, Shleifer, and Vishny 1989; Gollin, Parente, and Rogerson 2002).

Yet, the persistence of market and institutional failures in the form of low investment and poor public service delivery has plagued agricultural productivity in many sub-Saharan African countries. To overcome this challenge and design accurate industrial policy, one must highlight, firstly, the fundamental failures that weaken the entrepreneurial ability in developing countries and particularly in agricultural sector. After that, one can draw the framework of an active industrial policy accordingly to the perspective of Rodrik (2004, 2008a, 2008b), Hausmann et al. (2007), and Sabel (2005, 2016). According to these authors, the industrial policy in the developing world is dealing with two critical market failures.

[4] Early theoretical treatments of the relationships between agricultural productivity and industrial development include Nurkse (1953), Schultz (1953), and Rostow (1960).

One has to do with the informational spillovers involved in discovering the cost structure of an economy, and the other has to do with the coordination of investment activities with scale economies (Rodrik, 2004 and Hausmann et al., 2007).

In the case of agricultural sector, public-private partnerships (PPPs) are increasingly emerging as an attractive cooperative and risk sharing policy instrument (Poulton and Macartney, 2012). PPPs in agricultural sector are matching funds as opposite to conventional definition of PPPs[5]. A PPP in agricultural sector is a partnership that aims to harmonize public and private sector initiatives to achieve greater efficiency. By design, these mechanisms bring together public and private stakeholders in mutually agreed contractual arrangements that seek to reduce transaction costs and market uncertainties. Ultimately, by aligning private incentives with public policy objectives, agricultural PPPs are expected to enhance agricultural productivity and generate wider economic benefits along the supply chain (FAO, 2016). Given that the research on agriculture PPPs is still in its infancy, the circumstances under which these partnerships emerge and are likely to succeed remain poorly understood. One contribution of this paper is to document how an agricultural PPP project works to enhance research in cocoa sector in Côte d'Ivoire and overcome productivity issue.

Poulton and Macartney (2012) provide an early examination of the effectiveness of PPPs in stimulating private investment in poorly functioning agricultural value chains. Using pioneering data on PPPs involving international organizations, they find suggestive evidence that these arrangements can be investment enhancing. However, given the presence of asymmetric information (each economic agent has a partial view of the main issues of the sector) inherent to such contractual schemes, institutional capacity is key to successful implementation of agricultural PPPs. Other studies, including Spielman and von Grebmer (2004), Hartwich and Tola (2007), and Ferroni and Castle (2011), also support the idea that the enabling institutional environment is decisive for successful agricultural PPPs. The macroeconomic and political environment is enabled for investment in Cote d'Ivoire since the overall ranking of the Distance to Frontier indicator of the World Bank is increasing since 2012 meaning that the country is well performing in terms of doing business. The overall governance is also improving: the CPIA index moves from 2.8 (in 2011) to 4 (in 2016).

In a recent report, FAO (2016) examines 70 case studies from 15 developing countries involving agricultural PPPs for value chain development, innovation and technology transfer, market infrastructure, and agribusiness services. Overall, this study documents the potential of agricultural PPPs in delivering on their promises to generate inclusive economic benefits. For example, many of the case studies provide some evidence that PPPs improved the livelihood of smallholder farmers through increased employment opportunities, market access, high productivity and better product quality and technological know-how. In other cases, the partnerships helped agribusiness firms improved their access to primary commodities and led to a significant increase in sales and market shares. It is worth noting, however, that the authors of the report attempt to characterize the features that most of the successful agricultural PPPs had in common. These include: (i) the alignment of private incentives with public policy goals and priorities; (ii) the characterization of each party's responsibilities and expected benefits; (iii) the design of fair and transparent risk sharing and management mechanisms; (iv) the involvement of financial institutions in the partnership; (v) and the necessity to improve the monitoring and evaluation of the partnership. The answers to these questions will help inform policy debate about the importance of agricultural PPPs in the design and implementation of industrial strategy in Côte d'Ivoire, and elsewhere.

[5] Even there is no one widely accepted definition of public-private partnerships (PPP), the PPP Knowledge Lab defines a PPP as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance" (http://ppp.worldbank.org/public-private-partnership/overview/what-are-public-private-partnerships).

While providing useful theoretical and empirical discussions on the potential benefits of agricultural PPPs, this literature still lacks a rigorous evaluation of such partnerships. In the present study, we aim to fill this gap by understanding the mechanisms and determinants of success of the Vision For Change (V4C) program for cocoa sustainability in Côte d'Ivoire (see Graph 1). In doing so, we also contribute to the literature on the impacts of Farmer Field School (FFS). In fact, a key feature of the V4C program is the implementation of an agricultural PPP in the form of FFS, known as Cocoa Development Centers (CDCs). The FFS is a capacity building system for a group of farmers that involves a field and a competent facilitator. The goal is to promote best agricultural practices, build capacity, and boost productivity and income (Braun et al. 2006). Measuring the impact of this type of initiative requires that a number of issues are addressed including the definition of the intervention to assess which might include several dimensions in addition to the outcome of interest; and potential spillover effects (farmer-to-farmer diffusion). Using a combination of propensity score matching (PSM) and difference-in-differences (DD), Davis et al. (2012) show that participation to FFS improves crop productivity and agricultural income in East Africa. Similar results were found for food security, but the impact of FFS on poverty was inconclusive (Larsen and Lilleor 2014). Gockowski et al. (2010) show that participation in FFS has significantly modified production practices in Ghana. However, farmer-to-farmer diffusion tends to scale up the training (David 2007). Thus, the impact evaluation should account for neighboring farmers to avoid underestimating the impact of the intervention (Braun et al. 2006). Also, the technical and productivity efficiencies in cocoa sector are highly dependent on factor such as age of trees, farm size and labor (Binam et al. 2008) that can mitigate the impact of FFS. Finally, Gockowski et al. (2011) employ an ex ante modeling to show that introducing a hybrid coca improves farm profitability and income.

To assess quantitatively the effect of the projects, this paper relies on data collected from producers and CVC operators. The design of the survey enables us to deal with spillover effects of the program. Our empirical strategy relies on propensity score matching. Before applying the technique, a detailed description of the project helps to understand the interventions. This analysis is complemented by the description of the link between the V4C project and 2QC initiatives at macro level to see the connection between them. This paper guesses that collaboration can help to overcome coordination failures that plague agricultural reforms in Cote d'Ivoire because of the necessary partial view of the economy and the weak capability of government and other economic agents to undertake industrial policy as suggested by Kuznetsov and Sabel (2011).

3. V4C, 2QC and PPPP: which connection?

The intended objective of the Vision for Change (V4C) project is to revitalize the cocoa sector in Soubré (Côte d'Ivoire). The approach of the project is a holistic one in that the economical (increasing productivity), social (boosting rural communities) and environmental (establishing an effective environmental management) objectives of interventions are interdependent. The economical goal is to increase cocoa productivity of half of the farmers in the Soubré region by boosting the yield from an average of 500 kg per hectare to 1.5 tons per hectare by 2020. This will allow producers to increase their income, reinvest in their farms and better manage them as businesses. Therefore, the VC4 meets the main objective of the 2QC program. The V4C project also includes community empowerment programs. The purpose of these programs is to empower local people to leverage additional public and private funds into development projects aimed at improving the living standard in cocoa-producing communities. The environmental goal is to enable producers to reverse the loss of soil nutrients, use pest control and disease control products according to international standards, and better use land currently in production. This will enable them to manage their resources more efficiently and eventually diversify their crops or activities. In turn, this will help reducing deforestation and ensuring that farms do not degrade their environment.

For the governance purpose as well as the implementation, ICRAF worked with public as well private agencies[6]. In fact, all the activities carried out by the private sector under the 2QC program should be known to the platform to ensure proper coordination and evaluation of the actions carried out in the field. All the activities of the platform are overseen by a Plenary Assembly which defines the overall activities and validates the topics of the working groups. The main instrument of the platform is the thematic groups. These thematic or working groups contribute to the development of the platform action plans and budgets, and examine the issues of the sector to make proposals that will be submitted to the authorities after validation in plenary. To date, there are nine (9) thematic groups: (i) certification, (ii) input supply and productivity improvement, (iii) community development, (iv) fighting against Worst Forms of Child Labor, (v) coffee revival, (vi) extension activities, (vii) producer income and price issues, (viii) fight against deforestation and climate change and (ix) fighting against swollen shoot. Each thematic group is composed of a focal point and a secretariat.

One key player is the *Conseil Café-Cacao* (CCC) which is also the head of PPPP Office, another governance body of the PPPP. This is the principal state agency that has the responsibility to enforce regulations and implement existing policies. ICRAF and the CCC have agreed to co-finance micro-projects initiated as part of community development component[7]. Regarding the productivity dimension, the design of the current Orchard Rehabilitation Pilot Project under V4C project is an agreement between ICRAF and CCC.

For the research side of the project, the key actor is the CNRA (*Centre National de Recherche Agronomique*) which is a public research Centre that oversees the research of the component of the project. Its main role is the implementation of research activities for the development of improved plant material for cocoa farmers that will be distributed through the private sector. Its main duty is to test and select high quality clones, test the quality of the soils and propose the new formulation of the fertilizer. Within the 2QC program, CNRA is the institution that provides seeds to CCC and private stakeholders. By using one entry for seeds supply, one can easy control the origin and the quality of the plant material. This is critical as the main objective of the program is to improve productivity. To help the CNRA to make a sufficient quantity of seeds available, World Cocoa Foundation (WCF) and ICRAF have co-financed seed fields in Divo, Soubré and Abengourou[8].

CNRA's activities and therefore V4C's activities are part of the *input supply and productivity improvement* thematic group working agenda. The V4C activities are also part of the *fight against swollen shoot* thematic group working agenda. In fact, research activities have enabled the CNRA to develop hybrid varieties that are tolerant to swollen shoot. On this issue of fighting against swollen shoot, the PPP platform helped to harmonize the public and private sector interest[9] by identifying the gaps (technical and financial) between the program of the Ivorian Government and private interventions to implement a harmonized program. In this program, cocoa industry (Mars Inc., Nestlé, WCF) provided financial support for the rehabilitation of an early detection laboratory in Anguéledou (non-cocoa producing zone).

The outputs of research activities have been used by innovation platforms set up by the project to reach the farmers trough demonstrations and dissemination namely Cocoa Development Centers (CDCs) and

[6] The presentation focuses only on the key stakeholders in the implementation of the project and not on the governance side of the project.

[7] We focus only on the productivity side of the project and not the community development side.

[8] In the same vein, Nestlé has a somatic embryogenesis laboratory to increase the number of nurseries and make them available.

[9] The Ivorian government has developed a program to fight against swollen shoot disease and at the same time, the private sector, with regard to these interests in cocoa farming, decided to undertake actions to fight against the disease.

Cocoa Village Centres (CVCs). A CDC is a center for demonstration and training in advanced agronomic practices, particularly for the rehabilitation of old cocoa plots with quality planting material. CVCs are small, independent businesses that are linked to a specific CDC. They sell approved planting material and provide technical and agronomic interventions at the village level, such as rehabilitation, grafting, pruning and other good agricultural practices. While the workers in each CDC are fully funded by ICRAF, CVCs are managed by local entrepreneurs (trained by CDC). Cocoa companies such as ADM, Cargill, PACTS, OLAM and CONTINAF have committed to support CDCs and their corresponding CVCs while ZAMACOM, Barry Callebaut and Rainforest Alliance have planned to establish new CVCs. Although the initial idea of CDC and CVC is from Mars Inc., the technical and financial partners have agreed to accompany it. The operators of CDCs and CVCs benefited from the training provided by the ANADER, a public agency that provides extension services (training and coaching) to the farmers. The duty of the ANADER in the project is to oversee the extension component of the project and the capacity building of the communities in cocoa growing areas. It trains the operators of CVCs and the farmers through Plots of Demonstrations and Farmers' Field Schools. Therefore, it interacts with farmers (beneficiaries), CDCs, CVCs and researchers (CNRA). Moreover, ANADER helps in identifying community level projects. It liaises between donors and communities. Collaboration with ANADER has strengthened its capacity to carry out its extension activities. ANADER receives equipment and training support from ICRAF. The purpose of the training was to update the knowledge of ANADER's agents of the best approaches to extension.

4. What does VC4 do?

The project has seven components that are listed below:

(i) improvement in plant breeding and access to quality plant material;
(ii) insuring a sustainable development of cocoa production systems;
(iii) revitalization of orchards;
(iv) innovation platforms,
(v) extension activities,
(vi) community development and local governance;
(vii) monitoring and evaluation, and governance/partnership and institutional support.

The components (i), (iii) and (iv) are related to the economic objective of the project while the component (ii) addresses the environmental objective. The component (vi) is associated to the social objective.

The following description will focus on the components (i) to (v) because of the main objective of the paper which is to analyze impact of the V4C project on cocoa production.

4.1 Improvement in plant breeding and access to quality plant material

The major activities of plant breeding are the choice of efficient cocoa clones and the propagation of improved plants. This task was devoted to the national agricultural research center (CNRA or *Centre National de Recherche Agronomique* in French). Clones grafted onto mature plants in the field were evaluated in 16 Cocoa Development Centers (CDCs) in Soubré. The results showed that the production starts in the first year of grafting. In the fourth year, the yield of the five best clones exceeds 2 tons per hectare. Recall that a target of 1.5 tons per hectare was fixed by the project up 2020.

After the clone selection, the next step was to multiply plant material. The development and production of improved seeds and seedlings contributed to better access for cocoa farmers to efficient plant material.

More than 75% of producers use plant material from their neighbors' fields or their own fields[10]. These seedlings from several sources which are for almost all unimproved plants have a low yield especially when the plants are aging. The project helped to design a sustainable system of multiplication and diffusion of plant material to solve the problem of access. Firstly, the support provided to the CNRA enabled the establishment of 18.3 ha of clonal gardens and 5 ha of seed fields. Up to 2015, 76,835 grafted seedlings, rootstocks and cocoa cuttings and 18,062 companion tree seedlings were produced by the CNRA and are used for extension activities in innovation platforms. The annual production potential of the clonal gardens of 4,575,000 grafted woods enabling to rehabilitate 1,500 ha of cocoa per year. Secondly, the project also helped to operationalize a somatic embryogenesis lab located at the Central Laboratory of the CNRA. Somatic embryogenesis is a plant propagation technique that allows obtaining genetically identical to the mother plant seedlings. It offers an alternative to conventional methods of vegetative propagation. The laboratory has a productive capacity of 30,000 plants after 2 years.

4.2 Sustainable development of cocoa production systems

Under this component, the project aims at a better knowledge of the biotic (pressure of diseases and pests of cocoa) and abiotic (level of soil degradation, vegetation cover, importance of shade trees, climate change) constraints in Soubré for a sustainable management of cocoa orchards.

The activities began, on the one hand, with a survey of diseases and pests, and on the other hand with research and development on the state of soil health, plant diversity (companion cocoa trees), diseases and pests including swollen-shoot.

Studies have shown a low level of soil fertility compared to the standards recommended for cocoa farming. A new formulation of cocoa fertilizer was introduced by the project. Producers have access to this fertilizer through CVCs (Cocoa Village Centres).

To help better managing the pressure of swollen-shoot disease, demonstration plots of good practices using barrier trees have been installed in the study area. In addition, four long-term trials to evaluate the effectiveness of these barriers were also installed. Further trials on the use of systematic insecticides for the control of swollen-shoot mealybugs have been initiated.

In addition, nine meteorological stations have been set up to monitor climate data. Furthermore, studies were conducted to better understand endogenous diversification approaches in cocoa agroforestry and their contribution to the cocoa economy. Another study on the physical and chemical characteristics of cocoa beans was conducted. Finally, the CNRA and ESA (National Agronomy School or *Ecole Supérieure d'Agronomie* in French) soil analysis laboratories were equipped with infrared spectrometers allowing a fast-spectral analysis at a lower cost of soil and plants.

4.3 Innovation platforms

The model associating Cocoa Development Centers (CDCs) and Cocoa Village Centres (CVCs) is one of the main innovations of the V4C project. The basic idea is that physical and visual demonstration of farm rehabilitation and increased yields is a powerful motivator for change. It also recognizes that a profitable cocoa sector will create opportunities for the local private sector in the supply chain, particularly to produce planting material in private nurseries and the provision of the grafting service, to rehabilitate old cocoa plantations.

[10] These figures come from the baseline survey of 2012.

Cocoa Development Centers and revitalization of orchards

Sixteen CDCs set up by the project are functional. In each CDC, multidisciplinary teams composed of researchers, extension workers and cocoa producers demonstrate and test efficient regeneration technologies of old cocoa orchards (grafting, total replanting). These CDCs tested 11 clones. Each CDC tests 5 treatments that are (i) total replanting, (ii) farming practices, (iii) good practices and grafting of clones, (iv) good practices without fertilization, and (v) good practices with fertilization. The rehabilitation of old orchards by grafting is faster than replanting. Some clones also have good graining rates. In addition, the tests identified two recommended periods for grafting: May-June and August-September. The CDCs served as a training center for 80 technicians and 52 CVCs' operators. CDCs' technicians provide coaching for CVCs' operators and planting material to support rehabilitation actions.

Following discussions between ICRAF and the Coffee Cacao Council (CCC, in French Conseil Café-Cacao), Orchard Rehabilitation Pilot Project (ORPP) to scale up grafting in cocoa rehabilitation has been authorized in the Nawa region since 2015. This activity is embedded to *productivity improvement* thematic group working agenda. The aim is to rehabilitate 300 hectares of cocoa in 3 years with an average of 100 hectares per year. The first year, the plots of the producers should have an area between 0.25 and 0.5 hectare; this allows targeting between 200 and 300 producers. In the two last years, the plots should have an area of 0.5 hectare to target about 200 farmers each year.

Cocoa Village Centers (CVCs)

Two types of activities are conducted in CVCs. Each CVC has demonstration plots to test the technologies implemented as part of the project. In addition to testing, CVCs carry economic activities such as the sale of fertilizers, pesticides, cocoa plants, banana seedlings and soybeans. Furthermore, CVCs' operators assist producers in implementing good agricultural practices (plant size, product spreading), replanting plots or grafting.

At the end of 2015, a total of 52 CVCs operators have been trained by ICRAF / Mars Inc. (25) and its partners Cargill (15), ECOM (4), HFK (3) and BIOPARTENAIRE (5). It is worth noting that each CVC is under the umbrella of a CDC. A CDC covers between 1 to 5 CVCs.

CVCs' operators have all received training and a starter kit (warehouse, tools, inputs, input credit: pesticides and fertilizers). The CVCs of the project are formalized with obtaining administrative and legal documents.

Master trainer agronomists have been recruited and are mainly dedicated to coaching CVCs' operators during their first two years of operation to ensure effective quality control of the services provided to farmers and to strengthen their activities. It has also established a close and trusting relationship between CVCs' operators, CDCs' technicians and ANADER agents.

The partnership between ICRAF and public agencies (ANADER, CNRA, CCC, FIRCA) is one of the major benefits of the installation of CVCs' operators. The partnership with the *Conseil Café Cacao* has allowed CVCs to be supplied with hybrid cocoa seeds. The V4C project has established partnerships with pesticide and fertilizers companies that support CVCs' operators. These companies (RMG/YARA and FORO CI) support the 25 CVCs of Mars by providing inputs on credit. In addition, the AFAP's (African Fertilizer Agribusiness Partnership) incentive benefits to other three CVCs.

4.4 Extension activities

This component aims to broadly adopt and disseminate technology packages of the V4C project through capacity building of extension agents, CVCs' operators and farmers. The main actions carried out under the extension component of the V4C project can be summarized as follows:

(i) training technicians on various topics;
(ii) training of producers on good agricultural practices (GAP) through the main tools that are Farmers' Field Schools (FFS)[11], Plots of Demonstrations (PoDs) and exchange visits between producers.

ANADER and CDCs monitor the PoDs but FFS are only organized by ANADER. To raise farmers' awareness on innovative technologies promoted by the Project, open days and exchange visits were organized by CDCs and CVCs. 48 and 32 days have been organized respectively in 2014 and 2015. More than 4,000 farmers have been reached through these open days and visits. A communication plan for information and sensitization of producers was also developed and implemented in the CVC, through various tools (radio, posters, etc.).

4.5 A summary of the interventions

All the interventions of the V4C project can be summarized in three categories. The first intervention is *training*. Through CDCs, CVCs and ANADER, the farmers have been trained on good agriculture practices. The second and third categories of interventions are related to the *provision of technologies*. There are two ways of technology provision. On the one hand, we have the *provision of inputs* such as fertilizers, pesticides and cocoa plants. One the other hand, the CVCs' operators assist producers in implementing good agricultural practices, replanting or grafting (*provision of services*).

5. Theory of Change

The agricultural dimension of the project is based on the theory that providing new farming techniques using research and best agricultural practices will improve cocoa yields while mitigating the negative effects of declining fertility, tree ageing, and the spread of diseases. In practice, cocoa farmers can learn innovative techniques and adopt new technologies set by the program to boost their productivity. In addition to potential changes in productivity, these call for many small changes in the areas of interactions of stakeholders, access to inputs like seed and fertilizers, access to insurance, access to processing and value addition and access to end markets (Adekunle and Fatunbi, 2014). The theory of change of the project V4C is summarized in Graph 1 below.

Pertaining to the interactions between stakeholders, the strategic coordination between public and private stakeholders or *helping hand* (Lemma and Velde, 2017) through PPP platform avoid duplications of activities. Although the private sector is solely responsible of the funding of its activities, the platform requires that a sharing of the information among the members of the platform. Apart from ensuring a proper coordination of the activities, it allows also to identify and remove constraints and to design and implement strategies to transform the sector as well as evaluation of the actions (*accountability*). For example, the producers associate swollen shoot to HIV/AIDS virus. To overcome this issue, ICRAF and

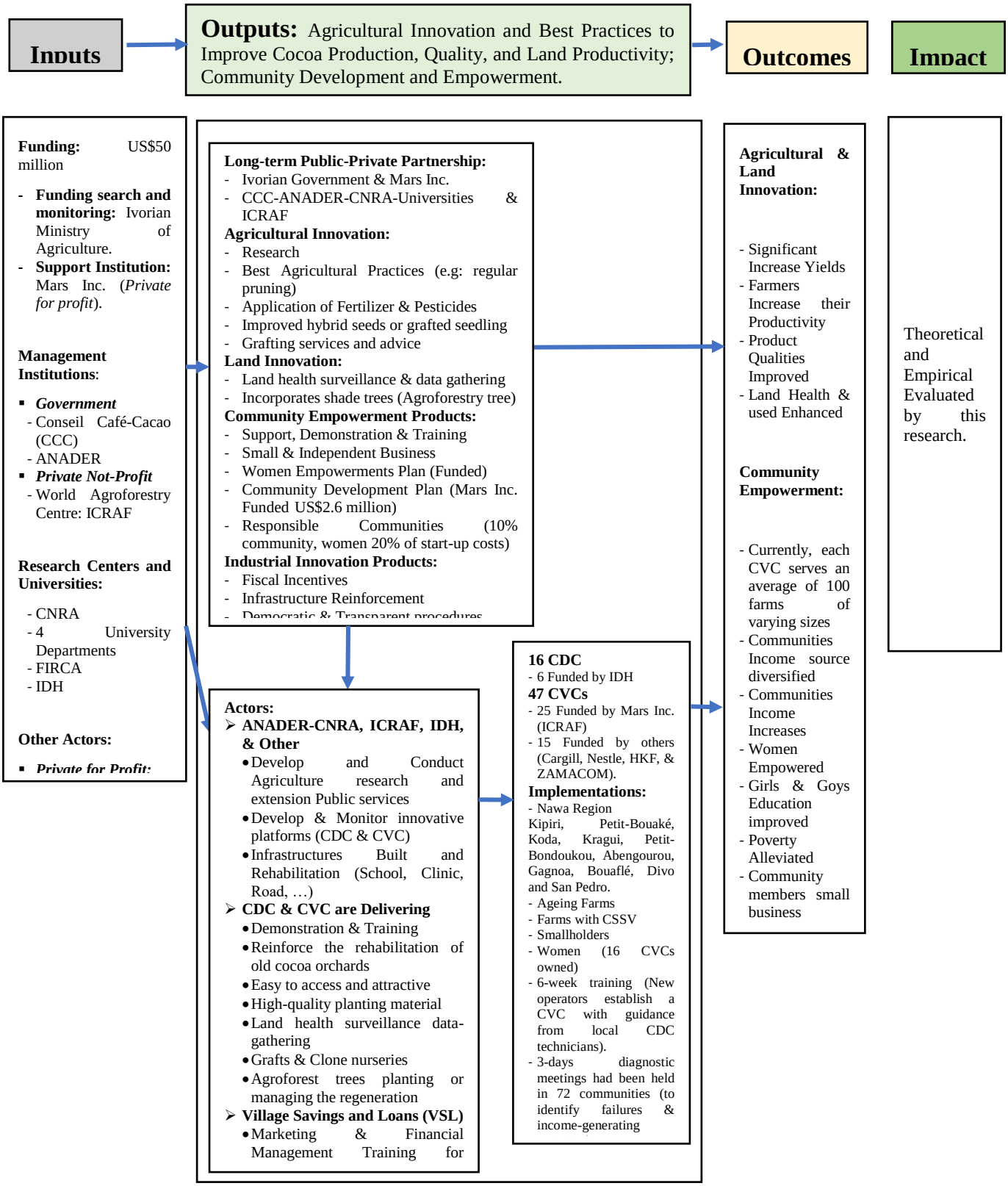
[11] The Farmers' Field School is a meeting and training framework for a group of producers (generally between 25 and 30 producers), a school "without walls", which takes place in a field, throughout a growing season. It is a place of exchange of experiences and knowledge where producers who share the same interests, seek, discuss and make decisions on the management of a field based on its actual situation.

WCF invest in search of high yield and swollen shoot resilient technology. To date, research comes out with high yield and swollen-shoot-tolerant hybrid varieties. The available technologies are not yet fully resilient but only tolerant. In addition, the V4C project has added in its training package approaches to better manage (circumscribe) swollen shoot disease. Overall, because of this partial view of the economy and the power of vested interest, and given the weak capabilities of governments and other economic agents to undertake industrial policy (Kuznetsov and Sabel, 2011), a dense links between government and the private sector is needed. The PPP platform plays this role. To be effective, this collaboration between the public and private sector should rely on embeddedness, discipline and accountability (According to Rodrik, 2013).

Combining input supply and productivity with swollen shoot fighting is one key of the success of the interventions. First, the producers' portrayal of the disease (swollen shoot is like the AIDS virus) means that some of them are reluctant to any variety that is not resistant to the disease. Second, the information sharing within the platform mitigates the effects of knowledge spillovers and allows the coordination of investment (Hausmann *et al*., 2007; Rodrik, 2004). It accelerates the identification of new opportunities of investment for the diversification by discovering process of new techniques and or their adoption to the local context. This process of discovery is costly if it involves only one firm. In this case study, the process of getting a new fertilizer formula is an illustration of the discovery of new techniques. This process involves soil testing (done by CNRA and ESA), new fertilizer formulation (*discovery*), manufacturing and dissemination. For fertilizer to be available, ICRAF has signed a MoU with IDH (the Sustainable Trade Initiative) for large scale production (manufacturing). Economies of scale made the products affordable for the producers compared to the fertilizer that exists on the market before. CVCs are the connection to the farmers. Without the MoU and the guarantee that farmers would use fertilizers, manufacturing costs would be high (low volume production that unable economies of scale) and unaffordable for end-users.

The governance of the platform that includes the public (CCC) and private (cocoa exporters and chocolate industry) sectors help to foster the *embeddedness* by managing the tension between coordination and corruption and rent-seeking as known as *capture* (Evans, 1995; Kim, 2017; Vu-Thanh, 2017). Close public-private relationships may end up serving as a mechanism to transfer rents to corrupt businessmen or bureaucrats (Page and Tarp, 2017). The variety of private sector interest (cocoa exporters do not necessary have the same needs as chocolate industry) and the expectations of the public sector make it difficult for any coalition that would encourage rent-seeking.

Graph 1: Theory of Change: The Vision for Change in Cocoa Industry Innovation



Regarding the productivity, the new technologies involve some research activities. These activities are undertaken mainly by the CNRA and ESA. The tests conducted through CDCs have shown that (i) good agricultural practice and grafting can yield up to 2,000 kg per hectare, and (ii) good agricultural practices and fertilization can yield up to 1,000 kg per hectare. As a result, the outcome of the research can increase production without increasing the area, especially since there is a shortage of land. Second, to reach farmers, ANADER plays the role of extension agency via training sections and assistance. Even this approach can produce appreciable results (Maiangwa et al., 2010), the limitation happens when the extension agency becomes weak due to the lack of governmental support and other institutional neglect. To mitigate this risk and to generate positive externalities, CDCs are used to show the results of research to farmers. This approach can accelerate the adoption of technologies. In fact, an important mechanism affecting the diffusion of new technologies among farmers in less-developed countries is copying by late adopters of early adopters (Pomp and Burger, 1995) due probability to information asymmetry. By alleviating the information asymmetry, CDCs can accelerate the adoption of technologies. In addition, to ensure the sustainability of the productivity outcome, CVCs are developed as local nurseries that facilitate the commercial distributions of cocoa plants. Because CVCs are small and independent businesses owned and managed locally, they provide an additional source of income and are thus likely to reduce the beneficiaries' vulnerability to negative income shocks.

Is the CVCs business model sustainable? The answer to this question depends on the stakeholders namely (i) the adequacy between the services delivered by CVCs and the needs of producers, and (ii) the contribution of other partners such as input suppliers and donors. The interaction of stakeholders plays a key role.

Thus, the hypotheses of this theory of change implemented in cocoa industry in Côte d'Ivoire can be summarized as follows. If the research leads to improved varieties and improved practices, then technologies will be available for use (Adekunle and Fatunbi, 2014). As we mentioned above, the technologies are available. We will document the large-scale reproduction of technology to meet the needs of farmers; e.g. availability of inputs such as fertilizers, pesticides; availability of seedling, etc. This leads to a second hypothesis namely if the extension system is functional, technologies will be available to the farmers. Now, if the technologies are accepted by farmers and meet their development needs, then the technologies will be adopted by the farmers. For example, if the change occurs in the cocoa production implying a shift from full sun-cocoa cultivation to cocoa agroforestry, and if the change incorporates shade trees with cocoa improves the agroecological balance in the landscape, then, the cocoa sector could enhance soil fertility, help conserve biodiversity, reduce deforestation and forest degradation. Agroecological change is another key point due to land pressure. One response to land constraints is agricultural intensification as suggested by Boserup (1965). Furthermore, if the price of the technologies is affordable, technologies will be adopted and used. If all these changes occur, it would increase cocoa yields and provide additional income for farmers through the increase in production since the project does not directly influence the price. But the program can indirectly influence price via information. That is why a subsection is devoted to the analysis of the effects of the program on price.

6. Data and summary statistics

This paper uses primary data collected from April to May 2018 in seven regions (Nawa, Gbokle, San Pedro, Haut-Sassandra, Goh, Guemon and Cavally) of Cote d'Ivoire. All the regions are in the western and southwestern parts of the country. The project is implemented in the region of Nawa which is therefore the intervention area. The other regions are the control area. To highlight how the control regions are selected, it is worth noting that two rounds baseline surveys have been collected in 2012 and 2014 for the V4C project. For each round, the sampling strategy is designed to split the area under study into three strata. The first stratum is composed the intervention area. The second and third strata are

control groups. The first control group aims at capturing the spill-over effect of the intervention. The second control group (stratum 3), which is outside the region of intervention, is used to ensure a proper control group. The 2012 and 2014 control groups are not the same (variation in methodology). Moreover, all the localities in the stratum 2 of the 2012 round are covered by the project as well those in strata 2 and 3 of the 2014 round. Only the localities in stratum 3 of the 2012 round are not affected by the interventions. Thereby, these control regions of this current study are those of the first baseline survey conducted in 2012.

Firstly, the enumeration areas (EAs)[12] are selected. We keep the same EAs as in 2012 in the control area. In each control EA, all the households are enumerated and 23 households have been randomly selected for the interview. In the treatment area, 25 EAs are randomly selected from the 2014 list. In each EA, the sample is split into beneficiaries and non-beneficiaries. A beneficiary is a person that uses one of the technologies of the project (provision of input or services) or has been exposed to a training related to the project. The beneficiaries are drawn from CVCs operators' customers list and ORPP list. We randomly select non-beneficiaries from the 2014 baseline data and check if there are beneficiaries or not. This last group within the intervention area aims at capturing the spill-over effect of the intervention. The summary of the surveyed households is given in Table 1. As we could see, only three producers (out of 231) benefit from the program in the control area. In the intervention area, 26% of the producers do not benefit from the project. All the households are cocoa producers. A questionnaire has been designed to collect information on households' characteristics, agricultural labor force, prices, yields and technology.

Table 1: Number of households per wave and status

	Control	Intervention	Total
Beneficiaries	3	383	386
Non-beneficiaries	228	138	366
Total	231	521	752

Source: ENSEA 2018

In addition to data collected from producers, CVC operators have been interviewed. A total of 32 CVCs' operators have been interviewed. Among these CVCs operators, 24 were trained by ICRAF alone, 2 by ICRAF and another partner and 6 by other partners. The two sources of information allow the comparison of information form CVCs' operators and producers.

Summary statistics

Table 2 provides some comparison tests between treated and controls of cocoa producers for some key characteristics of the farmers and their fields. Only 3.6% of the farmers are female and 30.2% of them are not Ivorian. The farmer's average age is 46.7. 90.2% of them are living in couple and 41.2% of them have never been schooled. However, no significant differences have been observed between treated and controls for these characteristics. In terms of household size, we find that farmer's households are greater (9.2 individuals on average) against 7.2 for the controls. Also, the field area is greater for treated.

[12] An enumeration area is an operational geographic unit for the collection of census data and has 200 to 300 households (around 1,000 inhabitants).

Table 2: Balanced groups tests

	Overall mean	Mean treated	Mean control in IAs	Mean control out of IAs	Difference Treated vs Controls in IAs	Difference Treated vs Controls out of IAs
			CDC			
Age of farmer	46.73	46.50	48.49	46.05	-1.99 [-1.543]	0.45 [0.4326]
Female farmer	3.59	4.15	3.63	2.63	0.52 [0.2683]	1.51 [0.9749]
Not Ivorian	30.19	31.61	23.91	31.58	7.69 [1.6995]	0.03 [0.0070]
Never schooled	41.22	39.38	55.80	35.53	-16.42*** [-3.34]	3.85 [0.9503]
Living with partner	90.16	92.49	86.96	88.16	5.53* [1.95]	4.33* [1.80]
Has TV	46.68	49.74	35.51	48.25	14.23*** [2.88]	1.50 [0.3581]
Household size	8.35	9.21	7.85	7.20	1.36** [2.42]	2.01*** [4.47]
Field area	5.61	6.31	6.51	3.85	-0.19 [-0.25]	2.48*** [4.54]

Source: ENSEA 2018

Among CVCs' operators, only one out of the 32 surveyed is a female. The average age of CVCs operators is 36 and they have high education level (71.9% have secondary school level, and 21.9 have university level). In terms of marital status, 65.6% of the CVCs operators live in couple. They have been CVC operators since 4 years on average. Before becoming CVC operator, 56.3% of them were already involved in agricultural activities while only 1 of them was out of the labor market.

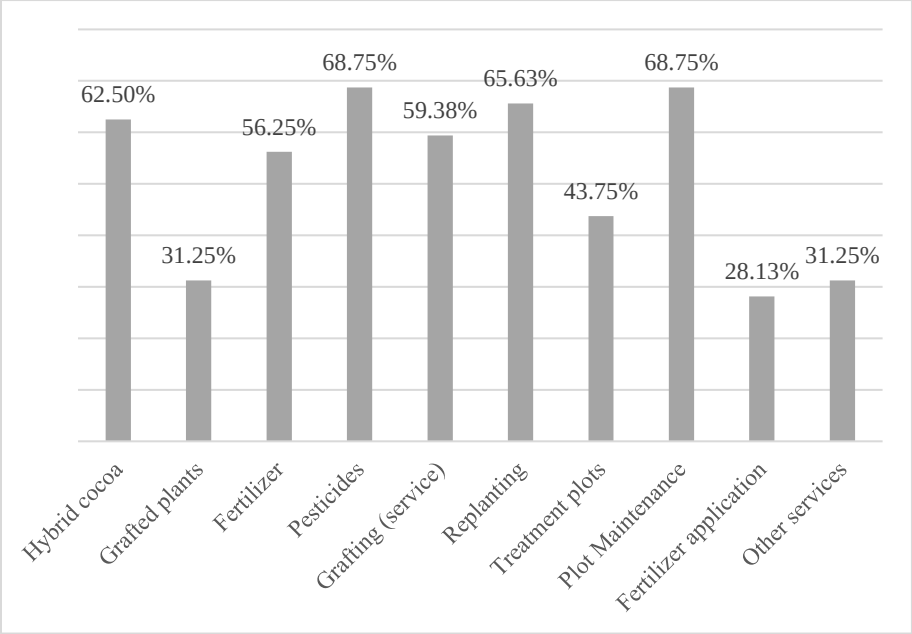
7. Results

Technologies are available and used by producers

The outcomes of the research are improved clones and improved fertilizers. The project also introduced grafting techniques to boost productivity. Statistics on technologies from the project management are reported in subsection 4.1. Data collected from CVCs' operators are used to complement this analysis. Figure 1 shows that CVC's operators sell plant material (more hybrid cocoa and less grafted plants), fertilizers and Pesticides. Plant materials come from CNRA or CCC. This is not surprising and consistent with *input supply and productivity improvement* thematic group agenda. Indeed, CCC buys seeds from CNRA and sells it to the private through this working group. By this process, one can control the origin of plant material.

CVCs' operators provide also extension services (grafting, replanting, and treatment) to farmers. The other services are mainly agriculture council. All these results show that technologies are available for use meaning that the technology can be accessible by farmers if they request for. Recall that CVCs make the connection between research as well as manufacturing and the end-users (farmers).

Figure 1: Services provided by CVC's operators



Note: This figure displays the services provided by the CVCs. Each percentage indicates the proportion of the CVCs that offer the given service. For example, 62.50% of the CVCs provide hybrid cocoa. Source: ENSEA 2018, computation of the authors.

Table 3: Services requested by the producers (in %) according to the frequency

	Mostly (%)	Often (%)	Rarely (%)	Obs.
Hybrid cocoa plants	40.91	45.45	13.64	22
Grafted plants	35.29	29.41	35.29	17
Grafting (service)	50.00	30.00	20.00	20
Replanting	46.43	42.86	10.71	28
Fertilizer	75.00	20.00	5.00	20
Pesticides	76.19	23.81	-	21
Treatment plots	48.00	28.00	24.00	25
Plot Maintenance	50.00	36.67	13.33	30
Fertilizer application	40.91	22.73	36.36	22
Other services	44.44	44.44	11.11	9

Source: ENSEA 2018

We also examine the services requested by the farmers according to CVCs' operators. According to the CVCs' operators, services provided seem to meet the demand of the producers (see Table 3). This matching can be explained by three main factors: background information, training and social network. The first is that background investigations at the beginning of the project help to design technologies that are adapted to the needs of the producers. Fertilizers are one typical example of the project as mentioned above. As we can see in Table 3, fertilizers and pesticides are the two mostly (at least 75%) requested services by producers. All the other services, including plant material, are mostly or often requested. Nevertheless, grafted plants are less requested by producers because almost the half (46.9%) of the operators does not received a request for this service. Even if producers do not request for grafted plants, grafting services (62.5%) and replanting (87.5%) are provided by the CVCs' operators. Training activities though CDCs or FFFs have probably played a role in this behavior of farmers (second factor). The social network of the CVC operators helps to understand the services requested by the farmers. A CVC operator lives in a village with the farmers and visits most of them. The close relationship increases the level of social trust and the ability of the farmers to make a deal with the CVC operator. This is also strengthening

by the ethnic group to which the CVC operator belongs to. A CVC operator starts trading with the members of its ethnic group because the social trust is high within a single ethnic group in the rural area. Then, the members of its ethnic group become relays to reach other members of the community and the nearest communities (similar to a copy by late adopters of early adopters).

Training activities

Program statistics show that extension activities through CVCs reached 12,900 producers up to 2015. These producers have been trained in FFS and PoDs. Table 4 gives a summary of the number of FFS and PoDs as well as the number of trained farmers. More than 100 FFS and 221 PoDs have been used to train 5,500 cocoa producers. Several of these producers have benefited and continue to benefit from the Orchard Rehabilitation Pilot Project that aims to scale up grafting in cocoa production. In addition, through the CVCs' network, the producers have found solutions to problems of quality (certified products), costs and unavailability of inputs. In 2015, 479 producers had access to the new fertilizer and 406 producers benefited from hybrid cocoa nurseries.

Table 4 : Number of farmers trained via FFS and PoDs

		2012	2013	2014	2015	Total
Farmers' Field Schools	Number of FFS	15	30	25	45	115
	Men	452	757	481	745	2,435
	Females	24	17	11	199	251
	Sub-total	476	774	492	944	2,686
Plots of Demonstrations	Number of PoDs	29	44	124	24	221
	Men	641	726	1086	315	2768
	Females	9	16	14	5	44
	Sub-total	650	742	1100	320	2,812
Total	Men	1,093	1,483	1,567	1,060	5,203
	Females	33	33	25	204	295
	Grand total	1,126	1,516	1,592	1,264	5,498

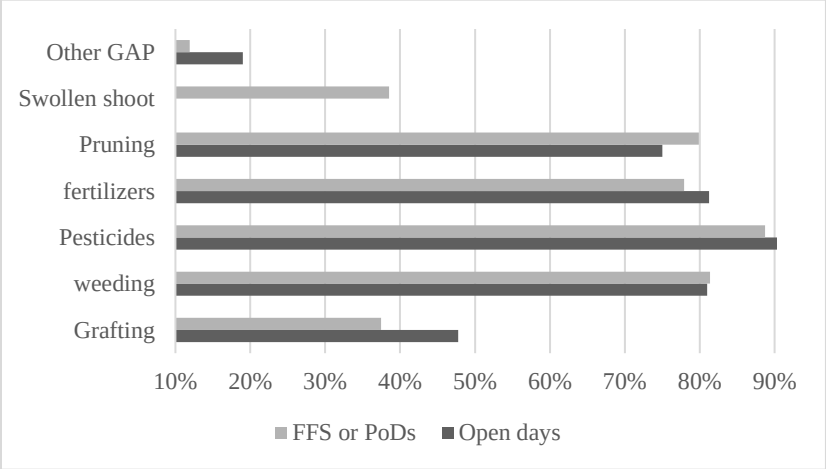
Note: FFS and PdDs denote Farmers' Field Schools (FFS) and Plots of Demonstrations (PoDs) respectively. Source: Assessment report of the project V4C, 2016

Do these training reach producers? Answer to this question uses data collected from producers to highlight their degree of knowledge and attendance. Data show that 64.5% of beneficiaries, 37.7% of non-beneficiaries in the treatment area know a CDC. This proportion is only 5.3% in control area. The figures are almost the same for CVCs: 98.4% of beneficiaries, 46.4% of non-beneficiaries in the intervention area and 2.2% of non-beneficiaries in the control area. Beneficiaries are randomly selected from the list of CVCs operators' customers or ORPP's list. Within those who know the CDCs, most of three quarters in the intervention area and one third in control area have visited a CDC (Table 5). The producers participate in open days activities or FFS particularly in intervention areas. In the control group, some of non-beneficiaries (24% for open days and 35% for FFSs) attend these training sessions and become therefore indirect beneficiaries. Almost all participants find the sessions useful since they help them improve their productivity (94% for open days and 97% for FFS).

The training sessions cover various topics such as grafting, weeding, pesticides, fertilizers, pruning, and other GAPs. Figure 2 shows that main topics are pruning, usage of fertilizers and pesticides as well as weeding. The focus of training sessions is GAP according to the protocol of the project. Fighting against swollen shoot is only cover during the training sessions of FFS or PoDs. Training on that disease is one is

an innovation of the project. There is no statistical difference between beneficiaries and non-beneficiaries in the intervention area as opposed to control area in terms of topics of the training sessions (Table 5).

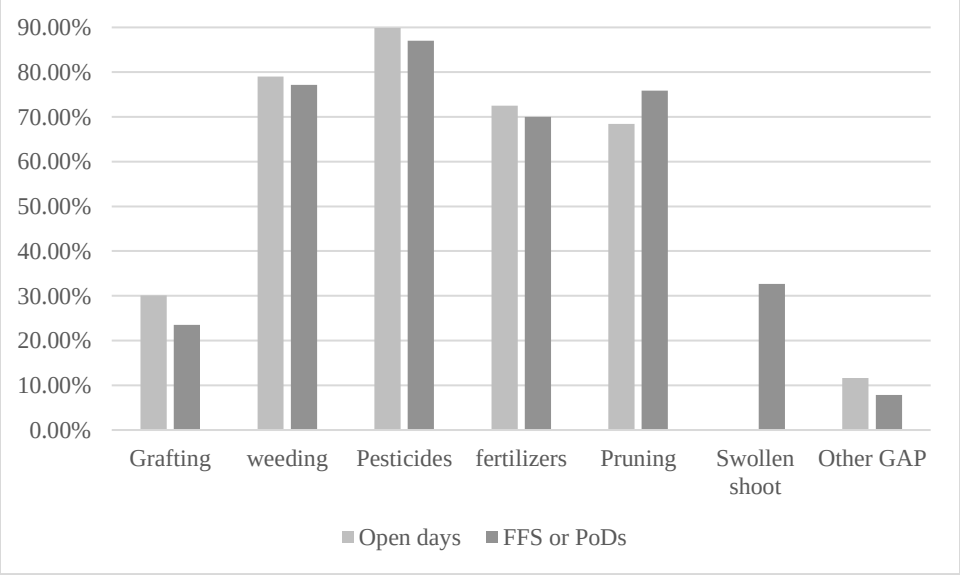
Figure 2: Topics of training sessions



Source: ENSEA 2018

Data show that producers have been exposed to training. Do they apply the techniques learned? Figure 3 shows that more than two thirds of the trained apply the techniques learned except for grafting, swollen shoot disease and other GAPs. It is worth noting that grafting and fight against swollen shoot disease may require external expertise. This may explain why these techniques are not so common. There is no difference between beneficiaries and non- beneficiaries in terms of application of the techniques in the intervention area except for grafting. A comparison between control and intervention areas displays a difference in terms of techniques application.

Figure 3: Proportion of producers who applies techniques learned



Source: ENSEA 2018

What services do the producers request from CVCs?

The mostly requested services are pesticides (68%), fertilizers (54%), grafting (33%) and replanting (29%). This is consistent with data from CVCs' operators. Before the project, the main issues faced by farmers were availability (37,3%), cost (33%) and to a lesser extent the payment method (19,1%) of the input and services. Producers do not recognize the quality as a big issue since only 3% raised it. Therefore, the project seems to provide solution to the availability, cost and the method of payment. Concerning the costs, the cost of the 50 kg of fertilizer lies between 13,500 and 18,000 CFA Francs compared to 25,000 CFA Francs (2012 baseline data). Almost one quarter of the CVCs' operators sell the fertilizer at 15,000. New fertilizer is less expensive than the fertilizer on the market at the beginning of the project. The MoU with IDH has played a role via economies of scale. Regarding the payment, the producers pay cash (76%) as before or by credit (43%). For some of them, the services are free of charge. Payment by credit is an innovation of the project.

Impact of the program on producers

The method implemented for this impact evaluation is a propensity score matching (PSM). We match treated and control based on demographic characteristics (age, gender, being in couple, level of education, and nationality), household characteristics (size, TV as communication medium) and field area. After the matching, we compute the average treatment on treated (ATT) as the indicator of the project impact on the treated. To ensure the quality of the matching, Figure 4 (on appendix) plots the common support and Table 8 displays the balancing test.

The effect of the program is assessed on productivity and income by using a matching approach. Table 6 summarizes the results of the estimation by using a one-to-one matching approach as well as the radius, the kernel, and the nearest neighbor approaches for robustness.

Pertaining to productivity, we highlight a ***significant effect of the program on yield (productivity).*** Without considering the control variables, it seems that there is no difference in the productivity between the treated and the control groups. After matching, we find significant difference between treated and control groups at 5 percent level. The average yield is 81.98 kilograms per hectare higher for the treated group.

This result can be explained by a great adoption rate of the new technologies by the treated and also better skills through training and better information, removal of credit constraint. The data shows that at least three third of cocoa producers implement the best practices learned in their field.

This increase in productivity translates into ***an increase in household income***. The estimated increase after matching is around 38% (see **Error! Reference source not found.**below Table 6). The intervention does improve the financial condition of the households by increasing their income.

Table 5: Statistics on the program collected from producers

Variable	Overall mean	Mean treated	Mean control in IAs	Mean control out of IAs	Difference Treated vs Controls in Ias	Difference Treated vs Controls out of Ias
CDC (in %)						
CDC visit	77.5	80.00	77.32	37.50	0.0268 [0.4934]	0.425*** [2.8024]
ANADER/ICRAF CDC (in %)						
open days (participate)	53.19	72.96	58.57	24.24	0.1440***[3.4670]	0.4872 ***[10.8726]
Benefit from open days	99.5	100	100	96.43		0.0357***[2.6630]
open days improves productivity	94	94.92	93.20	92.86	0.0172658 [0.6770]	0.0207 [0.5969]
ANADER CDC (in %)						
Participate in FFS	61.44	81.48	63.35	35.93	0.1813*** [4.6450]	0.4555***[10.3956]
Benefit from FFS	98.27	99.09	98.74	95.18	0.0035 [0.3279]	0.0391** [2.1788]
FFFs improve productivity	97.09	97.22	96.69	97.50	0.0053 [0.2949]	-0.0028 [-0.1309]
CVC CDC (in %)						
Knowing of CVCs	59.71	92.96	75.70	3.46	0.1727*** [5.4621]	0.8950*** [19.9835]
Request services	83.30	92.03	73.68	37.50	0.1835*** [5.2213]	0.5453*** [5.1417]
Plant material from CVC	22.85	38.95	18.80	0.98	0.2016*** [3.8034]	0.3797*** [7.0344]
Services requested from CVCs CDC (in %)						
Hybrid cocoa plants	17.91	18.18	17.14	33.33	0.010 [0.2536]	-0.1515 [-0.6733]
Grafted plants	15.24	16.88	12.14	33.33	0.0474 [1.2363]	-0.1645 [-0.7520]
Grafting (service)	33.16	41.99	19.29	0	0.2271*** [4.4940]	0.4199 [1.4669]
Replanting	28.61	31.17	25.00	0	0.0617 [1.2714]	0.3117 [1.1622]
Fertilizer	54.01	54.11	53.57	66.67	0.0054 [0.1014]	-0.1255 [-0.4337]
Pesticides	68.18	69.70	66.43	33.33	0.0327 [0.6567]	0.3636 [1.3559]
Other services	9.09	6.93	12.86	0	-0.0593* [-1.9192]	0.0693 [0.4723]
Topics of open days CDC (in %)						
Grafting	47.75	52.79	53.74	14.29	-0.0095[-0.1746]	0.3851***[5.1192]
weeding	81.00	85.79	87.76	46.43	-0.0197 [-0.5306]	0.3936***[6.1829]
Pesticides	91.50	93.40	93.88	78.57	-0.0048[-0.1787]	0.14830***[3.2815]
fertilizers	81.25	86.80	85.03	51.79	0.0177 [0.4682]	0.3502***[5.6820]
Pruning	75.00	76.65	83.67	46.43	-0.0702 [-1.6007]	0.3022***[4.3532]
Other GAPs	19.00	19.29	16.33	25.00	0.0296 [0.7072]	-0.0571 [-0.9332]
Topics of PoDs CDC (in %)						
Grafting	37.45	44.09	41.51	12.05	0.0258 [0.5009]	0.3204***[5.2045]
weeding	81.39	88.18	85.53	55.42	0.0265[0.7580]	0.3277***[6.2667]
Pesticides	88.74	94.09	91.19	69.88	0.0290[1.0816]	0.2421***[5.6751]
fertilizers	77.92	84.09	82.39	53.01	0.0170 [0.4389]	0.3108***[5.6157]
Pruning	79.87	84.09	79.87	68.67	0.0422[1.0619]	0.1541***[2.9845]

Swollen shoot	38.53	41.82	48.43	10.84	-0.0661[-1.2775]	0.3097***[5.1009]
Other GAPs	0.1190476	0.1	0.0880503	0.2289157	0.0119 [0.3916]	-.1289***[-2.9257]
Application of techniques learned during open days CDC (in %)						
Grafting	30.05	42.49	19.15	13.46	0.2334***[4.4929]	0.2903***[3.8627]
weeding	79.02	81.87	85.82	50.00	-0.0395 [-0.9614]	0.3187***[4.7164]
Pesticides	89.90	90.67	92.20	80.77	-0.0152 [-0.4889]	0.0990 **[1.9924]
fertilizers	72.54	76.17	74.47	53.85	0.0170[0.3561]	0.2232***[3.1622]
Pruning	68.39	71.50	72.34	46.15	-0.0084[-0.1682]	0.2535***[3.4279]
Other GAPs	11.66	10.88	10.64	17.31	0.0024 [0.0706]	-0.0643[-1.2548]
Application of techniques learned at PoDs CDC (in %)						
Grafting	23.49	34.26	14.57	11.25	0.1969***[4.2235]	0.2301***[3.9137]
weeding	77.18	84.26	80.13	52.50	0.0413 [1.0253]	0.3176***[5.6558]
Pesticides	87.02	92.59	89.40	67.50	0.0319[1.0655]	0.2509***[5.4944]
fertilizers	70.02	74.07	74.83	50.00	-0.0077[-0.1642]	0.2407***[3.9293]
Pruning	75.84	79.63	76.82	63.75	0.0281[0.6442]	0.1588**[2.8148]
Swollen shoot	32.66	37.04	37.09	12.50	-0.0005[-0.0096]	0.2454***[4.0755]
Other GAPs	7.83	6.48	5.30	16.25	0.0118[0.4700]	-0.0977***[-2.5923]

Note: IA is Intervention area, t-test or z-test are in brackets. ***: Significant at 1%, **: significant at 5%, *: significant at 10%. Source: ENSEA 2018, computations of authors.

Finally, we check the effect of the interventions on cocoa price and do find that the ***average price of cacao bean is higher*** for the beneficiaries than the non-beneficiaries. This unintended outcome of the project may be explained by the quality of the information, the quality of the buyer and the quality of the beans (see Table 10 on appendix for additional data). Only 2.3% of the beneficiaries apply a discount when they sell their cocoa beans compare to 8% of non-beneficiaries due mainly to the quality of beans and the quality of the buyer as well as quality of the roads. Concerning the quality of the beans, a producer must isolate sick beans and sort them before selling. However, 4.6% of the beneficiaries do not isolate sick beans and 8% of them do not sort them before selling. These numbers are low compare to 13% of non-beneficiaries that not isolate sick beans and 11% of them that do not sort. Regarding the quality of the buyer (Table 10 in appendix), while the beneficiaries sell 61.42% of their cocoa production to cooperatives, less than the half (43.91%) of the cocoa production of the non-beneficiaries is sold to cooperatives. In the control area, 21% of the cocoa production is sold to itinerant buyers compared to 9% for the beneficiaries. The trade process is well organized in the intervention area through cooperatives. One objective of the community development component of the VC4 is to organize the producers into economic interest groups, including cooperatives to better defend their interests and mobilize resources.

Table 6 : Effects of the program on household income, cocoa price and yield

	Yield	Log of income	Price
Unmatched	44.32	0.5026***	42.43***
	(30.07)	(0.0979)	(14.83)
Average Treatment Effect	81.98**	0.3790**	46.58**
	(41.13)	(0.1412)	(20.83)
Robustness check			
Average Treatment Effect Radius matching	44.32*	0.5026***	42.43***
	(24.22)	(0.0760)	(11.68)
Average Treatment Effect Epanechnikov kernel matching	53.50*	0.2873**	46.63**
	(32.99)	(0.1078)	(16.26)
Average Treatment Effect k-Nearest neighbors matching	64.87*	0.2582**	32.10*
	(34.60)	(0.1145)	(17.13)

Note: This table displays the effects of the intervention on the household income and the productivity (yield) before and after matching. Yield is defined as the ratio of cocoa production on area (in Kilogram per ha). Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Source: ENSEA 2018, computation of the authors.

Table 7 : Effects of the program on household income, cocoa price and yield (treatment=replanting)

	Yield	Log of income	Price
Unmatched	14.45	0.8169***	46.44***
	(57.51)	(0.1329)	(17.22)
Average Treatment Effect	80.19*	0.5643***	57.24**
	(44.51)	(0.1860)	(25.76)
Robustness check			
Average Treatment Effect Radius matching	14.45	0.8169***	46.44**
	(32.93)	(0.1040)	(19.63)
Average Treatment Effect Epanechnikov kernel matching	74.05*	0.4449***	46.03**
	(38.81)	(0.1126)	(20.74)
Average Treatment Effect k-Nearest neighbors matching	96.31**	0.4598***	51.03**
	(36.33)	(0.1235)	(21.58)

Note: This table displays the effects of the intervention on the household income and the productivity (yield) before and after matching. Yield is defined as the ratio of cocoa production on area (in Kilogram per ha). Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Source: ENSEA 2018, computation of the authors.

The previous analysis uses the definition of a beneficiary as any person that benefits from at least one intervention. Table 7 and Table 8 examine the effect of replanting (benefit from the Orchard Rehabilitation Pilot Project and ask for replanting via a CVC operator) and the use of at least one service provide by a CVC operator respectively.

Our previous results remain robust after splitting the analysis into sub-category except for yield when the beneficiary is the use of at least one service of the CVC (see Table 8). This result calls for caution because it depends on the matching process.

Table 8 : Effects of the program on household income, cocoa price and yield (treatment=use at least one service provided by a CVC operator)

	Yield	Log of income	Price
Unmatched	55.18 (36.76)	0.4571*** (0.0857)	41.51*** (10.98)
Average Treatment Effect	77.48 (58.42)	0.3145*** (0.1311)	38.76*** (15.90)
Robustness check			
Average Treatment Effect Radius matching	55.18* (29.58)	0.4571*** (0.0680)	41.51*** (9.23)
Average Treatment Effect Epanechnikov kernel matching	53.28 (39.87)	0.3171*** (0.0925)	42.12*** (11.80)
Average Treatment Effect k-Nearest neighbors matching	55.35 (42.71)	0.2589*** (0.1002)	37.97*** (12.35)

Note: This table displays the effects of the intervention on the household income and the productivity (yield) before and after matching. Yield is defined as the ratio of cocoa production on area (in Kilogram per ha). Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Source: ENSEA 2018, computation of the authors.

Is CVCs' business model sustainable? The time period of our analysis is short to talk about sustainability. We will focus on profitability. We find that the activity of CVCs leads to a positive profit (Table 9). On average, a CVC operator gets 221 253 XOF (around 337.3 euros) per month or 2 655 038 per annum. The sale of pesticides (45.8 cocoa producers as client on average per CVC operator), fertilizers (21 cocoa producers as client on average per CVC operator) and improved cocoa plant (10.3 cocoa producers as client per CVC operator) are the main activities of the CVC operators. In addition, we find that on average each CVC operator has less than four (3.8) cocoa producers for whom he provides a grafting support and less than three (2.6) cocoa producers for whom he provides a support for replanting.

Table 9: Income, Expenditures and profit of CVC operators

	Annual average value in XOF (confident interval in brackets)
Total income in 2017	3 263 846 [1 077 178 – 5 450 514]
Total expenditures in 2017 (acquisition, transportation, rental fees, other fees)	553 800 [303 300 – 804 300]
Profit in 2017	**2 655 038 [612 313 – 4 697 763]**

Source: ENSEA 2018, computation of the authors.

Conclusion

The aim of this paper is to understand how an agricultural PPP project namely Vision For Change (V4C) works by focusing on its productivity side. PPP in agricultural sector are matching funds and V4C is a PPP project financed by Mars Inc. and managed by ICRAF. The project aims at

revitalizing the cocoa sector in the Nawa Region in Côte d'Ivoire, in the largest cocoa growing region of Côte d'Ivoire. It is a collaborative effort between the public and private sectors in which each sector contributes to the activities needed to accomplish a shared objective (improving the living conditions of cocoa farmers via an increase in productivity). The design and implementation of the project are aligned with 2QC program within which a PPP platform has been set up to coordinate (develop and implement in a participatory manner), monitor and evaluate programs and projects of the Ivorian sustainable development plan for coffee and cocoa sectors. A single action aligned with the 2QC program should belong to a thematic group of the platform where the challenges of the sector are examined to come out with effective proposals. The activities of the V4C project are part of (i) input supply and productivity improvement, and (ii) fight against swollen shoot thematic groups.

Does the V4C project translate into higher cocoa yields and increase in income? This paper shows that the program significantly increases the yield by 81.98 kilograms per hectare, the income by 37.9% and the price by 46.58 XOF (0.071 euros) per kg. We also show that the CVC operator (extension arm of the project) business is sustainable since the net profit per month is 221 253 XOF (337.3 euros). Nonetheless, these are very short-term results since the adoption of provided technologies and replanting program have been implemented 2 to 4 years ago.

One factor of success of the project is the novel approach uses to provide high yield and swollen-shoot tolerant technology. Indeed, the producers' portrayal of the disease (swollen shoot is like the HIV/AIDS virus) means that some of them are reluctant to any variety that is not resistant to the disease. The PPP platform has been a useful tool to coordinate the interventions as well as generating learning among agents and thereby reducing the search and new discovery costs.

Second, the available technologies meet the demand of the producers. In fact, background investigations at the beginning of the project help to design technologies that are adapted to the needs of the producers since they use the technologies (plant material, fertilizers, pesticides, grafting service) promoted by the project. In addition, training activities though CDCs or FFFs (innovation platforms) have play a role in this behavior of farmers in terms of adoption by alleviating the information asymmetry that could lead to copy by late adopters of early adopters. Recall that, one output of the project is to come out with well-trained farmers in terms of good agricultural practices. The external support provides by the CVC operators help also to promote the new technologies. This promotion is strengthened by the social network of the CVC operators and the ethnic group to which they belong to since the close (distance and language) relationship increases the level of social trust and the ability of the farmers to trade with the CVC operator.

Clearly, CDCs and CVCs play a big role in the success of the project. These extension arms of the project complement the existing agricultural extension services provided by the public sector. It is worth noting that the public extension agency becomes weak over the year due to the lack of governmental support. Moreover, the agreements among institutions within the project lead to economies of scales and help to make new technologies affordable to the producers.

The results of this paper suggest that the project be scaling up. Indeed, the creation of the PPP platform and its functioning - via Plenary Assembly and Working Groups - are a solid ground for scaling up. Orchard Rehabilitation Pilot Project (ORPP) is a scaling up example of the grafting activity. The mid-term results for this initiative are promising in terms of productivity increase. Another extension of VC4 initiative is the activities of the CVCs that are right now beyond cocoa farming. The FIRCA sponsored the training of CVCs on new banana plant production techniques.

After the training, contracts were signed with 16 CVCs for the production and supply of 465,000 banana plants in 2016. In 2015, 25,695 banana seedlings were produced and sold.

The main lesson is that our findings suggest that PPP in agriculture, especially in cocoa sector can be a very interesting tool to reach the 2QC goal and avoid the shift to overs crops and ensure the sustainability of the cocoa industry by improving yield and farmer's income. Policy coordination at macro level with public sector and a wide range of private companies with variety of interest help to foster the embeddedness.

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Appendix

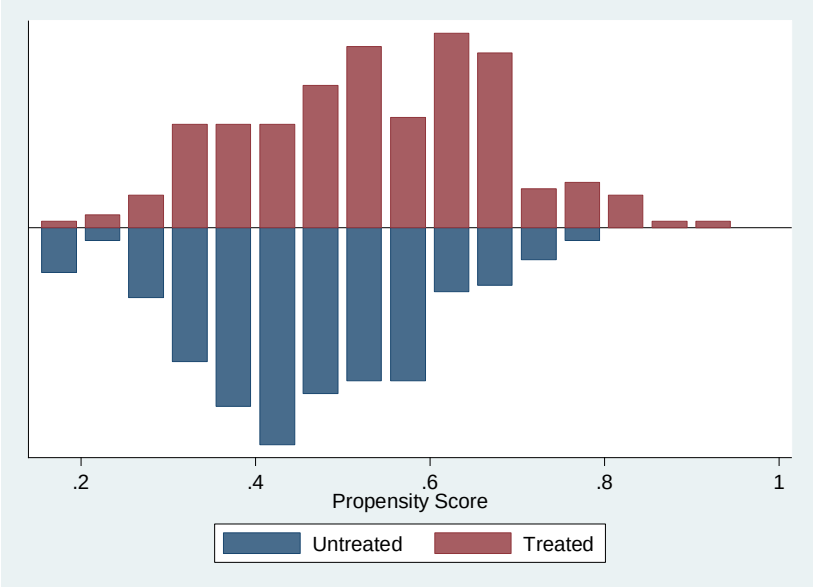
Table 10: Variables related to price

	Share of production sells to			Sale practices	Worst practices: proxy of bad cocoa quality		
	Certified buyers	Informal buyers (pisteur)	Cooperative	Applies discount	Do not isolate sick beans	Do not sort beans before sale	Number of drying days
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treated	22.84	8.92	61.42	2.27	4.55	7.95	6.84
Control	24.04	20.93	43.91	7.98	13.1	10.69	5.57
Difference	-1.20	-12.01***	17.51***	-5.71*	-8.56**	-2.74	1.27***
Use at least 1 CVC service	25.66	14.71	53.94	3.21	5.35	6.42	5.78
Not use any CVC service	22.16	24.28	38.07	11.38	18.78	14.29	5.65
Difference	3.5	-9.57***	15.87***	-8.17***	-13.44***	-7.87***	0.13
Has done replantation	26	13.37	56.03	1.99	5.97	5.47	5.63
Has not done replantation	17.82	22.25	35.31	10.5	27.62	20.44	5.52
Difference	8.18**	-8.88**	20.72***	-8.49***	-21.65***	-14.97***	0.11

Note: this table gives means and proportion comparison test between treated and controls on the sale behavior and the quality of cocoa beans proxied by practices from collection to sale. We consider the whole treatment as well as two specifics component of treatment namely the replanting and the use of at least one service provided by CVC. As interpretation, we can say that (for column 3 rows 1, 2 and 3) the treated sell 61.4% of their production to cooperative and 43.9% of the production of the controls is sold to cooperation; thus, between treated and controls, there is a significant difference of 17.5% of the production sold to cooperative. In column 4, we can read that 1.99% of those who have done replantation apply discount when selling their production while 10.5% of those who have not done replantation apply a discount. From column 5, we have 5.35% of the CVC service user that does not isolate sick beans and this figure is 18.78% for those who do not use any CVC service. *** p<0.01, ** p<0.05, * p<0.1. Source: ENSEA 2018, computation of the authors

Tests for the global model

Figure 4: Common support of the matching



Source: ENSEA 2018

Table 11: Bias reduction tests

Variable	Treated	Control	%bias	t-stat	V(Treated)/V(Control)
Age	48.18	48.48	-2.5	-0.24	1.01
Female	0.035	0.065	-18.4	-1.38	.
Couple	0.955	0.915	15.8	1.62	.
Number of children	3.505	3.42	3.7	0.33	1.15
Field area under 1 ha	0.065	0.065	0	0	.
Field area between 1 and 3 ha	0.28	0.30	-4.2	-0.44	.

* Variance ratio outside [0.76; 1.32]. Source: ENSEA 2018

Tests for the model with replantation as treatment

Figure 5: Common support of the matching

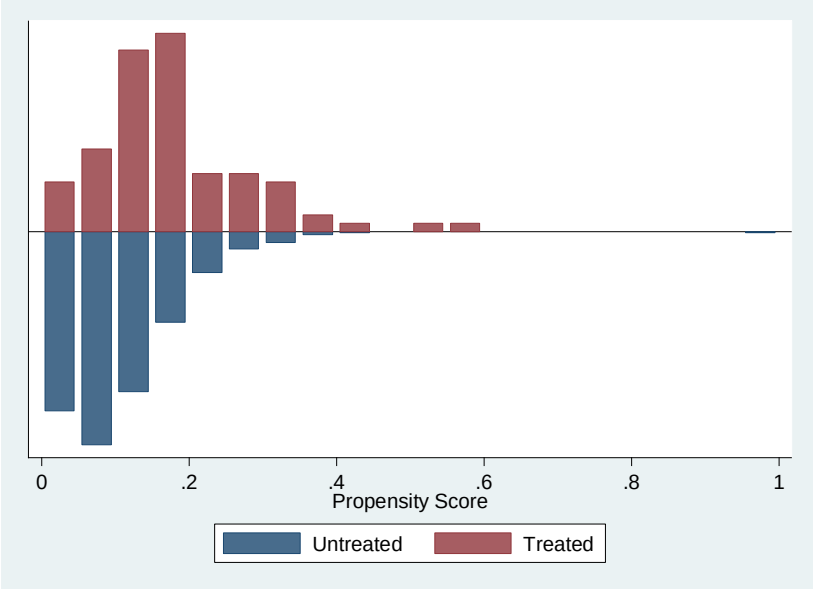


Table 12: Bias reduction tests

Variable	Treated	Control	%bias	t-stat	V(Treated)/V(Control)
Age	50.724	50.736	-0.1	-0.01	1.19
Female	0.02299	0.02299	0.0	-0.00	.
Couple	0.96552	0.97701	-4.5	-0.45	.
Household size	11.494	11.126	6.5	0.39	0.99
Never schooled	0.42529	0.50575	-16.3	-1.06	.
Non ivoirian	0.35632	0.36782	-2.4	-0.16	.
Has a TV	0.49425	0.44828	9.2	0.60	.
Has one field	0.55172	0.54023	2.4	0.15	.
Field area under 1 ha	0.02299	0	10.2	1.42	.
Field area between 1 and 3 ha	0.18391	0.18391	0.0	0.00	.

* Variance ratio outside [0.56; 1.53]. Source: ENSEA 2018

Tests for the model with use of at least one CVC service as treatment

Figure 6: Common support of the matching

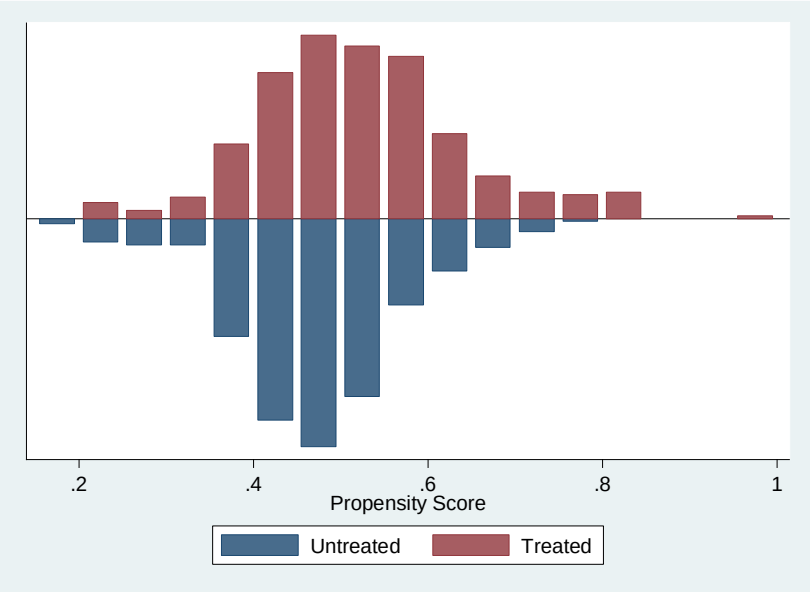


Table 13: Bias reduction tests

Variable	Treated	Control	%bias	t-stat	V(Treated)/V(Control)
Age	46.643	47.292	-5.1	-0.70	0.98
Female	0.0429	0.00268	21.6	3.71	.
Couple	0.92761	0.9571	-9.9	-1.73	.
Household size	9.2332	9.2842	-1.0	-0.13	1.67*
Never schooled	0.39678	0.39142	1.1	0.15	.
Non ivoirian	0.31903	0.32172	-0.6	-0.08	.
Has a TV	0.4933	0.58981	-19.3	-2.65	.
Has one field	0.6756	0.64075	7.4	1.00	.
Field area under 1 ha	0.06434	0.0563	3.0	0.46	.
Field area between 1 and 3 ha	0.32708	0.32172	1.1	0.16	.

* Variance ratio outside [0.82; 1.23]. Source: ENSEA 2018