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Impact of Swollen Shoot Disease on the Livelihoods of Smallholder Cocoa farmers in Côte d'Ivoire

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Abstract

The Cocoa Swollen Shoot Disease (CSSD) due to badnavirus species is endemic in West Africa and caused significant and irreversible economy losses for smallholder cocoa farmers in infected areas in Ghana and Côte d'Ivoire. The impact of the disease on the small farmers livelihoods has been investigated at cocoa farm households level in Côte d'Ivoire. For that, the propensity score matching method was used to construct a counterfactual and to compair group capturing the situation of affected households before the disease occuring on their plantation, based on the observable characteristics of non affected households. A total of 800 cocoa farmers were randomly interviewed using a semi-structured questionnaire. Results shown significant differences of expenditures for children's schooling and health of household's with plantations infected by the disease compared to non affected. It was also found that households with swollen shoot in their cocoa plantation use less modern health services and invest less in children's education.

Keywords: Cocoa, swollen shoot disease, impact, propensity score matching, livelihoods

Introduction

Cocoa plays an important economic and social role in Côte d'Ivoire. The country is the world's largest producer and exporter of cocoa beans with about 41% as share of the market (Hütz-Adams et al., 2016). Cocoa accounts for about 14% of GDP, contributes to more than one-third of export earnings, and finances 10% of government revenues. Cocoa is grown throughout the forest zone, covering 2,176,000 hectares, or 6% of the national territory. The crop employs more than 5 million people, or one-fifth of the population, and is by far the largest source of foreign exchange, accounting for nearly 40% of the country's merchandise exports (World Bank, 2019) It is also the primary source of agricultural income for these Ivorian cocoa farmers, 43% of whom have no other income.

However, in spite of its place of choice in the constitution of the national wealth, the cocoa culture in Côte d'Ivoire faces several constraints such as high pressure of pest and disease. Cocoa Swollen Shoot Disease (CSSD) caused important damages on farms and has been described as one of the most economically significant viral plant disease in the world (Dzahini Obiatey et al., 2010). The CSSD causes a drastic decrease on cocoa production and the destruction of infected cocoa trees within 3-5 years. Yields fall by 25% in the first year of infestation of cocoa trees, 50% in the second year and no yield from three to five years after infestation (CNRA, 2011). The cocoa swollen shoot disease seems endemic in West African countries. It was first reported in Ghana in 1936 (Steven 1937) where 200 millions of infected trees were cutting out in order to reduce the spreading of the disease. The disease has also been observed in the major cocoa producing countries of West Africa as Côte d'Ivoire (Alibert, 1946), Nigeria, Sierra Leone and Togo.

There is no chemical products for controlling the CSSD. Currently, the best way to control the disease is based on cutting down infected cocoa trees and replanted with tolerants planting material while applying good agricultural practices susch as agroforestry

The CSSD propagated rapidely to many cocoa producing areas from the outbreaks observed since 2003 at Sinfra and Bouaflé in Côte d'Ivoire where virulent strains were involved (Kouakou, 2011; 2012; Aka et al, 2020; Ramos et al, 2021). This situation had certainely a socio-economic impact on small farmers livilhoods witch need to be addressed. The present study therefore aims to estimate the impact of swollen shoot disease on the livelihoods of cocoa producers in infected areas in Côte d'Ivoire

Methods

Setting up an impact study implies being able to compare the situation of individuals before and after a program in order to identify the own specific or its causal effects. A program can be a project, a public policy, or, in case of this study, a disease, and impact evaluation is about studying whether changes in well-being are due to the program and not to other factors. One of the inherent difficulties in impact studies is having a control group or sample that allows for the description of the situation of treated individuals before they are exposed to the program. This is known as the counterfactual problem. Following Ezemenari and al. (2018), impact evaluation methods can be classified into two groups: experimental and non-experimental or quasi-experimental approaches. With the experimental or randomized approach, the counterfactual is constructed at the outset of the program by defining a target population and randomly assigning the program to a portion of that population. From then on, random assignment of the treatment makes it possible to set up two groups, a treatment group and a control group whose average observed and unobserved characteristics are statistically equivalent. As for the quasi-experimental evaluation, the treatment and comparison groups are defined ex-post. It is conducted during or after the program.

Our study plans to investigate the impact of Swollen Shoot, a disease of cocoa trees that has been reported to be on the rise since 2003. Since there is no data available before the resurgence of this disease, the quasi-experimental approach would be best suited for this study. There are several quasi-experimental methods in the literature for assessing impacts, the most commonly used are the double difference (DD) method, the instrumental variable (IV) method, the regression discontinuity (RD) method and the propensity score matching (PSM) method. These different methods attempt to construct the counterfactual by statistical methods from the study sample.

DD methods assume that unobserved selection is present and that it‘s time-invariant. The treatment effect is determined by measuring the difference in outcomes between treatment and control units before and after the program intervention. DD methods can be used in both experimental and non-experimental settings. IV designs can be used with cross-sectional or panel data. The goal is to find at least one variable that affects the occurrence of swollen shoot on the cocoa farm but does not affect the livelihoods variables. The main difficulty with these methods is finding valid instrumental variables. With the RD method, individuals are classified according to a specific and measurable criterion. There is a well-defined selection threshold (cutoff) that determines whether a person is eligible or not. Treated individuals are then compared to control individuals. The PSM method determines the comparison group from a sample of non-participants who resemble the participants, based on observable characteristics. In the case of our study, this will involve constructing a comparison group capturing the situation of affected households before the onset of swollen shoot in their plantation, based on observable characteristics of unaffected households. Thus, the PSM method was determined to be the most appropriate method for this study. However, it requires answering several methodological questions, which we present in the following section.

Presentation of the propensity score matching method

The idea of matching method is to associate each treated individual (producers with swollen shoot in their plantations) with an untreated individual (producers without swollen shoot in their plantations), whose characteristics are identical to those of the treated individual (Benedetto et al., 2018). The principle of estimation consists in using the information available on the untreated individuals to construct a counterfactual for each treated individual, i.e. an estimate of what his situation would have been if he had not been treated (Benedetto et al., 2018). To control for heterogeneity, a sample of the control group, composed of individuals with the same possible observable characteristics as the group of treated individuals, is chosen as the comparison group. However, it would be difficult to have a farmer among those who don't have swollen shoot on their farm with exactly the same values of all observed characteristics as any farmer who has swollen shoot on his farm. Indeed, it is recognized that an increase in CSSD will have a negative effect on the overall income of producers who have it on their farm (Koffié, 2014). But how can we be sure that the difference observed between cocoa farmers who have CSSD on their farms and those who do not is really due to the presence of CSSD ? A simple approach would be to consider the difference in, for example, average income between the two groups of farmers. However, there are many problems with interpreting this difference as a causal relationship between producers with CSSD on their farms and producers without CSSD on theirs. The main one is the existence of selection bias (Ferri-García and Rueda, 2020). Selection bias is based solely on observed characteristics.

For this, the Conditional Independence Assumption must be assumed. The Conditional Independence Assumption states that: conditional on a set of observable characteristics (X), the observed outcome is not related to whether or not the farm has swollen shoot (Benedetto et al., 2018; Scott, 2019; Caliendo and Tübbicke, 2020). Formally, this hypothesis is written:

$$(Y\ 1, Y\ 0\ ) \perp cssv|X \Longrightarrow (Y\ 1, Y\ 0\ ) \perp cssv|p(X)$$

This simply means that having swollen shoot on the farm is independent of potential outcomes but conditional on propensity scores $p(X)$. Propensity scores represent the probability of having swollen shoot on the cocoa farm, conditional on a set of observable characteristics X. The more information we have about the producers, the better it is possible to distinguish them in their behavior. By proceeding in this way, while respecting the conditions of conditional independence, matching by propensity score makes it possible to eliminate any kind of selection bias.

This hypothesis nevertheless presupposes the consideration of a large number of variables X, the limited number of which is justified by Caliendo and Tübbicke (2020). According to him, "we must keep in mind that what is important is not a description as faithful as possible of the probability of the treatment, but simply the determination of the variables necessary to obtain the independence property. Introducing too many variables can have negative consequences on the estimation in several ways. Firstly, description of treatment variable being better, supports of distributions of scores of treated and untreated individuals are likely to be more dissociated; the possibilities of matching will then be more restricted. More importantly, introducing too many conditioning variables may make estimation impossible. It is possible that the independence property is satisfied for a set of conditioning variables, but that it is no longer satisfied when other conditioning variables are added, even if they are significant in the score estimation.

For the matching method, a second important assumption called common support must be respected. This assumption imposes that for each treated individual, we have untreated individuals whose scores have values close to the score of the treated individual (Benedetto et al., 2018). This assumption ensures that individuals in the control group with the same observed characteristics are found in the sample. Formally:

$0 < p(cssv = 1) < 1$

To construct the common support for the propensity score, according to Benedetto and al (2018) and Caliendo and Tübbicke (2020), several techniques can be employed. The first is to exclude observations whose estimated propensity score is close to 1 or 0. One can also remove all observations in the control group for which the estimated propensity score is

lower than the minimum of the estimated propensity scores in the treatment group, and apply the same rule for the maximum. Finally, one can remove observations from the control group whose variables have a density below a certain threshold. The choice of the appropriate approach depends on the distribution of the propensity scores of the two groups.
Under the assumption of conditional independence and common support, attribution to treatment is random and the outcome of control subjects can be used to estimate the counterfactual outcome of treated individuals in case of no treatment.

In practice, propensity scores are estimated using the predicted probabilities from a binary qualitative choice model (Logit or Probit), explaining participation in a treatment or program by a large number of observable characteristics. However, the choice of the appropriate model depends on the nature of the program (Adejumo and al., 2020). In our study, the logistic regression model is used to model propensity scores. The model refers to the application of the dichotomous variable $CSSVi$ reflecting the presence or absence of swollen shoot in household's cocoa farm i. It takes the value 1 if the household has swollen shoot in its cocoa farm and 0 otherwise. This binary variable is associated with a latent variable $CSSVi*$ that is a function of a matrix of explanatory variables Xij that refer to observable characteristics of producing households (gender of the household head, age, household size, etc.) translated into the following equation:

$$CSSV_i^* = \alpha + \sum_{j=1}^{i} \beta_j X_{ij} + \varepsilon_i \quad \text{.........(1)}$$

Where ε_i is a random term whose distribution is given by the density functionf.

$$\begin{cases} CSSV_i = 1 \; si \; CSSV_i^* > 0 \\ CSSV_i = 0 \; si \; CSSV_i^* \leq 0 \end{cases} \quad \text{.........(2)}$$

Replacing (1) in (2), we get:

$$P(CSSV_i = 1) = P[\varepsilon_i > -(\alpha + \sum_{j=1}^{j} \beta_j X_{ij})] = P[-\varepsilon_i \leq (\alpha + \sum_{j=1}^{j} \beta_j X_{ij})] = F[\alpha + \sum_{j=1}^{j} \beta_j X_{ij}] \quad \text{.........(3)}$$

Where F is the distribution function corresponding to the density function f. Thus, the Logit model to be estimated can be specified as follows:

$$ln\left(\frac{P(CSSV_i)}{1-P(CSSV_i)}\right) = \alpha + \sum_{j=1}^{i} \beta_j X_{ij} + \varepsilon_i \quad \text{.........(4)}$$

Where $\beta_j X_{ij}$ represents the matrix of explanatory variables, β_j the coefficients to be estimated,, ε_i the error term and α the constant term.

The value of the score, i.e. the probability of having swollen shoot on the farm given the observable characteristics, is deduced for each producing household. The results of the logistic regression model should provide statistics for interpreting the factors favoring the presence or absence of

CSSV in cocoa fields. We will refer to chi-square statistic (Chi-square) to test the significance of the model and its parameters; and the pseudo R-square to test adequacy of the model and also to see the different significance levels and the marginal effects.

The impact of swollen shoot on farmers who have it in their cocoa farm (ATT) is estimated by the difference in mean scores between treated farmers and matched control.

$$ATT = E[Y_i^T | p(x), cssv = 1] - E[Y_i^C | p(x), cssv = 0] \quad \text{......(5)}$$

There are several methods for estimating this. As noted above, these methods associate producer households with swollen shoot on their cocoa farms with those that don't have swollen shoot on their cocoa farms that are closest in terms of propensity scores based on observable characteristics. Empirically, the measure of impact is given by the following expression (Clément, 2006; Ravallion, 2008):

$$\text{ATT} = \frac{1}{T}\sum_{J=1}^{T}(Y_{j1} - \sum_{i=1}^{C} w_{ij} Y_{ij0}) \quad \text{......(6)}$$

In this equation, Y_{j1} represents the outcome for the j^{th} swollen shoot affected household, Y_{ij0} the outcome for the i^{th} swollen shoot unaffected case joined to the j^{th} affected, T the total number of swollen shoot affected households, C the total number of unaffected households, and w_{ij} the weights or weighting function used for averaging the outcomes of unaffected households.

There are several propensity score matching methods, which the most used are radius (with various calipers), Kernel, and nearest-neighbors according to the literature. Latter method combines One-Nearest Neighbor and Multiple Nearest Neighbors. We propose to use the Nearest Neighbour Matching method to assess the impact of swollen shoot on the livelihoods of cocoa-producing households.

Data

Data were collected from a random sample of 800 cocoa farmers in the main cocoa producing regions of Côte d'Ivoire. The distribution of the sample across regions and the number of villages visited is presented in Table 1. Out of the 800 producers selected, 18.87% had cocoa farms affected by swollen shoot disease, compared to 81.13% with uninfected farms. Producers were surveyed using an individual questionnaire on the socio-economic characteristics of the cocoa producer's household (gender, age, number of active farmers, contact with extension, etc.), the characteristics of the cocoa farm (area planted, age of cocoa trees, presence of swollen shoot, etc.) and cultivation practices (type of labor, varieties of cocoa grown, other perennial crop grown, etc.).

Table 1. Number of producers surveyed

Regions	Number of villages visited	Number of producers with farms not affected by CSSD	Number of producers with affected farms by CSSD	Total producers	% Total
Nawa	16	110	41	151	18,87
Loh Guiboua	8	103	17	120	15,00
Haut-Sassandra	10	89	7	96	12,00
San Pedro	6	65	10	75	9,38
Goh	5	46	23	69	8,62
Agneby Tiassa	3	63	3	66	8,25
Sud Comoé	4	43	5	48	6,00
Guemon	5	34	10	44	5,50
Indenie	2	32	7	39	4,88
Me	3	27	8	35	4,38
Marahoue	6	7	18	25	3,12
Tonkpi	1	20	2	22	2,75
Belier	2	10	0	10	1,25
Total	**71**	**649**	**151**	**800**	**100**

Source : Field Survey 2019

Results

Comparative characteristics between producer groups

Table 2 presents the characteristics that differ between farmers who have swollen shoot on their cocoa farms and those who don't have it. These are the socio-economic characteristics of the cocoa farmer's household, the characteristics of the cocoa farm and cultivation practices.

The table shows that producers who have swollen shoot and those who don't have it have significantly different socioeconomic characteristics. Indeed, 37.75% of producers with swollen shoot have access to credit, compared to 25.58% of those without swollen shoot in their cocoa plantations. Producers who don't have swollen shoot have more off-farm sources of income than those who have it (76.27% versus 64.24%). Regarding experience in cocoa farming, 85.37% of producers without swollen shoot have more than five (5) years of experience compared to 76.76% of those with swollen shoot. In addition, 25.73% have had contact with the extension service as opposed to 11.92% of those with swollen shoot. In terms of agricultural practices in cocoa plantations, there are also significant differences between the two groups of producers. It can be observed that among producers who don't have it, 97.53% do at least two manual weeding operations per year, compared to 88.08% among those who have it. Also 69.80% of them use chemical fertilizer against 60.93% of those who have swollen shoot in their plantations. However, 92.72% of producers with swollen shoot in their plantations use family labor in cocoa production compared to 56.55% of producers without swollen shoot in their plantations.

With regard to factors related to the plantation, there is a significant difference in the age of the plantations. The plantations of producers with swollen shoot are a little over twenty-two (22) years old on average, compared to twenty (20) years old for those without swollen shoot.

Table 2. Presentation of the variables of the econometric analysis

Variables	**Untreated Group (without CSSD)**	**Treated Group (with CSSD**	**Pool**	**T-test[1]**
Socio-economic factors				
Male producer (%)	93.68	96.69	94.25	0.153
Age of producers (year)	47.69	47.99	47.74	0.784
Producers educated (%)	50.69	56.29	51.75	0.215
Acces to crédit (%)	25.58	37.75	27.88	0.003**
Possession of off-farm income source (%)	76.27	64.24	74.00	0.002**
Experience in cocoa production greater than 5 years (%)	85.67	76.16	83.88	0.004**
Contact with extension (%)	25.73	11.92	23.13	0.000***
Factors related to cultural practices				
Two or more annual weedings (%)	97.53	88.08	95.75	0.000***
Use of family labor (%)	56.55	92.72	63.38	0.000***
Use of chemical fertilizer (%)	69.80	60.93	68.13	0.035**
Plantation factors				
Age of the cocoa farm (year)	19.73	22.44	20.24	0.005**
Cocoa farm area (ha)	3.17	3.22	3.18	0.793

*****, **and *: indicates that the variables are statistically significant at 1% 5% and 10% risk levels respectively**

Source : Field Survey 2019

Determinants of swollen shoot status on cocoa farms

The analysis of results of logit model provides information on the factors that determine infestation of cocoa trees by swollen shoot disease. The variables that significantly determine the probability of having swollen shoot disease on the farm are the age of the farmer, level of education, access to credit, possession of off-farm income, number of years of experience in cocoa production, contact with extension, level of number of weedings, family labor, use of chemical fertilizer, and age of the cocoa farm.

[1] Student test for quantitative variables and Chi-2 test for qualitative variables

The age of the producer is significant at the 5% level and has a positive coefficient indicating that it is important. Indeed, older farmers are more exposed to swollen shoot compared to younger farmers. If we consider the results of the marginal effect, the probability of an older producer having swollen shoot is 0.24% compared to a younger producer.
It can be seen that at the level of education, in reference to the no education modality, the educated modality is significant at the 1% threshold with a positive coefficient reflecting a positive effect on the probability of having swollen shoot in the field. Thus, the probability of having swollen shoot among educated farmers is 4.17% higher than among farmers with no education.

Access to credit is significant at the 1% level and has a positive coefficient. We can see that in reference to producers who don‘t have access to credit, those who have access to it have cocoa plantations that are more exposed to swollen shoot. With marginal effects, relative to a farmer without access to credit, the probability that a farmer with access to credit has swollen shoot in its farm increases by 8.13%.

Possession of a non-farm source of income is significant at the 1% level and has a negative coefficient. Thus, compared to producers who do not have a source of off-farm income, those with off-farm income have cocoa fields that are less exposed to swollen shoot. In terms of marginal effects, in reference to a producer who does not have off-farm income, the probability that a producer with off-farm income sources will have swollen shoot in his cocoa field is less than 7.56%. Indeed, cocoa cultivation is an activity that requires maintenance. It is necessary to invest and without financial resources the producer is exposed to diseases and pests in his field

The number of years of experience in cocoa farming is significant at the 1% threshold. The coefficient of the variable is negative, indicating a negative relationship between the number of years of experience in cocoa production and the probability of having swollen shoot in the field. With marginal effects, we note that the probability decreases by 14.39% when the number of years experience of producer in cocoa farming increases.

The results also show that contact with extension has a significant effect on the probability of having swollen shoot. Coefficient of extension contact variable is negative at 1% level. Marginal effects shows that it reduces the probability of having swollen shoot by 18.95%. This result can be justified by the fact that contact with the extension service allows the farmer to have access to information on swollen shoot as well as on control methods.

The number of weedings carried out by the farmers per year, in reference to the one weeding modality, is significant at 1% level, with negative coefficients reflecting a negative effect on the probability of having swollen shoot in the field. With respect to marginal effects, the probability of having swollen shoot in households that do two or three or more annual weeding operations is less than 38.20% and 41.73% respectively, compared to farmers who do only one operation. This result shows the importance that should be given to good agricultural practices in cocoa farming recommended by research (Kébé et al., 2016).

The use of family labor is positively significant at 1% level. According to the marginal effects, farmers who use family labor increase their probability of having swollen shoot by 31.55% compared to those who use other labor in their cocoa plantations. The use of chemical fertilizer is negatively significant at 1% level. Marginal effects show that, with reference to farmers who do not use chemical fertilizer for cocoa production, the probability of having swollen shoot decreases by 8.84% for farmers who use chemical fertilizer on their cocoa farms.

The age of the cocoa farm is significant at 1% level. The coefficient of the variable is positive. This result shows that older cocoa fields have a high probability of having swollen shoot compared to younger fields. According to the marginal effects, the probability of an old field having swollen shoot is 0.38% compared to a young field.

Table 3. Results of the Logit model for estimating propensity scores

Variables	**Modalities**		**Coefficients (Sd)**	**marginal Effets**
Sex of producer	Female	Ref.		
	Male		0.440(0.603)	0.0514
Age of producer			0.021(0.009)**	0.0024
Producers educated	Not enrolled	Ref.		
	enrolled		0.356(0.215)*	0.0417
Access to credit	No	Ref.		
	yes		0.696(0.223)***	0.0813
Possession of off-farm income source	No	Ref.		
	yes		-0.647(0.226)***	-0.0756
Experience in cocoa production			-1.232(0.292)***	-0.1439
Contact avec la vulgarisation	No	Ref.		
	yes		-1.622(0.342)***	-0.1895
Number of annual weeding	One	Ref.		
	Two		-2.517(0.494)***	-0.3820
	Three or more		-2.823(0.484)***	-0.4173
Area of cocoa farm			0.127(0.319)	0.0149
Use of family labor	No	Ref.		
	yes		2.700(0.372)***	0.3155

Use of chemical fertilizer	No	Ref.		
	yes		-0.757(0.235)***	-0.0884
Age of the cocoa farm			0.032(0.011)***	0.0038
Constant			-1.365(0.928)	
Number of observation			800	
LR chi2(17)			187.23	
Prob > chi2			0.0000	
Pseudo R2			0.2425	
Log likelihood			-292.445	

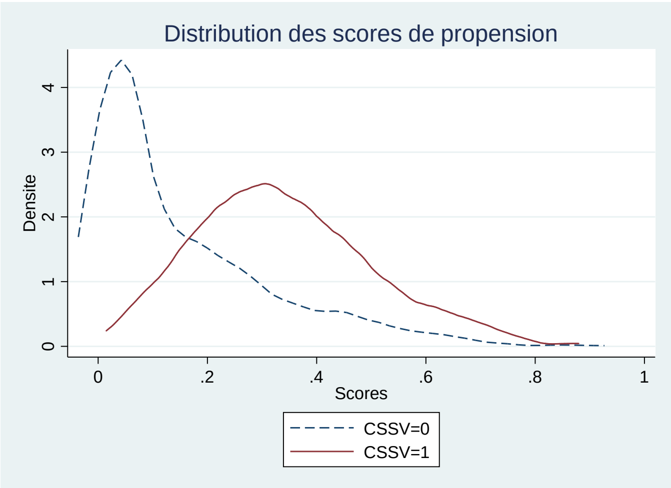
*****, **and *: indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk levels respectively**

Source : Field Survey 2019

Propensity scores

From the logistic regression model we have just built, we calculate the propensity scores. Figure 1 below shows the distribution of propensity scores in the sample. The average propensity score for households without swollen shoot in the field is 0.15. Those with the swollen shoot have an average score of 0.35. This result shows that there is a significant difference in observable characteristics between the two groups of cocoa producing households.

Figure 1. Distribution of propensity scores



After estimating the propensity scores, it‘s important to check the quality. We need to ensure that there is a common support in the distribution of propensity scores. It allows us to ensure that for each treated producer, there are producers in the untreated group with the same characteristics. To accomplish this, we compare the maxima and minima of the propensity score distribution for the two groups of producers. This condition consists of removing observations from the treated population whose propensity score is either lower or higher than the minimum and maximum scores of the control group households, respectively. Based on these considerations, seven (7) producers in the treatment group do not belong to the common support. Of the seven hundred and ninety-three (793) households in the treatment group, one hundred and forty-three (143) households have swollen shoot on their cocoa farms and six hundred and fifty (650) households do not. Respecting this assumption therefore removes less than 1% of our observations.

Once the common support is delineated, producer households who have CSSD on their farms and those who don't have it are matched. However, note that before matching, Table 2 above shows us that there are significant differences between the two groups depending on variables used for matching. If the matching is correct, there should no longer be any significant differences between the two groups of producers; this is the principle of the test of equality of means. The standardized differences test, on the other hand, determines the reduction in bias due to matching by the propensity score. Rosenbaum and Rubin (1985) point out that a standardized difference greater than 20 should be considered too large.

Table 4 shows that after matching, there are no significant differences between the two groups of producer households for all explanatory variables used. These results show that households that do not have swollen shoot on their farms are indeed identical (in terms of observable characteristics X) to producing households that have swollen shoot on the farms. In light of these tests, the quality of propensity score seems correct, validating the relevance of results obtained, which we will analyze in following sections.

Table 4. Characteristics of producers after matching

Variables	Mean Treated	Mean Control	%bais	t-test	p>
Socio-economic factors					
Male producer (%)	.96503	.97203	-3.3	-0.34	0.736
Age of producers (year)	48.042	49.79	-13.8	-1.09	0.275
Producers educated (%)	.56643	.53846	5.6	0.47	0.636
Acces to crédit (%)	.37762	.31469	13.6	1.12	0.265
Possession of off-farm income source (%)	.65035	.69231	-9.2	-0.75	0.452
Experience in cocoa production > 5 years (%)	.76224	.79021	-7.1	-0.57	0.572
Contact with extension (%)	.12587	.07692	12.7	1.37	0.171
Factors related to cultural practices					
Two or more annual weedings (%)	2.4545	2.5245	-11.2	-0.94	0.350
Use of family labor (%)	.92308	.95804	-8.8	-1.25	0.213
Use of chemical fertilizer (%)	.62238	.65035	-5.9	-0.49	0.624
Plantation factors					
Age of the cocoa farm (year)	.12587	.13287	-2.0	-0.18	0.861
Cocoa area (ha)	21.839	21.559	2.5	0.22	0.830

Source : Field Survey 2019

Results of the CSSD impact estimation

The impact of swollen shoot on the livelihoods of cocoa-producing households is reported in Table 5. The indicators of livelihoods used here reflect the ability of cocoa-producing households to satisfy basic needs such as food, housing, health care, children's education, clothing, housing and means of communication. A distinction is made between food and non-food expenditures. The latter include expenditures on health, education, housing, clothing, ceremonies, construction, housing and communication made by households in the last six months preceding the surveys. Food expenditures provide information on the total amount spent by the household in the week prior to the survey (last seven days) on food and beverages, including food consumed at home and elsewhere.

Based on these estimates, swollen shoot has a negative impact on the livelihoods of farmers who have it on their farms. All the indicators of livelihoods used are negative. However, the impact remains significant for total non-food expenditures, and particularly for household health expenditures and expenditures on schooling for children. It reduces health and schooling expenses for households that have it in their plantations by 46.63% and 31.62% respectively. In terms of non-food expenses, the decrease represents 30.15%. This result shows that producer households that have swollen shoot in their cocoa plantations invest less in their health and in their children's education.

Table 5. Results of swollen shoot impact estimates

Household expenditures	**Average expenditure after matching**		**Average effect of CSSD on treated**	**Proportion**
(FCFA)	**Treated**	**Untreated**	**(ATT)**	**(%)**
Total food expenditure	5.358	5.557	-199(358)	-3.58%
School expenditure	125.324	183.280	-57.956(23.814)**	-31.62%
Health care expenditure	67.100	125.728	-58.628(18.240)**	-46.63%
Clothing expenditure	27.741	30.848	-3.107(2.685)	-10.07%
Ceremonial expenditure	120.042	154.042	-34.000(17.455)	-22.07%
Construction and housing expenditure	132.420	174.667	-42.247(56.329)	-24.19%
Communication expenditure	15.500	15.915	-415(1.618)	-2.61%
Total non-food expenditure	684.273	979.610	-295.337(140.841)**	-30.15%

*****, **and *: indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk levels respectively; ( ): standard deviations**

Source : Field Survey 2019

Discussion

The discussion focuses on the impact of swollen shoot disease on the livelihoods of farmers.

Overall impact on livelihoods

The results of estimation of impact of swollen shoot on the livelihoods of producers are consistent with previous studies showing that plant diseases reduce agricultural production. Authors (Kouakou et al., 2011; Akrofi et al., 2014; Agyeman-Boaten and Fumey, 2021) have shown that swollen shoot like any other plant disease obviously leads to a significant decrease in production and thus affects the standard of living of producers. However, this study further shows the indicators of livelihoods that are affected by swollen shoot.

Considerable impacts on schooling and health care expenditures

Results show that swollen shoot has a considerable negative impact on education and health indicators and a relatively small impact on other livelihoods indicators. The results of the impact of swollen shoot on education are in line with those of Adolphe et al. (2016) who studied the socioeconomic impact of the coconut lethal yellowing disease on smallholder coconut farm families in Côte d'Ivoire.

Plant diseases are often considered agricultural shocks. In this sense, the study reinforces the general view of some authors. Indeed, several studies have highlighted the impact of agricultural shocks on the livelihoods of households. However, the most recurrent ones concern their impact on children's schooling and the demand for or consumption of health care by agricultural households. In terms of schooling, most studies show that the uncertainty induced by shocks affects the investment in human capital of school-age children, with households making a trade-off between school and work in order to absorb the negative impacts of shocks (Jensen, 2000; Beegle et al., 2006; De Janvry et al., 2006; Guarcello et al., 2010). At the health level, studies on health care utilization and household health expenditures during an illness episode have shown that household income plays an important role (Tape, 2007; Kochou and Rwenge, 2014; Dieng et al., 2015). However, the results on health expenditures are contrary to those of Lechtenfeld and Lohmann (2014). Indeed, they showed through their study of the impact of drought on health outcomes and health expenditures in rural Vietnam that drought-affected people have significantly higher health expenditures than others. But, the impact is felt in households with a high degree of dependence on agriculture and limited access to coping mechanisms such as selling assets or tapping into off-farm income sources.

Furthermore, results show that swollen shoot contributes to non-monetary poverty of cocoa farmers who have it in their plantations referring to the presentation made by Diarra (2018) as well as shown by Agyeman-Boaten and Fumey (2021) in their study in Ghana. The concept of non-monetary poverty can be presented in the aspects of livelihoods poverty, capability poverty, and relative deprivation. Poverty of livelihoods refers to the deprivation of access to basic services such as health, education, water and sanitation. While capability poverty is defined in terms of factors that prevent individuals or households from enjoying sufficient well-being. Relative deprivation poverty refers to the low accessibility of households to the basic services that are essential for a better well-being (access to health care, education, comfort, etc.).

Conclusion

This study showed that the probability of having swollen shoot in cocoa farm is related to the socioeconomic characteristics of producers, cultivation practices and farm characteristics. Among these factors, those that positively influence the probability of having swollen shoot are the age of producer, its level of education, access to credit, use of family labor, and age of cocoa farm. Inversely, possession of off-farm income, experience in cocoa production, contact with extension service, number of annual weeding operations, and use of chemical fertilizer have a negative influence. The study reveal that swollen shoot has a negative impact on the livelihoods of producer households. All indicators of livelihoods used are negative. However, the impact remains significant for total non-food expenditures, particularly for health and schooling expenditures. Regarding results of this study, it‘s recomended to reinforce producer awareness and training on cocoa swollen shoot disease. Also, cocoa farming households need to diversify their income to mitigate the negative impact of swollen shoot.

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References:

1. Adejumo, O., Okoruwa, V., Abass, A., & Salman, K. (2020). Post-harvest technology change in cassava processing: A choice paradigm. Scientific African, 7, e00276.

2. Adolphe, M. G., Mourifie, I., Konan, J. L., Ibo, J. G., & Koulou, N. (2016). Socio-economic impact of the coconut lethal yellowing disease on Ivorian smallholder coconut farm families.
3. Agyeman-Boaten, S. Y., & Fumey, A. (2021). Effects of cocoa swollen shoot virus disease (CSSVD) on the welfare of cocoa farmers in Ghana: evidence from Chorichori community of the Sefwi Akontombra district. SN Business & Economics, 1(11), 1-31.
4. Aka, A. R., Coulibaly, K., N'guessan, W. P., Kouakou, K., Tahi, G. M., N'guessan, K. F., ... & Zakra, N. (2020). Cocoa swollen shoot disease in Côte D'ivoire: history of expansion from 2008 to 2016. *International Journal of Sciences*, *1*, 52-60.
5. Akrofi, A. Y., Amoako-Atta, I., Assuah, M., & Kumi-Asare, E. (2014). Pink disease caused by Erythricium salmonicolor (Berk. & Broome) Burdsall: an epidemiological assessment of its potential effect on cocoa production in Ghana. Journal of Plant Pathology & Microbiology, 5(1), 1.
6. Alibert, H. (1946). « Note préliminaire sur une nouvelle maladie du cacaoyer le swollen shoot ». Agronomie Tropicale. Paris. V1. pp 34-43
7. Banque Mondiale (2019). Au pays du cacao – Comment transformer la Côte d'Ivoire. Juillet 2019 / Neuvième édition http://hdl.handle.net/10986/32156 (consulté le 19/06/2021)
8. Benedetto, U., Head, S. J., Angelini, G. D., & Blackstone, E. H. (2018). Statistical primer: propensity score matching and its alternatives. European Journal of Cardio-Thoracic Surgery, 53(6), 1112-1117.
9. Beegle K. Rajeev H. Dehjetia et Gatti R (2006). Child labor and agricultural shocks. Journal of Development Economics
10. Bergstra, S. A., Sepriano, A., Ramiro, S., & Landewé, R. (2019). Three handy tips and a practical guide to improve your propensity score models. RMD open, 5(1), e000953.
11. Caliendo, M., & Tübbicke, S. (2020). New evidence on long-term effects of start-up subsidies: matching estimates and their robustness. Empirical Economics, 59(4), 1605-1631.
12. Clément, M. (2006). *Impact redistributif des aides au logement en Russie : une analyse de propensity score matching*. Document de Travail du CED. n° 132. Université Montesquieu Bordeaux IV
13. CNRA (2011). Guide de la lutte contre la maladie du swollen shoot du cacaoyer en Côte d'Ivoire. Première édition.
14. De Janvry, A., Finan, F., Sadoulet, E., & Vakis, R. (2006). Can conditional cash transfer programs serve as safety nets in keeping

children at school and from working when exposed to shocks ? *Journal of development economics*, *79*(2), 349-373.
15. Diarra, I. (2018). Dynamique de la pauvreté en milieu rural agricole ivoirien (Thèse de doctorat, Clermont Auvergne).
16. Dieng, M., Audibert, M., Le Hesran, J. Y., & Dial, A. T. (2015). Déterminants de la demande de soins en milieu péri-urbain dans un contexte de subvention à Pikine, Sénégal.
17. Dzahini-Obiatey, H. Owusu, D. et Amoah, F. M. (2010). Over seventy years of a viral disease of cocoa in Ghana: From researchers' perspective *African Journal of Agricultural Research* Vol 5 (7). pp 476-485
18. Ezemenari, K., Rudqvist, A., & Subbarao, K. (2018). Impact Evaluation: Concepts and Methods. Evaluation and Poverty Reduction, 65-75.
19. Ferri-García, R., & Rueda, M. D. M. (2020). Propensity score adjustment using machine learning classification algorithms to control selection bias in online surveys. PloS one, 15(4), e0231500.
20. Guarcello, L., Mealli, F., & Rosati, F. C. (2010). Household vulnerability and child labor: the effect of shocks, credit rationing, and insurance. *Journal of population economics*, *23*(1), 169-198.
21. Hütz-Adams, F. Huber, C. Knoke, I. Morazán, P. & Mürlebach, M. (2016). Strengthening the competitiveness of cocoa production and improving the income of cocoa producers in West and Central Africa *Sudwind eV: Bonn*. 156
22. Jensen, R. (2000). Agricultural volatility and investments in children. *American Economic Review*, *90*(2), 399-404.
23. Kébé B.I., N'guessan K.F., Assiri A.A., Tahi G.M., N'guessan W.P., Aka A.R., Kouakou K. (2016). Bien lutter contre la maladie du swollen shoot du cacaoyer en Côte d'Ivoire. http://www.cnra.ci/downloads/ftec_cacao4_swollen_shoot.pdf (consulté le 20/06/2021)
24. Kochou, S. H., & Rwenge, M. J. (2014). Social factors of the nonuse or the inadequate use of prenatal care in Côte d'Ivoire. *African Evaluation Journal*, *2*(1), 12.
25. Kouakou, K., Kébé, B. I., Kouassi, N., Anno, A. P., Aké, S., & Muller, E. (2011). Impact de la maladie virale du swollen shoot du cacaoyer sur la production de cacao en milieu paysan à Bazré (Côte d'Ivoire). Journal of Applied Biosciences 43 : 2947–957
26. Kouakou K. (2014). Diversité moléculaire du CSSV (Cocoa Swollen shoot virus) et épidémiologie de la maladie du swollen shoot du cacaoyer (Theobroma cacao l.) en côte d'ivoire. Thèse de Doctorat de l'Université Felix Houphouët Boigny, 135p.

27. Lechtenfeld, T., & Lohmann, S. (2014). *The effect of drought on health outcomes and health expenditures in rural vietnam* (No. 156). Courant Research Centre: Poverty, Equity and Growth-Discussion Papers.
28. Lechner, M., & Strittmatter, A. (2019). Practical procedures to deal with common support problems in matching estimation. Econometric Reviews, 38(2), 193-207.
29. Mbaye, S. (2010). *Nouvelles méthodes d'analyse du bien-être et moyens d'évaluation des programmes de lutte contre la pauvreté en milieu rural sénégalais.* Humanities and Social SciencesUniversité d'Auvergne - Clermont-Ferrand I
30. Ramos-Sobrinho, R., Kouakou, K., Bi, A. B., Keith, C. V., Diby, L., Kouame, C., ... & Brown, J. K. (2021). Molecular detection of cacao swollen shoot badnavirus species by amplification with four PCR primer pairs, and evidence that Cacao swollen shoot Togo B virus-like isolates are highly prevalent in Côte d'Ivoire. *European Journal of Plant Pathology*, *159*(4), 941-947.
31. Ravallion. Martin (2008). «Evaluating Anti-Poverty Programs». *in Handbook of Development Economics*. vol. 4. éd Paul Schultz et John Strauss Amsterdam: Hollande-Septentrionale
32. Scott, P. W. (2019). Causal Inference Methods for selection on observed and unobserved factors: Propensity Score Matching, Heckit Models, and Instrumental Variable Estimation. Practical Assessment, Research, and Evaluation, 24(1), 3.
33. Steven, W. F. (1936). A new disease of cocoa in the Gold Coast. *Tropical Agriculture, Trinidad, 14.*