Environment, Development and Sustainability (2023) 25:3843–3865
https://doi.org/10.1007/s10668-022-02212-x

REVIEW

Economic performance of certified cocoa-based agroforestry systems in Cameroon

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Received: 6 June 2020 / Accepted: 10 February 2022 / Published online: 2 March 2022
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Abstract

Several studies exist today on the adoption of innovations (certification) in the cocoa value chain in Africa's largest cocoa-producing countries (Ivoiry Coast and Ghana). Despite the importance of the cocoa sector in Cameroon's economy and as a source of income to the majority of its farmers, similar studies are few. In view of the above, this article evaluates the impact of certification on the economic performance of cocoa-based agroforestry systems in Cameroon's main production basins (the Center and South West Regions). Primary data, from 506 identified farmers, were complemented by those from field observations and a survey of key resource persons of the cocoa sector. The evaluation was carried out using the quasi-experimental method. The endogenous switching regression (ESR) treatment effects complemented with a binary propensity score matching methods were adopted to test their robustness and reduced selection bias from both observed and unobserved characteristics. Obtained results showed that the adoption of certification significantly and positively impacted the economic performance of cocoa producers, in yield (at about 87 kg/ha) and value (~200 USD). Hence, government and private developmental partners should jointly finance and organize the cocoa sector and facilitate small farmers' access to certification norms.

Keywords Certification · ESR · PSM · Cocoa-producer · Cameroon

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1 Introduction

The economy of Cameroon is mostly dependent on agriculture, a sector that engages about 600,000 families for the majority of their income (FAO, 2013). The cocoa and coffee sectors jointly represent about a third of the country's non-petroleum exports and two-thirds of exports from its primary sector. Cocoa cultivation constitutes the main source of income of the country's rural population in the humid forest zone of Cameroon or half of its ten administrative regions (Center, East, Littoral, South and South West regions). This sector represents about 2% of the national gross domestic product (GDP), 6% of its primary GDP and about 30% of the GDP of the agricultural sub-sector destined for export and transformation. In Cameroon's main cocoa-production basins (Center and South West Regions), the crop assembles about 90% of its agricultural population (Kamdem, 2014) and a cultivated area of about 420,000 hectares (ICCO, 2014; Alemagi et al., 2014).

Cocoa producers are recently being criticized by the media and those who protect the environment. They opine that the later destroy the tropical forest, use child labor and exploit the elderly. This has caused chocolate industries to insist on the establishment of rules and norms that consider the pillars of a sustainable system in their production process (Ruf et al., 2013). Cameroon is engaged in initiatives geared toward assuring the certification of the cocoa value chain, but this is not yet effective at the level of the producers. The cocoa-production sector in Cameroon has been marked during the past decades by certification initiatives put in place by cocoa producers. There are hundreds of certifications norms in agriculture. In Cameroon, three of these norms are operational in the cocoa sector: the Rainforest Alliance for the preservation of the ecosystem, UTZ Certified for good agricultural practice, and Fairtrade for a better life for workers. Apart from the specificity of each certification standard, all work for the improvement of social well-being. However, the adoption of standards requires human, material, financial and infrastructural resources. The non-compliance of most small producers with these rules is due to insufficient resources and generally high certification costs. This weak adhesion greatly influence the performance of producers (Ruf, 2009). In fact, Cameroon exported 5,446 tons of certified cocoa out of a total of 230,000 tons produced in 2013, more than 10,000 tons of certified cocoa out of a total of 423,200 tons recorded in 2015 (Economie, 2015; WCF, 2015). This represents only 2% of the world's production against 49%, 33% and 16%, respectively for Côte d'Ivoire, Ghana and Nigeria (ICCO, 2015). This situation is due to the low dissemination of certification norms as put in place by Fairtrade, Rainforest Alliance, UTZ and also because biological norms are operational in Cameroon but not to the same extent in all of the country's cocoa-producing regions (Mithöfer et al., 2017).

Results from studies on the impact of certification on the economic performance of the agricultural sector in Côte d'Ivoire show that yields from certified farms are 70% higher than those from non-certified farms (Mithöfer et al., 2017; Potts et al., 2010). Similarly results were obtained in Ghana where 95% of their certified farmers doubled or tripled their yields and improved their income through the introduction of UTZ farming practices (Daniele et al., 2014). Among the many existing works, an outstanding group interested in environmental governance could be distinguished. This group questions the emergence of this particular type of institutional arrangement alongside more traditional regulatory instruments, known as "command and control"(Johansson, 2012; Pattberg, 2006; Eberlein et al., 2014). This approach elaborates the rise in power of forms of private governance in a context of globalization and loss of power of nation-states: faced with the difficulties of managing cross-border or global environmental problems, certification would have

emerged in order to remedy the shortcomings and slowness of intergovernmental regulations (Conroy et al., 2008; Marx and Cuypers, 2010).

In general, certification is a mechanism to certify, after an independent and neutral audit, that production or service meets a given standard or quality standard. Although some controversy exists over the effects of certification on farm performance, this concept has generally been identified as one of the determining factors of performance (Bélières et al., 2008), with positive economic effects for small and medium-sized enterprises (McAdam, 1999). Indeed, it has been demonstrated that when small farmers convert to organic production, they incurred additional costs but experienced long-term improvements in yields and profitability, which they attribute to improved management and farming practices (Giovannucci & Purcell, 2008; Mendez, 2010). Elsewhere like in Kenya, certification of UTZ coffee does not imply a higher income for certified producers, but induces greater savings and investment as well as better access to credit (Kamau et al., 2010). However, less enthusiastic results abound: effect of certification of fair trade coffee on yields and income in Ethiopia (Jena et al., 2012), organic certification and UTZ certification on poverty in Uganda (Chiputwa et al., (2015) organic coffee cultivation on premiums, costs and low productivity in Costa Rica (Donovan, 2011), and in Nicaragua (Soto et al., 2011; Haggar et al., 2012). An analysis of the effects of land certification for rural farm households in Ethiopia show that the majority of farm households (71.7%) identified a reduction of disputes after certification and also land management practices improved from 70.3% before certification to 90.1% after certification (Gedefaw et al., 2020). (Khan et al., 2021) analyze the link between the adoption of ISO 56002–2019 and green innovation, and frim sustainable development goal performance thus showing that adoption of green innovation reporting and ISO 56002–2019 will enhance the level of transparency of business activities and create greater stakeholder confidence along with enhancing the firm's sustainable development of global performance. The recent study of (Vogel et al., 2020) focuses on the stakeholders' perceptions on sustainability transition pathways of the cocoa value chain in Cameroon, show that certification standards have been elaborated as tools that should bring economic, ecological and social dimension to global value chains of cocoa. Furthermore, actors are not finding a way of adopting new organizational structures and letting a transition occur effectively, like in the case of certification standards.

Based on the above, one is forced to ask some questions concerning the contribution that certification has in improving the well-being of cocoa producers: what are the explanatory factors for the adoption of certification standards? Is it directly linked to the policies and demands of the industrialists favoring this new way of cultivation practices or indirectly to those of the "old" farming practices? Does the development of new cultivation practices result from a simple adoption of certification? Does the massive increase in certification standards meet a need to improve the yields and profit margins of cocoa producers? According to (Sanial & Ruf, 2018) the chocolate industry, concerned about production so concentrated in one country and its dependence on the forest, is trying to convince smallholders to obtain 'cocoa certification. Thus in Ivoiry Coast, The advent of the certification of cocoa cultivation is the result of a partnership between the chocolate industry and environmental protection NGOs. Despite the fact that chocolate companies and certification agencies have defined standards, without taking into account the practices and needs of farmers and without any consultation with them, the result is that smallholders rarely apply these standards (Ruf et al., 2013; Sanial & Ruf, 2018).

Accordingly, these situations demand a continuous impact evaluation of certification on the economic performance of cocoa-based agroforestry systems to ensure they have not yet reached a saturation point, which seems to be the case in Cameroon. Certification

influences the way cocoa can be produced and consequently affects economic performance of cocoa farmers. Thus, the economic performance of cocoa producers will be a key factor in the willingness of Cameroonian's cocoa farmers to continue to participate in certification.

This study therefore analyze how the impact of adopting certification on the economic performance of cocoa producers in the Center and South West Regions of Cameroon increase the quality of cocoa beans, their yield, margin, and improve their social welfare.

The paper is structured as follows: Sect. 2 presents the theoretical concept of the effects of certification (innovation) on the economic performance of agroforestry systems. Section 3 presents methods used in this study. Section 4 presents the results obtained through the adoptions of certification norms involved in the socio-technical regime of the cocoa value chain of the study. Section 5 discusses the result and compares with the literature on performance, and finally, Sect. 6 presents the conclusions.

2 Theoretical concept of the effects of certification on the economic performance of agroforestry systems

The capacity of certification systems to impose themselves in the regions of the major cocoa-production basins in Cameroon, to offer opportunities for local development and to influence the behavior of stakeholders with a view to taking better account of biodiversity depends on many factors. Considering a farm as an enterprise makes it possible to mobilize concepts such as the functioning or management of farms, which is particularly relevant in considering the impacts of certification on the economic performance of agroforestry systems (Ruf et al., 2013; Favreau, 2014). Among the existing theories, we will rely on the new institutional theory to explain the effect of certification (innovation) on the performance of cocoa producers.

2.1 The New Institutional Economic Theory (NIE) approach to the effects of certification on economic performance

The new institutional economic theory or neo-institutionalism refers to a set of schools of thought that contributed to the renewal of the economic analysis of institutions in the 1970s. Although the NIE emerged in the 1970s, its birth stems from the article "The Nature of the Firm, by Coase, 1937)"; he is the founding father of the new institutional economic theory. Studies that have focused on the fundamentals of this theory, explaining the evolution of the concepts of certification and performance are numerous and diverse. They are based on works that seek to understand how farms are certified. This theory is embodied in its definition by a set of laws, rules, norms, etc., highlighting the basic idea of the new institutional economic theory, which stipulates that institutions contribute to the economic performance of communities or individuals on the one hand, and on the other hand, it makes it possible to establish, based on the work of authors such as Nord, Williamson and Coase, a close relationship between certification, institution and performance. This relationship is based on the fact that certification and institution are governed by norms, laws and rules as their main characteristics.

2.2 The concept of certification as an economic institution

According to institutional economics, habits, norms, rules and institutions play an important role in the choice of the firm, as well as in human behavior without giving up a certain rationality in individual behavior which is, however, limited by the economic and social environment (Alastair Smith, 2014). For (Veciana & Urbano, 2008), institutions are "dominant habits of thought at a given time in a community" (Leisure Class Theory). (Urbano & Alvarez, 2014) define them as 'collective action in the control, liberation and expansion of individual action'. The definitions are therefore broad (some would say vague). In summary, for the early twentieth century economists, institutions are rules derived from collective representations that guide the behavior of individuals, particularly in their economic transactions.

2.3 The notion of certification as a determinant of performance

It has been demonstrated by authors who link certification and institutions that institutions work to improve the economic performance of communities or individuals. This basic principle of the new economic theory of institutions help in understanding that certification and performance are not antinomic. Rather, they tend to provide an explanatory framework for the choices of economic operators in relation to certification, articulating rational calculated decisions and the internalization of norms by actors. They also make it possible to explain why certification is more developed in some.

3 Methods

To achieve its objectives, the present study follows a methodology which starts by proposing a basic theoretical model before specifying the econometric methods of analysis to be used and then the presentation of its results.

3.1 The basic theoretical model

The basic theoretical model used in this study stems from the neoclassical theory of business behavior which suggests that the goal of business is to maximize production and profit while minimizing costs (Smith, 1937; Knight, 1921; Coase, 1937). Analyzing the impact of the complementarity between certified and non-certified on the farmers' performance amounts to analyzing the effects of maximizing their yields and margins and improving their export performance. The optimal indirect function of maximizing the performance of cocoa producers according to their multiple inputs and output is written as follows:

$$\pi^*(p,w) = pf(x^*(p,w)) - wx^*(p,w) \tag{1}$$

where: $\pi(p,w)$ is the performance of cocoa producers, p is the price of the outputs, w is the price of the inputs, x is the vector of inputs and f is the vector of outputs. To characterize how certification influences the performance of cocoa producers, the reduced form of the optimal function of demand for inputs supply of outputs is written as follows:

$$\pi(p,w,\ C\ ;E^h) = pf(x^*(p,w,\ C)) - wx^*(p,w,\ C) \tag{2}$$

With C corresponding to participation in certification of cocoa producers, E^h is a set of the farm characteristics. Equation 2 implies that participation for certification is a choice of variables that can be affected by the likelihood of cocoa producers. It is assumed that participation for the certification in terms of good agricultural practices (improved seeds, use of fertilizers and seed treatment) compared to other types of certification (use of herbicide and pesticide) constitutes an optimal strategy for maximizing yield and margin of cocoa producers.

3.2 Specification of the econometric model

Considering that certification is increasingly being considered as one of the surest alternatives to enhance the socioeconomic conditions of producers, as well as the yields and quality of their cocoa, this study was therefore undertaken to assess the impact of certification on the economic performance of cocoa-production in Cameroon. In addition, the aforementioned studies did not base their analysis on innovation impact assessment on farmers' performance by using propensity score matching or other estimation technics. Despite the relevance of different studies, many of them adopted methodological approaches, as they used the methods of random assignment, discontinuity and regression, and or double difference to analyze the econometric impact of certification on the economic performance of producers. They so far have achieved better results prior to their ability to eliminate the problem of selection bias and unobserved traits during data collection. Given that the nature of our data which did not previously obey the section of the experimental and control group, we therefore use the ESR and then the PSM to correct these problems of selection bias and unobserved characteristics. These approaches comparatively to others are based on the observed and unobserved characteristics of both treated and untreated group. They are thus useful in avoiding attrition and contamination problems related to the use of pre-experimental sample. The use of ESR and PSM together helps in avoiding the unobservable bias which is the source of endogeneity problem.

.Endogenous switching regression—ESR (Maddala, 1983) and propensity score matching—PSM techniques (Heckman et al., 1997; Rosenbaum & Rubin, 1983) were employed from certification related variables, notably yield and profit margin (to capture performance), and other personal characteristics of respondents (farmer' age, gender, education, waste handling, use of pesticides and improved seeds, sales method, fermentation and drying methods, duration of fermentation, as well as age of farmland). The consecutive impact analyses from the ESR and PSM were used to assess the robustness of the models, as well as those of the various treatment effects.

3.2.1 Endogenous switching regression method (ESR)

For the ESR model to be identified, the Z variables in the adoption model should contain the selection instruments in addition to those that were automatically generated by the nonlinear selected adoption model. Access to agricultural loans and experience in agriculture were instrumental variables chosen to model the impact of certification on economic performance of the cocoa-based agroforestry systems. The choices relied on the exogenous nature of these variables, correlated with the endogenous variables of the certification equation, the both of which were not correlated with the error term of the explanatory equation.

Modeling the impact of certification within the framework of the ESR method was in two phases: (i) decision to adopt certification (Eq. 1), and (ii) with the help of a probit model and Ordinary Least Squares (OLS) regression with selective correction. These two equations could be represented as follows:

$$\text{Regime1}(\textit{certifie})Y_{1i} = X_{1i}\beta_1 + W_{1i}\, si\, P = 1 \tag{3a}$$

$$\text{Regime2}(\textit{non certifie})Y_{2i} = X_{2i}\beta_2 + W_{2i}\, si\, P = 0 \tag{3b}$$

where X_{1i} and X_{2i} were vectors of endogenous covariates, β_1 and β_2 were vectors of parameters; while W_{1i} and W_{2i} were perturbing random terms while using the OLS, β_1 and β_2 can lead to biased estimations, given that the expected values of error terms (W_1 and W_2) that are conditioned on the selection criteria are non-zero (Shiferaw et al., 2014). The error terms in Eqs. (1) and (3) are supposed to have normal trivial distributions with the vector of zero mean and the covariance matrix:

$$\Omega = \operatorname{cov}\left(\varepsilon_1\ W_1\ W_2\right) = \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon 1} & \sigma_{\varepsilon 2} \\ \sigma_{\varepsilon 1} & \sigma_1^2 & . \\ \sigma_{2\varepsilon} & . & \sigma_2^2 \end{bmatrix} \tag{4}$$

where $\sigma_\varepsilon^2 = \operatorname{var}(\varepsilon), \sigma_1^2 = \operatorname{var}\left(W_1\right), \sigma_2^2 = \operatorname{var}\left(W_2\right)\sigma_{\varepsilon 1} = \operatorname{cov}\left(\varepsilon, W_1\right),\ et\ \sigma_{\varepsilon 2} = \operatorname{cov}\left(\varepsilon, W_2\right)$.

Assuming that σ_ε^2 is equal to 1, (α is estimable only to a scalar factor), and that Y_1 and Y_2 are never observed simultaneously, the covariance between W_1 and W_2 is not defined (Maddala, 1983). The error structure is importantly involved here because the error term of the selected Eq. (1) ε_i correlated with the error terms of the functions of the farmers' outcome (W_1 and W_2), because the expected values W_1 and W_2 conditional to the sample selections are nonzero (Asfaw et al., 2012);

The above ESR framework could be used to estimate the effect of mean treatment and treated «Average Treatment effect on the Treated» (ATT) and of untreated treatment «Average Treatment effect on the untreated» (ATU), while comparing the expected value of the outcomes of those who adopted and those who did not adopt in the actual and counter-factual scenarios:

The average effect of treatment on the treated (ATT) is given by the equation below;

$$ATT = \left(Y_{i1}/P = 1; x\right) - \left(Y_{i2}/P = 1; x\right) = X_{i1}\left(\beta_1 - \beta_2\right) + \lambda_{i1}\left(\sigma_{\varepsilon 1} - \sigma_{\varepsilon 2}\right) \tag{5}$$

The average effect of treatment on the untreated (ATU) is given by the equation below;

$$ATU = \left(Y_{i1}/P = 0; x\right) - \left(Y_{i2}/P = 0; x\right) = X_{i2}\left(\beta_1 - \beta_2\right) + \lambda_{i2}\left(\sigma_{\varepsilon 1} - \sigma_{\varepsilon 2}\right) \tag{6}$$

The second term λ is the selected term that capture all potential effects of the differences in non-observed variables. The reason we associate the PSM model to cover up this insufficiency.

3.2.2 Propensity score matching (PSM)

In observatory studies, the selection of treatment is always influenced by the characteristic of the title. However, the initial characteristics of the treated subject is always

systematically different from those of the untreated. It is therefore, important to consider the different systems in the basic characteristics between the treated and the untreated subjects during the estimation of treatment on the results. Indeed, the PSM is a nonparametric technique that does not depend either on the functional form or on the distributive assumptions of the model. The method is used to match the observations according to the predicted propensity scores of the treatment variable. The matching procedure creates the conditions for a randomized experiment in order to estimate the causal effect of the variables. The coefficients of the matching process come from unbiased and consistent estimators. Thus, the PSM model helps in reducing or eliminating the effects of confusion during the use of the observed variable (Austin, 2011). According to Heckman et al., (1997), let Y_1 be the value of well-being when the farmer is certified ($P = 1$) and Y_0 the same variable when the farmer is not certified ($P = 0$), ATT could thus be defined as follows:

$$ATT = E\{Y_1 - Y_2/P = 1\} = E\left(Y_1/P = 1\right) - E\left(Y_0/P = 1\right) \tag{7}$$

We could observe the outcome variables of the certified $E\left(Y_1/P = 1\right)$, it therefore means that we could not have observed the result of the certified farmers had they not adopt certification $E\left(Y_0/P = 1\right)$, and ATT using Eq. (10) could lead to biased estimations (Takahashi and Barrett 2013). Matching with the propensity score is dependent on a conditioned independence hypothesis, considering the observable co-variables 0, an outcome of interest in the absence of treatment, and the certification status, the probabilities P are statistically independent. (Rosenbaum & Rubin, 1983) define the propensity score or the probability to receive a particular treatment as follows:

$$P(X) = \Pr(P = 1)/X \tag{8}$$

Another important hypothesis of the PSM is its common support condition, which requires an important overlap of covariates between the certified and non-certified, in such a way that farmers who are involved in this comparism have a common probability of being both certified and non-certified $0 \prec P(X) \prec 1$ (Takahashi & Barrett, 2013). If these two hypotheses are met, then the PSM estimator for ATT can be specified as the mean difference of the certified that corresponds to the non-certified who are balanced to the propensity score and fall within the level of common support as written below:

$$ATT = E\left(Y_1/P = 1,\ P(x)\right) - E\left(Y_0/P = 1,\ P(x)\right) \tag{9}$$

3.3 Economic methods of calculating yield and profit margin

3.3.1 Calculation of yield

The farm yield was estimated as the ratio of the total production (in tons) to the total surface area (in hectares) of the farmland. Within the framework of this study, crops associated to cocoa are not considered.

3.3.2 Calculation of the profit margin

The profit margin of one hectare was equal to the total production minus the total cost of production. The total production cost is the product of the quantity produced and the unit price of cocoa. For certified cocoa, the unit price is the sum of the standard price and the 40–50 F CFA premium. The total cost of production is equal to expenditures in inputs, labor and the annual cost of equipment (annual depreciation).

The profit margin of one hectare was estimated as the difference between the total revenue and the total cost of production. The total revenue was estimated as the product of the quantity produced and the unit standard price of cocoa while the total cost of production was the sum of all expenses (inputs, labor and annual depreciation of equipment). For certified cocoa, the unit price was the sum of the standard price and a premium (0.10–0.15 USD).

3.4 Data and Socioeconomic characteristics of cocoa farmers

This study is based on twelve months of cocoa field work in Center and South West Regions of Cameroon, where information on the role and added value of adopting certification of agroforestry systems were collected during the 2017–2018 farming season, from 506 certified and non-certified farmers. These regions gave the highest importance to cocoa cultivation with about 90% of Cameroon's cocoa farmers (Kamdem, 2014). Sampling of farmers' opinions took place in 04 administrative divisions (Table 1), chosen after some stratified sampling procedure among producers with relatively young (3–8 years old, mature (9–30 years) and old (above 31 years) farmlands. In a random manner, 73 farmers were selected per division for the non-certified and 53 farmers for the certified. Designed questionnaires were tested and corrected for concision and clarity before being administered to farmers. Surveyors were trained and enlightened on the certification phenomenon. Leaders of some cooperatives and non-governmental organizations of cocoa producers supported the survey team through translation in local dialects. The questionnaire covered the farmers' characteristics, their farmland, types of certification organization, training on good agricultural practices, use of pesticides, quality of cocoa produced, productivity, exploitation, certification norms and socioeconomic considerations. Logistical travel support was provided to enumerators and an awareness campaign carried out among the producers, their cooperatives and farmers' organizations. Raw data constitute the set of feedback from producers received from investigators. These data were analyzed, sorted, eliminating any questionnaires not having all the required information. The data entry was done by us by reporting all the information from each questionnaire in a data mask

Table 1 Distribution by regions and by divisions of certified and non-certified farmers

Region	Division	Certified	Non-Certified	Total
Center	Nyong and So'o	46	78	124
	Mefou-Akono	66	62	128
Sud-West	Fako	65	82	147
	Mémé	37	70	107
Total		214	292	506

Source calculations using the survey data

of the SPSS 25 software. Data processing was done from the SPSS software before being exported to STATA 14 for analysis by imputation and coherence. The various estimates and analysis of the results are made using the STATA 14 software by using statistical data. The information received makes it possible from the STATA software to establish the various statistical tables**.** Data were analyzed using Bi-variate and multi-variate analyses for statistical description and regression, toward farmer's performance indicators yields and profit margin.

4 Results

We first present the characteristics of certification in the agricultural sector by emphasizing its merits between 2015 and 2018, then the explanatory factors for the certification of cocoa-based agroforestry systems in Cameroon, then presented the impact of certification on yield and profit margin was estimated using the ESR and PSM methods of propensity score matching.

4.1 Characteristics of certification in the agricultural sector

Certification is integrated into Cameroonian policy through forest certification in 1994, the practice of certification has aroused the enthusiasm of producers, salespeople and processors to respond to the concerns of consumers who want an improvement of performance and management sustainable farming in Africa. Operational certification are Utz, Rainforest Fair Trade and Flo Sert. If their specifications differ, all these certification bodies fight for good agricultural practices therefore improving performance takes into account the social well-being of producers while strictly respecting the environment. We note a clear improvement in yield and income, sometimes from simple to double of producers who have adopted certification compared to non-adopters between 2015 and 2018 in cocoa-producing countries in Africa. Adoption of certification, although voluntary, is motivated by the award of a premium (0.10–0.15 USD per kg of certified cocoa) and could be enhanced through sales to cooperatives. State subsidies to outweigh the high cost of certification and render the system more attractive. Furthermore, adopting certification improved economic performance of cocoa-based farms in the humid forests of Cameroon. Development policies for production of cocoa-based agroforestry systems in Cameroon should increase access to credit, and subsidize certification norms for small farmers so as to improve farm yields, profit margins and enhance rural welfare.

4.2 Factors explaining the adoption of certification of cocoa in Cameroon

The parameters that estimate the probit model of certifying agroforestry systems (Tables 2 and 3), Pseudo R2 of 0.29, was correctly predicted by the certified and non-certified, representing 48 and 52%, respectively. This indicates that the explanatory variants were statistically significant ($P < 0.01$) and robust. The probit model as demonstrated by the ESR method (Appendix 2) had ten significant variables.

The men, be they certified or non-certified were much more involved in cocoa cultivation than women. Results on the treatment of pesticide wastes proved that certification plays a positive role in enhancing farmers' performances. The positive ratio of the application of herbicides could be explained by the fact that from a farmer who used herbicide to

Table 2 Probit Estimation of Certification determinants

Variable	dy/dx	*Z*	*P* > z
Farmer's age			
25–35 years	–	–	–
36–50 years	−0.061(0.07)	−0.85	0.398
50–80 years	0.054(0.7)	0.74	0.461
Gender			
Female	–	–	–
Male	−0.187(0.9) **	−1.99	0.047
Farmer's educational level			
Did not go to school	–	–	–
Primary	0.082(0.14)	0.58	0.560
Secondary	−0.026(0.05)	−0.49	0.626
University	−0.063(0.10)	−0.61	0.543
Treatment of pesticide waste			
Do not treat pesticide waste	–	–	–
Treat of pesticide waste	0.277(0.05) ***	5.48	0.000
Use of herbicides			
Use herbicides	–	–	–
Do not use herbicides	0.107(0.06)*	1.56	0.118
Access to improved cocoa seeds			
Have access to improved seeds	–	–	–
Do not have access to improved seeds	0.198(0.06) ***	3.22	0.001
Means of selling cocoa			
Sell cocoa to cooperatives	–	–	–
Sell cocoa to middlemen	−0.398(0.04) ***	−8.62	0.000
Method of fermenting cocoa			
Do not ferment cocoa	–	–	–
Spread on the ground on banana leaves	0.874(0.02) ***	29.34	0.000
Ferment in a box	0.728(0.04) ***	15.75	0.000
Fermentation duration			
Ferment for three days	–	–	–
Ferment for four days	0.303(0.08) ***	3.45	0.001
Ferment for six days	0.121(0.13)	0.94	0.350
Method of dryingcocoa			
Dry in an oven	–	–	–
Dry on elevated bamboo mats	−0.171(0.06) ***	−2.84	0.005
Age of cocoa farm			
3–15 years (young)	–	–	–
16–35 years (mature)	−0.098(0.08)	−1.19	0.233
36 years and above (old)	−0.141(0.08)*	−1.65	0.100
Statistic Resume			
Wald Chi2	2665.33		
Pseudo Likelihood	−236.39		
Pseudo R2	0.3092		
Prob sup à Chi2	0.000		
Number of farmers sampled	506		

Table 2 (continued)

Standard errors in parenthesis. *, ** and *** denote significance at 10%, 5% and 1%, respectively

one who used the homologated dose or did not use at all, there was increasing conformity to the respect of environmental norms. However, the sales method had a negative but significant value indicating that selling out of the cooperative was less profitable to producers. Hence, the use of improved seeds had a significant and positive impact in enhancing yields and the farmers' profit margins although few had access due to the high prices that they could not afford. The ratio of improved seeds had a significant and positive influence in enhancing farmers' yields and profit margins, most especially the certified.

4.3 The effects of certification on the economic performance of cocoa farmers

Given that the phenomenon of certification is an innovative technology in most rural areas, the correlation between the adoption of new technologies and the results variable (yield and profit margin) was made evident by the ESR and PSM models. More precisely, the impact of certification on yield and profit margin was estimated using the ESR and PSM methods of propensity score matching.

4.3.1 ESR results

Estimating the probit from the endogenous switching regression (ESR) model shows that the probit model has an R-squared/Pseudo of 0.28 (Appendix 2) this indicates that the explanatory variables are statistically significant ($P < 0.01$) for a percentage of 57.11 and 42.89%, respectively, non-certified and certified program. Among the variables taken into account in the model, the result shows that: The education of the producer has a positive and significant influence on adoption certification to improve the cocoa yield. When moving to a higher class, the yield of the non-certified increases by 44 kg/ha against 45 kg/ha for the certified. The variable treatment of hazardous waste has a negative and significant influence on participation in certification to improve the cocoa yield and profit margin. The result shows that if we increase the treatment of hazardous waste by one point, the yield of the non-certified decreases by 66 kg/ha while those of the certified increase by 17.67 kg/ha. Likewise, the profit decreases on 82,089 Fcfa/ha against an increase of 7278Fcfa/ha, respectively, among non-certified and certified. The application of herbicides has a negative and significant influence on adoption certification to improve the yield and profit margins. The result shows that if we increase the application of herbicides on the farm by one point, the yield decreases by − 5.09 kg/ha against an increase of 117.29 kg/ha, respectively, for the non-certified and certified. This ambiguity can be explained by the fact that certified producers use approved herbicides at a reasonable dose, compared to non-certified. Likewise, the profit margin fell by − 55,395 CFA francs/ha against an increase of 39,508 CFA/ha, respectively, for the non-certified and certified. sales within the cooperative versus cokser shows that the profit margin decreases by 23,333 F cfa/ha against an increase of 182,688 F cfa/ha, respectively, for the non-certified and certified.

Based on the predicted effects on average treatment, results as proven by the ESR model showed that adopting certification increased yield, and the profit margin of cocoa producers (Table 4). Here we are only talking of the average treatment effects on the treated (ATT) and untreated (ATU) that are statistically significant from zero. Using the ESR regression,

Table 3 Propensity score matching: quality test

Algorithm matching	Results	Pseudo R^2		LRx^2		$P>X^2$		Mean standardized bias		Total % bias reduced
		Before	After	Before	After	Before	After	Before	After	
Propensity Score Matching	Yield	0.29	0.055	200.04	30.59	0	0.01	29.8	13.7	0
	Profit Margin	0.29	0.055	200.04	30.59	0	0.01	29.8	13.7	0
Kernel	Yield	0.29	0.044	200.04	24.72	0	0.05	29.8	11.8	100
	Profit Margin	0.29	0.044	200.04	24.72	0	0.05	29.8	11.8	100

Source: author, calculations using the survey data

Table 4 Average treatment effects: Endogenous switching regression model

Outcome variables	Type of producer t	Certification decision		Effect of mean treatment
		Certified	Non-certified	
Yield (kg/ha)	Certified farmer (ATT)	393.8	373.7	14.08** (7.87)
	Non-certified farmer (ATU)	346.9	313.6	33.31*** (6.12)
Profit Margin (F CFA/ha)	Certified farmer (ATT)	489,325	326,780	162,544*** (7899)
	Non-certified farmer (ATU)	244,011	237,653	6357 (5347)

Standard errors in parenthesis. ** and *** denotes significances at 5% and 1%, respectively

the ATT certified farmers who are certified produce an average of 394 kg/h superior to those of the non-certified 374 kg/ha difference of 20 kg/ha, and receive an average of F CFA 499 325 per hectare as against F CFA 326,780 for the non-certified making a difference of F CFA 162,545/ha, and the ATU non-certified farmers who are certified produce an average of 345 kg/ha superior to those of non-certified 314 kg/ha. ESR is more advantageous than PSM in that it could predict the yield and profit margin of the certified had they not adopt certification. The ATU certification results on non-certified farmers show that they would have gained more in terms of yield and profit margin if they were certified. (Table 4) The different results show that certification can considerably enhance farmers' income in the Center and South West Regions of Cameroon.

4.3.2 PSM results

The same variables were used to check the PSM predictions (Table 5). The method is also used to validate the ESR results on the impact of certification on cocoa-based agroforestry systems. Besides, the tests that were carried out before the PSM predictions permit us to realize a real overlapping in common support between the certified and the non-certified (Fig. 1). The visual inspection for the estimated propensity scores for the two groups shows that the common support condition is satisfactory. Hence the predicted score for the certified and the non-certified ranges from 0.0022 and 0.99 with an average of 0.44. The common support hypothesis is thus satisfied in 0.0022 and 0.99 for the minima and maxima for the certified and non-certified. It therefore means that the region of common support for the distribution of the propensity scores equally bring out the distribution density of the two groups (Fig. 1). The distribution of the propensity scores for the certified and non-certified is substantially overlapping (Fig. 2). In addition, the common support enable the

Table 5 Average treatment effects: Propensity score matching model

Algorithm Matching	outcome variables	Mean of outcome variables		ATT difference
		Certified	Non-certified	
Kernel	Yield kg/ha	392.2	305.9	86,33* (1.63)
	Profit Margin (FCFA/ha)	325,657	220,848	104,809*** (2.72)
Nearest neighbor	Yield kg/ha	392.2	302.1	90,14*** (2.84)
	Profit Margin (FCFA/ha)	325,657	220,892	104,765*** (3.56)

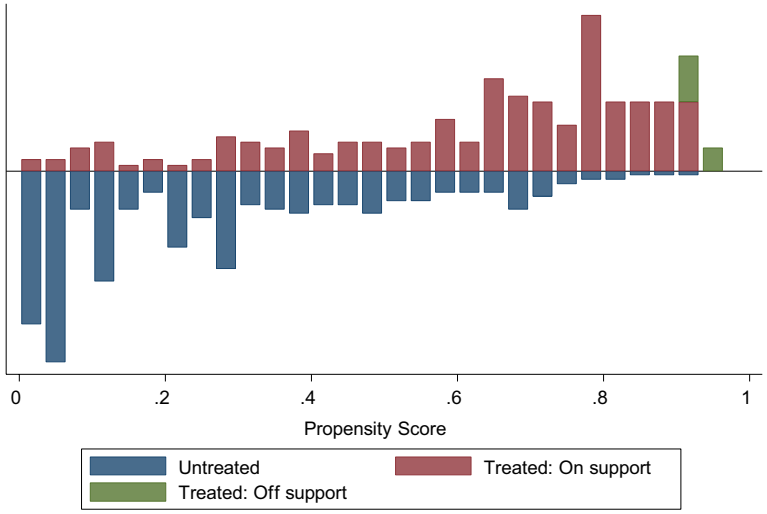

Fig. 1 Histogram on the distribution of Propensity Score certified and non-certified

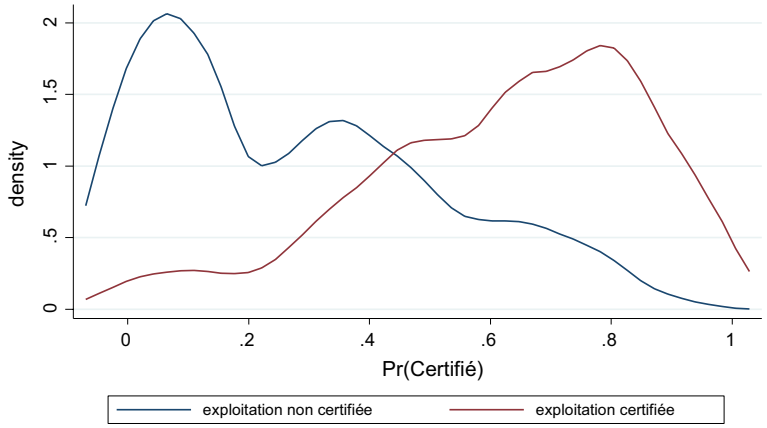

Fig. 2 Distribution of the propensity score between the certified and non-certified

comparism between certified and non-certified farmers who are having the same characteristics. Visualization shows that, before certification, non-certified farmers were obtaining yield and a profit margin which were superior or equal to those obtained by certified farmers. The reverse is true after they adopt certification and this actually proves the importance of certification.

In addition, the different average of the standardized bias for the overall covariates used in the estimation process of PSM has been reduced to 29.8% before matching to a range of 13.7% after matching without correcting the bias (Table 3), but it was corrected from 29.8 to 11.8% before correcting the bias to 100% during the matching process. Furthermore, the *P* value of the likelihood ratio test, proves the joint significance of all regression in the probit model of after matching but not before. The pseudo R^2 indicates how well the regression explain the participation probability. Besides this results, it was further proven that

the pseudo R^2 was reduced from 0.296 points before matching and at about 0.055% points after matching without reducing the bias, and from 0.296 to 0044% with 100% reduction. This was fairly low and an indicator to the fact that after matching, there were no systematic difference in the distribution of covariates between the both groups. The low rate of pseudo R^2, low average standardized bias, high total bias reduction and the insignificant P value of the likelihood ratio test after matching show the specification of propensity score prediction process is successful as per balancing the distribution of covariates between the certified and non-certified. The PSM regression model show, from the Kernel method that those who certified realized 392 kg/ha as against 306 kg/ha for the non-certified making a difference of 86 kg/ha. Whereas the certified received F CFA 325,660 as against F CFA 220,850 for the non-certified making a difference of F CFA 104,810, and the nearest neighbor method that those who certified realized 392 kg/ha as against 302 kg/ha for the non-certified making a difference of 90 kg/ha. Whereas the certified received F CFA 325,650 as against F CFA 220,890 for the non-certified making a difference of F CFA 104,765, added to the premium of 40–50 CFA francs per kg of certified cocoa sold further justifies the relevance of the certification program. Results of the ATT producers who adopted certification based on Kernel's and nearest neighbor's propensity score matching method show that the average production rate and also the profit margin of a certified farmer are higher than those of a non-certified farmer.

Combining the two results, we realize that the ESR results are relatively high as compared to the PSM results. This is probably due to unobservable factors that could not be controlled during the use of the ESR technique. The results on the average effect of the non-treated (ATU) from ESR equally indicate that the non-certified could have realized more yield and profit margin had it been they were certified.

5 Discussions

Given that the ESR method could be biased based on non-observable factors, the PSM method was equally used to correct the robustness of predicted effects from the ESR method. The confirmation of the ESR result by the PSM method shows that results from the ESR approach are very robust than the ones from PSM in the context of this study. These results are similar to those obtained in Ivory Coast, Ghana and Brazil (Daniels et al., 2012; ICCO, 2014) and are in the same light with those of other works (Potts et al., 2010) in Ivory Coast, which showed that certified farmers yields (576 kg/ha) are 70% higher than those of non-certified farmers (334 kg/ha) on average. Similarly, in Ghana the (ICCO, 2014) impact report revealed that among Ghanaian certified farmer, about 95% "doubled or tripled their output and improved their income through the implementation of UTZ agricultural practices"; yields increased from 200 kg/ha in 2008 to 512 kg/ha in 2012 (Gyau et al., 2014), while during the same period the average yields of non-certified farmers were 312 kg/ha (Lemeilleur et al., 2017). Similarly, results in Ivory Coast also showed that the yield and income of certified farmers is significantly higher than those of non-certified (620 kg/ha of cocoa for certified producers against 570 kg/ha for non-certified farmers). The work of Potts et al., (2010) in Ivory Coast demonstrated that certification also has a positive impact on the profit margin of certified farmers compared to non-certified farmers. Certified farmers receive an average of fcfa/ha 461.000/ha, which is 75% more than the average of non-certified farmers who receive 262.000 fcfa/ha. The study of (Dorr and Grote, 2009) on the adoption of certification by producers of mangoes and

grapes in the Juazeiro and Petrolina regions of the Sao Francisco valley in Brazil, showed that the average yields of mango trees are 19.3 t/ha for the non-certified produce, and 25.9 t/ha for the certified. Concerning the grapes, the yields for the non-certified are 16.3 t/ha and for the certified 23 t/ha. Similar results have been obtained in Tanzania on the use of improved maize seeds (Amare et al., 2012) and on the adoption of improved sorghum in Ethiopia (El-Shater et al., 2015). Similar results have been obtained in Tanzania on the use of improved maize seeds (Amare et al., 2012) and on the adoption of improved sorghum in Ethiopia (El-Shater et al., 2015). Compared to Indian farms, there are gender inequalities and a weak organization of non-certified farms in Kenya (Dolan, 2010). In examining other economic disadvantages of certification as reported in the literature (Dolan, 2010; Roosma et al., 2014), they did not address the problem of insufficient demand for certified products. On the contrary, certified farms cite better market access both as a motive and as one of the most important benefits of their evaluations. Finally, Adgo et al., (2014) reported that 100% of the Worja kebele in the northern region and 90% of the Beresa Kebeles in the Oromia region showed that the land certification program promoted equality of sexes. The participation of households in certification programs has shown an improvement in the process of farm sustainability. This finding is consistent with the findings of Adgo et al., (2014) in the Kilte Awela'elo woreda of the Tigray region, where 85.2% of households were involved in different types of long-term land investment practices. Likewise, (Deininger et al., 2015) found that certification of rural land in Ethiopia increases incentives to invest in tree planting (88%), soil and water conservation structures (86%) and the sustainable management of common resources (66%). This result is consistent with that of Dadi et al., (2018), where 63.3% of households in pilot areas and 50% of households in non-pilot woredas in Amhara region agreed that land productivity agriculture does not change after land certification. The study of Tey and al (2020) proved the certification of the Roundtable sustainable palm oil standard to be elastic to changes only in proportion to the planted area. They recommended education and technical and financial assistance, and inclusive regulations that enable environment factors for certification adoption strategies. Gedefaw et al. (2020) found that most farm households feel that their land use rights are secured after the certification process. The majority of farm households identified the level of disputes reduced, and land management practices improved after certification than before certification. Khan et al. (2021) suggests that engaging in environmental business practices, such as green innovation practices and reporting, may help companies gain competitive advantage and enhance their organizational and environmental performance. Vogel et al. (2020) Cameroon showed that the actors' perceptions toward future transitions are not actively coordinated. Furthermore, actors are not finding a way of adopting new organizational structures and letting a transition occur effectively, like in the case of certification standards.

6 Conclusions

Although its obvious desirability at both the level of cocoa industries and farms, the adoption of certification standard has remained limited. The need for coherence among cocoa stakeholders (present certified exploitations and cocoa industries) is still a dilemma. Some exploitation obviously hope to avoid certification entirely with compliance standards becoming more stringent and expensive coupled with the long duration between application and certification. The use of the endogenous switching regression (ESR) treatment effects complemented with a binary propensity score matching (PSM) methods contributed

to demonstrate the importance of adopting certification norm to increase the revenue and improve the socioeconomic welfare of producers. This study assessed the impacts the economic performance of certified cocoa-based agroforestry systems in Cameroon. Results obtained indicated that adopting certification, although voluntary, is motivated by the award of a premium (40 to 50 FCFA per kg of certified cocoa sold) and could be enhanced through sales to cooperatives, provision of subsidies to offset the high cost of certification. Adopting certification improved the economic performance of cocoa-based farms in the humid forests of Cameroon. Using the ESR regression model, certified farmers produce more than non-certified farmers (394 and 375 kg/ha, respectively) and receive with a net improvement in revenue of about 300 USD. The PSM regression model showed, from the Kernel and nearest neighbor method that those who certified realized about 87 kg/ha (or 90 USD) more of produce than those who never certified. Although average effects of certification varied from one econometric method to the other, they all led to results that will spur cocoa farmers in Cameroon to adopt the certification initiatives.

However, the somewhat doubtful view that performance capacity derives from potential compliance to an international certification standard remains. Development policies for the production of cocoa-based agroforestry systems in Cameroon would need to remedy this situation and aggressively increase access to credit, and the use of certification norm as such investments will contribute in improving farm yields, profit margins and enhance rural welfare. There is therefore need for public authorities responsible for the development of Cameroon's cocoa sector and extension services, to implement policies of good governance, which will enhance adhesion to certification. These will in return, enhance the quantity and quality of household productions as well as their incomes.

Appendix

Appendix 1

See Table 6.

Table 6 Socioeconomic characteristics of farmers of the agroforestry systems in each Division (certified and non-certified)

Variables	Mean			Mean		Mean
	Divisions			Certification Participation		Both groups
	Mefou-Akono ($N=128$)	Fako and Mémé ($N=254$)	Nyong and So'o ($N=124$)	Non-certified ($N=292$)	Certified ($N=214$)	Certified and non-certified ($N=506$)
Farmer's age (year)	53.53	45.32	51.22	48	50	48
Gender (1 = Male, 0 = Female)	0.93	0.95	0.92	0.95	0.92	0.94
Educational level (1 = primary, 2 = No formal schooling, 3 = secondary and 4 = university)	0.47	0.40	0.58	2.03	1.95	2.00
Treatment of dangerous waste (1 = Yes, 0 No)	0.43	0.28	0.38	0.19	0.55	0,18
Application of herbicides (1 = Yes, 0 = No)	0.01	0.34	0.04	0.17	0.21	0.18
Access to improved seeds (1 = Yes, 0 = No)	0.46	0.13	0.37	0.18	0.41	0.27
Mode of selling cocoa (1 = Cooperatives, 0 = Middlemen)	0.25	0.34	0.38	0.52	0.07	0.33
Method of fermenting cocoa (1 = in box, 0 = on the ground)	1.67	1.66	1.73	1.67	1.70	1.68
Duration of fermentation (0 = 3 days, 2 = 4 days, 3 = 6 days)	1.17	1.08	1.18	1.15	1.10	1.13
Method of drying cocoa (1 = on mat and 0 = in an oven)	1	1.63	1	1.42	1.23	1.34
Age of farm (1 = young, 2 = mature and 3 = old)	2.82	2.08	2.72	2.39	2.47	2.42
Farm yields (kg/ha)	301	405	349	346	392	365
Profit margin (F CFA/ha)	305.429	236,080	337.272	243.297	326.347	278.421

Standard errors in parenthesis. Bootstrapped standard errors using 50 replicates of the sample. * and *** denotes significances at 10% and 1%, respectively

Appendix 2

See Table 7.

Table 7 Probit estimation on the impact of certification on yield and Profit Margin: ESR Method

Variable	Yield				Profit margin			
	Non-certified		Certified		Non-certified		Certified	
	Coef.	$P>z$	Coef.	$P>z$	Coef.	$P>z$	Coef.	$P>z$
Farmer's age	−5.67 (14.03)	0.68	22.77 (34.85)	0.51	−11,572.9 (12,689.01)	0.36	−3418.10 (34,737.6)	0.92
Gender	−16.9 (47.84)	0.72	70.79 (87.21)	0.41	−80,120.2 (43,199.63)	0.06	14,927.54 (87,455.18)	0.86
Educational levels	24.10 (9.26)***	0.00	26.99 (21.40)	0.20	10,418.76 (8358.02)	0.21	26,336.18 (21,482.93)	0.22
Treat dangerous waste	−82.52 (24.44)***	0.00	−6.68 (49.50)	0.89	−66,973.54 (22,075.6)***	0.00	15,985.1 (49,525.4)	0.74
Application of herbicides	2.29 (25.55)	0.92	150.97 (59.34)**	0.01	−59,924.97 (23,071.6)**	0.01	85,378.5 (59,429.74)*	0.15
Access to improved seeds	14.28 (28.24)	0.61	−48.01 (47.01)	0.30	25,490.06 (25,534.01)	0.31	−26,110.96 (47,200.82)	0.58
Mode of selling cocoa	−21.28 (20.09)	0.29	−90.91 (88.17)	0.30	−17,580.8 (18,159.46)	0.33	168,300.5 (88,365.4)**	0.05
fermentation method	8.94 (18.89)	0.63	−17.10 (49.79)	0.73	14,362.62 (17,057.7)	0.40	−20,237.17 (50,003.33)	0.68
Duration of fermentation	21.08 (17.01)	0.21	−35.93 (67.88)	0.59	38,695.44 (15,362.32)**	0.01	−28,268.16 (68,040.33)	0.67
Method of drying cocoa	109.2 (24.17)***	0.00	7.54 (62.08)	0.90	−41,000.72 (21,830.49)**	0.06	9200.32 (62,059.4)	0.88
Age of cocoa farm	−2.93 (16.94)	0.86	−35.26 (35.50)	0.33	3222.66 (15,302.52)	0.83	50,651.63 (36,360.18)*	0.16
Constant	160.4 (99.12)*	0.10	397.52 (196.36)**	0.04	323,072.5 (89,479.6)***	0.00	243,674.7 (194,454.7)	0.21
Model diagnosis								
Prob > Chi^2	0.000				0.000			
R-squared/Pseudo R^2	0.28				0.28			
Number of observations	506				506			

Source: Author, constructed from the outcome estimates, Standard errors in parenthesis significant to 1% *** $p<0.01$, à 5%** <0.05, and at 10%* $p<0.1$

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