Economics Bulletin

Volume 44, Issue 3

Diffusion and adoption of agricultural innovations: the role of a market based on public-private partnership in Cameroon

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Abstract

The aim of this article is to propose a paradigm for the promotion and distribution of agricultural innovations, based on public-private partnership (PPP). It is based on the case of improved seeds in Cameroon. The PPP here is established in the light of the seed law. It shows that the faulty part of the improved seed supply chain runs from distribution to use. In addition, data from a recent survey on cassava and maize production are used, with the estimation of a logit model, to assess the factors explaining the propensity to buy improved seeds. The results show that a hypothetical PPP has a positive and significant effect on the willingness to buy improved seeds. Based on the results obtained, a number of economic policy proposals are formulated.

The authors would like to thank an anonymous referee for the valuable comments. We also thank international institute of tropical agriculture for providing databases. All errors are those of the authors. Corresponding author. Tel : +237 693 503 224. E-mail address: ononino998@gmail.com.
Citation: Jean Charles Ononino and Cyrille Bergaly Kamdem and Raymond Ekodo and Yannick Fosso Djoumessi, (2024) "Diffusion and adoption of agricultural innovations: the role of a market based on public-private partnership in Cameroon", *Economics Bulletin*, Volume 44, Issue 3, pages 904-917
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Submitted: November 25, 2023. **Published:** September 30, 2024.

1. Introduction

The third decade of the 21st century calls for multidimensional resilience on the African continent. Indeed, while this continent is bearing the full brunt of the adverse consequences of climate change (Eichsteller et al., 2022), covid 19, through its effects on the food supply chain (Erokhin & Gao, 2020), has revealed the degree of fragility of local economies. To cap it all, the Russo-Ukrainian conflict, through the inflation it has drained from foodstuffs (Lin et al., 2023), signals the urgent need for a new configuration of African economies. This new configuration should make it possible to meet people's food needs and gradually reduce poverty.

To meet the challenge of food self-sufficiency, and ultimately improve the living standards of poor populations, several studies have presented the agricultural sector as an effective pathway in economies in their first phase of development (Abebe & Alemu, 2017; Irz et al., 2001). However, bringing the agricultural sector into line with this development model requires higher productivity. To meet the challenge of increasing agricultural productivity, greater producer efficiency is recommended (Warr & Suphannachart, 2021). In line with Sickles & Zelenyuk (2019), efficiency refers to the ability to obtain a maximum level of production with a given quantity of inputs (output orientation), or to minimize the quantity of inputs to obtain a specific level of production (input orientation). In the context of African countries, output orientation should be favored. Indeed, the main factors used in the agricultural sector (mainly land and labor) are widely available to ensure self-sufficiency in agricultural products. By extension, for the African continent, the results provided by the analysis of empirical literature, make it possible to link a low level of agricultural productivity to production technologies (Oduol et al., 2011).

To this end, an abundant literature presents innovation in the agricultural sector as a sine qua non condition for improving productivity levels (DeLay et al., 2022; Djoumessi, 2021). The example of factor-poor countries speaks volumes about the benefits of agricultural innovations on socio-economic well-being. Asian countries, for example, have developed high-production-capacity (intensive production) technologies such as irrigation, fertilizers, plant protection products, the production and distribution of improved seeds and many others, to compensate for land scarcity. These developments have enabled these countries to meet the food needs of their populations, to the point of exporting surplus production (Wu et al., 2010). Although intensive production technologies, have provided convincing results under other skies, they remain very little used in sub-Saharan Africa (Mondo et al., 2019). Indeed, the level of use of intensive agricultural production technologies is lower in Africa than in any other region in the world (Djoumessi, 2020). Yet diffusion theory stipulates that such technologies are bound to be communicated among the members of a social system, via certain channels (Orr, 2003).

Following on from diffusion theory, there is a substantial literature exploring the determinants of innovation adoption in the agricultural sector, in the context of countries lagging behind in development. In this sense, while Feder & Umali (1993) identified the agro-climatic environment, Mondo et al. (2019) identified membership of farmers' organizations, access to planting material in the form of credit, level of education among others. Following Sánchez-Toledano et al. (2018); Sapkota et al. (2017) identified social factors including risk perception. Another class of research, on the contrary, has linked the issue of innovation adoption in the agricultural fold, to infrastructure. In this sense, for Stifel & Minten (2008), the level of agricultural productivity is inversely linked to isolation. Shamdasani (2021) identifies the construction of road infrastructure as a solution to the diffusion of agricultural innovations. This is not an isolated finding. It has been observed in several previous works (Lokesha & Mahesha, 2017; Ogunleye et al., 2018). Yet, an informed analysis of these latest works, allows us to

understand that road infrastructure affects the agricultural sector through its ability to connect the market to producers. Among the purposes of this relationship, we can cite : marketing of production, contact with extension services, acquisition of inputs and many others.

Considering the last two purposes (contact with extension services and acquisition of inputs), and in the light of the above-mentioned literature (pointing to low adoption of innovations in African countries), the traditional agricultural extension system seems inoperative. The adoption of improved seeds, through their ability to guarantee food self-sufficiency (Abebe & Alemu, 2017), is a matter of public utility. To meet the challenges linked to the convergence of public utility issues, the implementation of a public-private partnership (PPP), has been evoked in several works, as a palliative to the inefficiency of policies linked to issues of this order. In this sense, we can mention Mukherjee & Maity (2015), who observed the inability of the traditional Indian dissemination system to respond to the new paradigm of the local agricultural sector. To overcome this deficit, the authors present the essential factors for a well-functioning public-private partnership. In this area, they join Ponnusamy (2013). Nwangwu (2019) observed that the level of public-sector funding for Nigeria's agricultural sector was low. In addition, he notes the lack of private-sector interest in investing in the agricultural sector, as a cause of the sector's underdevelopment. He then proposed the implementation of a PPP to overcome these problems. Hermans et al. (2019) highlight the different ways in which PPPs act as systemic policy instruments in the Dutch agricultural innovation system. They observe that, PPPs are particularly suited as policy instruments for economies in their early stages of development. Since PPPs stimulate innovation system functions such as knowledge development, networking, dissemination and research orientation. Poulton & Macartney (2012) as well as Ferroni & Castle (2011); Oriola (2012), have helped to understand that, PPP implemented in an appropriate framework, can overcome market failures in agricultural value chains.

The literature thus suggests that it would be relevant for developing economies to consider an effective paradigm in which extension services and the distribution of agricultural innovations produce the desired results. In this respect, a public-private partnership (PPP) might be appropriate. Thus, this article aims to present the conceptual framework of a public-private partnership, in which, the dissemination and adoption of agricultural innovations, are ensured. We then verify this relationship using empirical data.

2. Public-private partnerships: a conceptual framework

Before any analysis, we would like to point out that the public-private partnership in this study is based exclusively on agricultural innovations relating to seeds. It should be noted that there is no universally accepted definition of a public-private partnership (PPP). However, we borrow from the World Bank, for whom a PPP translates into arrangements, usually medium- to long-term, between the public and private sectors whereby certain services that are the responsibility of the public sector are administered by the private sector, sealed by a clear agreement on common objectives relating to the delivery of infrastructure and/or public services. From this definition, three entities emerge: a private actor (a natural or legal person), a public actor (the ministry in charge of agriculture, for example) and the object of the partnership (in this case, improved seeds).

The role of the public sector. In African countries, as in most others, the seed business is governed by law. In Cameroon, for example, the law in question is Law n° 2001/014 of July 23, 2001. The second paragraph of Article 1 of this law states that one of its aims is to promote agricultural development by guaranteeing the quality of seeds intended for farmers. However,

the concept of seed quality is fairly subjective. Seed quality can be linked to purity, germination or sanitary quality (McDonald, 1998; Mulesa et al., 2021). However, this is quality in the agronomic sense, since the FAO (2016), referring to seed security, extends quality to varietal characteristics that meet farmers' (generally organoleptic) preferences. The challenge in this context would then be to implement a control mechanism guaranteeing end-users access to quality seeds. In view of the seed law, we can assume that the "varietal creation" aspect is relatively well supervised. Indeed, it is relatively easy for the public authorities to exercise control over breeders[1] (research being quite costly, in Africa in general and in Cameroon in particular, accredited institutions such as IRAD and IITA[2] perform this function), since they are easily identifiable and very limited in number.

The second level of the improved seed supply chain concerns multipliers (agri-multipliers). Although this part of the activity is fairly open (article 5 of the seed law, paragraph 2, states that seed activity is freely exercised throughout the national territory by any individual or legal entity etc), the regulations nevertheless provide the public authorities with opportunities for supervision. This is achieved, on the one hand, by requiring prior declaration of the activity (article 5, paragraph 2), and, on the other hand, by requiring seed certification (article 11, paragraph 1). Moreover, in terms of rationality, it would be more advantageous for an agri-multiplier to operate within the legal framework. For it should be noted that, for agri-multipliers, certification is not only a mechanism of confidence as to the identity and genetic characteristics of the seeds they sell (McDonald, 1998). This reduces farmers' risk aversion. In addition, certification can enable agri-multipliers in good standing to benefit from the public administration network (recommendation to sometimes very important clients such as NGOs), in order to facilitate seed marketing.

The third level in the supply chain for improved seeds is marketing. This aspect of the seed business is not neglected by the legislator either (article 11, paragraph 2). Moreover, strict repressive measures are provided for, with the intention of deterring fraud (article 19). However, the supervision of this activity is subject to numerous constraints. These constraints are of various kinds. Among others, we can cite the atomicity of agro-distributors and the control of corruption. Although the law requires prior declaration, there are thousands of agro-distributors in Cameroon (reference), many of whom operate illegally. Due to their large numbers and the corruptibility of certain public officials (Orock & Mbuagbo, 2012), many seed distributors escape the regulatory net. In this context, standards of chemical treatment, storage, packaging and labelling (see article 14 paragraph 2), are not always guaranteed. As a result, the quality of seeds is called into question and, in turn, small-scale producers become more risk-averse.

The role of private individuals. As can be deduced from the above, private individuals (natural or legal) intervene at all levels of the seed business. They can be plant breeders, agri-multipliers, agro-distributors and, with the blessing of the public authority, they can provide extension services.

The purpose of the partnership. Seed, in the context of this proposal, is the trait that is supposed to unite the private and the public. Indeed, most countries that today claim to be self-sufficient in food have gone through a green revolution. This was characterized, among other things, by high productivity resulting from the adoption of innovative, high-yield technologies (Evenson & Gollin, 2003; Parayil, 1992). High-yield agricultural technologies have often

[1] Breeder: a person who has discovered and developed a variety. The term does not include a person who has redeveloped or rediscovered a variety whose existence is publicly known or a subject of ordinary knowledge (Article 2 of the Cameroon Seed Law).

[2] IRAD Institut de Recherche Agricole pour le Développement. IITA International Institut of Tropical Agriculture.

benefited from extensive promotion (communication) to catalyze their dissemination and adoption. Countries where adoption has been strongly observed have benefited from strong government intervention (Latruffe et al., 2013; Mukherjee & Maity, 2015). In African countries, however, the adoption of these technologies is lamentably low. The main hindrances identified are generally: poor understanding of farmers' preferences, limited extension (Nkamleu & Adesina, 2000), inadequate payment mechanism, geographical and economic inaccessibility, perception of risk, farmers' exposure to extension (Mondo et al., 2019; Sapkota et al., 2017; Takam-Fongang et al., 2019), the unsuitability of seeds for the production system, marketing constraints (Dontsop Nguezet et al., 2016), basically the constraints are intrinsic to each environment (Mondo et al., 2019).

3. Example of PPP in the seed value chain in Cameroon

It has been shown above that, the most important failures in the seed value chain in Cameroon, are identified at the level of seed distribution and use (adoption). To improve the efficiency of the improved seed supply chain, our proposal does not aim to detail the operation of a PPP. This has already been done extensively (Hartwich et al., 2007; Spielman & von Grebmer, 2006). This contribution focuses on the dissemination and adoption aspects. To this end, the PPP we propose is based on the creation of private enterprises that bring together young people and women trained in agricultural trades. The role of these companies will then be to ensure the extension and distribution of seeds.

Although the Ministry of Agriculture hosts a few projects and programs designed to disseminate agricultural innovations (PRO-SAPVA, PADRT, PADFA, etc.[3]), the level of adoption of these technologies is still unsatisfactory. Yet these projects and programs benefit from substantial public and international funding. Several studies have attributed the poor performance of agricultural extension programs to bureaucratic inefficiency, poor program design, certain weaknesses inherent in innovation dissemination systems operated by the public sector and ineffective transmission of knowledge to farmers (Feder et al., 2004; Kamdem, 2018). To overcome these limitations, several alternatives have been proposed. These include farmer field schools (FFS) and agricultural cooperatives, which have been used as a means of intensive knowledge dissemination (Abebaw & Haile, 2013; Kamdem, 2018). However, their business model is not designed to perform this function on an ongoing basis. For example, FFSs were conceived as programs designed to improve producers' knowledge of certain technologies (Godtland et al., 2004). However, beyond the period allotted to training, these programs provide neither follow-up nor input supply.

Regarding PPPs, the ability to identify opportunities, develop common interests and negotiate commitments have been identified as key factors in their failure (Hartwich et al., 2007). Accordingly, the PPP we propose is based on the neoclassical postulate of agent rationality. We then assume that, in a PPP, each stakeholder seeks to maximize its profit (utility). In the context of the dissemination and adoption of agricultural innovations, it would make sense for the PPP to be sealed on the basis of an obligation of result. This requirement aims to ensure common interests. It should therefore be backed by a set of specifications in which the public partner defines the expected levels of production and yield (based on the confidence interval provided by the breeder). Since yield is indirectly an indicator of the adoption of innovative technologies (yield is proportional to the degree of adoption (DeLay et al., 2022)). As a result, the minimum level required must be higher than that obtained with traditional seeds. The private partner is

[3] Respectively: Projet national de structuration et d'accompagnement des producteurs et de vulgarisation agricole, Projet d'appui au développement des racines et tubercules, Programme d'Appui au Développement des Filières Agricoles.

therefore required to propose a detailed action plan. This must: present the stages in the implementation of the plan, specify the expected outputs for each stage, formulate the material and financial requirements, and define the indicators inherent in each level.

Based on the literature, we can anticipate the following behaviours: i) the payment mechanism has been identified as one of the obstacles to technology adoption. As farmers' incomes are seasonal, the private partner will be able to set up a payment mechanism that enables producers to acquire seeds easily (e.g. credit purchases, payments in kind, etc.). ii) As adoption is in some cases linked to consumer habits, the private partner will try to understand the grower's preferences, in order to offer him the seeds that correspond best to his needs (according to soil, climatological, organoleptic characteristics, etc.). iii) As the influence of leaders has been recognized in the literature as a factor stimulating the adoption decision, the private partner may set up pilot farms run by local leaders. The results obtained by the leaders will thus act as catalysts for adoption by wary farmers. iv) As road infrastructure and geographical isolation have been identified as obstacles to the dissemination of innovations, the private partner can develop local distribution mechanisms (home delivery by young people using motorcycles, setting up local distribution points). v) Since the use of any new technology requires an appropriate level of knowledge, the private partner can promote innovations (using appropriate channels to communicate the benefits of adopting innovations), and train and monitor producers (passing on operating instructions and ensuring that technical itineraries are followed).

As for the public partner, it will be able to: i) benefit from efficient use of available funds. In Cameroon, most public projects and programs aimed at boosting agricultural productivity have proved ineffective. Reallocating funds from public initiatives to a PPP is likely to be more useful. ii) Easier control of seed quality. Setting up a PPP will ultimately have the effect of evicting traders on the bangs of the regulations. Since the private partner will also be in charge of distribution, it is likely to be the market leader. What's more, its market share will be so large that it will benefit from economies of scale. In this way, public players will be able to be assured of seed quality, simply by checking with producers (since traceability is guaranteed). iii) Have a reliable database on agricultural production, and thus have decision-making tools should the need arise to set up an agri-business. iv) Be able to identify priority infrastructure needs (roads, markets, storage granaries etc).

4. Methodological approach

4.1. Data

The data used in this contribution were collected July and August 2022. The collection was carried out in 3 regions of the country (Centre, Littoral and Sud), considered to be the main production basins for cassava and maize crops. A structured questionnaire was used to collect data from a population based on simple random sampling. The sample comprised 322 households, including 109, 103 and 110 for the Centre, Littoral and South regions respectively. The population is thus made up of 162 maize growers and 213 cassava growers, i.e. 53 households producing both maize and cassava.

4.2. Description of the sample

Divided into 5 sections, the data we mobilized provide information on: household socio-demographic characteristics, cassava production, maize production, access to land and apprehension of a PPP. Table I gives a statistical description of the variables used in our contribution. It shows that most of the maize and cassava growers are women. However, men are more inclined towards maize production (on average, one out of every two maize producers is male). It can be observed that producers are generally well-educated. Approximately 60% of

producers have attained or exceeded the secondary level of education. Additionally, it is noteworthy that fewer than 5% of producers are illiterate. The cultivated areas for both maize and cassava production indicate that agriculture is predominantly practiced by smallholder farmers. Indeed, the average cultivated areas are less than one hectare. However, it is observed that larger areas are dedicated to cassava production compared to maize production.

Both maize and cassava growers are sufficiently mature. Their average age is 45, and they say they have been farming for an average of 15 years. Producers live in households of around 7 people, and on average one in four is a member of a farmers' organization. Regarding production, the monoculture production system is more accepted among maize growers than among cassava growers. Indeed, while almost 70% of cassava growers prefer production systems in which several products are combined on the same plot, on average only one maize grower in two (50%) prefers this practice. Among cassava growers, groundnuts are the preferred associated product. It is combined on 45% of farms. In contrast, maize growers prefer to combine taro yam. This association is made by 28% of producers.

As far as improved seeds are concerned, growers are not generally reluctant to adopt them. However, the maize seed market is more eligible than the cassava seed market. While over 80% of maize growers are willing to buy improved maize seed, less than 70% of cassava growers are willing to do so. Awareness of the benefits of using improved seeds, as well as the actual use of these technologies, requires growers to have the appropriate knowledge. To this end, only 10% of the cassava growers in our sample have ever received training in the use of improved seeds. Twice as many maize growers, on the other hand, have already received similar training. Financing economic activity is an important factor in expanding production. Farmers finance themselves through a few financial institutions, including banks, microfinance institutions, village banks and many others. In our sample, an average of 40% of both maize and cassava growers are affiliated to a financial institution.

4.3. Estimation method

Since the aim is to estimate the effect of a possible PPP on the decision to adopt improved seeds, modeling is based on hypothetical variables. To this end, the endogenous variable in our model is willingness to adopt. This information was captured in our database through the questions "2.1.7 and 3.1.7 Would you be willing to buy improved varieties (of maize or cassava) on a regular basis?". This question implies two response modalities (Yes or No). Modeling the explanation of this type of variable requires binomial-type qualitative models. Two approaches are commonly used in this context: the probit model and the logit model. The fundamental difference between these two models lies in the distribution of the error term, which follows a normal distribution for the probit model and a logistic distribution for the logit model. If the aim is to estimate the probability of a producer adopting or not adopting a technology, the two approaches nevertheless produce similar results (Wu et al., 2010). However, due to its simplicity, the logit model is most often preferred to the probit model (Abebaw & Haile, 2013; Dontsop Nguezet et al., 2016; Mondo et al., 2019). For this purpose, our choice is then oriented towards the logit model whose distribution can be specified as follows :

$$P_i = \frac{e^{z_i}}{1 + e^{z_i}} \qquad (1)$$

In "(1)" P_i represents the probability of a producer i agreeing to adopt improved seeds. Its values are between 0 and 1. e is the base of the natural logarithm. z_i is the function of a vector with n exogenous variables and can be expressed by equation "(2)".

$$z_i = \alpha + \sum \beta_i X_i \qquad (2)$$

Table I: Descriptive statistics of producers' characteristics

Variables	Variables description	Cassava	maize
Gender of household head	1 if male; 0 if otherwise	0.4	0.47
Age of head of household	Number of years	46.047	45.55
Household size	Number of Members	6.73	7
Farm size	Cultivated area in hectares	0.83	0.67
Production experience	Number of years in farming	16.05	15.44
Cooperative member	1 if yes; 0 if otherwise	0.23	0.25
Farming system	1 if associated; 0 if otherwise	0.67	0.51
Associated product1	1 if groundnuts; 0 if otherwise	0.46	0.27
Associated product2	1 if taro yam; 0 if otherwise	0.39	0.28
Willingness to buy improved seeds	1 if yes; 0 if otherwise	0.67	0.82
technical Support in production	1 if yes; 0 if otherwise	0.11	0.2
Access to credit	1 if yes; 0 if otherwise	0.37	0.39
Youth partnership	1 if yes; 0 if otherwise	0.77	0.73
Partnership with women	1 if yes; 0 if otherwise	0.72	0.68
Level of education	1 if Not attended; 2 if Primary school; 3 if Secondary school; 4 if University level		
1.education Not attended	1 if yes; 0 if otherwise	0.03	0.04
2.education Primary school	1 if yes; 0 if otherwise	0.30	0.27
3.education Secondary school	1 if yes; 0 if otherwise	0.58	0.61
4. education University level	1 if yes; 0 if otherwise	0.09	0.07
Satisfaction by actual seed using	1 if Not satisfactory at all; 2 if Unsatisfactory; 3 if Indifferent; 4 if Satisfactory; 5 if Fully satisfactory		
1.Not satisfactory at all	1 if yes; 0 if otherwise	0.02	0.02
2.Unsatisfactory	1 if yes; 0 if otherwise	0.07	0.04
3.Indifferent	1 if yes; 0 if otherwise	0.24	0.20
4.Satisfactory	1 if yes; 0 if otherwise	0.62	0.62
5.Fully satisfactory	1 if yes; 0 if otherwise	0.06	0.12

For the empirical evidence, there are several options for utilizing logit modeling to assess the effect of the PPP on the intention to adopt quality seeds (Cramer, 2003). To ensure the robustness of our observed results, we estimated two binomial logit models using dummy variables for maize and cassava adoption, respectively. The estimation process was preceded by tests for multicollinearity and heteroscedasticity. These tests led us to remove certain variables to avoid stability issues and to perform robust error estimation (see tables A1 and A2 in the appendix).

From a comprehensive perspective, the adoption model is presented as follows:

$$L = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_j X_j + \varepsilon \qquad (3)$$

In "(3)", L represents the adoption variable, which takes two values in the binomial logit modeling (0 and 1). X_j is the explanatory variable j. Thus, among the j we find PPP. The

parameter α is a constant and β_j is the coefficient associated with the explanatory variable j. ε is the error term. It should be pointed out that, the other explanatory variables used in this contribution as control variables, are taken from the literature on the determinants of agricultural technology adoption (Abebaw & Haile, 2013; Mondo et al., 2019; Sánchez-Toledano et al., 2018).

5. Results and discussion

Table II presents the results of the estimates for the adoption models of maize (1) and cassava (3) using binomial logit modeling. The Hosmer-Lemeshow statistics (Goodness-of-fit test after logistic model) indicate that both adoption models are well-specified and that the underlying assumptions are met. This statistic ensures that the variables included in the models are relevant for predicting the intention to adopt. Among the 15 variables included in each model, it can be observed that 5 and 6 variables are significant at a minimum threshold of 10% in the adoption models for improved maize and cassava varieties, respectively.

From this table, it is evident that considering a Public-Private Partnership (PPP) where young people are responsible for promoting and distributing quality seeds has a positive and significant effect on the producers' expressed willingness to adopt. Specifically, all other factors being equal, considering this PPP increases by approximately 15% the likelihood that a producer will be willing to adopt maize seeds, and by 25% the likelihood of adopting improved cassava planting materials. This result supports the idea that, in contexts where traditional dissemination mechanisms are ineffective, a PPP can be an efficient solution (Mukherjee & Maity, 2015). Additionally, when the PPP is considered in a model where women are responsible for promoting and distributing seeds, producers are reluctant to adopt improved seeds. More specifically, at a 10% significance level among cassava producers, a gender-based PPP has a negative effect on the intention to adopt improved cassava planting materials. This result reflects a lack of trust among producers towards women, aligning with the observations of Ogunlela & Mukhtar (2009), who noted that gender inequality is dominant in the agricultural sector, creating a bottleneck for development. However, when women are empowered to realize their potential, they are more effective and contribute to agricultural expansion. Our results confirm this idea, particularly for maize, where considering female producers increases the intention to adopt quality seeds by about 10%.

For both cassava and maize producers, educational level has a positive and significant effect on the expressed willingness to adopt. It appears that, all other things being equal, when producers have a higher level of education, the probability that they will be willing to purchase improved seeds increases by 10% and 1%, respectively, at the 1% and 5% significance levels for maize and cassava producers. This result echoes Matuschke & Qaim (2009), who found that farmers with higher human capital tend to adopt innovative systems early on. This result is further reinforced by the significance and positive value of the variable “technical support in production”.

The level of satisfaction that producers derive from traditional seeds is a very important factor in their willingness to purchase improved seeds. Indeed, it can be observed that the “satisfaction level” variable is significant at the 1% threshold for cassava producers. However, the negative sign associated with the coefficients of this variable indicates that the more satisfied a producer is with the seed they are using, the less likely they will be to purchase a new variety. Nevertheless, if the producer is rational, it would still be possible to encourage them to adopt improved varieties. This would only be possible if they are convinced that the proposed variety

will offer them greater utility (in terms of yield, resistance to various shocks, organoleptic characteristics, etc.). To achieve this, it is important to understand the criteria guiding producers' choices. This result supports the findings of Mondo et al. (2019), who showed that the most adopted improved varieties are those that possess desirable traditional characteristics (yield potential, taste, high disease resistance, and early maturity).

Table II: **Results of the binomial Logit Model Estimation**

	(1)	(2) Maize	(3)	(4) cassava
VARIABLES	Maize	Dydx	cassava	dydx
Youth partnership	1.587**	0.168**	1.514***	0.263***
	(0.767)	(0.0733)	(0.411)	(0.0626)
Partnership with women	0.842	0.0889	-0.555	-0.0962
	(0.569)	(0.0621)	(0.404)	(0.0690)
Gender of household head	0.974*	0.103*	-0.0333	-0.00578
	(0.553)	(0.0582)	(0.344)	(0.0598)
Age of head of household	-0.0122	-0.00128	-0.0156	-0.00271
	(0.0147)	(0.00155)	(0.0120)	(0.00205)
Level of education	1.030***	0.109***	0.565**	0.0980**
	(0.351)	(0.0358)	(0.275)	(0.0457)
Household size	0.110	0.0116	0.0465	0.00807
	(0.0757)	(0.00802)	(0.0447)	(0.00774)
Cooperative member	1.188	0.125	-0.667	-0.116
	(0.837)	(0.0836)	(0.441)	(0.0735)
Satisfaction by actual seed using	-0.375	-0.0396	-0.603**	-0.105***
	(0.332)	(0.0356)	(0.238)	(0.0391)
technical Support in production	1.626**	0.172**	0.832	0.144
	(0.660)	(0.0741)	(0.658)	(0.113)
Access to credit	1.054*	0.111*	1.128***	0.196***
	(0.642)	(0.0651)	(0.394)	(0.0629)
Production experience	0.0332	0.00351	0.0287*	0.00497*
	(0.0419)	(0.00445)	(0.0152)	(0.00259)
Farming system	-0.201	-0.0212	-1.438***	-0.249***
	(0.739)	(0.0781)	(0.508)	(0.0816)
Associated product1	-0.360	-0.0380	-0.289	-0.0502
	(0.688)	(0.0722)	(0.465)	(0.0804)
Associated product2	0.202	0.0214	-0.328	-0.0569
	(0.784)	(0.0826)	(0.506)	(0.0873)
Farm size	-0.463	-0.0489	-0.204	-0.0353
	(0.515)	(0.0562)	(0.299)	(0.0521)
Constant	-2.045		1.289	
	(1.640)		(1.100)	
Fischer statistic (Prob > chi2)	0.0000		0.0007	
GOF (Prob > chi2)	0.5733		0.1076	
Log pseudolikelihood	-56.835		-116.011	
Observations	168	168	213	213

Note: Robust standard errors in parentheses; *** ;** and * indicate significance at the 1%, 5% and 10% thresholds, dydx are marginal effects. GOF: Goodness-of-fit test after logistic model.

It can also be observed that access to credit is a factor influencing the likelihood of being willing to purchase improved seeds. All other factors being equal, at significance levels of 10% and 1% for maize and cassava, respectively, when producers are affiliated with institutions that provide

them with access to credit, their willingness to adopt improved seeds increases by 10% and 20%, respectively. This result demonstrates that the ability to finance agricultural activities is an important factor in the adoption of agricultural innovations and confirms the validity of establishing financial systems tailored to farmers, as theorized by Muhammad Yunus.

It is observed, particularly among maize producers, that the production system has a negative effect. This finding indicates that crop diversification within plots hampers the intention to adopt improved seeds. This result may be attributed to the potential benefits offered by agroforestry systems in terms of productivity, such as the ability of legumes to fix nitrogen. Among cassava producers, it is observed that farm size significantly reduces (at a 5% significance level) the likelihood of adopting improved cassava planting materials. This result shows that producers with large farms are relatively less open to adopting quality seeds. It indicates that extensive agriculture remains the prevailing model for Cameroonian producers.

6. Conclusion

In a context where the traditional paradigm for promoting and distributing agricultural innovations is unable to meet the expectations of both public authorities and producers, there is an urgent need to define new mechanisms capable of closing the gap between expected and achieved results. This study has enabled us to define a paradigm for the promotion and distribution of innovative agricultural seeds, based on a public-private partnership (PPP). Using up-to-date data, we were able to empirically verify the impact of a PPP on farmers' willingness to buy improved seeds. This study confirmed that the type of PPP we are proposing can be effective in meeting the challenge of improving the dissemination and adoption of improved seeds. However, empirical evidence shows that gender issues are still very much present in the agricultural sector in Cameroon. This observation leads us to recommend, before any PPP where women are actors in the promotion and dissemination of agricultural innovations, gender promotion campaigns in rural areas. We have further observed that farmers in Cameroon are still heavily focused on extensive agriculture. This leads us to recommend awareness campaigns aimed at explaining and demonstrating the benefits of adopting agricultural innovations such as improved seeds. Such initiatives could help reduce deforestation while enhancing agricultural performance. Public-private partnerships (PPPs) are certainly a model worth exploring. However, for greater effectiveness, they should be considered within a conducive framework. In addition, we have once again found that educational level plays a major role in the propensity to adopt technologies. As a result, andragogy programs can be recommended to upgrade farmers with low levels of education.

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Appendix

Table A1: Variance inflation factor

	VIF (1)	VIF (2)	VIF (3)	VIF (4)
	Maize	Maize	cassava	cassava
[a] Number of working-age individuals	3.073		2.706	
Household size	3.12	1.075	2.69	1.117
Farming system	1.975	1.967	1.974	1.973
Associated product2	1.834	1.834	1.888	1.888
Associated product1	1.772	1.767	1.57	1.559
Youth partnership	1.378	1.368	1.48	1.48
Partnership with women	1.298	1.298	1.476	1.475
Production experience	1.146	1.146	1.359	1.352
Level of education	1.256	1.253	1.305	.766
Age of head of household	1.186	1.165	1.305	1.304
Gender of household head	1.3	1.3	1.269	1.269
Access to credit	1.198	1.198	1.231	1.227
Cooperative member	1.288	1.283	1.2	1.2
Farm size	1.245	1.245	1.196	1.188
technical Support in production	1.18	1.166	1.139	1.139
Satisfaction by actual seed using	1.085	1.078	1.053	1.052
Mean VIF	1.583	1.343	1.553	1.368

[a] Number of working-age individuals (in the household): this variable was excluded from the regression equations.

Table A2: Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

Maize	**Cassava**
Assumption: Normal error terms Variable: Fitted values of Willingness to buy improved seeds H0: Constant variance chi2(1) = 32.02 Prob > chi2 = 0.0000	Assumption: Normal error terms Variable: Fitted values of Willingness to buy improved cassava planting material H0: Constant variance chi2(1) = 4.35 Prob > chi2 = 0.0370